‘That important branch of rural science’: historical geographies of lime burning in Scotland

Douglas Mitchell

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School of Geographical and Earth Sciences

College of Science and Engineering

University of Glasgow

Abstract

Lime burning was an essential resource in the development of Scottish agriculture and industry during the eighteenth and nineteenth centuries. Lime was produced by burning limestone at high temperatures using kilns. Lime kilns, which ranged widely in form and scale, became important features of the rural economy, and their remains are a common sight in many parts of Scotland today. Despite this importance, lime burning has been largely overlooked in historical and archaeological studies of Scottish industry and agriculture. This thesis addresses this omission by broadening the thematic and geographic scope of current narrow conceptions of the industry, thereby constructing a national historical geography of lime burning in Scotland. Employing a wide range of methods and sources, including historical GIS and traditional archival scholarship, this research explores several aspects of the lime industry: the distribution and spatial patterns of lime kilns; kiln types and their usage; the movement of materials and their influence on transport infrastructure; the changing ownership and operation of kilns; the production and dissemination of knowledge; and the connections between lime and the development of agricultural science. As such, this thesis makes a substantial empirical contribution to our understanding of the lime industry, whilst also contributing to broader histories and geographies of agricultural change, industrialisation, science and Enlightenment in Scotland.

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Meagaidh, I’m not sure if you were a help or a hindrance.

Author's Declaration

I declare that, except where explicit reference is made to the contribution of others, this thesis is the result of my own work and has not been submitted for any other degree at the University of Glasgow or at any other institution.

Signature: ……..

Printed Name: Douglas Mitchell

Abbreviations

ABC	Argyll and Bute Council
BGS	British Geological Society
EDINA	JISC-funded UK data centre
GIS	Geographic Information System
HES	Historic Environments Scotland
HGIS	Historical Geographic Information System
MIT	Mitchell Library
NLS	National Library of Scotland
NRS	National Records of Scotland
NSA	‘New’ Statistical Account of Scotland
OS	Ordnance Survey
OSA	‘Old’ Statistical Account of Scotland
PKC	Perth and Kinross Council
RHASS	Royal Highland & Agricultural Society of Scotland
SLCT	Scottish Lime Centre Trust
WMS	Web Map Service

1 Introduction

1.1 Introduction

Lime is one of the foundational materials of human civilisation.[1] Historically, lime was produced by burning limestone or other calcareous material at high temperatures in a kiln (Figure 1). The resulting substance had manifold important uses in industry, construction and, especially, in agriculture. Accordingly, lime burning was an important rural industry during the eighteenth and nineteenth centuries, a period in which Scotland underwent a series of dramatic socio-economic transformations. Lime kilns and their remnants are subsequently common features of the rural landscape in many places. Despite its importance, however, lime burning has been neglected locally and nationally in Britain, and this once widespread practice has become largely lost from memory, overshadowed by more glamorous and storied industries such as coal mining and shipbuilding.[2]

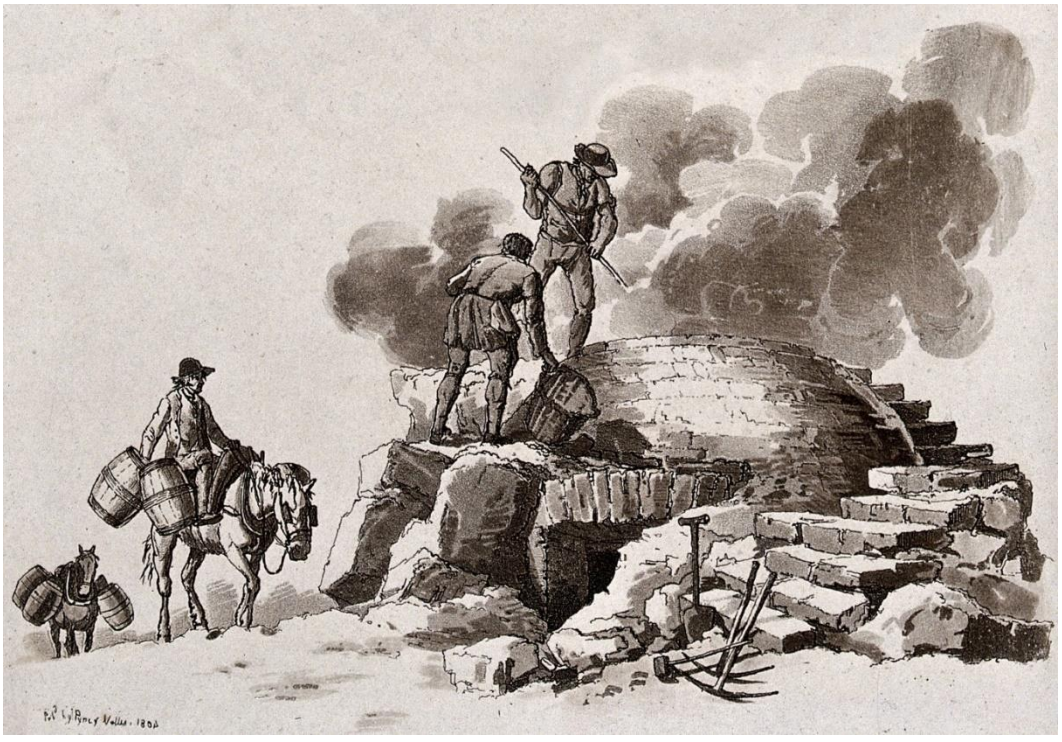

Figure 1 Men firing a lime kiln, from Pyne's *Costume of Great Britain.* Aquatinit with etching by W.H. Pyne, 1804. Credit: Wellcome Collection. CC BY.

[1] Lewis Dartnell, *The Knowledge: How To Rebuild Our World After An Apocalypse* (London: Vintage Books, 2015), 107–10.
[2] David Bick, "Lime-Kilns on the Gloucestershire-Herefordshire Border," *Industrial Archaeology Review* 7, no. 1 (1984): 85.

This thesis addresses this omission, bringing together fragmentary work by historians and archaeologists, and constructing a national historical geography of lime burning in Scotland. In doing so, it sheds new light on the industry in several ways. It provides a unique overview of the distribution and spatial patterns of lime burning across Scotland, gained from comprehensive analysis of historical Ordnance Survey mapping that highlights the widespread nature of the industry and the diversity of practice it contained. This emphasis on different scales and locations of production is carried forward in subsequent analyses of key aspects of the industry and its geographies. This thesis is also unique in considering lime burning within its broader cultural and social contexts—Scotland in an era of improvement and Enlightenment. In doing so it highlights the vital role that lime played in shaping ideas around agrarian theory and practice, around harnessing the land, and around nascent forms of agrarian science.

This introductory chapter outlines the properties of lime, the ways in which it was produced, and its applications. From there, and as a way of justifying the aims of the thesis, the importance of lime to Scottish history is explained. This is followed by a review of literature dealing directly with the lime industry, which sets up the research objectives and subsequent structure of the thesis.

1.2 Lime and lime kilns

1.2.1 Lime chemistry

Converting limestone and other calcareous material into lime requires heating the stone to between 900 and 1000ºC in order to calcine it. Overheating lime leads to sintering, where the lime becomes less reactive, sometimes referred to as being 'solid burnt'.[3] At higher still temperatures, lime becomes 'dead burnt', producing unreactive clinker. Controlled correctly, the process of calcination drives off carbon dioxide and moisture, leaving a powdery calcium oxide (CaO) or quicklime, otherwise referred to simply as lime.

[3] Peter Swallow and David Carrington, "Limes and Lime Mortars - Part One," *Journal of Architectural Conservation* 1, no. 3 (1995): 8.

Limestone → quicklime + carbon dioxide

$$CaCO_3 \rightarrow CaO + CO_2$$

Adding water to quicklime, or 'slaking' it, produces calcium hydroxide ($Ca(OH)^2$), or slaked lime. Lime is caustic and produces an exothermic reaction on contact with water. Depending on the amount of water added, different substances can be made. An excess of water produces lime putty, while an even greater ratio of water to lime produces lime water. When left open to the air, lime will react with moisture in the atmosphere and gradually slake itself.

Quicklime + water → slaked lime

$$CaO + H_2O \rightarrow Ca(OH)_2$$

The process of reversion or hardening is carbonation, in which the quick lime or slaked lime recombines with carbon dioxide to form calcium carbonate. This process is what allows lime to be used for mortar. When mixed with an aggregate, such as sand, this hardening is what allows lime to be used in mortar.

Lime + water + sand → mortar

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

The qualities of different limes are largely determined by the composition of the limestone from which they are produced. Limestone is never found in a completely pure state in nature; the characteristics of calcareous rocks vary considerably.[4]

[4] For more detailed descriptions of the characteristics of limes and the subsequent implications for mortars and conservation work, see Pat Gibbons, "Traditional Lime Mortar," in *Materials and Traditions in Scottish Building*, ed. Anne Riches and Geoffrey Stell (Edinburgh: Scottish Vernacular Buildings Working Group, 1992); Swallow and Carrington, "Limes and Lime Mortars - Part One"; Kerstin Elert *et al.*, "Lime Mortars for the Conservation of Historic Buildings," *Studies in Conservation* 47, no. 1 (2002): 62–75; Paul Livesey, "Building Limes in the United Kingdom," *Proceedings of the ICE - Construction Materials* 164, no. 1 (2011): 13–20.

1.2.2 Uses of lime

Lime is a highly versatile substance that has been used for a range of purposes and continues to be essential to many industries and practices.[5] Lime has been used to bind stone in building for thousands of years.[6] Lime acts as a plasticiser that, when mixed with an aggregate, hardens to make mortar. Hydraulic limes will set under water, a discovery attributed to engineer John Smeaton in 1756, enabling the construction of docks, lighthouses and bridges. In building, lime was also was widely used for harling, plaster and lime washes. Lime is also a key ingredient in Portland cement, which was discovered by Joseph Aspdin in 1824.[7]

Lime is essential to iron production, where it acts as a flux. It was also used in the bleaching of textiles, tanning animal skins, and cosmetics.[8] Lime water, a dilute solution of lime, found a range of uses, including as a medicament and in the production of parchment.[9] In a completely different setting, in the nineteenth century lime was used in stage lighting, giving the name 'limelight' to the kind of lanterns commonly used in theatres and music halls.[10]

Perhaps the most important usage of lime comes from its role in agriculture. Ploughed into soil, lime reduces acidity and improves the texture, thereby increasing access to nitrogen for crops. This process was especially valuable in Scotland, where the soils are noticeably acidic because of high rainfall and the decomposition of the associated abundant vegetation, yielding organic acids. These properties of lime first began to be formally recognised in Scotland around the beginning of the seventeenth century, and it is agricultural liming, often associated with bringing new areas of land into production, that has accounted for the bulk of lime production and subsequently historical

[5] For an extended review of modern industrial uses of lime, see Aideen Dowling, Jean O'Dwyer, and Catherine C. Adley, "Lime in the Limelight," *Journal of Cleaner Production* 92 (April 2015): 13–22.
[6] Dorn Carran *et al.*, "A Short History of the Use of Lime as a Building Material beyond Europe and North America," *International Journal of Architectural Heritage* 6, no. 2 (2012): 117–46.
[7] Andrew Wright, "Early Portland Cement: Its Use and Influence on Architectural Design," *Architectural Heritage* 22 (2011): 99–114.
[8] Frederick G Page, "Lime in the Early Bleaching Industry of Britain 1633 – 1828: Its Prohibition and Repeal," *Annals of Science* 60 (2003): 185–200.
[9] Matthew D Eddy, "The Aberdeen Agricola: Chemical Principles and Practice in James Anderson's Georgics and Geology," in *New Narratives in Eighteenth-Century Chemistry*, ed. Lawrance M Principe (Dordrecht: Springer, 2007), 142.
[10] For the somewhat tangential connection between lime and the professionalisation of Geography, see Emily Hayes, "Geographical Light: The Magic Lantern, the Reform of the Royal Geographical Society and the Professionalization of Geography c.1885-1894," *Journal of Historical Geography* 62 (2018): 24–36.

interest.[11] As such the majority of sources encountered in the course of this research dealt primarily with lime as an agricultural resource.

1.2.3 Lime kilns

The simplest method of burning lime requires no kiln at all—limestone and fuel can be simply heaped together and set alight.[12] However, in order to retain heat and improve efficiency (thereby reducing the fuel ratio), whilst also enabling some control over the burn, some form of kiln was usually constructed. Kilns used in Scotland ranged substantially in scale, construction and complexity. Three broad classifications of lime kiln are considered in the course of this thesis; draw, clamp and field kilns. The characteristics and development of kiln types are discussed in greater depth in Chapter Four (see p.168). The distribution of kilns across Scotland is the subject of Chapter Three.

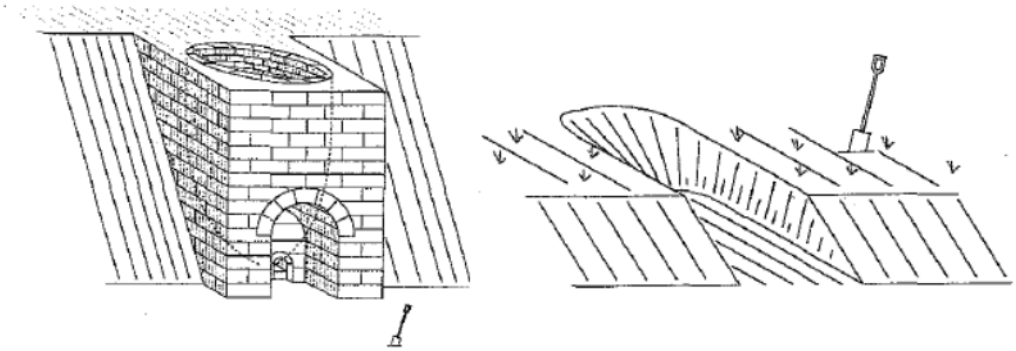

Figure 2 Simplified diagram of, left, a draw kiln, and, right, a clamp kiln. Image: Stuart Nisbet.[13]

Draw kilns were vertical masonry structures, consisting of an enclosed pot, and at least one draw hole at the bottom. Vents or eyes may also have been built into the walls to allow airflow to be controlled and the charge to be loosened with metal tools. Fuel and limestone were loaded together into the pot at the top of the kiln, moving downwards as they burned. Lime and ash were drawn out from the draw hole at the base. Because these kilns could be operated continuously—producing lime for as long as fuel and limestone continued to be added—they were more commonly associated with

[11] Stuart Nisbet, "The 18th Century Lime Industry in Scotland," *Scottish Local History* 58 (2003): 8.
[12] Michael Wingate, *Small-Scale Lime-Burning: A Practical Introduction* (London: Intermediate Technology Publications, 1985), 70.
[13] Nisbet, "The 18th Century Lime Industry in Scotland."

commercial production. This kind of operation required intensive labour to maintain a ready supply of materials. Some examples grew large and were often constructed as banks of multiple draw kilns.

Clamp kilns refer to shallow pits, usually with an opening at one end, that could be filled with interlayered limestone and fuel and then covered over (or 'clamped') with turf and sods to control the burn. They were operated intermittently, meaning that the kiln had to cool and be partially deconstructed in order to unload the lime. Groups of larger clamps could also support commercial production. The terms 'sod', 'turf' and 'sow' have all been used to describe clamp kilns in different times and places.[14]

Figure 3 Left: remains of draw kilns at Port Ramsay, Isle of Lismore. Image: Geograph. Right: Kilnpothall clamp kilns, South Lanarkshire. Image: Tam Ward.

Field kilns are certainly the most ambiguously defined category. The term field kilns has been used by several archaeologists, including David Johnson, as a shorthand way of differentiating smaller kilns not intended for commercial production without specifying a particular mode of operation.[15] Field kilns could be stone built or earthen, and varied in size and construction. They were usually operated intermittently, being loaded with limestone and fuel and allowed to burn through and cool

[14] David Johnson, "The Archaeology and Technology of Early-Modern Lime Burning in the Yorkshire Dales: Developing a Clamp Kiln Model," *Industrial Archaeology Review* 30, no. 2 (2008): 141; John T Leach, "Burning Lime in Derbyshire Pye Kilns," *Industrial Archaeology Review* 17, no. 2 (1995): 145–58.

[15] David Johnson, "Lime Kilns in the Central Pennines: Results of a Field Survey in the Yorkshire Dales and Contiguous Areas of North and West Yorkshire," *Yorkshire Archaeological Journal* 82, no. 1 (2010): 231–62; John Barnatt and A Dickson, "Survey and Interpretation of a Limekiln Complex at Peak Forest, Derbyshire; and Review of Early Limeburning in the North-West Peak," *Derbyshire Archaeological Journal* 124 (2004): 141–215; Richard Williams, *Lime Kilns and Lime Burning*, 2nd ed. (Princes Risborough: Shire Publications Ltd, 2004).

before unloading. They may also have been mixed feed (fuel and limestone in contact) or flare kilns (fuel and limestone kept apart).

For most purposes, including agriculture, ground or powdered limestone operates just as effectively as quicklime produced by calcination, a fact that was widely understood in the eighteenth century.[16] Nowadays lime is produced by grinding limestone into powder using mills and crushers. Before the twentieth century and the advent of modern machinery, however, it was more economical to break limestone down by burning than grinding it and thus the kiln was of prime importance.

1.3 Lime burning in Scotland

1.3.1 Why Scotland?

The decision to examine Scottish lime burning on a national scale reflects several factors. Perhaps most fundamentally, this research derives from a collaborative doctoral partnership with Historic Environment Scotland, an organisation whose remit is obviously confined to Scotland. Nevertheless, lime has played an important role in Scottish history. As noted above, lime was crucial in the transformation of agriculture and it has been suggested that 'larger quantities of lime per acre were used in Scotland than in any other European country'.[17] Much of this importance stems from the climatic and geological factors facing Scottish farmers. Scotland receives high levels of rainfall and much of the soil is naturally highly acidic, conditions that combine to leave many areas requiring sweetening with lime in order to support crops.[18] Compared with continental Europe, where limestone is abundant and the soils generally less acidic, landowners and agriculturalists in Scotland became greatly interested in the use and production of lime.[19] The widespread utilisation of Scotland's relatively scant limestone resources is testimony to this enthusiasm.[20] By contrast, French travellers to Scotland in the eighteenth century—whose journals provide a commentary of ongoing

[16] For contemporary discussion of ground lime, see p.120.
[17] Archibald Clow and Nan Louise Clow, *The Chemical Revolution: A Contribution to Social Technology* (London: Batchworth Press, 1952), 472.
[18] Alexander Mather, "Geology, Soils, Climate and Vegetation," in *Scottish Life and Society Volume 2: Farming and the Land*, ed. Alexander Fenton and Kenneth Veitch (Edinburgh: John Donald, 2011), 63–86.
[19] Contemporary debates around lime and lime burning are the subject of Chapter Seven.
[20] 'In contrast to the rest of the UK, Scotland possess few limestone resources', see British Geological Survey, *Limestone Mineral Planning Factsheet* (Office of the Deputy Prime Minister, 2006), p. 6.

agrarian changes—noted the existence of lime kilns along their journeys, but remarked little on the use of lime to improve soil.[21]

The significance of lime in Scottish agricultural improvement cannot be overstated. Chris Smout and Alexander Fenton argue that 'perhaps the most important of the innovations [in farming] sprang from the realisation at the turn of the seventeenth century of the value of liming'.[22] Likewise, historian Robert Hay suggests that liming was the 'single most important step in agricultural improvement'.[23] This status was not unnoticed by contemporary observers. At the end of the eighteenth century, James Anderson, whose agricultural writings and contributions to the development of liming are discussed in this thesis, called lime 'the basis of all essential improvements in this country'.[24] Liming, therefore, had a tremendous impact on Scotland's rural economy and landscape, allowing new areas of land to be brought into arable farming and significantly increasing crop yields. Smout argues that 'probably nothing had greater potential for permanently changing the face of the countryside than lime or marl', such was their ability to enhance soil and change the nature of land use.[25]

The context of Scottish agricultural change is also notable. Scotland was the second nation, after England, to change from feudal to capitalist modes of farming, but at a greater speed and intensity than all other European countries.[26] The rapid population growth experienced in Scotland during the eighteenth century could not have been sustained without similarly radical increases in agricultural productivity, nor could the new towns and expanded cities have been built without ready supplies of mortar.[27] These developments also have profound connections to the period of Enlightenment in Scotland, whereby 'rational principles', developed and diffused through various forms of intellectual

[21] Elizabeth Anne Mcfarlane, "French Travellers to Scotland, 1780-1830: An Analysis of Some Travel Journals" (PhD Thesis, University of Stirling, 2015), 138–39.
[22] Thomas Christopher Smout and Alexander Fenton, "Scottish Agriculture before the Improvers - an Exploration," *Agricultural History Review* 13, no. 2 (1965): 82. Smout and Fenton, 82.
[23] Robert Hay, "Crops and Livestock in the Improvement Era," in *Scottish Life and Society Volume 2: Farming and the Land*, ed. Alexander Fenton and Kenneth Veitch (Edinburgh: John Donald, 2011), 248.
[24] James Anderson, *General View of the Agriculture and Rural Economy of the County of Aberdeen,* (1794): 58.
[25] Thomas Christopher Smout, *Nature Contested: Environmental History in Scotland and Northern England Since 1600* (Edinburgh University Press, 2000), 73.
[26] Neil Davidson, "The Scottish Path to Capitalist Agriculture 1: From the Crisis of Feudalism to the Origins of Agrarian Transformation (1688-1746)," *Journal of Agrarian Change* 4, no. 3 (2004): 227–68.
[27] Thomas M Devine, *The Scottish Nation: A Modern History* (London: Penguin Books, 2012).

discourse, were applied to agriculture and to industry.[28] Lime, therefore, was an essential resource that linked nearly all areas of socio-economic change.

In light of this significance, and in order to give this oft-overlooked practice its due, it seems only apt to consider lime burning against the backdrop of transformations on a national scale; to provide a national perspective on the industry in Scotland. In some senses this is a change of direction for historical geography, a discipline that has for some time revered the telling of 'small stories.'[29] Such work has tended towards narrower, perhaps more provable, subjects and timescales, focusing on specific places, institutions, individuals and even objects.[30] In the right hands, small stories enable scholars to evidence big themes through everyday overlooked occurrences that serve as 'entry points to the working out of conceptual ideas in local contexts.'[31] Such work shares many scholarly affinities with micro-history.[32] As Brian Short and John Godfrey attest, 'in these small-scale human interactions, breaking down boundaries between public and private, economic and non-economic, and production and consumption, we deal holistically with life-in-the-round.'[33] These kinds of analyses can prompt vital questioning of broad-brush accounts, models and theories. Research of this kind, however, requires a depth of source material in order to examine and enliven the minutiae of the lived experience. Without methodological rigour and speaking to broader themes, small-scale, narrow studies can slip into what Jack Morrell called 'myopic piecemeal empiricism'.[34] In the 1970s, agricultural historian George Fussell reflected on the 'mass of research' then being done into local

[28] Neil Davidson, "The Scottish Path to Capitalist Agriculture 3: The Enlightenment as the Theory and Practice of Improvement," *Journal of Agrarian Change* 5, no. 1 (2005): 1–72; Ian H Adams, "The Agents of Agricultural Change," in *The Making of the Scottish Countryside*, ed. M L Parry and Terry R. Slater (London: Croom Helm, 1980), 155–76.
[29] Hayden Lorimer, "Telling Small Stories: Spaces of Knowledge and the Practice of Geography," *Transactions of the Institute of British Geographers* 28, no. 2 (2003): 197–217.
[30] Cheryl McGeachan, Isla Forsyth, and William Hasty, "Certain Subjects? Working with Biography and Life-Writing in Historical Geography," *Historical Geography* 40 (2012): 169–85; Cheryl McGeachan, "Historical Geography III: Hope Persists," *Progress in Human Geography* 41, no. 6 (2017): 1–12; Simon Naylor, "Historical Geography in Transactions," *Transactions of the Institute of British Geographers* 42, no. 4 (2017): 485–88.
[31] Lorimer, "Telling Small Stories: Spaces of Knowledge and the Practice of Geography," 214.
[32] Simon Naylor, "Historical Geography: Geographies and Historiographies," *Progress in Human Geography* 32, no. 2 (2008): 265–74.
[33] Brian Short and John Godfrey, "'The Outhwaite Controversy': A Micro-History of the Edwardian Land Campaign," *Journal of Historical Geography* 33, no. 1 (2007): 46.
[34] Jack B Morrell, "Reflections on the History of Scottish Science," *History of Science* 7 (1974): 86.

history: 'who', he asked, 'will ever have the capacity, time, and knowledge to collate it all?'[35] It is true that 'so much history is a history of regional and spatial variation', there is merit in attempting to knit together local experiences across a broader canvas, while not losing sight of that diversity.[36]

The lime industry was undoubtedly of national significance in Scotland. Sufficiently much is known about the practices of liming and lime burning in certain regions and locations (as discussed below) to merit a larger synthesis of national spatial data, regional accounts, local voices and textual discourse. The available archival and documentary source material does not, at present, permit analyses at the level of individual interactions and inner lives, of the kind outlined above. As such, the national perspective taken by this research, to some extent, reflects these methodological considerations as much as it does the thematic interests of the researcher. Crucially, this thesis does not seek to use its national framing as means through which to impose a model of lime burning in Scotland, rather it seeks, in its analysis, to preserve the granularity, the local detail and difference, of the data sources it draws upon, thereby casting a poorly understood practice in new light.

1.3.2 A brief history of lime in Scotland

Lime burning in Britain is known to date back to the Roman occupation and remnants of some Roman kilns have been found in Scotland.[37] Less is known about lime burning through the medieval period until the seventeenth century. During this time, lime burning was primarily associated with the mortar needs of building projects. Glasgow's cathedral, for instance, was built in the twelfth century using lime sourced from Campsie to the north of the city.[38] When exactly agricultural liming took hold in Scotland is hard to determine, although the most widely accepted dating is around the latter part of the sixteenth century in the Lowlands.[39] The earliest known reference to liming comes from a description of Ayrshire, believed to be written by cartographer Timothy Pont between 1604 and 1608. He wrote that the lowlands of Cunninghame had become 'much enriched by the industrious

[35] George E Fussell, "Farming History and Its Framework," *Agricultural History* 52, no. 1 (1978): 138.
[36] Short and Godfrey, "'The Outhwaite Controversy': A Micro-History of the Edwardian Land Campaign," 46.
[37] Williams, *Lime Kilns and Lime Burning*.
[38] Stuart Nisbet, "The Archaeology of the Lime Industry in Renfrewshire," *Renfrewshire Local History Forum* 13 (2005): 46.
[39] Robert A Dodgshon, *Land and Society in Early Scotland* (Oxford University Press, 1981); Ian Whyte, *Agriculture and Society in Seventeenth-Century Scotland* (Edinburgh: John Donald Publishers Ltd, 1979).

inhabitants lymeing [sic] . . . ther grounds, querby [sic] it is become much richer than befor'.[40] Numerous references to *lyme* and *lyming* also appear in parish reports from the Lothians from 1627.[41] Atkinson even suggests liming may have been utilised in Ayrshire from as early as the 1520s.[42]

It was the beginning of the seventeenth century that saw the first considerable rise in lime production for agriculture, with the period of greatest expansion occurring later during the onset of the improvement period from the mid- to late-eighteenth century.[43] Already well established in many parts of the Lowlands, lime burning, initially at small scales, became increasingly common in the Highlands as new areas of land were brought into production. The 'revolutionary effect' of lime, Devine argues, was reflected in rising rent prices in the latter half of the eighteenth century.[44] In addition to the needs of the soil, lime was required for industrial purposes and to enable the construction of Scotland's rapidly growing and increasingly stone-built urban centres.[45] As a major consumer of coal, the lime industry also provided a spur to Scottish coal mining. Over time lime production became increasingly industrialised where conditions were favourable, resulting in larger and more numerous kilns capable of sustaining continuous output. Consumption of lime continued to rise in the early decades of the nineteenth century, with Robert Bald declaring the lime industry to be 'only in its infancy' in 1808.[46] Similarly, in a revealing quote from 1812, John Wilson observed (in Renfrewshire):

> In consequence of the improved roads, and of a more complete knowledge of agriculture, which seems to be gradually diffusing among the farmers, the consumption of lime has increased every year, nor does it yet appear to be at its height.[47]

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[40] Whyte, *Agriculture and Society in Seventeenth-Century Scotland*, 201.
[41] *Reports on the State of Certain Parishes of Scotland, 1627*, (Maitland Club, 1835)
[42] John A Atkinson, "An Archaeological Analysis of Industrialisation within the Rural Context of Post-Medieval South West Scotland" (PhD Thesis, University of Glasgow, 1997), 307.
[43] Whyte, *Agriculture and Society in Seventeenth-Century Scotland*, 201; Thomas M Devine, *The Transformation of Rural Scotland: Social Change and the Agrarian Economy, 1660-1815* (Edinburgh University Press, 1994).
[44] Devine, *The Transformation of Rural Scotland: Social Change and the Agrarian Economy, 1660-1815*, 54–55.
[45] Thomas M Devine, *Exploring the Scottish Past: Themes in the History of Scottish Society* (East Linton: Tuckwell Press, 1995), 107–13.
[46] Robert Bald, *A General View of the Coal Trade in Scotland*, 95
[47] John Wilson, *General View of the Agriculture of Renfrewshire … and an Account of its Commerce and Manufactures*, 23-4

Indeed, the role of these practical and social factors—the 'improved roads' and 'more complete knowledge'—in shaping the lime industry is the focus of much of this thesis.

From the mid-nineteenth century, new sources of soil enrichment, such as guano imported from South America and, later, artificial fertilisers, reduced the demand for lime for the land.[48] By 1920 most lime works in Scotland had closed, production having become increasingly centralised as improved transport infrastructure enabled ever larger lime works to serve distant markets, putting local burners out of business.[49] As of 2006, agricultural lime production in Scotland is restricted to a few sites in the Central Highlands and Shetland and, at the time of writing, no lime is produced for mortar.[50]

1.4 Lime burning literature

This section introduces literature relating to lime burning in Scotland and elsewhere in Britain, highlighting important contributions and lacunas. The lime industry overlaps with many broader themes in Scottish history and historical geography. These literatures, which include discourse around improvement, enlightenment and industrialisation, are addressed in the context of their relevant chapters within the thesis.

Lime burning remains a relatively under-studied aspect of British industrialisation and agricultural change in the eighteenth and nineteenth centuries. Yorkshire archaeologist David Johnson called the lime industry the 'Cinderella' of British industrial archaeology; a subject largely ignored in favour of other more 'glamorous' industries, such as coal mining, iron smelting and textile manufacturing.[51] Many of the formal changes to agricultural practice and land organisation that were characteristic of the improvement period, such as leases, field structures and the form of steadings, have been well documented, but some of the most fundamental changes, including the development of lime

[48] John R Barrett, *The Making of a Scottish Landscape: Moray's Regular Revolution, 1760-1840* (Fonthill, 2015), 209.
[49] Basil C Skinner, *The Lime Industry in the Lothians* (University of Edinburgh, 1969), 9.
[50] British Geological Survey, *Limestone Mineral Planning Factsheet*, (Office of the Deputy Prime Minister, 2006), p. 6; Roz Artis, pers comm.
[51] David Johnson, *Limestone Industries of the Yorkshire Dales*, 2nd ed. (Stroud: Amberley, 2013), 7; Atkinson, "An Archaeological Analysis of Industrialisation within the Rural Context of Post-Medieval South West Scotland," 308.

production, remain as 'footnotes' in Scotland's agricultural history.[52] However, since the late 1960s, a small body of work has built up concerning the lime industry.[53] Much of this research has been conducted by enthusiasts and history societies investigating the remains of lost industries. Academic contributions have mostly come from archaeological studies, where there is a growing interest in kiln technology. Several attempts have been made at developing kiln typologies, as is discussed below. A summary of relevant literature dealing with lime kilns and lime burning in Britain is shown in Table 1.[54]

Table 1 Summary of literature on lime burning and lime kilns, 1953-2017.[55]

Author	Year	Scale	Location (where applicable)	A[56]	G	H	T	U
Gardner & Garner	1953	General						x
Skinner	1969	Regional	The Lothians	x	x	x	x	
Skinner	1970	Regional	Scotland	x			x	
Donnachie	1971	Regional	South-West Scotland			x	x	x
Havinden	1974	Regional	Devon			x		x
Mackay	1977	Regional	Stirlingshire	x		x	x	
Dodgshon	1978	Regional	Roxburghshire & Berwickshire					x
Bick	1984	Regional	Gloucestershire/Herefordshire	x	x			
Wingate	1985	General					x	
Clark	1987	Site	Dumfriesshire			x	x	x
Moore-Colyer	1988	Regional	South-West Wales	x	x	x		x
Toft	1988	Local	Gower	x			x	
Moore-Colyer	1989	Regional	South-West Wales			x		
G. Bailey	1992	Local	Falkirk	x	x	x		
Marshall, Palmer & Neaverson	1992	Site	Derbyshire	x		x		
Trueman	1992	Site	North Yorkshire	x		x	x	
Harrison	1993	Local	Stirlingshire			x		x
Leach	1995	Regional	Derbyshire	x	x	x	x	
Stanier	1995	Regional	Dorset				x	
Starmer	1995	General					x	
Swallow & Carrington	1995	General				x	x	
Alexander	1996	Site	North Lanarkshire	x				

[52] Atkinson, "An Archaeological Analysis of Industrialisation within the Rural Context of Post-Medieval South West Scotland," 91.

[53] Excepting Gardner and Gardner's 1953 book on the use of lime in farming, which is primarily an agricultural guide with some historical information. See *The Use of Lime in British Agriculture* (London: Farmer & Stock-Breeder Publications Ltd., 1953).

[54] This summary omits archaeological survey reports. Full references can be found in the Bibliography.

[55] Table adapted and revised from David Johnson, "Lime Burning in the Central Pennines: The Use of Lime in the Improvement of Agriculture Land from the Late Thirteenth Century to c. 1990" (PhD Thesis, Lancaster University, 2009), 71.

[56] Letters indicate the scope of each study. A = deals with archaeological evidence. G = includes a gazetteer of lime kiln sites. H = provides historical context. T = discusses kiln technology/typology. U = considers the local uses of lime. Full references can be found in the Bibliography (p.291).

Author	Year	Scale	Location (where applicable)	A[56]	G	H	T	U
Carrington & Swallow	1996	General						x
Atkinson	1997	Regional	Ayrshire	x	x			
Trueman	2000	General					x	
Johnson	2002	General					x	
Nisbet	2003	Regional	Scotland			x	x	
Johnson	2003	General					x	
Barnatt & Dickson	2004	Site	Derbyshire	x		x	x	
Cruikshank, Nisbet & Greig	2004	Local	Upper Donside	x	x	x		x
Williams	2004	General				x	x	
Nisbet	2005	Local	Renfrewshire	x	x	x	x	
O'Sullivan & Downey	2005	Regional	Ireland			x	x	x
Ward	2005	Site	Braehead	x	x			
Alexander	2006	Site	Arran	x		x	x	x
C. Martin & P. Martin	2006	Local	Lismore	x		x		
Scottish Lime Centre Trust	2006	Site	Charlestown			x		
White	2006	Regional	Yorkshire Dales	x	x			
Nisbet	2007	Regional	Scotland			x		x
Johnson	2008	Regional	Yorkshire Dales	x	x		x	
Johnson	2010	Regional	Central Pennines	x		x	x	
Johnson	2010	Regional	Pennines	x		x		
L.A. Bailey	2012	Site	North Ayrshire	x	x	x		
Johnson	2013	Regional	Yorkshire Dales			x	x	x
Allen	2017	Regional	Berkshire			x		
Bishop, Cuenca-Garcia, Jones & Cook	2017	Local	Western Central Belt	x		x	x	
Nisbet	2017	Local	East Kilbride & Thortonhall			x		

1.4.1 Scotland

By far the most influential work on Scottish lime burning has been Basil Skinner's *The Lime Industry of the Lothians*. Published in 1969, it was the first publication to explore the subject in any great detail and it remains frequently the only work cited on lime burning across a range of historical and archaeological texts.[57] For Skinner, the Lothians were 'the cradle of the industry' in Scotland, partly due to the local availability of both coal and limestone, but also owing to the progressive nature of the area's farming and the 'pioneering theorists and practitioners' operating there.[58] He argues that the most dramatic expansion of the industry in this region occurred around 1750, after which demand

[57] For example, see Christopher A Whatley, *The Industrial Revolution in Scotland* (Cambridge University Press, 1993); John R. Hume, *The Industrial Archaeology of Scotland I: The Lowlands and the Borders* (London: Batsford Books Ltd, 1976).
[58] Basil C Skinner, "The Archaeology of the Lime Industry in Scotland," *Post-Medieval Archaeology* 9 (1970): 226; Skinner, *The Lime Industry in the Lothians*, 10.

for lime increased significantly as a result of agricultural change, industrialisation and urban growth. His research draws heavily from Carmichael's account of Scottish lime works from 1837 (most of which were located in the Lothians), working papers from Raw Camps lime works, and some archaeological observations. His focus is primarily on commercial lime production using large draw kilns, which, he proposes, 'became the characteristic feature of the industry'.[59] From kiln remains Skinner develops a loose typology of draw kilns based on the number and configuration of pots and vents (Figure 4).

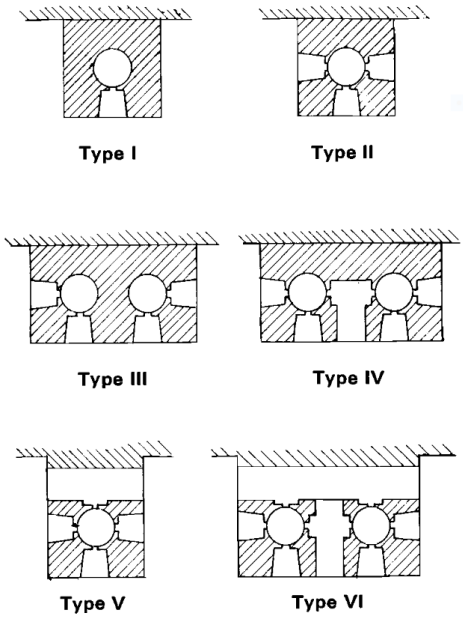

Figure 4 Plan section of kiln types, from Skinner's *The Lime Industry in the Lothians*, p. 16. Drawings depict kilns from above, showing the circular pot(s) and one or more vents. Some kiln banks (types V and VI here) also included passages running behind the kiln pots providing access and ventilation from the rear.

Skinner points out, however, that attempts at classification should carry 'no implication of chronological sequence from the simplest to the sophisticated'.[60] Despite this assertion, he largely side-lines small-scale production—summarising simply that 'a few giant concerns meant the extinction of the local entrepreneur'.[61] His position is clarified in a later paper in which he states 'we are concerned . . . with the development of an "industry" rather than with the operation of *ad hoc*, temporary or strictly local enterprises'.[62] Clamp kilns, he argues, 'could not compare economically

[59] Skinner, *The Lime Industry in the Lothians*, 12.
[60] Skinner, "The Archaeology of the Lime Industry in Scotland," 229.
[61] Skinner, *The Lime Industry in the Lothians*, 9.
[62] Skinner, "The Archaeology of the Lime Industry in Scotland," 225.

with the greater output of lime from massive draw kilns', and as such they are largely absent from his consideration.[63] While this statement may have been true of the Lothians, his attitude has arguably coloured subsequent depictions of the lime industry by historians who have tended to view large draw kilns as somehow the pre-eminent mode of production. Although the Lothians were indeed an area of considerable lime production and use, they arguably serve as a problematic model for other parts of the country which differed greatly in terms of population, infrastructure, geology, farming patterns, and local industries.

Following Skinner's work in the Lothians, several other regional studies were published. In a short paper from 1971, Ian Donnachie sketched the history of lime burning in Dumfries and Galloway for the local history society, noting the influence of a small number of large lime works there. The few smaller kilns in this area are thought to date from the late-eighteenth century, with Donnachie distinguishing between what he refers to as 'primitive' modes of small-scale production and 'more orthodox' later kilns.[64] By contrast, Ken Mackay's more detailed account of Stirlingshire shows greater appreciation for the range of kilns used. He draws on archaeological field work and archival sources to assess five lime burning sites near Stirling. Although the sites discussed consist mostly of banks of draw kilns, he notes more than 40 'horse-shoe kilns' and a smaller number of possible clamp kilns at Swallowhaugh following a limestone seam near the Bannock Burn.[65] Little attempt is made to date these kilns, although the opening up of the area to supplies of lime from further afield following improvements to roads and river crossings after 1760 suggest that these kilns were abandoned in the second half of the eighteenth century.[66] The remains of several small lime kilns were also found at Sauchie Crags and are thought to have been worked at the same time as Swallowhaugh, although they continued production into the nineteenth century. Three of these kilns are said to be of 'particularly fine style', although he does not elaborate on their distinguishing

[63] Skinner, *The Lime Industry in the Lothians,* 12.
[64] Ian Donnachie, "The Lime Industry in South-West Scotland," *Transactions of the Dumfriesshire and Galloway Natural History and Antiquarian Society* XLVIII (1971): 151.
[65] Ken J H Mackay, "Limestone Working: A Forgotten Stirlingshire Industry," *Forth Naturalist and Historian* 2 (1977): 87.
[66] Some of these kilns have been recently excavated and dated by Heather James and Paul Bishop, see 'Pilot Investigation of Lime Clamp Kiln Chronology in Upper Bannock Burn', Calluna Archaeology Interim Data Structure Report, March 28th, 2018

features.[67] In describing the kiln bank at Cambusbarron, Mackay notes that Skinner's classification code does not extend to cover its layout and construction, highlighting the problem of developing typologies from restricted geographical areas.[68]

A more academic regional study was conducted for Roxburghshire and Berwickshire by Robert Dodgshon in 1978. Examining the use of lime and marl in eighteenth century farming more than their production, he underlines their 'vital role' in transforming the agrarian landscape.[69] He stops short, however, of quantifying their impact on agricultural yields. Such assessments are hampered by the lack of detail required regarding the condition of individual fields before liming and marling were introduced, while their effects are almost impossible to isolate due to the range of other capital-intensive improvements employed at the same time. Available estimates place the impact at anything from a 25 to 100 per cent increase in crop yields.[70] Due to the lack of local lime producers, the transition from marl (which was available on some estates in the region) to lime was closely linked to the opening-up of transport infrastructure enabling lime burned further afield to be carted to farms.

Other regional studies include Geoff Bailey's work on Falkirk and John Harrison's on Stirling, both writing for local history societies.[71] Bailey notes the influence of industry and infrastructure in shaping local production. A notable example from the area was the Carron Iron Works, established in 1759, which opened its own lime works at Newbigging and harbour at Starleyburn early in the nineteenth century as a means of ensuring its demands for lime could be met. The Forth and Clyde canal in the 1780s and the Union Canal in the 1820s were also credited for adding 'impetus to the trade in lime'.[72] Harrison expands on Mackay's study of Stirlingshire by exploring the supply of building lime and extending his focus back as far as the late-fourteenth century. His work highlights the 'intimate connection' between coal, lime and transport in the region.[73] Until the middle of the

[67] Mackay, "Limestone Working: A Forgotten Stirlingshire Industry," 87.
[68] Mackay, 103.
[69] Robert A Dodgshon, "Land Improvement in Scottish Farming: Marl and Lime in Roxburghshire and Berwickshire in the Eighteenth Century," *The Agricultural History Review* 26, no. 1 (1978): 13.
[70] Dodgshon, 13.
[71] Geoff B Bailey, "Lime and Limekilns in the Falkirk District," *Calatria: The Journal of the Falkirk Local History Society* 3 (1992): 63–87; John G Harrison, "Lime Supply in the Stirling Area from the 14th to the 18th Centuries," *The Forth Naturalist and Historian* 16 (1993): 82–89.
[72] Bailey, "Lime and Limekilns in the Falkirk District," 65.
[73] Harrison, "Lime Supply in the Stirling Area from the 14th to the 18th Centuries," 85.

eighteenth century, Harrison suggests, Stirling's building lime was primarily supplied by boat, often transported distances of up to 40 kilometres along the River Forth from workings at Aberdour, Burntisland, Kinghorn and Limekilns. Local supplies also came from near Bannock Burn, little more than two kilometres away. The scale of local production in the seventeenth century was, however, limited: construction of Cowane's Hospital in Stirling was said to have required several deliveries of lime by boat from further afield.

John Atkinson's study of lime burning in Ayrshire forms part of a broader thesis on the archaeology of rural industrialisation in south-west Scotland, yet it is one of the most considered analyses of lime burning in Scotland to date.[74] He makes several important arguments about the varying scales of lime production, highlighting in particular the role of lime burning as an agricultural service industry. Rather than being strictly domestic (intended for the use of one farm) or commercial (intended for sale to the market), many kilns were constructed and operated by estates to supply lime to their tenants or within a defined geographical area, with the aim of facilitating improvement, industry and construction projects rather than simply generating revenue. Given their importance to agriculture and the rural economy, such kilns have been wrongly overlooked in favour of the later period industrialised works. Atkinson argues that agricultural liming 'lacks a coherent position within the history of industrialisation' of rural Scotland, a problem that he believes will 'only be reversed when clearer national priorities are expressed'. [75]

The most northerly study yet carried out is by Ken Cruickshank, John Nisbet and Moira Greig, who surveyed lime kilns in four parishes comprising the Upper Donside area in Aberdeenshire.[76] This work, which includes a full gazetteer of all kilns in the study area, provides a detailed picture of lime burning in the context of local agricultural changes in the eighteenth and nineteenth centuries. With the exception of one 'quarry kiln', all of the kilns in the study were described as draw kilns that were operated intermittently for domestic supply, being sited 'on their farms and crofts, next to the fields

[74] Atkinson, "An Archaeological Analysis of Industrialisation within the Rural Context of Post-Medieval South West Scotland," 264–308.
[75] Atkinson, 308.
[76] Ken Cruickshank, John Nisbet, and Moira Greig, *The Limekilns of Upper Donside: A Forgotten Heritage* (Aberdeenshire Council, 2004).

where the lime was to be used'.[77] Although the kilns were built along effectively the same basic plan, closer inspection reveals the 'striking . . . individuality in appearance' of the farmer-built kilns, hinting at how knowledge of kiln construction was spread and adapted.[78]

Stuart Nisbet has published several papers on lime burning for local history groups. In his work on Renfrewshire—which reveals a large number of previously unrecognised lime burning sites—he critiques the lack of attention paid to the industry in parts of Scotland besides the Lothians, illustrating the continued influence of Skinner's work from the sixties.[79] Nisbet also calls greater attention to clamp kiln burning than did previous studies. He attempts to construct a simple typology of clamps based on the size, construction and presumed age of remains. In doing so he provides evidence to refute the 'serious accusation' that these kilns were crude or ephemeral, pointing to larger scale industrial workings from the nineteenth century that employed banks of clamp kilns. Subsequent papers have dealt with the waterborne trade in lime and shed light on the extensive lime working in East Kilbride parish.[80]

Building on the work of Nisbet and Mackay, Paul Bishop *et al.* directly address the question of clamp kilns and their role in the nineteenth century lime industry.[81] Their study, which draws on a field study and analysis of kiln remains around Campsie and Baldernock, highlights that clamp kilns were widespread in parts of the Central Belt until the latter part of the nineteenth century. Several of the clamps investigated were large and showed signs of permanent masonry linings. Arranged in long banks, several clamp kilns could be operated cyclically to sustain commercial output. Bishop *et al.* suggest that the large number of clamp kilns in the area reflects a local preference for the technology, as well as the interbedded nature of the coal and limestone that allowed them to be extracted together. Their findings support Nisbet's argument that clamp kilns should not be thought of as precursors to

[77] Cruickshank, Nisbet, and Greig, 20.
[78] Cruickshank, Nisbet, and Greig, 30.
[79] Nisbet, "The Archaeology of the Lime Industry in Renfrewshire."
[80] Stuart Nisbet, "'A Hot Cargo' The Waterborne Supply of Lime in Scotland," *History Scotland* Nov/Dec (2007); Stuart Nisbet, "A Hidden Secret: Lime Working in East Kilbride and Thortonhall," *Scottish Local History* 98 (2017): 3–8.
[81] Paul Bishop *et al.*, "Lime Burning in Clamp Kilns in Scotland's Western Central Belt: Primitive Industry or Simple But Perfectly Adequate Technology?," *Industrial Archaeology Review* 39, no. 1 (2017): 1–23.

more sophisticated forms of kiln. Bishop's earlier work on lime kilns in Baldernock and Campsie sparked interest in their representation on early maps (which is discussed further in Chapter Three).[82]

Several site-specific studies have also been carried out in Scotland.[83] Notable among these is Richard Clarke's account of Charles Menteath's lime works at Closeburn in Dumfriesshire.[84] The study focuses primarily on the innovative use of water power to drive the haulage of limestone along a railway at the site (along with other machinery further upstream), but also delves into the construction and working of the kilns themselves. In his narrative of the site's development, Clarke touches on the processes of invention and iteration that took place at the works—processes usually overlooked in other accounts of the industry. Menteath's lime works attracted considerable attention among agrarian and improvement circles during the late-eighteenth and early-nineteenth centuries, not least because of his own efforts at self-promotion. His writing and influence are discussed further in Chapter Six.

An investigation into Hullerhirst quarry and lime kilns in north Ayrshire by Laura Alexis Bailey brings to light the history and development of a less well-known lime burning site.[85] Analysis of the remains of two draw kilns there revealed the 'rapid development of kiln technology and design'. The first was built in 1776, at a time of intense local agricultural change and in response to a growing demand for lime, with the second constructed some time before 1837 (when the site ceased operating). Bailey notes that, although the two kilns 'displayed superficially similar architectural characteristics', their designs were very different and locally distinctive.[86] The later of the two kilns is notable for its inclusion of draw arches facing multiple directions and larger covered areas,

[82] Paul Bishop and Gavin Thomson, "How OS Depicted Limekilns in Scotland's Central Belt," *Sheetlines* 98 (2013): 19–31; Paul Bishop and David Munro, "Further Comment on OS Mapping of Limekilns in Scotland," *Sheetlines* 101 (2014): 42–47; Paul Bishop, "Over-Cooking Lime Kilns?," *Sheetlines* 106 (2016): 32–33; Doug Mitchell and Paul Bishop, "Limekilns – Still a Burning Issue," *Sheetlines* 107 (2016): 20–22.
[83] Tam Ward, "Braehead Village Survey Report," *Biggar Archaeology*, 2005; Derek Alexander, "Excavation of a Small Limekiln at North Medrox, Mollinsburn, North Lanarkshire," *Glasgow Archaeological Journal* 20 (1996): 77–82; Derek Alexander, "Brodick Castle Clamp-Kiln and the Lime Industry of Arran," *History Scotland* Jan/Feb (2006); Colin Martin and Paula Martin, "The Lismore Limekilns," 2006.
[84] Richard J Clarke, "The Closeburn Limeworks Scheme: A Dumfriesshire Waterpower Complex," *Industrial Archaeology Review* 10, no. 1 (1987): 5–22.
[85] Laura Alexis Bailey, "Hullerhirst Quarry and Lime Kilns, North Ayrshire," *Scottish Archaeological Journal* 34, no. 5 (2012): 99–116.
[86] Bailey, 112.

presumably allowing lime to be drawn regardless of weather and wind direction. Her study also called into question the role of larger kilns, like those at Hullerhirst, in agricultural areas with numerous smaller kilns operated by farmers. Finally, a review of the working papers of Charlestown lime works in Fife by the Lime Centre Trust revealed the unprofitability of the works as well as the spatial extent of the large lime producers. Lime from Charlestown was sold all along the east coast of Scotland and carried as far afield as Sweden and Canada.[87]

1.4.2 England and Wales

David Johnson is responsible for the most substantial body of research concerning lime burning anywhere in Britain. Focusing primarily on Yorkshire, where he has conducted extensive field surveys, his work has brought to attention a range of overlooked aspects of the industry, including alternative methods of extracting limestone, the role of clamp kilns, and agricultural liming before the fifteenth century.[88] In terms of clamp kilns, his work has demonstrated that clamps were both more important in the lime trade and more widespread than previously believed. This misinterpretation, he argues, comes partly from the subtle and easily unnoticed nature of their remains, but also from the 'discriminatory' way in which they have been portrayed in historical accounts.[89] Johnson has contributed to the typology and nomenclature debates insofar as to suggest that they may ultimately prove fruitless given the limitations of archaeological evidence, the interchangeability of terms in historical records, and the growing diversity of kiln design revealed by ongoing research.[90]

[87] Scottish Lime Centre Trust, *Charlestown Limeworks: Research and Conservation* (Edinburgh: Historic Scotland, 2006).
[88] Johnson, "Lime Kilns in the Central Pennines: Results of a Field Survey in the Yorkshire Dales and Contiguous Areas of North and West Yorkshire"; David Johnson, "Hushes, Delfs and River Stonary: Alternative Methods of Obtaining Lime in the Gritstone Pennines in the Early Modern Period," *Landscape History* 31, no. 1 (2010): 37–52; Johnson, "The Archaeology and Technology of Early-Modern Lime Burning in the Yorkshire Dales: Developing a Clamp Kiln Model"; Johnson, "Lime Burning in the Central Pennines: The Use of Lime in the Improvement of Agriculture Land from the Late Thirteenth Century to c. 1990."
[89] Johnson, "The Archaeology and Technology of Early-Modern Lime Burning in the Yorkshire Dales: Developing a Clamp Kiln Model," 141.
[90] Johnson, *Limestone Industries of the Yorkshire Dales*, 50.

Prior to Johnson's work in Yorkshire, the area of England receiving the most attention in terms of lime burning was Derbyshire, where there are extensive areas of worked limestone outcrops.[91] John Leach's study in this region was one of the first to draw attention away from large masonry kilns and towards smaller, earthen kilns. He describes the 'pye' kiln, which he believes to be locally distinctive and closely related to clamp kilns found elsewhere. These 'pye' kilns, he argued, were a technological leap in terms of ease of production and use from the traditional intermittent sod kilns, though they could not operate as efficiently as draw kilns.[92] More recent work includes Barnatt and Dickson's rigorous survey of an extensive commercial lime kiln complex in the Peak Forest, where they examine the transition from 'traditional earthen sale-kilns' in the eighteenth century to vertical masonry kilns in the nineteenth.[93] They emphasise, however, that this transition in kiln type was part of a wider, 'more radical' set of changes in the nature of lime production involving greater financial investment, more elaborate quarry workings and, ultimately, a conversion in working pattern from seasonal proto-industry to year-round industrial output.[94]

Accounts of lime burning from elsewhere have tended towards straightforward descriptions of individual sites and local trades, and traditional narratives of industrial progression, from which limited conclusions can be drawn.[95] For example, Richard Moore-Colyer, describing the lime industry in coastal Wales, refers to clamp kilns as 'essentially ephemeral', overlooking them in favour of draw kiln sites.[96]

[91] Leach, "Burning Lime in Derbyshire Pye Kilns"; Gary Marshall, Marilyn Palmer, and Peter Neaverson, "The History and Archaeology of the Calke Abbey Lime-Yards," *Industrial Archaeology Review* XIV, no. 2 (1992): 145–76; Barnatt and Dickson, "Survey and Interpretation of a Limekiln Complex at Peak Forest, Derbyshire; and Review of Early Limeburning in the North-West Peak."
[92] Leach, "Burning Lime in Derbyshire Pye Kilns."
[93] Barnatt and Dickson, "Survey and Interpretation of a Limekiln Complex at Peak Forest, Derbyshire; and Review of Early Limeburning in the North-West Peak," 205.
[94] Barnatt and Dickson, 205.
[95] Bick, "Lime-Kilns on the Gloucestershire-Herefordshire Border"; Richard J Moore-Colyer, "Of Lime and Men: Aspects of the Coastal Trade in Lime in South-West Wales in the Eighteenth and Nineteenth Centuries," *Welsh History Review* 14 (1988): 54–77; J. R.L. Allen, "Geological Resources and Their Exploitation in the Berkshire Chalklands of the Later Nineteenth Century: A First Survey," *Landscape History* 38, no. 1 (2017): 67–80.
[96] Richard J Moore-Colyer, "Coastal Limekilns in South-West Wales," *Folk Life - Journal of Ethnological Studies* 28, no. 1 (1989): 22.

In a more explorative study of kilns on the Gower Peninsula, in south Wales, Luke Toft compared the theoretical operating temperatures of kilns. He concluded that economic competition led to replacement of small farm kilns by massive draw kilns, since the latter were able to achieve higher operating temperatures, thereby reducing the production cycle time.[97] Whilst he was able to draw on modern understanding of the chemical reactions behind calcining, his analysis also highlights the challenging 'art' of lime burning using early kilns.[98]

1.4.3 General texts

A small number of publications deal with lime kilns and lime burning on a more general level, rather than describing local histories or the development of particular sites. Richard Williams' *Limekilns and Lime Burning* provides an accessible introduction to the subject, albeit one that largely focuses on big industrial kilns.[99] Gardner and Garner's guide to the use of lime in agriculture contains one of the first condensed histories of the lime industry alongside practical advice concerning its use on the soil. Somewhat tellingly, however, it opens with the assertion that lime only 'played a big part' in farming after the passing of the Land Fertility Act (sic) in 1937, a statement running counter to most modern narratives of the agricultural revolution.[100] More useful is Michael Wingate's manual on practical lime burning techniques, which gives valuable insight into the complexity of managing heat in a lime kilns and the properties of various fuels and limestones.[101]

Interest in lime burning has prompted some archaeologists to attempt to develop a formal typology of lime kilns.[102] Michael Trueman, on behalf of the English Heritage Monument Protection Programme produced a model based on variations of kiln technology and operation (Figure 5). However, such attempts have been met with caution by archaeologists citing local exceptions to the structure and inconsistencies in regional kiln naming conventions, as well as difficulties around

[97] L.A. Toft, "Lime Burning on the Gower Peninsula's Limestone Belt," *Industrial Archaeology Review* 11, no. 1 (1988): 75–85.
[98] Toft, 83.
[99] Williams, *Lime Kilns and Lime Burning*.
[100] Gardner and Garner, *The Use of Lime in British Agriculture*, v.
[101] Wingate, *Small-Scale Lime-Burning: A Practical Introduction*.
[102] Geoffrey Starmer, "Limekilns and Typologies," *Industrial Archaeology News* 92 (1995): 2; Peter Stanier, "A Suggested Typology for Dorset Limekilns," *Industrial Archaeology News* 92 (1995): 3.

determining usage from remains.[103] Models such as Trueman's also imply a fixed sequence of technological development over time, giving little scope for variations within certain kiln categories, such as the difference between single intermittent clamp kilns and large banks of clamp kilns operated sequentially to achieve continuous output.

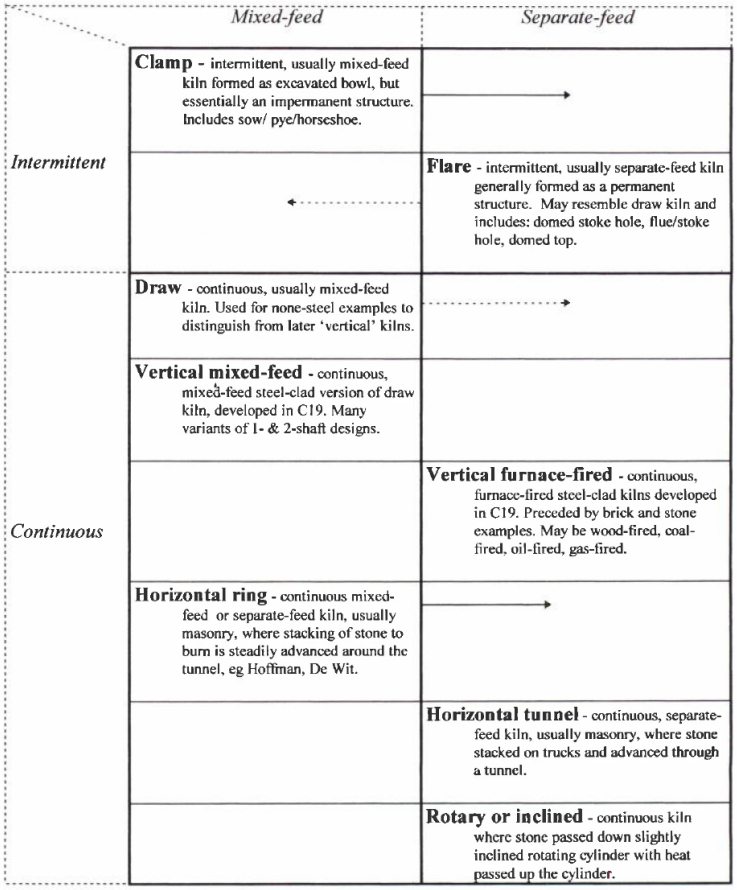

Figure 5 Trueman's model of lime kiln technologies.[104]

Finally, Johnson published a two-part history of the development of the Hoffman kiln, a style of late-period horizontal kiln that became common in parts of England at the end of the nineteenth century.[105] Although of little direct relevance to the Scottish lime industry, this work is important since it deals

[103] Barnatt and Dickson, "Survey and Interpretation of a Limekiln Complex at Peak Forest, Derbyshire; and Review of Early Limeburning in the North-West Peak," 151–52; Johnson, "Lime Kilns in the Central Pennines: Results of a Field Survey in the Yorkshire Dales and Contiguous Areas of North and West Yorkshire," 236.
[104] Michael R.G. Trueman, "Lime Kilns - Modelling Their Technological Development," *Industrial Archaeology News* 112 (2000): 4.
[105] David Johnson, "Friedrich Edouard Hoffmann and the Invention of Continuous Kiln Technology: The Archaeology of the Hoffmann Kiln and 19th-Century Industrial Development (Part 1)," *Industrial Archaeology Review* 26, no. 2 (2002): 119–32; David Johnson, "Friedrich Edouard Hoffmann and the Invention of Continuous Kiln Technology: The Archaeology of the Hoffmann Kiln and 19th-Century Industrial Development (Part 2)," *Industrial Archaeology Review* 25, no. 2 (2003): 15–29.

in some depth with the processes of innovation and iteration in design, and with the role of individuals in communicating and implementing new ideas.

1.4.4 Literature summary

The review of literature highlights several key knowledge gaps. Firstly, studies of Scottish lime burning are limited in their geographic scope. Most research has focused on particular sites or restricted regions, often the product of local history societies or excavations by enthusiasts. While such studies provide valuable empirical material, little attempt has yet been made to knit together these histories, to fill in the blanks, and examine the industry on a national scale. It is notable that little is known about lime burning north of Stirlingshire, given the obvious importance of lime for the improvement of upland soils. Attention is mostly drawn to areas already famed for their lime industry, such as the Lothians, Fife and parts of Ayrshire. However, the lack of awareness of lime burning in northerly areas may prove the result of, to quote Nisbet, simply a 'lack of looking'.[106]

Secondly, clamp kilns remain a marginalised and often mischaracterised aspect of the lime industry, although this prejudice has, following work by Johnson, Nisbet and Bishop, recently begun to be redressed.[107] Many writers, particularly those drawing from earlier literature, continue to classify clamp kilns as ephemeral and simplistic, despite recent studies revealing their continued importance in commercial lime production in the nineteenth century. This tendency may stem from a broader trend in the literature common in other areas of landscape history, namely the over-representation of what Taylor referred to 'high-status sites'.[108] In this instance, high-status sites refer to famed lime works, often those operated by notable individuals, which had a large economic impact or which have left behind imposing and well-preserved remains. Such sites are almost invariably draw kilns. Smaller, less substantial, kilns, including clamps, may have been initially overlooked due to their

[106] Nisbet, "The Archaeology of the Lime Industry in Renfrewshire," 41.
[107] Johnson, "The Archaeology and Technology of Early-Modern Lime Burning in the Yorkshire Dales: Developing a Clamp Kiln Model"; Bishop *et al.*, "Lime Burning in Clamp Kilns in Scotland's Western Central Belt: Primitive Industry or Simple But Perfectly Adequate Technology?"
[108] C.C. Taylor, "The plus Fours in the Wardrobe: A Personal View of Landscape History," in *Landscape: The Richest Historical Record*, Hooke, O (Westbury: Society for Lanscape Studies, 2000), 161.

lower ‘archaeological visibility’, but nevertheless their contribution to agriculture and rural industry has been fundamentally important.[109]

The poor understanding of clamp kilns is compounded by unresolved debates and confusion surrounding lime kiln typologies and nomenclature. Archaeologists and historians are yet to agree on the defining characteristics of different kiln types and where these fit in the development of kiln technology over time. These ambiguities are further complicated by the litany of names used for kilns across different parts of Britain, which may or may not refer to the same structures. Indeed, this complexity suggests that kilns were subject to high degrees of local specificity and were the product of a combination of local experience, site conditions and the availability of materials and capital.

Lastly, little attempt has been made to analyse lime burning at the national scale in Scotland, or indeed elsewhere. Local histories and excavations of kilns largely fail to tie developments in the lime industry to their wider historical contexts. During a transformational period in Scotland’s history, lime was intimately associated with agricultural improvement and vital for the development of Scotland’s industry and built environment. As such, it would be remiss not to consider how lime production was shaped by the broader intellectual and ideological forces that drove these developments. This thesis contributes to filling these four lacunae in our understanding of this important industry.

1.5 Intellectual and historiographical context

Stepping back from extant research on lime burning specifically, by engaging with lime kilns and their remains, this research closely associates with the traditions of industrial archaeology, a ‘necessarily hybrid subject’ that extends beyond the purely functional analysis of industrial landscapes, structures and artefacts to a broader consideration of their cultural meaning and value.[110] The relationship between people and things in the past is ultimately an interdisciplinary concern. Hicks and Beaudry, for example, urge archaeologists, anthropologists, historians and geographers to

[109] Johnson, “The Archaeology and Technology of Early-Modern Lime Burning in the Yorkshire Dales: Developing a Clamp Kiln Model,” 141.
[110] Kenneth Hudson, *Industrial Archaeology: An Introduction* (John Baker Publishers Ltd, 1963), 15; Peter Neaverson, *Industrial Archaeology: Principles and Practice* (London: Routledge, 1998).

study both material and immaterial concerns by 'folding together broader narratives (geographical or temporal) with rich and nuanced local stories, and exploring the permeabilities between human and material worlds.'[111] Historical geography and archaeology share many commonalities in terms of disciplinary origins and areas of interest, including heritage, materiality and landscape.[112] Part of this similarity is methodological; both geographer and archaeologist, Kenneth Hudson suggests, have 'a duty—and a pleasure—to go and see things for himself [sic] on the ground', while the mapping and spatial analysis of material artefacts in GIS is also increasingly central to archaeological research.[113] Fieldwork and spatial analysis inform the present research, as Chapter Two discusses further.

In reconstructing and analysing the distribution of lime kilns and associated flows of materials, the present research also overlaps with the themes of industrial geography, a sub-branch of economic geography concerned with the 'spaces, places, and geographical circulation of industry', which are themselves 'the consequence of historical process.'[114] Industrial questions were at the heart of the development of locational theory in the early twentieth century, which addressed questions about what economic activities are located where, and why.[115] This thesis returns to recognisably similar themes, but seeks to place analysis of the lime industry within a broader scientific, cultural and philosophical narrative.

More broadly, this thesis positions itself within long-established traditions of British and Anglo-American historical and geographic research, dating back to figures such as Henry Clifford Darby, Hugh Prince and Alan Baker in the 1960s and '70s. The formative years of the geographical sub-

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[111] Dan Hicks and Mary C Beaudry, *The Cambridge Companion to Historical Archaeology* (Cambridge University Press, 2006), 7.
[112] Lisa J Hill, "Human Geography and Archaeology: Strange Bedfellows?," *Progress in Human Geography* 39, no. 4 (2015): 412–31; William George Hoskins, *The Making of the English Landscape* (London: Hodder and Stoughton, 1955); Michael. Aston, *Interpreting the Landscape: Landscape Archaeology and Local History* (New York: Routledge, 1997); Christopher Tilley, *The Materiality of Stone: Explorations in Landscape Phenomenology* (Oxford: Berg, 2004).
[113] Hudson, *Industrial Archaeology: An Introduction*, 18; Mark Gillings, Piraye Hacıgüzeller, and Gary Lock, eds., *Re-Mapping Archaeology: Critical Perspectives, Alternative Mappings* (London: Routledge, 2018).
[114] Derek Gregory et al., eds., *The Dictionary of Human Geography*, 5th ed. (Chichester: Wiley-Blackwell, 2009), 376; James W Harrington and Barney Warf, *Industrial Location: Principles, Practice and Policy* (London: Routledge, 1995), 115.
[115] Alfred Weber, *Theory of the Location of Industries*, trans. Carl J Friedrich (Chicago: University of Chicago, 1929); Peter Haggett, *Locational Analysis in Human Geography* (Sevenoaks, Kent: Edward Arnold, 1965).

discipline that became recognised as historical geography were, to a large extent, bound up with the study of agriculture and landscape change. The *Historical Geography Research Group* of the *Institute of British Geographers* was so named in 1973, having previously been known as the *The Agrarian Landscape Terminology Study Group* and *The Agrarian Landscape Research Group*.[116] Two major national historical geographies of Scotland appeared in the 1980s, both with a strong emphasis on agricultural and associated changes.[117] The important role of lime in these transformations is rightly recognised in both volumes, yet the industry itself is addressed only briefly, capturing none of its diversity, development and geographies. Following William Hoskins' landmark book in 1955, landscape histories, concerned with how (often rural) landscapes have been *made* in various ways, are now something of an enduring British staple.[118] In Scotland, the work of Christopher Smout has been of particular importance in terms of exploring the relationship between environmental and landscape changes and political and socio-economic shifts.[119] Since the mid-nineties there has been sustained attention within historical geography on questions around scientific knowledge and practice, encompassing such topics as experimentation, instrumentation, dissemination, travel and national identity.[120] This thesis, then, with its emphasis on agricultural thought and practice, as well as on the ideological and technological drivers of landscape change, speaks to some of the sub-discipline's earliest and longest-held interests.

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[116] Robin A Butlin, ed., *The Historical Geography Research Group: A History* (Cheltenham: IBG Historical Geography Research Group, 2013).

[117] David Turnock, *The Historical Geography of Scotland Since 1707* (Cambridge University Press, 1982); G Whittington and Ian Whyte, eds., *An Historical Geography of Scotland* (London: Academic Press Inc, 1983).

[118] Hoskins, *The Making of the English Landscape*; Martin Parry and Terry Slater, eds., *Making of the Scottish Countryside* (Croom Helm Ltd, 1980); Oliver Rackham, *History of the Countryside* (London: Dent, 1986); David Turnock, *The Making of the Scottish Rural Landscape* (Ashgate, 1995); Francis Pryor, *The Making of the British Landscape: How We Have Transformed the Land, from Prehistory to Today* (London: Penguin, 2011); Nicholas Crane, *The Making of the British Landscape: From the Ice Age to the Present* (London: Weidenfield & Nicholson, 2016).

[119] Sally Foster and Thomas Christopher Smout, eds., *The History of Soils and Field Systems* (Aberdeen: Scottish Cultural Press, 1994); Smout, *Nature Contested: Environmental History in Scotland and Northern England Since 1600*; Thomas Christopher Smout, *Exploring Environmental History: Selected Essays* (Edinburgh University Press, 2005).

[120] David N. Livingstone, "The Spaces of Knowledge - Contributions Towards a Historical Geography of Science," *Environment and Planning D-Society & Space* 13, no. 1 (1995): 5–34; Charles W J Withers, *Geography, Science and National Identity: Scotland since 1520* (Cambridge University Press, 2001); David N. Livingstone, *Putting Science in Its Place: Geographies of Scientific Knowledge* (University of Chicago Press, 2003); Simon Naylor, "Historical Geography: Knowledge, in Place and on the Move," *Progress in Human Geography* 29, no. 5 (2005): 626–34; Peter Meusburger, David N. Livingston, and Henke Jöns, eds., *Geographies of Science*, 2010; David N. Livingstone and Charles W. J. Withers, eds., *Geographies of Nineteenth-Century Science* (London: University of Chicago Press, 2011).

A problem remains, nevertheless, in attempting to classify the present research against these various disciplines and sub-disciplines, whether by methodology or subject matter. Despite dealing with an industry's physical remains, this thesis is not an industrial archaeology of lime. 'Proper' archaeology comes with it a set of methodologies and sensibilities that one cannot simply 'have a go' at—and this researcher is not a trained archaeologist. Neither is it an industrial geography of lime. Although it deals with many of the locational factors that underpinned that sub-discipline, it seeks to examine more than simply why kilns were where they were. Agricultural history is also an unsatisfactory fit, since the focus here is on the production side of, an admittedly agricultural, practice, rather than on the agrarian use of lime and its subsequent impact on yields. Similarly, this work cannot be described as landscape history, since its analysis is not grounded in traditional readings of landscape forms or representations. Aspects of the thesis do address scientific themes, but these are only part of the story. Ultimately, in addressing a wide range of themes and approaches, this thesis might best be described as a hybrid, or perhaps holistic, historical geography of lime burning in Scotland.

1.6 Research Objectives

In light of the knowledge gaps outlined above, this thesis addresses several research objectives. First, on an empirical level, this thesis broadens the geographic scope of histories of the lime industry to produce a national historical geography of lime burning in Scotland. This large-scale approach holds several advantages that include enabling comparisons between geographically distinct regions of Scotland and the opportunity to connect the practice of lime burning to wider themes in Scottish history. As analysis of existing literature has shown, studies of lime burning have been largely limited to the scale of sites and regions—no attempt has yet been made to construct a picture of the industry on a national scale that encompasses the diverse forms of production contained within it. By considering the industry across the country as a whole, this research highlights lime burning beyond those areas most frequently heralded for their lime industry (such as the Lothians). A national approach also refocuses attention away from the most prominent examples of lime kilns (such as Charlestown) towards other smaller producers. In this regard, this thesis provides a new and much needed perspective on an important industry.

Second, and related to the first objective, this research applies elements of spatial analysis to the lime industry. Analysis of this kind constitutes an altogether new and innovative approach to the study of Scottish lime burning. Using data derived from historical mapping, lime kilns are shown to have been widespread across much of Scotland. Several spatial patterns are revealed. Some insights from this approach empirically confirm existing conceptions of the industry—clamp kilns, for instance, are found to be concentrated in areas with abundant fuel and limestone, while commercial burning is concentrated in the Central Belt region. Crucially, this approach highlights the large number of small lime burning sites that existed alongside larger industrial concerns, challenging the long-held emphasis on the latter in the literature.

Third, this thesis pays particular attention to the role of clamp kilns within the lime industry to improve understanding of this method of burning. Although somewhat overlooked in early histories of lime burning, recent studies have argued that clamp kilns were widely employed and continued to be used in some places throughout the period of industrialisation. Thus, by actively looking for evidence of clamp kiln usage around Scotland and analysing their representation within contemporary improving literatures, insight is gained regarding the importance of clamps and how they came to be misunderstood at the time and subsequently by recent scholars.

Fourth, this thesis argues that social status was attached to burning lime or owning a draw kiln. From their remains it is clear that many lime kilns were elaborately built and imposing structures, suggesting that, during a period of competitive social display, lime kilns may have acted as objects through which to convey the wealth or agricultural prowess of their owner. I argue that this social aspect of the industry, which has been hitherto overlooked, contributes to understanding of why certain kiln types became popular and how ideas associated with lime burning were spread.

Fifth, this thesis addresses the cultural and intellectual contexts of lime in eighteenth- and nineteenth-century Scotland by examining the relationship between lime burning and questions of science, improvement and enlightenment. By virtue of its cross-cutting importance to so many socio-economic activities, lime was connected to many aspects of intellectual enquiry during this period, connections that are revealed by the circulation of practical and theoretical knowledge through a

range of fora. Specifically, it will be argued that contemporary discourses around lime played a crucial role in the development of scientific agriculture. This dimension of the industry, hitherto unexplored in the historiography, likely had a crucial impact on the formation of best-practices and the diffusion of agricultural knowledge.

Finally, in the course of addressing the above research questions, I assess how diverse methodologies can combine to improve understanding of a rural industry. A mixture of traditional and non-traditional historical geographical methods is employed in this research. Although there are challenges associated with connecting at times disparate sources with different spatial and temporal resolutions, it is shown that this approach provides unique insight that would be missed by researchers employing archival study or archaeological excavation alone.

1.7 Thesis Structure

As with nearly all attempts to turn multifaceted and interlinked ideas and data into a linear narrative document, this structure is the product of compromise. Following an extended introduction that sets out the state of knowledge on lime burning and the that lacunae this work seeks to fill, the thesis employs a thematic structure that forefronts the map-based analysis. This approach allows the maps to inform subsequent chapters, emphasising the geographical nature of this thesis. As such, the focus of the thesis gradually shifts in scale through the successive empirical chapters, starting with a national perspective gained from the mapping of kilns (in effect a bird's-eye view), to the movement of materials across regional scales, down to the level of sites and kilns, and finally to examining the role of individuals, texts and ideas (recognising, of course, that texts and ideas can themselves travel and play a role in constituting what might be conceived as a 'national' discourse around the importance of lime and the means of its production). A reversal of this order, in which contemporary intellectual and ideological discourses around lime are brought to the beginning before later discussion of practices and patterns within the lime industry 'on the ground', could also have been possible. This approach, however, would, in sequential reading, delay the valuable contextualisation that the mapping offers.

Two alternative thesis structures were considered during the research and write-up stages. The first, which was dismissed relatively early-on in the research process, was to use a case-study approach, employing a series of sites, areas or even individuals through which to develop a rigorous and comparative national analysis of the industry. However, this approach was stymied by the inconsistency of available data. Case studies are reliant on a sufficient depth of relevant material. Since, as is discussed further in the Methodology, there is no single archive of the lime industry, while the estates, the primary organising unit in Scotland and the foremost sources for the study of rural industry, have been decidedly patchy in their recording of their own lime burning. It hence proved impossible to find suitable volumes of like data across multiple sites of comparable period or status to support an entirely case-based approach. Furthermore, no obviously prominent persons have emerged in the lime industry, save perhaps for Charles Bruce, 5th Earl of Elgin and founder of Charlestown lime works and planned village, and Stuart Menteath of Closeburn lime works, both of whom have already been the subject of scholarly attention.[121] Indeed, the experiences of these aristocratic individuals cannot be taken as representative of vernacular lime burning as it was most widely practiced in Scotland.

The second alternative structure that was considered and ultimately rejected was to address the material chronologically, building chapters sequentially around key periods in the industry. The advantage of this approach would have been to support arguments around causality. However, chronologically arranging the data does expose the temporal unevenness of the source material. One of the challenges that the present structure overcomes is that of the time periods to which the various data relate. The OS mapping, upon which the geodatabase of lime burning sites is based, originates from the second half of the nineteenth century. In a chronologically arranged thesis, this would appear towards the end, introducing a keystone dataset and innovative methodology during the period of the lime industry's decline in Scotland. Bringing this data, and the spatial visualisations that they offer, forward to the beginning of the empirical chapter sequence, both places them proximate to

[121] Normal Fotheringham, *Charlestown: Built on Lime* (Dunfermline: Carnegie Dunfermline Trust, 1999); Scottish Lime Centre Trust, *Charlestown Limeworks: Research and Conservation*; Skinner, *The Lime Industry in the Lothians*; Clarke, "The Closeburn Limeworks Scheme: A Dumfriesshire Waterpower Complex."

relevant methodological discussion and allows associated findings and visualisations to inform other aspects of the thesis, such as exploration of the circulation of resources.

This **Introduction** chapter has provided an overview of the main concepts and contexts of this thesis. It has also, following a review of literature on lime burning, highlighted the key knowledge gaps in the subject area and set out the research aims of this work.

To begin with, **Chapter Two** outlines and justifies the methods and sources used in the course of this research. This thesis employs a mixture of traditional historical scholarship and historical GIS. The chapter is organised by source, dealing in turn with archival material, contemporary published work, historical GIS, site visits and participatory fieldwork. The methodological considerations and logistical factors of each are considered, with some discussion of how they relate to one another. The relationship between methods is one of the overarching themes of the thesis and is addressed in more depth in the Conclusion.

Chapter Three explores the broad spatial patterns of the lime industry by drawing on data from the Ordnance Survey's first edition six-inch mapping of Scotland. The cartographic symbols used to represent lime kilns are discussed with examples, and a schema for interpreting these is presented. Based on this understanding, an account of the distribution of kilns recorded from the OS maps is given, supported by original mapping. In turn, an exploratory analysis of these data is performed, highlighting spatial patterns in the industry and addressing some of the challenges associated with visualising and interpreting historical datasets. This chapter shows how cartographic sources can enable analysis on a national scale, allowing new perspectives to be gained on the industry.

Chapter Four is concerned primarily with the movement of materials within the lime industry. It addresses the key resources involved in lime burning—fuel, limestone and lime itself—and the ways in which these were sourced, valued and transported. It begins by discussing the primary fuels used in burning, coal and peat, and the factors that influenced their usage, as well as alternative approaches when neither was available. Following this, the chapter deals with the discovery and extraction of limestones. Then the movement of lime at various scales, from the level of the site to international trade, is discussed. Ultimately, this chapter argues that the transportation of lime and fuel during the

eighteenth and nineteenth centuries had a profound influence on the development of transport infrastructure across Scotland.

The theme of **Chapter Five** is the modernisation of the industry, which is examined through the means of lime production and the role of persons involved in it. It begins with an analysis of main kiln types found in Scotland, exploring what kinds of production they were used for, how this changed, and the work required to construct them. The discussion moves on to the changing role and identity of the lime burner, the organisation of labour at lime works, and the working conditions experienced by those involved in the lime trade. The chapter then considers the owners of lime kilns, detailing the different models of ownership, a factor that changed considerably alongside the changing nature of land ownership and estate operations. Finally, the chapter uses the way in which lime was sold, particularly the weights and measures used, to show how the industry became modernised in the nineteenth century.

In **Chapter Six**, lime burning is considered in its wider social, cultural and intellectual contexts. It begins by exploring the subject of lime through the lens of useful knowledge, providing an analysis of lime burning debates across a range of publications, societies and activities associated with improvement. The question of how lime and lime kilns might be thought of as status symbols is then considered. The chapter ends by discussing lime in relation to the wider 'projects' of Enlightenment Scotland, particularly with regard the role of lime in developing understandings of agricultural science. An argument is made that lime was a uniquely cross-cutting concern, a subject of great importance to a range of important thinkers engaged in enlightened discourse throughout the eighteenth and early nineteenth centuries.

Chapter Seven concludes the thesis. It brings together findings from the four empirical chapters to present a historical geography of Scottish lime burning, highlighting in particular new ways of looking at the industry and its remains. The contribution this thesis makes to several areas of scholarship is then outlined, including to histories of science, Enlightenment studies, agricultural history, as well as to the history of lime burning itself. A number of methodological considerations are also discussed, such as the integration of data from diverse sources, and an argument is made for

telling bigger stories in historical geography. Finally, some thoughts are presented on future work and further research questions that arise from this project.

2 Methods and sources

2.1 Introduction and methodological framework

This chapter explains how a mixture of qualitative and quantitative sources were used to answer the research questions set out in Chapter One regarding lime burning in eighteenth and nineteenth century Scotland. It begins by setting out a methodological framework for the research, positioning the research approach within the field of historical geography and justifying the scope and methods used. Each of the primary data sources is discussed in terms of its methodological issues, practical constraints and the actions taken in the course of this research. The sources used were archives, contemporary published material, historical GIS, site visits and other *ad-hoc* fieldwork. Finally, the analytical strategy is accounted for, describing the process of collating and coding the data into coherent research themes.

Historical geography's 'fertile interdisciplinarity' sees it engage with subjects, methods and sources in common with several overlapping disciplines, including history, archaeology and anthropology.[1] The sources used in the course of this research have been central to studies of early modern Scotland: estate papers, agrarian manuals, maps and plans, and official publications. Much of the available historical material relating to lime pertains to issues of agriculture and rural industry rather than urban industrialism and engineering, reflecting the centrality of agricultural improvement to eighteenth and early-nineteenth century Scotland.

In terms of the scope of the research, as Chapter One has shown, studies of lime burning have so far focused on particular sites (such as Charles Menteath's Closeburn works) or regions, with the Lothians receiving particular attention. Focused studies are unquestionably valuable in their contribution to the understanding of industry and commerce at local scales. However, there is opportunity for knitting together such local accounts and attempting to understand an industry operating at the national level, and in doing so investigating its relationship to some of the broader

[1] Alan R H Baker, *Geography and History: Bridging the Divide* (Cambridge University Press, 2003), 16.

themes of the period. Sarah Tarlow's analysis of the archaeology of improvement articulates this argument thus:

> The valorisation of the local and the small-scale in British archaeology is fashionable and widespread, in both academic and management circles. Research frameworks and projects are developed with reference primarily to particular local areas. This work is essential to our knowledge and understanding of the period. However, unalloyed localism is also handicapping our wider understanding of the ideological, cultural and social developments of the later historical period.[2]

Research is, therefore, required that attempts more 'high-level interpretive analysis that goes well beyond the low-level conclusions about trade routes, manufacture or the constitution of a household'.[3] As such, this project attempts to answer Tarlow's call for writing 'geographically and culturally broad pasts' by synthesising existing local understanding of the lime industry and bringing together a range of primary sources that are both methodologically and geographically wide-ranging.[4] In attempting to tell a national story of lime burning, this work hopes to follow the achievements of Baron Duckham and others, who managed to tame manifold source material and develop cogent narratives of Scotland's industries and practices at the national scale.[5]

In attempting to construct a national story of lime burning, this thesis carefully synthesises information produced and collected across a range of scales: the nation; the region; the county; the estate; the parish; and the kiln site. The geodatabase of lime burning sites is at once a countrywide source and a cartographic composite that itself is a product of its own multi-scale assemblage (nations, editions, counties, sheets). Scotland's history has often been viewed through the prism of its regions.[6] Although many aspects of Scottish life exhibit regional characteristics—kinship, climate, language, political allegiance, and so on—designations such as Highland and Lowland have more meaning in the *telling* of Scottish history than they ever likely did for people living in the

[2] Sarah Tarlow, *The Archaeology of Improvement in Britain, 1750–1850* (Cambridge University Press, 2007), 195.
[3] Tarlow, 195.
[4] Tarlow, 195.
[5] Baron F Duckham, *A History of the Scottish Coal Industry, Vol. I 1700-1815* (Newton Abbot, Devon: David & Charles, 1970); Alexander Fenton, *Scottish Country Life*, Revised ed (Edinburgh: John Donald, 1999). For an alternative argument in support of historical geographies of less significant figures and subjects, see Lorimer, "Telling Small Stories: Spaces of Knowledge and the Practice of Geography."
[6] Michael Lynch, *Scotland: A New History* (London: Pimlico, 1991).

periods studied here.[7] Counties (or shires), although lacking the administrative functions of their modern equivalents, served as the organisational basis for the Board of Agriculture's *County Surveys*. Parishes, meanwhile, or rather their ministers, were the source of the Board's first and second *Statistical Accounts,* perhaps the most important and granular *national* resource from the period. Arguably the most significant spatial unit are the estates, both in terms of their influence on the contemporary rural economy and in an historiographic sense as the authors and repositors of much surviving archival material. At the level of the kiln site, further microscales might be considered, since many sites consisted of multiple kilns, with perhaps a quarry or mine proximate, and provisions made for the transport of material within and beyond. Additionally, certain textual sources represent both a small scale—the writing desk or reading room—but also an expansive, occasionally international, network of correspondence. Data collection from each of these sources and scales is discussed below.

As well as scalar implications, the sources addressed in this thesis also have their own asynchronous but overlapping chronologies. The last volumes of the second *Statistical Account*, for example, appeared in 1845, two years after the first sheets in the six-inch first edition map series were published by the Ordnance Survey, an undertaking that continued until the late-1880s. Sources interpreted in isolation can give the misleading impression of representing static moments in time—an effect often artificially accentuated by HGIS methodologies—yet in truth they depict their own periods of evolution and change that reflect the processes and subjectivities of their collection, production or publication.[8] As such, this thesis is neither entirely diachronic nor synchronic in its analysis. The history of lime burning is not bracketed here into arbitrarily fixed periods for evaluation and comparison, nor are sequences and causality examined through a comprehensive chronology. Instead, change and development within the industry is studied thematically, an approach that reflects the availability of data and the research objectives (thesis structure is addressed in 1.7 above).

[7] Frequent references are made throughout the thesis, for the sake of explanation, to regions of a decidedly modern conception. The Central Belt, for example, though understood geographically by most readers, is entirely a twentieth-century invention.

[8] Sam Griffiths, "GIS and Research Into Historical 'Spaces of Practice': Overcoming the Epistemological Barriers," in *History and GIS: Epistemologies, Considerations and Reflections*, ed. Alexander von Lünen and Charles Travis (Dordrecht: Springer, 2013), 153–71.

Data collection was split into three broad phases: (1) digitising kilns from the Ordnance Survey six-inch first edition; (2) archival research in estate collections from various parts of the country; and (3) analysis of contemporary publications. These stages were interspersed with site visits. Many of the materials used are available digitally—an issue and opportunity that is discussed further below.

2.2 Archives

2.2.1 Archives in historical geography

Archival research is fundamental to the study of people and practices from the past. Traditional historians have often tended to characterise archives as straightforward 'storage spaces', repositories of resources from which to 'assemble more accurate and fuller versions of past geographies'.[9] More recently however, geographers have sought to examine more critically the process of establishing archives, archival research and the role that archives play in shaping stories of the past.[10] Archives are increasingly recognised as being the product of both careful decisions and random actions, that in turn affect what is kept, catalogued, and lost.[11] Consequently, they are heavily influenced by wider societal and institutional values at the time of their creation, and thus their content, and the way in which they are organised, reflects these values. As Withers highlights, 'issues of place, of power, of political and classificatory authority are . . . central to an understanding of what an archive is as both topological site and nomological space'.[12] Such considerations are especially true of Scottish estate archives, which are well established sources in the construction of Scotland's 'national memory'.[13] Papers relating to landed estates, including correspondence, business papers, receipts, titles, leases, and so on, that have been bequeathed or donated to the public record, make up a sizeable proportion of materials held in National Archives. Many estates also retain their own archives. These sources

[9] Hayden Lorimer, "Caught in the Nick of Time: Archives and Fieldwork," in *The SAGE Handbook of Qualitative Geography*, ed. Dydia DeLyser *et al.* (London: SAGE Publications, 2010), 252.
[10] Lorimer, "Caught in the Nick of Time: Archives and Fieldwork"; Francesca P L Moore, "Tales from the Archive: Methodological and Ethical Issues in Historical Geography Research," *Area* 42, no. 3 (2010): 262–70; Sarah Mills, "Cultural-Historical Geographies of the Archive: Fragments, Objects and Ghosts," *Geography Compass* 7, no. 10 (2013): 701–13; David Beel *et al.*, "The Geographies of Community History Digital Archives in Rural Scotland," *Scottish Geographical Journal* 131 (2015): 201–11.
[11] Lorimer, "Caught in the Nick of Time: Archives and Fieldwork."
[12] Charles W J Withers, "Constructing the Geographical Archive," *Area* 34, no. 3 (2002): 304.
[13] Mike Featherstone, "Archive," *Theory, Culture & Society* 23, no. 2–3 (2006): 592.

inherently reflect the lives and interests of a small elite in society—those who owned land, who operated commercial ventures, and who were literate. Consequently, they tend to obscure the experiences of those of lower standing. As Taylor writes, in Scotland, 'far below the gentry lay the various ranks of peasantry, their status confusingly vague, their very existence in the historical record shadowy.'[14] It is rare for common people to talk with 'authentic voices' in the written record—their words being typically scribed by teachers or ministers, or otherwise spoken on their behalf by the higher classes.[15] When seeking to address questions relating to practical aspects of agriculture or industry, the voices of those who owned the land are likely to tell a very different story to those who worked it. Attempting to elevate more diverse voices has led many historical geographers to utilise increasingly diverse, 'scrappy' sources.[16] These sources reflect unlikely and disordered fragments that survive seemingly at random and appear in unstructured 'small' archives. In the context of the more traditional archives used in this research, the search for 'scrappy' sources relates to morsels of valuable evidence not hinted at by the archive's supposed content, such as revelations about the importance of skill in lime burning plucked from a bundle of papers concerning mineral surveys of the Highlands.[17]

Another aspect of archival sources that requires acknowledgement is that most eighteenth-century observers took the functioning of the rural economy largely for granted, leading to a lack of critical reflection on changes taking place around the authors of written sources.[18] Before the onset of industrialisation at the end of the eighteenth century, industrial activity was also little remarked upon by contemporary observers.[19] As a result, many papers relating to the operation of lime kilns say very

[14] David Taylor, *The Wild Black Region: Badenoch 1750-1800* (Edinburgh: John Donald, 2016), 28.
[15] Taylor, 90.
[16] Hayden Lorimer and Chris Philo, "Disorderly Archives and Orderly Accounts: Reflections on the Occasion of Glasgow's Geographical Centenary," *Scottish Geographical Journal* 125, no. 3–4 (2009): 249; Elizabeth Gagen, Hayden Lorimer, and Alex Vasudevan, eds., *Practising the Archive: Reflections on Method and Practice in Historical Geography* (Historical Geography Research Group, 2007); Cheryl McGeachan, "Historical Geography I: What Remains?," *Progress in Human Geography* 38, no. 6 (2014): 824–37; Cheryl McGeachan, "Historical Geography II: Traces Remain," *Progress in Human Geography*, 2016.
[17] Letters from John Williams to the Duke of Gordon regarding a mineral survey of Badenoch and Lochaber 1769-1775 (NRS GD44/28/34)
[18] Peter M Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature* (Oxford: Oxford University Press, 2016), 3.
[19] Ian Donnachie, "A Tour of the Works: Early Scottish Industry Observed, 1790-1825," in *Industry, Business and Society in Scotland Since 1700*, ed. A G J Cummings and Thomas M Devine (Edinburgh: John Donald Publishers Ltd, 1994), 43–57.

little about the nature of the work, leading to unsatisfying instances where an account book might refer to 'alterations to the kiln' without any supplementary evidence existing to indicate the nature of these changes. Similarly, written sources can often gloss over the substance of the labours they purport to describe. To address this lack some degree of archaeological knowledge or physical engagement with the subject is required. Effie Photos-Jones et al propose that, in order to understand processes in coherent practical terms, researchers should not be constrained by evidence from the written record and instead should focus on physical remains and their implications for people's working lives. They argue that the study of practice (rather than the way objects or activities were valued) is 'surprisingly egalitarian', giving insight into the experiences of ordinary working people as well as the everyday lives of the elite.[20] Mindful of this point, non-archival sources, including site visits, were consulted in order to retain some balance between the theoretical and the practical (discussed further below).

2.2.2 Search strategies

It is important to acknowledge here that no archive of lime burning exists. This fact constitutes one of the major challenges of this research. While other studies might draw on dedicated repositories relevant to their research topic—for example writing the history of an institution by reading that institution's own archive—the study of lime burning has required following the subject through a range of potentially related sources. Since landed estates were the dominant organisational unit within which the rural economy operated during the eighteenth and nineteenth centuries, they made a logical starting point in the search for lime.[21]

The initial search phase involved searching through archival databases (such the National Records of Scotland) for material relating to lime burning using keywords such as 'lime kiln', 'lime', 'limestone quarry', and so on.[22] The names of known sites (e.g. 'Askomill Lime Works') were also searched for. I also contacted several archivists to enquire about relevant sources held at archives

[20] Effie Photos-Jones *et al.*, "Between Archives and the Site: The 19th-Century Iron and Steel Industry in the Monklands, Central Scotland," *Post-Medieval Archaeology* 42, no. 1 (2008): 175.
[21] Devine, *The Scottish Nation: A Modern History*, 114–15.
[22] Databases included the Scottish Archive Network (http://www.scan.org.uk/), NRS (http://catalogue.nrscotland.gov.uk/nrsonlinecatalogue/welcome.aspx), and local archive databases, such as (http://www.calmview.eu/Hubcat/CalmView/default.aspx)

around Scotland. In addition, particular attention was paid to records pertaining to lands where limestone was known to have been worked (e.g. the Macbiehill estate), where kilns were numerous on the OS mapping (e.g. the parish of Cults), or where improvements using lime were known to have been carried out.

As mentioned in the Introduction, this thesis set out to examine lime burning on a national scale and over an extended period in Scotland's history. The broad geographical and temporal scope of the research objectives meant using material from a similarly wide range of sources. This approach allows a greater variety of places and experiences to be represented than in previous, more narrowly focused research on the industry. This research design, however, came with inherent sacrifices insofar as there was reduced opportunity to 'go deep' into single archives. For example, the Duke of Gordon's papers, held by the NRS, and from which the records of Ardonald Lime Works are drawn, are extensive. Entire theses could be written from this source alone (and indeed some have), delving into the successive Dukes' attitudes towards their role as landowner, investment in their estate, and personal interests.[23] However, due to time restrictions attendant on the breadth and multiple foci of this thesis, engagement with the source was limited to those records considered most directly related to the burning of lime.

Although lime burning was a common part of the running of many estates by the eighteenth century, not all surviving written records include any mention of the work. Tracing lime in the archive may not have been quite a 'needle-in-the-haystack operation', but it certainly required careful sifting for material of relevance.[24] In many cases, archives that were examined because of known lime working on certain estates did not prove to contain —after reasonable searching—any relevant information about the use or production of lime. For example, several notable limestone quarries operated on the Macbiehill Estate in West Lothian, including Whitfield lime works, yet the estate records at the NRS contain no mention of lime burning there. As Harris put it, when it comes to searching through archives, 'some hunches pan out; others do not'.[25]

[23] For example, Taylor's work on Badenoch is to a large extent based on the archival records of the Dukes of Gordon, see *The Wild Black Region: Badenoch 1750-1800*.
[24] Cole Harris, "Archival Fieldwork," *Geographical Review* 91, no. 1–2 (2001): 331.
[25] Harris, 331.

Archives present their own methodological challenges. They are never complete. Items are not always signed, dated or explained in terms of their intended purpose or audience. Promises written down might not be kept, nor instructions carried out. Details might not be recorded faithfully. Conflict and change generate a larger paper record than does stability.[26] The process of gathering data from the archive can be further limited by several practical factors, including the legibility of handwriting (compounded at times by antiquated or inaccurate spelling), condition of materials (papers may be torn, soiled, or creased in such a way as to obscure text—for an example, see Figure 6), and a sheer volume of available material. Distant archives pose the additional challenge of limited time to visit them.

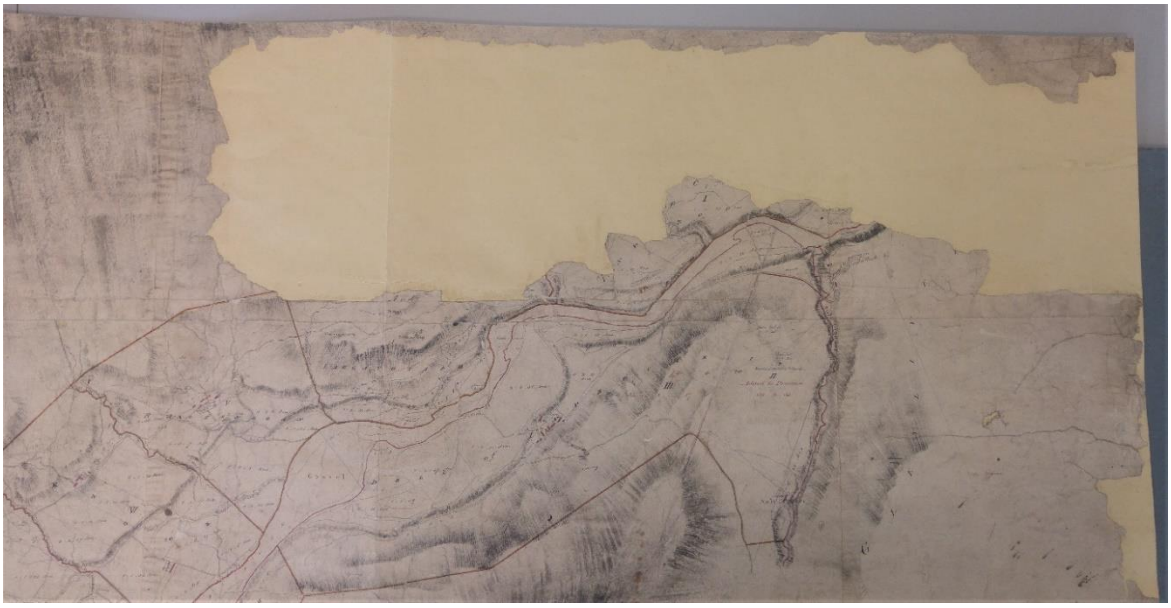

Figure 6 Plan of Strathavon, Banffshire, 1839 (NRS RHP1807) in a state of some disrepair.

In cases where archival sources are not photographed or transcribed in their entirety, the first act of coding takes place within the archive itself. The researcher must choose what to transcribe verbatim, what to summarise in note form, and what to omit. The decision to note down and transcribe was led by the research objectives (set out in the Introduction) and grouped around the following themes: kiln types, evidence of status, spatial factors, lime usage, infrastructure, fuels, kiln construction, and connections to science or natural philosophy. The choice of what to record was often easier to make

[26] Examples encountered include an encroachment disagreement at the edge of Scullingour Lime Works and disputes over measures used on the Duke of Montrose's estate, see MIT T-LX 6/22 and NRAS GD220/6/523 respectively.

in records containing only infrequent mentions of lime burning than in those entirely concerned with the operation of a lime works. Occasionally the amount of relevant data precluded exhaustive transcription. For example, many papers originating from lime works contained voluminous financial data, often in the form of account books and receipts. Because an economic history of lime was not one of the intended research outcomes, and because transcribing that quantity of data by hand would have taken too much time, the decision was taken to record only summaries of financial records. Of greater interest in these instances were the things being purchased (such as materials and services), rather than the costs.

The period of archival research was also a learning process, and the practice of gathering data from the archive changed over the duration. As the archival research progressed and I became more familiar with the material and more alert to subtexts, the coding system was relaxed slightly, becoming less rigid (meaning that a greater range of content was recorded) and also omitting relevant but repetitive material (i.e. things I had already acquired from elsewhere). It became clear that many of the research themes were not explicitly articulated within the archives. This is a challenge facing many research projects. For example, as Peter Jones points out with regards to the development of practical sciences, a theme also explored in this research, 'direct testimony as to how natural knowledge crossed the interface and was converted into a usable technique is rather sparse'.[27]

Once the data collection phase was complete, the notes were revisited for close reading and discourse analysis—an important step for 're-familiarisation' with the material.[28] Notes were then re-coded according to the main research objectives and emergent themes revealed by the data. Any instances where further research (either by returning to the original records or from other sources) was required was noted. Notes relating to the various codes were then collated into themed documents. These documents became the basis for thesis chapters.

[27] Peter M Jones, *Industrial Enlightenment: Science, Technology and Culture in Birmingham and the West Midlands 1760-1820* (Manchester: Manchester University Press, 2013), 70.
[28] Mike Crang, "Analysing Qualitative Material," in *Methods in Human Geography*, ed. Robin Flowerdew and David Martin, Second Edi (Harlow: Routledge, 2005), 220.

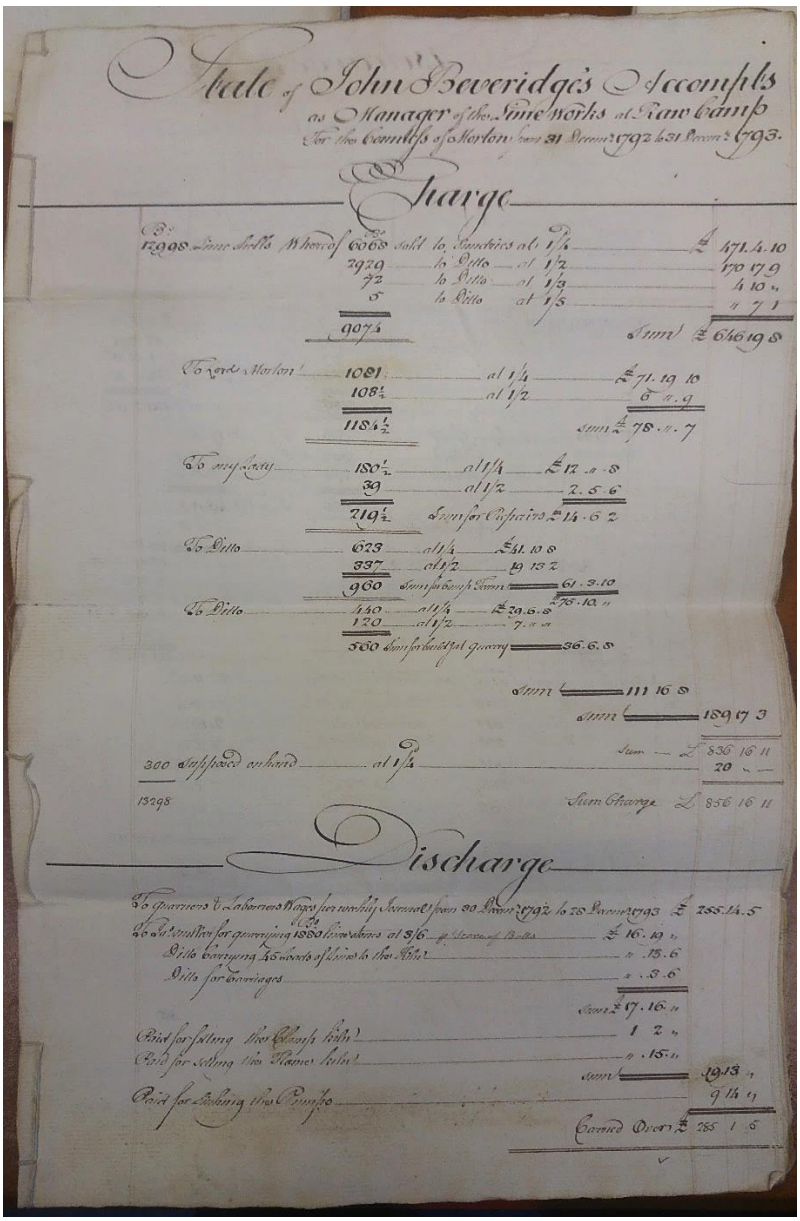

Figure 7 Example of account book from Raw Camps Lime Works. National Records of Scotland, Edinburgh. GD150/2359

2.2.3 Archives used

A full list of archival series is given in the appendix. A large volume of estate records is held at the National Records of Scotland in Edinburgh and is organised by landowning families. These records contain a range of materials. With regards to lime burning, much of material held by estates is primarily financial in nature, relating to the running of the estate and comprised of documents such as account books, receipts and bills (see Figure 7). Such information holds clues as to the organisation of labour, sources of materials and the efficiency of the works. Some estates also hold correspondence relating to lime works or their proprietor (Figure 8). These papers evidence attitudes

to lime burning, commonly held knowledge, personal motivations and sources of information. Several estate maps and plans held by the NRS were also viewed. These were examined either digitally in the reading room of General Register House or else physically at Thomas Thomson House, both in Edinburgh. Some maps could be copied or photographed and others not, in which case extensive descriptive notes were taken.

Several archives outside of Edinburgh were visited where database searches or correspondence with local archivists indicated the presence of material relating to lime burning. These included the Mitchell Library in Glasgow, the Perth and Kinross archive in Perth, and the Argyll and Bute archive in Lochgilphead. The materials held in these were similar to those in the NRS, being primarily correspondence and records originating from estate operation. Many other published materials were analysed, discussed below.

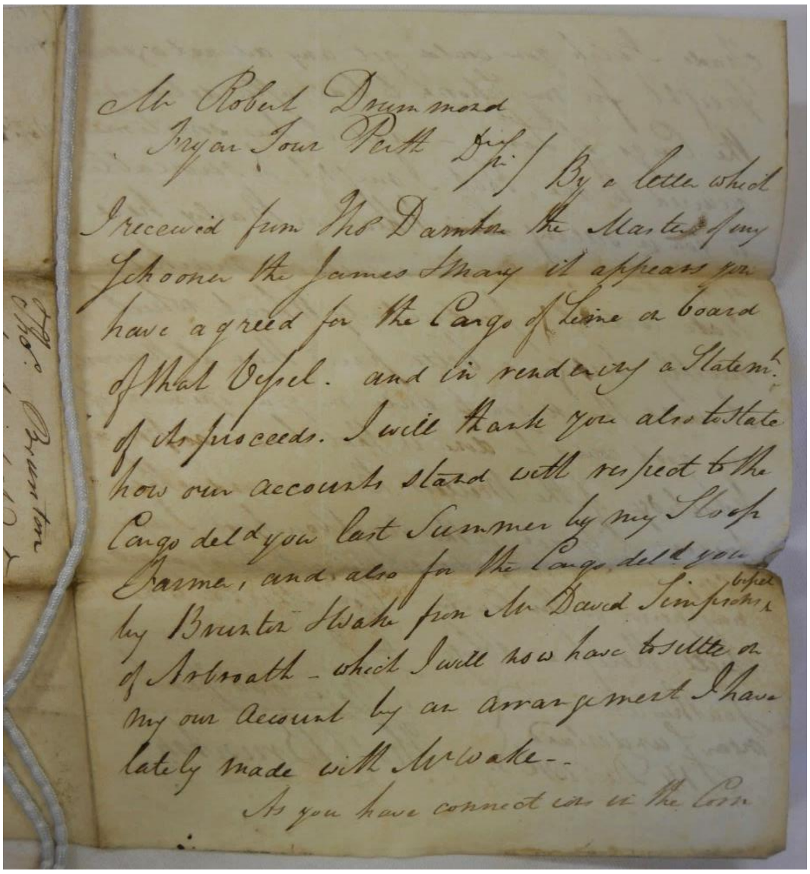
Mr Robert Drummond
Tryon Tour Perth
Sir / By a letter which
I received from Thos Darnton the Master of my
Schooner the James & Mary it appears you
have agreed for the Cargo of Lime on board
of that Vessel. and in rendering a Statemt.
of its proceeds. I will thank you also to State
how our accounts stand with respect to the
Cargo deld you last Summer by my Sloop
Carme, and also for the Cargo deld you
by Brewster & Wake from Mr David Simpson Vessel
of Arbroath - which I will now have to settle on
my own Account by an arrangement I have
lately made with Mr Wake - -
As you have connection in the Corn

Figure 8 Example of correspondence to Robert Scott of Duninauld regarding shipments of lime. Perth & Kinross archive, Perth, MS32

2.3 Published sources

Agricultural historians of eighteenth and nineteenth century Britain—and Scotland in particular—are blessed with a large volume of contemporary published material from which to analyse practices, ideologies and knowledge flows during the period.[29] Of course, texts themselves have their own geographies of production, circulation and reception.[30] By considering Scottish agrarian manuals as an aspect of material culture, Heather Holmes has explored how they were valued, how they were read, and how they were used to enhance the personal status of both authors and readers.[31] More tightly focused work, such as Mathew Eddy's analysis of James Anderson's *Essay on Quicklime*, highlights the importance of single texts in terms of the ideas they conveyed, but also what they reveal about the culture and education of the individual who wrote them.[32]

A range of such sources was utilised for discourse analysis in the course of this research, including statistical surveys, agricultural reports, agrarian manuals, and newspapers. Many of these sources, such as the *Statistical Accounts* and numerous agricultural texts, have been digitised and are freely available online. This kind of 'digital history' is a growing phenomenon in historical geography and historical research more generally, and has implications, both positive and negative, for the disciplines.[33] While these new formats greatly facilitate access, they potentially introduce new layers of determinism in the discovery process, with the researcher at risk of being led by what is most easily discoverable. Furthermore, when sources are discovered through databases or open search engines (i.e. Google), their context and materiality (including the condition and physical format of a document) can be lost. One of the most widely utilised aspects of digitised texts is the ability to

[29] Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature*, 3–5.
[30] Miles Ogborn and Charles W J Withers, eds., *Geographies of the Book* (Farnham: Ashgate, 2010).
[31] Heather Holmes, "Scottish Agricultural Writers and the Creation of Their Personal Identities between 1697 and 1790," *Folk Life - Journal of Ethnological Studies* 44, no. 1 (2005): 87–109; Heather Holmes, "The Circulation of Scottish Agricultural Books during the Eighteenth Century," *Agricultural History Review* 54, no. 1 (2006): 45–78.
[32] Eddy, "The Aberdeen Agricola: Chemical Principles and Practice in James Anderson's Georgics and Geology."
[33] Karl Offen, "Historical Geography II: Digital Imaginations," *Progress in Human Geography* 37, no. 4 (2012): 564–77; Gerben Zaagsma, "On Digital History," *Low Countries Historical Review* 128–4 (2013): 3–29.

search for words and phrases.[34] This approach allows large bodies of text to be quickly assessed for relevant data, but throws up new methodological challenges in terms of 'phrasing history', particularly when attempting to explore nebulous concepts using strictly defined text-strings.[35] In the context of this research, physical objects and materials—words like 'lime', 'kiln' or 'coal'—lent themselves far more to these kinds of searches than less tangible notions such as ownership or knowledge exchange.[36] Of course, search results can only point the researcher in the direction of information held in documents; further analytical steps were required to understand and synthesise it. Furthermore, to fully comprehend the relevance and importance of information, care was taken to consider documents beyond the supposedly relevant text returned by search processes. Ian Gregory sums up this challenge: 'to do good history that combines the computer's ability to search and summarize, with the researcher's ability to interpret and argue'.[37]

2.3.1 The Statistical Accounts of Scotland, 1791-1845

The *Statistical Accounts of Scotland* are perhaps the most frequently used of all Scottish historical sources.[38] The first was published between 1791 and 1799, and referred to at the time as simply the *Statistical Account* (though it has since become widely known as either the 'Old' or 'First' *Statistical Account*, or else simply the *OSA*). It was conceived by the agriculturalist, writer and parliamentarian Sir John Sinclair, who sought to compile a complete and rigorous state of the nation in terms of its productivity, natural history and population—reflecting his personal enthusiasm for collecting 'useful information'.[39] Sinclair's influence on the historiography of British agriculture has been considerable and much has been written about his life and accomplishments, which also include establishing the Board of Agriculture and the initiation of the *County Surveys* (discussed below).[40]

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[34] Hieke Huistra and Bram Mellink, "Phrasing History: Selecting Sources in Digital Repositories," *Historical Methods* 49, no. 4 (2016): 220–29.
[35] Huistra and Mellink.
[36] Setting aside the vagaries of precise phrasing. For instance, references to lime kilns could be written in many forms, including 'kills', 'limekilns' or 'lime-kilns', or else might be referred to simply as 'lime burning' or 'burnt lime' and so on.
[37] Ian N. Gregory, "Challenges and Opportunities for Digital History," *Frontiers in Digital Humanities* 1, no. December (2014): 1.
[38] Rosalind Mitchison, quoted on The Statistical Accounts of Scotland Online web page.
[39] R L Plackett, "The Old Statistical Account," *Journal of the Royal Statistical Society* 149, no. 3 (1986): 248.
[40] See Rosalind Mitchison, *Agricultural Sir John: The Life of Sir John Sinclair of Ulbster, 1754-1835* (London: Bles, 1962); Heather Holmes, "Sir John Sinclair, the County Agricultural Surveys, and the Collection and

The second *Statistical Account* (*NSA)*, which used much the same structure as its forebear, was published between 1834 and 1845.[41]

Parish accounts in both the 'old' and the 'new' *Statistical Accounts* were compiled at different times and published over several volumes, and therefore document an extended period rather than a 'snapshot' of Scottish history.[42] Since the accounts were organised by parish, the reports are inherently geographical in nature. Comparison between editions also allows observation of local change over time.

For the *OSA*, ministers compiled their reports based on more than 160 pre-set questions covering a range of topics, including local geography, natural resources, history, population, industry and agriculture.[43] Lime was frequently remarked upon, usually in relation to geological deposits and resources, local industrial activity, or the progress of agricultural improvement. The accounts vary in quality, emphasis and accuracy depending on the proclivities of the reporting ministers.[44] Indeed, the *NSA* was designed expressly to expunge the imprecision and discursiveness that were characteristic of its predecessor, although personal and moral bias remained an issue in both.[45] Ministers also had to be relatively circumspect in their views, since unflattering or unwelcome comment might displease their patron and prejudice their livelihood.[46] When compiling their reports for the *NSA*, some evidently sought the advice of local industrialists and landowners, and occasionally managers and foremen.[47] Such cases give valuable insight into the organisation and economics of lime working. For example, Reverend Hugh Laird was able to include a thorough

Dissemination of Knowledge 1793-1817, with a Bibliography of the Surveys: Part 1," *Journal of the Edinburgh Bibliographical Society* 7 (2012): 29–70.

[41] Sinclair was largely excluded from conducting the *NSA*, see Ian Hill, "The Origins of the New Statistical Account of Scotland," *The Scottish Historical Review* 96, no. 2 (2017): 161–86.

[42] Charles W J Withers, "Scotland Accounted For: An Introduction to the 'Old' (1791-1799) and the New (1834-1845) Statistical Accounts of Scotland," The Statistical Accounts of Scotland Online, accessed August 21, 2017, http://statacc.blogs.edina.ac.uk/an-introduction/.

[43] Plackett, "The Old Statistical Account"; Withers, "Scotland Accounted For: An Introduction to the 'Old' (1791-1799) and the New (1834-1845) Statistical Accounts of Scotland."

[44] Plackett, "The Old Statistical Account," 249.

[45] Hill, "The Origins of the New Statistical Account of Scotland," 177.

[46] Donnachie, "A Tour of the Works: Early Scottish Industry Observed, 1790-1825."

[47] Donnachie.

breakdown of costs for the working of limestone in the parish of Portmoak for the *NSA*, a level of detail almost certainly gained from someone overseeing the work.[48]

For the purposes of this research, the *OSA* and *NSA* were viewed in their digitised form through the EDINA online subscription service.[49] Individual accounts from each edition are organised by parish (they also can be found geographically using an interactive map) and the text is fully searchable. Parishes of interest, such as those in which lime workings were known to have been located, were accessed and read individually. Searches were also performed for certain terms, such as 'draw kiln', to uncover relevant material and determine the extent to which certain features or practices were distributed across Scotland. Most accounts contain some reference to lime (especially by the time of the *NSA*), although this does not indicate that it was worked or used everywhere—many ministers were equally vocal about its unavailability in their parishes. Indeed, such comments regarding the unavailability of lime are revealing in terms of lime's status when the statistical accounts were written.

2.3.2 Board of Agriculture County Surveys, 1793-1817

The Board of Agriculture and Internal Improvement was established in 1793, with the remit to collect useful information pertaining to Britain's agriculture, develop theory, and disseminate best-practice. Perhaps its key achievement was the production of the *County Surveys:* a series of regional reports covering various aspects of agriculture and rural industry. These surveys were initiated largely at the behest of Sir John Sinclair, who was founder and president of the Board from 1793 to 1798 and 1806 to 1813.[50] The *Surveys* were intended to bring together 'every fact or observation known in this country, connected with the improvement of the soil, or the stock it maintained'.[51] By collecting this information at the district level, they formed the second layer in Sinclair's pyramid of statistical inquiry (Figure 9).[52]

[48] *NSA*, Parish of Portmoak, vol. 9, p.31-32
[49] Available at http://stataccscot.edina.ac.uk/static/statacc/dist/home
[50] Holmes, "Sir John Sinclair, the County Agricultural Surveys, and the Collection and Dissemination of Knowledge 1793-1817, with a Bibliography of the Surveys: Part 1," 28.
[51] Sir John Sinclair, in Holmes, 29.
[52] The role of the board and the *County Surveys* in developing theory and disseminating knowledge is analysed in Chapter Seven.

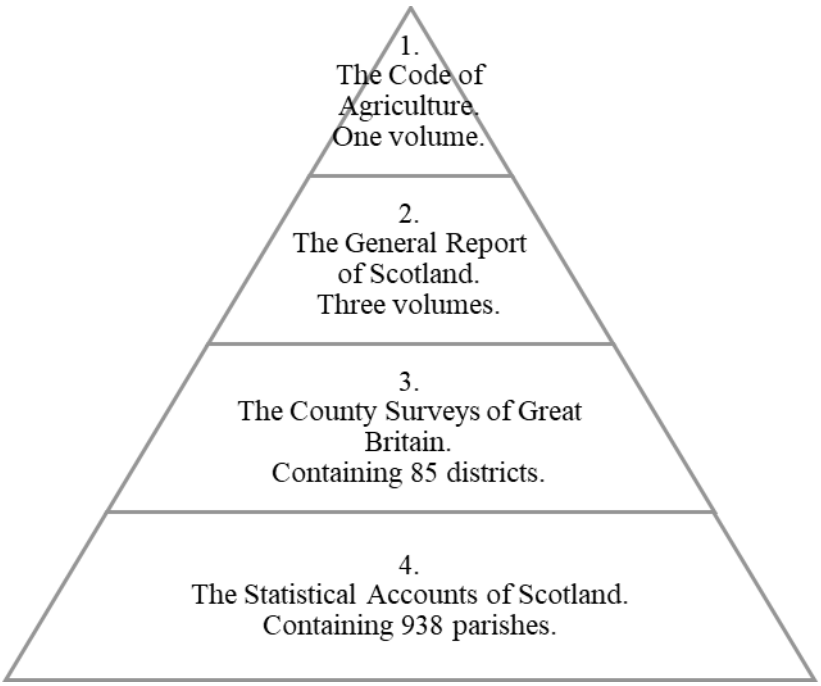


Figure 9 The pyramid of Statistical Inquiries, adapted from Holmes 2012.

Also referred to as the *County Surveys* or *General Views*, fifty-four volumes were produced for Scotland between 1793 and 1816, written by forty-three different authors.[53] Of these, twenty-nine were published in the first phase of the survey. The remaining thirty-three were published as part of the second phase, also known as the 'corrected' or 'reprinted' surveys.[54] Many of the geographical areas to which these second phase surveys relate are different from the first. Some (such as Ayrshire) used the same survey area in each phase, whereas others combined or separated districts.

The surveys were to be structured around a set list of topics set out by Sinclair, with the corrected surveys given a circumscribed format designed to limit the discursiveness of the first series. Perhaps to a greater extent than the *Statistical Accounts*, the content and quality of the *County Surveys* vary with authorship. Indeed, the reports were met with some criticism upon their publication for their inaccuracies on farming matters.[55] Nevertheless, they contain valuable observations on the

[53] Their titles generally take the form '*The General View of the agriculture of x: drawn up for the consideration of the Board of Agriculture',* with *x* being a specific county or district.
[54] For more detailed bibliographic information, including publishing, printing, sales, and alternative editions, see Holmes, "Sir John Sinclair, the County Agricultural Surveys, and the Collection and Dissemination of Knowledge 1793-1817, with a Bibliography of the Surveys: Part 1"; Heather Holmes, "Sir John Sinclair, the County Agricultural Surveys, and the Collection and Dissemination of Knowledge 1793-1817, with a Bibliography of the Surveys: Part 2," *Journal of the Edinburgh Bibliographical Society* 8 (2013): 67–136.
[55] Arthur Young complained that many of the authors 'scarcely knew the right end of a plough'. Rosalind Mitchison, "The Old Board of Agriculture (1793-1822)," *English Historical Review* 74, no. 290 (1959): 49.

geographic distribution of practices and resources, as well as evincing the agrarian ideologies at play during the period. Some of the surveys show evidence of data gathering in the field, with the authors apparently walking the land and recording features, often accompanied by the local landowner. For example, James Macdonald, in his account of the Hebrides, stated 'we counted 88 lime kilns belonging to farmers on Mr Campbell of Shawfield's estate in Islay in one day's walk'.[56]

In the course of this research, the *County Surveys* were sourced using Holmes' comprehensive bibliographies of both the first and second phases as a guide. Many editions are housed in the University of Glasgow library, while others were retrieved freely online in digitised form.[57]

2.3.3 Improving literature

The eighteenth and early nineteenth centuries saw a rapid growth in agricultural publishing in Scotland.[58] In terms of discovering relevant sources, Holmes' exhaustive bibliography of Scottish agricultural texts until 1790 was an especially useful starting point.[59] Sourcing later publications was largely a matter of following up documents cited in academic work or other contemporary sources. Searching for digitised copies of these publications revealed another facet of using electronic resources: the serendipitous nature of search engine discovery. In some cases, searching for the title and author of a known text (particularly ones composed of common words, such as 'Essays on Agriculture' by James Anderson) would reveal other relevant but previously unknown digitised documents that shared text in common, either by referencing the originally searched-for book or by including the search terms (including author names) in the main body of the text. Several agricultural books were discovered in this way.[60]

Agricultural societies were a distinctive feature of Scottish agricultural improvement, one that generated extensive written records in the form of published essays and transactions.[61] Perhaps the

[56] James Macdonald, *General View of the Agriculture of the Hebrides, or Western Isles of Scotland*, (1811), p. 34
[57] Primarily from Internet Archive (https://archive.org/) and Google Books (https://books.google.co.uk/).
[58] Holmes, "The Circulation of Scottish Agricultural Books during the Eighteenth Century."
[59] Heather Holmes, "A Bibliography of Scottish Agricultural Books to 1790," *Journal of the Edinburgh Bibliographical Society* 2 (2007).
[60] A complete list of primary publications used is included in the Reference List.
[61] R. C. Boud, "Scottish Agricultural Improvement Societies, 1723-1835," *Review of Scottish Culture* 1 (1984): 70–90.

best-known such society, The Royal Highland and Agricultural Society of Scotland (RHASS), was established in 1784 with the goal of providing a forum for its elite members to discuss the issue of improving the productive capacity of the Highlands.[62] It proved a lasting institution and its focus expanded to encompass most aspects of rural industry by the middle of the nineteenth century. The RHASS maintains an online archive of *Transactions*—compiled essays submitted by its membership—dating from 1790 to 1969.[63] This resource was used to examine the importance of lime to the Society and the methods of use and production they encouraged.

Similar to the transactions of the RHASS, *The Farmer's Magazine* was another forum for discussion of topics relating to agriculture and rural affairs. Articles were submitted by subscribers, reflecting the practical interests of its readership. It was one of the oldest agricultural journals in Britain and was published in Edinburgh between 1800 and 1825.[64] A complete back catalogue is available online.[65]

Questions of voice and representation are highly relevant to agricultural publishing of the eighteenth and nineteenth centuries. Writers of books and correspondents to journals were overwhelmingly those with the luxury of leisure— 'noblemen and gentlemen' as the RHASS itself still proudly declares.[66] As with other archival sources, farmers of lower status but of greater practical experience are much less represented in surviving texts. The editorial that opened the first issue of *The Farmer's Magazine* highlights this issue, suggesting it was a matter understood by at least some contemporaries:

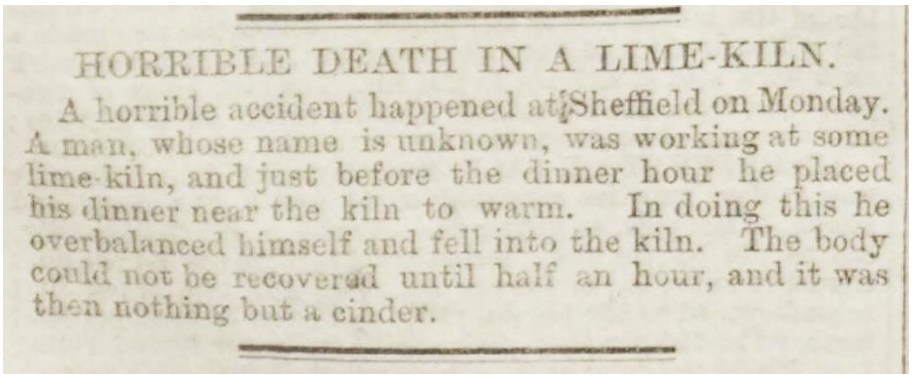
> One thing is necessary to notice; many farmers, out of diffidence about themselves, are withheld from committing their observations to the public, from an apprehension that their style and manner of writing are unfit for publication: In that way, many facts and observations, highly interesting to society, are either entirely lost, or but very partially known.[67]

[62] Thomas Christopher Smout, "A New Look at the Scottish Improvers," *Scottish Historical Review* 91, no. 1 (2012): 144.
[63] Available at https://archive.rhass.org.uk/archive/transactions-of-rhass-1790-1969.
[64] Heather Holmes, "Scottish Agricultural Newspapers and Journals and The Industrialisation of Agriculture, 1800-1880," *Folk Life - Journal of Ethnological Studies* 40, no. 1 (2001): 26.
[65] A complete back-catalogue of *The Farmer's Magazine* between January 1800 and November 1825 is held by ProQuest, available via www.proquest.com
[66] 'About', RHASS https://archive.rhass.org.uk/about
[67] 'Introduction', *The Farmer's Magazine,* vol. 1(1), Jan 1800, p.16

The editorial continues by encouraging submissions from all landowners or farmers regardless of their education level. Nevertheless, historical biases towards the literate and the monied within most available written source material are clear. This challenge faces all researchers of the period and requires continued critical engagement with the source material.

2.3.4 Newspapers

Newspapers are a valuable source of information about the lime industry. Lime for sale and leases of lime works were frequently advertised in newsprint, and many newspapers provided a forum for publicising a range of agrarian topics.[68] The British Newspaper Archive, which holds an extensive online database of digitised newspapers, was used to access news articles.[69] Given the volume of material available and the constraints of time, searches were carried out to discover articles relating to 'lime', 'lime kiln(s)' and 'lime burning' only. Results were restricted to Scottish publications within the time period 1700-1899. Relevant articles were then read and coded according to their content. Most articles from this period were very short (see Figure 10 for an example), providing brief insight into the issues considered relevant or of interest to the paper's audience.



HORRIBLE DEATH IN A LIME-KILN.

A horrible accident happened at Sheffield on Monday. A man, whose name is unknown, was working at some lime-kiln, and just before the dinner hour he placed his dinner near the kiln to warm. In doing this he overbalanced himself and fell into the kiln. The body could not be recovered until half an hour, and it was then nothing but a cinder.

Figure 10 Example of a newspaper article from the *Aberdeen Press & Journal*, 27th August 1877.

2.3.5 Other published material

Alongside dedicated research on various kinds of agrarian literature, a range of other primary sources were consulted. Several published diaries exist that give insight into the daily routines and periodic

[68] Holmes, "Scottish Agricultural Newspapers and Journals and The Industrialisation of Agriculture, 1800-1880."
[69] Available at https://www.britishnewspaperarchive.co.uk

cycles of agrarian life in the eighteenth and nineteenth century. For example, the diary of J. Badenoch, a farmer from Stonehaven, between 1789 and 1797 details a wide range of activities, including the purchasing and transporting of lime for the farm.[70] Marie Robinson recently published a transcription and analysis of the diary of Thomas Graham Bonar of Greigston, Fife, from the beginning of the nineteenth century.[71] The farm included a limestone quarry and several clamp (or 'soo') kilns.[72] Other diaries illustrate the interconnected intellectual networks that people circulated within, characterised by correspondence and travel, often in the form of grand tours.[73] One example is the journal of Charles Hatchett's tour of Scotland and England, which paid particular attention to mining and other industries.[74] Other published primary materials have also been used, such as the compiled correspondence of renowned eighteenth century land surveyor Peter May.[75]

In a pre-photography age, artistic forms of representation—paintings, sketches, etc—also provide insight into the ways in which sites were operated as well as hinting at how certain practices were culturally valued.[76] The use of such materials requires an understanding of the contexts in which they were produced and the conventions of art at different times. Eighteenth century landscape painters, for instance, largely chose to ignore the various aspects of agricultural change going on around them, such as enclosure, treating them as 'intrusions' on an otherwise idyllic rural life.[77] Landscapes of this period can thus often be viewed as proprietorial 'escapist fantasies', devoid of the drudgery of agrarian labour or rural industry.[78] As such, it is often as important to consider what is not shown,

[70] Mowbray Pearson, ed., *Flitting the Flakes: The Diary of J. Badenoch a Stonehaven Farmer 1789-1797* (Aberdeen University Press, 1992). This work also reveals a common misunderstanding of the term 'lime shells' as a form of geological deposit (rather than a common name for unslaked lime) on the part of its editor, illustrating the limited knowledge of the lime trade even among agricultural historians. Other writers have mistakenly interpreted 'lime shells' as meaning the burning of marine shells.
[71] Marie Robinson, *Farm and Family in Early Nineteenth-Century Fife: The Diary of Thomas Graham Bonar of Greigston* (The Strathmartine Trust, 2017).
[72] Robinson, 104.
[73] Mcfarlane, "French Travellers to Scotland, 1780-1830: An Analysis of Some Travel Journals."
[74] Arthur Raistrick, ed., *The Hatchett Diary: A Tour through the Counties of England and Scotland in 1796 Visiting Their Mines and Manufacturies* (Truro: Barton, 1967).
[75] Ian H Adams, ed., *Papers on Peter May Land Surveyor, 1749-1793* (Edinburgh: T & A Constable Ltd, 1979).
[76] Francis D Klingender, *Art and the Industrial Revolution* (St Albans: Paladin, 1972); Sarah Wilmot, *"The Business of Improvement": Agriculture and Scientific Culture in Britain, c.1700-1870* (Cheltenham: IBG Historical Geography Research Group, 1990).
[77] Hugh Prince, "Art and Agrarian Change, 1710-1815," in *The Iconography of Landscape*, ed. Denis Cosgrove and Stephen Daniels (Cambridge University Press, 1998), 98.
[78] Prince, 98–99.

informed by other historical sources, as much as what is. To find relevant artworks (such as Figure 11, above), searches were conducted for works containing lime kilns on several leading art databases, and where possible these were further refined to Scottish locations or painters.[79]

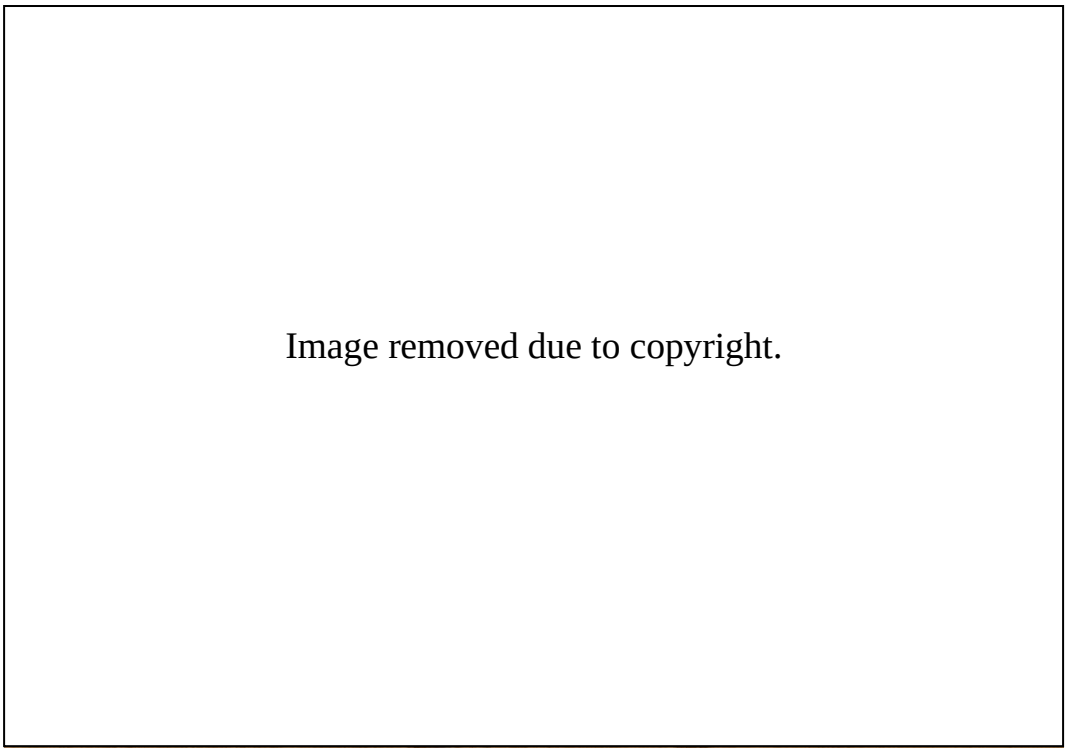


Figure 11 Thomas Miles Richardson I (1784-1848) *Lime kilns near Dumfries* (undated). Watercolour over pencil. Image: Guy Peppiatt Fine Art.

2.4 Historical GIS

In order to investigate spatial patterns in the lime burning industry, a geodatabase of lime burning sites was constructed from the Ordnance Survey's first edition six-inch map series (discussed below). Historical GIS is increasingly commonplace in historical research.[80]

Historical GIS (HGIS) is not defined by topic, regional focus or methodology. GIS-based methods employed by historical scholars 'range from basic cartography to sophisticated forms of spatial

[79] The following image databases were used: Art UK https://artuk.org/; Google Arts & Culture https://artsandculture.google.com/; National Galleries of Scotland https://www.nationalgalleries.org/; Watercolour World https://www.watercolourworld.org/. The latter has georeferenced artworks, enabling searches to be carried out by specific locations. The example shown in Figure 11 was discovered using Watercolourworld.

[80] Ian N. Gregory and Paul Ell, *Historical GIS: Technologies, Methodologies and Scholarship* (Cambridge University Press, 2007); Offen, "Historical Geography II: Digital Imaginations."

analysis and spatial statistics'.[81] This flexibility of approach makes HGIS suitable for addressing a range of subjects and questions close to my own, as the following discussion of relevant work shows. Anne Knowles and Richard Healey's analysis of Pennsylvania's nineteenth century iron industry is a classic example of GIS-led research into a historical industry.[82] Their analysis, which was largely based on data from a single documentary source enhanced by additional site information, revealed spatial connections between various segments of the industry and defined the regional segmentation of markets.[83] Many researchers make use of GIS methods without acknowledging it in their approach. David Alderton, for example, in his examination of the relationship between industries (including lime burning) and transport, makes extensive use of plotted industrial sites to support inductive arguments.[84] Rosemary Thornes and Terry Slater's work on detached gardens is another recent example of understated but effective GIS analysis.[85] They digitised the layout of towns and gardens from eighteenth century town plans and used GIS to determine the extent of gardens lying within particular distances of the urban edge. Like the present research, qualitative information about land use had to be inferred from map symbology. The map data were then interpreted alongside a longitudinal case study to understand the factors influencing the growth and decline of gardens along the urban fringe.

GIS can also be a useful way of addressing questions of scale, as Peter Szabó *et al.* acknowledge in their work on woodland management in Czech Republic. They found that, although site-based studies provided a wealth of information, bringing a database of written sources on coppicing into GIS allowed the practice to be understood 'at the landscape scale'.[86] The spread of coppiced woodland across their geodatabase, based on parish polygons, was extrapolated from surviving written accounts using a mathematical model originally devised for calculating ecological distributions. Their work

[81] Anne Kelly Knowles, "Emerging Trends in Historical GIS," *Historical Geography* 33 (2005): 7–8.
[82] Anne Kelly Knowles and Richard G. Healey, "Geography, Timing, and Technology: A GIS-Based Analysis of Pennsylvania's Iron Industry, 1825-1875," *The Journal of Economic History* 66, no. 3 (2006): 608–34.
[83] Their source was a 1859 guide to the Pennsylvania iron industry, perhaps analogous to Carmichael's 1837 account of the lime quarries of Scotland.
[84] David Alderton, "The Chicken or the Egg? The Relationship Between Industry and Transport in East Anglia," *Industrial Archaeology Review* 27, no. 1 (2005): 121–28.
[85] Rosemary Thornes and Terry R. Slater, "Detached Gardens and the Urban Fringe of Eighteenth- and Nineteenth-Century English Provincial Towns," *Journal of Historical Geography* 53 (2016): 28–44.
[86] Péter Szabó *et al.*, "Intensive Woodland Management in the Middle Ages: Spatial Modelling Based on Archival Data," *Journal of Historical Geography* 48 (2015): 1–10.

also highlights another growing area of interest for researchers: the integration of GIS and archival data. This issue was central for Robert Tierney *et al.* in their work on the spatial distribution of drought impacts in New South Wales at the turn of the twentieth century.[87] By aggregating data relating to grain prices and rainfall, they were able to discern regional conditions from local extremes.

Comprehensive digitisation of map content is a growing aspect of historical research. Several recent studies have already sought to utilise digitised OS mapping in similar ways to my project. The First Edition Survey Project (FESP), jointly managed and funded by Historic Scotland and RCAHMS (bodies that have since merged to become Historic Environment Scotland), digitised a range of features from the six-inch first edition in order to produce a database and subsequent analysis of abandoned farm settlements across Scotland (published in 2002 as *But the Walls Remained*).[88] Lime kilns were among the agricultural features recorded as part of this project, but only those associated with abandoned farmsteads and townships, and without their associated symbology. The new resource produced by this work has proved valuable for both research and management of historic remains. Mapping features enables new kinds of inductive investigation, in this case allowing regional differences in the distribution of features to be observed for the first time and revealing 'several themes that would benefit from further investigation'.[89]

The recently completed GB1900 project—a collaborative effort between the national libraries of Wales and Scotland and the University of Portsmouth—crowdsourced the digitisation of all map text from the second and later editions of the OS six-inch series.[90] The data produced by this monumental undertaking are freely accessible and available to download, and have been incorporated into the gazetteer for the associated map series on the NLS website (a considerable boon to searchability). As with FESP, this project also documented lime kilns where they are annotated on the map, but do not record other information about the kilns themselves and use the text rather than the feature to

[87] Robert Tierney, Kevin A. Parton, and Deanna Duffy, "'Three Raindrops and Some Dust': Combining Archival and GIS Analysis to Map the Spatial Distribution of the Impact of the Federation Drought of 1895–1903 in Rural New South Wales," *Journal of Historical Geography* 55 (2017): 1–16.
[88] *But the Walls Remained* (Edinburgh: Royal Commission on the Ancient and Historical Monuments of Scotland & Historic Scotland, 2002).
[89] *But the Walls Remained*, 75.
[90] Available at http://www.gb1900.org/

define the location. Thus, the digitisation element of this present project, with its focus on symbology, represents a new development in the use of electronic cartographic sources for historical geography.

2.4.1 The 6" First Edition

The first edition of the Ordnance Survey's six-inch map was the first large scale map series to cover the whole of Scotland. Designed to become 'standard tools of rural land-use management', these maps record 'practically all man-made and natural features in the landscape' at a scale of six inches to a mile (1:10,560).[91] Each county was surveyed with its own central meridian, based on a Cassini projection.[92] Surveying began in 1841, with the first sheets published in 1843. After 1854, surveys were conducted at 1:2500 in cultivated areas and 1:10,560 in uncultivated areas.[93] The last sheets were published 39 years later in 1882. In total, the series comprises 2,158 sheets across 33 counties.[94] The maps were engraved on copper and published in sheets of 36 by 24 inches (91.5cm by 61cm), covering an area six miles by four miles.[95] Because of the long duration of its production, and like the *Statistical Accounts*, the map series taken as a whole depicts an extended view of Scotland's topography during the nineteenth century, rather than a single snapshot in time.

The six-inch map has long been a valuable resource for historians and archaeologists. The detail and accuracy of the cartography, including the recording of lime burning sites, have been noted by other researchers. For example, Bailey, surveying a series of kilns in north Ayrshire, found that, although the kilns were obscured by dense vegetation, 'the extent and composition of the upstanding remains closely resembled the forms that appeared on the First Edition Ordnance Survey map of 1855'.[96] This relationship between kiln form and map depiction, which forms the basis of the cartographic analysis

[91] Christopher Fleet, Margaret Wilkes, and Charles W J Withers, *Scotland: Mapping the Nation* (Edinburgh: Birlinn Limited, 2011), 144; Christopher Fleet and Charles W J Withers, "A Scottish Paper Landscape: Ordnance Survey's Six-Inch Maps, 1843-1882," National Library of Scotland, 2005, http://maps.nls.uk/os/6inch/os_info1.html.
[92] Fleet and Withers, "A Scottish Paper Landscape: Ordnance Survey's Six-Inch Maps, 1843-1882."
[93] The issue of scaling has a long and storied history for this map series, see Tim Owen and Elaine Pilbeam, *Ordnance Survey: Map Makers to Britain since 1791* (Southampton: Ordnance Survey, 1992), 45–51.
[94] Some regions were subdivided and surveyed separately for projection reasons.
[95] Richard Oliver, *Ordnance Survey Maps: A Concise Guide for Historians*, 3rd ed. (London: Charles Close Society, 2013), 43–45.
[96] Bailey, "Hullerhirst Quarry and Lime Kilns, North Ayrshire," 99–100.

in this thesis, is the subject of several publications by Bishop since 2013.[97] During the nineteenth century OS standards allowed for a maximum locational error of less than three metres, with further error sometimes introduced by the various tracing and copying processes involved in map production.[98]

The National Library of Scotland (NLS) website hosts the entire OS six-inch first edition series.[99] The maps can be viewed as individual sheets (Figure 12), as a seamless zoomable georeferenced layer (Figure 13), or side-by-side with modern mapping.[100] The georeferenced six-inch map layer is also provided by the NLS as a Web Map Service (WMS) layer for use in GIS.[101]

2.4.2 Digitising

The process of gathering or creating spatial datasets is typically the most labour-intensive part of any GIS method.[102] Only kilns from the six-inch first edition OS maps were digitised. Kilns from later editions and other map features were considered, but these were considered not worth the significant time investment required. The individual map sheets provided by the NLS website were used as the primary source for finding and recording lime kilns for three reasons. First, the individual sheets provided the greatest image quality (compared with the online zoomable overlay and the GIS web layer), allowing the small details of map symbols to be examined closely. Second, survey and publication dates for each map sheet could be recorded at the same time as the kilns themselves. Third, by viewing each map sheet in order (by county and by numbered sheet), the digitisation process was kept systematic and consistent, ensuring no parts of Scotland were missed.

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[97] Bishop and Thomson, "How OS Depicted Limekilns in Scotland's Central Belt"; Bishop and Munro, "Further Comment on OS Mapping of Limekilns in Scotland"; Bishop, "Over-Cooking Lime Kilns?"; Mitchell and Bishop, "Limekilns – Still a Burning Issue."

[98] Oliver, *Ordnance Survey Maps: A Concise Guide for Historians*, 64. By comparison, 99% of points on modern OS maps surveyed at 1:2500 should be in error by no more than 0.7m for built-up areas and 2.4m outside of built-up areas.

[99] Available at https://maps.nls.uk/os/6inch/index.html. Physical map sheets were also consulted at the University of Glasgow Library.

[100] Christopher Fleet, "New NLS Online Maps," *Sheetlines* 93 (2012).

[101] WMS layers provide a web link to a raster dataset held on another organisation's server. The layer can only be viewed in GIS and not edited in any way.

[102] Gregory and Ell, *Historical GIS: Technologies, Methodologies and Scholarship*.

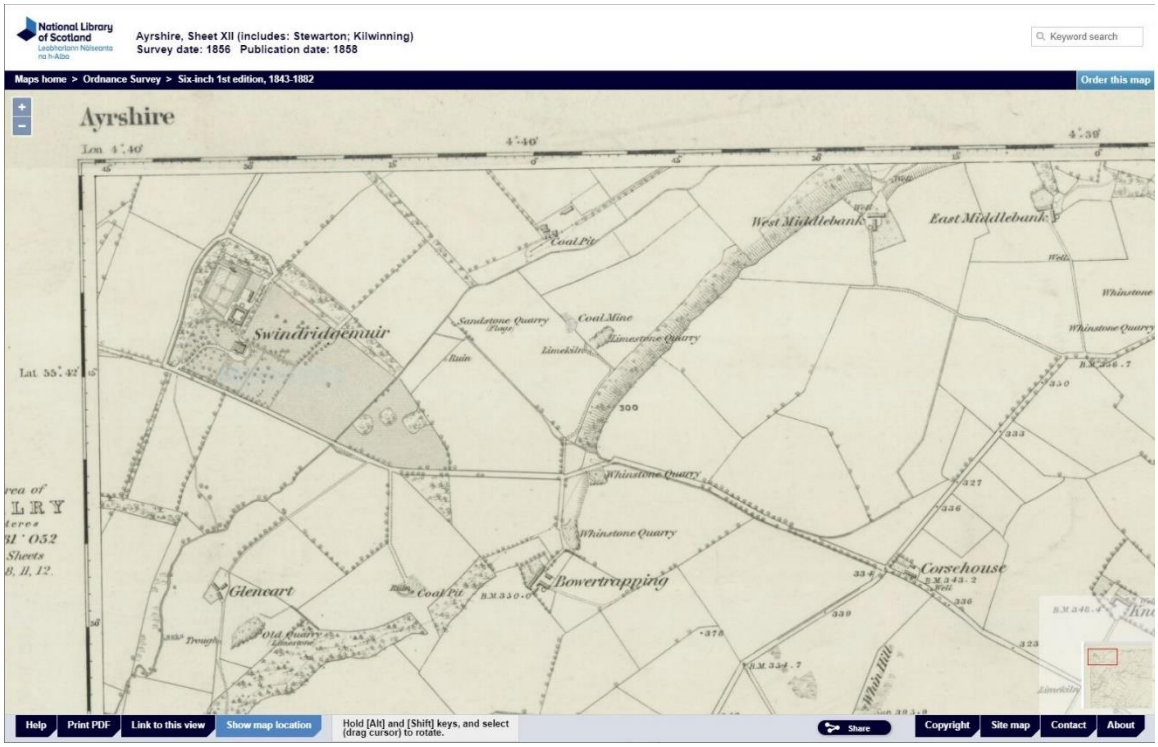

Figure 12 NLS online single map sheet viewer. Note the map sheet survey and publication dates in the top-left of the window and the orientation panel in the bottom-right.

Digitising kilns found on the individual map sheets was a three-stage process. Firstly, each map sheet was opened in turn and the viewing window, held at a constant size, was moved across the map extent from left to right, starting in the top-left corner and ending in the bottom-right (see Figure 12). Second, information about each site was recorded: name (usually based on a nearby named feature), the number of kilns at the site, whether they were in-use, notable features (such as nearby infrastructure, unusual symbols, etc), and metadata relating to the map sheet.[103] The symbol type used to represent each kiln was recorded using the classification schema developed by Bishop and Thomson, with points assigned a code relating to its symbology.[104] This original symbol schema was later adapted based on my own findings, but using it for digitising ensured the continuity of the two data collection phases. Finally, the location was fixed using the seamless georeferenced layer (open in another browser window) by moving the cursor over the kiln and recording the coordinates shown in the bottom-right of the viewing window.[105] All data was entered into a spreadsheet using a

[103] Representation of kilns on the OS maps are covered in more detail in Chapter Three
[104] Bishop and Thomson, "How OS Depicted Limekilns in Scotland's Central Belt," 23.
[105] The work of the NLS in georeferencing the OS map sheets saved considerable effort. Earlier digitisation efforts, such as the FESP project, required map sheets from each county to be georeferenced separately using control points.

template. Once digitisation was complete, some point locations were adjusted in GIS after visually inspecting the digitised points over-laid on the raster WMS layer.

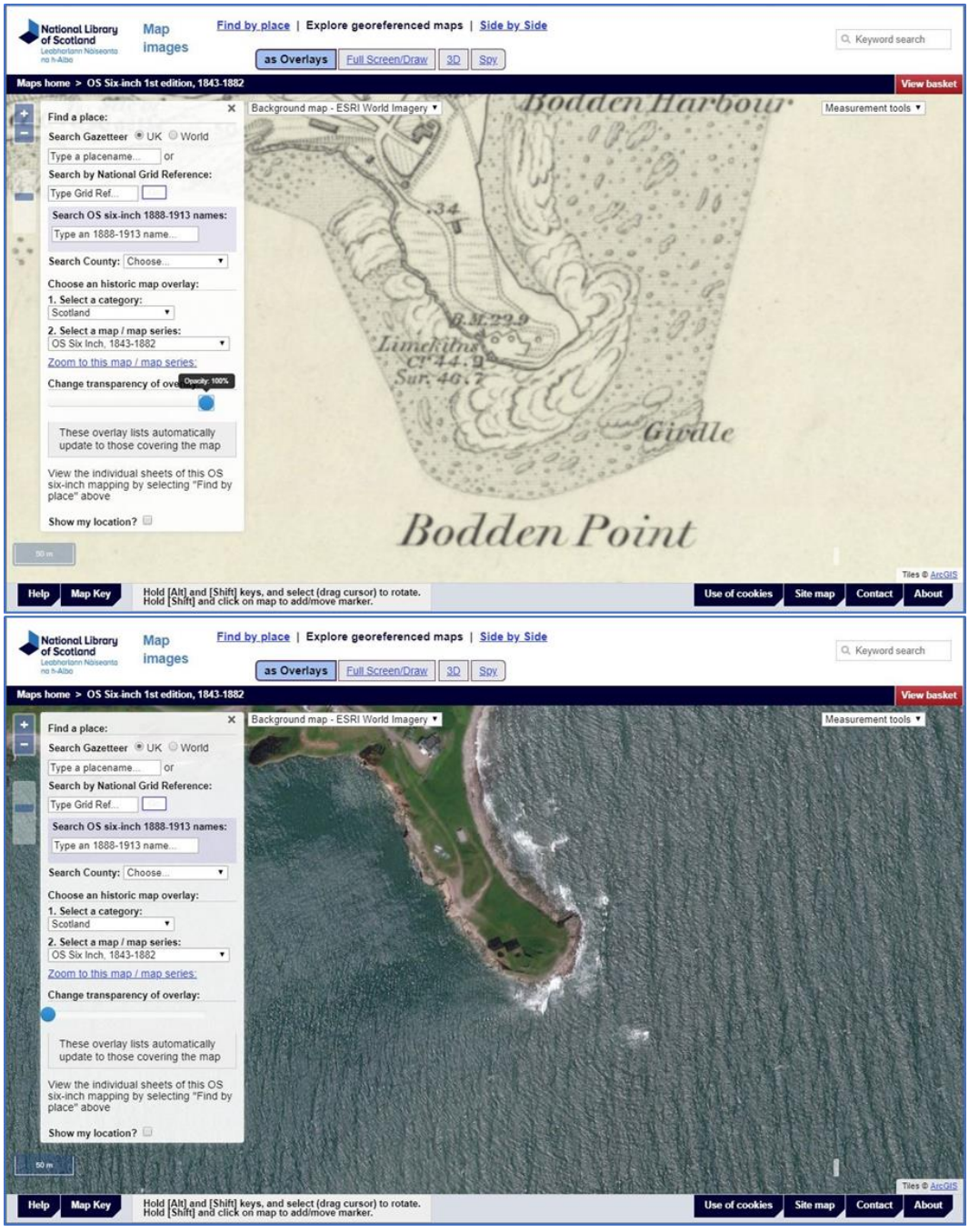

Figure 13 Example of NLS online seamless zoomable overlay viewer. Above: OS Six Inch (1843-1882) mapping centred on Bodden (Boddin) Point lime kilns, south of Montrose (NO713533). Below: the same view with map opacity turned to zero, showing the background layer (in this case ESRI World Imagery). Note that coordinates are not visible in the bottom-right of the viewing window due to the cursor being outside of the web browser window when the screenshot was captured.

In 2015 Bishop and Thomson recorded the location—in latitude and longtitude—of lime kilns in the counties that make up Scotland's central belt. These point co-ordinates were then converted to British National Grid to integrate with the points I digitised. Following completion of the digitisation

process, in GIS, using the WMS layer, the Bishop and Thomson points were adjusted to improve their accuracy relative to their position on the map.[106] A search was also conducted through these Central Belt counties to pick up any kilns that had previously been missed.

2.4.3 GIS analysis

Once the digitising process was completed, the resulting geodatabase was managed in Microsoft Access, which allowed large scale updates to the symbol schema and classifications to be applied to the entire dataset. Spatial analysis and visualisation were conducted using the QGIS software package. Statistical analysis of results produced in QGIS was conducted using Minitab statistical software. In terms of analytical strategy, spatial analysis is more suitable for describing observable states, identifying features of interest, and generating ideas for further enquiry than it is for constructing models or testing hypotheses.[107] Thus HGIS is best employed for exploratory over confirmatory analyses. As Sam Griffiths argues, GIS visualisation should form part of an 'ongoing heuristic-hermeneutic process' rather than simply an end product.[108] In other words, simply projecting and overlaying spatial datasets can enable the researcher to explore and understand their data, without immediately reaching for quantitative validation or formal cartographic outputs.

Several additional datasets were acquired to enable analysis and visualisation (Table 2). One of the biggest obstacles to HGIS research is the availability of datasets that are relevant to the geography, time period, and research questions of a given project.[109] Many researchers overcome this by digitising source material themselves, but to do this for multiple features (such as roads) on a national scale would prove prohibitively time-consuming (see above). Projects such as the Great Britain

[106] Bishop and Thomson had located kilns using the physical map sheets, recording latitude and longitude from the map edges. The manual nature of this process introduced greater potential for error and imprecision. Their points were overlaid on the WMS layer in GIS so that misplacements could be easily seen.
[107] Gregory and Ell, *Historical GIS: Technologies, Methodologies and Scholarship*, 163.
[108] Griffiths, "GIS and Research Into Historical 'Spaces of Practice': Overcoming the Epistemological Barriers," 168.
[109] Gregory and Ell, *Historical GIS: Technologies, Methodologies and Scholarship*.

Historical GIS (also known as *A Vision of Britain Through Time*) are steadily working to produce ever more data to support research.[110]

Canmore, the national record of the historic environment, maintains a spatial dataset of archaeological sites, including lime kilns, which would potentially be of use for spatial analysis of the industry. However, these records are variable in their spatial accuracy (co-ordinates may refer to specific kilns or to larger archaeological groupings), detail (some reports are meticulous while others refer to lime kilns only in a generic sense), and information source (some have been extensively surveyed and others added from various cartographic sources). Marrying these data with those from the OS introduces further complications in terms of duplication and dating.

Table 2 Datasets used in GIS.

Dataset	**Source**
Counties of Scotland pre 1890	Vision of Britain[111]
Parishes of Scotland 1951	Vision of Britain
Bedrock and Superficial geology polygons, 1:50,000 scale	BGS
BRITPITS	BGS
OS Terrain 50 DTM and contours	Ordnance Survey
OS Open Rivers	Ordnance Survey
OSM TF Landscape	OpenStreetMap, Thunderforest
ESRI World Imagery	ESRI
Strategi, base mapping	Ordnance Survey
OS 6-inch 1st Edition WMS Layer	National Library of Scotland

Kiln points were also uploaded to a private Google Map accessible online using a computer or smartphone. This allowed the dataset to be viewed when in the field (aiding the discovery of kiln remains) or used as a quick reference resource when conducting archival visits. Analysis of the data and symbology is discussed in more detail in the next chapter.

2.4.4 Interpreting map symbols

Since the analysis of the geodatabase relied on symbology to provide qualitative information about the kinds of kilns used at each of the sites recorded from the map, it was important to establish as reliably as possible the relationship between map symbols and physical forms. Bishop developed the

[110] See Humphrey Southall, "Rebuilding the Great Britain Historical GIS, Part 1: Building an Indefinitely Scalable Statistical Database," *Historical Methods* 44, no. 3 (2011): 149–59; Humphrey Southall, "Rebuilding the Great Britain Historical GIS, Part 2: A Geo-Spatial Ontology of Administrative Units," *Historical Methods* 45, no. 3 (2012): 119–34; Humphrey Southall, "Rebuilding the Great Britain Historical GIS, Part 3: Integrating Qualitative Content for a Sense of Place," *Historical Methods* 47, no. 1 (2014): 31–44.
[111] Available at http://www.visionofbritain.org.uk/

first symbol schema relating to lime kilns, particularly clamp kilns.[112] Several innovative methods were used to 'ground truth' a sample of each of these and subsequent symbol categories found during the digitising process. The seamless zoomable georeferenced historic map layer can be overlaid over a choice of background maps and aerial photography.[113] By changing the opacity of the map layer, cartographic features can be quickly compared with any features on the ground (see Figure 13, above and Figure 20, p.80). This process was also useful for directing site visits by indicating whether any remains were likely to be found at the location.

Archival sources could also be used to corroborate map symbols. The OS Name Books were particularly relevant in this regard, since they complement each map sheet, providing supplementary and source information for all named features. Similarly, newspapers and estate records were useful information sources. For example, an advert from 1826 for Shawsmill limestone quarry mentions 'five clamp kilns' at the site, which can be linked to the five lime kiln symbols found at Shawsmill on the OS first edition from 1856.[114] The Canmore archive contains many site descriptions, archaeological reports and photographs from which the nature of lime burning sites can be investigated.[115] The georeferenced photographs held on the website Geograph also proved useful for assessing kiln remains.[116] Lime kilns, and in particular draw kilns, are notable landscape features, and are as a consequence frequently photographed by Geograph users. Because the uploaded images can be matched to specific locations, they are potentially useful sources of evidence about kiln remains. Some Geograph users have also compiled detailed field reports of lime burning features in parts of Scotland, such the one produced for Dumbarton Muir by the user 'Lairich Rig'.[117]

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[112] Bishop and Thomson, "How OS Depicted Limekilns in Scotland's Central Belt"; Bishop and Munro, "Further Comment on OS Mapping of Limekilns in Scotland."

[113] The NLS website provides a choice of backdrop between ESRI World Imagery or Bing Aerial mapping. Google Maps and Apple maps aerial imagery were also used in separate windows. Image quality and sun angle (based on the time of day and year the photographs were taken) at specific places varies between image set, so often multiple sources of aerial imagery were compared.

[114] 'Farm in Fife To Let', *Caledonian Mercury*, Monday 18 September 1826, p.3; see NT227930, Fife, Sheet 31, published 1856

[115] Available at https://canmore.org.uk/

[116] Geograph is a crowdsourced photography project that aims to collect 'geographically representative photographs and information for every square kilometre of Great Britain and Ireland'. Available at http://www.geograph.org.uk/.

[117] Lairich Rig, 'Relics of the Limestone Industry on Dumbarton Muir', September 2012, available at http://www.geograph.org.uk/article/West-Dunbartonshire-Limestone-Industry-Network

Where kilns are sited near roads, Google Street View images (part of the Google Maps image set) were used to inspect their remains. This approach, as with aerial photographs, provides a rapid indication of the general structure of kiln remains (see Figure 14). Published archaeological reports of former lime burning sites, where they can be matched to kilns in the database, were also useful for interpreting symbols. Reports that include a gazetteer with coordinates were of particular value, such as Atkinson's study of Ayrshire, Skinner's of the Lothians, and Cruickshank *et al.*'s study of Upper Donside in Aberdeenshire.[118] Finally, many sites were also visited in-person (discussed below). It is important here to note that remains on the ground (or recorded by others) may post-date the OS map surveys and thus may not be an accurate reflection of what the cartographers were trying to represent.

Figure 14 The two draw kilns of Side Lime Works (NT292551, OS First Edition six-inch, Edinburghshire, Sheet 18) are clearly visible from the road using Google Street View, allowing for rapid assessment of the site and associated map symbols.

[118] Atkinson, "An Archaeological Analysis of Industrialisation within the Rural Context of Post-Medieval South West Scotland"; Skinner, *The Lime Industry in the Lothians*; Cruickshank, Nisbet, and Greig, *The Limekilns of Upper Donside: A Forgotten Heritage*. Cruickshank *et al's* report even included individual photographs of all the kilns in their study area, which could then be directly compared to points on the OS map.

2.4.5 Other historical cartographic sources

In addition to the OS six-inch first edition, several other cartographic sources were viewed but not digitised or used in GIS. Later editions of the six-inch map series (1892-1960) were used to check the longevity of certain sites and to compare symbology.[119] The 25-inch first edition (1855-1882) was also used in this way. This map series provides greater detail than the six-inch, but coverage is only to cultivated lowland areas.[120] The OS ten-mile to the inch planning map series includes maps of coal and iron as well as limestone, dating from 1945 and 1955 respectively.[121] Several estate maps and plans were also inspected. Some of these have been digitised and are held by the NLS while others are stored by the NRS and were viewed in the course of archival research (see above).[122]

2.5 Site visits and other fieldwork

Although a large proportion of lime kilns have been levelled, built over or are otherwise obscured by degradation and overgrowth, many kilns remain standing and traces of lime working are evident in many parts of rural Scotland. In the course of this research, several site visits were carried out around Scotland.[123] It must be acknowledged here that I am not a trained archaeologist, and that this research was not intended to be archaeological in focus. Nevertheless, an 'archaeological imagination' is a growing phenomenon among geographers, with many researchers choosing to apply archaeological methodologies and sensibilities when engaging with subjects from the present and recent past.[124] Through this archaeological imagination, Michael Shanks argues, researchers can seek to 'recreate the world behind the ruin in the land, to reanimate the people behind the shard of antique pottery', thereby opening up possibilities for exploring 'change, innovation . . . the roles of individual perception, practice and agency'.[125] The present study of lime burning, being grounded in the physical remains of a lost industry, inevitably addresses archaeological matters of materiality,

[119] Symbology in the second edition appears simplified compared with the first, but no large-scale study has yet been conducted to draw firm conclusions on this.
[120] See https://maps.nls.uk/os/25inch/info1.html
[121] Limestone: https://maps.nls.uk/view/91546032; Coal and Iron: https://maps.nls.uk/view/91547448
[122] Complete list of maps and plans in Appendix.
[123] List of site visits in Appendix.
[124] Michael Shanks, *The Archaeological Imagination* (London: Routledge, 2012); Hill, "Human Geography and Archaeology: Strange Bedfellows?"; McGeachan, "Historical Geography III: Hope Persists."
[125] Shanks, *The Archaeological Imagination*, 17–25.

reconstruction, and dating. Visiting lime burning sites proved invaluable for understanding kiln designs and the practicalities of site layout, particularly during the early stages of the research. As Photos-Jones *et al.* note (see above), such visits ensured that conclusions founded in written sources are rendered more coherent and realistic.[126] Photographs (see Figure 15) were taken during visits and notes written up after leaving the field.

Figure 15 The author inspecting the Ardonald draw kiln. This and all subsequent photographs are the author's own, unless otherwise stated.

In July 2016 I visited the Scottish Lime Centre Trust (SLCT) in Charlestown, Fife, to meet with Roz Artis and her team to learn about their work analysing and tracing lime mortar samples and the ways in which my research might contribute to their building conservation work. Later that month I attended a two-day practical course at the Centre—'Repairing Traditional Masonry'—aimed at amateur conservationists interested in learning about mixing and using lime mortars in restoration work. The course covered burning limestone, handling quicklime, mixing mortars, and applying mortar to traditional stonework (see Figure 16). This experience shared some minor similarities with the kinds of practice-based methods favoured by some archaeologists and historical geographers.[127]

[126] Photos-Jones *et al.*, "Between Archives and the Site: The 19th-Century Iron and Steel Industry in the Monklands, Central Scotland."
[127] Lisa J Hill, "Time and the Practice of Charcoal Burning," *Cultural Geographies* 21, no. 3 (2014): 411–27.

Physically working with lime, even for a short time, revealed some of the inherent practicalities of the lime industry, such as the unpleasantness of quicklime and the weight of materials involved.

Figure 16 Lime mortaring course at the Scottish Lime Centre Trust, Charlestown 2016. Left: burning limestone in a rudimentary kiln made of breezeblocks. The kiln was left to burn overnight, and the lime used to make mortar the next day. Right: slaking the lime before mixing it with sand.

2.6 Ethics

Due to the nature of the research, no formal ethical clearance was required. Nevertheless, I always followed AHRC ethical guidelines.[128] During the visits to the SLCT and completion of the lime mortaring course no data was gathered on the other participants.

2.7 Summary

This research explores the historical geographies of lime burning in Scotland through a broad range of source material. The sources and methods discussed above appear in some form throughout this thesis, although some are leant more heavily upon in each chapter than in others. The aim of the next chapter, Chapter Three, is to provide an overview of the distribution of lime kilns and an analysis of the spatial patterns of the industry. As such, it draws directly from the OS map data and HGIS. The chapter also provides further discussion of map symbology in relation to kiln types, as well as an evaluation of the OS maps as a data source. Chapters Four and Five utilise data from a range of

[128] AHRC Code of Practice, available at https://ahrc.ukri.org/about/policies/codeofpractice/

published sources and estate archives to look at a several themes relating to the lime industry. The first of these explores material flows and resource use, making extensive use of papers from lime works (which record transactions relating to fuel and lime) and sources from among the Statistical Inquiries (providing information on resource use from across the country). Chapter Five deals with the practice of lime burning, the construction of kilns, and the ownership of lime works, to tell a story about the modernisation of the industry. It makes use of estate papers, focusing in this case on those that reveal the activities of workers and the building of kilns. Tacks and leases were also used to explore questions of land ownership in relation to kilns. Chapter Six focuses more closely on published material produced by improving writers and agrarian institutions to follow the subject of lime through several knowledge spaces and to explore the connection between ideas and practice. In doing so, this chapter examines discourses associated with improvement, Enlightenment, science, and their connections with lime burning. The Conclusion to this thesis (Chapter Seven) offers some reflection on the extent to which the different data sources worked in concert with one another and the opportunities that this admixture represents for future research.

3 Symbols and maps

3.1 Introduction

This chapter deals with the representation of lime kilns on the Ordnance Survey's first edition six-inch mapping and the ways in which this information can be interpreted, visualised and analysed to increase understanding of the industry. Following the digitising methodology outlined in Chapter Two, nearly 3,000 kilns were recorded from the OS map sheets. These kilns were then interpreted based on their symbology, giving clues as to their form and structure. This chapter begins by delving into the six-inch map's origins and production, providing context to discussion of depiction of kilns. Examples and explanations of lime kiln symbology are then given. An overview of results is provided, including a regional breakdown of kiln sites. Following this section, opportunities and challenges for visualisation and analysis are discussed.

3.2 Interpreting the map data

3.2.1 Origins of the six-inch first edition map

As discussed in the previous chapter, digitised historical maps are becoming an ever more established source for HGIS and historical geography more generally. When working with any cartographic sources, however, it is important to look beyond the map itself and identify the power and motivations that produced it.[1] Also relevant are the technical and logistical factors that influence its design and production, as well as its eventual audience and usage. The Ordnance Survey's first edition six-inch map of Scotland was produced between 1843 and 1882. Its precursor in terms of style and specification was the six-inch map of Ireland (completed in 1842), which provided a template for the Survey's work in mainland Britain. Agricultural improvement was at the heart of the map's inception. As the Irish survey neared completion in the 1840s, Scottish landowners and agriculturalists 'agitated' for work to begin in earnest.[2] Agrarian societies, particularly *The Highland*

[1] John Brian Harley, "Deconstructing the Map," *Cartographica* 26, no. 2 (1989): 1–20.
[2] Fleet and Withers, "A Scottish Paper Landscape: Ordnance Survey's Six-Inch Maps, 1843-1882."

and Agricultural Society of Scotland (*HAS)*, were instrumental in lobbying for and guiding the work of the OS in Scotland.[3] When the British Treasury eventually consented to the mapping project, it explicitly invoked the national drive for improvement, stating that,

> the demand of the present day is for such a national survey as shall be permanently useful in aiding the improvement of the country, by serving as a basis and guide in the formation of railroads, canals, and other public works, besides assisting in the geological structure of the country, and promoting, in various other ways, the progress of science and statistical knowledge.[4]

The influence of the *HAS*, and the esteem in which it was held, is evidenced by the opinion of Lieutenant Colby, who sought its input as to the kind of survey that would be of greatest use for improving the land. The *HAS*, he suggested, was the institution likely to possess 'more information than any other public body, as it enters into almost every question connected with the agriculture, manufacture, and commerce of Scotland'.[5] Given the importance of lime for improvement, and the attention paid to it by agrarian societies like the *HAS* (the subject of Chapter Six), the lime industry would have been of particular interest to the map's proponents.

The surveys were intended to proceed across Scotland from south to north on a county-by-county basis. A proprietor from the Hebrides, however, petitioned for the survey to begin on the islands, on the grounds that areas requiring improvement be prioritised. Subsequently, the survey started with Lewis in 1846.[6] By 1859 most of the Lowlands had been surveyed, and by 1869 almost everywhere as far as the Great Glen was complete. Surveys of Orkney and Shetland were finished by 1877, and all maps eventually published by 1882. The survey dates of individual kilns (Figure 17) illustrate the progress of the Survey across Scotland.

[3] R. C. Boud, "The Highland and Agricultural Society of Scotland and the Ordnance Survey of Scotland, 1837-1875," *The Cartographic Journal* 23, no. 1 (1986): 3–26.
[4] Treasury Minute, 1 October 1840, in Boud.
[5] Colby, 1840, in Boud.
[6] Fleet and Withers, "A Scottish Paper Landscape: Ordnance Survey's Six-Inch Maps, 1843-1882."

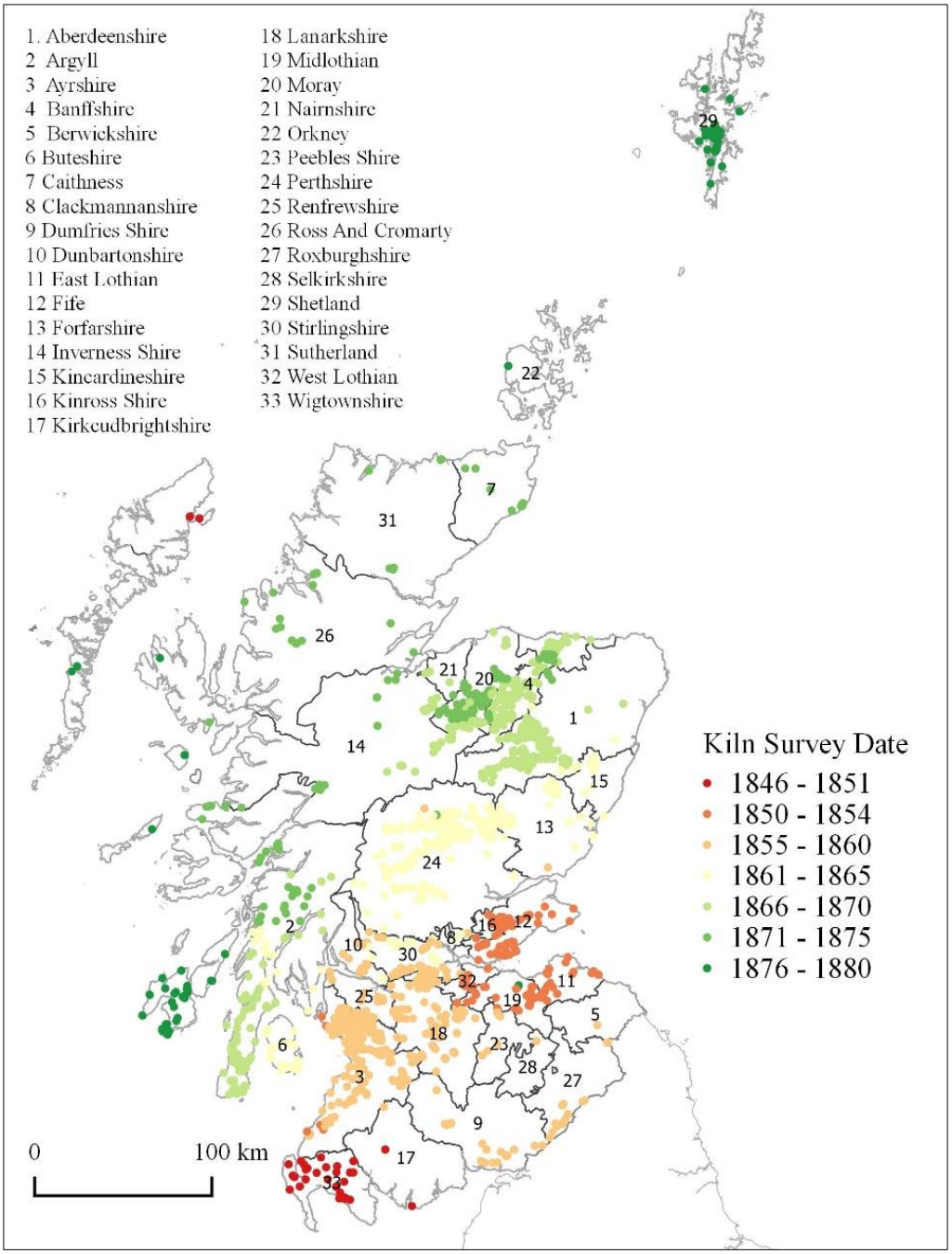

Figure 17 Lime burning sites colour coded by survey date. For context, pre-1890 county boundaries are shown, although these do not necessarily correspond to the county boundaries used by the OS.[7]

3.2.2 Map symbols and their meaning

Early symbology of the OS has received little attention in historical accounts of the institution and its achievements.[8] Major-General Sir Henry James, director general of the OS, in his account of the

[7] Pre-1890 counties from *Vision of Britain*, http://www.visionofbritain.org.uk/data/.
[8] For example, histories such as Owen and Pilbeam's *Ordnance Survey: Map Makers to Britain since 1791* (Southampton: Ordnance Survey, 1992) only cover map symbols from the twentieth century onwards. A

Survey's methods and processes at the turn of the twentieth century affords less than a page to the painstaking work of draughtsmen and engravers who hand drew the features recorded in the field.[9] It was the role of the draughtsman, his report states, to 'make a perfect representation according to the scale of the map' and to 'represent objects clearly and distinctly to scale according to the conventional rules'.[10] This step followed the work of surveyors and examiners who recorded and interpreted the physical world. Along with classifying and positioning parcels of land, surveyors were tasked with recording the 'usual detail of houses, roads, fences, streams, railways, canals, etc'.[11] The examiner would then verify the accuracy of these details and communicate important qualitative information to the draughtsmen by annotating 'customary explanatory writing to minor objects'.[12] Beyond these unwritten style conventions, the final appearance of lime kilns on the maps was ultimately the product of several individual decisions by those responsible in turn for identifying kilns in the field, accurately recording their position, ascertaining (whether from experience or evidence) their form, function and status, and then communicating this information so that it could be drawn then engraved in readable form.

Despite their absence from the six-inch characteristics sheet, lime kilns are prominent and numerous on the maps.[13] Isolated kilns are labelled 'Limekiln' (very occasionally abbreviated to 'L.K.'), with the plural used for pairs or small groups. Allusions to lime burning appear in several place names, presumably in areas with a history of lime use or production. The most notable example of this is the town of Limekilns in Fife, but there are numerous others, such as a 'Lime Kiln Park', 'Lime Kiln Loch' and 'Lime Kiln Nursery' all found in the vicinity of a draw kiln near Stranraer in Wigtownshire (NX089597).[14] The Gaelic for lime kiln is *àth-aoil* and the word *aoil* ('lime') crops up frequently in

notable exception to this comes from Bill Bignell's work on windmills in early maps, see *Mapping the Windmill* (London: Charles Close Society, 2013).

[9] Major-General Sir Henry James, *Account of the Methods and Processes Adopted for the Production of the Maps of the Ordnance Survey of the United Kingdom*, 2nd ed. (London: HMSO, 1901).

[10] Major-General Sir Henry James, 46.

[11] Major-General Sir Henry James, 46.

[12] Major-General Sir Henry James, 46.

[13] Characteristics sheet given by the NLS available at https://maps.nls.uk/view/74477147.

[14] This example is last recorded on the 25-inch map from 1895 and appears not to be in modern usage. Other cases go the other way. For example, a Limekilns Pool and Limekilns Cottage can be found on the River Findhorn in Moray, at the site of what was formerly Cothall Quarries and lime kilns (NJ011559). It is not known when the present naming came to be established.

a variety of Gaelic place names. For instance, *Cnoc an aoil* ('hill of lime') appears several times on both the six-inch first edition and modern OS mapping.[15]

Lime works, suggestive of larger commercially oriented operations, are indicated and usually named (e.g. 'Askomill Lime Works'). Within these amalgamations, individual kilns are depicted in symbol form, but not always labelled individually, an OS practice that survived until the 1960s.[16] Kiln symbols varied in size, although this does not appear to have a consistent relationship with the size of kilns on the ground.[17]

Kilns considered abandoned, ruinous or otherwise not in use were labelled accordingly, most commonly as 'Old Limekiln', but sometimes as 'disused' or 'in ruins'. This distinction is valuable for determining whether kilns were active at the time of survey, although no indication is given as to how long a kiln had been in or out of use. Indeed, the OS appear to have been relatively inconsistent in whether it recorded abandoned kilns at all. For instance, none of the kilns shown on an 1814 plan of Mundole Commonty, near Forres, appears on the first edition OS map of 1868, whereas several kilns in Wigtownshire dating back to the 1780s were included on the first edition OS map of 1848.[18] This issue, along with other inconsistencies, is considered further below.

Like many early maps, the six-inch sheets did not include a legend on the map sheet itself. Consequently, symbols had to be readily understood by the map's readership.[19] In the case of lime kilns, a range of symbol styles were used to represent and communicate individual kiln structures. Some exhibit pictorial or pictographic characteristics, mimicking the visual appearance of a kiln in symbol form. Others appear to represent kilns by their outline as if viewed from an absolute vertical

[15] *Aoil* is a grammatical form of *aol* (meaning the substance 'lime'). According to LearnGaelic (https://learngaelic.net/), the term *sòrn-aoil* (literally 'lime stove') was also used for a lime kiln. For further discussion of the Survey's role in inscribing authority over Gaelic Scotland through the cartographic naming of places, see Charles W J Withers, "Authorizing Landscape: 'Authority', Naming and the Ordnance Survey's Mapping of the Scottish Highlands in the Nineteenth Century," *Journal of Historical Geography* 26, no. 4 (2000): 532–54.

[16] Oliver, *Ordnance Survey Maps: A Concise Guide for Historians*, 102.

[17] Bishop *et al.* have argued that, at least in the case of clamp kilns on the second edition, mapped size does represent the size on the ground, see "Lime Burning in Clamp Kilns in Scotland's Western Central Belt: Primitive Industry or Simple But Perfectly Adequate Technology?"

[18] Plan of Mundole Commonty, 1814 (NRS RHP4004); Donnachie, "The Lime Industry in South-West Scotland," 151.

[19] Richard Oliver, "Is There an Optimum Size for Topographic Maps?," *Sheetlines* 109 (2017): 42–52.

position. Others still might be considered ideographs, socially constructed symbols that communicate an idea without faithfully depicting it.[20] Crucially, symbol variations appear to relate to the physical form of the kilns depicted, which therefore holds clues as to their function when in use. A range of symbol characteristics were observed and organised into like groups during this project's data collection phase. A table of these symbol groups, with examples, is included in the Appendix. Codes used subsequently (e.g. 'symbol group A') relate to the codes in this table.

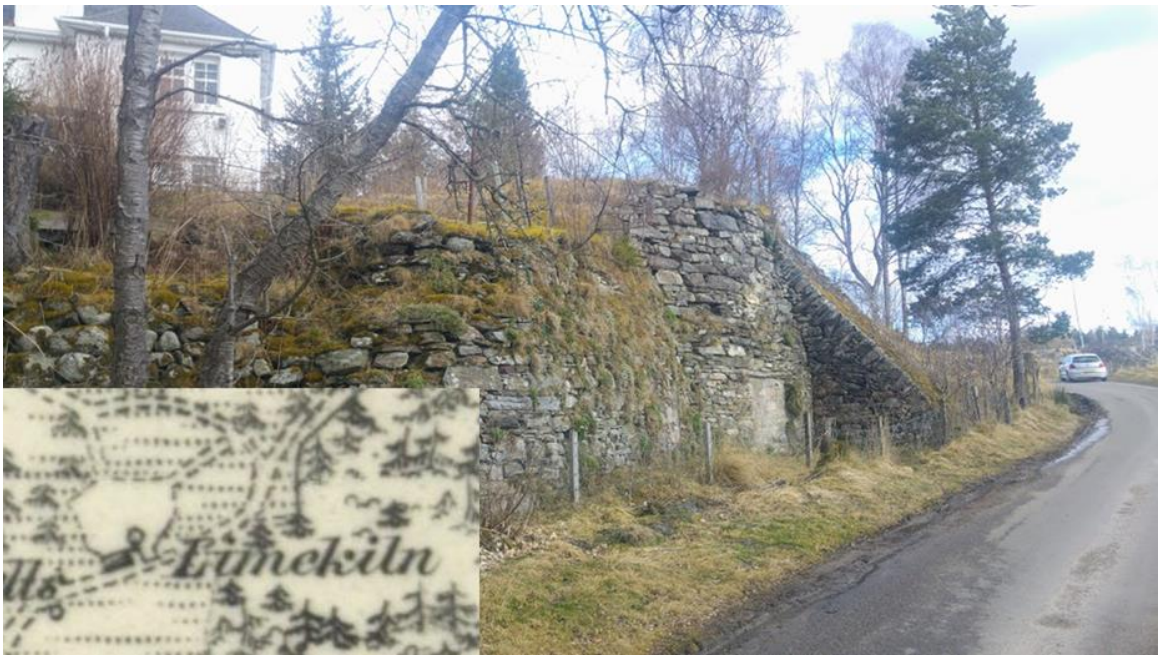

Figure 18 Draw kiln at Dulnain Bridge. Photo taken from the road to the south-west of the kiln, looking north-east. Inset: kiln shown on the OS map (NH998249, Inverness-shire (Mainland) Sheet 46, published 1875). Note the representation of the buttress and flat loading platform to the rear of the circular kiln pot.

The most widespread and simplest symbol used for lime kilns is a plain circle (symbol group D). On their own, these typically represent free-standing, circular kilns, which may have been operated as draw kilns but more likely as intermittent field kilns.[21] Circles vary in size, but this does not appear to be consistent with the size of the kiln. When these circles are enclosed entirely or partially by lines or shading, the effect is to signal an embankment, masonry surrounds or buttressing (for example, see Figure 18). In this case the circle, rather than symbolising the kiln in its entirety, represents the

[20] Bishop and Munro, "Further Comment on OS Mapping of Limekilns in Scotland." For other examples of ideographic symbols used by the OS, see Bignell, *Mapping the Windmill*.
[21] This classification is based on several assumptions, including their number and typical placement. For further commentary on kiln types, see Chapter Five, 157.

kiln pot in a planimetric sense. Multiple circles within such shapes are taken to indicate multiple pots.[22]

The second most frequent symbol classification consists of a circle with either a dot either inside it or on its circumference (symbol groups E and F respectively).[23] The latter symbol occurs less frequently, appearing primarily in three distinct clusters along the Eastern Highlands, but also sporadically elsewhere. These two symbols are used interchangeably in a variety of contexts to depict different types of kiln form: from free-standing field or draw kilns, to the individual pots within a bank of kilns (such as at Charlestown, see Figure 19). It was thought that the inner dot might represent the pot or vent, or that that the marking on the circumference might indicate the location of the draw hole, but neither of these explanations can be confirmed.[24] Similarly, the circular symbol shape is not indicative of kiln form. For example, at Upper Donside, the same symbol is used for a series of round field kilns as well as a larger square 'quarry' kiln.[25] The variant with the dot on the circumference also appears in the Old Series OS maps of England and Wales, as well as on the OS first edition six-inch mapping of Ireland, and so may represent the emergence of an ideographic symbol, widely recognisable to contemporary map users. Further evidence in support of this suggestion comes from the fact that it is the only symbol for a lime kiln to appear on any six-inch classification sheet.[26] As with plain circles, this kiln was interpreted here as indicating field kilns where on its own and draw kilns when adorned with additional surrounds.

[22] Multiple pots within the same contiguous structure were still counted as two kilns during data collection, since the pots could operate separately.
[23] There exists something of a spectrum between these two symbols, with some showing dots clearly in the centre (clear of the edge) and others clearly positioned on the circumference, while others are positioned slightly off-centre or with the edge of the dot grazing the circumference of the symbol. A judgement was made in each case. This issue is further complicated where smaller symbols render it difficult to tell whether overlapping dots and edges are the product of deliberate design choices or simply congestion on the page.
[24] Bishop and Munro, "Further Comment on OS Mapping of Limekilns in Scotland."
[25] Cruickshank, Nisbet, and Greig, *The Limekilns of Upper Donside: A Forgotten Heritage*, 46.
[26] Lime kilns do in fact appear on a classification sheet digitised by the NLS (available https://maps.nls.uk/view/128076804). However, the publication date and associated map series remain unclear beyond its having been produced in the latter half of the eighteenth century. Chris Fleet, pers. comm. 07/08/2017.

Figure 19 Map symbols for Charlestown Harbour in Fife (NT064835, Fife and Kinross-shire, Sheet 39, published 1856). Charlestown lime works was at one time the largest producer of lime in Scotland. Note the sequence of symbols set against the line depicting the edge of the kiln bank, with each symbol representing one of the nine pots on the site. The variations in symbol here do not correspond to any known difference in kiln pot design, hence the opinion that the circle-dot symbol (and its variants) represents some kiln of generic lime kiln.

Open-ended U-shaped symbols, which can be either rounded or squared off at the closed end (symbol group A and B respectively), appear unequivocally to represent clamp kilns, a stylistic symbol that Bishop and Munro argue may be unique to Scotland.[27] These symbols are planimetric in style, recognisably tracing the outline of the clamp shape. In most cases the orientation of the open end of the symbol closely matches the layout on the ground (although with exceptions, as will be discussed below). It is not clear to what extent the roundedness of the closed end corresponds with the shape of the kiln itself—clamp kilns could be either simple elongated basins dug into the ground or more substantial stone or masonry lined bays (clamp kiln structures are discussed further in Chapter Five).[28] The distinctive nature of these symbols and their unambiguous depiction of clamp kilns is useful in identifying the ongoing practice of nineteenth clamp-burning, an issue revisited below.

[27] Bishop and Munro, "Further Comment on OS Mapping of Limekilns in Scotland."
[28] Lining can be difficult to determine from physical inspection. Since after firing, these dug embayments will end up with a vitrified lining and it may not be clear whether they were intentionally lined or not (e.g., an embayment purposely lined with packed clay can end up superficially looking like it is stone lined, remembering also that lining stones will end up being vitrified).

Figure 20 Disused lime kilns at Greenknowes in Fife (NT109932, Perth and Kinross, Sheet 30). Left: six clamp kiln symbols on the map (two are obscured by the quarry shading). Right: the same view from Bing aerial photography showing clear clamp kiln shaped depressions on the ground. Note that the more degraded kiln on the left is faithfully represented, whereas the relative size of the other clamps appears quite different between the photograph and the map.

Rectangular symbols (symbol group C) present the greatest ambiguity in the dataset. Individual rectangles have been found to represent single clamp kilns (for example among the kilns depicted at Cults and Pitlessie Lime Works) as well as stone-built upright kilns (such as at Loch an Eilean, near Aviemore). As with circular symbols, rectangles vary in size, from almost square to elongated rectangles. Where these symbols are connected in long stacks, this is understood to more reliably represent banks of clamp kilns, for instance at Haugh Lime Works in Renfrewshire.[29] The symbol itself might be considered an abstraction from the physical form of the kilns, whether clamp or draw. Functionally, clamp kilns are usually open at one end (sometimes both) to allow burned lime to be drawn out, and this is clearly represented in the other clamp symbols discussed above. Rectangular clamps may represent a variation on the clamp design, perhaps signalling built-up sides, although testing this interpretation would require further field investigations.[30] Without annotation, the symbol can be further confused with other unroofed structures and small enclosures. For example, at Ardonald Lime Works, near Huntly, archival records suggest that a clamp kiln was operated along with two draw kilns.[31] Although none of these kilns is labelled individually on the site, the two draw kilns are clearly identifiable by their symbols (circles within square enclosures), whereas several

[29] Nisbet, "The Archaeology of the Lime Industry in Renfrewshire."
[30] Clamp kiln variations are discussed further in Chapter Five.
[31] A clamp kiln is mentioned in John Menzie's state and accounts 1803 (NRS GD44/51/535/2). The joint operation of clamps and draw kilns is examined in Chapter Five.

unroofed structures could potentially indicate the clamp kiln. Field work at the site revealed the clamp kiln (see Figure 50, p.174) at the south end of the site, where it was represented by a rectangular symbol. Bishop and Thomson noted another example of a kiln shown using an open-ended rectangle in the first edition of the six-inch map, that was then replaced with a closed rectangle symbol in the second edition.[32] On the ground the structure is an open-ended U-shaped clamp kiln.

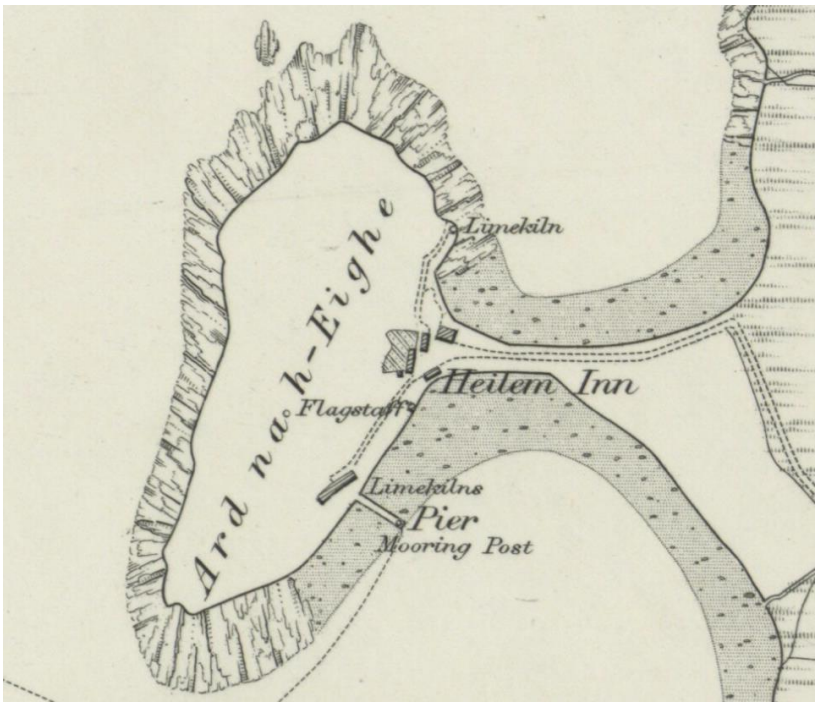

Figure 21 Roofed-building symbol used for Ard Neakie kilns, Loch Eriboll, Sutherland (MAP REF). Not the different symbols used for the bank of draw kilns to the south, next to the pier, and the much smaller kiln to the north.

Less frequently, the OS employed their standard roofed-building symbol, a shaded polygon with line weighting used to suggest a north-western light source (symbol group H).[33] Use of this symbol seems to have been reserved for large banks of masonry-built draw kilns, an example of which can be seen at Ard Neakie, in Sutherland (Figure 21).[34] With the exception of one example (Figure 22), no indication is given of flare or draw holes. Consequently, this approach relies almost entirely on annotation to indicate the presence of lime kilns.

[32] Bishop and Thomson, "How OS Depicted Limekilns in Scotland's Central Belt," 26.
[33] Although a common OS style, this shading remains odd since in the northern hemisphere the sun would never be shining from the north-west. Oliver, *Ordnance Survey Maps: A Concise Guide for Historians*.
[34] Bishop reports a pictorial example of a clamp kiln symbol on the 25-inch First Edition, complete with hill shading: see "Over-Cooking Lime Kilns?"

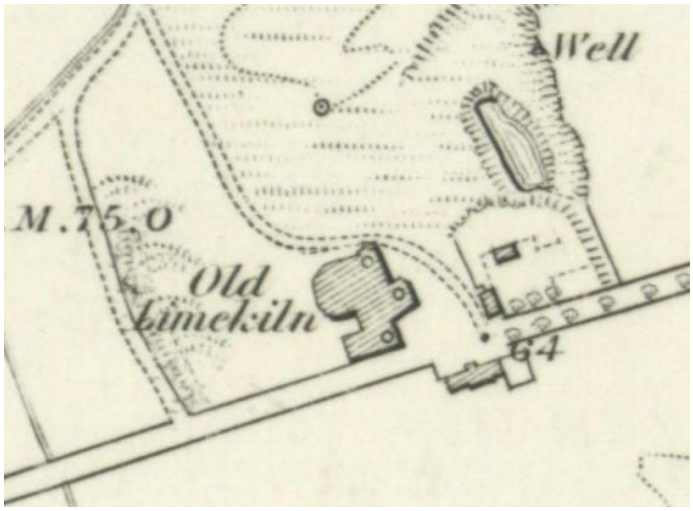

Figure 22 Roofed building symbol with three obvious draw holes. No trace remains of what appears to have been a substantial bank of draw kilns. Forfarshire Sheet 28, published 1865.

Another rarely used symbol was circular and included radial lines (symbol group G). The interior circle could be solid or dashed (see dashed example in Figure 23). Only a few examples exist of these symbols, and scant remains survive of the kilns from which to determine their structure. They may represent some form of simple field kiln, or even a pye kiln, but this is largely a matter of speculation.

Figure 23 Symbol group G. Old lime kiln and limestone quarry near Auchmannoch House in East Ayrshire (Ayrshire, Sheet 24, Published 1860).

Several unique symbols appear within the map series which cannot reasonably be considered to belong to one of the devised symbol classifications. Unique symbolisation, however, does not appear to imply unique kiln design. In cases that could be verified, these symbols tend to closely resemble the physical structure of the kiln itself in a planimetric or pictographic style. For instance, in the case of an unshaded, T-shaped polygon found near Loch an Eilean, the layout and orientation of the symbol was suggestive of the ‘wings’ of the kiln and the loading ramp to its rear (see Figure 54, p.183).

Unique symbols were not reserved only for elaborate draw kilns. A notable example of this can be seen at Whitfield, in Peeblesshire, where an array of elongated, shaded rectangles arranged parallel to one another are mapped (Figure 24, right). Following site visits and inspection of aerial photography, these were understood to represent raised divisions between open ended clamps.[35] Other symbols remained enigmatic. At Bogie Lime Works, in Kirkcaldy, seven rectangular symbols, with dots on their southern edges present something of a mystery (Figure 24, left). The positioning of the dots within the shape resembles the generic symbol discussed above, yet the layout of the symbols, their number and shape, are unusual for draw kilns. This site has since been redeveloped as a housing estate, meaning that, barring some clear indication from historical sources, determining the nature of the kilns is all but impossible.

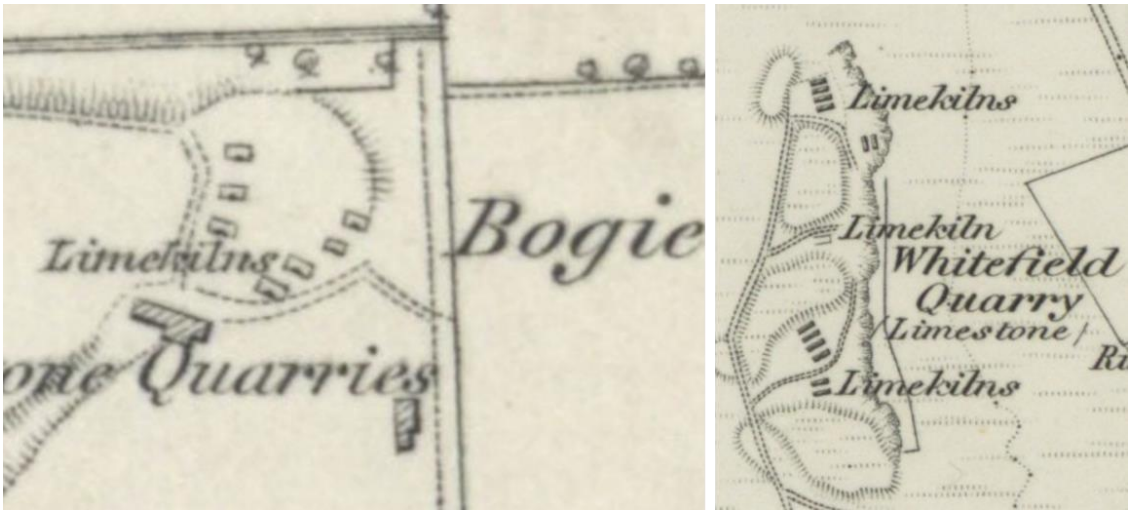

Figure 24 Unique map symbols. Left: Bogie Lime Works, Kirkcaldy, (NT263935, Fife, Sheet 32, published 1856). Right: Whitfield Quarry, Peeblesshire (NT171579, Peebles-shire, Sheet 5, published 1858). Note the use of a single open-ended rectangular clamp symbol in the middle of the complex along with the distinctive ridge symbols to the north and south. The map symbols closely conform to the remains on the ground.

3.2.3 Completeness and accuracy

The OS first edition six-inch maps cannot be considered a complete record of lime kiln sites.[36] Comparison with older historical sources indicate that many kilns have been lost entirely. For example, in Birse, Aberdeenshire, the *OSA* of 1794 states quite precisely that there were '3 large lime

[35] Mitchell and Bishop, "Limekilns – Still a Burning Issue."
[36] The map record is further complicated by the fact that a small number of the kilns identified by the OS may prove to be corn kilns rather than lime kilns, see *But the Walls Remained*, 44–45.

kilns and quarries in the parish' along with '32 small lime kilns'.[37] By 1866, when the OS surveyors had passed through the area, only 13 kilns were recorded, two of which were considered in use. No kilns were recorded by the OS in the parish of Rothiemay, Banffshire, yet the minister in 1797 remarked that there were 'about 50 lime-kilns in the parish'.[38] Similarly, in 1811, when compiling his County Survey of the Hebrides, James Macdonald declared that he 'counted 88 kilns . . . in one day's walk' on Campbell of Shawfield's estate on Islay.[39] The total number of kilns eventually recorded by the OS on the whole of Islay was just 29. One final example comes from Tomintoul, in Moray, where an estate plan from 1837 shows eight circular lime kilns at the north end of the village, while the OS map of 1872 shows one (Figure 25). It is perhaps unsurprising that kilns dating from prior to the first edition survey were not included on the map. Often, after kilns had ceased to be useful, their stones were recycled to be used in new buildings, dykes or field drainage.[40] Indeed a substantial proportion of mapped kilns have since been lost.[41] In many cases the only evidence of the presence of kilns are piles of stones, kiln waste or depressions left in the ground. Such faint remains, were they to exist during the nineteenth century, are unlikely to have interested the surveyors. The loss of kilns, both before and after the survey, does indicate, however, that many early kilns were to some extent ephemeral in nature.

[37] *OSA*, Parish of Birse, vol 9, p.117-18
[38] *OSA*, Parish of Rothiemay, p.389
[39] James Macdonald, *General View of the Agriculture of the Hebrides or Western Isles of Scotland*, (1811): 34
[40] Cruickshank, Nisbet, and Greig, *The Limekilns of Upper Donside: A Forgotten Heritage*, 33. The use of kiln material in dykes may represent a double effect of liming on the process of enclosure—not only did lime bring areas of outfield into cultivation, the stones from the kilns that burned could then used to physically enclose the land.
[41] Comparisons between remains on the ground (from aerial photography) and symbols on the map were not made for all kilns during the digitising process, so an exact removal rate cannot be calculated. The nature of removal also differs between kilns—some are lost without trace, having been replaced by new buildings or roads, while others have only seriously overgrown and may potentially be recovered with dedicated excavation.

Figure 25 Comparison between estate map and OS First Edition. Right: Group of eight lime kilns at the north end of the village of Tomintoul in Moray, from a plan of Strathavon, surveyed by George McWilliam, 1839 (NRS, RHP1807). The same plan shows a further four kilns immediately to the south of the village. Left: The corresponding OS sheet, Banffshire Sheet XL, surveyed 1869 and published 1872, shows only a single kiln symbol at each end of the village.

Clamp kilns appear to be least complete in their representation by the OS. Several surveys of lime burning sites have revealed sizeable discrepancies between the kilns mapped by the OS and remains found on the ground. Following a survey of Upper Bannock Burn, Mackay recorded 45 clamp kilns, none of which was included in the six-inch first edition sheet of 1860.[42] Two more clamp kilns, to the south-east of nearby Craigend Limeworks, were also omitted by the Survey.[43] Tam Ward conducted a survey of limestone quarries and associated kilns near the village of Braehead in South Lanarkshire.[44] Ward noted significantly greater numbers of clamp kiln remains on the ground than were recorded in the OS First Edition mapping. For example, at the site to the south of the village, the OS depicts eight clamp kilns, yet Ward found 24. Some sites were more comparable—the site to the west of the village comprised eleven kilns on the OS map while fourteen were found by Ward—however, others appear to have been entirely overlooked by the OS, such as Blasé Wood, where the remains of 25 separate kilns were found, none of which were mapped. Many of these clamp kilns were large, some measuring up to 8m by 3m. Although some kilns were positioned on their own, most formed rows or close groups of up to eight, indicating some degree of continuous output. Bishop

[42] Mackay, "Limestone Working: A Forgotten Stirlingshire Industry," 85, 90.; Mackay pers. comm.
[43] These kilns are visible from Bing aerial photography. The use of aerial imagery to assess lime burning sites is discussed in more detail Chapter Two, p.57.
[44] Ward, "Braehead Village Survey Report."

et al's survey of clamp kilns in Campsie and Baldernock similarly found more than double the number of clamp kilns on the ground than were recorded by the OS.[45]

The omission of clamp kilns in each case presumably has one of three explanations: that the OS overlooked the kilns when surveying the area; that the OS consciously omitted kilns or reduced their number; or, that the kilns were constructed in the latter half of the nineteenth century, after the survey had been completed. The first of these explanations is unproblematic and reasonably likely given the subtlety of clamp kiln structures, and this issue should be borne in mind when considering the accuracy of the lime kiln database drawn from this map series. However, this explanation does not account for why the OS mapped some kilns and omitted immediately adjacent neighbouring ones that are just as subdued. The second explanation is harder to test, but may have been the case in areas where large numbers of kilns existed, especially if other kilns were more physically prominent (an approach that could equally apply to other forms of kilns).[46] Map symbols in these situations may then have served as representative of the kind of lime burning in the area rather than remaining faithful to the exact layout of the site, acting as a kind of generalisation of complex features.[47] In the latter case, this would suggest that supposedly simpler burning methods continued to be employed at a time when traditional portrayals of the industry suggest large industrialised draw kilns were the dominant form of production.

Even some draw kilns were overlooked. The large draw kiln at Craighall, which was reportedly built of stones from the ruins of Craighall Castle in 1814, is not labelled as a lime kiln, nor is its depiction on the map representative of its distinctive form (see Figure 26).[48] Although the kiln ceased to operate in 1837, it remains an imposing structure, making it surprising that the OS did not note its former function. It is ultimately a difficult exercise to estimate with any confidence the proportion of kilns existing in the nineteenth century that were omitted by the OS. To investigate these issues further,

[45] Bishop *et al.*, "Lime Burning in Clamp Kilns in Scotland's Western Central Belt: Primitive Industry or Simple But Perfectly Adequate Technology?," 4.
[46] See Bishop *et al.*, "Lime Burning in Clamp Kilns in Scotland's Western Central Belt: Primitive Industry or Simple But Perfectly Adequate Technology?"
[47] This issue highlights the opacity of OS surveying practices and the representation of kilns, as indeed other features, may have been at the discretion of the individual surveyors or engravers.
[48] James Allen, *Geograph*, NO4010: Craighall limekilns, https://www.geograph.org.uk/photo/2892525. I am indebted to Eddie Cole for alerting me to the existence of this kiln.

sites will require accurate dating to determine when kilns were constructed or altered relative to when the surveyors passed through. It is harder still to speculate how many kilns there might have been when the lime industry was at its peak, bearing in mind the much greater number of kilns that are mentioned in historical sources. Future archaeological investigations will likely continue to reveal kilns dating from the eighteenth century and earlier.[49]

Figure 26 Craighhall lime kiln. Left: Craighall Castle on the OS map (NO406106, Fife, Sheet 18, published 1855). The kiln is located in the white space below the word 'Ruins'. Right: remains of Craighall lime kiln today. Source: James Allen, *Geograph*.

This section has established the link between cartographic form and kiln structure. Based on the valuable information gained from this relationship, it is possible to examine the regional and spatial patterns of the lime industry. The next section deals with the results of this investigation. Firstly, a regional overview of kilns found on the maps is conducted, followed by analysis and visualisation of the data.

3.3 The data

A total of 2,909 kilns were mapped in the course of this research, spread across 2,185 sites. Of all the kilns mapped by the OS, 75% were considered to be in use at the time of survey. A breakdown of kilns by type, based on map symbols, is shown in Table 3. Over half the kilns digitised were considered to be field kilns—earthen or stone built kilns intended for intermittent production. More

[49] The last firing of a kiln recently excavated by Bishop at Bannockburn has been dated to be 1656AD.

than three times as many clamp kilns as draw kilns were recorded, calling into question the emphasis placed on the latter in studies of the lime industry to date. Almost fifty kilns either did not fit any of the established symbol patterns or were indistinguishable from other features on the map.

Table 3 Total kilns by type and status at time of survey.

Kiln Type	Not In Use	In Use	Total	
Clamp	336	659	995	(34.2%)
Draw	60	251	311	(10.7)
Field	308	1247	1555	(53.5)
Other / Unknown	31	17	48	(1.6)
Total	733	2174	2909	

Figure 27 provides an overview of the distribution of lime burning sites across Scotland. Although representing so many points on a small map presents a somewhat chaotic picture, the overall impression is clear: lime burning was a widespread practice, occurring to some extent everywhere that people lived and farmed. Lime kilns are distributed widely across the Central Belt and in particular concentrations in upland parts of the central and eastern Highlands. What follows is regional overview of the lime industry as depicted in the OS first edition six-inch maps.[50]

[50] Information on limestone resources comes from BGS data and T. Robertson, J B Simpson, and J G C Anderson, *The Limestones of Scotland* (Edinburgh: HMSO, 1976).

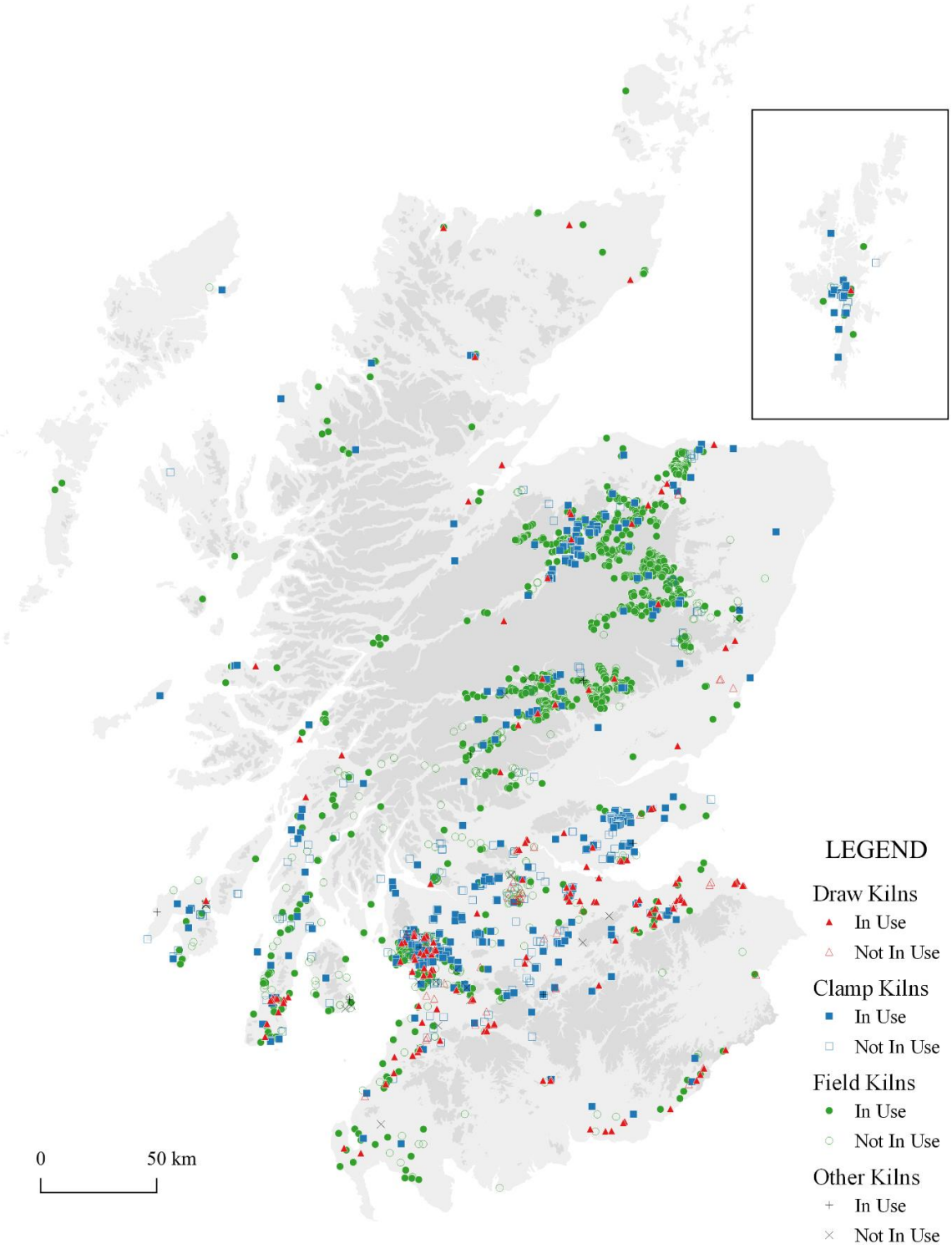

Figure 27 Overview of all lime burning sites on OS First Edition 6-inch mapping. Points indicate kiln classification and whether the site was in use at the time of the survey. Displaying so many points at small scale—whilst also attempting to convey some qualitative information about them—introduces obvious challenges for legibility and clarity. Apologies to Shetland for putting it in a box.

3.3.1 The Borders

Table 4 OS First Edition kilns in the Borders.

		Clamp		Draw		Field		Other		
Historic County	**Surveyed**	**I**[51]	**A**	**I**	**A**	**I**	**A**	**I**	**A**	**Total**
Berwickshire	1858-1858					2				2
Dumfriesshire	1856-1858	1	5		21	5	1	1		34
Kirkcudbrightshire	1849-1850					2				2
Roxburghshire	1858-1859		3	3	6	2	8			22
Selkirkshire	1858-1858					1				1
Wigtownshire	1846-1848		2		2	6	16	1		27

Few lime kilns were found in the most southerly counties in Scotland. However, despite there being no limestone in Wigtownshire, nearly thirty kilns, including two active draw kilns, were recorded in the region by the OS in 1858. Limestone was likely brought from Cumberland, or else Ayrshire or Nithsdale.[52] In contrast, in neighbouring Kirkudbrightshire, where limestone is similarly absent, only two kilns are recorded, both of which were abandoned field kilns. Large quantities of lime were known to be used in Dumfriesshire in 1794 and, by mid-nineteenth century, the county appears to have been largely supplied from a few important lime works.[53] The largest of these sites, Closeburn and Park lime works, are located on the middle reaches of the River Nith, utilising the Carboniferous Closeburn limestone formation. Further south, several lime works can be found following the Yoredale group that runs from north of Annan in the west to south of Langholm to the east. In Roxburghshire, several draw kilns, including Larriston lime works, can be found to the south, near Liddesdale, following a series of limestone outcrops that are an extension of those from Dumfriesshire. Lime depots marked at Kelso and Sprouston railway stations indicate the flow of lime by rail from over the border. To the north, in Selkirkshire, only one small kiln is shown, out of use by 1858. No calcareous resources are located in the county, and Johnston's account from 1794 laments the 'great distance from the lime makes it little to be used as a manure'.[54] On the east coast, in Berwickshire, the only kilns are two located near Greenlaws in the centre of the county. Lime was

[51] I = Inactive, A = Active. The same abbreviation is used on all subsequent tables in this chapter.
[52] Bryce Johnston, *General View of the Agriculture of the County of Dumfries*, (1794), 23
[53] *Ibid.*
[54] Johnston, *General View Selkirk*, 22.

mostly brought from Berwick harbour and from Northumberland, or from Mid or East Lothian at the end of the eighteenth century.[55] Calcareous marl was also known to be widely used in Berwickshire until the late-eighteenth century.[56]Although some limestone exists on the coast a few miles south of Eyemouth, by 1808 attempts to burn limestone in inland parts of Berwickshire were stymied by a lack of local coal and quickly abandoned.[57] Given the lack of local burning, lime was closely associated with the extension of new roads—an aspect of the industry discussed in more depth in the next chapter.

3.3.2 Central Scotland

Table 5 OS First Edition kilns in Central Scotland.

		Clamp		Draw		Field		Other		
Historic County	**Surveyed**	**I**	**A**	**I**	**A**	**I**	**A**	**I**	**A**	**Total**
Ayrshire	1855-1857	61	70	14	60	58	134	9	3	409
Dunbartonshire	1859-1861	22	2	4	5	23	6			62
Edinburghshire (Mid-Lothian)	1852-1877	5	9	2	23	2	23	1		65
Haddingtonshire (East Lothian)	1853-1853		3	4	21		7	1		36
Lanarkshire	1858-1859	40	98	14	4	21	18	2	1	198
Linlithgowshire (West Lothian)	1854-1855	12	7		13	8	3		1	44
Peebles-shire	1856-1859	6	16		3	2				27
Renfrewshire	1857-1859	16	42				3			61
Stirlingshire	1859-1863	85	36	5	12	15	11	2		166

Central Scotland accounts for most of the lime production of the eighteenth and nineteenth centuries. Ayrshire contains large and widely distributed limestone resources and more lime kilns were found in Ayrshire than in any other part of Scotland. Kilns of virtually all kinds are recorded, represented on the map by a great diversity of symbols. Indeed, Ayrshire alone disproves any notion that kiln symbology was regionally or temporally specific. In terms of distribution, the greatest concentration of kilns can be found in the north, near the towns of Stevenson, Kilwinning, Dalry and Stewarton. Ten lime works, along with hundreds of individual farm kilns, are in this area, close to numerous

[55] Alexander Lowe, *General View of the Agriculture of the County of Berwick*, (1794), 34
[56] Dodgshon, "Land Improvement in Scottish Farming: Marl and Lime in Roxburghshire and Berwickshire in the Eighteenth Century."
[57] Kerr, *General View Berwick*, 38.

outcrops associated with the Upper and Lower Limestone Formations. The sheer number and variety of kilns and limestone resources make the county difficult to summarise.

Lime kilns are similarly numerous in parts of Lanarkshire, though they are more tightly clustered around sources of limestone. In the north, a group of mostly abandoned kilns associated with farms, can be found between Cumbernauld and Airdrie. Slightly further south, several clamp kilns are recorded to the east and south of East Kilbride, where they follow the Top Hosie Limestone (part of the Lower Limestone Formation) and Blackbyre Limestone (part of the Strathclyde Group). In the upland areas to the south, kilns can be found on three isolated limestone outcrops, including the Whitecleuch and Wildshaw lime works, both of which employed clamp kilns. Kilns were less widespread in Renfrewshire, with lime working largely restricted to six lime works employing large clamp kilns, as documented by Nisbet.[58] In Dumbartonshire, a string of disused field kilns are found following a source of dolostone, part of the Ballagan Formation, at Murroch Glen, north of Dumbarton.[59] Longfaulds Coal & Lime Works, abandoned by the time of the survey, was comprised of thirteen clamp kilns and is located in what is now Bearsden. In Western Dumbartonshire (an enclave that is separated from the rest of the county) there are several disused field and draw kilns, while Castlecary Lime Works sits on the Castlecary Limestone, part of the Upper Limestone Formation, northwest of Cumbernauld. North of Dumbartonshire, in Stirlingshire, there were extensive lime workings, both active and inactive, mostly concentrated in a few sites. Parts of Baldernock and Campsie, between Milngavie and Kilsyth, hosted many clamp kilns, some active, some inactive.[60] These exploited the Blackhall and Hurlet Limestones. Two lime works employing banks of draw kilns, Murrayshall and Craigend, are to the east of Stirling.[61]

[58] Nisbet, "The Archaeology of the Lime Industry in Renfrewshire."
[59] Based on their circular symbols, these kilns were classified during digitisation as field kilns. Results of a survey of Murroch Glen in 2012 by Geograph user Lairich Rig suggest, however, that these may have been old pye kilns, often characterised as an antecedent to the clamp kiln. See http://www.geograph.org.uk/article/West-Dunbartonshire-Limestone-Industry-Network
[60] Bishop and Thomson, "How OS Depicted Limekilns in Scotland's Central Belt"; Bishop and Munro, "Further Comment on OS Mapping of Limekilns in Scotland"; Bishop *et al.*, "Lime Burning in Clamp Kilns in Scotland's Western Central Belt: Primitive Industry or Simple But Perfectly Adequate Technology?"
[61] See Mackay, "Limestone Working: A Forgotten Stirlingshire Industry."

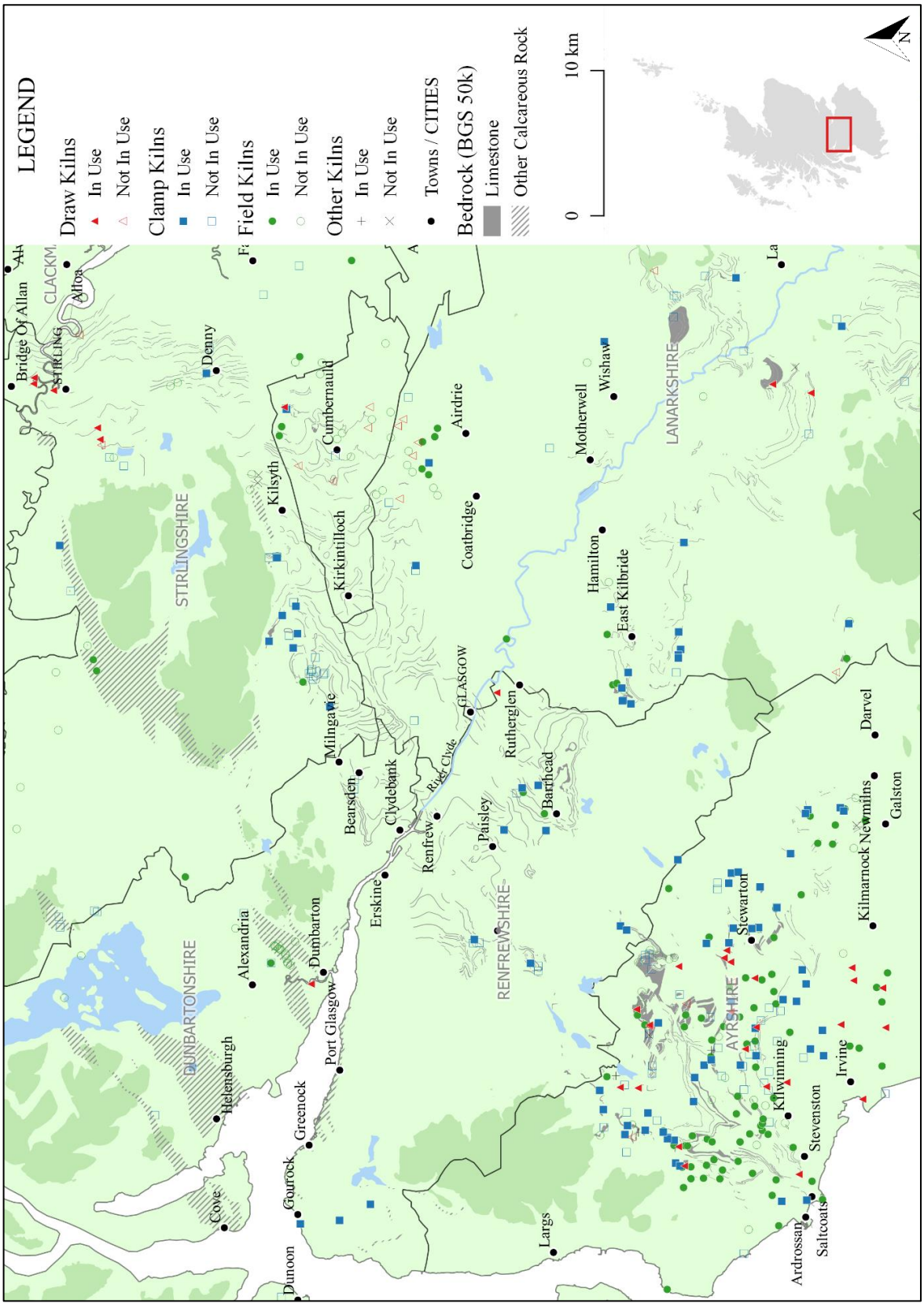

Figure 28 West Central Scotland, showing kilns and limestone resources

The Lothians (Figure 29) are dominated by several medium-size lime works, accounting for the relatively low number of kilns overall and the higher proportion of draw kilns across these counties.

The lime kilns in West Lothian (Linlithgowshire) are mostly associated with the Petershill and Blackhall limestone outcrops that form part of the Upper and Lower Limestone Formations running north-south through the middle of the county. Several large lime works are located here between Bathgate and Linlithgow. Only a handful of other kilns are located elsewhere in the county, such as the Dundas Lime Works on south shore of the Forth by an outcrop of Burdiehouse limestone. Midlothian (Edinburgh-shire) is similarly dominated by a few large lime works rather than small kilns. Most of these can be found to the south-east of the city following two concentric bands of, first, Burdiehouse limestone (near Loanhead) and then the Hurlet and Blackhall limestones. To the east, near Livingston, is Murieston Lime Works atop the Burdiehouse limestone. Lime burning in East Lothian (Haddingtonshire) is concentrated in two main clusters; one to the east which is a continuation of the Hurlet and Blackhall limestones from Midlothian, and another in the west around Dunbar. The kilns are almost exclusively draw kilns. South of the Lothians, in Peebleshire, lime burning is primarily concentrated in the north, notably at Whitfield quarry where a large bank of clamp kilns remained in use at the time of survey.[62]

[62] These kilns are represented by a unique set of symbols, discussed above.

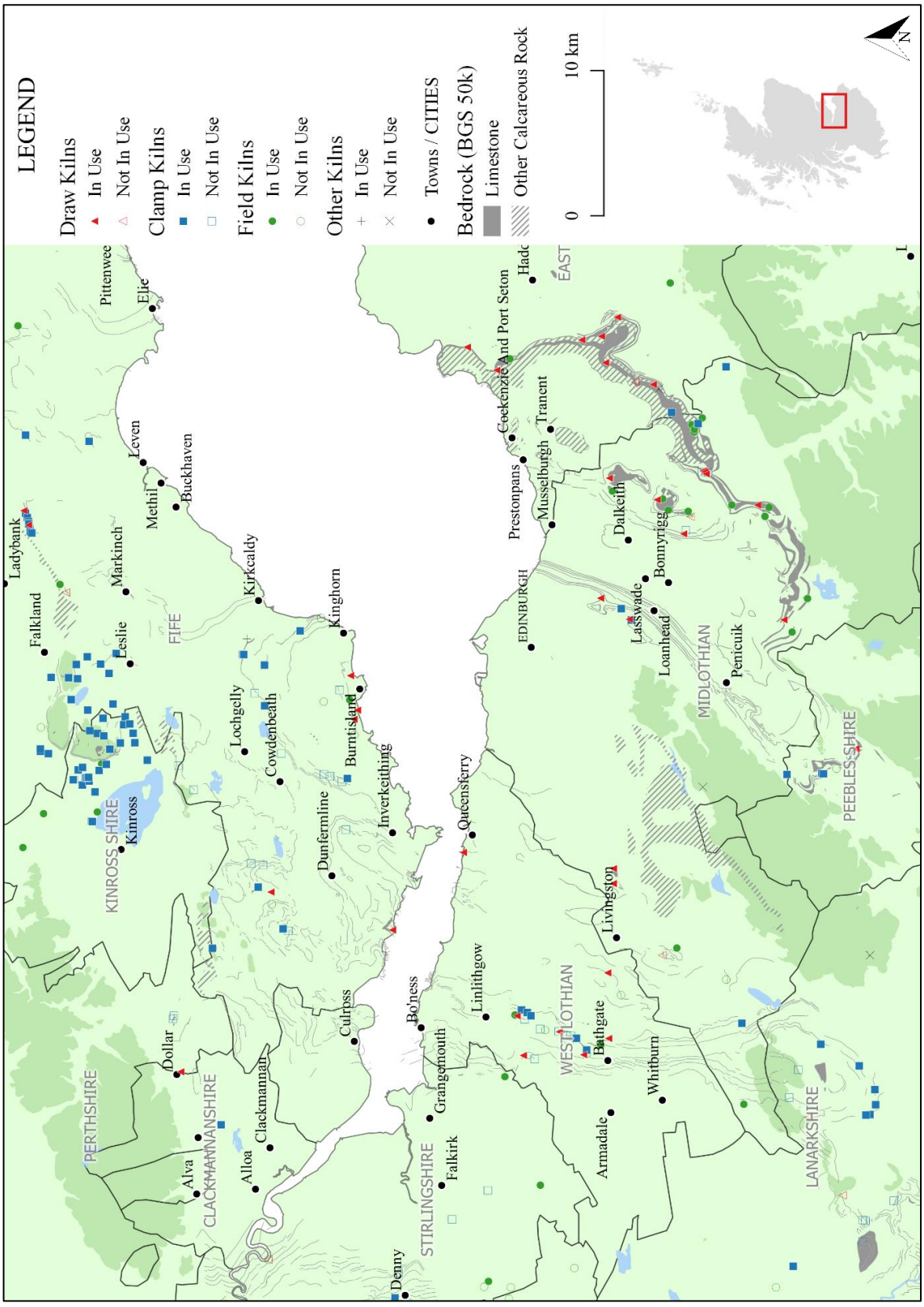

Figure 29 East Central Scotland, showing kilns and limestone resources. The county of Clackmannanshire was surveyed by the OS as part of the 'unified' Perth and Clackmannan region.

3.3.3 North-east

Table 6 OS First Edition kilns in the North-east.

		Clamp		Draw		Field		Other		
Historic County	**Surveyed**	**I**	**A**	**I**	**A**	**I**	**A**	**I**	**A**	**Total**
Aberdeenshire	1865-1871	4	11	2	1	19	187			224
Banffshire	1866-1871	5	22		12	9	164	1		213
Elginshire (Moray)	1868-1871		24		3		60			87
Fife and Kinross Shires	1853-1855	31	179	1	18	8	26		7	270
Forfarshire (Angus)	1858-1864	2	4	5	2	19	58			90
Kincardineshire	1862-1865		2		2	2	2	2		10

In north-eastern Scotland, running from Fife and Kinross on the north shores of the Forth to the Moray coastline east of the Cairngorm massif, several distinct patterns of kiln distribution can be observed. Fife is one of the most famous lime producing regions in Scotland, owing largely to the Charlestown lime works and associated settlement on the shore of the Forth. Several other commercial producers employing draw kilns, are located along the coast, such as near Burntisland. The overwhelming majority of inland kilns are clamps, most which can be found in two main clusters (see Figure 29). The first consists of individual farm kilns spread across an area straddling Fife and Kinross, east of Loch Leven. The second is a dense chain of kilns belonging to the Pitlessie, Bunzion, and Cults lime works roughly ten kilometres to the east. Owing to this latter grouping, the parish of Cults contained the greatest concentration of lime kilns anywhere in Scotland. Further north, a clear division emerges between the large number of field kilns found in upland areas and the sparse draw kilns of the lowlands. In Forfarshire, a handful of disused draw kilns is to be found to the lowland areas of the south and east, near Monifeith, Brechin and Montrose. Most of the kilns in the county are in the west, where more than thirty are found along Glen Isla. A similar distribution of largely abandoned kilns is also found in the north-east of the county at Glen Esk. This pattern of field kilns following upland glens is repeated in other parts of the Highlands. In neighbouring Kincardinshire, small occurrences of metalimestone near Brechin account for all of the lime production in the county. In Aberdeenshire, the contrast between upland and lowland areas is particularly stark. There are almost no kilns in the county east of Aboyne (on the River Dee, 15km west of Ballater). In the east, along the upper reaches of the rivers Dee and Don, there are almost 200 active field kilns, along with a handful of clamp kilns (Figure 30). Most of these are associated with small farms. The counties of

Banffshire and Moray (Elginshire) have some of the heaviest concentrations of kilns anywhere in Scotland. Between the towns of Keith, Huntly and Dufftown are a series of lime works, including Ardonald, Drummuir, Blackhillock, and Douglasbrae, all employing banks of draw kilns. To the north and south of these in Banffshire are large numbers of small active field kilns. Similarly, in Moray, nearly 150 kilns—a mixture of clamp and field kilns—can be found following the Spey valley as far south as Boat of Garten.

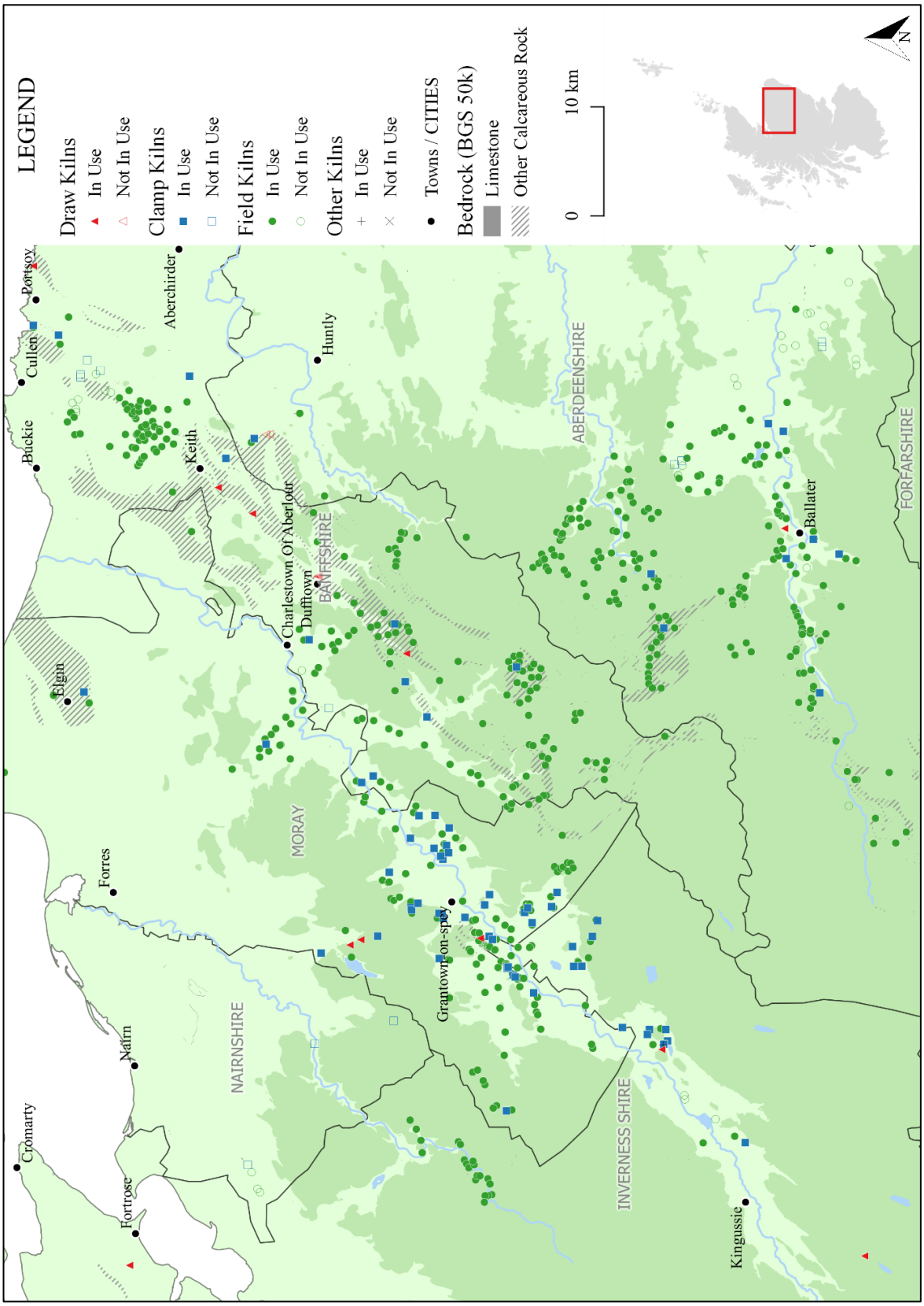

Figure 30 Spey Valley, Northeast Highlands and the Moray coast, showing kilns and limestone resources.

3.3.4 Highlands and Islands

Table 7 OS First Edition kilns in the Highlands and Islands.

		Clamp		Draw		Field		Other		
Historic County	**Surveyed**	**I**	**A**	**I**	**A**	**I**	**A**	**I**	**A**	**Total**
Argyllshire and Buteshire	1863-1878	26	32		23	45	75	8	2	211
Caithness	1871-1872				2		11			13
Inverness-shire (Mainland)	1869-1873		33		3	3	126		1	166
Nairn	1869-1871	3				3				6
Perthshire and Clackmannanshire	1859-1864	10	33		12	52	271	3	2	383
Ross and Cromarty Shires (Mainland)	1872-1875		3		1		13			17
Sutherland	1873-1874		2		7		5			14
Inverness-shire (Hebrides)	1878-1878						2			2
Inverness-shire (Isle of Skye)	1875-1877	3					2			5
Orkney Islands	1880-1880						1			1
Ross and Cromarty Shires (Isle of Lewis)	1849-1849		1			1				2
Shetland Islands	1877-1878	5	19		1	3	11			39

The Highlands and Islands cover a large and diverse geography. Most of the kilns in Argyll are found in Kintyre, following occurrences of metalimestone associated with the Loch Tay Limestone Formation. These are mostly small field and clamp kilns, aside from around Campbeltown, where there are several draw kilns as well as Askomill Lime Works. Sporadic field kilns are dotted around northern Argyll, particularly along the coast, such as at Swordle on the Ardnamurchan peninsula. Four banks of draw kilns can also be found on the island of Lismore, which is composed almost entirely of limestone. A little over a dozen kilns, most of which were abandoned by the time of the survey, are located around the shoreline of Arran. A single field kiln is located on the southern tip of Bute. Lime kilns are virtually absent in the Inner Hebrides, with the exception of Islay, on which nearly thirty (mostly clamp) kilns are located, making use of the metalimestones on the island that form part of the Keills and Storakaig Limestone groups.[63]

Like Argyll, Perthshire covers diverse terrain, from the fertile lowlands in the south to the mountains in the north. Almost four hundred kilns are located in the county, the majority being field kilns that follow rivers and mountain glens in the north. The areas of Kirkmichael, Pitlochry, Aberfeldy and

[63] For a comparison between historical accounts of lime burning on Islay and kilns recorded by the OS see p.12, above.

Bridge of Tilt contain particularly dense concentrations of small kilns, with some sparser kilns found around Loch Earn to the west of Creiff.

Lime kilns are less common in the more northerly parts of the Highlands. Although there are many field kilns in eastern parts of Inverness-shire along the upper reaches of the Spey and the Findhorn, the mountainous and sparsely populated western and central areas contain only a handful of kilns. There are only six kilns in Nairnshire to the north, none of which was in use at the time of the survey. Similarly, Ross and Cromarty contains only a few kilns associated with farm settlements to the west. In Sutherland, lime burning is mostly confined to two larger commercial works at Lairg, at the southern end of Loch Shin, and at Ard Neakie, Loch Eriboll on the north coast. Only a dozen kilns are located in Caithness, mostly belonging to a cluster of farms south of Wick.

In the Outer Hebrides, two kilns each are located on Lewis and Uist. Only one kiln is marked on Orkney. Nearly forty kilns are recorded on the Shetland Isles. Almost all of these kilns were located on Mainland, where they closely follow metalimestones associated with the Weisdale and Whitness Limestone groups, although single kilns can be found on each of the smaller islands of Hildasay, West Burra, East Burra, and Whalsay.

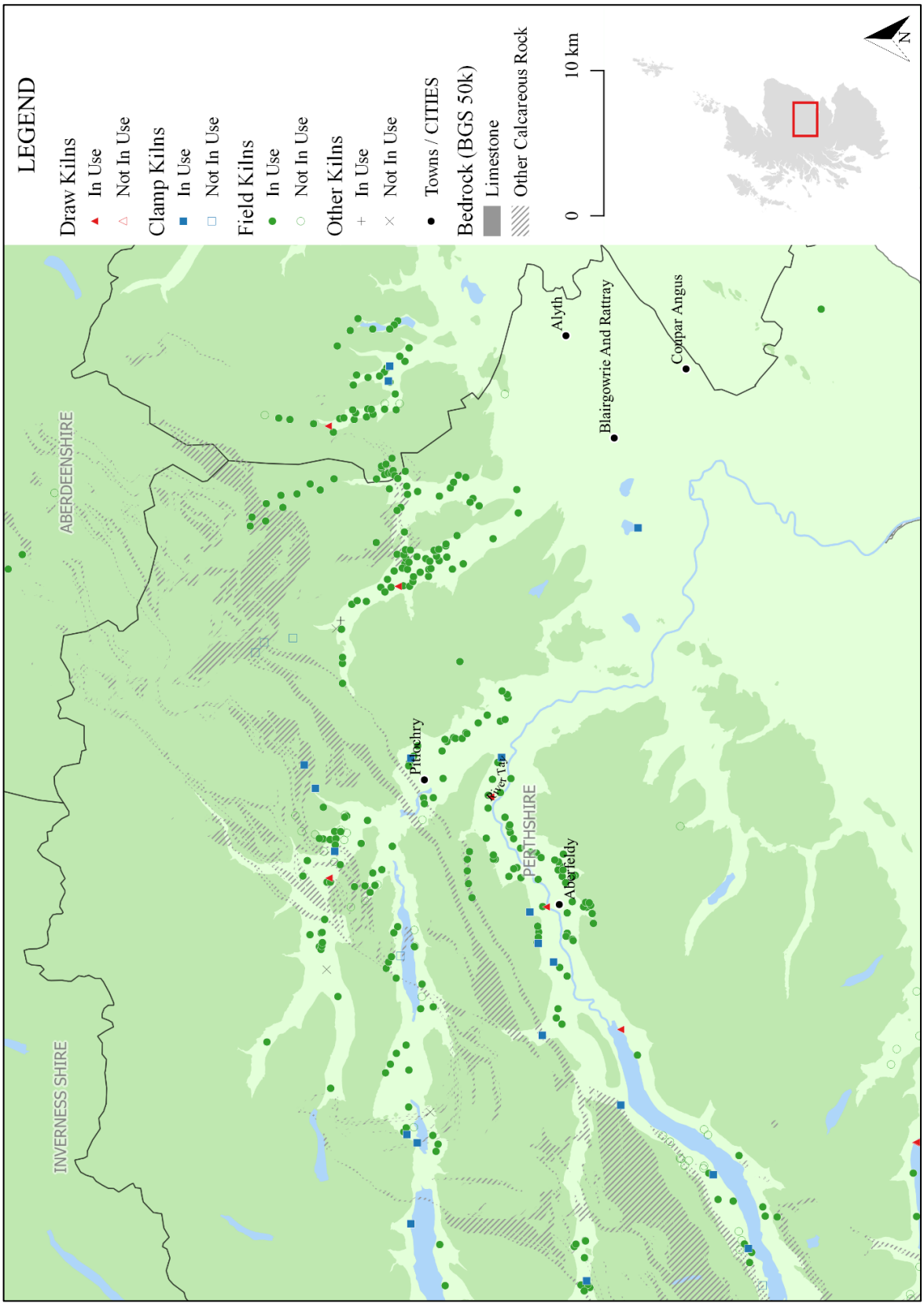

Figure 31 Central Highlands, showing kilns and limestone resources.

3.4 Visualisation and spatial analysis

As highlighted above (see Figure 27), visualising and analysing voluminous point data at small scales presents several challenges in terms of legibility and accuracy. To get around these problems, binning is a way of mapping large point-based datasets without interpolation by converting point data into a regular grid of polygons so that each polygon represents the aggregation of points that fall within it. To allow for experimentation with different granularities of visualisation, hexagonal grids of cell sizes in diameter 2,500m, 5,000m and 10,000m were creating using the MMQGIS grid tool.[64] Larger cells enable the data to be clearly represented at larger scales, while smaller cells allow for more granular results to be shown. The results (an example of which can be seen in Figure 32, below) provide an aesthetically pleasing and highly ordered way of visualising the data. Immediately apparent is that kilns are both widely distributed across Scotland and highly clustered in certain localities.

[64] MMQGIS is a set of Python plugins for manipulating vector maps in QGIS.

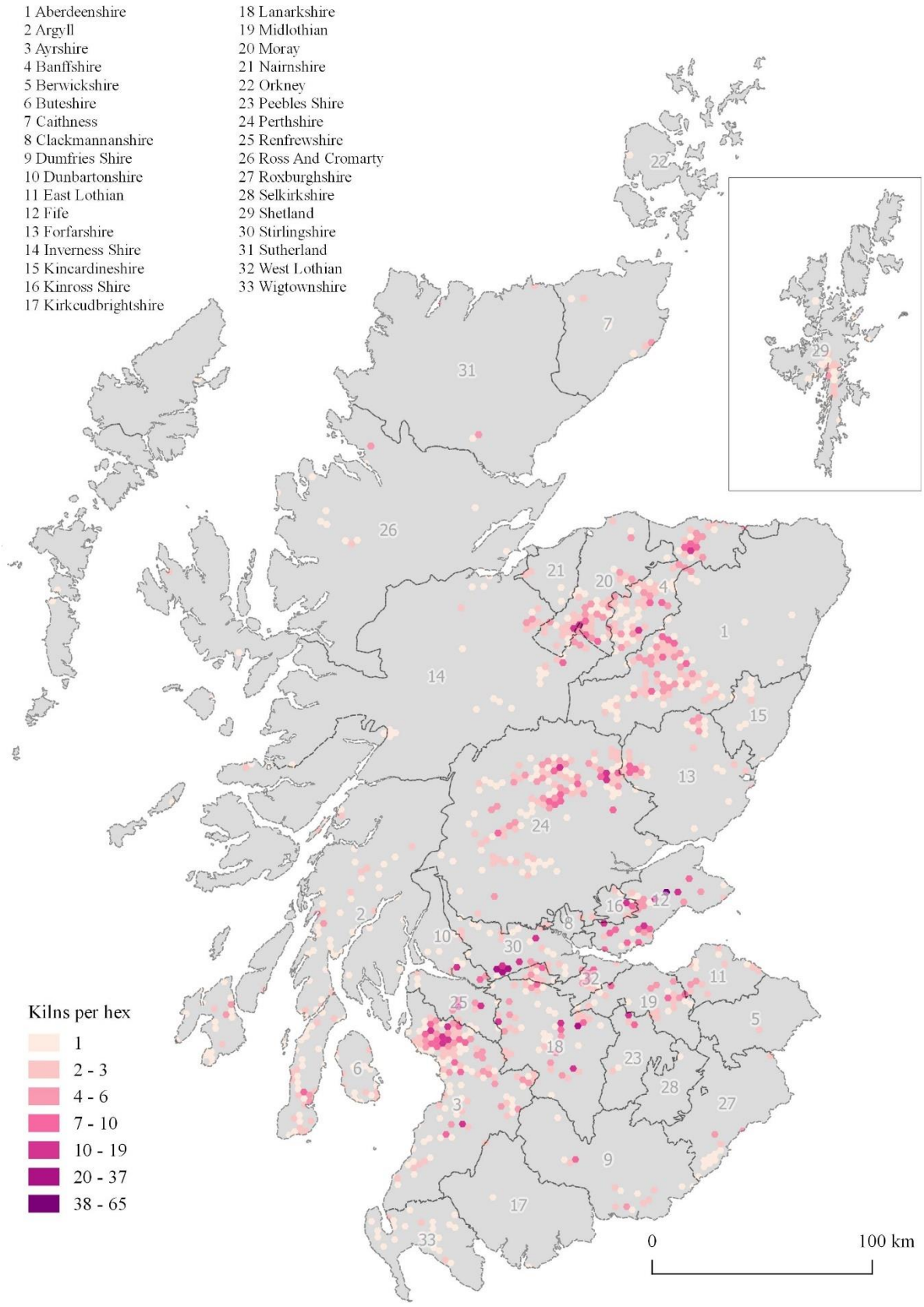

Figure 32 All kilns shown using a 2.5km hexagonal grid. Colour gradation illustrates the total number of kilns within each hex, with bands selected using the Jenks natural breaks classification method.

Binning is also useful for representing other facets of the data. For example, the distribution of active kilns across Scotland (Figure 33). This mapping suggests that most of the small kilns found in the central and eastern Highlands were still in use during the mid-nineteenth century.

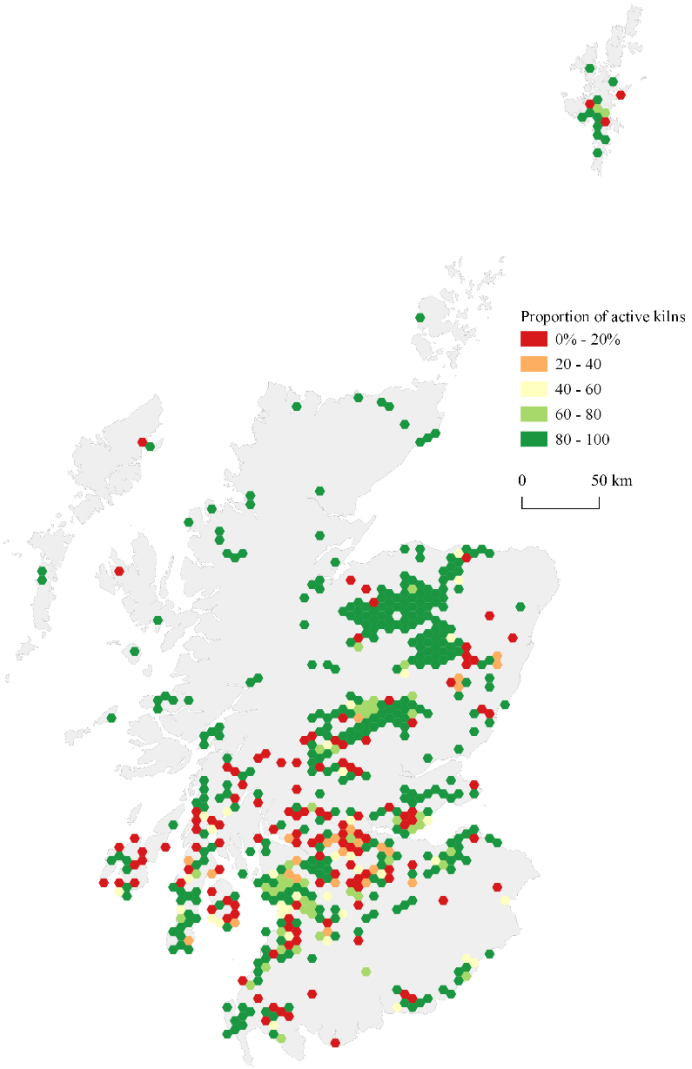

Figure 33 Proportion of kilns considered active at the time of survey, based on OS labelling. Shown using a 5km hex grid.

A high-level review of commercial sites was conducted using data from the maps (Figure 34). Commercial sites were determined based on the OS designation 'works' in the site label (discussed above) as well as unlabelled sites consisting of more than two kilns. This approach followed Johnson's survey of the Yorkshire Dales, where he concludes that sites with more than two kilns were 'without exception' associated with large-scale mid-to-late nineteenth century commercial

production.[65] Of all the points recorded from the maps, only 139 sites (6.4% of the total) were described as 'works' by OS. Of these, just 81 were named.[66] With the exception of a few producers along the Scottish border, and a small enclave of lime works in the north-east near Huntly, commercial lime production were primarily distributed throughout the Central Belt, where coal and limestone were most readily available and the population was greatest (see Figure 35).

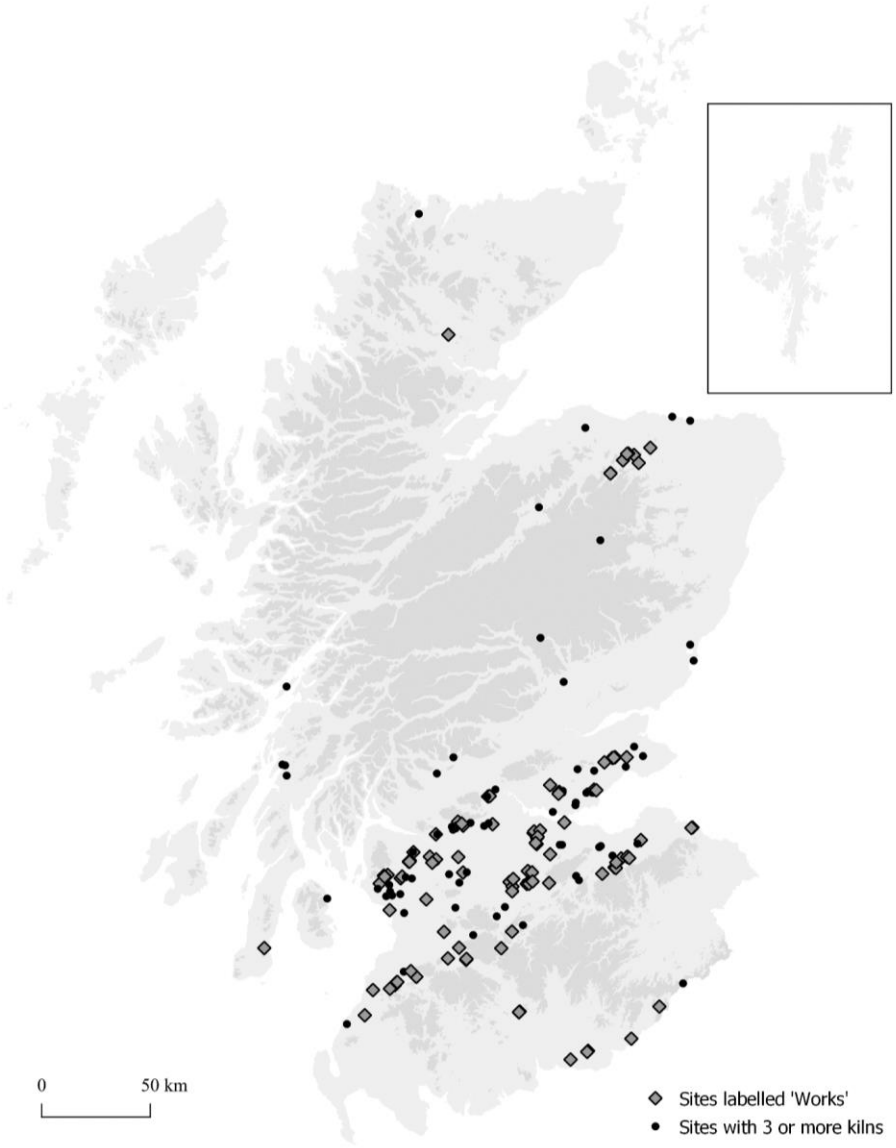

Figure 34 Distribution of commercial lime production.

[65] Johnson, "Lime Kilns in the Central Pennines: Results of a Field Survey in the Yorkshire Dales and Contiguous Areas of North and West Yorkshire," 255–56.

[66] Despite being the largest and arguably most famous lime producer in Scotland, Charlestown lime works was not named on the OS map nor was it labelled as a 'works' (see Figure 19). Nevertheless, the settlement named for its initial proprietor and the associated town of Limekilns remain a testament to the site's role in the Scottish lime industry.

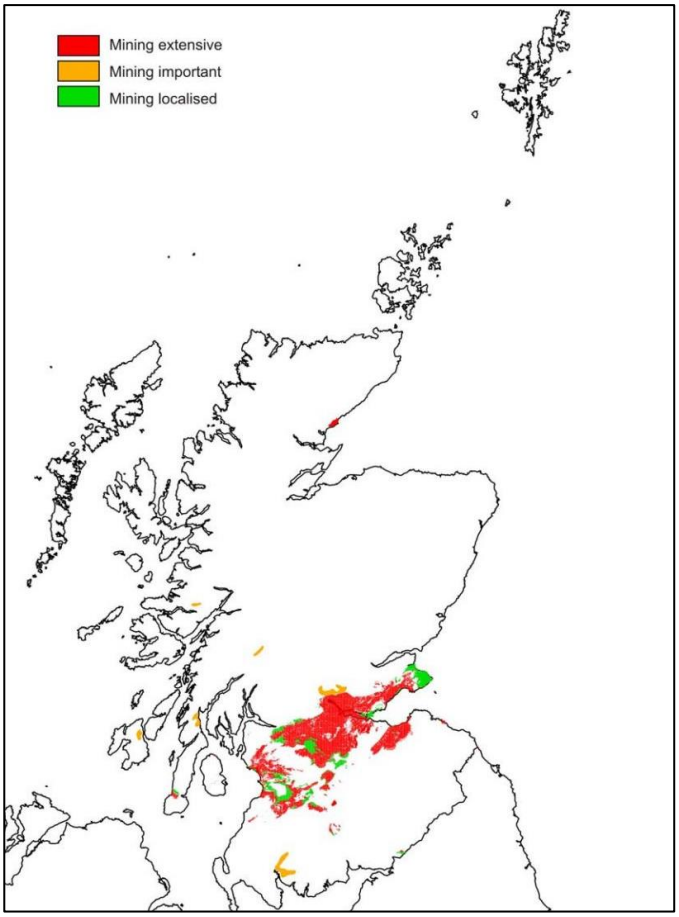

Figure 35 Extent of historic mining activities in Scotland, the vast majority of which was coal extraction. Source: BGS. [67]

To explore the spatial patterns of different kiln points across Scotland, it was necessary to move away from viewing point data, where high concentrations of points could mislead reading of the map. Heatmaps are a useful visualisation tool for dense point data, allowing clusters where there are high concentrations of certain features to be easily identified.[68] By altering the radius (the distance to which a point will have an influence) and weighting (to give greater influence to points of a higher given value), the threshold for clusters, and thus the appearance of the maps, can be influenced. Heatmaps were produced using the associated geoalgorithm in QGIS. A radius of 10km was set for each point to give an exaggerated representation of distribution and concentration. Points were left unweighted (rather than weighted by the number of kilns per point) to reflect the distribution of sites

[67] A M MacDonal *et al.*, "A GIS of the Extent of Historical Mining Activities in Scotland: Explanatory Notes," 2003.
[68] Gregory and Ell, *Historical GIS: Technologies, Methodologies and Scholarship*.

utilising each kiln type rather than the actual number of kilns. The advantage of this approach is that it disentangles point symbols (which tend to overlap or be rendered illegible) in maps at small scales (see Figure 32, above), giving a sense of the relative density of features in a given space. Exceptional examples (isolated single kilns) are rendered as transparent, with clusters appearing increasingly opaque with density.

The resultant heatmaps (Figure 36) allow for some high-level observations to be made. Field kilns are found over much of Scotland but appear in large clusters in the Highlands, as well as in northern Ayrshire. Clamp kilns are mostly associated with the Western Central Belt and Fife, with one notable cluster further north around Banffshire and Moray. Draw kilns are most numerous in the Central Belt, but appear in several tighter clusters in many parts of Scotland.

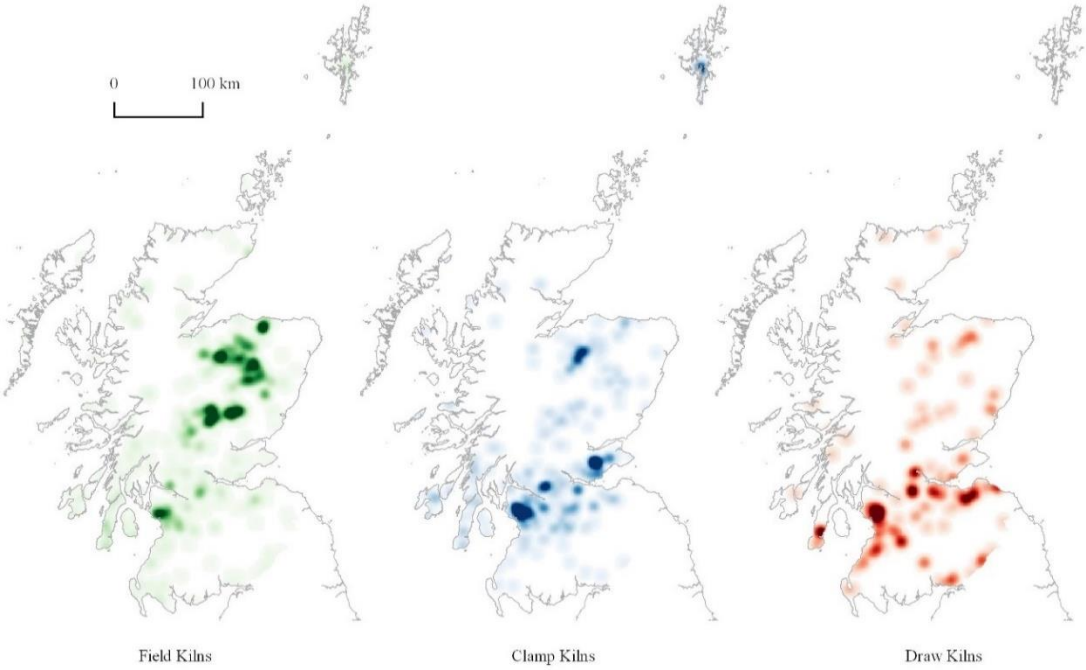

Figure 36 Heatmaps of kiln locations by type.

To further investigate the distribution of kiln types relative to each other, it was necessary to find a way of comparing spatial patterns without data becoming obscured. One way to achieve this was to convert the kiln point data to a raster surface for multispectral analysis.[69] This process involved first creating three rectangular grid layers of 2.5km^2 cells (similar to the binning technique described

[69] Raster surfaces are grids of rectangular pixels, each of which are assigned a value. In multiband rasters, each pixel can hold multiple values.

above) and, for each, counting the number of kilns of a particular type that fell within each cell. Once the cells in each of the grid layers had been assigned values, they were converted into three separate raster layers of the same resolution. Cell values in the raster layers corresponded to the number of kilns of each type. The raster layers were then combined into a single virtual raster using the GDAL Plugin. Each of the three kiln types assigned to one band of the RGB colour spectrum: red (r255g0b0) for draw kilns, green (r0g255b0) for clamp kilns, and blue (r0g0b255) for field kilns. On this basis, colour mixing for each cell represents both the number of kilns (brightness) and the proportion of each kiln type within its area. Analysis of this output, shown in Figure 37, emphasises the prevalence of field kilns in upland areas and the predominance of clamp kilns and field kilns in the Central Belt. This latter distribution closely follows the spatial extent of commercial lime production (Figure 34) and coal mining activity (Figure 35) shown above.

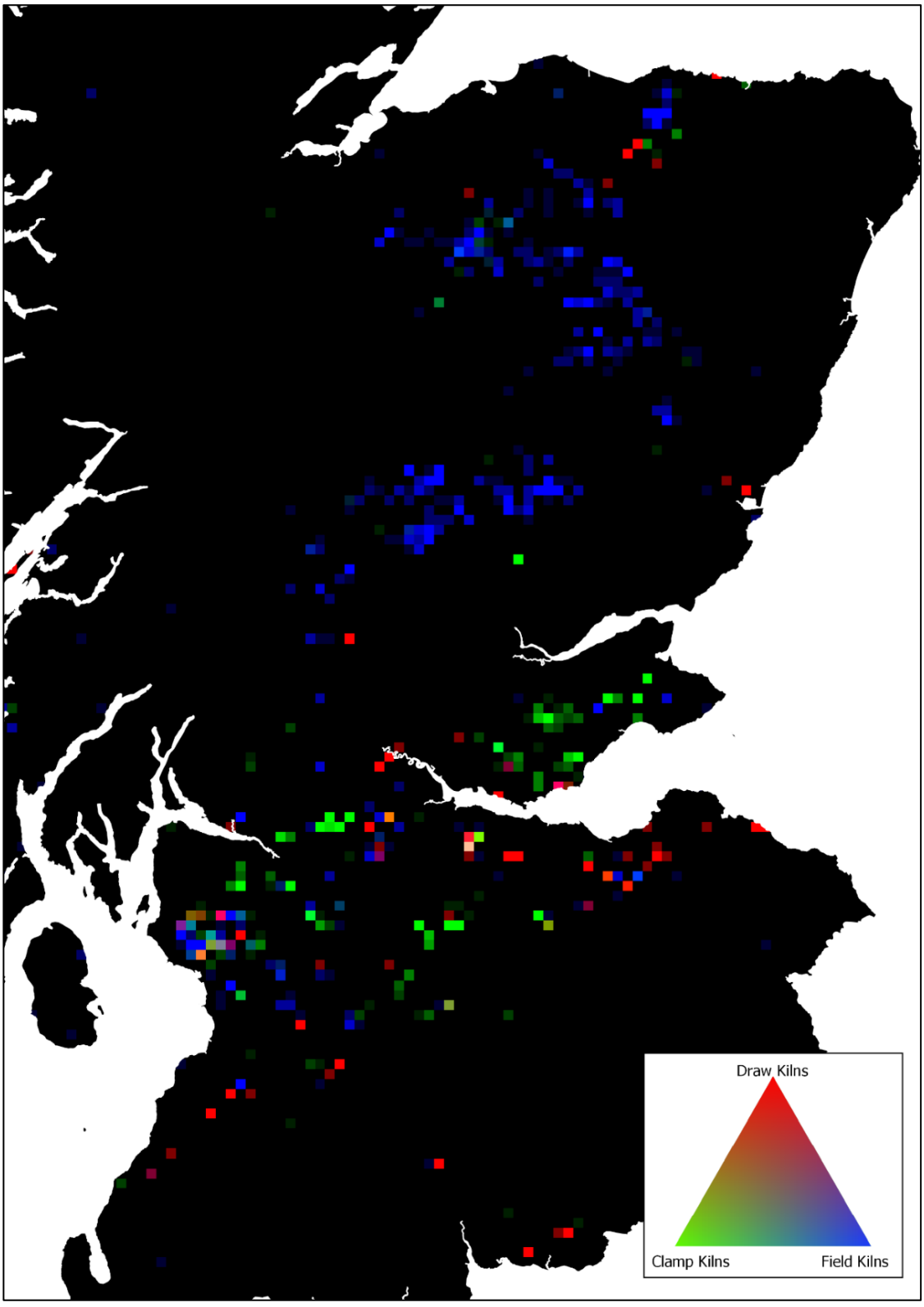

Figure 37 Mainland Scotland showing rasterised (2.5km resolution) kiln distribution using a multiband colour spectrum (RGB). Brighter cell colours indicate higher numbers of kilns. Colour mixing is proportionate to the ratio of kiln types within each cell. Black (r0g0b0) indicates an absence of kilns of any type.

Further analysis was conducted to explore the relationship of kiln types to limestone resources and fuel for burning. Straight line distances from individual kiln points to fuel and limestone sources

were calculated using the NNJoin plugin.[70] Outcrops of limestone (and other suitable material) were determined using the BGS 1:50,000 scale bedrock polygons, which were filtered for calcareous material.[71] For coal, the BGS BRITPITS layer was used. Because the geology layer comes in the form of polygons, while the BRITPITS layer is point data, the distance from each kiln to limestone is far likelier to be zero since there is a greater area in which to overlap. Results from this analysis, broken down by kiln type, are shown in Table 8 below. These indicate that field kilns were typically sited further from limestone resources than clamp and draw kilns, which is reflective of their predominance in the Highlands. Likewise, field kilns are also considerably further, on average, from coal.

Table 8 Descriptive statistics showing distances, in kilometres, of kiln points, by kiln class, to limestone and coal resources.

Variable	Kiln Class	N	Mean	SE Mean	StDev	Min	Q1	Med	Q3	Max
Limestone distance	Clamp	537	1.62	0.17	3.97	0.00	0.01	0.13	1.40	56.68
	Draw	198	1.35	0.27	3.84	0.00	0.00	0.04	0.66	25.79
	Field	1408	2.67	0.13	4.87	0.00	0.06	1.13	3.40	57.26
	Other	41	1.22	0.47	3.00	0.00	0.00	0.06	0.96	13.32
Coal distance	Clamp	537	30.77	2.46	57.11	0.01	1.45	4.66	45.07	289.29
	Draw	198	15.78	1.96	27.51	0.02	1.38	4.03	18.69	271.94
	Field	1408	47.98	0.92	34.59	0.03	24.80	52.02	66.33	290.89
	Other	41	25.88	4.30	27.52	0.04	1.70	6.59	51.92	84.77

By separating kiln classes into their respective symbol codes further trends can be observed (Table 9). Most noticeably, symbols groups A and B in the table, representing sub-categories of clamp kiln, appear highly distinctive in terms of their proximity to both limestone and coal. These findings support the argument that clamp kilns were employed primarily at sites where fuel and limestone were easily extracted together.[72] The results also suggest that symbol group C—square symbols taken to represent clamp kilns—may in fact represent a range of kiln types. Re-examination of the

[70] NNJoin joins two vector layers by the nearest neighbour of the input and provides the distance between each, see https://plugins.qgis.org/plugins/NNJoin/

[71] These polygons included limestone as well as other calcareous rocks such as dolostone and calcareous mudstones, which appear to have been exploited in some places for lime production.

[72] Bishop *et al.*, "Lime Burning in Clamp Kilns in Scotland's Western Central Belt: Primitive Industry or Simple But Perfectly Adequate Technology?"

map sheets and further ground-truthing may improve understanding of this symbol group. Such calculations, however, only give a very simplified picture of fuel sourcing, one that does not consider true journey times, local markets, and so on. More detailed spatial analyses in this area require more accurate site locations and supporting data.

Table 9 Descriptive statistics showing distances, in kilometres, of kiln points, by symbol group, to limestone and coal resources.

Variable	Symbol Group	N	Mean (km)	SE Mean	StDev	Min	Q1	Med	Q3	Max
Limestone distance	A	114	0.62	0.22	2.38	0.00	0.00	0.04	0.28	21.94
	B	121	0.67	0.12	1.27	0.00	0.01	0.10	0.68	7.04
	C	304	2.37	0.28	4.89	0.00	0.01	0.46	3.00	56.68
	D	1007	2.67	0.14	4.56	0.00	0.05	1.19	3.46	41.67
	E	483	2.06	0.23	5.15	0.00	0.01	0.47	2.10	57.26
	F	74	2.83	0.45	3.88	0.00	0.00	1.78	4.36	20.24
	G	10	1.68	1.31	4.13	0.00	0.02	0.05	1.02	13.32
	H	41	3.40	1.01	6.49	0.00	0.00	0.16	3.93	25.79
	U	30	1.03	0.48	2.64	0.00	0.00	0.05	0.88	13.10
Coal distance	A	114	6.63	1.40	14.94	0.02	0.58	2.23	3.98	83.35
	B	121	5.64	1.02	11.21	0.02	0.99	2.29	5.56	82.54
	C	304	49.85	3.98	69.34	0.01	3.56	38.27	55.21	289.29
	D	1007	45.80	1.19	37.87	0.03	18.74	48.90	61.34	290.89
	E	483	40.06	1.44	31.69	0.02	3.99	50.20	68.67	148.20
	F	74	56.36	2.25	19.36	1.15	50.58	58.10	71.51	83.50
	G	10	14.33	4.29	13.57	0.65	1.38	14.04	27.13	29.49
	H	41	25.25	3.53	22.63	0.03	2.23	21.10	39.43	82.94
	U	30	28.31	5.39	29.54	0.04	1.97	6.26	57.30	84.77

3.4.1 Data limitations

There are several factors that should caution any conclusions drawn from the OS first edition six-inch map data, some of which are inherent in most HGIS projects. Once brought into GIS and displayed on a map, the kiln data present themselves as a deceptively cohesive and unambiguous dataset. Subtle variations in symbology observable on the map are, out of necessity, smoothed over by the fixed categorisation necessary for analysis at the larger regional scale. Similarly, the almost forty-year time difference between the first and last kilns surveyed—a duration that could easily encompass economic fluctuations, developments in kiln technology, or changes to survey practice—

is masked by the map's static appearance. GIS rarely reflects this kind of 'messiness' and complexity in historical source material.[73]

Inconsistencies in the thoroughness and accuracy of the OS surveyors are also brought to light upon close analysis of the maps. In particular, the apparent willingness of the OS to use single kiln symbols to represent clusters undermines the empirical value of the dataset. When ground-truthing symbols, it is difficult, without extensive local research or archaeological survey, to know whether the remains on the ground pre-date the map or were built or altered after its completion. This issue may also account for some of the discrepancies found in the symbology. Such factors underline why historical maps are an example of an 'imagined' geography of the past, one that cannot be relied upon as a strictly accurate snapshot of previous land uses.[74]

Questions of scale also arise throughout this project. Point data collected from large-scale mapping poses several challenges in terms of visualisation and analysis at the national scale. These issues are compounded by the unavailability of supporting datasets. As mentioned above, accurate analysis of the costs and distances involved in the extraction and carriage of material requires an understanding of site layout, bedrock angle, water tables, road conditions and so on—a level of detail that is not possible when considering thousands of sites on the national scale. A recent thesis by Tracey Partida highlights the painstaking digitisation and reconstruction work required to study the progress and extent of enclosure, just one aspect of improvement, in a single county.[75]

3.5 Conclusion

Despite having outlined, in the previous section, the limitations of the OS maps as a data source and of HGIS more generally, the exercise of digitising kilns and exploring the data in GIS nevertheless proved highly valuable and informative in the context of this research. What the maps do highlight is that lime burning was widely practised at thousands of sites across Scotland. Of this total, only a small percentage might be thought of as notable commercial producers. 'High-status sites', such as

[73] Griffiths, "GIS and Research Into Historical 'Spaces of Practice': Overcoming the Epistemological Barriers."
[74] Baker, *Geography and History: Bridging the Divide*, 211.
[75] Tracey Partida, "Drawing the Lines: A GIS Study of Enclosure and Landscape in Northamptonshire" (University of Huddersfield, 2014).

Charlestown and other named lime works were vastly outnumbered by 'low-status sites', calling into question the research attention thus far committed to the former.[76] Considering the ephemeral nature of some kilns and the apparent inconsistency of surveyors, the number of small kilns that existed in Scotland at the end of the eighteenth century must have reached a far greater total than made it to the OS engraver. Small scale lime burning, although contracting compared with historical totals, was far from being completely usurped by larger commercial works by the mid-nineteenth century.

The maps also reveal certain clues about the usage and distribution of different kinds of kilns. Field kilns, often cast as the most basic form of lime production and suffering from vagaries of classification, are shown to be an important part of rural life. Their predominance in upland areas—parts of Scotland that received improvements latest—perhaps gives insight into earlier agricultural liming and the nascent stages of the lime industry elsewhere. Similarly, evidence from the maps helps overcome the low 'archaeological visibility' of clamp kilns.[77] Although most numerous in the Central Belt, clamps were hardly confined to just a few sites around Scotland and appear a major part of the industry in the mid-nineteenth century. Indeed, Johnson has argued that previous characterisations of clamp kilns as rare, unusual, and locally specific were based on a limited understanding and a lack of '*looking* [emphasis in original]'.[78] With that in mind, map symbology may present an effective way of looking for various kinds of kilns, or indeed other features. Indeed, a greater sensitivity to cartographic symbols, informed by careful analysis and understanding of the map's origins, would benefit a range of historical geography projects as the mass digitisation of cartographic sources continues to grow in popularity.

Beyond its role as an analytical tool, mapping the kilns provides a useful overview of Scottish lime burning and a prompt for further investigation using other sources—a starting point from which to discuss the industry in more depth.[79] Having established the distribution of the industry across Scotland, the next two chapters draw on more traditional historical scholarship, dealing in turn with

[76] Taylor's assessment of high- and low-status sites is also set out in the Introduction chapter, see "The plus Fours in the Wardrobe: A Personal View of Landscape History," 161.
[77] Johnson, "The Archaeology and Technology of Early-Modern Lime Burning in the Yorkshire Dales: Developing a Clamp Kiln Model," 141.
[78] Johnson, "The Archaeology and Technology of Early-Modern Lime Burning in the Yorkshire Dales: Developing a Clamp Kiln Model."
[79] The extent to which these sources inform one another is discussed in Chapter Seven (Conclusion).

the sourcing and movement of materials within the industry (Chapter Four) before considering the who and how of lime burning (Chapter Five).

4 Materials and mobilities

4.1 Introduction

The previous chapter has outlined the distribution of lime burning across Scotland, highlighting several important spatial patterns. This chapter focuses on the material resources of the lime industry, the resources that to some extent drove the spatial patterns observed in the previous chapter—fuel, limestone, and lime itself. Each resource is considered in turn, exploring how materials were selected, valued, moved in response to different circumstances and modes of lime production. This discussion of materials leads to some reflection on how the lime industry influenced the development of transport infrastructure in Scotland.

Lime burning was an industry that functioned over multiple scales and modes of operation. For the purposes of the present chapter it is instructive to distinguish between domestic burning and commercial production. These categories, however, should not be conflated with time periods or regions. Domestic burning, which was usually small-scale, refers to the production of lime for use by the burner (or those in their employ) on their own lands or construction projects (ownership structures associated with lime burning are considered in more depth in the next chapter). Commercial lime burning on the other hand was conducted expressly for the retail of lime, with the aim of returning a profit to the proprietor. This model of operation accounts for the industrialisation witnessed towards the end of the nineteenth century, but is not restricted to these scales of production – some early commercial burners operated at relatively small scales, while some commercial works in the nineteenth century used kiln forms associated with domestic burning. Furthermore, existing between these levels of production was estate-led burning, where lime was worked at the behest of a landowner to make lime widely available to their tenants. Whilst these works often sold lime and could grow large to supply sufficient volume, profit from the sale of lime often does not appear to be the primary motivation. As this and subsequent chapters show, there is significant temporal and spatial overlap between levels and types of lime production.

This chapter deals with several important themes in Scottish history. Firstly, in considering fuels, questions of energy in early modern industry are addressed. The lime industry was long associated with coal mining and the development of industrialised lime production was heavily reliant on sources of coal. Recent analyses of industrialisation more generally have found coal to have been a vital component of industrial change.[1] On technical and structural matters this chapter draws on Baron Duckham's detailed history of the early Scottish coal industry.[2] Because limestone is the larger part of the calcination mix, lime kilns were usually located closer to sources of stone, with fuel making longer journeys to be burnt. This uniquely freeing aspect of fossil fuels, which can be transported to where energy is needed, has been highlighted by Andreas Malm as enabling new spatial patterns of industry to emerge in the nineteenth century (with later consequences for the global climate).[3]

Secondly, this chapter touches on ways in which the land and its resources were discovered and valued. Historical discussion of the practical side of these activities, the actual prospecting for minerals, is thin on the ground.[4] Certainly, means of locating valuable minerals, including limestone, was a highly respected branch of knowledge, one that linked economic objectives with other branches of theoretical learning. The concept of the 'geological scale', which enabled prospectors to anticipate the location of coal and other minerals, was entirely English in conception, but evolved and improved as it was extended northwards, carried by networks of correspondence and interaction.[5] More is

[1] Christopher A Whatley, *Scottish Society, 1707-1830: Beyond Jacobitism, Towards Industrialisation* (Manchester University Press, 2000), 8; Gregory Clark and David Jacks, "Coal and the Industrial Revolution, 1700-1869," *European Review of Economic History* 11, no. 1 (2007): 39–72.
[2] Duckham, *A History of the Scottish Coal Industry, Vol. I 1700-1815*. Unfortunately, Vol II was never published.
[3] Andreas Malm, "The Origins of Fossil Capital: From Water to Steam in the British Cotton Industry," *Historical Materialism* 21, no. 1 (2013): 15–68.
[4] Hugh S Torrens, "The History of Coal Prospecting in Britain 1650-1900," in *Energie in Der Geschichte, Papers Presented to the 11th ICOHTEC (International History of Technology) Symposium, Dusseldorf, Germany*, 1984, 88–94; Hugh S Torrens, "The History of Coal Prospecting in Britain - a Neglected Subject," *Geology Today* Mar-Apr (1986): 57–58.
[5] Hugh S Torrens, "William Smith (1769-1839) and the Search for English Raw Materials: Some Parallels with Hugh Miller and with Scotland," in *Celebrating the Life and Times of Hugh Miller*, ed. Lesley Borley (Cromarty Arts Trust, 2003); Jean Jones, Hugh S Torrens, and Eric Robinson, "The Correspondence between James Hutton (1726–1797) and James Watt (1736–1819) with Two Letters from Hutton to George Clerk-Maxwell (1715–1784): Part I," *Annals of Science* 51, no. 6 (1994): 637–53; Jean Jones, Hugh S Torrens, and Eric Robinson, "The Correspondence between James Hutton (1726–1797) and James Watt (1736–1819) with Two Letters from Hutton to George Clerk-Maxwell (1715–1784): Part II," *Annals of Science* 52, no. 4 (1995):

known about the broader process of documenting the land in order to exploit it. As is discussed below, many eighteenth-century landowners seeking to implement improvements employed men to walk their lands and collect information about resources and opportunities for improvement. Early surveyors thus had an important role in facilitating and promoting socioeconomic restructuring of the landscape, and enabled landlords to manage their estates from afar.[6] Ian Adams suggests that these surveyors were more than simply 'recorders' of landscape; rather they can be seen as important 'innovators', able to interpret and imagine new potential states.[7]

Finally, this chapter also deals with the history of transport infrastructure in Scotland, an important aspect in the development of the lime industry as well as the economic development of the country. Indeed, Smout argues that two key pre-requisites for Scottish industrial growth were a well-founded mining industry and a well-founded transport system.[8] Greater ease of commercial travel not only enabled access to materials and products, but also increased economic integration and interaction between markets and regions.[9] Such conditions served to make possible the transition in Scotland from subsistence to capitalist modes of agricultural production.[10] Despite the importance of transport, relatively little is known about the nature and development of transportation prior to the period of industrial-led growth that began at the end of the eighteenth century, with its much-vaunted canals, harbours, and, later, the railways.[11] Transport is also one area in which the role of landlords in driving change was particularly felt.[12] Many landowners, as part of wider programmes of improvement and

357–82; Matthew D Eddy, "Geology, Mineralogy and Time in John Walker's University of Edinburgh Natural History Lectures (1779-1803)," *History of Science* 39, no. 1 (2001): 95–119.

[6] Andrew McRae, "To Know One's Own: Estate Surveying and the Representation of the Land in Early Modern England," *Huntington Library Quarterly* 56, no. 4 (1993): 333–57.

[7] Ian H Adams, "The Land Surveyor and His Influence on the Scottish Rural Landsape," *Scottish Geographical Magazine* 84, no. 3 (1968): 254.

[8] Thomas Christopher Smout, "Scottish Landowners and Economic Growth, 1650–1850," *Scottish Journal of Political Economy* 9, no. 3 (1962): 222.

[9] Andrew Popp, "From Town to Town: How Commercial Travel Connected Manufacturers and Markets during the Industrial Revolution," *Journal of Historical Geography* 35, no. 4 (2009): 642–67.

[10] Davidson, "The Scottish Path to Capitalist Agriculture 1: From the Crisis of Feudalism to the Origins of Agrarian Transformation (1688-1746)."

[11] Owen Silver, "The Roads of Scotland: From Statute Labour to Tolls the First Phase, 1700 to 1775," *Scottish Geographical Magazine* 103, no. 3 (December 27, 1987): 141–49; Ian Donnachie, "Roads, 1600-1900," in *Scottish Life and Society Volume 8: Transport and Communications*, ed. Kenneth Veitch (Edinburgh: John Donald, 2009), 214–338.

[12] Richard Saville, "Scottish Modernism Prior to the Industrial Revolution," in *Eighteenth Century Scotland: New Perspectives*, ed. Thomas M Devine and John R Young (East Linton, East Lothian : Tuckwell Press, 1999), 18–19.

to facilitate the operation of their own commercial ventures, laid new roads across much of Scotland.[13] In this sense, transport can be both a stimulus and product of industrial growth.[14]

4.2 Fuel

Calcining limestone requires a combustible fuel able to raise and sustain the temperature inside the kiln to the required temperature of 900°C.[15] The type of fuel used, and the eventual temperature and duration of the burn, influenced the quality of lime produced. Fuel was thus an important consideration for lime burners, who had to assess a range of suitability and availability factors in selecting it. The 'original' and best fuel for burning limestone, according to Wingate, was wood since it burns with long, even flames of mild heat, requires only natural draught, and so enables heat to penetrate more evenly within a kiln.[16] However, wood appears to have been used only sparingly for the burning of lime in Scotland, largely due to the depletion of woodland—cutting trees for fuel was a 'hurtful occupation' in the words of one respondent to Sinclair's *Statistical Account*.[17] Achieving and sustaining sufficiently high temperatures with wood alone would have been difficult.[18] Where wood is recorded as being used in lime burning, it is typically in conjunction with other fuels.[19] For example, in the Aberdeenshire parish of Birse, tenants were said to burn limestone with 'peat, mixed often with wood, or even with lime coals from Aberdeen.'[20] The primary fuels in eighteenth and nineteenth century Scotland—peat and coal—are considered below, while the design of kilns, which evolved with changing fuel supplies, growing demand for lime, and the drive towards efficiency, is discussed in the next chapter.

[13] Smout, "Scottish Landowners and Economic Growth, 1650–1850," 223.
[14] Alderton, "The Chicken or the Egg? The Relationship Between Industry and Transport in East Anglia."
[15] Wingate, *Small-Scale Lime-Burning: A Practical Introduction*, 8–14.
[16] Wingate, 43.
[17] *OSA*, Prospectus of a Lochow Canal, (1799), vol. 21, p.290.
[18] Toft, "Lime Burning on the Gower Peninsula's Limestone Belt," 76.
[19] James Robertson, *General View of the Agriculture in the Southern Districts of the County of Perth*, (1799): 287; William Marshall, *General View of the Agriculture of the Central Highlands of Scotland*, (1794): 36.
[20] *OSA*, Parish of Birse, (1793) vol. 9, p.110.

4.2.1 Peat

For several centuries before coal became the pre-eminent fuel of the lime industry, small, pre-industrial kilns burned peat.[21] Peat mosses occur widely in Scotland and in many places peat was an established domestic fuel before the onset of lime burning.[22] In virtually all parts of the country where peat was available and lime was burned, peat was used for that purpose, at least for a time. In some cases a combination of peat and coal were used to keep fuel costs low, such as on the Duntrune estate in Argyll where lime was burned using one-third coal and two-thirds peat.[23] In areas where coal was particularly distant or expensive, small-scale burning continued to utilise peat until well into the nineteenth century.[24]

Peat cutting was a labour intensive and largely seasonal activity, since it required dry weather.[25] Several contributors to the first *Statistical Account* bemoaned the time and effort required to collect and dry peats for fuel during the favourable months: 'peats can only be manufactured in the fine months of May or June', wrote Alexander McGibbon of Kilmadock, Stirlingshire, 'when the time of the farmer would be much better employed in improving his land'.[26] This seasonality was shared with agricultural liming, which also usually took place during the summer. On the Poltalloch estate, in Argyll, the factor James Gow remarked to his master that the timing of the peat cutting did not suit the laying of lime on the land. Peats were typically cut on the estate in August and September, too late in the season for liming the fields. Instead, he requested that either the peats be held over until spring or the lime kept unslaked in a shed until that time.[27]

Peat is bulkier than coal, but also less efficient in terms of energy by volume, and so requires a greater volume to burn the same quantity of lime. As many as four or five cart loads of peat were necessary

[21] Whyte, *Agriculture and Society in Seventeenth-Century Scotland*.
[22] Alexander Fenton and Angus Martin, "Peat and Turf," in *Scottish Life and Society Volume 2: Farming and the Land*, ed. Alexander Fenton and Kenneth Veitch (Edinburgh: John Donald, 2011), 751–72.
[23] Letter, John Murray to James Gow, 06/03/1797 (ABC DR/2/1).
[24] *NSA*, Parish of Old Deer (1845), vol. 7, p.142.
[25] When a kiln was to be used throughout the year, it was suggested that damp peats collected in summer could be stacked near the draw hole to dry over winter, see J.D., 'On Burning Limestone with Peats', *The Farmer's Magazine*, vol. 3(12), Nov 1802, p.483.
[26] *OSA*, Parish of Kilmadock – Appendix (1799), vol. 21, p.350; see also *OSA*, Parish of Johnstone (1792), vol. 4, p.225; *OSA*, Parish of Forbes and Kearn (1794), vol. 11, p.192.
[27] Letter, James Gow to Neil Malcolm Esq., 15/12/1796 (ABC DR/2/1/8).

to burn one cart of limestone, producing less than half a cart load of lime.[28] The quantities of ash produced by such a large proportion of fuel compromised the quality of the burned lime. Agricultural writer Adam Dickson suggested that such lime was fine if 'intended for manure', but the peat ashes rendered it 'improper for mortar'.[29] Compounding the issue of its bulk, most peat was cut in rough terrain unsuitable for wheeled transport, meaning that the volume of peats required could be off-putting to prospective lime burners. This concern was articulated by the factor of the Poltalloch estate, who weighed up whether to burn lime at all or to simply purchase it from commercial suppliers: 'the whole of the rental peats would be required for firing what might be got east otherwise'.[30] Indeed, this point highlights the differing labour and commercial structures associated with peat cutting and coal mining. Unlike the latter, which was quickly commercialised, peat cutting remained in many places a resource held in common (at least until the widespread division and enclosure of commonties), with landlords often supplied with a measure of cut peats as part of a tenancy.[31] Cutting enough peat to fuel a lime kiln, on top of their family's domestic needs, would have placed a significant burden on a tenant farmer's time, whilst in many places proprietors also feared the over-exploitation of peat mosses.[32]

As agricultural improvement extended across Scotland and liming became more widely practised, the selection and efficient use of fuels to burn limestone became a subject of much importance to landowners and agriculturalists. Despite the obvious importance of peat in large parts of the country, by the start of the nineteenth century many commentators began to dismiss it as an unsuitable and insignificant fuel for lime production. In their reports to the *Board of Agriculture*, for instance, William Marshall stated that peat produced 'a weak ineffectual firing', while Charles Findlater called it a 'poor succedaneum for coal'.[33] However, several accounts from around this time were more

[28] Cruickshank, Nisbet, and Greig, *The Limekilns of Upper Donside: A Forgotten Heritage*.
[29] Adam Dickson, *Husbandry of the Ancients*, vol. 1, (Edinburgh, 1788): 338
[30] Letter, James Gow to Neil Malcolm Esq., 15/12/1796 (ABC DR/2/1/8)
[31] Fenton and Martin, "Peat and Turf"; Davidson, "The Scottish Path to Capitalist Agriculture 1: From the Crisis of Feudalism to the Origins of Agrarian Transformation (1688-1746)"; Andy Wightman, *The Poor Had No Lawyers: Who Owns Scotland and How They Got It*, 1st ed. (Edinburgh: Birlinn, 2013).
[32] *NSA*, Parish of Inveraven, (1832), vol. 8, p.127; Anne Gordon, *To Move With the Times: The Story of Transport and Travel in Scotland* (Aberdeen University Press, 1988), 190.
[33] William Marshall, *General View of the Agriculture of the Central Highlands of Scotland*, (1794): 36; Charles Findlater, *General View of the Agriculture of the County of Peebles, with Various Suggestions*, (1802): 21.

supportive of peat burning, running counter to the arguments articulated above. In a submission to the *Highland Society of Scotland* in 1803, Jonathan Radcliff advised on the burning of lime with peat using an intermittent kiln of his own design (the description of which resembled a large rectangular clamp kiln).[34] Two essays appeared in the *Farmer's Magazine* highlighting the favourable qualities of peat for lime burning.[35] One writer was convinced, 'from evidence', that limestone could be burned 'to better purpose, and less expence [sic], with peat, than with coal'.[36] Not only would this constitute a personal saving, he argued, were readers of the *Magazine* to follow suit, coal—'that valuable mineral which cannot be too much economized'—might be saved for other more pressing demands.[37] Further support came from an essay written to the *Board of Agriculture* by Mr John Dodgson of Cumberland, England, in 1805. His fervour for peat is evident from the essay's preface: 'I have for some years past practised the burning of limestone with peat, which I find by experience to answer so well, that I have laid aside the burning lime with coals, though I am only about two miles distant from the coal pit.'[38] The advantage of peat, besides its proximity to his farm and cheapness compared with coal, was, he argued, its ability to allow airflow within the kiln and the reduced risk of reaching too high a temperature (which can cause limestone to turn into overcooked clinker). Dodgshon used a 'common draw kiln', dispelling any notion that peat was only suitable for 'primitive' kilns.[39] He stated that, while he was not the first to burn lime with peat, the only other place he had heard of it being used was Dumfries—although clearly at this time peat burning had been commonplace in many parts of Scotland for more than two centuries.[40] Others, sensitive to the unavailability of coal in many parts of the country, continued to promote peat in their efforts to encourage lime burning for agricultural improvement. James Macdonald, for example, writing for

[34] Jonathan Radcliff, 'On Burning Lime with Peat', *Prize Essays and Transactions of the Highland Society of Scotland,* 2 (1803): 160-163. Radcliff goes on to state that '[t]he best limestone is most difficult to burn, and the best fuel for burning is the brittle black species,' although it is not clear whether he is referring to coal or a particular type of peat.
[35] P.H., 'On the Burning of Limestone with Peats', *The Farmer's Magazine,* vol. 3(10), May 1802, pp.210-3; J.D, 'On Burning Limestone with Peats', *The Farmer's Magazine,* vol. 3(12), Nov 1802, pp. 483-4.
[36] J.D., 'On Burning Limestone with Peats', 483
[37] *Ibid.*
[38] John Dodgson, 'On Burning Lime with Peat', *Communications to the Board of Agriculture on Subjects Relative to the Husbandry and Internal Improvement of the Country,* vol. IV, no. XII, (1805): 331-334.
[39] See Donnachie, "The Lime Industry in South-West Scotland"; Skinner, *The Lime Industry in the Lothians*.
[40] Nisbet, "The Archaeology of the Lime Industry in Renfrewshire," 56.

the *Board of Agriculture*, observed in 1811 that lime burning with peats had been successful in Islay on the lands of Campbell of Shawfield, and he recommended that farmers in other parts of the Hebrides do likewise.[41]

Few examples exist of peat being used for larger scale lime production. For example, the limestone quarry of Leny, on the Perthshire annexed estate, despite the high quality of the stone and the abundance of local peats, never operated commercially, purportedly due to a lack of nearby coal.[42] Curiously, although coal was the primary fuel used in the draw kilns at Ardonald lime works in Aberdeenshire, accounts from the works also reveal that a small quantity of peats were purchased each year 'for the clamp kiln'.[43] This connection between clamp kilns and peat also occurs elsewhere. Records from the Nethermuir Estate, for instance, document the cutting of peats by tenants near the lime quarry and the sale of these 'to be burnt in the lime kills (sic)'.[44] It is not clear from these records to which quarry they refer—besides two disused quarries on the OS First Edition six-inch map ('Kiddshill' and 'Cairncummer'), little trace survives of any lime working in that area. However, a later entry in the *NSA* for the parish of Old Deer refers to a commercial quarry at Annochie, close to Nethermuir House, where limestone was 'calcined in small clump kilns by peats'.[45] This relationship to kiln type is further explored in Chapter Five. Ultimately, peat was most widely viewed as a fuel of convenience, a low cost, local alternative to coal for small scale lime burning.[46] Its lower calorific value compared with coal, coupled with the difficulty of extracting and transporting sufficient volumes, meant it could not support larger scale commercial burning. Indeed, in areas where coal was plentiful, some remarked that peat was the dearer fuel.[47]

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[41] James Macdonald, *General View of the Agriculture of the Hebrides, or Western Isles of Scotland,* (1811): 574.
[42] Proposals by Lord Kames with respect to the lime stone quarry of Leny, 1762 (NRS E777/259/1); Alexander McGibbon, *Report as to Improving the Navigation of the Rivers Forth etc and the Advantages of Small Canals Demonstrated,* (1810): p.9.
[43] John Menzie's state and accounts, Ardonald Lime Works 1803, 1804 (NRS GD44/51/535/2; GD44/51/536/1). The use of clamp kilns at this site is discussed further in Chapter Five, p.159.
[44] State of Lyme Quarries of Nethermuir for peats of 1772, 1773 and payment thereof 1775 (NRS GD36/45).
[45] NSA, Parish of Old Deer (1845), vol. 7, p.142.
[46] *OSA*, Parish of Kilmuir Easter, (1793), vol. 6.
[47] Andrew Wight, *Present State of Husbandry in Scotland,* (1778): 31; Letter, James Gow to Neil Malcolm Esq., 15/12/1796 (ABC DR/2/1/8); *OSA*, Parish of Bervie (1794), vol. 13, p.7.

4.2.2 Coal

Although the previous section has shown that peat was an important fuel in many parts of Scotland, coal was undoubtedly the most sought-after source of energy. The major Scottish coal fields are largely restricted to an area of land running approximately north-easterly from Ayrshire to the Firth of Forth, and it is within this relatively narrow strip of the country that almost all significant coal extraction took place during the eighteenth and nineteenth centuries.[48] Some coalfields also occur on the Mull of Kintyre at Machrihanish, at Sanquhar in Dumfriesshire, on the Isle of Arran, and on the east coast of Sutherland, near Brora, although of these only the first two were ever exploited to any great extent.[49] Coal mining along the coast in connection with salt panning and small-scale lime burning appears to have taken place since as early as the twelfth century, yet significant growth in Scottish coal production did not occur until the middle of the eighteenth.[50] Duckham and others have linked this expansion to the rise of lime burning associated with agricultural improvement. At its peak, lime burning consumed a large proportion of Scotland's national coal output. In 1808, Bald attributed an observed increase in coal consumption to three factors: a growing number of domestic fires burning in the home, the expansion of industries employing steam engines, and the production of lime for agricultural use (which he described at the time as being 'only in its infancy').[51] It is difficult to calculate exactly the quantities of fuel consumed by the industry, but Duckham proposed that between 100,000 and 150,000 tons of coal were used annually for lime burning.[52] This amounts to between twenty and thirty per cent of John Nef's upper estimate for annual Scottish coal production at the end of the eighteenth century (475,000 tons).[53]

The ratio of coal to limestone used in burning varied with the quality of both materials. Skinner suggests that a typical ratio, based on his study of the Lothians, was approximately one measure of

[48] Duckham, *A History of the Scottish Coal Industry, Vol. I 1700-1815*.
[49] Bald, *Coal Trade*, 98-9; Ian Donnachie, *Industrial Archaeology of Galloway* (David & Charles, 1971), 133.
[50] P. R. Crowe, "The Scottish Coalfields," *Scottish Geographical Magazine* 45, no. 6 (1929): 321–37; Duckham, *A History of the Scottish Coal Industry, Vol. I 1700-1815*.
[51] Bald, *Coal Trade*. 95-96.
[52] Duckham, *A History of the Scottish Coal Industry, Vol. I 1700-1815*, 25.
[53] Christopher A Whatley, "New Light on Nef's Numbers: Coal Mining and the First Phase of Scottish Industrialisation, c. 1700-1830," in *Industry, Business and Society in Scotland Since 1700*, ed. A J G Cummings and Thomas M Devine (Edinburgh: John Donald Publishers Ltd, 1994), 1–23.

coal to four of limestone.[54] James Carmichael's account of Scottish lime quarries shows a ratio as high as 1:1½ at Cousland and as low as 1:4 at Jerusalem, whereas Bald made his calculation of the value of a coal miner to the improvement of land using a lower ratio of 1:6.[55] Carmichael's account reveals the range in fuel efficiency between large lime works. He observed, for example, that at Middleton and Crighton Dean lime works twelve carts of limestone could be burned with three carts of coal, whereas at Jerusalem works three carts of coal could burn only four of stone.[56] Ardonald lime works consumed 1,380 tons of coal in 1810, producing 30,000 bolls of lime shells, a ratio of roughly 1:3⅔.[57]

In those districts with ready access to coal, it was used to burn lime from a very early stage. Harrison notes a tack from Stirlingshire detailing the supply of coal for lime burning at the end of the seventeenth century.[58] As discussed above, coal holds several advantages over peat: it more easily reaches a higher temperature, it was more efficient by volume, and it could be readily purchased at commercial pits and mines. By the time of the first series of county surveys coal was considered a pre-requisite for improvement and economic prosperity. Landowners expended considerable effort to identify local coal resources. Those with access to both coal and limestone were often encouraged by the demand for lime to open coal pits and mines on their estates.[59] Surplus coal from these workings could be sold as well as the lime, which had the effect of lowering the cost of coal as more of it reached the market. The Dukes of Gordon papers contain observations made of Garnkirk Limeworks in 1808, where it was determined that, were the works taken on, 'a lot of shells to the extent of 8,000 chalders may be expected and that a sale of good house coal would be unlimited.'[60]

For some lime burners the decision to use coal over peat was one of necessity. In Dumfries in the 1790s, for example, when the peat mosses were nearly exhausted, people were compelled to carry

[54] Skinner, *The Lime Industry in the Lothians*, 22.
[55] Robert Bald, *A General View of the Coal Trade of Scotland*, (1808): 76-77.
[56] James Carmichael, 'Account of the Principle Limestone Quarries of Scotland', Transactions of the Highland and Agricultural Society of Scotland 5 (1837).
[57] Ardonald lime works sales, 1810 (NRS GD44/39/30/5); one boll of shells estimated at 25 stone weight – see weights and measures section.
[58] Harrison, "Lime Supply in the Stirling Area from the 14th to the 18th Centuries," 85.
[59] George Wilson, "Industrial Coal Markets in Fife 1760–1860," *Scottish Geographical Magazine* 96, no. 2 (1980): 86.
[60] 'Garnkirk Limeworks', 11 Sept 1808 [author unknown] (NRS GD44/39/30/3).

coal '30 and 40 miles distance by land' in order to burn lime.[61] Similarly, the minister for Grange parish in Aberdeenshire stated that '[s]ome years ago, a very wet season compelled some of [the tenants] to try coal, and they found a mixture of peat and coal to answer so well, that they continue to use a little coal now and then'.[62] Were it not for the high cost of purchasing coal at the shore, he argued, the parishioners would 'gain two months of the summer' from not having to prepare peat.[63] Even in places where alternative fuels were available, however, coal had become so desirable a fuel by the end of the eighteenth century that some saw its lack as an outright barrier to lime burning. Following a disruption to the operation of the Duke of Buccleuch's coal works at Canonbie in 1770, the deputy chamberlain in charge of the works wrote that 'the country crys [sic] out for want of coal to burn their lime in the summer season'.[64] This reliance on coal appeared to exasperate James Robertson, who, observing the agriculture in Inverness-shire in 1808, noted:

> Lime has been discovered in many parts of the county, but it has not been hitherto used in the cultivation of the soil, in proportion to its importance as a manure. The causes of this neglect seem to be, the want of fuel, the inattention of the common tenantry, and in many places, the precarious tenure by which the people hold their farms; *but no fuel is scarce except coals*: and lime is plentifully burnt in many countries by peats, and wood. The lower class of farmer must have examples set before them, to excite their industry, and leases in their pockets to ensure the fruits of their labour.[65]

Robertson's observation shows how fuel selection, and indeed the decision to burn lime at all, could be led by more than simply resource availability—in this case secure tenancy and positive encouragement were considered necessary to stimulate the practice. When demand for lime was great enough, people used whatever fuels were most readily available.

Pre-industrial lime sellers often allowed customers to bring their own coal to the kiln, or to purchase it separately at the works. Where lime burning was a commercial interest, proprietors placed great emphasis on good economy in managing coal.[66] Although some writers stressed the need to use the

[61] *OSA*, Parish of Lochmaben (1793), vol. 7, p.242.
[62] *OSA*, Parish of Grange (1793), vol. 9, p.579.
[63] *Ibid.*
[64] Coal journal, William Little, 12/06/1770 (NRS GD224/459).
[65] James Robertson, *General View of the Agriculture of the County of Inverness* (1808), p.241—emphasis added.
[66] Note headed 'Lime Works at Raw Camp for 1800', author unknown (NRS GD150/2359).

best fuels, lime burning was widely considered a useful outlet for poor quality coal.[67] This was especially the case with agricultural lime, which tolerated higher ash contents and less even burns than limes intended for mortars or plaster. 'Lime coal' became common lexicon in the coal trade, synonymous with 'panwood' in describing low quality.[68] Rising demand for lime spurred many landowners to open up new coal seams on their estates, seeing a new market for previously low value minerals.[69] Occasionally coke was used, though it was more often avoided on account of its tendency to cake easily.[70] Nevertheless, Charles Menteith, at his lime works in Dumfriesshire, converted his coal to coke at the mine, saving around 40% of the weight that had to be carried to the kilns.[71]

When possible, commercial lime works opened at sites near to supplies of both limestone and coal, with the latter either extracted locally or coming from a major infrastructure connection, such as a port. As the industry became more industrialised and transport infrastructure expanded across the country, works were able to utilise collieries at much greater distances. Lime producers in the Central Belt had access to a wide number of small and large coal suppliers. Accounts from Raw Camps (Table 10), for example, show how lime works in these areas were able to shift suppliers according to fluctuations in price, demand, and availability.

Table 10 Deliveries of coal at Raw Camps lime works, 1792-1794.[72]

Source	1792	1793	1794
Blackburn	7425 (loads of coal)	5139	
Bathgate		2183	4709
Woodmuir		657	906
Bo'ness		270	
Bonhar		93	1001
Houston		282	
Halbeath (via Queensferry)			300
Cults		52	
Collington Burn			62
Total	7425	8676	6978

[67] Bald, *Coal Trade*.
[68] Duckham, *A History of the Scottish Coal Industry, Vol. I 1700-1815*.
[69] Wilson, "Industrial Coal Markets in Fife 1760–1860," 86.
[70] Skinner, *The Lime Industry in the Lothians*, 22.
[71] Clarke, "The Closeburn Limeworks Scheme: A Dumfriesshire Waterpower Complex," 7–8.
[72] Charge and Discharge of Raw Camps Lime Works between the Countess of Morton and James Beveridge, 31/12/1791 - 31/12/1794 (NRS GD150/2359). Unfortunately, the quantity of a 'load' of coal was undefined in the records. It was likely set by the size of the carts used to transport it. The challenge posed by vagaries of weights and measured is discussed in Chapter Five.

At Scullingour lime works, in Campsie, the limestone is interbedded with the coal, allowing each to be extracted together, although neither the coal nor the limestone were considered of high quality.[73] The works operated under the name of 'Scullingour Lime & Coal Works' for the first half of the nineteenth century, but when the lease was renewed in 1854 the 'Coal' was dropped from the title and the works traded almost exclusively on its lime—the coal mined was for 'burning lime only'.[74] The drive towards fuel efficiency also played a significant part in the development of improved kiln designs, a topic that is discussed in greater detail in subsequent chapters.

Before the construction of the railways, which allowed lime to reach markets from a small number of centralised works, the coastal trade in coal was vital to the interests of lime works in northern Scotland. Distance always raised the price of coal, and the enforcement of duties on coal carried by sea north of the Redhead Promontory (near Arbroath) exacerbated the issue for consumers until 1793. James Headrick's assertion in 1813 that the tax 'operated as an effectual prohibition against the burning of lime' in Angus was typical of many agricultural commentators from the north of Scotland.[75] Once the duty was lifted, coal was more freely shipped to more distant ports.[76] The commercial coal works in Aberdeenshire relied heavily upon the coastal coal trade to support lime burning. Ardonald lime works, for example, was owned by the Duke of Gordon and operated for more than sixty years until 1857.[77] Records from the works show an extensive network of trade connections. Coal for burning at Ardonald lime works was shipped north from Fife collieries at Inverkeithing, Dunfermline and Buckhaven on the Forth, and landed at several small ports near the mouth of the Spey, at Port Gordon, Kingston and Tugnet. From there it was carted along the Huntly turnpike to the works, an overland distance of more than 23km, and a total journey of almost

[73] Notes on Scullingour lime works, 20/01/1863 (MIT T-LX6/21/1).
[74] Kennedy's report on Scullingour, 1816 (MIT T-LX6/21/2).
[75] James Headrick, *General View of the Agriculture of the County of Angus, or Forfarshire*, (1813): 505.
[76] Whatley and Duckham have both argued that the tax was in fact a boon for the Fife collieries since it did not apply within the Forth estuary, allowing them a near captive market and protecting them from competing with cheaper English coal. See Whatley, "New Light on Nef's Numbers: Coal Mining and the First Phase of Scottish Industrialisation, c. 1700-1830."
[77] OS Name Book (OS1/1/12/57).

350km.[78] The price of carrying coal to Ardonald was more than double the price of the coal itself, as the records from 1804 show:[79]

Table 11 Purchase and Carriage of Coal for Ardonald Lime Works, 1804

Purchase and carriage of coal for Ardonald Lime Works, 1804			
55 ¼ tons coal from Dunfermline:	£22	2	-
694 tons coal from Inverkeithing:	£242	18	-
Sum for coal:	**£265**	**5**	**-**
Sum for freight of coal	£408	19	3
Sum [inclusive] for unloading and carriage of coal (primarily Tugnett to Ardonald)	£457	6	9
Total	**£722**	**11**	**9**

Earlier accounts from the works suggest that, prior to establishing supply chains from the collieries on the Forth sufficient to meet demand, the proprietors utilised whatever supplies were made available at the various north-eastern coal markets. Accounts from 1802 show that alongside '388 tons of Scotch coal' shipped from Inverkeithing, '521 barrels of English coal' was purchased from Aberdeen, 368 barrels bought from Banff, and 60 tons brought from St Davids of the Findlater and Scafield.[80]

The lime works at Askomill, near Campbeltown on the Kintyre peninsula was the property of Campbell Davies Esq. and had been in operation since at least 1801 when it was noted on George Langland's map of Argyllshire.[81] In 1847 Askomill lime works, near Campbeltown, was being supplied with 21 wagons of coal, at a cost of £5 5s. including freight, every two to four weeks between August and December. The coal was landed in Campbeltown before being carted to the works in 42 cart loads, at an additional cost of around £1. The source of this coal is not clear. A small colliery was in operation at nearby Macrahainish at the time, and a canal led from there to Campbeltown. However, following the repeal of the coal duties, Campbeltown was frequently supplied with coal from Greenock. By 1852 coal was only delivered in the month of August, and in

[78] Ardonald Lime Works, accounts 1808 (NAS GD44/51/537/3), Ardonald Lime Works, accounts 1809 (NRS GD44/51/538/1); for further discussion of early roads in Aberdeenshire see Thomas Day, "The Construction of Aberdeenshire's First Turnpike Roads," *The Journal of Transport History* 24, no. 2 (2003): 154–76.
[79] Account of charge and discharge of John Menzie's Management of the Lime Works at Ardonald, season 1804 (NAS GD44/51/536/1).
[80] Ardonald Lime Works, accounts 1802 (ABC GD44/51/535/1).
[81] Argyll OS Name Books, 1868-1878 (OS1/2/78/143); George Langland, *This map of Argyllshire…* (1801).

much smaller quantities, suggesting a decline in production at the site. An increase in the price of coal may have been to blame – 7 wagons of coal in 1852 were priced at £3 3s.[82]

The price of freight also often depended on the presence of other traded commodities along the same routes. At Hedderwick lime works coal was purchased from St Davids and shipped to the nearby harbour of Montrose, where it was led thee miles overland to the kilns. The price was 1/3 per boll 'when grain goes to the Firth of Forth', but 2/3 in the off season when no grain was traded.[83]

4.2.3 'Pounding' lime

Where fuel was costly or altogether unavailable, some proposed that limestone be ground down mechanically into limestone powder for agricultural use. That ground limestone could be similarly effective on the soil as quicklime was widely understood by the second half of the eighteenth century; with one report to the commissioners of the Annexed Estates noting that 'Pounded Lime goes a much greater Length than brunt [burnt] Lime'.[84] Lord Kames, who was a vocal proponent of ground or crushed limestone, persuaded the board of the Perthshire Annexed Estates to finance the construction of a 'machine for pounding limestone' at Callander in the 1764, the cost of which was to 'not exceed £50'.[85] However, low water levels in the burn on which it was sited meant the machine only ever produced a small quantity of usable lime. By 1799 further misfortune had befallen the scheme when 'a torrent in the stream that drave [sic] the machinery, was allowed to sweep the whole away'.[86] It was never reinstated.

[82] Askomill Lime Works books of accounts, cash book, 1847-1852 (ABC DR/4/2/1).
[83] Memorandum of Hedderwick Limeworks belonging to George Robertson Scott esq. of Benholme near Bervie, from Mr James Kandow the Factor's information, undated [c.1810] (NRS GD44/39/30/14).
[84] George Nicholson's Report, Estates of Struan and Lochgarrie, 1777 (NRS E788/22/1).
[85] Lord Kames, *The Gentleman Farmer,* 3rd ed. (1798): 378; Papers concerning Perth Improvements (E777/262/1 & E777/262/2).
[86] James Robertson, *General View of the Agriculture in the Southern Districts of the County of Perth*, (1799): 33.

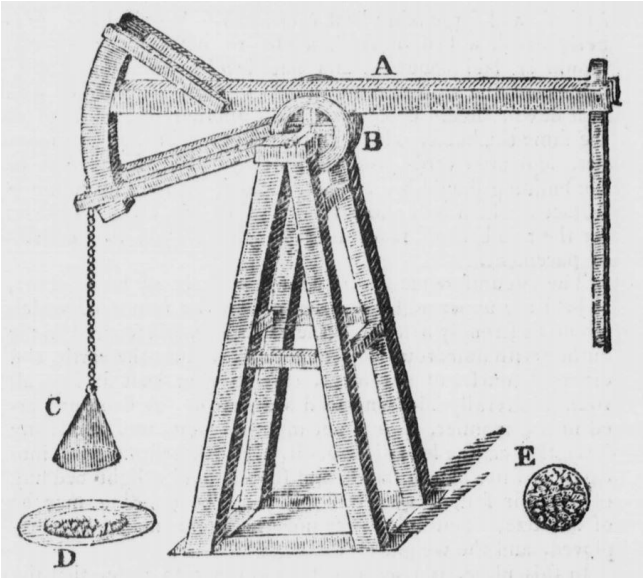


Figure 38 Sketch of a machine for pounding limestone. Labelled components as follows: A. a beam, supported by four strong posts. B. a wheel with a groove on the circumference to receive the beam, with a large iron spindle or axis. C: a conical cast-iron weight, the base of which was studded with abrasive knobs. D. a circular 'building' sunk below the surface of the ground (like a well) with a heavily reinforced lining and floor. E. the face of the weight (C). The weight would be repeatedly dropped or driven onto limestone placed in the sunken building, with the contraption, according to its inventor, able to be driven by steam, water, wind or horses.

In the years following this failed experiment, intermittent calls were made to harness the power of water to drive grinding machines, particularly by James Robertson, who reported on the Highlands where 'there are plenty of streams to drive machinery of any power.'[87] In his view, grinding was the obvious solution for places distant from ports and fuel: '[w]hat an unspeakable advantage [it will be] to all the adjacent Highlands in this respect, where fuel is scanty . . . when some method will be devised for pounding raw limestone into manure!'.[88] However, such calls were never answered with much success. An account of a machine for pounding limestone was published in the *Farmer's Magazine* in 1802, that unwittingly illustrated the confounding intricacy required to implement such schemes.[89] The proposed design (Figure 38) involved driving an abrasive cast-iron weight onto limestone by a machine that, according to its inventor, could be driven by a range of energy sources. Pounding the limestones, the inventor added, could be 'greatly facilitated' by 'a very simple contrivance': pre-burning the limestone for 'ten or twelve hours' using whatever fuels were

[87] James Robertson, *General View of the Agriculture of the County of Inverness*, (1808): 43.
[88] *Ibid.* 339.
[89] A.B., 'Drawing and a Description of a Machine for Pounding Limestone', *The Farmer's Magazine,* vol. 3(10), May 1802, pp.146-49.

available.[90] Such an arrangement begs the question where the advantage was in grinding the limestone. Indeed, in November of the same year, the *Magazine* published a scathing response from another of its contributors who stated he could 'by no means approve of [that] enormous and expensive battering ram'.[91] His solution: burn the limestone outright using peat.

4.3 Limestone

4.3.1 Searching for limestone

Calcareous rock of some description can be found in almost every part of Scotland (for further discussion of limestone formations and their spatial distribution across Scotland, see previous chapter).[92] Identifying these rocks and determining their worth was the crucial first step in utilising them, yet the history of active prospecting for limestone is relatively sparse.[93] This process became more targeted, economical and scientific over time as the value and importance of lime grew.

Early lime burners made relatively opportunistic use of easily identifiable and accessible limestone outcrops. Local knowledge of such sites and resources was held largely by those that used them—masons and farmers. Such was the abundance of limestone in some parts of Scotland, several accounts refer to 'mountains' of it, and in places it is said to have been 'accidentally discovered'.[94] In Glenlivet, for example, Rev. William Asher remarked that limestone was found 'in almost every burn' and 'under every field.'[95]

With growing awareness of the agricultural and commercial utility of lime, efforts to uncover 'hidden treasure' on the land became more rigorous.[96] Renowned surveyor Peter May was tasked with seeking opportunities for improvement on James Grant's Highland estate during the middle of the

[90] *Ibid.* 148. Unfortunately, the author stated that 'no accurate estimate of the expence [sic] of such a machine can be given'.
[91] J.D, 'On Burning Limestone with Peats', 483.
[92] Robertson, Simpson, and Anderson, *The Limestones of Scotland*.
[93] The history of prospecting for coal has been similarly overlooked, despite the greater historical interest in it compared to lime, see Torrens, "The History of Coal Prospecting in Britain - a Neglected Subject"; Torrens, "The History of Coal Prospecting in Britain 1650-1900."
[94] OSA Parish of Rothiemurchus (1792), vol. 4, p. 308; John Smith, *General View of the Agriculture of the County of Argyll*, (1798): 11; James Macdonald, *General View of the Agriculture of the Hebrides, or Western Isles of Scotland*, (1811): 29; *OSA*, Parish of Ruthwell (1793), vol. 10
[95] *NSA*, Parish of Inverarnan (1832).
[96] John Henderson, *General View of the Agriculture of the County of Caithness*, (1812): 14.

eighteenth century, work that included sending teams of men on a determined 'search for lime quarries'.[97] In 1769, on the orders of the Duke of Gordon, John Williams was dispatched to survey the lands of Badenoch and Lochaber, part of an upland district which by that point had seen relatively little change to the manner of its farming. His role was to identify mineral resources, chiefly limestone, and thus 'point out some of the great and many improvements that can be made'.[98] His journal and reports display a working understanding of limestones: 'most of the rocks in [Glenavon] are excellent limestone, some of which is remarkably white, of an open grain texture, easy to burn.'[99]

Understandably, due to the costs and time involved in such prospecting, as well as the networks of knowledgeable persons whose advice was sought on the location of minerals and evaluation of specimens, these efforts were the preserve of the landowners. Concerted attempts to find exploitable limestone deposits initially took place in areas which had begun to implement agricultural improvement or that had witnessed the nearby successes of liming. For example, the minister for West Kilbride, in northern Ayrshire, stated in 1794 that, following the persuasion of the tenantry to partake in liming, 'pains have been made to discover [coal and lime], and attempts made to sink pits for that purpose', indicating an active effort on the part of the proprietors.[100] By contrast, at the same time, in Alford, Aberdeenshire, it was noted that 'attempts to discover workable lime-stone have not hitherto been either general, or well conducted, and though there are many indications of it in the county, no regular quarry has been hitherto found.'[101]

From the middle of the eighteenth century onwards, modernising landowners, with a view to implementing various improvements, were increasingly enlisting professional surveyors to produce cartographic audits of estate resources. Estate plans effectively replaced verbal surveys and folk knowledge, formalising and documenting information about the productivity of the rural landscape.[102] The intersection between cartography and geology became further established from the mid nineteenth century onwards as the OS and the Geological Survey of Scotland began to map the

[97] Adams, *Papers on Peter May Land Surveyor, 1749-1793*, 143–45.
[98] Mr Williams, of his Survey of the Lordship of Lochaber, 1769 (NRS GD44/28/34/40).
[99] Journal of John Williams' mineral survey, 1769 (NRS GD44/28/34/49).
[100] *OSA*, Parish of West Kilbride (1794), vol. 12, p.408.
[101] *OSA*, Parish of Alford (1795), vol. 15.
[102] Barrett, *The Making of a Scottish Landscape: Moray's Regular Revolution, 1760-1840*, 94–118.

country's surface and subsurface.[103] By the nineteenth century most limestone strata had been discovered in Scotland. Attention turned towards the identification of commercially viable quarries, taking into consideration ease of extraction and the strategic location of fuel for burning and markets for sale. Roy Porter suggests that, unlike other industrial activities of the eighteenth and early-nineteenth centuries, the development of geological science and mining expertise took place largely in parallel, rather than one influencing the other.[104] Consequently, many 'time honoured' ways of discovering and accessing minerals persisted until the end of the eighteenth century.[105]

Prospecting for limestone took many of the forms associated with the search for other minerals, chiefly coal. The digging of shallow trenches with the aim of uncovering outcrops presented one relatively cheap if imprecise method of prospecting. However, by the mid-eighteenth century sinking bore holes had become a more established means of peering below the surface. The Scullingour working papers from the early part of the nineteenth century illustrate the extensive boring and analysis of limestone quarries conducted by the proprietors in order to determine the economic potential of the site.[106] The costs involved in this kind of prospecting meant that 'rule of thumb' methods for locating limestone persisted among small scale producers since it was often simpler to dig trial pits to assess the stone directly.[107] Another means by which limestone may well have been discovered and accessed was hushing. This process involves the use of fast flowing water forced down channels to remove soil and dislodge boulders of limestone (or other desired rocks). Although Johnson found evidence of hushing for limestone in the Pennines, no clear mention of hushing appears in any of the sources consulted in the present study, and there are no known archaeological records of hushes associated with limestone in Scotland.[108] However, Duckham speculates that occasional natural hushes would have occurred following downpours, revealing outcrops and

[103] R. C. Boud, "The Highland and Agricultural Society of Scotland and John Macculloch's Geological Map of Scotland," *Cartographica* 22, no. 2 (1985): 92–115; Boud, "The Highland and Agricultural Society of Scotland and the Ordnance Survey of Scotland, 1837-1875."
[104] Roy Porter, "The Industrial Revolution and the Rise of the Science of Geology," in *Changing Perspectives in the History of Science: Essays in Honour of Joseph Needham* (London: Heinemann Educational, 1973), 320–43.
[105] Rachel Lauden, *From Minerology to Geology* (London: University of Chicago Press, 1987), 50–57.
[106] Scullingour Working Papers, [date] (MIT T-LX6/21/1).
[107] Duckham, *A History of the Scottish Coal Industry, Vol. I 1700-1815*, 44.
[108] Johnson, "Hushes, Delfs and River Stonary: Alternative Methods of Obtaining Lime in the Gritstone Pennines in the Early Modern Period."

boulders as the top-soil was washed away. Rev. Asher's comments regarding finding limestone 'in every burn' also allude to this being the case.[109]

When limestone was unavailable or too costly to import, other calcareous materials were utilised to make lime for building or for farming. For example, an early first-hand account from the parish of Kirkinner, in Galloway, dating from the seventeenth century describes the burning of cockleshells washed ashore by storms ('the onely lime which this countrey affoords [sic]') to produce 'excellent lime . . . [that] binds stones together surer and better than stone lime itself'.[110] Mussel shells collected by fishermen in Findhorn continued to be burnt for lime of a high quality until the start of the nineteenth century.[111] Fragments of shells can also be found in many excavated kilns, such as the one at Mollinsburn in North Lanarkshire, although these could also have been embedded in limestone itself.[112] Another alternative source of calcareous material was from the mortar of ruined stone buildings; in Aberdeenshire it was observed that 'the rubbish of old houses, consisting chiefly of dry lime mortar and plaster reduced to powder, sells at a good price as manure'.[113]

The chemical composition of limestones determined the applications to which it was suited, while the nature of the burn (including the kiln design, fuel type, temperature reached and so on) determined the quality of the resulting product. High quality lime, with low ash content and attractive colouring, was sought for things like mortars and plasters. Similarly, industrial activities such as smelting required a consistent product of known properties. Lower quality products could be more readily used for farming, although again higher calcareous content produced better results on soil. Only rocks of suitable quality could justify the expense of bringing fuel to meet it.[114] As with locating the stone, these qualities were initially determined by first-hand experience – the ease with which it could be calcined, the effect of the lime on the soil, the quality of the mortar. Strata of known qualities were

[109] Duckham, *A History of the Scottish Coal Industry, Vol. I 1700-1815*, 41.; *NSA*, Parish of Inverarnan (1832), p.127.
[110] Arthur Mitchell (ed.), *Geographical Collections Relating to Scotland Made by Walter Macfarlane*, 1906: 79.
[111] William Leslie, *General View of the Agriculture of the Counties of Nairn and Moray*, (1813): 283.
[112] Alexander, "Excavation of a Small Limekiln at North Medrox, Mollinsburn, North Lanarkshire."
[113] James Anderson, *General View of the Agriculture and Rural Economy of the County of Aberdeen*, (1794): 106.
[114] John Sherriff, *General View of the Agriculture of the Orkney Islands*, (1814): p.113.

followed and identified primarily by the colour or aesthetic features ('the experienced workman can in general distinguish by eye', 'the limestone is blue, with beautiful veins of white').[115] Colloquial assignations were widely used: Lord Kames favourably described the limestone at Leny for example as 'sort of bastard marable [sic]' capable of producing high quality lime.[116] The identification of limestone strata was prone to speculation and confusion before the development of modern geology.[117] One notable example of this kind of ad hoc discovery comes from the parish of Portmoak, in Fife:

> In the fissures, which vary in size, are found a great variety of petrifactions, and a substance resembling ice, which the quarriers were accustomed to throw away, but latterly have burnt, finding it to be the purest lime.[118]

By the nineteenth century the increasingly professionalised universities were called upon to provide chemical and geological insight into the nature of limestone deposits and to give recommendations as to their economic value and potential applications. In 1848, the factor of the Duke of Montrose's estate sent two samples of limestone from Buchanan, in western Stirlingshire, to Frederick Penny, professor of chemistry at the Andersonian University in Glasgow.[119] The samples were taken from two strata of limestone found near the old manse: one from the uppermost layer of white limestone and the other 'from the top of the bed first below the white . . . what people call the "div lime"'.[120] Professor Penny declared the first sample to be 'a very rich specimen of magnesian limestone', 'hard and compact susceptible to a fine polish, . . . well adapted for use as a building stone'. When burnt the limestone yielded a 'yellowish-brown lime, which slakes with difficulty and when in power hardens under water and forms a solid mass'. However, it was declared 'decidedly unfit for general agricultural purposes.'[121] This information was then conveyed to the Duke by William Jolly, who expressed his disappointment at the unsuitability of the material for the field. With continued

[115] *NSA*, Parish of Old Deer (1840), vol. 7, p.142; *OSA*, Parish of Aberfoyle (1794), vol. 10.
[116] Proposals by Lord Kames with respect to the lime stone quarry of Leny, 1762 (NRS E777/259/1).
[117] Bailey, "Lime and Limekilns in the Falkirk District."
[118] *NSA*, Parish of Portmoak, (1839), vol. 9, p.31.
[119] The Andersonian University (or Anderson's University) later became, and continues to be, known as the University of Strathclyde. Professor Frederick Penny's papers can be found in the University of Strathclyde Archives (GB 249 OM/126).
[120] Letter, William Jolly to Duke of Montrose, 28/02/1848 (NRS GD220/6/557/21).
[121] Chemical analysis of a specimen of limestone from Buchanan, Frederick Penny, Professor of Chemistry, 1848 (NRS GD220/6/556/48).

excavation they hoped to access a seam of prized 'Aberfoyle Blue' limestone.[122] A kiln of each type was then burned by Jolly in order to determine for himself the quality of their respective products.

From these examples, the different types of knowledges deployed are evident – from the practical, experiential knowledge located at the site of utilisation, to more formalised types of knowledge contained in centres of learning. Discovering and valuing resources also changed, becoming more systematic, scientific and commercial with time.

4.3.2 'Winning the lime rock'

The quarrying and mining of limestone were fundamental to lime burning. Early workings, as mentioned above, typically made use of easily accessible outcrops of rock, where the limestone was exposed at the surface. Limestone boulders were also utilised. Shallow, opencast quarries, where the surface material was removed (or 'tirred') were common, referred to as the 'usual way'.[123] Explosives were used to break apart the rock face, and the men used iron tools to prise apart the blocks of stone.[124] The process relied heavily on the labours of quarriers and draught animals. By the nineteenth centuries, a number of quarries employed steam engines to carry stone away from the quarry face.[125]

Valuable limestones were followed underground: '[w]here the lime is very valuable, the whole stratum is sometimes worked out, as the roof supported by posts or props of wood, in the same manner as coal is worked in Shropshire or the long-way, as the miners term it.'[126] Such mining was more expensive, and many works were abandoned where extraction became uneconomical. Having produced an average of almost 27,000 bolls of lime per year between 1818 and 1841 (yielding almost £70,000), Ardonald lime work closed in 1857 once heavy overburden rendered the remaining stone too difficult to reach.[127] At Park lime works in Dumfrieshire, the 20 degree slope of the quarry drove

[122] Letter, William Jolly to Duke of Montrose, 28/02/1848 (NRS GD220/6/557/21).
[123] *OSA*, Parish of Logie Pert (1793), vol. 9, p.37.
[124] State of expenses Dr Hunter's lime quarry for the year 1793 (NRS GD71/233); Askomill Lime Works cash book, 1849 (ABC DR/4/2/1).
[125] 'Lime Works at Raw Camp for 1800' (NRS GD150/2359); 'Garnkirk Limeworks' 11/09/1808 (GD44/39/30/3).
[126] Robert Belsches, *General View of the Agriculture of the County of Stirling: with observations on the means of its improvement* (1794).
[127] NSA Parish of Cairnie (1842), vol. 12, p.1017; Robertson, Simpson, and Anderson, *The Limestones of Scotland*, 79.

the development of water power to drive pumps and carts, eventually bringing its proprietor, Charles Menteath, much acclaim.[128]

Since limestone is the heaviest part of lime production, and it loses half its weight during calcining, limestone itself usually travelled little during working. Most kilns were sited near the source of limestone.[129] This was especially true of the larger commercial lime works, which were typically integrated within a broader quarry site. By the 1830s several of the larger limeworks, particularly around the Central Belt, were employing railways to carry limestone from the quarry face to the kilns. At Nethertston Limeworks, for example, the stone was loaded into a cart, which was pulled along a rail by a man.[130]

Waterborne limestone could travel longer distances. At the end of the eighteenth century, Fullarton noted that limestone was brought as ships' ballast from Lerne [Larne] in Ireland and landed on the Ayrshire coast, where it cost 3s 6d per ton of stones delivered at the harbour.[131] Other small harbours may also have received limestone to be burned on the coast. This was likely the case at Kingsbarns in Fife, where the remains of a clamp kiln can be found just behind the beach.[132] In areas without local resources, kilns were often located on the coast to receive fuel or stone.

Some evidence from small-scale domestic agricultural burning runs counter to the commercial experience. Several accounts suggest that many farmers brought limestone to their farms to be burned. The stone was usually purchased from a quarry which itself probably also burned lime – many works note the sale of 'raw' limestone alongside lime shells and slaked lime. For example, George Robertson described the practice in Ayrshire in 1829:

> Lime required for manure is generally purchased by the farmers in its raw state, in blocks or pieces, as it comes from the quarry. They cart it home during the summer,

[128] Clarke, "The Closeburn Limeworks Scheme: A Dumfriesshire Waterpower Complex."
[129] Bishop *et al.*, "Lime Burning in Clamp Kilns in Scotland's Western Central Belt: Primitive Industry or Simple But Perfectly Adequate Technology?"
[130] J Wallace, 'Account of the Method of Calcining Limestone in Some of the Limestone Quarries in Scotland', *Transactions of the Highland and Agricultural Society of Scotland,* vol. 5, (1837): 448.
[131] Col. William Fullarton, *General View of the Agriculture of the County of Ayr*, (1793).
[132] Thomas Christopher Smout, "Kingsbarns: A Farmers' Harbour," *Journal of Scottish Historical Studies* 36, no. 1 (2016): 2.

> and burn it in temporary turf-kilns, made on the fields where it is to be applied, and nearly on the spot where it is to be laid.[133]

Sometimes both fuel and limestone were procured at distance. At the end of the eighteenth century James Robson observed that tenants in northern Perthshire 'drive coals from twenty to thirty miles, and limestone ten or fifteen miles, to meet these coals, and burnt it on their farms, and find their advantage in doing so.' Similar activity was noted in Dunkeld where 'a great proportion of farmers have their lime-kilns for farm purposes', but limestone was gained from the parish of Blair, 'twelve miles distant'.[134]

Where fuel, particularly peat, was plentiful, some farmers sought to turn a profit through the sale of lime to their neighbours, without engaging in a wholly commercial enterprise.[135] This appears to have been the case in several places, including the parishes of Deskford, Keith and Grange in Banffshire, where a large concentration of farm kilns can be found on OS first edition maps dating from the early 1870s.[136] The *NSA* entry for Deskford from 1836 describes these kilns as being supplied with limestone from a nearby quarry, which was then 'prepared by the tenantry, partly for sale, and partly for their own use in agriculture and in building.'[137] As Johnson argues, most small field kilns, even those of a draw design, could not have been run continuously for long (the operation of kilns is a subject that will be addressed to a fuller degree in the next chapter). The amount of labour, materials and market opportunities required simply would not support it.[138] Tenant farmers were recommended to erect kilns only when to do so would be cheaper than importing from some other areas.[139] Therefore, to ensure a steady local supply without turning to the large commercial producers, farmers may have effectively taken turns to burn lime, sharing or selling the excess. The proliferation of field kilns in the archaeological and cartographic record, that were distant from both raw materials and larger lime works would appear to support this explanation. However, these examples remain

[133] George Robertson, *Rural Recollections; or the Progress of Improvement in Agriculture and Rural Affairs*, (1829): 618.
[134] James Robson, *General View of the Agriculture in the County of Argyll. And Western Part of Inverness-shire*, (1794): 27; *NSA*, Parish of Dunkeld (1845).
[135] *OSA*, Parish of Rothiemay, p.389.
[136] OS six inch first edition, Banffshire sheets 8 (1871) & 14 (1871).
[137] NSA, Parish of Deskford, vol. 8, p.65
[138] Johnson, *Limestone Industries of the Yorkshire Dales*, 62–63.
[139] John Shirreff, *General View of the Agriculture of the Orkney Islands*, (1814): 192.

contrary to the norm, and as the industry became more industrialised into the nineteenth century and the tendrils of infrastructure extended northwards and inland, it was the product itself—lime—which travelled the greatest distances, as the following section will show.

Figure 39 Plan of the limestone quarry of Craighead, in Dailly, Ayrshire, 1797 (NRS RHP1628). Limestone was carried a short distance from the quarry face to be loaded in the head of the four draw kilns. Coal was led up to the working platform along a short road. The burned lime was then drawn out level with the lime road and carted off for sale.

As lime burning became more industrialised, with greater volumes of material extraction and movement, lime kilns can be seen as the 'focal point' of broader industrial landscapes comprising quarry workings, coal mines and connecting infrastructure.[140] Compared to the *burning* of limestone, encompassing the design and operation of kilns, the efficiency of quarrying and immediate movement of material appears to have been of paramount concern for proprietors of commercial lime works. For example, the Duke of Gordon papers from the first decade of the nineteenth century contain reports, compiled by his factor, of lime works that were contemporary (and competitors, albeit distantly) to his own at Ardonald. In each case careful attention is paid firstly to the expense and method quarrying of the limestone and conveying it to the kiln head, and secondly to the fuel

[140] Bailey, "Hullerhirst Quarry and Lime Kilns, North Ayrshire," 107.

consumed. The observations at Garnkirk, for example describe the use of an 'engine' to break stones from the wall face, the use of another engine to draw the stone 'along an iron rail from the quarry', where it was placed on a scaffold and then 'thrown at once into the kiln without prior breaking'.[141] Similarly, the method and costs of quarrying of the rock and conveying it to the kilns is recounted in such detail for Hedderwick works that even the fact that the quarrying tools were provided by the master and returned at the end of the day was noted, yet almost no attention is given to the design or operation of the kilns in which the limestone was calcined.[142] This focus on extracting and moving resources (rather than on the process of calcining itself) is a feature of the accounts kept for commercial lime works, especially as the nineteenth century wears on. The records from Scullingour, which date from the 1840s to 1860s, make no mention of the lime kilns at the site—other sources, including maps, reveal that clamp kilns were used. However, in the earlier part of the eighteenth century, when the practice of lime burning was still relatively new in many places, closer attention was paid to kiln design, as is discussed in Chapters Five and Six.

4.4 Lime

4.4.1 Slaking and storing

Once burned, lime underwent its own transformations and movements. After the kiln's contents had been removed, unburnt stones were sometimes sieved out or 'riddled' and sold separately from the lime shells as 'flour' that could be spread over fields.[143] Although for many applications lime was slaked before use, most lime was sold dry as 'shells'. At Ardonald, for example, accounts from 1804 show that 23,505 bolls of shells were sold compared to just 388 bolls of slaked lime.[144] Since slaked lime contained water, lime shells were the lightest form in which lime could be transported, which may explain its popularity. However, the powerful exothermic reaction produced when quicklime comes into contact with water meant that transporting shells could be dangerous. Carts, carriages and ships were known to be occasionally set on fire by the heat.[145] In 1838 the sloop *Union*, of Limekilns,

[141] 'Garnkirk Limeworks' 11/09/1808 (GD44/39/30/3).
[142] Memorandum of Hedderwick Lime Works from James Kandow's information (NRS GD44/51/30/14).
[143] J Wallace, 'Limestone Quarries in Scotland', p.449.
[144] John Menzie's state and accounts for Ardonald Lime Works, 1804 (NRS GD44/51/536/1).
[145] Nisbet, "'A Hot Cargo' The Waterborne Supply of Lime in Scotland."

caught fire while sailing up the Forth loaded with lime. Sailors threw sand over the lime to slow the fire, but eventually the ship was lost, thankfully taking with it only its cargo.[146]

During storage it was essential to prevent lime from slaking naturally with rainwater or moisture in the air so that burners could ensure a consistent and high-quality product. Lime was typically not stored for long if it could be helped. The urgency of shipping lime stocks is clear in letters to Perth lime merchant Robert Drummond from his supplier in Sunderland: 'I wish you could send me a few vessels to load as the lime is now very good and I am afraid of its getting small if it lays too long'.[147] In the Lothians, so short was the time between burning and sale that the lime was said to be 'sold hot',[148] a practice recommended by some agriculturalists.[149] However, lime produced at works and unsold during the 'season' (spring to autumn) was usually kept and sold the following year. Occasionally a 'lime house' was erected (a few are labelled on early OS maps) for storage purposes.[150] Slaking at the kilns was more common where lime was to be used on contiguous or nearby fields. Radcliff's advice on positioning a lime kiln suggests that access to water was an important consideration: 'in the vicinity of water is to be preferred, as the sods are the more easily raised, and the lime may be converted into powder by the water on the spot where it is burnt '.[151]

4.4.2 Transporting lime

The early stages of the lime industry are characterised by relatively limited travel of lime. As with fuel, distance added cost. Many of the first kilns for agricultural or building use served adjacent construction sites or contiguous fields. The poor state of roads before the latter part of the eighteenth century meant that procuring lime for agriculture from other districts, particularly overland, was an arduous task. At Longforgan, in Perthshire, the minister remarked that 'the idea of bringing lime or

[146] 'Ship burned', *Inverness Courier*, Wednesday 1st August 1838, p.2.
[147] Letter, Mr Baker, Gill, to Mr Drummond, Perth, 29/07/1817 (PKC MS32).
[148] George Buchan-Hepburn, *General View of the Agriculture and Rural Economy of East Lothian*, (1794): 85.
[149] David Young, *Agriculture, the Primary Interest of Great Britain* (1788): 168.
[150] Skinner, *The Lime Industry in the Lothians*.
[151] Radcliff, 'On Burning Lime with Peat', 160-161; Alongside limestone and fuel, water might be considered a third key resource in lime production. Not only is it used to slake lime, it afforded some protection from heat or fire. The energy from streams was used to power quarry engines and drive infrastructure, while attempts were also made to turn it to the grinding of limestones. Furthermore, kilns sited on the coast or by navigable rivers could make use of the waterways to import and export materials.

dung from any distance was scarce to be entertained' before the construction of new roads around the year 1790.[152] In 1768, the 'novelty of bringing lime' was introduced to the parish of Killearn in west Stirlingshire by the then minister, before which lime had 'never been thought of as a manure'.[153] Nevertheless, as the agricultural value of lime became more widely known, a growing number of improving farmers in areas unable to produce their own lime were making journeys to collect it and encouraging the infrastructure to facilitate further trade. These early efforts were the preserve of a pioneering (and monied) few. One such individual from Roxburghshire is described thus by Robert Douglas:

> Mr Brown, late of Elliestown, deserves to be recorded, both as a principal promoter of a road thro' the centre of the country, and also as one of the first great proprietors, who brought lime by that road, and the western road by Gala-water, from Mid-Lothian, and by cross-roads from Northumberland, each 27 or 28 miles from his estate, in such quantities as to manure completely at least 150 acres; at a time, too, when such an undertaking was apt to be considered as a certain indication, either of a disordered mind, or of an overflowing purse. [154]

By the end of the eighteenth century, frequent journeys to collect lime had become a mainstay of farming in many areas. On the Duke of Buccleuch's south country estates in 1780, his factor William Kerr remarked that some tenants, since no other minerals were locally available, were bringing lime more than 24 miles overland from Northumberland. At such a distance it was expensive to use as a manure (spread at a cost of £3"10 per acre), but still the tenants 'found it preferable to use lime as a manure even at that expense'.[155] James Badenoch's diary shows that each year numerous carts made the eighteen mile round trip between his farm near Stonehaven and a quarry at Mathers to collect lime for building work and use on the fields.[156] During the summer season, when lime was laid on the ground, several loads of lime could be collected each week, with longer journeys often requiring carters to travel overnight.[157]

[152] *OSA*, Parish of Longforgan (1797), vol. 19, p.552.
[153] *NSA*, Parish of Killearn, (1845), vol. 8, p.71.
[154] Robert Douglas, *General View of the Agriculture of the Counties of Roxburgh and Selkirk*, (1798): 138-139.
[155] Report on Marle at Eckford, William Keir, November 1780 (NRS GD224/522/1/3).
[156] Pearson, *Flitting the Flakes: The Diary of J. Badenoch a Stonehaven Farmer 1789-1797*, 44–45.
[157] Alexander Lowe, *General View of the Agriculture of the County of Berwick*, (1794): 54.

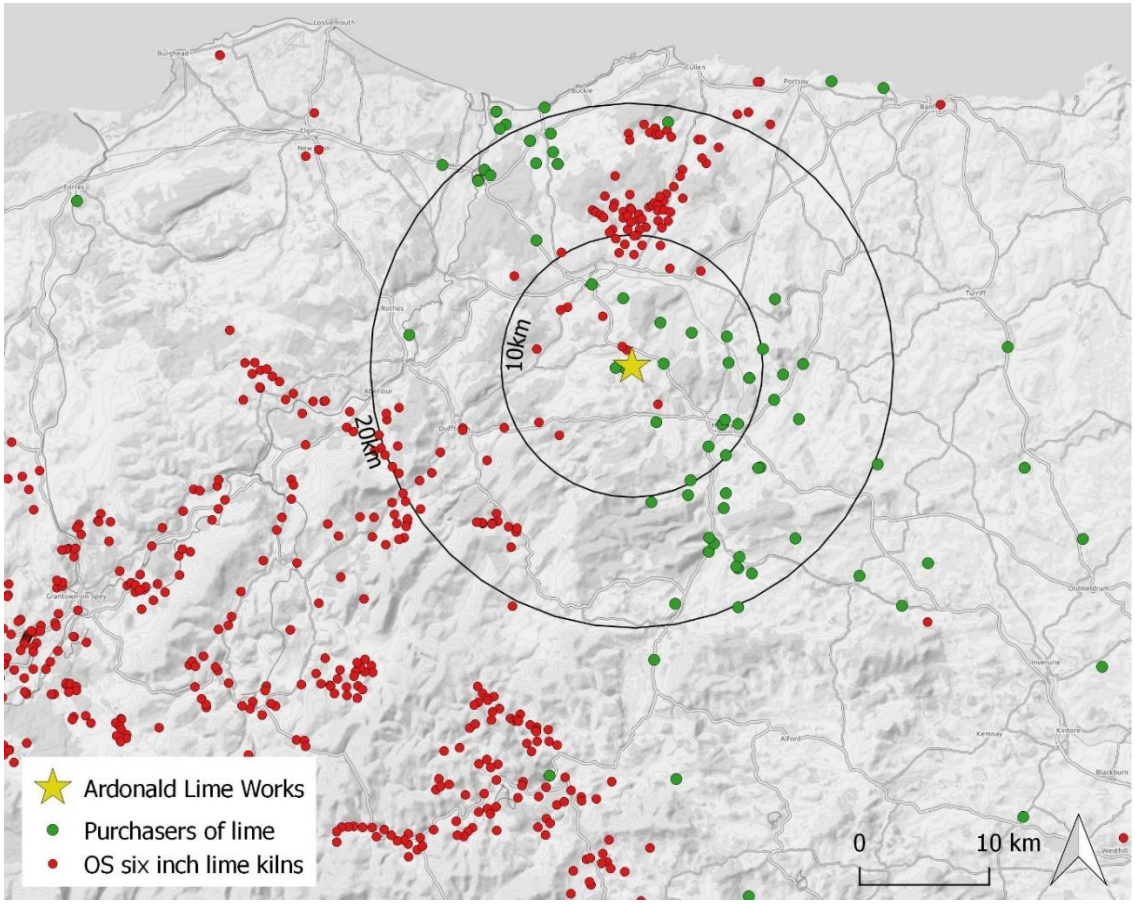


Figure 40 Location of purchasers of lime (in green) from Ardonald Lime Works in 1805. Locations were parsed from a list of persons to whom lime was sold on credit.[158] Comparison with the location of lime kilns on the first edition six-inch OS map (in red) suggests that lime works such as Ardonald primarily served areas where lime was not burned domestically.

Sales receipts from Ardonald (mapped in Figure 40) show that inland lime works could supply lime to large area, with some purchasers coming as far as 28 miles.[159] The distribution of sales also shows how commercial lime works primarily served areas where farmers did not burn their own lime. Statistical account entries from 1845 support the map findings, such as from the neighbouring parish of Gartly where lime was 'so small in quantity' that the farmers would obtain lime from Ardonald in the neighbouring parish at a cheaper rate.[160]

[158] Most customers of the lime works bought lime with ready money, so those who purchased on credit represent only a minority of the customer base. The list of credit sales noted customer location, likely as a means of identification and to help recover debts. Some of the places recorded in the ledger could not be linked to known places and so were omitted from the map.
[159] Inventory of lime sold on credit, 1805 (NAS GD44/51/536/1).
[160] *NSA*, Parish of Gartley, (1845), p.96.

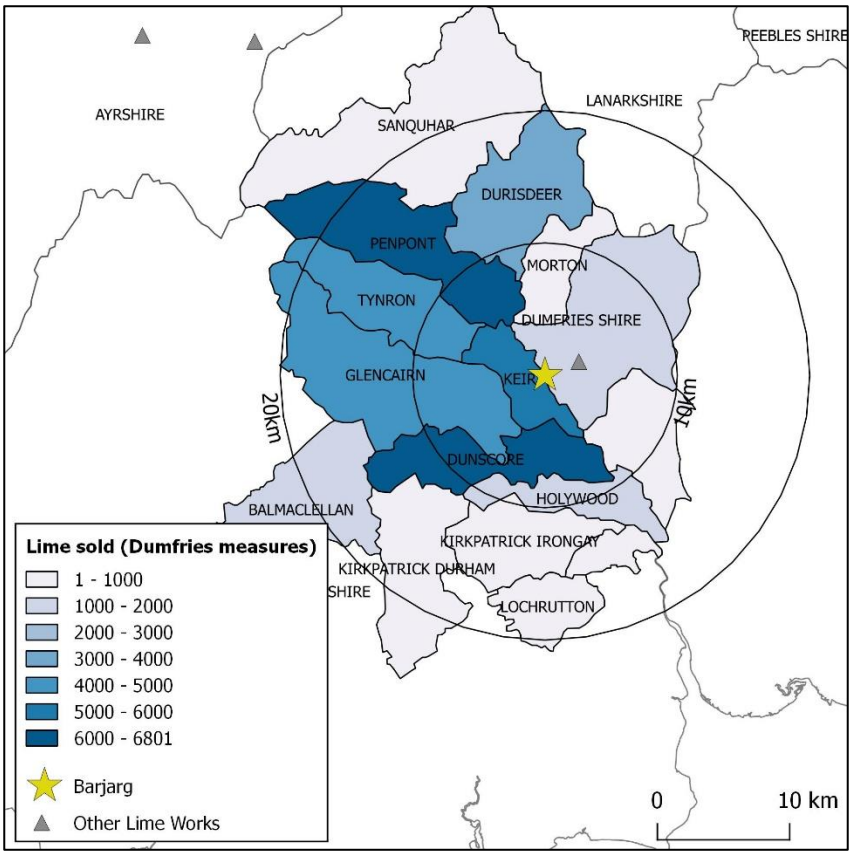


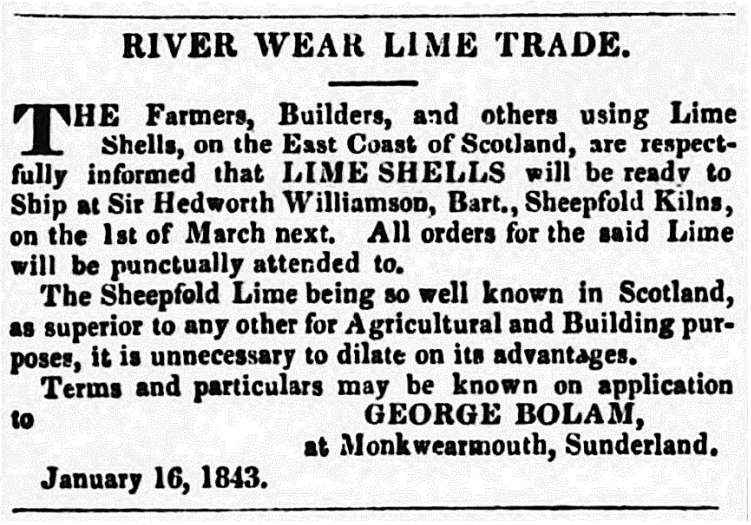
Figure 41 Parishes to which lime was sold from Barjarg lime works, 1805. According to the ledger, 156 measures made their way to Dalry parish (off the map), 80km to the northeast.

Accounts from the works also indicate that almost one third of the 23,505 bolls of shells sold in 1804 were recorded as having been sold 'mostly to coal drivers' at a reduced price of 2/ per boll, suggesting that the carters that transported coal from the coast to the lime works may have purchased lime for resale further inland as they continued their journeys.[161] At Barjarg works in Dumfriesshire, most lime was sold to parishes within 13 miles.

In areas with access to the sea, consumers and producers of lime could take advantage of the costal lime trade that emerged during the eighteenth century. The west of Scotland saw only limited shipping of lime, largely due to a lack of large lime works, the circuitous coastline, and low levels of population and improved farming north of Helensburgh. Some attempts were made to export lime commercially from the Island of Lismore in the latter half of the nineteenth century, but these were

[161] Account of charge and discharge of John Menzie's Management of the Lime Works at Ardonald, season 1804 (NAS GD44/51/536/1).

restricted by the cost of fuel and limited markets.[162] In the south, English lime was landed in Dumfries and Kirkcudbright.[163]



RIVER WEAR LIME TRADE.

THE Farmers, Builders, and others using Lime Shells, on the East Coast of Scotland, are respectfully informed that LIME SHELLS will be ready to Ship at Sir Hedworth Williamson, Bart., Sheepfold Kilns, on the 1st of March next. All orders for the said Lime will be punctually attended to.

The Sheepfold Lime being so well known in Scotland, as superior to any other for Agricultural and Building purposes, it is unnecessary to dilate on its advantages.

Terms and particulars may be known on application to GEORGE BOLAM, at Monkwearmouth, Sunderland.

January 16, 1843.

Figure 42 An example of lime from Sunderland being advertised for sale on the north-east coast of Scotland. *Inverness Courier,* Wednesday 25 January 1843, p.1

On the east coast, however, by the end of the eighteenth century the lime trade was extensive and dominated by the large lime works in Fife and the north east of England, particularly those at the mouths of the rivers Tyne and Wear (see Figure 42). A farm at Fintray, near Forfar, was said to be taking advantage of lime from both Sunderland and 'Lord Elgin's kilns' at Charlestown (Figure 43) in 1778, the lime priced at 21d. and 19½d. per boll respectively.[164] James Anderson noted in 1794 that large quantities of lime shells from the same sources were landed at Aberdeen and sold to farmers at a more expensive rate of 3s to 3s 4d. the boll.[165] He also mentioned lime arriving by ship from the Baltic, although he did not elaborate further on its source, quantity or qualities.[166] Further north in Moray, where the properties of lime were said to have been known since the beginning of the eighteenth century, imports from Fife and Sunderland began to appear around 1790.[167] Even in Caithness importing from Sunderland was considered 'the cheapest mode of furnishing lime' at the

[162] Martin and Martin, "The Lismore Limekilns."
[163] Bryce Johnstone, *General View of the Agriculture of the County of Dumfries*, (1794): 23; *OSA*, Parish of Kirkcudbright (1793), vol. 7.
[164] Andrew Wight, *Present State of Husbandry in Scotland*, (1778): 325.
[165] James Anderson, *General View of the Agriculture and Rural Economy of the County of Aberdeen*, (1794): 105.
[166] *Ibid*, 17.
[167] William Leslie, *General View of the Agriculture of the Countries of Nairn and Moray* (1813), p.282.

beginning of the nineteenth century.[168] Buying from large commercial producers, even at such great distances, was often, it seems, a question of reliability and convenience over cost—farmers could be assured of procuring the full quantity needed 'readily and at once' without committing to the labour of burning it themselves.[169]

Figure 43 View of ships at Charlestown harbour with lime kilns in the background, 1882. Scanned image from plate glass negative. Original envelope annotated by Erskine Beveridge 'Ships at Charlestown'. RCAHMS: Erskine Beveridge (N Maylan Collection)

Establishing and maintaining this kind of long-distance trade required networks of merchants and suppliers linking producers and consumers. One such person was Robert Drummond (1768-1819), a farmer and lime merchant from Perth.[170] He purchased large quantities of lime from Sunderland and the Earl of Elgin in Fife, which he then sold on to farmers from nearby districts.[171] Indeed, Perth was a key node from which several upland areas were supplied with agricultural lime.[172] From Sunderland he appears to have negotiated a favourable rate for sought after 'blue' lime—one contact, a Mr Baker from Gill (near Sunderland) wrote in 1817: 'you'll be so good as not to mention to any person the

[168] John Henderson, *General View of the Agriculture of the County of Caithness*, (1812).
[169] Leslie, *General View Nairn and Moray*, p.282.
[170] Biographical information from Perth & Kinross Council archive record description: person NA14639, Robert Drummond.
[171] Letter, McIntyre to Drummond, 09/06/1817 (PKC MS32).
[172] *OSA*, Parish of Clune (1793), vol. 9, p.276; *OSA*, Parish of St Martins (1794), vol. 13, p.633; William Marshall, *General View of the Agriculture of the Central Highlands of Scotland*, (1794).

price that I have offered you the Blue Lime at'.[173] Much of his role was gauging local demand for lime and communicating that to the Wearside works, as well as arranging freight to collect it and land it in Perth. Baker wrote to him:

> I should like to have your opinion respecting the sale of Blue Lime next year, the quantity that you think you could sell, I understand from my Captains that the farmers likes the Blue Lime, I should suppose a quantity could be vended, and also if you could engage vessels to load it, they should be fixed for the season as there is no certainty without it, and it is a great disappointment when they do not come according to promise.[174]

Merchants like Drummond clearly played an important role in facilitating and encouraging lime production and trade by connecting networks of consumers and producers. Other goods were also traded together with lime. Thomas Brunton from Southwick wrote to Drummond in 1816 offering him the opportunity to have wheat or barley carried on the return journey from Perth to Newcastle, where there was 'an excellent market for these articles'.[175]

Lime burners were keenly aware that the coastal lime trade offered the best prospect of profitable returns. Robert Hogg, factor to Sir Hew Dalrymple of Drummore, wrote to his master in London in 1754 informing him of his progress in purchasing a sloop with which to trade in lime and other goods. Dalrymple was, at the time, in the process of constructing draw kilns on his North Berwick estate. Shipping the lime from these kilns could, Hogg proposed, 'treble profit' above the existing land borne trade (sales to the 'country').[176] About a third of the annual output of Cults lime works in Fife (approximately 25,000 bolls) in middle of the nineteenth century was shipped at Newburgh for Dundee and Perth. From there it was carried overland to Dunkeld, Crieff, Methven, Cupar and Angus, and other inland areas.[177] At the largest scales of production, much of the growth of Lord Elgin's famous lime works at Charlestown was based on the favourable positioning of high quality resources, but its coastal position also allowed it to reach an extensive market, from nearby farmers along the Forth to the most northerly parts of Scotland. Indeed, due to the consistency of its hydraulic

[173] Letter, Baker to Drummond, 19/05/1817 (PKC MS32).
[174] Letter, Baker to Drummond, 11/09/1817 (PKC MS32).
[175] Letter, Thomas Brunton to Drummond, 05/06/1816 (PKC MS32).
[176] Letter, Robert Hogg to Sir Hew Dalrymple, 1754 (NRS GD110/927/39).
[177] *NSA*, Parish of Cults (1845), vol. 9, p.558.

limes, which were attractive to architects and engineers, some shipments were sent as far afield as Sweden and Canada.[178] Given these distances, it is noteworthy that so few Charlestown lime sales were destined for the west coast of Scotland.

4.5 Infrastructure

The development of the lime industry had a significant and material impact on many aspects of the infrastructure in Scotland. As farms and industries became more reliant on lime, the means of meeting that demand became of great concern to landowners.

4.5.1 Vehicles

At the start of the eighteenth century, Scotland was virtually 'a land without vehicles'.[179] Cart routes were few and far between, primarily serving to connect the major towns. These early roads were often highly seasonal, becoming impassable in winter and frequently washed out during periods of heavy rain. Lime and other goods were thus typically carried on horseback, a practice that continued in places until around 1770.[180] Approximately four to six bushels could be tied to each horse, meaning that multiple journeys would often had to be made to collect sufficient lime for a farm of moderate size.[181] James Donaldson described the way horses were used in Banffshire forty years prior to his writing in 1793:

> In those days, creels, or *currocks*, a semi-circular basket made of twigs, and fixed on one side of a horse by means of a kind of saddle supplied the place of the dung cart, and were also employed in carrying the stock of fuel from the moss. The grain, meal and lime (of which last article from 50 to 60,000 bolls were annually exported . . .) were carried in sacks on horses backs, often for ten, fifteen, and sometimes twenty miles on a stretch. [182]

Similarly loaded donkeys were depicted by Pyne in his *Costume of Great Britain* from 1804 (Figure 44). Evidently the transport of lime and other produce required a great expenditure of human and animal labour. As the practice of liming became more widespread and the carting of lime grew in

[178] Scottish Lime Centre Trust, *Charlestown Limeworks: Research and Conservation*.
[179] Donnachie, "Roads, 1600-1900," 314–15.
[180] John Wilson, *General View of the Agriculture of Renfrewshire . . . and an Account of its Commerce and Manufactures,* (1812).
[181] William Leslie, *General View of the Agriculture of the Counties of Nairn and Moray,* (1813).
[182] James Donaldson, *General View of the Agriculture of the County of Banff,* (1793): 19-20.

importance, more horses were required for carrying lime than had previously been sufficient for transporting crops to market and ploughing the fields in winter.[183] The growing reliance on horses for carrying loads, and later pulling carts, resulted in another change to rural life: the decline of oxen as working animals on the farm. This transition was noted by a number of early-nineteenth century observers, who attributed it to the demands of transporting lime. [184] Others, such as Thomas Johnston, suggested that the decreased reliance on oxen was down to the introduction of the lighter Scots plough, although Johnston also noted that 'when oxen are kept, horses are needed also, for driving lime and coal, these being at so great a distance, and oxen not so expeditious in the cart as horses'.[185]

Figure 44 Donkeys carrying panniers loaded with lime. From Pyne's *Costume of Great Britain.* Aquatint with etching by W.H. Pyne, 1804. Credit: Wellcome Collection. CC BY.

Although providing carting services to an estate was at times an 'onerous burden' for tenant farmers, carrying lime became a profitable exercise in many parts of the country.[186] Rev. Thomas Birnie, for example, records the busy carting of lime in Alford, Aberdeenshire, in 1795:

> When Aberdeen carters are employed to transport lime-shells to this country, they are paid at the rate of 11s. or 12s. for every three bolls, according to the distance; three bolls, weigh about 1300 cwt, and require two horses, as neither the roads nor the horses are good. Some reckon this the cheapest way, but others hire the carters

[183] Alexander Lowe, *General View of the Agriculture of the County of Berwick,* (1794).
[184] George Buchan-Hepburn, *General View of the Agriculture and Rural Economy of East Lothian,* (1794): 138; John Shirreff, *General View of the Agriculture of the Orkney Islands,* (1814).
[185] Thomas Johnston, *General View of the Agriculture of the County of Tweedale,* (1794): 31.
[186] Terence J. Byres, "In Pursuit of Capitalist Agrarian Transition," *Journal of Agrarian Change* 16, no. 3 (2016): 446.

> to deliver the shells 15 miles from Aberdeen, where they take them up with their own cattle; and they pay at the rate of 20d. per boll; but it is not uncommon to send horses and servants to Aberdeen with grain, and even without a load, and to bring home lime-shells in return.[187]

Similarly, William Leslie noted that crofters in Banff engaged in 'a kind of trade' carting lime to neighbouring parishes.[188] By the mid-nineteenth century lime works afforded significant employment to carters. The minister for Cults, in Fife, remarked that the hundred or so tenant farmers engaged in carting between the limestone quarries and the port of Bewburgh 'but for the carting of coal and lime, would not afford sufficient work for their horses'.[189] Spurred by the lime trade, the growth in wheeled transport, both in terms of the number and size of carts, caused deterioration in the condition of roads, which had to be substantially improved to meet this new activity.[190]

4.5.2 Roads

Relatively little is known of the internal communications of the country prior to the middle of the eighteenth century. Until that point roads were constructed and maintained by local statute labour, organised primarily by overseers appointed by the Commissioners of Supply.[191] From 1750 onwards this system was replaced by the Turnpike Trusts, toll roads almost entirely financed by local landowners. These roads were a significant upgrade on their predecessors, enabling greater volumes and reliability of communication. Although few turnpikes were ever profitable in themselves, by enabling wider circulation of lime and fuel they stimulated a wider package of improvements in the areas they reached.[192] In some counties tolls were reduced for those carrying lime for manure.[193] Indeed, the connection between road building and access to lime (for building as well as agriculture) was stressed by many of the writers of the *General Views* and *Statistical Accounts*, either in calling

[187] *OSA*, Parish of Alford (1795), vol. 15, 466.
[188] William Leslie, *General View of the Agriculture of the Counties of Nairn and Moray*, (1813): 65.
[189] *NSA*, Parish of Cults (1845), vol. 9, p. 558.
[190] George Buchan-Hepburn, *General View of the Agriculture and Rural Economy of East Lothian,* (1794): 155.
[191] Donnachie, "Roads, 1600-1900."
[192] Smout, "Scottish Landowners and Economic Growth, 1650–1850."
[193] John Wilson, *General View of the Agriculture of Renfrewshire ... and an Account of its Commerce and Manufactures*, (1812): 176.

for new roads to be constructed or extolling the virtues of those recently laid. For example, the impact of improved infrastructure in Stow, near Galasheils, was enthusiastically recounted by its minister:

> Anno 1754, the turnpike roads from Edinburgh to Selkirk were made. This produced a total change in the system of farming. No lime had been brought to this country but for building, and on horse-back. The expence of this mode of carriage prevented the use of lime as a manure. A carriage-road being now opened to Middleton lime-kilns, the farmers, who before had only used sledges and tumbler carts to lead in their corn and earth-elding, (the winning and leading of which was the whole summer work of their servants and horses), to improve this advantage, now were induced to increase the number of their horses, and change the construction of their carts, to lead coals instead of peats, and lime for their land.[194]

Similarly, Alexander Lowe described the benefit of new bridges and roads in enabling long distance internal trade, whilst also observing the move away from the use of packhorses as a result:

> [Roads and bridges] have been of the greatest use in promoting the prosperity of the county of Berwick. The building of Coldstream bridge some years ago, and opening the west road to England, has produced a striking change upon the western part of the county. Coal and lime are now brought in carts to all parts of Lauderdale, and even to Teviotdale, from Lothian.
>
> Upon the eastern part of the county, since building the Pease bridge, the like access is opened to the lime works in East Lothian. At all seasons, by the goodness of these roads and bridges, there is ready access, free of danger, to markets, often near thirty miles: where the distance is so very great, they travel much in the night time, carrying to market, grain, the produce of the farm, and next day returning loaded with either coal or lime; neither of which, in the former state of the country, could have been attempted, except only when carried in bags upon horse-back.[195]

In addition to the turnpikes, considerable stretches of private road were laid by landowners, usually as part of the re-organisation of their estates. Likewise industrial ventures, such as mines, foundries, and indeed lime works, required connections by road or prompted the improvement of existing routes.[196] This new network of roads, of a quality and extent hitherto unseen, greatly facilitated the transport of lime, fuel and produce across much of Scotland. Andrew Wight remarked upon the activity along the roads laid on Lord Kames' estate in 1778, which he compared with the best turnpikes:

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[194] *OSA*, Parish of Stow (1793), vol. 7, p.135.
[195] Alexander Lowe, *General View of the Agriculture of the County of Berwick*, (1794).
[196] Proposals by Lord Kames with respect to the lime stone quarry of Leny, 1762 (NRS E777/259/1).

> Behold one remarkable consequence! Formerly nothing but sledges to carry corn from the field to the stack-yard: now carts are used every where, and the high-roads swarm with them, carrying coal, lime and other commodities.[197]

This investment by the landed-proprietors constituted perhaps the most significant contribution to the overall improvement of the nation, as Smout suggests: 'probably nowhere else outside purely agricultural activities did the eighteenth-century landowners sink so much capital, take so much initiative upon themselves, or do so much lasting benefit to their country'.[198] Naturally, their motivations were not only altruistic; new roads were advantageous to proprietors' own commercial interests. Wright, for example, recounted in 1784 the accomplishments of John Hamilton, on the Bargany estate in Ayrshire, who worked lime 'for his own interest and that of the neighbourhood'.[199] Being a 'public spirited gentleman', he diligently went about improving the roads on his lands (Figure 45) so that they could better admit wheeled carriage.[200] Of course, 'one immediate reward [for] his patriotism' was to 'increase considerably the demand for his coal and lime'.[201]

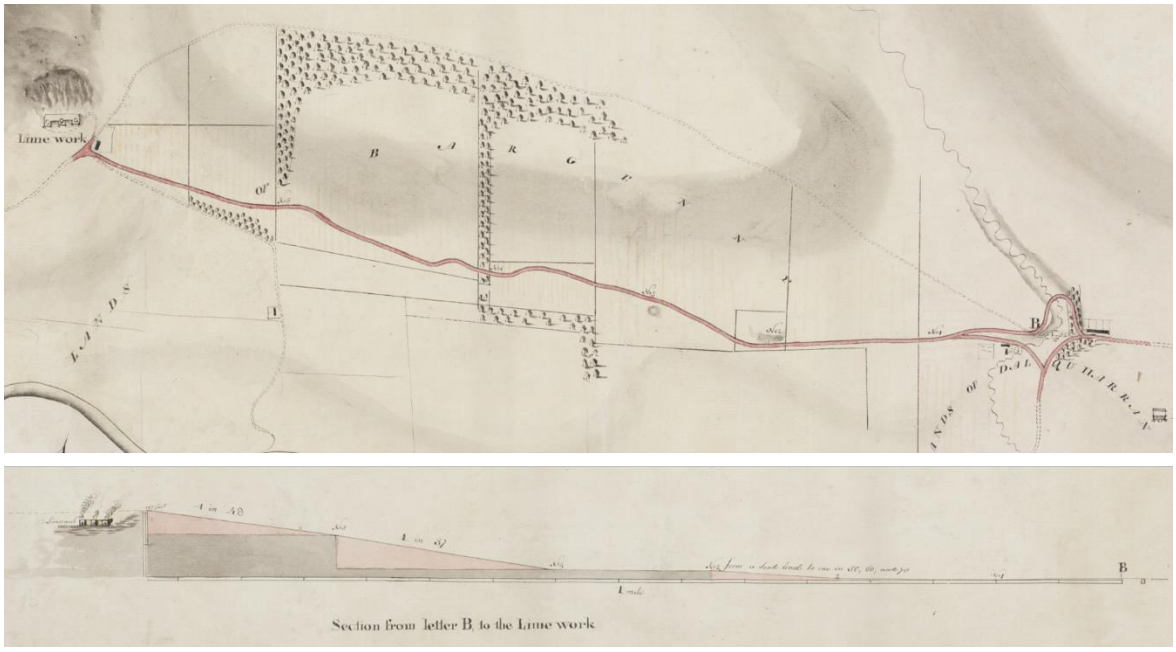

Figure 45 Two details from *Plan of the further extension of the lime road near Dalqgharran to the lime work of Bargenny*, 1800 (RHP2743).

[197] Andrew Wight, *Present state of husbandry in Scotland*, (1778): 379.
[198] Smout, "Scottish Landowners and Economic Growth, 1650–1850," 223.
[199] [Wright, Andrew], *Present State of Husbandry in Scotland. Extracted from Reports Made to the Commissioners of the Annexed Estates, and Published by their Authority*, vol. 3(1), (Edinburgh, 1784), p.153.
[200] *Ibid.*
[201] *Ibid.*

The growing need for vehicular transport and the purchasing of resources from outwith the farm or estate also constitutes an important part of the transition from feudal and subsistence modes of farming towards capitalist agriculture.[202] Purchasing lime required money, necessitating the sale of goods which in previous centuries had typically been used entirely to subsist and pay rent in kind. The farm became less of a self-contained entity, requiring more inputs from outside, such as fuel and fertilisers. This transition required different sources of power and labour, and vehicular transport became an important resource for farmers. As Lowe noted in Berwick in 1794, 'fifty or sixty years ago, there was hardly a farmer who had a cart in his possession', but by the time of writing they had become a near essential commodity.[203]

4.5.3 Shipping

Compared to overland transport until the extension of the railways, the bulk of Scottish domestic trade was carried on coastal shipping.[204] Those burning lime in areas away from the major coal fields also relied heavily on shipborne coal. These two articles, coal and lime, made up a significant proportion of the goods carried during the eighteenth century: of the eighty-five ships to unload at Stonehaven harbour between May 1793 and May 1794, forty-two carried lime shells, and a further eighteen were laden with coals.[205] The volume of lime landed at Kincardine harbour more than trebled from 2,330 chalders in 1784 to 8,042 ten years later.[206] Coastal areas were among the first to be able to purchase lime for agricultural improvement, and it was not until roads were improved that this lime could be carried further inland. This was especially true along the east coast, where 'shore lime' was carried great distances from the major works in Sunderland and Fife.[207] Robertson observed in Inverness:

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[202] Davidson, "The Scottish Path to Capitalist Agriculture 1: From the Crisis of Feudalism to the Origins of Agrarian Transformation (1688-1746)."
[203] Alexander Lowe, *General View of the Agriculture of the County of Berwick,* (1794): 103.
[204] Eric J Graham, "Maritime Activity, C1650-1790," in *Scottish Life and Society Volume 8: Transport and Communications*, ed. Kenneth Veitch (Edinburgh: John Donald, 2009).
[205] James Donaldson, *General View of the Agriculture of the County of Kincardine,* (1795): 11.
[206] James Robertson, *General View of the Agricultural in the Southern Districts of the County of Perth*, (1799): 374.
[207] Robertson, *General View Perth*, 284-5.

> It has been taken notice of, that the improvers on the East Coast, make use of lime which is imported: the effects of this practice are so beneficial and so evident, that this kind of lime will soon be carried further into the interior.[208]

Many of the northerly commercial lime producers, including Ardonald, were supplied by long supply chains of shipborne coal. Remote sites like Ard Neakie, in Loch Eriboll, and the kilns on Lismore, were entirely reliant on coastal shipping for both coal and the export of their lime. The coastal trade in lime and coal also spurred the construction of a number of harbours at which they could be imported and exported. In 1808, for example, the Carron Company, seeking to ensure a steady supply of lime for their ironworks, bought Newbigging Limework, near Burntisland, and built the small Carron harbour specifically for shipment of lime.[209] Other enterprising landowners established similar ports. Mr Young of Inveruglie, for instance, spent more than three thousand pounds of his own money at the start of the nineteenth century building a small harbour at Hopeman (about three miles east of Burgh-head) to receive coal for his lime work and then export the lime produced.[210]

Figure 46 Men loading a boat with lime. From Pyne's *Costume of Great Britain.* Aquatinit with etching by W.H. Pyne, 1804. Credit: Wellcome Collection. CC BY.

[208] James Robertson, *General View of the Agriculture of the County of Inverness,* (1808): 339.
[209] Wilson, "Industrial Coal Markets in Fife 1760–1860," 86.
[210] William Leslie, *General View of the Agriculture of the Counties of Nairn and Moray,* (1813): 410.

Inland waterways were also heavily utilised by the lime industry. Around 1870 a small steamer was kept on Loch Shin with the purpose of conveying limestone from the Shiness Quarry to the Duke of Sutherland's lime works at Lairg (which was located next to the railway station), a distance of approximately seven miles.[211] The limestone was carried from the quarry to the shore by a few hundred yards of tramway.[212] Later a bank of three draw kilns was erected at the quarry itself, with the lime carried to Lairg to be distributed by rail.

Agriculturalists made frequent calls for canals to be dug to facilitate the transport of lime and coal in nearly all parts of Scotland.[213] Although relatively few were ever constructed, those that were became closely integrated into the lime trade, particularly for large industrial works. Like turnpikes, they charged dues based on cargo, often with lower rates for the carriage of coal and lime. On the Forth and Clyde Canal, for example, carriage dues in 1786 were 1 1/2d per ton per mile for chalk, but only 1d per ton per mile for coal, lime shells and slaked lime.[214] Some enterprising proprietors undertook their own canal projects for the use of their works. For example, Mr Low of Burnturk opened a small canal between his colliery at Burnturk and the lime quarry belonging to the Earl of Crawford. The canal ran level with the top of the draw kilns, allowing the limestone and coal to be unloaded directly into the kiln pot. Another canal ran along the bottom of the kilns, carrying the burnt lime a short distance to where it could be loaded into carts and driven more easily downhill to 'shades' from which the lime was stored and sold.[215]

[211] Sutherland OS Name Books, 1871-1875 (OS1/33/7/22).
[212] Sutherland OS Name Books, 1871-1875 (OS1/33/31/10).
[213] James Anderson, *General View of the Agriculture and Rural Economy of the County of Aberdeen,* (1794): 142.
[214] Bailey, "Lime and Limekilns in the Falkirk District," 72.
[215] John Thomson, *General View of the Agriculture of the County of Fife,* (1794): 403-404.

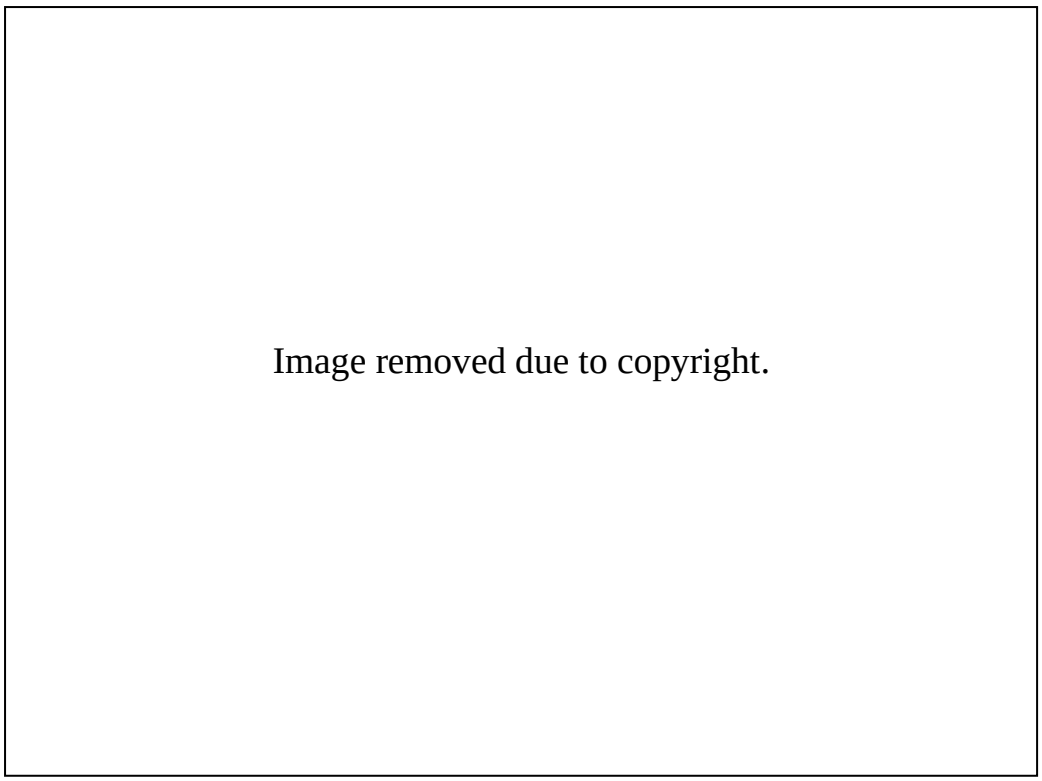

Figure 47 *Limekiln by an Estuary*, attributed to John Henderson (1764-1843). Graphite and watercolour on paper. Tate Gallery.

As well as proving a difficult cargo due to its reactivity with water, lime burning posed additional dangers to shipping. Kilns burning near the shore at night frequently misled ships who mistook their glow for lighthouses, leading to several accidents. In 1811, *HMS Amiable* reportedly ran aground in Berwick Bay after its pilot mistook the light from a kiln on the shore for the May Light. The same lime kiln was also responsible for the loss of two other ships, the *Nymphe* and the *Pallas*.[216] Similarly, the large number of lime kilns burning around Ayr 'completely deceived' the *Brig of Whitehaven*, causing it to miss the harbour and run aground in November 1821.[217] To prevent such mishaps, provisions of statute were put in place that prohibited the use of lime kilns within certain distances or within view of lighthouses, leading to the closure of some quarries.[218]

[216] 'Court martial', *Aberdeen Press and Journal*, Wednesday 16 January 1811, p. 3; *The Scots Magazine*, Thursday 1st August 1811, p.8.
[217] 'Shipping Intelligence', *Caledonian Mercury*, Sunday 24 November 1821, p.3.
[218] *NSA*, Dunoon and Kilmun (1845), p.580.

4.5.4 Rail

As lime production became more industrialised, increasing numbers of lime works made use of rails and wagonways to move materials within and between sites (Figure 48). Indeed, the coal and lime industries were among the first to utilise rail technology before the development of a national rail network.[219] However, by 1837 this was still a relatively rare practice and calls were made for proprietors to make greater usage of rails and machinery at their limestone quarries.[220]

By the latter part of the nineteenth century, railways were at the heart of Scottish industry. In areas rich in minerals, including lime, rail companies competed intensely for freight traffic.[221] Lime works with access to rail links were able to reach markets further afield. For example, receipts from Scullingour show more than ten times as much lime sold by railway, carried by the *Edinburgh and Glasgow Railway Co,* than was sold to local customers during the summer of 1856.[222] Although the coming of the railways allowed some remote sites to exist, like the kilns at Lairg, they spelled the end for small-scale lime production.

[219] Andrew C. O'Dell, "A Geographical Examination of the Development of Scottish Railways. Newbigin Memorial Essay, 1938," *Scottish Geographical Magazine* 55, no. 3 (1939): 129–48.
[220] Wallace, 'Limestone Quarries in Scotland', p.454.
[221] David Spaven, *The Railway Atlas of Scotland: Two Hundred Years of History in Maps* (Edinburgh: Birlinn, 2015), 31.
[222] Receipts 1856, Scullingour lime works (MIT T-LX6/21/4); Receipts 1857, Scullingour lime works (MIT T-LX7/24).

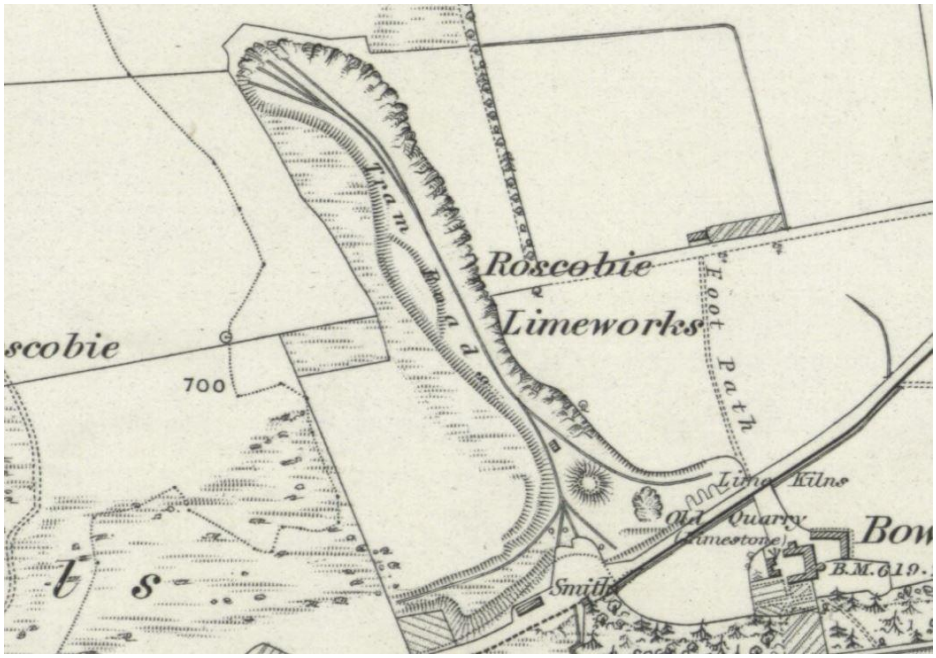

Figure 48 Roscobie Limeworks in Fife (Six-inch first edition, Fife sheet 30, published 1856). Note the use of 'Tram Roads' leading from the quarry face to a bank of three clamp kilns.

4.6 Conclusion

Having considered nature of material selection and transport in relation to Scottish lime burning, two main arguments can be made. Firstly, on the subject of fuel, much has been made, both in contemporary discourse and subsequent historical literature, about the importance of coal, with its increasing availability seen as vital to the advance of lime and improvement. It seems clear that coal was the superior fuel—more efficient than peat and able to sustain the industry for longer than wood—and it was crucial for the development of industrialised commercial lime production. But it was peat, with all its limitations, that first enabled lime to be burned in the upland districts, distant from the coasts where coal or ship lime might be procured. Furthermore, peat remained a relevant fuel in many peripheral areas well into the nineteenth century. Lime burners were indeed, as has been argued before, opportunistic with fuel selection, but the valuation of fuels was also influenced by local knowledge and attitudes, themselves affected by the circulation of ideas on the national scale. Aside from a brief flirtation with water-driven crushing of limestone, an overwhelming consensus was reached on the efficacy of burning using fossil fuels, with coal in particular reaching exalted status among most modernising writers. Coal itself has been cited as a key factor in the industrialisation of Scotland. In which case, given that the lime industry provided such an important

stimulus to coal mining, the indirect impact of lime burning on the country's economic trajectory may be more significant than previously acknowledged.

Secondly, the efficient movement of materials was a crucial factor for the development of lime production. At the scales of individual kilns, quarries and works, proprietors and lime burners made great efforts to streamline the movement of stone and fuel to the kilns, and their product to consumers. At the larger scale, this same desire for ease of transport led the lime industry fundamentally to stimulate and shape development of transport infrastructure in Scotland from the late eighteenth century onwards. In calling for the construction for new roads, canals and ports, contemporary observers time and again cited access to lime (or the fuel to burn it) as the advantage to be gained. Thus, as with coal, lime can be seen as a catalyst for important changes that were to lay the foundation for modernising Scotland's economy.

5 Practice and proprietorship

5.1 Introduction

The previous chapter has discussed the material resources of lime production and the ways in which the need to move these materials influenced the development of transport infrastructure across Scotland. In turn, this chapter explores the practice of lime burning: the kilns used, the people who operated them, and the people who owned them. In the century after 1750, lime burning underwent several changes in terms of the scales, methods and organisation of production—changes amounting to an overall modernisation of the lime industry. The chapter begins by addressing lime kilns, offering further discussion of construction and usage of the main kiln types employed in Scotland. The second section explores the role of the lime burner, including their identity, skills, and place within the rural economy, as well as the organisation of labour at larger lime works. The ownership of kilns is explored in the third section, which deals with the contribution of landowners in encouraging lime burning, leasing mineral rights and organising their works. The final section considers factors associated with the sale of lime, including the complexity of weights and measures in the industry. In order to provide context for this sequence, of points this introduction offers an overview of several important historical themes. These include research into the physical remnants of improvement (of which lime kilns are but one example), industrialisation in Scotland, and the nature of land ownership.

5.1.1 Archaeology of improvement

Lime burning has left a lasting physical legacy in Scotland's rural environment, not only in the form of kilns themselves, but in the transformation of farmland and in the stone-built farm buildings and new towns that it enabled. Studies of lime burning have been overwhelmingly archaeological in focus. An overview of this research is included in the Introduction, while debates around kiln structures and typologies are addressed below. More generally, there remains a close connection between archaeology and the historical and geographical study of Scotland's past. Reconstructing and analysing the physical landscapes and buildings of the improvement era has long been a tradition

in British historical geography.[1] Physical features are treated as markers of past practices and land uses, from which maps, timelines and sequences can be derived. More recent analyses of improvement, such as Wes Forsythe's studies of rural Ireland, have focused on the ways in which new ideologies and land management brought people into contact with new materials and objects in their everyday lives, and changed their relationship with their property and possessions.[2] Lisa Hill has done much to highlight the many commonalities between geography and archaeology, particularly their shared focus on questions of heritage, materiality and landscape.[3] Her own work, which deals with industrial sites and practices closely related to lime burning (charcoal burning and coal mining), uses non-representational theory and participatory methods to re-examine the ways in which people engage with material worlds of the past and present.[4] On the subject of agriculture more directly, Sarah Tarlow provides a valuable overview of the interconnected physical remains of the improvement period and points to the intertwining, often competing, ideological and practical motivations implied within them.[5] She argues that the segregation of industrial archaeology as a sub-discipline can result in an unfortunate separation between studies of demand and studies of consumption. To illustrate, she cites the example of those who have studied glass production—industrial archaeologists—but who have not also considered the impact on the wider world of newly available clear, uniform and large windows[6]. Thus, when considering an industry like lime burning, it is essential to also consider what changes in that industry say about, for instance, changing attitudes to agriculture or landownership.

[1] See George Kay, "The Landscape of Improvement: A Case Study of Agricultural Change in North East Scotland," *Scottish Geographical Magazine* 78, no. 2 (1962): 100–111; David Turnock, "Stages of Agricultural Improvement in the Uplands of Scotland's Grampian Region," *Journal of Historical Geography* 3, no. 4 (1977): 327–47; Steve Boyle, "Mapping Landscapes of the Improvement Period: Surveys of North Lochtayside, 1769 and 2000," *Scottish Geographical Journal* 125, no. 1 (2009): 43–60.
[2] Wes Forsythe, "On the Edge of Improvement: Rathlin Island and the Modern World," *International Journal of Historical Archaeology* 11, no. 3 (2007): 221–40; Wes Forsythe, "The Measures and Materiality of Improvement in Ireland," *International Journal of Historical Archaeology* 17, no. 1 (2013): 72–93.
[3] Hill, "Human Geography and Archaeology: Strange Bedfellows?"
[4] Hill, "Time and the Practice of Charcoal Burning"; Lisa J Hill, "Archaeologies and Geographies of the Post-Industrial Past: Landscape, Memory and the Spectral," *Cultural Geographies* 20, no. 3 (2013): 379–96.
[5] Tarlow, *The Archaeology of Improvement in Britain, 1750–1850*.
[6] Tarlow, 196.

5.1.2 Industrialisation

Industrialisation in Scotland, Christopher Whatley argues, 'appears to have been among the fastest of all European nations'.[7] Preceded by a period of less far-reaching change from around 1760, the most rapid transformation occurred after 1830 with the expansion of the textile industry alongside growth in mining, engineering and manufacturing.[8] These changes, Gordon argues, were founded on the use of three 'fundamental mineral ingredients': coal, ironstone and limestone.[9] Until 1815, however, industrialisation was still 'primarily a rural phenomenon'.[10] Industrial and agricultural change were closely linked—they were 'two sides of the same coin'.[11] In histories of the period, however, Atkinson argues that the development of large-scale industry have tended to overshadow the 'integration of industrial expertise within agricultural regimes' that were essential for both agrarian improvement and the diversification of revenue streams on rural estates.[12] Researchers, partly led by the availability of material, have focused mainly on the largest examples of new industries, such as the Carron Company, but overlooked the role of smaller-scale industrial development in rural economy areas.[13] A similar pattern can be seen in studies of lime burning, which was conducted at a range of scales, with histories of the industry skewed towards the largest and most commercial, overlooking the important role of small and medium scale enterprises in supporting the agricultural economy.

As Dodgshon admits, however, smaller-scale industry, particularly that which was not primarily commercial in nature and took place in the home or on the farm, is less easily researched.[14] Many historians, seeking to understand connections between the growth of domestic industry and eventual

[7] Christopher A Whatley, "The Experience of Work," in *People and Society in Scotland, Vol. I, 1760-1830*, ed. Thomas M Devine and Rosalind Mitchinson (Edinburgh: John Donald, 1988), 227.
[8] Thomas Christopher Smout, *A History of the Scottish People, 1560-1830.* (Fontana, 1969), 196–97; Thomas Christopher Smout, *A Century of the Scottish People, 1830-1950* (London: Fontana, 1997).
[9] G Gordon, "Industrial Development, c.1750-1980," in *An Historical Geography of Scotland*, ed. G Whittington and Ian Whyte (London: Academic Press Inc, 1983), 167.
[10] Devine, *The Transformation of Rural Scotland: Social Change and the Agrarian Economy, 1660-1815*.
[11] Thomas M Devine, "The Transformation of Agriculture: Cultivation and Clearance," in *The Transformation of Scotland: The Economy since 1700*, ed. Thomas M Devine, Clive Howard Lee, and G C Peden (University of Edinburgh, 2005), 71.
[12] Atkinson, "An Archaeological Analysis of Industrialisation within the Rural Context of Post-Medieval South West Scotland," 91.
[13] Brian Watters, *Where Iron Runs Like Water! A New History of the Carron Iron Works 1759-1982* (Edinburgh: John Donald Publishers Ltd, 1998).
[14] Dodgshon, *Land and Society in Early Scotland*, 226.

full industrialisation, have sought to apply Franklin Mendels' model of proto-industrialisation, a pre-industrial condition that would eventually result in centralised patterns of production.[15] His concept has three main conditions: the production of goods intended for sale in markets outside the producer's own region (thus differentiating it from local handiwork); a labour force consisting mainly of farmers and labourers who alternate during the year between farm work and work in the proto-industry; and a dependence on the expansion of commercial agriculture.[16] Since Mendels' intention was to model the development of industrial manufacturing practices, subsequent analyses of the concept have largely focused on textile sectors and other crafts. Most analyses have rejected the theory, pointing to inconsistencies and exceptions in practice.[17] Nevertheless, proto-industry remains a lingering heuristic through which to examine the development of rural industries. Indeed, early lime burning bears many of the characteristics of a proto-industry, including its seasonality and connection with commercial agriculture (as is discussed below). Mike Gill, testing the hypothesis that early non-ferrous metal mining and smelting was organised on a similar basis to the proto-industrial textile sector, argues that proto-industry should not be considered a step along the path towards full industrialisation, but rather a mode of smaller scale production from which an area could regress as well as progress.[18] Proto-industrial models of the lead industry, for example, persisted into the late nineteenth century, coexisting with larger scale industrialised mines, in situations with obvious parallels in lime burning.

An important element of the industrialisation process was the re-organisation of labour. In increasing numbers of industries, skilled individuals and craftsmen, who worked on all aspects of a job, were replaced with teams of workers whose labour could be focused on a subsidiary part of the whole

[15] Rab Houston and Keith D M Snell, "Proto-Industrialization? Cottage Industry, Social Change, and Industrial Revolution," *The Historical Journal* 27, no. 2 (1984): 473–92; Ian Whyte, "Proto-Industrialisation in Scotland," in *Regions and Industries: A Perspective on the Industrial Revolution in Britain*, ed. Pat Hudson (Cambridge: Cambridge University Press, 1989), 228–51; Whatley, *Scottish Society, 1707-1830: Beyond Jacobitism, Towards Industrialisation*.
[16] Franklin F Mendels, "Proto-Industrialization: The First Phase of the Industrialization Process," *The Journal of Economic History* 32, no. 1 (1972): 241–61.
[17] Houston and Snell, "Proto-Industrialization? Cottage Industry, Social Change, and Industrial Revolution"; Whyte, "Proto-Industrialisation in Scotland"; Whatley, *Scottish Society, 1707-1830: Beyond Jacobitism, Towards Industrialisation*.
[18] Mike C Gill, "Mining and Proto-Industrialisation," *British Mining*, no. 41 (1990): 106.

task.[19] The result of this change was an increase in the efficiency of many industries, along with a decline in skills, wages and status among many in the working population.[20] The lime industry was no exception to this pattern.

5.1.3 Land ownership

Scotland in the eighteenth century was, to quote Smout, 'a landowners' world'.[21] Concentrated patterns of land ownership in Scotland compared with the rest of Europe meant that landlords were a powerful force in the country, one that was ultimately responsible for a 'revolution from above' in terms of agricultural improvement.[22] During this period the relationship of the landed classes to their estates underwent significant change. Beginning in the second half of the seventeenth, feudal power structures steadily diminished in the Lowlands of Scotland: 'land was increasingly seen by many as an asset to be exploited rather than simply the basis of personal authority and family power'.[23] After 1745, landlords sought to transform their lands into 'efficient income machines'.[24] This process resulted in the introduction of new industries and farming methods, and produced a dramatic reorganisation of the rural economy along commercial lines that, by 1830, had been experienced by all parts of Scotland, including the most remote.[25] These changes were readily embraced by a receptive landowning class.[26] Feudal relationships, nevertheless, persisted longer in the Highlands. As Tom Devine states, 'the aristocratic world of the period was one of competitive display where social standing was increasingly defined by material status'.[27] Agricultural improvement and the exploitation of mineral resources were ways in which estate owners could finance their aristocratic lifestyles and the upkeep of their physical property.[28] Improvement on many estates was also

[19] Kirsten Bruland, "The Transformation of Work in European Industrialization," in *The First Industrial Revolutions*, ed. Peter Mathias and John A Davies (Oxford: Blackwell, 1989), 154–70.
[20] W. Knox, "The Political and Workplace Culture of the Scottish Working Class, 1832-1914," in *People and Society in Scotland, Vol. II, 1830-1914*, ed. W Hamish Fraser and R J Morris (Edinburgh: John Donald, 1990), 138–66; Whatley, *Scottish Society, 1707-1830: Beyond Jacobitism, Towards Industrialisation*.
[21] Smout, *A History of the Scottish People, 1560-1830.*, 282.
[22] Devine, *The Transformation of Rural Scotland: Social Change and the Agrarian Economy, 1660-1815*, 165.
[23] Devine, 1.
[24] Adams, "The Agents of Agricultural Change," 173.
[25] R H Campbell and Thomas M Devine, "The Rural Experience," in *People and Society in Scotland, Vol. II, 1830-1914*, ed. W Hamish Fraser and R J Morris (Edinburgh: John Donald, 1990), 46.
[26] Smout, "Scottish Landowners and Economic Growth, 1650–1850."
[27] Devine, *The Transformation of Rural Scotland: Social Change and the Agrarian Economy, 1660-1815*, 64.
[28] Clarisse Godard Desmarest, "Financing the Cost of an Eighteenth-Century Scottish Estate," *Études Écossaises* 15 (2012): 145–63.

financed by colonial surpluses, capital accumulated overseas and funnelled into land and industry in Scotland.[29] Profits from trade and industry saw increasing investment in land from a growing mercantile class, with implications for estate exploitation.[30] Saville highlights the importance of long-run investment and bank loans—made possible by the high surplus of rents available to a small number of landlords—for enabling land owners to utilise extra profits from mineral resources on their estates.[31]

From 1760, the growing wealth of industrialists and merchants, such as the Tobacco Lords and the Sugar Barons, challenged the economic standing of traditional Scottish landowners. However, many landed proprietors regarded new industrial activities as providing them with additional sources of revenue from rents and royalties or through direct industrial participation.[32] Smout argues that lingering notions of feudal power influenced landowners into the eighteenth century, keeping their focus on rural enterprises in the face of the diversifying opportunities that were opening up in the towns and cities:

> What the landlord valued above all other attributes of his position was not his comfortable income but his sense of power, and it followed from this that he was interested in national economic development only in so far as it strengthened his paternal standing in the local community. Applied to industry, this meant that he limited his enthusiasm to rural industries, which fascinated him by their ability to provide rent and accommodation.[33]

Lime burning, along with coal mining, lead mining and salt panning, held the landlord's interest throughout. A growing interpretation of land as capital signalled a shift among landowners away from the careful innovation and experimentation in agriculture that was characteristic of the early improvement period. In the eighteenth century, Smout argues, improving landowners 'took a much more detailed and personal interest in the techniques of agriculture than they did in the nineteenth'.[34]

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[29] Byres, "In Pursuit of Capitalist Agrarian Transition," 447; Eric Grant and Alistair Mutch, "Indian Wealth and Agricultural Improvement in Northern Scotland," *Journal of Scottish Historical Studies* 35, no. 1 (2015): 25–44.
[30] S G E Lythe and John Butt, *An Economic History of Scotland 1100-1939* (Blackie, 1975), 166.
[31] Saville, "Scottish Modernism Prior to the Industrial Revolution."
[32] R H Campbell, "The Landed Classes," in *People and Society in Scotland, Vol. I, 1760-1830*, ed. Thomas M Devine and Rosalind Mitchinson (Edinburgh: John Donald, 1988), 94.
[33] Smout, "Scottish Landowners and Economic Growth, 1650–1850," 231.
[34] Thomas Christopher Smout, "Landowners in Scotland, Ireland and Denmark in the Age of Improvement," *Scandinavian Journal of History* 12, no. 1 (1987): 85.

In other words, their relationship to the land became less custodial and more commercial and extractive.

Many landlords controlled their lands in absentia, giving subsidiary figures—factors, agents and tacksmen—increased significance in the management of estates resources and the implementation of improvement. In the Highlands, tacksmen, who had a dual role as both farmer and manager, were, in the second half of the eighteenth century, 'developing their managerial role into the realm of commercialism' by directly employing greater numbers of people and conducting their own business ventures.[35] Estate factors became highly influential in the rural economy by supplying their employer with information and guidance (since it was often they who walked the land and engaged with the tenants), as well as directly shaping and initiating changes.[36] Indeed, many factors were as attentive to the theory and practice of improvement as their masters.[37] William Kier, for example, factor to the Duke of Buccleuch, worked closely on developing his programme of improvement and was highly involved in the promotion of liming and the running of limestone quarries on the Duke's Borders estates.[38]

Land ownership was no 'universal concept'; landowners were subject to various social and economic influences in the management of their lands. As David Taylor states, land ownership was a 'highly subjective force driven by the personality, ideology, ambition, even whim, of the individual'.[39] Studies of land ownership examine the drivers and influences on landlords at local scales. Bonnyman's account of improvement on the 3rd Duke Buccleuch's estate illustrates the complex and competing priorities at play—the need to balance economic gain over long and short terms—whilst 'simultaneously maintaining the family's wider moral, social and political influence'.[40] Taylor's study of Badenoch at the end of the eighteenth century is in effect an analysis of the Dukes of

[35] Taylor, *The Wild Black Region: Badenoch 1750-1800*, 22.
[36] Adams, "The Agents of Agricultural Change."
[37] Alasdair Ross, "Improvement on the Grant Estates in Strathspey in the Later Eighteenth Century: Theory, Practice and Failure?," in *Custom, Improvement and the Landscape in Early Modern Britain*, ed. R W Hoyle (London: Routledge, 2011), 293.
[38] Brian Bonnyman, "Agricultural Improvement in the Scottish Enlightenment: The Third Duke of Buccleuch , Willliam Keir and the Buccleuch Estates, 1751-1812" (PhD Thesis, University of Edinburgh, 2004).
[39] Taylor, *The Wild Black Region: Badenoch 1750-1800*, 17.
[40] Brian Bonnyman, *The Third Duke of Buccleuch and Adam Smith: Estate Management and Improvement in Enlightenment Scotland* (Edinburgh University Press, 2014), 196.

Gordon's proprietorship over the period.[41] His narrative highlights the importance of local geography and history in shaping the actions of proprietors, and also how their personal failings—largesse and short-sightedness—could hamper economic projects.

One of the most important roles of the landowner was in their influence over tenurial patterns.[42] New lease arrangements were an early form of agrarian change that was underway by the seventeenth century in the Scottish Lowlands.[43] The prevailing attitude in the Scottish Lowlands from the middle of the eighteenth century was that small tenant farmers or cottars should be discouraged, that holding size should be increased, subdivision allowed. Consequently, there emerged a large group of prosperous capitalist tenants, who paid high rents through intensive farming practices.[44] In the Highlands, by comparison, leases grew in length and improvements were stipulated by the landowner, including the liming of land and the construction of kilns.[45] The length of leases may also have influenced the selection of soil stimulus by tenants. Dodgshon found that farmers on shorter leases in Roxburghshire and Berwickshire favoured quicker-acting marl over lime.[46] Leases of land generally reserved the rights over coal, stone and other minerals, providing, Devine argues, the legal basis for the landowner to 'extract as much return as possible from the natural endowment of his estate'. As such, they effectively 'symbolised land as property, as an asset to be exploited systematically'.[47] Analysis of the capitalist transition in Scottish agriculture has highlighted its impact on class relations and the lives of tenants and subtenants.[48] Changes in tenurial patterns 'dismantled the social hierarchy of the cooperative countryside', resulting in the social dislocation of large numbers of people.[49]

[41] Taylor, *The Wild Black Region: Badenoch 1750-1800*.
[42] Smout, "Landowners in Scotland, Ireland and Denmark in the Age of Improvement," 89.
[43] Ian Whyte, "The Emergence of the New Estate Structure," in *The Making of the Scottish Countryside*, ed. M L Parry and Terry R. Slater (London: Croom Helm, 1980), 117–35.
[44] Smout, "Landowners in Scotland, Ireland and Denmark in the Age of Improvement," 91.
[45] Devine, *The Transformation of Rural Scotland: Social Change and the Agrarian Economy, 1660-1815*.
[46] Dodgshon, "Land Improvement in Scottish Farming: Marl and Lime in Roxburghshire and Berwickshire in the Eighteenth Century."
[47] Devine, *The Transformation of Rural Scotland: Social Change and the Agrarian Economy, 1660-1815*, 47.
[48] Byres, "In Pursuit of Capitalist Agrarian Transition"; Davidson, "The Scottish Path to Capitalist Agriculture 1: From the Crisis of Feudalism to the Origins of Agrarian Transformation (1688-1746)"; Neil Davidson, "The Scottish Path to Capitalist Agriculture 2: The Capitalist Offensive (1747-1815)," *Journal of Agrarian Change* 4, no. 4 (2004): 411–60.
[49] Barrett, *The Making of a Scottish Landscape: Moray's Regular Revolution, 1760-1840*, 208.

5.2 Lime kilns

This section addresses important points about the kilns used to burn lime in Scotland, in doing so contributing to a series of long-running debates, outlined below, about the nature of lime kilns. As Chapter Three has demonstrated, based on nineteenth century OS data, lime burning was practised across much of Scotland. The range of cartographic symbols used to represent kiln highlights the diversity of kilns used for the purpose. Important questions remain: what kinds of kilns were used in Scotland and for what purposes; how were they built (and by whom); and how did this change in relation to period, function and purpose?

Two interconnected debates have emerged among archaeologists around the structure and operation of lime kilns.[50] The first concerns whether burning was continuous or not. Depending on their design, kilns could be operated continuously by adding more fuel and limestone to an already burning kiln whilst also drawing out burned lime and ash, or else intermittently by loading a kiln with fuel and limestone and allowing it to burn through and cool before extraction, a process which may or may not have required dismantling the kiln to some degree. Commercial lime production, of the kind that gave rise to industrial lime works in the nineteenth century, generally (but not always) employed the former approach to ensure uninterrupted supply. Domestic lime burning, for periodic use in building projects or farm work, was less reliant on continuous output. Contemporary accounts reflect this difference between lime worked by 'proprietors and farmers, for their own use' and that 'wrought for general sale', a distinction that largely manifested itself in the kinds of kilns used and the organisation of labour.[51] The parallel operation of domestic and commercial lime producers operating at different scales can be observed, for example in Birse, Aberdeenshire, where the *OSA* noted that there were three 'large lime kilns and quarries' in the parish as well as thirty-two 'small lime kilns'.[52] However, it cannot be assumed that certain forms of production demanded certain types of kilns, nor that certain types of kilns imply certain modes of production. Indeed, Johnson argues that whether a

[50] Johnson, *Limestone Industries of the Yorkshire Dales*.
[51] James Headrick, *General View of the Agriculture of the County of Angus, or Forfarshire* (1813), p.30; William Leslie, *General View of the Agriculture of the Counties of Nairn and Moray* (1813), p.20-1.
[52] *OSA*, Parish of Birse, (1793), vol. 9, p.117-8.

kiln was operated continuously or intermittently cannot be reliably determined from remains alone and must also be inferred from archival or other evidence.[53]

The other debate relates to nomenclature of kilns and the development of kiln typology.[54] Various names have been applied by historians and archaeologists to kiln forms found in the field and described in historical sources. Many of these terms are difficult to cross reference between regions, while contemporary writers were often imprecise in their naming or descriptions of kilns. Furthermore, as Johnson has emphasised, determining the way a kiln was operated, and by extension its type, from archaeological evidence is highly unreliable.[55] This thesis does not seek to resolve or even reopen this debate, yet it aims to provide useful Scottish examples from which more archaeologically-minded researchers can build a more complete understanding of kiln structures and their remains in the landscape. As discussed in the Introduction, it is instructive to consider three broad categories of kiln: clamp kilns, field kilns and draw kilns, each of which varied in size, complexity and mode of operation. These are now discussed in turn.

5.2.1 Clamp kilns

The clamp kiln—alternatively referred to in its various forms as the sod, sow or 'clump'—refers to a shallow pit, with an opening on one end that could be filled with limestone and fuel and then covered over (or clamped) with turf and sods to control the burn.[56] The kiln could be constructed in an almost circular horse-shoe shape, or a more elongated U-shape. The closed end may be rounded or squared-off (or in some cases they may be open at both ends). Clamp kilns represent one of the simplest forms of kiln, one that could take advantage of even a natural declivity in the ground. Indeed, clamp kilns are thought to date back to the mediaeval period.[57] Several names are used to describe

[53] Johnson, *Limestone Industries of the Yorkshire Dales*, 49.
[54] For an extended discussion of kiln typologies, see Starmer, "Limekilns and Typologies"; Stanier, "A Suggested Typology for Dorset Limekilns"; John T Leach, "A Proposed Limekiln Typology," *Industrial Archaeology News* 110 (1999): 5–7; Johnson, "The Archaeology and Technology of Early-Modern Lime Burning in the Yorkshire Dales: Developing a Clamp Kiln Model."
[55] Johnson, *Limestone Industries of the Yorkshire Dales*, 50.
[56] Johnson, "The Archaeology and Technology of Early-Modern Lime Burning in the Yorkshire Dales: Developing a Clamp Kiln Model," 141. Note the interchangeable use of 'clamp' and 'sow' in Wallace, *Account of the Method of Calcining Limestone*, 447; See also the use of 'clump' in *NSA*, Parish of Old Deer (1840), p.142.
[57] Johnson, *Limestone Industries of the Yorkshire Dales*, 50.

variations of clamp, such ‘pye’ (large rectangular clamps) or ‘sow’ (small, sub-rounded clamps), although satisfactory differentiation of these terms has not been achieved.[58] This simplicity has led many to suggest that there is something ‘primitive’ about clamp kilns and that they were superseded by later forms.[59] One of the advantages of clamp kilns was their inexpensive construction, which allowed them to be treated as temporary or single-use. At several quarries the remains of clamp kilns can be seen to follow the face of the quarry as it progressed.[60] However, notions of clamp kilns as somehow archaic and ephemeral are a mischaracterisation, as recent evidence, discussed below, has shown.

Figure 49 Aerial photograph of Whitfield lime works in West Lothian. Photo: Canmore.

Nisbet, in his study of Renfrewshire lime burning, proposed a rough typology of clamp kilns to capture the range of scales and structures used.[61] The ‘earliest and simplest’ clamps—Type 1—were U-shapes dug into a slope, occurring as single kilns or scattered groups.[62] They could be earth lined or lined with rubble. Wallace also noted lime burned in clamp kilns built ‘with earth and lined with clay’ which, after first firing, was ‘equal to brick’.[63] Type 2 kilns were found at larger, more organised sites, usually arrayed in banks of kilns of similar size to type two, repeating structures in lines or

[58] Johnson, 50–51.
[59] Williams, *Lime Kilns and Lime Burning*, 13.
[60] Skinner, *The Lime Industry in the Lothians*, 20.
[61] Nisbet, “The Archaeology of the Lime Industry in Renfrewshire,” 48–50.
[62] Nisbet, 48.
[63] Wallace, *Account of the Methods of Burning Limestone*, 447.

arcs, often numbering in the dozens. Type 3 kilns, usually later period, were typically larger and masonry lined. Clamp kilns used at Blinkbonny quarry in 1837 were in the 'horse-shoe form', measured approximately 9m long, 2m deep, tapering from 3.5m wide at the top to 2.5 on the bottom.[64] The clamp kilns at Glorat Lime Works in the Milton of Campsie Parish, which operated until the second half of the nineteenth century, measured up to 16m long.[65] Several excavations have also noted the existence of vents of flues built into the kilns, further hinting at their status as permanent, carefully considered structures.[66] Wallace described clamp kilns at Baldoran, on the Glorat estate, using 'three small pipes or pens through the bottom of the kiln, and up the sides and ends of the kiln, in order to give them air', a feature that he argued 'should be attended to in all clamp kilns' to hasten the burning.[67] Similar kilns were used in Duntocher, where lime burning was said to be done mostly in 'old clamp or sow kilns, improved as much as possible by air pens'.[68]

The portrayal of the clamp here as 'old' may not reflect the attitude of the burners themselves, but rather the predilection for draw kilns that existed among the improving community whose testimony dominates histories of the period (a theme explored further in the next chapter). Indeed, the marginalised status of clamp kilns in many modern historical and archaeological studies arguably originates with their omission from contemporary historical accounts. 'Clamp' or 'sow' kilns are together mentioned only three times across the whole of both the *OSA* and *NSA*, compared with more than twenty specific references to 'draw kilns'.[69] Likewise, clamp kilns appear in none of the Board of Agriculture's reports which vocally advocated for the establishment of draw kilns in many parts of the country. Setting aside descriptions that allude to unspecified 'older' ways of burning in the ground, the lack of a widely used naming convention for clamp kilns reinforced their status—among

[64] Carmichael, *Principle Limestone Quarries*, 64.
[65] Bishop *et al.*, "Lime Burning in Clamp Kilns in Scotland's Western Central Belt: Primitive Industry or Simple But Perfectly Adequate Technology?," 18.
[66] Alexander, "Brodick Castle Clamp-Kiln and the Lime Industry of Arran"; Johnson, "The Archaeology and Technology of Early-Modern Lime Burning in the Yorkshire Dales: Developing a Clamp Kiln Model"; Bishop *et al.*, "Lime Burning in Clamp Kilns in Scotland's Western Central Belt: Primitive Industry or Simple But Perfectly Adequate Technology?"
[67] Wallace, *Account of the Method of Calcining Limestone*, 447.
[68] Wallace, *Account of the Method of Calcining Limestone*, 447-8.
[69] Specific mentions of 'clamp kilns' versus 'draw kilns' using the text search tool on the *Statistical Accounts of Scotland* website, available at: http://stataccscot.edina.ac.uk/static/statacc/dist/home

a certain body of the agricultural commentariat at least—as vernacular modes of lime burning to be 'replaced' with new, modern, named designs.

Although many agricultural observers considered clamp kilns to be an outmoded means of production, some lime burners, it seems, may have preferred to use clamps. Carmichael described the clamp kilns at Blinkbonny, outside Edinburgh[70]:

> These kilns are preferred by many to the draw kilns, on account of the slow and superior manner in which the stones are calcined; whereas the practice of daily removing a quantity of lime from the draw kiln, either hurries the operation or defeats it, bringing down the limestone before it is thoroughly calcined.[71]

Nor were clamp kilns confined to agricultural lime: the lime from Blinkbonny was 'slaked, made into mortar, and laid down in town' during the construction of the Edinburgh's New Town.[72] An account from Abercorn also suggested that 'sow' kilns were used to burn local limestone that was 'so extremely friable in the process of burning' it was considered 'unfit for the draw kiln'.[73] Clamp kilns may have been favoured because of the reduced intensity of the burn and high levels of control afforded the skilled lime burner. Such qualities, and the simplicity of their construction, led some to question the worth of more substantial draw kilns. One Welsh contributor to *The Farmer's Magazine* in 1816 described with enthusiasm the manner of burning lime kiln in his homeland in 'shallow kilns' or sometimes 'without any kiln at all'.[74] In these cases, heaps of limestone were calcined in a manner resembling charcoal burning, with turfs and earth used to insulate the burning material. 'As proof of the superior advantage that lime burnt in these *clamps* or *cloaks* has over . . . the old method', he wrote, 'where farmers have an option of taking either lime at the same price, a preference is invariably given to that burnt in heaps'.[75] Moreover, given the cheapness of these kilns and the greater

[70] These kilns were however replaced with draw kilns by the time of the OS First Edition 6-inch map. See https://canmore.org.uk/site/306855/blinkbonny.
[71] James Carmichael, 'Account of the Principle Limestone Quarries of Scotland', *Prize Essays and Transactions of the Royal Highland and Agricultural Society of Scotland*, vol 11 (1837): 64.
[72] Carmichael, *Principle Limestone Quarries*, 64.
[73] *NSA*, Parish of Abercorn (1843), vol. 2, p.29.
[74] A Constant Reader, 'On Burning Lime without Kilns', *The Farmer's Magazine,* vol. 17(65), Feb 1816, p.61. Burning without kilns may have taken place in parts of Scotland: a receipt from Gilmerton and Nundyhouse lime quarry from 3rd to 10th February 1810 (NRS GD44/39/30/21) recorded the names of two tenants who purchased limestone to burn themselves. One is said to have used a draw kiln, while the other used an 'openkiln'—the only reference to such a kiln that appeared in the course of this research.
[75] It is assumed that the 'old method' here is a kind of field kiln, built above ground with rudimentary walls of rubble or earth, described below.

quality of the lime, he argued that constructing elaborate draw kilns would appear entirely a waste of effort. However, his closing remark was revealing: 'a little more coal is used [in the heap kilns]; but in this county, where fuel is cheap, that is no objection of importance'.

Evidence suggests that clamp kilns continued to be used extensively in many parts of Scotland until the latter part of the nineteenth century, especially in those regions where coal and limestone occurred together or where coal could be bought cheaply—west-central Scotland, Fife and parts of the Lothians.[76] They were not restricted to these areas, however: before the construction of draw kilns at the short-lived Mill O'Wood lime works in Banffshire in 1886, clamp kilns had 'only hitherto been known in this part of the country'.[77] Many new clamps were constructed during the mid-nineteenth century. For example, the clamp kilns and quarry that appear on the 1856 OS map at Whitfield in West Lothian are not included on the estate plan of the area from 1835. That plan shows lime working at a nearby site to the south on the other side of the road. At that time the *NSA* for Linton parish described 20,000 bolls of lime being sold from the works each season.[78] This shows that, when the works moved over the road sometime between 1835 and 1856, the proprietor, Rev. John Beresford, chose to continue working lime commercially using the clamp kiln design that he had employed at the earlier quarry site (multiple new clamps were constructed at the new site). Only later, after 1856, when the quarry workings moved again to the north, was a draw kiln finally constructed.

Large banks of large clamp kilns, of the kind that operated throughout much of the nineteenth century, were, by rigorous cyclical organisation, capable of sustaining large-scale and, to a degree, continuous lime production. Clamps could be left to burn while others were cooling, being loaded, or being emptied. Some clamp designs may also have supported continuous production from a single kiln. Wight observed such a kiln used by a farmer in Clackmannanshire in 1788: 'in order to have hot lime, he erects a very long clamp kiln . . . [t]he great length of the kiln permits shells to be carried off from one end while the other is burning' [79] This mode of operation may explain the large clamps

[76] See Chapter Three, p.79 onwards.
[77] 'New Enterprise in Keith District. The Mill O'Wood Limework', *Banffshire Journal and General Advertiser,* Tuesday 22nd June 1886, pp.5-6.
[78] OS First Edition Six-inch, Peebles-shire, Sheet 5, published 1858; Plan of the Estate of Macbiehill, 1835 (NRS RHP1438).
[79] [Andrew Wight], *Present State of Husbandry in Scotland.* Vol. 2, (Edinburgh, 1788), p.111.

open at both ends found at Whitfield and other sites in West Lothian. An alternative explanation may be that the open-ended design allowed ease of loading from the quarry at one end and unloading towards the track at the other.[80] The installation of large clamp kilns in the second half of the nineteenth century, at the Glorat Lime Works in Campsie, as well as at Baljaffray, illustrates that clamp kilns were considered a valid technology for commercial lime production.[81] The Glorat works developed into a highly organised industrial venture, including a tramway connection to the railway. Some degree of local preference or experience may also have led choices around kiln types.

Figure 50 Remains of clamp kiln at Ardonald lime works. The edges of the kiln picked out with red line. Note exposed stone lining at rear.

Not only were clamp kilns not entirely replaced by draw kilns at commercial sites, the two kiln types may have complemented each other. Records from Ardonald lime works indicate at least one clamp kiln was used at the site alongside a draw kiln and one other kiln of indeterminate type. Payments made in 1803 included £5-11- on peats 'purchased for the clamp kiln', a trifling amount compared

[80] Mitchell and Bishop, "Limekilns – Still a Burning Issue."
[81] Bishop *et al.*, "Lime Burning in Clamp Kilns in Scotland's Western Central Belt: Primitive Industry or Simple But Perfectly Adequate Technology?"

to the total sum paid that year for fuel overall (including carriage): £1125-13-6.[82] Similar purchases of peats for the clamp kiln appeared in account books from other years. When the works were leased to James Allardes in 1818, two draw kilns and a clamp kiln were listed among the property.[83] 'Divots and turf' were also purchased 'for covering the kilns', at a cost of nine shillings.[84] It is not clear what function the clamp kiln served within the operation of the lime works. The overwhelming majority of fuel consumed was coal, and only peat seems to have been specified for the clamp. Nevertheless, the clamp's presence and continued value were confirmed when the works were let in 1810, a newspaper advert stated that lime burning was 'aided occasionally by what is called a clamp-kiln'.[85] A large draw kiln was built at the site between 1802 and 1803, and its lining was replaced in 1808 alongside various augmentations and repairs.[86] The clamp kiln may also have served to burn lime needed for this and other sundry masonry work on the site. This suggestion is supported by the accounts of Raw Camps lime works in West Lothian. There, payments for filling both a 'clamp kiln' and a 'flare kiln' appear in accounts from 1793, a time when new kilns were being built on the north side of the quarry.[87] The flare kiln reappears in the 1794 accounts, when the draw kilns were still to be completed.[88] Nisbet suggests that clamp kilns may have been used to burn lime of a different quality or for different uses, a suggestion supported by Carmichael's claims regarding the superiority of their slow-burning nature.[89] They may also have allowed the works to meet varying seasonal demand—although they would have been subject to weather conditions over winter.

5.2.2 Field kilns

Field kiln has become something of a catch-all to describe the kinds of smaller, pre-industrial kilns that became a common sight on British farmland from the seventeenth century onwards, without

[82] John Menzie's state and accounts 1803 (NRS GD44/51/535/2).
[83] Lease of Ardonald Limeworks between Alexander Duke of Gordon and James Allardes of Bonymill, 1818 (NRS GD44/51/539).
[84] Ardonald Lime Works accounts, 1808 (NRS GD44/51/537/3).
[85] 'The Duke of Gordon's Lime-Works To Let', *Aberdeen Press and Journal*, Wednesday 21 February 1810, p.2. The inclusion of 'what is called…' also suggests that clamp kilns were not an entirely familiar concept.
[86] Ardonald Lime Works accounts, 1808 (NRS GD44/51/537/3).
[87] Charges and Discharges, 31/12/1793 (NRS GD150/2359).
[88] Charges and Discharges, 31/12/1793 (NRS GD150/2359).
[89] Nisbet, "The Archaeology of the Lime Industry in Renfrewshire," 49.; Carmichael, 'Principle Limestone Quarries', 64.

specifying any structural elements or modes of operation. Although the term is not often used in Scotland, several archaeologists refer to field kilns in this way.[90] The range of structures that constituted field kilns can be conceived of as a continuum spanning from the simplest forms of heaped kiln to large masonry-built structures akin to draw kilns. Archaeologist Robert White proposes the following definition:

> The term 'field kiln' describes a wide range of structures ranging from small relatively primitive kilns with narrow draw hole openings, almost certainly built to provide lime for an individual farm or even an individual building project, to some much larger kilns which were effectively small commercial or selling kilns. There is considerable variation in appearance, particularly in plan form; kiln height; and shape, depth and construction of draw hole.[91]

The terms 'flare kiln' or 'sod kiln' are sometimes also used to describe variations on this kind of kiln.[92] Field kilns can be distinguished from clamp kilns by their more permanent, above ground structures and from draw kilns by being used intermittently. Construction materials and designs varied significantly. The simplest field kilns were often ephemeral and rarely sited far from where the lime was to be used. George Robertson, for example, noted that farmers in Ayrshire purchased limestone and carted it back to their farms to be burned in 'temporary turf kilns, made on the fields where it is to be applied, and nearly on the spot where it is to be laid'.[93] An argument could be made that Robertson was describing a clamp kiln here, being 'clamped' by the turf. However, since the kilns were apparently being constructed on the field, and he described neither a pit nor an embayment, they could also be interpreted as a form of short-lived field kiln. This distinction between clamp and field kilns is further complicated by recent excavations by Bishop that indicate some clamp kilns may have been built up further above ground by walls of stone, a form that bears resemblance to

[90] The term field kiln is also used by several other archaeologist, see Johnson, *Limestone Industries of the Yorkshire Dales*, 53–61; Barnatt and Dickson, "Survey and Interpretation of a Limekiln Complex at Peak Forest, Derbyshire; and Review of Early Limeburning in the North-West Peak"; Williams, *Lime Kilns and Lime Burning*.
[91] Robert White, "Aspects of the Management of the Remains of Limestone Industries in the Yorkshire Dales," *Industrial Archaeology Review* 28, no. 2 (2006): 108.
[92] Leach, "Burning Lime in Derbyshire Pye Kilns." Flare kilns typically denote intermittent firing kilns, while sod kilns refer to kilns of earthen construction, however the terms are not used consistently.
[93] George Robertson, *Rural Recollections; or the Progress of Improvement in Agriculture and Rural Affairs* (1829).

unusual ‘large walled pye kilns’ described in Nottinghamshire.[94] Nevertheless, such examples highlight the ambiguity of historical sources and the difficulty of applying them to archaeological typologies.

In the Highlands the intimacy between field and kiln was taken even further. William Marshall observed there in 1794 that kilns were often built ‘of sods, set upon the surface of the ground from whence, perhaps, the sods were taken’. After firing and the lime emptied, the sods, having ‘performed their office as walls of the kiln’, were ‘themselves carried to the fields as manure’.[95] Earthen kilns were commonplace in many parts of Scotland until the end of the eighteenth century, certainly more numerous than stone draw kilns. In the parish of Southend, in Argyll, for instance, all but one kiln in the parish was made of turf in 1792.[96] Construction varied with local knowledge and available materials. Limestone in Orkney at the beginning of the nineteenth century was burned for mortar in kilns in the form of an inverted cone six to eight feet in diameter at the top and nearly the same deep. These kilns were ‘usually built only of turf’ and were ‘continually needing repairs’, indicating that they were more than simply single-use constructions.[97] Some earthen kilns could be ‘as large as a cottage house’.[98] In 1794 David Ure described kilns ‘of earth’ in Dumbartonshire made with two ‘loggies’ or fireplaces in the bottom.[99] Limestone was piled in an arch over the loggies into which were thrown peats for ‘two days and three nights’ until the heat had penetrated through all the stones. Each such kiln could produce about twelve chalders of lime.

[94] Heather James and Paul Bishop, “Pilot Investigation of Lime Clamp Kiln Chronology in Upper Bannock Burn”, Interim Data Structure Report, (2018); P. Leach, “Burning Lime in Derbyshire Pye Kilns,” 156.
[95] William Marshall, *General View of the Agriculture of the Central Highlands of Scotland* (1794), p.36
[96] *OSA*, Parish of Southend, p.364.
[97] John Fleming, *Report on the Economical Mineralogy of the Orkney and Zetland Islands* (1811): 110.
[98] P.H. ‘On the Burning of Limestone with Peats’, *The Farmer’s Magazine*, vol. 3(10), May 1802, p.211.
[99] David Ure, *General View of the Agriculture in the County of Dumbarton* (1794), p.35.

Figure 51. Remains of a small field kiln near Wester Laggan, Grantown-on-Spey. Limestone was likely brought from the quarry about 0.6km further up hill.

Later field kilns became more permanent, constructed partly or entirely of stone. Many such kilns were constructed during the end of the eighteenth and start of the nineteenth century, commonly associated with enclosure of large wastes and commons.[100] As argued in Chapter Three, these kinds of kilns make up a large proportion of the kilns visible on the OS maps from the mid-nineteenth century onwards. The remains of these kilns can range from insubstantial (Figure 51) to imposing (Figure 52), with stones often repurposed over time for field boundaries or new structures. Detailed written descriptions are few. Among the first instructions for building a kiln recorded comes from Maxwell's *Practical Husbandman* in 1757, in which two kilns are described from submissions made by improving farmers. Robert Scott of Duninauld described in detail a kiln owned by his master, Mr Hope of Rankeilor.[101] Although termed a 'reverberatory kiln' (which would imply fuel and limestone were kept separate), from his account it seems that coal and limestone were burned in the same pot, with a layer of limestone sitting atop one of coal. The whole was emptied from the bottom between firings. The kiln itself was large: almost 6 meters high with a pot shaped like an inverted cone, four and a half metres wide at the top narrowing to a metre at the bottom. According to the account, it

[100] Barnatt and Dickson, "Survey and Interpretation of a Limekiln Complex at Peak Forest, Derbyshire; and Review of Early Limeburning in the North-West Peak," 142.
[101] Maxwell, *Practical Husbandman*, 196.

could burn up to twenty bolls of limestone at a time and was fired overnight to be filled and emptied each day.[102]

Figure 52 Lime kiln in Rothiemurchus, indicating the difficulty of determining whether kilns were continuous or not from their remains. The kiln walls are of dry-stone construction, with the draw arch mortared. Photo: David Taylor.

A similar intermittent kiln, described in the same volume by Mr Lummis, an English farmer, was set into the side of a small hill, enabling free access to the pot.[103] Its pot was described as being the shape of 'a Hogshead' (a barrel): small at the bottom, widening in the middle, and narrowing again at the top, a design that would have been more efficient at retaining heat than earlier conical kiln pots.[104] Alternating layers of coal and limestone were carefully arranged within the pot, with the largest stones near the centre where the heat would be strongest. Such a kiln, Lummis claimed, would burn limestone twice as efficiently as 'the common Way above Ground'.[105] Local experience of building simple field kilns may also have influenced the design of later more sophisticated kilns. Marshall speculated that the shallowness and width of early stone kilns in the Highlands was taken from the

[102] It is actually unlikely, given the size of the kiln, that it could reach 900ºC and cool within 24 hours.
[103] Maxwell, *Practical Husbandman*, 191.
[104] Johnson, *Limestone Industries of the Yorkshire Dales*, 55.
[105] Maxwell, *Practical Husbandman*, 192.

shape of the temporary turf kilns more commonly used there.[106] By the eighteenth century it was understood that larger kilns were the key to greater efficiency: 'the smaller the kiln the more expensive the burning' was the general rule.[107] As Johnson points out, many larger field kilns are almost indistinguishable from draw kilns, particularly in their ruinous state, and indeed many of the more substantial were probably operated continuously for short periods.[108] Many such example are documented in Ken Cruickshank *et al.*'s gazetteer of lime kilns from Upper Donside in Aberdeenshire.[109]

The rate of the burn in field kilns was controlled by the addition of fuel and the flow of air into the kiln, leaving them vulnerable to wind and rain. 'Miscarriages will happen in burning with bad weather,' wrote Robert Scott.[110] Some kilns had vents or shutters with which to control airflow, but many simpler field kilns did not. Logically, then, facing the kiln draw hole into the prevailing winds would ensure adequate oxygen for the burn. Johnson's analysis of the aspect of kiln remains in North Yorkshire found that sixty per cent of kilns were aligned between south-east and north-west, the range of directions from which the dominant winds blow.[111] That said, a significant proportion of kilns faced away from the prevailing winds, suggesting that either wind was not regarded as particularly important or that other factors, such as the orientation of the kiln to sources of fuel or limestone for ease of loading, took precedence. Indeed, the choice of fuel may also have been a factor: Alex Dirom remarked in 1767 that 'peats need lots of air; coals much less'.[112] A study of kiln aspect in Scottish kilns with regards local prevailing winds would be illuminating as to the importance of this factor.[113]

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[106] Marshall, *General View Highlands*, 36.
[107] Alex Dirom (Snr) to Peter May, 11/07/1767, in Adams, *Papers on Peter May Land Surveyor, 1749-1793*, 151.
[108] Johnson, *Limestone Industries of the Yorkshire Dales*, 63.
[109] Cruickshank, Nisbet, and Greig, *The Limekilns of Upper Donside: A Forgotten Heritage*.
[110] Maxwell, *Practical Husbandman*, 197.
[111] Johnson, "Lime Kilns in the Central Pennines: Results of a Field Survey in the Yorkshire Dales and Contiguous Areas of North and West Yorkshire," 243–45.
[112] Alex Dirom (Snr) to Peter May, 11/07/1767, in Adams, *Papers on Peter May Land Surveyor, 1749-1793*, 152.
[113] Bishop has already touched on this aspect to some extent, noting the different draft requirements of clamp and draw kilns, see "How OS Depicted Limekilns in Scotland's Central Belt," 25–26.

5.2.3 Draw kilns

Previous histories of the lime industry, in Scotland and elsewhere, have focused almost exclusively on draw kilns, giving the impression that they were somehow the pre-eminent mode of lime production.[114] Draw kilns operated by continuously loading fuel and limestone into the pot from above and drawing out the lime from the draw hole at the base, causing the burning mass to move downwards. Even small kilns of this kind were considered more efficient than single-use field kilns.[115] On this principle, lime kilns could be kept running for several months.[116] Designs allowed the kilns to be kept alight for several days without being employed to burn limestone, saving fuel by keeping the kiln hot while allowing for fluctuating demand to be met swiftly and removing the need to store large quantities of burnt lime with all the problems that entailed.[117] Dimensions of the kiln pot were also sometimes kept small where demand was agricultural and prone to seasonal and day-to-day fluctuations.[118] Unlike field kilns, which were often sited close to where the lime was to be used but relatively distant from the source of limestone, draw kilns were typically located immediately adjacent to, or indeed within, limestone quarries.

[114] Skinner, *The Lime Industry in the Lothians*.
[115] John Smith, *General View of the Agriculture of the County of Argyll*, (1798), 199.
[116] *OSA,* Parish of Stevenson (1793), vol. 7, p.9; James Adam, *Practical Essays on Agriculture*, vol. 1 (1789): 144.
[117] Wallace, *Account of the Method of Burning Limestone,* 443-4.
[118] Wallace, *Account of the Method of Burning Limestone,* 442.

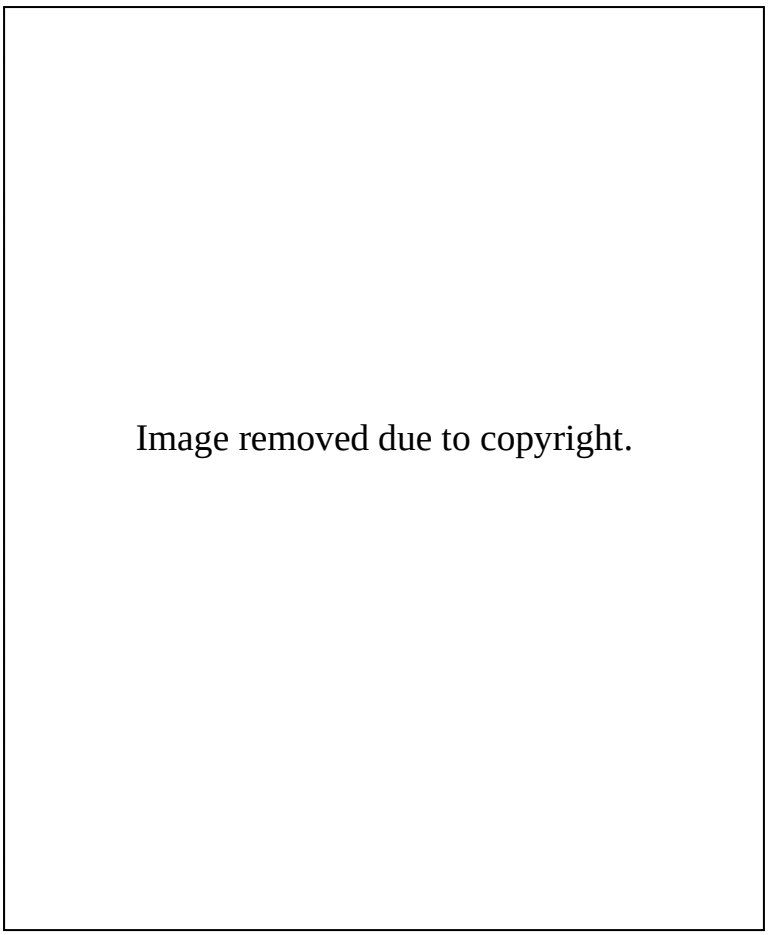

Figure 53 Small lit draw kiln being loaded. William Marshall Craig, *Landscape with Lime Kiln and Workmen*, c.1808 , watercolour, ink and graphite. Yale Centre for British Art, Paul Mellon Collection.

Although draw kilns were much discussed in contemporary literature, no consensus emerged regarding the specifics of their construction. Archibald Grant, a notable improver in Aberdeenshire, gave instructions for the construction of a 'perpetual kiln' in 1756.[119] The kiln pot he described was narrow at the bottom, widening towards the top, before contracting again before the rim—a design that would be replicated and iterated upon at many lime works around Scotland. Others describe kiln pots the shape of an 'egg' or an 'inverted bottle'.[120] Openings were to be made on the sides of the kiln above the draw holes to allow the burners to control airflow and clear blockages with iron implements. The pot should be lined with smooth hard bricks. Agriculturalist James Adam suggested that 'the outside form is best cylindrical', although he does not say why, and indeed draw kilns took many shapes and sizes.[121] Many in Scotland were of square plan—such as at Ardonald (Figure 55)—

[119] Sir Archibald Grant, *The Farmer's New-year's Gift to his Countrymen, Heritors, and Farmers, for the Year 1757*, (Aberdeen, 1756), pp.29-30.
[120] Smith, *General View Argyll*, 199; Adam, *Practical Essays*, 141.
[121] Adam, *Practical Essays*, 141.

which may have reflected ease of construction or the opportunity to integrate attendant structures. Adam proposed two draw holes facing each other from which the burned lime could be drawn out using a 'drag and shovel', but kilns were built with as few as one draw hole or as many as four. Since kiln walls were prone to breaching under the stress of firing and the heavy loading of limestone and fuel, kiln pots were increasingly encased in thick outer cladding or the whole kiln reinforced by buttresses—an example of which can be seen in Figure 54.[122] Many kilns were built into a bank or hill, lending support to the structure and giving access to the kiln head for loading.[123] Larger kilns with thick walls were designed to give space for workers, while thick outer walls further recessed the draw holes, affording the lime some protection from the elements as it was unloaded.

Figure 54 Draw kiln at Loch an Eilein, Rothiemurchus. A small limestone quarry is located a short distance up the hill behind the kiln. Note the long buttresses on either side, which likely offered support for the kiln facing.

Draw kilns remained relatively novel at the turn of the nineteenth century. Several of the respondents to the *OSA* remarked on new draw kilns in their parishes, many of which were recently built in response to growing demand for lime.[124] With the exception of parts of Central Scotland where banks of clamp kilns were common, the bulk commercial lime production was carried out with draw kilns (see Chapter Three). Although designs varied as a likely consequence of local building materials,

[122] Dirom, *Plan and Description of Lime Kilns*, 110; Scottish Lime Centre Trust, *Charlestown Limeworks: Research and Conservation*.
[123] Adam, *Practical Essays*, 141.
[124] *OSA*, Parish of Sorn (1798), vol. 20, p.153; *OSA*, Parish of Eckford (1793), vol. 8, p.26; *OSA*, Parish of Kilpatrick-New (1793), vol. 7, p.104.

site layouts, knowledge, scale of intended production, and so on, they largely conformed to the same basic principles. Exceptions, such as Brigadier-General Dirom's domed kilns at Mount Annan, were relatively rare.[125] Distinct regional styles appear not to have developed, reflecting, perhaps, Tarlow's argument about the fundamental homogeneity of certain features of improvement.[126] However, the extent to which they became a 'necessary appendage to every farm', as one observer suggested, is questionable.[127] While 'improved' husbandry often demanded large quantities of lime, the labour and volumes of material involved with operating a continuous kiln would not likely have been worthwhile for most tenant farmers interested in simply meeting their own needs.[128] Thus draw kilns were much more commonly associated with intentional commercial output or were used to supply several farms on an estate, as is discussed below.

Figure 55 Northernmost and newest lime kiln at Ardonald lime works, measuring approximately 9m tall. Three draw holes are visible on each side of the kiln. A tunnel (now infilled) runs behind the pot and may have given access to a fourth draw hole. An adjoining building on the north side (not shown) was likely

[125] 'Plan and Description of Lime-kilns Built in 1801 by Brigadier-General Dirom of Mount Annan', *Prize Essays and Transactions of the Highland Society of Scotland*, vol. 3 (1807): 110.
[126] Tarlow, *The Archaeology of Improvement in Britain, 1750–1850*, 193.
[127] John Smith, *General View of the Agriculture of the County of Argyll,* (1798), p.199.
[128] As an indication of the growing rate of liming over the eighteenth and nineteenth centuries, John Ramsay noted that 'a farmer who formerly laid on a few chalders yearly for two-thirds of his lease, thought nothing of driving a quantity equal in value to half his rent. Instead of the old practice of adding 2 to 3 chalders per acre, it is now considered good husbandry to double the quantity.' See Ramsay (Alexander Allardyce ed.), *Scotland and Scotsmen in the Eighteenth Century*, (1888).

used for storing lime and may have provided covered access to the draw hole on that side. It is indicated on the OS first edition map.

Multiple kilns were crucial for large commercial enterprises, since they allowed production to scale up or down to meet demand, and for sales to continue while repairs or alterations were carried out on a kiln. For instance, between December 1794 and April 1795, before a second kiln was constructed at Raw Camps, only raw limestone could be sold from the works while the original kiln there was being widened.[129] At the most industrialised sites, draw kilns were often built into conjoined banks of two or more kilns—an example of which can be seen in Figure 56.

Figure 56 Bank of four draw kilns at Ard Neakie, Loch Eriboll, with pier in foreground and quarry to the rear. The different shape of the arches on the left and right of the kiln suggest that one side was built after the other, perhaps by different masons. Photo: Angus Mitchell.

5.2.4 Constructing kilns

The simple construction of early kilns suggests that farmers and lime burners could be expected to build kilns themselves. Even small draw kilns might be considered a project appropriate to a tenant farmer and the labour available to him: John Smith suggested that one could be ‘scooped out and

[129] Accounts, 1795 (NRS GD150/2356).

built in the face of a hill at a trifling expense'.[130] Cruickshank et al noted the 'striking . . . individuality of appearance' of the kilns in their study of Upper Donside.[131] Almost all were built of field stones on the same design principles: 'circular, slightly tapering inwardly to the top, with a single draw hole in the centre of the front face and a number of inverted, stepped lintels in the roof of the draw how, supporting the weight of the bowl'.[132] Within this basic design, however, each kiln varied substantially in terms of dimension, construction and style. This uniqueness, they argue, suggests that the farmers themselves were the ones who built them, whereas if construction had been the responsibility of the estate or local masons a more regular plan and size would likely have been used. As kilns grew in stature and complexity, the effort and cost of constructing them rose significantly.

Correspondence pertaining to the building of a reasonably small draw kiln at Endertill, near Kirkcaldy, in 1793 gives insight into the construction process and the design considerations. George Burns, a mason from Kirkcaldy, made an estimate for constructing the kiln along the following plan:

> The foundations to be duge [dug] to a suficient [sufficient] depth fitt [fit] for founding on, the bottom of the kiln to be sunk as low as the top of the road, thickness of walls at foundation to be nine feet two inches to diminish to the top and there not to be less than six feet thick, width of kiln at top thirteen feet, height twenty feet, the retaining walls to be founded four feet six inches thick and to have intake at five different heights and at top not to be less than two feet thick, all the outside of kiln and retaining walls to [be] of plain double building, arches above the eyes to be of crotched stone or brick. The outside of the kiln to be lined with common brick laid all header ways nine inches in lenth [sic] into the building, the banking at back of walls to be made with an easy rise of one foot in fifteen.[133]

The initial estimated price for this work was £96-8-8, including ten thousand bricks for lining the inside of the kiln.[134] Space for building a second kiln should demand increase was taken into consideration. Burns was at liberty to quarry stones for the work from the area in the vicinity of the kiln where most convenient. A later memorandum of the work calculated the total price to have been £103-6-0, broken down as follows:[135]

[130] Smith, *General View Argyll*, 199
[131] Cruickshank, Nisbet, and Greig, *The Limekilns of Upper Donside: A Forgotten Heritage*, 30.
[132] Cruickshank, Nisbet, and Greig, 30.
[133] 'Estimate for Bulding [sic] a Lime Kiln at Endertill agriable [agreeable] to a Plan made owt [out] for the same by George Burns – signed George Burns, Kirkaldy [Kirkcaldy]', 03/09/1792 (NRS GD164/832/1).
[134] Accompanying note for 'Estimate for Building a Lime Kiln…' (NRS GD164/832/2).
[135] 'Memorandum of Prices of Endertill Lime' (NRS GD164/832/11).

Table 12 Expenditure on Endertill lime kiln, 1793.

Mason work	£76	11	-
Drain at the back	1	1	-
Rail on top of the kiln	2	3	-
Cutting and forcing	10	-	-
Shed	13	11	-

The construction of substantial new kilns at Raw Camps lime works in 1792 and 1793 illustrates the amount of labour required to enact such works:[136]

Table 13 Expenditure on labour, totalling more than £233, for building new kilns at Raw Camps lime works, 1793.[137]

Building New Kilns			
To William Shaw and other masons for building new kilns on the north side of the quarry per accompt in April and Novem 1793	£60	1 4	4
To labourers wages per accompt from 16 February to 30 Novem 1793	91	1 9	9
To William Shaw for quarrying free stones 4 roods 26 yairds at 10/ per accompt 1 November 1793	2	7	22
To William Wilkie for quarrying stones per acco in November 1793	-	3	6
To James Thomson driving stones to the draw kiln 24 Sep 1793	-	1 2	-
To George Kelso for driving stones and sand per acc 24 Octo 1793	2	6	6
To Robert Alexander for driving 160 carts ditto per 4 receipts	8	-	-
To John Bishop for _____ 121 Ditto _____ per accompt	6	1	-
To James Kimley for _____ 164 Ditto _____ per accompt	9	2	8
To John Garvies for quarrying and driving stones per 2 accompts in June and Septem 1793	8	1 4	5
To George Somerville for driving stones in January 1793	1	1	6
To John Anderson for Carraiges per accompt in August 1793 N.B. 6/ of this was carriage of coal in January 1793	2	9	-
To William Smith for Carriages of sand	-	2	-
To George Boag for Ditto	-	5	-
To J. Thomson surface damages during the driving of sand through his farm of Gliftonhall	1	-	-
To Thomas Falconer for driving sand	1	1 6	-
To George Fleming for cutting and filling Whins for the kiln	-	3	-
To sum charged on the Complov for these buildings 560 Bolls of Lime	36	6	8

The accounts show that the mason's work was the second largest single cost, after the labourer's wages, but also that a great deal of effort and time was required to clear ground, quarry stones and

[136] Abstract of John Beveridges Accounts as Manager of the Lime Works at Raw Camps for the Countess of Morton, from 14 November to 31 December 1792 (NRS GD150/2359).
[137] State of John Beveridges Accounts as Manager of the Lime Works at Raw Camp for the Countess of Morton from 31 December 1792 to 31 December 1793 (NRS GD150/2359).

move materials. When further improvements to the kilns were carried out in 1805, the manager actively sought out the mason responsible for building a kiln belonging to the Earl of Wemyss, suggesting that their reputation and experience working with known kilns were highly valued.[138]

A new draw kiln, shown in Figure 55, was constructed at Ardonald Lime Works in 1802. Accounts from the works, detailed in Table 14, show that construction of the kiln amounted to almost twenty-three percent of their year's expenditure, making it a significant investment on the part of the proprietors. [139]

Table 14 Ardonald Lime Works, Expenses 1802

Building kiln and shed	£429	3	5½
Price of coal, peats and carriage	845	7	11
Quarriers and labourers wages	418	9	1
Tools and furnishings	95	1	½
Overseers Wages	33	14	1
Bank Charge	32	2	-
Total	1853	17	1

A mason from Huntly, Thomas Smith, was paid the hefty sum of £392-17-9 for building and lining the kiln between 1801 and 1802.[140] The new kiln was larger and of a markedly different design to the older one. The first had been constructed towards the end of the eighteenth century and was built into a bank closer to the quarry workings at the south of the site. Although now collapsed and heavily overgrown, it appears roughly conical in exterior shape and one deeply recessed draw arch is visible. The new kiln, positioned next to the mine opening at the north of the site, had at least three draw holes and was of square plan. Adjoining it was a large stone shed, likely built for storage or shelter. The archival record does not elaborate on the design of the 1802 kiln, and so it is possible only to speculate on the reasoning behind the new design. Different masons may have been employed, bringing with them their own preferred construction, or it may reflect a deliberate attempt, on the part of the proprietors, to address deficiencies of the former kiln. When a lease of the works was advertised in 1810, it mentions 'only one draw-kiln erected', suggesting that the previous kiln may

[138] Letter, William Douglas to the Countess of Morton, 05/03/1805 (NRS GD150/2359).
[139] Accounts, 1802 (NRS GD44/51/535/1).
[140] John Menzie's state and accounts 1803 (NRS GD44/51/535/2).

have been operated intermittently or had ceased to be operational.[141] Upkeep of the draw kiln was ongoing throughout the lifetime of the works. In 1808 a wooden frame was erected to reinforce it (metal pins and fastenings are visible on the exterior walls) and the lining was replaced. Rails were added to the kiln head, presumably to aid loading.[142]

Local masons certainly had an important role in the construction of lime kilns. In 1849 an advertisement was placed in the *Aberdeen Press and Journal* seeking masons for building kilns near the Ardonald lime works:

> ESTIMATES are wanted for BUILDING a LIME KILN, at ACHAIRN, Parish of Cairnie.
>
> Specification will be seen, and any other information given on application to Mr M'PHERSON Gibston, near Huntly, at whose office, in Huntly, intending offerers are requested to attend, on THURSDAY the 15th November ensuing, at noon.
>
> The lowest offer may not be accepted unless otherwise satisfactory.[143]

On the OS First Edition map, surveyed in 1871, there are two lime kilns and signs of quarrying on the farm of Wester Auchairn. It is reasonable to suppose that these were built following placement of the advert above.[144] The farm is less than a mile from Ardonald, which ceased production in 1857 after the limestone became exhausted—the new kilns may have been an attempt to revive diminishing lime production in the area. The kilns are not shown on the six-inch second edition and are marked as 'Old' on the 25-inch first edition map.[145] Their remains have since been completely erased by farming, suggesting that they may not have been built to the same stature as the nearby Ardonald kilns.

[141] 'The Duke of Gordon's Lime-Works To Let', *Aberdeen Press and Journal,* Wednesday 21 February 1810, p.2.
[142] Ardonald Lime Works, Accounts 1808 (NRS GD44/51/537/3).
[143] 'To Masons', *Aberdeen Press and Journal,* Wednesday 07th November 1849, p.3.
[144] There are no kilns shown at the other farms in the area: Upper Auchairn, Easter Auchairn, and Croft of Wester Auchairn.
[145] OS 6-inch First Edition sheet 16, published 1874; 25-inch 16, published 1892.

5.3 The lime burner

5.3.1 Who burned lime?

The identity of the lime burner in Scotland largely relates to the availability of resources and the nature of local demand for lime, as well as the relationship between the farmer and the land. Where calcareous material and fuel to burn it were plentiful, farmers would often burn their own lime. In places like the parish of Grange, in Banffshire, where limestone was said to be 'inexhaustible', 'a great proportion of the small farms [had] their lime kiln'.[146] Likewise, in Ayrshire, most farmers would 'generally burn their own lime for the use of the farm'.[147] Lime was also burned 'at home' out of necessity when it could not be purchased cheaply from local commercial suppliers.[148] In places where large scale industrialised lime burning never developed, such domestic kilns remained frequent until well into the nineteenth century: Reverend James Grant of Cromdale, near Grantown-on-Spey, remarked in 1845 that 'there is scarcely a tenant in the parish, occupying a L.5 farm, who has not his own lime-kiln'.[149] The preference in the Lowlands for large tenancies, and the prosperous farming class it produced, meant that many tenant farmers had the lands to justify their own lime supply and the capital to fund it. In some parts of the country even sub-tenants were known to have their own kilns.[150] .

In the seventeenth century, lime burning for the farm was considered a part of the day-to-day labour for male, and indeed female, farm servants in parts of rural Scotland. The Justice of the Peace for Midlothian drew up an *Assessment of Wages* in 1656, outlining a hierarchy of workers, their expected duties and associated pay scales. Among the duties of the wives of workers were 'to Shear dayly in Harvest, while their Masters Corn be cut down. They are also to be [until] assisting with their Husbands in winning their Masters Hay and Peats, setting of his Lime-kills, Gathering, Filling, Carting and Spreading their Masters Muck, and all other sort of Fuilzie [manure], fit for Gooding

[146] *NSA*, Parish of Grange, vol. 8 (1842), p.217.
[147] *OSA*, Parish of Dalry, (1794).
[148] *NSA*, Parish of Birse (1845), vol. 7, p.795.
[149] *NSA*, Parish of Cromdale (1845), p.433. Such statements also hint at lime kilns being something of a status symbol among prosperous farmers, a theme discussed in more detail in the next chapter.
[150] *OSA*, Parish of Birse, (1793), vol. 9, p.117-8.

and Improving the Land.'[151] The acknowledged involvement of women in lime work here is notable since subsequent records of lime burners and labourers in the lime industry refer almost exclusively to men. Later records of women burning lime are scant. A workforce of fifty women was employed at the Gilmerton lime works near Edinburgh, carrying stones to the bank-head with 'creels fastened on their backs' in a manner resembling the work of women in coal mines elsewhere in Scotland.[152] Their labour at Gilmerton was later replaced by asses, which in turn were replaced by a steam engine.[153] The reasons for the male dominance of lime burning, particularly in non-extractive roles, are unclear. There were no more than a handful of industries in Scotland where women were not employed, and women had well documented roles in the coal industry so closely related to lime production.[154] The difference may lie in the fact that waged lime workers escaped the serfdom that was characteristic of coal mining, thus families were not tied to a local lime works.[155] Or else it may be to do with the gradual movement of lime burning away from the domestic settings of farm and field to dedicated industrial sites. For whatever reason, very few women are recorded as having worked in the lime industry, as data from the 1841 census illustrates (Table 12).

Table 15 Persons involved in the lime trade in Scotland, taken from the 1841 census.[156]

	Male, age 20 and upwards	Male, under 20	Female, age 20 and upwards	Female, under 20
Lime-burner	288	22	0	0
Quarrier, Limestone	342	32	2	0
Lime-dealer or Merchant	23	2	0	0

However, census results tell only a part of a story. More than ten times as many kilns were recorded in Scotland from the OS first edition six-inch maps (see Chapter Three) than there were lime burners in the 1841 census. Only a small number of people produced lime as their full-time occupation; most lime was burned as a subsidiary part of running a farm or estate. It is highly probable, therefore, that

[151] Fenton, *Scottish Country Life*, 166.
[152] *NSA*, Parish of Liberton, (1845), vol. 1, p.19.
[153] Skinner, *The Lime Industry in the Lothians*, 19.
[154] Whatley, *Scottish Society, 1707-1830: Beyond Jacobitism, Towards Industrialisation*, 127; Duckham, *A History of the Scottish Coal Industry, Vol. I 1700-1815*.
[155] Harrison, "Lime Supply in the Stirling Area from the 14th to the 18th Centuries," 87.
[156] Data sourced from *A Vision of Britain Through Time* (http://www.visionofbritain.org.uk/census/). Note that the figure for limestone quarriers does not include those who recorded their occupation as unspecified quarriers or labourers.

in parts of Scotland some women were indeed involved in lime burning, either directly or by making various 'hidden' contributions to production within the context of the family economy.[157]

Although in some places farmers were able to produce lime 'partly for sale, and partly for their own use', commercial supply was simply too great an effort for most individuals to carry out themselves.[158] As Reverend Hugh Laird of Portmoak, Kinross, remarked in 1845:

> There is hardly an instance of a person who lives by farming burning lime for sale; and yet it seldom happens that in this trade much money is earned. It seems to be only strong working people who gain by it, through an application of more time and strength than can be long continued.[159]

Anyone with the know-how and access to the resources could burn lime using simple kilns, but only a small number chose to live by it. As the discussion above regarding the operation of kilns has shown, maintaining a continuous output of lime required a significant physical effort in terms of moving and preparing stones, loading fuel, and unloading lime. As larger lime producers began to employ larger draw kilns, at considerable initial expense, smaller producers in crowded markets could not compete and make a good living. By the second half of the nineteenth century, private entrepreneurs or small groups of associates were yielding to larger companies.[160] As late at the 1830's, though, when Carmichael completed his survey, many works were operated by single men.

5.3.2 The role of the lime burner

Some people were regarded as specialist lime burners or lime workers, earning all or a large part of their living from the practice. Evidence of this role appears as far back as the sixteenth century: in the 1520s, at Mauchline in East Ayrshire, lime was purchased during the spring and 'the lime man' sent for to prepare it.[161] Early lime suppliers in Stirlingshire were tenants who either owned or rented kilns and regularly sold lime, although probably as a subsidiary to farming.[162] By the eighteenth

[157] Whatley, *Scottish Society, 1707-1830: Beyond Jacobitism, Towards Industrialisation*, 127; Ivy Pinchbeck, *Women Workers in the Industrial Revolution* (London: Routledge, 1969), 271.
[158] *NSA*, Parish of Deskford, (1836) vol. 8, p.65.
[159] *NSA*, Parish of Portmoak (1793), vol. 9, p. 32; *NSA*, Parish of Cromdale (1845), p.433.
[160] Skinner, *The Lime Industry in the Lothians*, 33.
[161] Margaret H B Sanderson, "Agricultural Labour in the Lowlands during the Sixteenth and Seventeenth Centuries," in *Scottish Life and Society Volume 2: Farming and the Land*, ed. Alexander Fenton and Kenneth Veitch (Edinburgh: John Donald, 2011), 407.
[162] Harrison, "Lime Supply in the Stirling Area from the 14th to the 18th Centuries," 86.

century, many estates either directly employed or had an established arrangement with a local lime burner. For example, James Dallas, tenant of Sir James Grant, was appointed as a lime burner in 1770 to supply large quantities of cheap lime for the farmers in Strathspey, a duty he carried out for seven years before moving to Rothiemurchus, where he continued in the trade.[163] Many lime burners held the position for much of their working life. In Callander, by 1787 James Crawford had been quarrying and burning lime for the Duke of Montrose for more than sixteen years, selling to the Duke's tenants in the baronies of Menteith as well as 'those without the Duke's estate as may demand it'.[164] At small scales, quarrying was the responsibility of the lime burner, either carried out himself or by directing others. John Burrel's accounts from Arran record payments to local lime burner Jamie Fullarton for 'quarrying limestone out of Knockanburn, setting the kiln, knapping the stones and slaking the lime'. A William Stevenson was also paid for providing a barrel to measure the lime in and Alex Brown (presumably the local blacksmith) provided quarry wedges and repaired the lime tools.[165] On the forfeited Strowan Estate in Perthshire, Hugh MacDonald burned lime for more than twenty years. He was allowed a boll of meal in return for every thirty bolls of lime produced and sold to the tenants at an agreed rate. When he first began the work in 1754 '[n]o lime was used in the country, but what he made'. By 1772 some of the tenants were burning their own lime, 'but he has to direct them how to break the stones and fill the kilns'.[166] Thus the lime burner can be seen as responsible not only for supplying valuable agricultural and building materials, but also acting as an important vessel of knowledge and experience.

In a pre-instrument age, formalised instructions for burning lime were scant on detail; lime burning was an 'art'.[167] During the eighteenth century, when many estate owners were seeking to improve their lands by the use of lime, a lack of local 'burners of lime' could be as much a barrier as the unavailability of limestone or fuel.[168] Patrick Gordon, who toured the Highlands extensively on

[163] 'James Dallas, lime burner', May 1777 (NAS GD128/53).
[164] Petition regarding disputed measures, Nov 1787 (NRS GD220/6/523/2); James Crawford's tack (NRS GD220/6/523/5).
[165] Alexander, "Brodick Castle Clamp-Kiln and the Lime Industry of Arran," 21.
[166] Cruickshank, Nisbet, and Greig, *The Limekilns of Upper Donside: A Forgotten Heritage*, 6.
[167] Johnson, *Limestone Industries of the Yorkshire Dales*, 62.
[168] Patrick Gordon of Kinrara to Alexander Duke of Gordon, 01/09/1727 (NAS GD44/43/16).

behalf of the Duke of Gordon looking for opportunities to improve his lands, bemoaned the fact that in many areas, not only were resources for producing lime scarce, but farmers had 'no skill to burn it'.[169] In such cases, knowledgeable lime burners would have been prized assets to an estate. On being informed that the 'limer' in Urquhart was 'drunken and not to be depended upon', surveyor Peter May advised that, to preserve his expertise, his employer, James Grant, send some of his 'most sagacious labourers to learn with him in case of accidents'.[170] May also recommended that, his unreliability aside, the lime burner's method of burning was preferable to that used on Grant's other estate in Strathspey, and that his advice should be sought for improving the latter.[171] In areas where small kilns proliferated from earlier on, techniques for burning lime were more ingrained among the farming community. For example, in Ayrshire, George Robertson noted that 'from long practice in [the] craft' local farmers had become 'very dexterous' lime burners and 'it seldom happens that a kiln goes wrong'.[172]

Some lime burners appear to have moved around, operating as skilled journeymen seeking employment on different estates. In 1797 John Murray offered his services burning lime to Neil Malcolm's Poltalloch Estate in Argyll. He set out his terms in a letter to estate factor, James Gow:

> The above John Murray proposes hiring by the year (for the purposes of burning lime and when there is no lime wanted to work at any mason work that is required about the farm and he being a bred mason) on the following terms viz.
>
> To have a house and garden and firing carted and in winter have ten shillings per week from the 11th of Nov until 14th of February and during the rest of the year to have thirteen shillings per week; and a croft or Cowsgraze summer and winter and potato ground which he will pay for at the rate of the country.
>
> The said John Murray is fully of [the] opinion that he can furnish on these premises the lime burned with a mixture of peats and coal of one third coals the other two thirds peats; for 7d per boll or under. Mr Malcolm is further to enjoy to furnish the said John Murray with the tools necessary for these operations to and keep him in constant employ should Mr Malcolm agree to the above proposal you are to return one an answer in the course of ten days or a fortnight at the farthest.[173]

[169] John Williams to Alexander Duke of Gordon, 30/01/1769 (NAS GD44/28/34/97).
[170] Peter May to James Grant, 10/07/1769 in Adams, *Papers on Peter May Land Surveyor, 1749-1793*, 78.
[171] Unfortunately, no parties in the correspondence elaborate on the difference between the two.
[172] George Robertson, *Rural Recollections*, 618.
[173] Letter, John Murray to James Gow, 06/03/1797 (ABC DR/2/1/9).

Gow agreed to take on Murray, on the provision that lime would not exceed 7d per boll (or if it did, Murray would himself make up the difference in price).[174] Before approaching Malcolm's men, Murray was noted as having been employed burning lime on the nearby Campbell estate. He may have been prompted to make contact following Malcolm's intention to erect a 'good limekiln' on Island Macaskin to replace the temporary kilns previously used there. The lime was desired for a series of improvements on the estate, notably bringing into production the moss at Moine Mhor, for which Gow believed lime to be the 'cheapest and most expeditious plan to be adopted'.[175] Before Murray made his offer, the new kiln had been intended for the tenants to use 'as they think proper'. [176] But, by taking on a dedicated lime burner, the estate may have decided to save the effort and inexpert technique of the local tenantry. Murray's letter itself is unusual since it gives voice to a class of labourer that was typically silent in the written record. His terms also reveal the almost proto-industrial nature of the lime burner's trade: a primary income from the seasonal sale of lime supplemented by his own farming and other ad hoc work. The close association between the mason's trade and the lime burner is also evident.

Even once lime production had become more industrialised, setting and lighting kilns remained a valuable skill. Kindling, fuel and stones had to be arranged carefully, so that the whole would burn steadily and evenly. Once properly alight, maintaining the burn by adding additional fuel and limestone was a more straightforward exercise.[177] Records from Charlestown show that other lime works sought advice and instruction from their experienced lime burners. In one instance from 1803, a kilnheadsman was dispatched to a lime works in Alloa, with a letter sent ahead of him informing the lime burners there that he would 'assist in setting your kiln'. The letter also advised that they could 'safely entrust the management of your kiln and instructions of your workmen' to the man, and that he would 'stay with you until you consider your own people to go on without him'.[178] A nineteenth century limeburner was included as part of Whistler's series of views depicting

[174] Letter, James Gow to John Murray, 17/03/1797 (ABC DR/2/1/9).
[175] 'Memo for Gow', 1796 (ABC DR/2/1/8).
[176] Letter, James Gow to Neil Malcolm, 06/02/1797 (ABC DR/2/1/9); 'Memo for Gow', 1796 (ABC DR/2/1/8).
[177] Johnson quotes one former lime burner who remarked, when asked about the precision of feeding a draw kiln, 'I was put on the kilnhead, enveloped in smoke, to throw in stones and coals.'. See Johnson, *Limestone Industries of the Yorkshire Dales*, 62.
[178] Scottish Lime Centre Trust, *Charlestown Limeworks: Research and Conservation*, 11.

dilapidated warehouses and wharves along the Thames (Figure 57). The melancholic scene—many of the sites Whistler depicted were facing imminent demolition—includes some evidence of the lime burner's trade: the riddle by his side was likely for sifting the lime for uncalcined lumps; the barrels were for sealing the lime from the air; and ships on the Thames in the background hint at the coastal lime trade.[179]

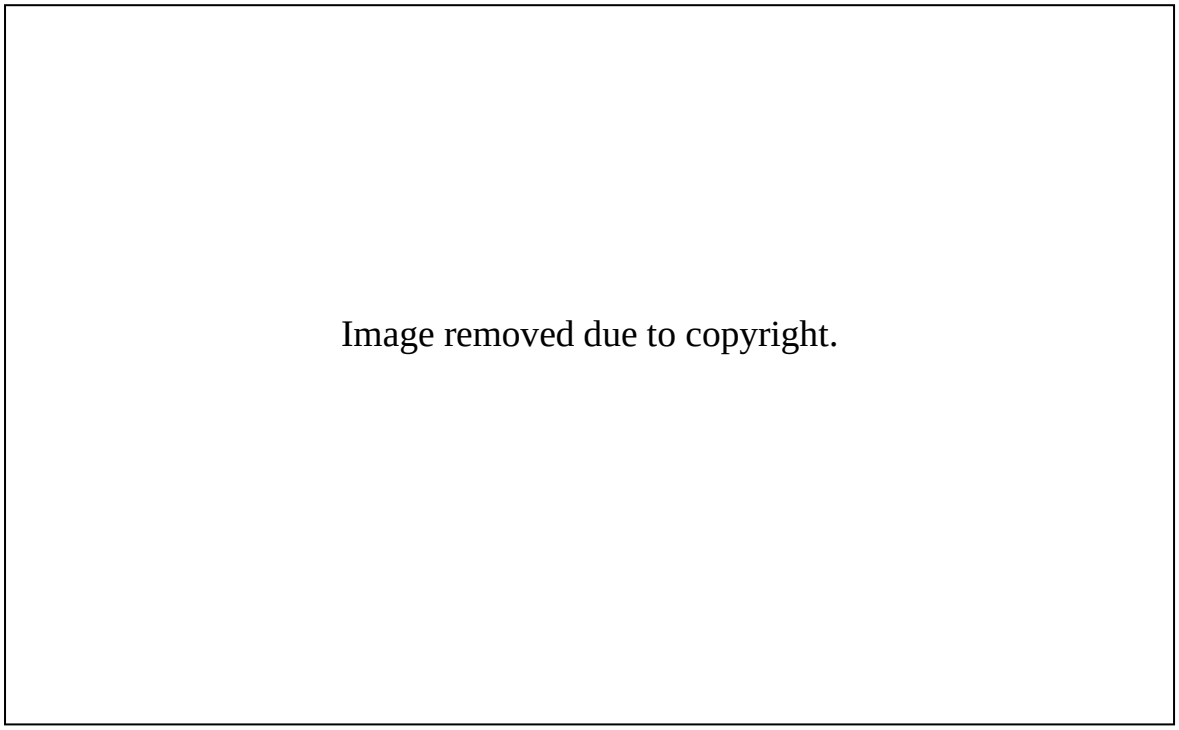

Figure 57 James Abbot McNeill Whistler (1834-1903), Detail from *The Lime Burner*, 1859, etching on paper. National Galleries of Scotland

Despite the obvious close association with the burning of lime, quarrying and preparing limestone were largely regarded as a 'distinct article'.[180] Here too there was considerable skill involved, although this was not universally recognised. John Wallace, in his account of lime burning for the *Highland and Agricultural Society* in 1837, emphasised this point:

> Mr Louden, in his Encyclopedia of Agriculture, says "The working of limes is a simple operation, and one depending on more strength than skill." This is erroneous, as considerable skill and experience are required, not only in blasting rocks and

[179] National Galleries of Scotland, *The Lime Burner*, https://www.nationalgalleries.org/art-and-artists/95276/lime-burner.
[180] 'Lime Works at Raw Camp for 1800' (NRS GD150/2359).

> putting in the charge where it will take the greatest effect, but also in the use of the lever and mell and large hammer.[181]

Though the winning and breaking of stones was often the work of casual labourers, it was a crucial part of the lime burning process. Frequent complaints were made about the improper quarrying of the rock or loading the kiln with stones of too great or uneven a size. Proprietors could be demanding of their labourers—Robert Scott, for instance, complained about his stone breakers sitting while they worked, questioning whether it was the result of 'the hardness of my stone' or the 'laziness of the people'.[182]As mines and quarries grew in size and depth, greater numbers of labourers were required to extract limestone and proper management of the work was of great concern.

5.3.3 Labour organisation

From the second half of the eighteenth century and throughout the nineteenth, the trend within most industries was towards increased labour rationalisation—the division of complex operations into multiple subordinate tasks.[183] The lime industry was no exception. James Donaldson, in his capacity as surveyor for the Board of Agriculture, embraced the spirit of this aspect of industrialisation in calling for proprietors to take control of production by erecting draw kilns and employing 'experienced persons to manufacture lime'.[184] 'It cannot be supposed', he wrote, 'that these men can do as much work, as the same number would do, if by a proper division of labour, and under the direction of proper persons, they were confined each to that part of the work to which he was accustomed'.[185] A consequence of this organisational model, which was to be steadily implemented across all lime works, was the de-skilling of the lime worker. The role of the lime burner gradually disappeared, or rather it evolved into the position of manager or foreman of the lime works. James Beveridge, overseer of Raw Camps, was referred to in correspondence as 'man of the lime'.[186]

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[181] John Wallace, 'Account of the Method of Calcining Limestone in Some of the Limestone Quarries in Scotland', *Transactions of the Highland and Agricultural Society of Scotland*, vol. 5 (1837): 451.
[182] Maxwell, *Practical Husbandman*, 197.
[183] Whatley, *Scottish Society, 1707-1830: Beyond Jacobitism, Towards Industrialisation*, 266–67.
[184] Sentiments he articulated in his accounts of both Banff (1793) and Elgin/Moray (1794).
[185] James Donaldson, *General View of the Agriculture of the County of Banff* (1793), p.41-2.
[186] Accompt of Charge and Discharge between the Countess of Morton and James Beveridge, 31/12/1794 (NRS GD150/2359).

The extractive nature of lime burning, and the weight of materials involved, meant that significant labour input was required for even relatively small operations. Robert Scott describes the work of seven men that supplied a single kiln belonging to Mr Hope of Rankeilor in the 1750s: two men 'boring and blasting' at the quarry; three breaking stones and helping to fill the kiln; one drawing the limestone from the kiln before slaking it and delivering it to customers; and one that drove a two-horse cart for leading the limestone from the quarry to the kiln head.[187] The exact division of tasks likely varied according to local conditions. As lime works grew in scale, so did the workforce required to operate them. By one estimation, it took one worker for every 500 tons of limestone quarried annually, besides those employed bearing and carting the limestone and coals to the kiln.[188] Some lime works also employed persons to draw the money and manage the sales.[189] As such, larger lime works were reliant on a readily available casual labour pool, with the number of required hands varying in accordance with demand for lime.[190] Workers were usually contracted for the following season, with work, in most cases, suspended or reduced in scale over the winter months. Closeburn lime works, for example, employed between thirty and forty labourers for seven or eight months of the year.[191] Likewise, production at Ardonald lime works ran from May until November, with peak demand during July and August (Figure 58).[192] However, some sites maintained a work-force all year. Ledgers from Askomill lime works, near Campbeltown, show that, in the middle of the nineteenth century, a small crew was employed year-round.[193] The overseer, a Mr Fadzean, was paid £1-10 every two weeks, with three other workers receiving between nineteen and sixteen shillings each for eleven and a half days work.[194]

Most labourers were paid either day wages or by the quantity of limestone quarried or lime produced: in the parish of Pert in 1793, 'good hands' could expect 1/2 per day working lime or 6d. per boll

[187] Maxwell, *Practical Husbandman*, 196.
[188] *OSA*, Parish of Sorn (1798), vol. 20
[189] 'Garnkirk Limeworks', author unknown, 11/09/1808 (NRS GD44/39/30/3)
[190] *OSA*, Parish of Sorn (1798), vol. 20
[191] Donnachie, "The Lime Industry in South-West Scotland," 149.
[192] Lime produced, season 1808 (NRS GD44/51/537/3); Lime produced, season 1809 (NRS GD44/51/538/1)
[193] Askomill Lime Works book of account (ABC DR/4/2/1)
[194] Another individual, Donald Galbraith, also appears in the ledger, receiving wages often in excess of the overseer's for fewer days work, usually between five and eight days every two weeks. His position at Askomill is not clear, but his high pay may indicate some specialist role or skill, such as masonry.

burned.[195] The same piece-rate was paid to the workers at Whitfield, with economy and efficiency further incentivised by a bonus of 4d per boll for all production in excess of 200 bolls of lime from 100 bolls of coal.[196]

Figure 58 Lime produced each month at Ardonald Lime Works, seasons 1804, 1808 and 1809.

Most of the labour was required to quarry limestone and move it (or coal) to the kilns. Although quarriers had little role in the operation of kilns, they were paid by the quantity of lime burned—what John Beveridge referred to as 'converted bolls'—since it encouraged them to ensure the stones were broken small enough to calcine easily.[197] At Hedderwick, near Montrose, quarriers were paid 3 3/4d per boll of shells burned. They used tools provided by the master of the works, which they returned at the end of each day. They were required to pay for their own houses and gardens and find their own coals for domestic use. The master was responsible for maintaining and repairing the kilns, at a cost about £10 a year.[198] By engaging large numbers of casual labourers from the pool of underemployed rural workers, lime burning in many parts of the country played an important role in

[195] *OSA*, Logie Pert, (1793), vol. 9, p. 37
[196] Skinner, *The Lime Industry in the Lothians*, 25.
[197] 'Lime Works at Raw Camp for 1800' (NRS GD150/2359).
[198] 'Memorandum of Hedderwick Limeworks' (NRS GD44/39/30/14).

stimulating the countryside economy.[199] An account from Liberton captures with relish the effect that lime burning and connected industries had on the local area:

> The lime-stone quarries at that place [Gilmerton] yield 70,000 bolls of lime, and employ 35 men, annually; and two other quarries, in the parish, have yielded above 30,000 bolls of lime per annum. There is no place where the poorer sort, who are able or inclined to work, meet with more encouragement than here. Not to mention the draw kiln at Bourdeaux; not to mention the collieries; not to mention those who are employed in the public roads, or those whom the farmers are obliged continually to employ, the quarries, the lime kilns, afford work to great numbers. Many also earn their bread by driving of carts, and they live decently, and become independent.[200]

Furthermore, by offering waged opportunities for labour, the lime industry, along with blast furnaces, glasshouses and cotton mills, put pressure on the old institution of estate mine and collier serfdom.[201] Despite the close connection with coal mining, lime burners never faced the same restrictive labour conditions as miners, as evidenced by the role of the journeyman burners.

5.3.4 Working conditions

The lime worker's job was strenuous and, at times, dangerous. Quicklime is highly caustic and can cause irritation and burns to moist skin. In its powdered state it could easily be blown around by the wind 'to the great Hurt and detriment of both Men and Horses'.[202] Working closely with lime was no doubt unpleasant. Peter May, describing the loading of lime at harbour, stated that 'going into a ship with unslacked limestone [lime] and working among it is going into hell'.[203] Few, if any, of the modern safety measures recommended when handling lime, such as goggles, dust masks, and a ready supply of saline solution for rinsing eyes out, would have been available to the eighteenth or nineteenth century lime worker.[204] Breaking stones and loading the kiln was highly physical labour, while the high temperature of kilns and their contents made burns an ever-present risk, especially when hot lime was being unloaded.

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[199] Whatley, "The Experience of Work."
[200] *OSA*, Parish of Liberton (1793), vol. 6, p.508.
[201] Duckham, *A History of the Scottish Coal Industry, Vol. I 1700-1815*, 31.
[202] Mr Lummus, in Robert Maxwell, *The Practical Husbandman* (Edinburgh 1757), 193.
[203] Peter May to James Ross, 28/04/1767, in Adams, *Papers on Peter May Land Surveyor, 1749-1793*, 152.
[204] David Carrington and Peter Swallow, "Limes and Lime Mortars - Part Two," *Journal of Architectural Conservation* 2, no. 1 (1996): 8.

William William's painting (Figure 59) of a lime kiln being operated at the end of the eighteenth century in Wales gives an indication of some of the obvious hazards facing lime burners. Workers operating larger draw kilns would routinely walk across unburned material at the kiln head while firing was in progress, an activity that presented obvious dangers were the stones to shift unexpectedly as the lower layers burned away. One such case was recorded in the *Perthshire Courier* in 1844, where a labourer became embedded in the centre of a kiln when the stone he was standing on suddenly sank under his weight. Rescuers tried in vain to pull the man out but could not prevent his 'slow and horrible' demise.[205] The *John o'Groat Journal* in 1849 told of a similarly unfortunate individual thought to have become enveloped while loading a kiln. Reportedly, after workers had searched through the lime for his body, all that remained were 'some calcined bones and the burned haft of his tobacco knife'.[206] Gruesome deaths of this kind appeared frequently in newspapers during the nineteenth century, although they perhaps say more about the morbid interests of the press than they do about the dangers of lime burning.[207]

[205] 'Awful Death', *Perthshire Courier,* Thursday 2nd May 1844, p.2.
[206] 'A Man Consumed in a Lime Kiln', *John o'Groat Journal*, Friday 14 September 1849, p.4.
[207] *Caledonian Mercury,* Monday 7th September 1812, p.2; 'Accidents, Offences, Etc', *Perthshire Courier,* Thursday 15th October 1829, p.2; 'Horrible Death in a Lime Kiln', *Aberdeen Press and Journal*, 27th June 1877, p.8; 'Killed in a Lime Kiln', *Glasgow Evening Post,* 1 July 1887, p.2; *Derby Mercury,* Tuesday 8th January 1740, p.2.

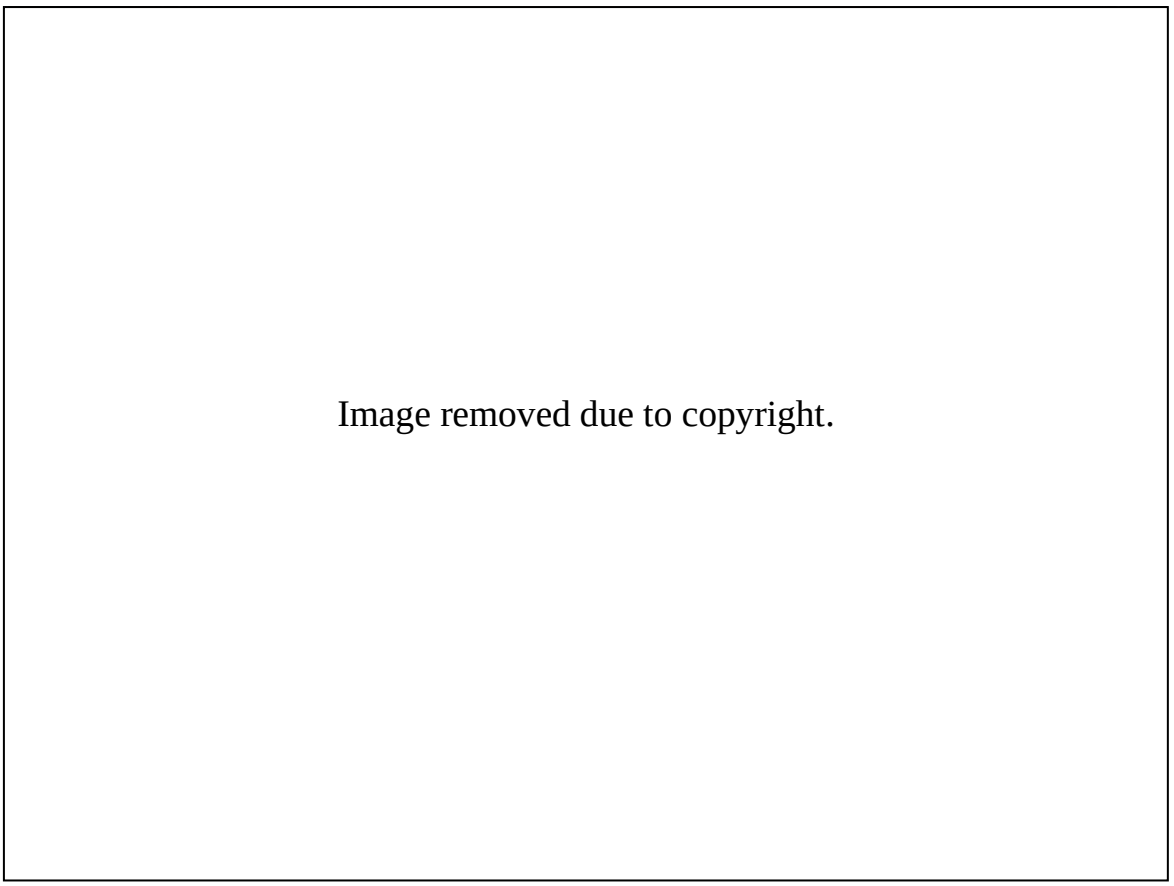

Figure 59 William Williams (1728-1794), Limekiln at Night, c.1794, oil on canvas. Llyfrgell Genedlaethol Cymru / The National Library of Wales

Williams' painting also hints at the lime kiln as a space of congregation—note the two men, either side figure in the centre, who appear to be warming themselves by the pot while the others work. Lime kilns gave off large amounts of heat and larger draw kilns frequently had covered areas to keep rain off the lime and the workers. It was not uncommon for people to take shelter in such places or to seek warmth from the kiln itself. However, the smoke and gases (burning limestone produces CO_2) given off during burning—a 'most pestilential vapour'—were unpleasant and could pose a serious risk to life.[208] The death of one farmer from the Stirlingshire parish of Kilmadock was reported in the *Caledonian Mercury* in 1773 after he was 'unluckily suffocated with smoke' when 'stooping down the vent' of his lime kiln to see whether it was kindling or not.[209] Several accounts also exist of vagrants who died after sleeping next to kilns.[210] In one instance, an individual, who had already

[208] 'Jury Court', *Caledonian Mercury*, Saturday 30th December 1826, p.3.
[209] *Caledonian Mercury*, Saturday 11th September 1773, p.3.
[210] 'A Tramp Suffocated at a Lime Kiln', *Dundee Evening Telegraph*, 5 December 1877, p.2

been ‘in the habit of lying about the lime kiln’, was asphyxiated after he climbed in to the cooling kiln pot in search of shelter from bad weather.[211] Kilns themselves could also be dangerously unstable, especially when weakened after firing. For instance, a farmer in Fenwick was killed in 1814 after his kiln gave way and overwhelmed him while he unloaded its contents.[212]

5.4 The owner

5.4.1 Tenants and improvement

As discussed above, landowners had a powerful and influential role in the development of the lime industry. Although lime was used in some parts of Scotland from much earlier, it was during the mid-eighteenth century that the value of liming for improving agricultural lands became widely acknowledged. The culture of improvement that emerged at this time among some rural landowners, and the networks of communication that arose between them, served to heighten awareness of lime. Many took a keen interest in the methods of lime burning and in the action of lime on soil.[213] Seeing opportunity either to modernise their husbandry or raise rents (or both), many landowners began to take steps to encourage or enforce the use and production of lime on their lands.[214] Contemporary accounts from the end of the eighteenth century abound with rising rents following programmes of improvement, usually initiated by dressings of lime. In the parish of Logie Pert, in Forfar, for example one proprietor was said to have quadrupled the rent on his lands having fallowed, limed, drained and enclosed the ground.[215] The minister there was clear to link the annual rising of land values to the ‘advantage of lime’ recently opened up in the area.

Terms of leases were a well-known way of enforcing that improvement be carried out over the course of a tenancy.[216] For example, the tack of Ouchars farm between John Cunningham and Alexander Caldwell in 1798 required the latter to lay four hundred and eighty chalders of lime on his land within

[211] ‘Melancholy Occurrence’ – *Glasgow Herald*, Monday 22 January 1821, p.4 Indeed, after they had been abandoned, many larger kilns took on a new function, operating as informal ‘doss houses’ for homeless wayfarers long into the twentieth century, see Bailey, “Hullerhirst Quarry and Lime Kilns, North Ayrshire,” 107.
[212] *Perthshire Courier*, Thursday 1 September 1814, p.3.
[213] See next chapter.
[214] Fenton, *Scottish Country Life*, 14.
[215] *OSA*, Parish of Logie Pert (1793), vol. 9, p.37.
[216] Devine, *The Transformation of Rural Scotland: Social Change and the Agrarian Economy, 1660-1815*, 47.

the first five years of his lease.[217] One hundred chalders were to be laid in each of the years between 1799 and 1802, falling to eighty chalders in 1803. The price of the lime at the kiln was to be deducted from the rent. Some, usually earlier, leases also encouraged the tenant to erect kilns and start burning lime. The following extract from a tack from 1748 is typical of many improving leases from the period:

> if it please said Robert Nimmo to build a kiln on said lands said Patrick Calder [the landholder] binds himself to aliment the masons and pay their wages as also to provide timber, said Robert Nimmo to lead the stones, timber and lime, and perform all the services by serving the masons and otherwise at building said kiln; and it is agreed that the master shall pay for 20 loads of lime yearly to be carried by the tenant and laid on the lands, the tenant always laying 20 loads of lime yearly to be carried by the tenant and laid on the lands, the tenant always laying 20 loads of lime more thereon yearly at his own charges[218]

Lime burning was incentivised by the proprietor's offer to finance the construction of a kiln, but the operation of the kiln, the labour involved in filling and emptying it, was to be carried out by the tenant. Despite obligations to burn lime, and in some cases construct kilns, being written in to many tacks, in some cases at least there is no evidence to suggest that the leasee necessarily fulfilled them, as Bishop et al found on the Woodhead Estate.[219]

Tensions could arise between landowner and tenantry over competing priorities regarding the working of lime. The imposition of lime burning could amount to additional labour requirements on the tenant and the disruption of farmland by the opening of the ground and the laying of roads. A letter, probably from a local tenant, informing Captain James Small, an officer of the Annexed Estates, of a source of limestone on the Perth estate and noted 'an intention to conceal limestone there if possible' among his fellow tenantry.[220] Conversely, enthusiastic lime burning by farmers could be detrimental to farmland. A lease between Mr Dowall and James Barr in 1801 allowed Barr to work lime and coal on the land for the use of the farm so long as he did so 'without injuring the

[217] Tack of Ouchars farm between Alexander Caldwell and John Cunningham, 1798 (MIT T-LX14/57/1).
[218] Tack between Patrick Calder of Redford and Robert Nimmo, tenant, 14/10/1748 (NRS GD332/91).
[219] Bishop *et al.*, "Lime Burning in Clamp Kilns in Scotland's Western Central Belt: Primitive Industry or Simple But Perfectly Adequate Technology?," 18.
[220] Letter, [unknown] to Capt. James Small, Annexed Estate Officer, 'Limerock found in Glenlochan', 30/06/1777 (NRS E777/138/4).

arable land'.[221] In other instances, tenants were banned outright from burning or carrying lime, lest they become distracted from their agrarian duties by the prospect of a new income source.[222] Cruickshank *et al.* cite the case of William, 1st Earl of Fife, who, in the 1760s, prohibited anyone, including his own tenants on the Glenbuchat estate, from quarrying or burning limestone on his lands.[223] This situation infuriated the minister of the neighbouring parish of Kildrummy, who railed against the decision to restrict such a valuable resource:

> Lime is brought for manure in considerable quantities from the parish of Cabrach on the north . . . The parish of Glenbucket on the west, contains an inexhaustible store of this fertilizing mineral, [but] because by an ill directed policy of the landlord, it as been there for some years locked up; for as both the stone and peat in that very inland district are more than equal to the consumpt of all generations, this restraint must have been imposed from the idea of inducing the people to bestow that labour on the soil, which would be otherwise laid out on the calcination and carriage of lime-stone.
>
> In a country, where [on] the whole cattle are supported during the summer, on widely extended mountain pasturage inaccessible to the plough, and where the whole arable land is under crop at farthest by the middle of June, there is an interval of nearly 3 months, in which the whole operations of the field are necessarily suspended, when the industry of the people coinciding with their own inclination, might be more profitably exerted in making lime for sale, than by their present casual and often misguided exertions.[224]

His statement highlights that, not only was access to lime important for the improvement of land, it also afforded an opportunity for rural tenants to diversify their incomes and enter the market economy.

5.4.2 Leasing the works

As the value of lime as a source of income as well as improvement became more apparent, access rights to minerals became ever more tightly controlled, such that usually no lime could be burned without express permission of the landholder.[225] Leases often allowed the use but not the commercial sale of minerals.[226] The process of enclosure, so closely linked with liming, largely swept away

[221] Tack between Mr Dowall and James Barr, 1801 (MIT T-LX14/57/2).
[222] Mackay, "Limestone Working: A Forgotten Stirlingshire Industry," 86; Cruickshank, Nisbet, and Greig, *The Limekilns of Upper Donside: A Forgotten Heritage*, 63.
[223] Cruickshank, Nisbet, and Greig, *The Limekilns of Upper Donside: A Forgotten Heritage*, 63–64.
[224] *OSA*, Parish of Kildrummy (1796), Vol. 18, p.412-13.
[225] James Ross to William Tod, 13/06/1772 (NAS GD44/52/37/109).
[226] Lease between James Connel and John Cunningham, 1815 (MT T-LX14/57/1).

traditional commonties, which prior to the eighteenth century had provided a wide range of valuable resources for communities, including limestone.[227] The loss of these common resources was widely remarked upon. In East Lothian, the abundance of limestone in the area around Haddington was, in the words of the reporting reverend, 'of considerable emolument' to the tenantry.[228] This access to limestone was however revoked 'for obvious reasons' in 1792 and the lime quarries were leased to a single tacksman. Two 'excellent draw kilns' were then built to supply lime to the county with shells at 1s. per boll.[229]

In order to maintain a lime supply for improvements, as well as for the physical upkeep of buildings, many landowners established estate kilns, from which lime was sold, often at preferential rates for their own tenants. In 1769, brothers Robert and William McArch, who took up the tack of a farm and lime craig near Monteith, were bound to give preferential service to the tenants of their master. Under the terms, they were 'obliged to furnish the Duke's tenants with limestones, at all times when they call for it preferable to any other persons living without the Duke's grounds'.[230]

Increasingly, quarries and kilns were leased directly, rather than as part of larger holdings which could be worked for the purposes of improvement. This approach, which centralised lime production, was particularly important in areas where liming, or indeed arable farming, was new 'to encourage the use of it with those that have not skill to prepare it.'[231] William Marshall, writing about the Central Highlands, also endorsed this model, arguing that it was part of the landlord's duty to his tenants and himself. It 'behoves the proprietors' he wrote, to 'establish sale kilns for the use of small tenants'[232] Similarly, Lord Kames argued that the leasee of a lime quarry at Leny, on the annexed Perth Estate, should be 'bound to serve the Tenants . . . at a certain rate per boll'. Such an arrangement would be 'a great convenience to a considerable part of the Perth estate and a large country in the neighbourhood'.[233] Elsewhere, in Strath, on the Isle of Skye, the landowner, Lord Macdonald, 'with

[227] Wightman, *The Poor Had No Lawyers: Who Owns Scotland and How They Got It*, 69.
[228] *OSA*, Parish of Salton, vol. 10, p.258.
[229] *Ibid.*
[230] Letter, from Robert and William McArch, 11/07/1769 (NRS GD220/6/523/12).
[231] Letter, John Williams to Duke of Gordon, 02/09/1769 (NRS GD44/28/34/99x).
[232] Marshall, *General View Central Highlands,* p.67.
[233] Proposals by Lord Kames with respect the lime stone quarry of Leny, 1762 (NRS E777/259/1).

his usual attention to the interests of his tenants', bound the lessee of his lime kiln to supply his tenants with lime for building at 6d and for the land at 4d. The usual price for the public was 9d.[234] And on the Urquhart estate, Sir James Grant was celebrated for allowing all limestone quarried to be given free of all cost, except carriage, to his tenants.[235] Estate kilns of this kind may be thought of as agricultural service industries, different in scale and purpose from commercial works designed simply to collect revenues from the market.[236] However, in many ways they served as the immediate precursor to capitalist lime burning that eventually accounted for the majority of lime produced during the nineteenth century.

With growing commercial exploitation of lime, landowners were quick to decide that mining, quarrying and burning, with all their associated risks, 'was a game most safely played from the touchline'.[237] Many were happy to take a hands-off approach and simply collect revenue from the minerals on their estate. Scullingour lime works at Balgrochan was leased to a Mr Fervie for 10 years. He then sub-let the 'tirring, mining and working of their minerals' to contractors, whom he paid 6/ per chalder of burned lime (rising first to 6/6 and later 8/ as the quarrying became deep and more difficult). The contractors took upon themselves all the expense and trouble of not only working the lime but selling it and keeping accounts. The selling price for all those ten years was 12/ per chalder. Fervie paid a lordship to the proprietor of 3/ per chalder, while the rent was his profit.[238] When Ardonald was leased to James Allardes of Bonymill in 1818, rent for the works was £400 in the first year and £500 for the remainder of the seven years. The adjoining farm was rented at £75 annually. A further lordship was to be paid: 'one sixth part of the gross sales arising from the said lime works while the price does not exceed five shilling and six pence for each boll of shells', with a further ¾ expected if the selling price rose above that.[239] The lease of Crichton and Hope lime works in 1809 stated that new lime kilns should be built and left 'fit for use' and 'at least of the same

[234] *NSA*, Parish of Strath, (1845), p.311.
[235] James Robertson, *General View Inverness*, p.241.
[236] Atkinson, "An Archaeological Analysis of Industrialisation within the Rural Context of Post-Medieval South West Scotland."
[237] Duckham, *A History of the Scottish Coal Industry, Vol. I 1700-1815*, 159.
[238] 'Notes to the cost of producing burnt lime in the parish of Campsie' Undated and unsigned. Based on papers it was bundled with, likely date c. 1826-1855. (MIT T-LX6/21).
[239] Ardonald Limeworks Papers (NRS GD44/51/539).

value as the present ones' at the end of the lease.[240] Leasing the works also protected the owner from losses. The Countess of Morton was advised in 1803 to let her works Raw Camps since the expected losses 'will fall on the Tenant'.[241] During times of agricultural depression, leases for lime works were frequently advertised.[242]

As a consequence of many landowners' hands-off approach to lime burning, factors or estate foremen often had prominent and active roles in the management of their employer's works. It was usually they who liaised with the lessee and observed the works. Alexander, 4th Duke of Gordon, for example, was a primarily absentee landlord, who left the running of his Ardonald works to his factor and whoever held the lease at the time. Some owners did take an active interest in the running of their lime enterprises. The Countess of Morton engaged in some lengthy debate with the manager of her Raw Camps works, William Douglas, on alterations to the draw kilns.[243] The Countess and Douglas in fact disagreed on several points, such as the number of eyes (draw holes) the kiln should have.

5.5 Selling lime

5.5.1 Weights and measures

The complexity of old weights and measures have long added difficulty to historical analyses.[244] The transmutable nature of lime added complexity to its measurement and valuation, both for buyers and sellers at the time, as well as for historians. It was understood that lime would increase in weight with exposure to moisture and air, but that this did not add to the value of the lime. James Headrick, who was interested in the properties of lime, observed that farmers 'endeavour to cart home the lime they use as soon as possible after it comes out of the kiln. If any remains uncarted, it should be

[240] Excerpt of Clauses for Tack of Limeworks with Lands, Sir John Callander to Mr James Peden, 1809 (NRS GD44/39/30/4).
[241] Letter, Farquarson to the Countess of Morton, 14/07/1803 (NRS GD150/2359).
[242] 'The Duke of Gordon's Lime-Works To Let', *Aberdeen Press and Journal*, Wednesday 21 February 1810, p.2; 'Lime Works on the Coast of Banffshire To Be Let', *Inverness Courier*, Thursday 18 April 1822, p.1.
[243] Letter, William Douglas to the Countess of Morton, 05/03/1805; Letter, William Douglas to the Countess of Morton, 05/03/1805 (NRS GD150/2359).
[244] Ronald Edward Zupko, *A Dictionary of Weights and Measures for the British Isles: The Middle Ages to the Twentieth Century* (Philadelphia: American Philosophical Society, 1985).

covered as much as possible from rain and excluded from air'.[245] Robert Scott's account of measuring lime at his kiln gives some indication of the complexity of measuring lime for sale:

> Our Boll is Linlithgow Meal-measure, 8 per cent more than the Standard. With this Firlot we measure Shells, or burnt Stones and slaked Lime. The Shells are heaped on the Firlot with Spades or Shovels. The slaked Lime is straiked Measure. Unburnt Stones will sometimes weigh about 32 Stone Weight Amsterdam per Boll. Shells will weigh about 25' Stone Weight the Boll. The Boll of Shells will yield three Bolls of slaked Lime, and the three Bolls of slaked Lime will weigh about 39 Stone Weight.[246]

By convention, lime was sold by volume since heavier forms—unburned or slaked—did not add value to the product. Selling by weight introduced uncertainty on the part of the buyer (and seller) and potential for fraud. Some sellers did nevertheless sell lime by weight, as appeared to be the case at Raw Camps where 'all the lime is sold by the hundredweight' as calculated by a simple 'weighing machine' on site.[247] An article on the subject was published in *The Farmer's Magazine* in 1810, submitted by a farmer writing under the pseudonym 'Junior Novice'.[248] Since unburnt limestone is heavier than burned lime, those stones that were insufficiently burnt would add to the weight of the lime sold.[249] The 'obvious' consequence of this fact, he argued, was that 'it affords a temptation to the lime-burners to burn them too little', thereby adding to the price of the sale and placing a worthless additional burden on cartage. Having himself recently experienced the 'evil', Novice urged the *Magazine* to warn other farmers against buying from lime burners selling by weight instead of measure. A note from the editors by way of reply stated that the issue had already been highlighted in their publication some six years earlier and that the 'absurd practice' was believed to have been discontinued. Seeing that it had not, they concluded that the practice was probably not punishable by law and recommended that the Board of Agriculture give the matter some 'serious consideration'. Until such time as a legislative intervention was made to regulate the industry, the *Magazine*

[245] James Headrick, General View of the Agriculture of the County of Angus, or Forfarshire (1813), 403-4
[246] Maxwell, *Practical Husbandman,* 191. Straiked (alternatively straked or streaked) means to level something, such as grain, in a measure using a strake or straight edged implement.
[247] 'Lime Works at Raw Camp for 1800' (NRS GD150/2359). Accounts from the works record sales of lime shells by the boll. The reason for declaring that lime should be sold by the hundredweight is not clear, although the paper that states it also discusses the weighing of coals and limestone, so it could have been to do with establishing the burning ratio.
[248] Junior Novice, 'On Selling Lime by Weight', *The Farmer's Magazine,* vol. 11(43), Aug 1810, p.323.
[249] Customers at Raw Camps were entitled to reject any shells that were 'imperfectly burnt'.

proposed that its readership exercise their collective power to condemn such behaviour: 'were a general association entered into by those concerned, expressly declaring that the subscribers would only purchase lime by measure, very probably the practice complained of would be speedily relinquished'. The presence of weighing machines at several lime works in the mid-nineteenth century, many of which are recorded on the OS six-inch first edition, suggests that this position had little impact on the conduct of the lime trade.[250]

As with other produce in this period, a range of locally defined measures were employed to portion lime for sale. Quantities of lime in Scotland, as with other agricultural goods, were typically measured by the boll.[251] The most frequently cited unit was the Linlithgow barley measure, which was in common usage in the Lothians and elsewhere.[252] Four firlots made one boll, sixteen bolls made a chalder. Garnkirk lime works based its boll on this Linlithgow measure, which reputedly contained 6,417 cubic inches or 68 Scots pints. Charlestown lime works, on the other hand, employed the Linlithgow peas boll of 8,797 cubic inches or 85 scots pints.[253] Other local variations were common. In Roxburgh, for example, the boll was slightly inflated, believed to be made of '2 ⅖ Linlithgow firlots' barley measure.[254] Other units of sale were also used. In the parish of Old Deer, Aberdeenshire, lime was sold in a measure known as a 'quarter', a unit described as 'a heap of stones built rudely into something like the form of a cube, 5 feet on each side, four of these measures, or 500 solid feet, being estimated to yield 100 bolls of lime'.[255] Of course such estimates could apply to local limestones, since the purity of the stone determined the proportion of lime produced after burning. Carts added further complication, since they could vary in size and loading almost infinitely.

Nonstandard units could easily give rise to disputes and confusion. Uncertainty around different local measures and the physical handling of lime plagued enterprising lime merchants. Correspondence

[250] For example, a weighing machine can be seen at Auchenmade Quarry, in Ayrshire, (NS338486).
[251] Zupko, *A Dictionary of Weights and Measures for the British Isles: The Middle Ages to the Twentieth Century*, 40.
[252] Note of queries and answers (NRS GD44/39/30/7).
[253] 'Garnkirk Limeworks', 11/09/1808 (NRS GD44/39/30/3).
[254] Douglas, *General View Roxburgh and Selkirk*, 139.
[255] *NSA*, Parish of Old Deer, vol. 7, p. 142.

between Robert Hogg and his master Sir Hew Dalrymple about the potential for establishing lime trade between North Berwick and the north of England in 1754 highlights this issue:

> I am with yours of the 5th as I have not time for this post to talk to Robert Mackenzie about the Cariage of the Limestone to Estimate the Expense of Burning it, so as to come to the certain knowledge what it may stand at Bushell, I must beg your Patience till another occasion though I don't think an Estimate can be made justly till we see what Bushells of Limestone a Hogh'd will contain or rather how many Bushells it will measure out at London and what it will turn out to in cash; a Hh'd should contain 8 bushells of corn, but I suspect the Lime measure is larger for I can't conceive how Lime shells can be streaked or rolled over like corn, but of this you may inform yourself, nay would it not be worth your while to send your servant to see a Hh'd measured by the Lime bushell and even after being satified in this, we will still persevere in sending up two Hh'd by a Dunbar ship that they may know the quality of the Lime and be absolutely certain what said 2 Hh'ds will measure out there.'[256]

The material state in which lime was measured also differed, further complicating matters:

> you say Lime would yuld [yield] 10d a bushell, but do you mean the corn bushell, or whether is it the Lime after Slocking [slaking] or the Limeshell, if you'll resolve me in these points, I think I could make a pretty Exact Computation of your profits, So pray inform yourself of the Bushell and how many go to a tun and whether it is the lime or the limeshell that is most vendible and what season of the year is most requested.[257]

Calculating the profitability of lime ventures required not only an understanding of the properties of the lime (and the fuel used to burn it), but the local units used to sell it.

Local measures also relied upon some degree of general consensus—what Schaffer called a 'customary moral economy'.[258] In 1787 a petition reached the Duke of Montrose regarding disputed lime measures used by his lime burner near Callander, James Crawford.[259] John McArthur, the cooper who made the firlot used by Crawford, swore an oath that it was exactly the same size and dimensions as those used at the nearby quarry at Leny, each containing twenty-four scots pints.[260] Limestone quarried by Crawford could be purchased by the boat (a cask containing three chalders worth) and either burned in his kiln or carted away to be burned on their own farms. Two tenants, John Harrison

[256] Letter, Robert Hogg to William Dalrymple, 10/12/1754, (NRS GD110/927/38). A 'Hogh'd' or 'Hh'd' refers to the 'hogshead', a large cask or barrel of a locally agreed quantity.
[257] Letter, Robert Hogg to William Dalrymple, 07/03/1745, (NRS GD110/927/17).
[258] Simon Schaffer, "Metrology, Metrication and Victorian Values," in *Victorian Science in Context*, ed. Bernard Lightman (London: University of Chicago Press, 1997), 440.
[259] Petition regarding disputed lime measures (NRS GD220/6/523/2).
[260] Letter, J. Hamilton to Duke of Montrose, 15/11/1787 (NRS GD220/6/523/1).

and William Gilchrist, wrote to the Duke citing several example of limestones bought from Crawford that failed to produce an expected quantity of lime once burned.[261] They wrote that he 'must think it very hard to be pursued for bad measure, when it is provable that the measure he commonly gave was ten chalders for nine according to the just Leny measure'. Although the archival record is inconclusive in terms of how this matter was resolved, it does serve to illustrate how the lack of uniform standards introduced inconsistency and opportunities for fraud.

By the beginning of the nineteenth century, lack of standardised measurement had become a widespread grievance.[262] The lime industry was particularly challenged in this regard. The boll, complained William Aiton, 'is a measure almost non-descript . . . The diversity of impurities in the lime, adds to the difficulty of ascertaining its measure or value.'[263] Likewise Carmichael, in his authoritative account of the lime industry in 1837, also argued that the erratic use of measures was 'productive of much inconvenience'.[264] He wrote:

> no two districts agree in this respect, one using the barley firlot, another the wheat, another the imperial bushel; while in one place two firlots and two bushels in another, are termed a boll, as if bushels, bolls, and quarters were synonymous, or aliquots of each other.

Inconsistencies and local allowances were commonplace. A note from among the Scullingour working papers, regarding the cost of lime production in the mid-nineteenth century, stated that, although the Wheatfield was the 'proper measure', four of which made a boll, the workers there had 'all along been in the habit' of selling 'a great deal more than this quantity'.[265] Instead, they were 'allowed to take nearly as much as they like in the name of half a chalder', which was 'at least 9 bolls, and sometimes 10 bolls'. Elsewhere more stringent measures had begun to be enforced. Robert Kerr observed in Berwick that by 1808, following the improvement of roads and the adoption of horse carts, 'considerabl[y] more lime can now be brought home at one journey than in 1794. But

[261] Letter, Harrison and Gilchrist to Duke of Montrose, 06/01/1788 (NRS GD220/6/523/4).
[262] Julian Hoppit, "Reforming Britain's Weights and Measures, 1660-1824," *The English Historical Review* 108, no. 426 (1993): 82–104.
[263] William Aiton, *General View of the Agriculture of the County of Ayr; with Observations on the Means of its Improvement,* (1811), 383.
[264] Carmichael, 'Principle Quarries', 83.
[265] 'Notes to the cost of producing burnt lime in the parish of Campsie'. Undated and unsigned. (MIT T-LX6/21). The nature of the 'Wheatfield' is unclear.

this latter, it is believed, is fully compensated for, by the more rigid measurement now given to the lime at the kilns'.[266]

Of course, the drive towards universal measurement was not confined to lime industry: David Ure, writing for the Board of Agriculture in 1794, stated that the '[w]ant of uniformity in *weights* and *measures* is universally allowed to be a considerable grievance . . . to the country at large'.[267] Standardising measures and achieving quantitative precision were considered essential projects of a modernising, newly industrial nation, a goal that united the interests of industry, commerce and science.[268] Enlightenment thinkers were at the heart of this drive, believing the removal of metrological diversity to be 'essential for advances in science, politics and daily life'.[269] Throughout the nineteenth century, common terms and measures used by workmen were 'systematically replaced by industrially and geographically universal values'.[270] By the Weights and Measures Act of 1824, uniformity was statutorily established throughout Britain.[271] Older measures were assigned fractions of the Imperial-hundred weight. Evidently, though, the adoption of these conventions was only gradual across Scotland, and many places clung to historical precedents.

5.6 Conclusion

The theme of this chapter has been the modernisation of the lime industry, indeed the transformation of a rural practice into an industry. These seemingly discrete elements—the kilns, the workers, the owners and the sale of lime—all evidence the trajectory of change, but they also highlight the contested and at times contradictory nature of that change. The growth and development of the lime industry should not be thought of in terms of uniform progress. While industrialised lime production become the dominant form of enterprise, a large number of works were not intended to supply the commercial market, and many supposedly 'ancient' practices persisted well into the nineteenth century.

[266] Robert Kerr, *General View of the Agriculture of the County of Berwick* (1808), p.372
[267] David Ure, *General View of the Agriculture of the County of Roxburgh* (1794), p.84
[268] Norton Wise, ed., *The Values of Precision* (Princeton University Press, 1995).
[269] Charles W J Withers, *Zero Degrees: Geographies of the Prime Meridian* (Harvard University Press, 2017), 107.
[270] Schaffer, "Metrology, Metrication and Victorian Values."
[271] Hoppit, "Reforming Britain's Weights and Measures, 1660-1824."

Linear narratives of the development of kiln design are undoubtedly influenced by contemporary conceptions of progress and improvement that accompanied the period of greatest expansion within the industry. Agriculturalist Adam Dickson, for example, made a sweeping generalisation in 1788, declaring that only two kinds of kiln were used in Britain, the first being a rudimentary flare kiln and the second being a recognisable draw kiln design.[272] Such notions gloss over the diversity of kiln structures that were employed for centuries and persisted until nearly the 1900s. It would seem likely that this counter-narrative stems from the mindset of the improvers and the silencing of vernacular knowledge in the historical record—small-scale lime burners did not publish accounts of their works. This theme of practical and theoretical knowledge is explored further in the next chapter. It is, nevertheless, the case that by the nineteenth century draw kilns, as part of highly organised industrial works, were responsible for the greatest share of lime output in the Scottish agricultural and industrial economy.

In some parts of Scotland, such as Ayrshire, lime burning appears to have operated on a proto-industrial basis, with many farmers possessing the knowhow and capacity to supply themselves and their neighbours with lime. In others, the lime burner was an important individual for the functioning of the rural economy, an example of the kind of 'neglected labourer' whose skills and knowledge facilitated a whole host of other technological and organisational changes.[273] Their role can be seen to change with the onset of industrialised lime burning, bringing new kilns, larger operations and new ways of organising labour. The organisation of lime work into its constituent elements was, in many ways, an important pre-condition for industrial production: the large draw kilns of the nineteenth century, which had to be fed continuously with limestone and fuel, could not have operated without it.[274] From at least the seventeenth century, lime burning had been long associated with the running of the farm and with the day-to-day practical skills of the labourer. So long as there was demand for lime and resources available to produce it, a lime burner could support themselves for at least part of the year burning lime for the use of their neighbours. These figures were often

[272] Dickson, *Husbandry of the Ancients*, 339.
[273] S. Macdonald, "Agricultural Improvement and the Neglected Labourer," *Agricultural History Review* 31, no. 2 (1983): 81–90.
[274] Bruland, "The Transformation of Work in European Industrialization," 168–69.

attached to an estate, the owners of which sought to retain this valuable skill and source of material for the improvement of their lands. As estate works grew stature, so the lime burner's role evolved into something more akin to a manager or overseer. Larger works meant more labour, more specialisation, and for the most part less skill. Lime burners were also no longer solely responsible for the construction of kilns, work which was outsourced to masons and labourers building to increasingly elaborate plans.

The relationship of the landowner to lime burning can also be seen to change as Scotland's innovating elite 'dedicated themselves to a search for modernisation'.[275] Where landowners took an early interest in lime, it was for the improvement of their estates. In order to implement the new system of husbandry, tenants were to be induced to burn it and to spread it on their fields. Lime burners in their employ were required to give preference and subsidy to the estate tenants, with the goal of raising demand for lime and then sustaining its use. Those proprietors of an improving persuasion, who innovated and experimented in farming practice and wrote and corresponded on the subject, took an active role in these enterprises, pontificating on the most efficient techniques and most worthy pursuits. This aspect of the development of theories of lime and lime burning, along with other 'motives less material', such as those associated with improvement and display, are explored in the next chapter.[276] As the eighteenth century turned to the nineteenth, and landed power became almost entirely grounded in capital, lime burning became another financial venture, another resource to be extracted and sold. Lime works were leased and sub-let, with many owners satisfied to receive rents and leave the labouring, innovating and risk in the hands of others.

Finally, this drive towards modernisation can be seen in the frequent calls at the start of the nineteenth century for universal weights and measures to be brought in to facilitate trade and ready comparison of value for industry in Scotland. In effect, these were calls to move the lime industry away from the local and the customary towards the modern and the standardised. The unique characteristics of lime, its mutability and materiality, only served to highlight the complexity of the ancient system of

[275] Smout, "Landowners in Scotland, Ireland and Denmark in the Age of Improvement," 86.
[276] Smout, "Scottish Landowners and Economic Growth, 1650–1850," 231.

measures. Agriculturalists, so connected to many other industries and influential spheres of societies, may well have found their experience of the lime trade to be a spur to action on this matter.

6 Knowledge and enlightenment

6.1 Introduction

This chapter explores the intellectual and cultural contexts of lime burning in eighteenth and early nineteenth century Scotland. Expansion of lime burning was concurrent with two important and interrelated intellectual cultural phenomena in Scotland: Enlightenment and improvement. These concepts are fundamental to the arguments made throughout this chapter. As such, this chapter begins by establishing these key concepts as they relate to Scotland and explores their relationship to developments in science, industry and agriculture. Three main themes are then examined in turn. Firstly, the chapter follows the production and dissemination of useful knowledge regarding lime burning through several important agricultural fora. Secondly, taking into account the values and ideologies of improvement, the notion of lime burning as a status symbol is addressed. Lastly, the subject of lime is examined in context of an emergent science of agriculture. Throughout, this chapter deals with two crucial themes of eighteenth and early-nineteenth century Scotland: improvement and Enlightenment. These themes are framed below.

6.1.1 Enlightenment

The meaning of 'Enlightenment' has been the subject of sustained and nuanced debate since the eighteenth century.[1] In its simplest terms, Enlightenment refers to both a collection of ideas as well as a period in (largely European but increasingly global) history 'when the world was made modern'.[2] Temporally, it describes, depending on how one chooses to mark its beginning and end, the extended flourishing of philosophical and scientific thinking over the 'long' eighteenth century.[3] Intellectually, it refers to a set of ideas led by philosophical enquiry and debate, relating to reason, rationalism and secularism.[4] These ideas represented a departure from long-held customs and beliefs grounded in tradition, superstition and theology, fundamentally reshaping civil society along 'progressive' lines.

[1] Dorinda Outram, *The Enlightenment*, 3rd ed. (Cambridge University Press, 2013).
[2] Charles W J Withers, *Placing the Enlightenment: Thinking Geographically about the Age of Reason* (Chicago: University of Chicago Press, 2007), 1.
[3] Withers, *Placing the Enlightenment: Thinking Geographically about the Age of Reason*.
[4] Outram, *The Enlightenment*.

Many historians have pointed to the important (and disproportionately numerous) contributions made in the fields of philosophy, science, and economics by Scottish thinkers, the intellectual and cultural vibrancy of Edinburgh, or Scotland's complex political and cultural contexts in attaching a national character to enlightenment's various manifestations—a distinctive *Scottish* Enlightenment.[5] Such is its position as 'icon of Scottish self-esteem and identity', the Scottish Enlightenment has received innumerable framings and analyses seeking to understand how it originated, how it was constituted, and how it impacted the nation and the wider world.[6]

Stepping back from national conceptions of Enlightenment, Robertson has emphasised the essential intellectual unity of Enlightenment thought across countries, based on two important commonalities: that enlightened thinkers sought the material betterment of the world for all people; and that smaller nations or provinces (of which Scotland was one) sought to redress their social and economic 'backwardness' relative to larger, more powerful neighbours.[7] Charles Withers prefers to conceive of Enlightenment geographically as a supranational phenomenon, a 'Republic of Letters' in which individuals and places were linked by 'overlapping circuits of movement and overlapping social worlds'.[8] The Enlightenment was constituted by those who 'lived' it by participating in its various forms of local cultural production. Along these networks, within and between countries, it is possible to locate 'sites of endeavour' at which knowledge was produced, shared or put into practice.[9] Peter Jones conducts analyses of Enlightenment through its manifestations in the fields of industry and

[5] Nicholas Phillipson, "The Scottish Enlightenment," in *The Enlightenment in National Context*, ed. Roy Porter and Mikulas Teich (Cambridge: Cambridge University Press, 1981), 19–40; Alexander Broadie, ed., *The Scottish Enlightenment: An Anthology* (Edinburgh: Canongate, 1997).
[6] Bruce Lenman, *Enlightenment and Change: Scotland 1746-1832*, 2nd ed. (Edinburgh: Edinburgh University Press, 2009), 244. See for example, Anand C Chitnis, *The Scottish Enlightenment: A Social History* (London: Croom Helm, 1976); Craig Beveridge and Ronald Turnbull, *Scotland After Enlightenment: Image and Tradition in Modern Scottish Culture* (Edinburgh: Polygon, 1997); Arthur Herman, *The Scottish Enlightenment: The Scots' Invention of the Modern World* (London: Fourth Estate, 2003); James Buchan, *Crowded with Genius: The Scottish Enlightenment: Edinburgh's Moment of the Mind* (New York: Harper Perennial, 2004); Silvia Sebastiani, *The Scottish Enlightenment: Race, Gender, and the Limits of Progress*, trans. Jeremy Carden (New York: Palgrave Macmillan, 2013); Richard B Sher, *Church and University in the Scottish Enlightenment: The Moderate Literati of Edinburgh* (Edinburgh: Edinburgh University Press, 2015); Ralph McLean, Ronnie Young, and Kenneth Simpson, eds., *The Scottish Enlightenment and Literary Culture* (Bucknell University Press, 2016); C B Bow, *Common Sense in the Scottish Enlightenment* (Oxford: Oxford University Press, 2018).
[7] John Robertson, *The Case for Enlightenment: Scotland and Naples 1680-1760* (Cambridge University Press, 2005), 374–75.
[8] Withers, *Placing the Enlightenment: Thinking Geographically about the Age of Reason*, 77.
[9] Withers, 63.

agriculture. Industrial Enlightenment, he proposes, was a bridging of the gap between practical science, characterised by physical and metaphorical 'to-ing and fro-ing' between intellectual space, like the laboratory and lecture hall, and practical spaces, such as the workshop.[10] Its counterpart, Agricultural Enlightenment, is founded on a similar set of assumptions: agrarian change resulted from the diffusion of knowledge, the transfer of skills and the role of technology, all of which arose from Enlightenment worldviews and modes of discourse.[11]

While the notion of a *Scottish Enlightenment* might neglect some of the universalities of enlightened thought as well as the crucial supranational aspects of interaction and knowledge exchange at the time, it is instructive to think of Enlightenment *in* Scotland as an important aspect of society during the period in question, one involving multiple intersecting actors, manifestations, and subsequent impacts. This chapter, by virtue of its subject matter and geographic scope, is concerned primarily with Scottish thinkers and writers, those whose values and engagement in enlightened discourse would have the greatest impact on Scotland's agriculture and industry.

6.1.2 Improvement

In Scotland, Enlightenment has long been closely associated with the idea of improvement. Much has been written on the overlap between these concepts.[12] At its most superficial level, Jones suggests, improvement can be understood as 'the collective effort of landowners to extract the maximum economic benefit from their properties: an effort triggered usually by an awareness of expanding market opportunities.'[13] Neil Davidson argues that Enlightenment underpinned

[10] Jones, *Industrial Enlightenment: Science, Technology and Culture in Birmingham and the West Midlands 1760-1820*.
[11] Peter M Jones, "Making Chemistry the 'science' of Agriculture, c. 1760-1840," *History of Science* 54, no. 2 (2016): 169–94.
[12] Thomas M Devine, ed., *Lairds and Improvement in the Scotland of the Enlightenment* (Glasgow: Proceedings of the Ninth Scottish Historical Conference, 1978); Charles W J Withers, "Improvement and Enlightenment: Agriculture and Natural History in the Work of Rev. Dr. John Walker (1713-1803)," in *Philosophy and Science in the Scottish Enlightenment*, ed. Peter Jones (Edinburgh: John Donald, 1988), 102–16; Thomas M Devine, ed., *Improvement and Enlightenment* (Edinburgh: John Donald, 1989); Davidson, "The Scottish Path to Capitalist Agriculture 3: The Enlightenment as the Theory and Practice of Improvement"; Charles McKean, "Improvement and Modernisation in Everyday Enlightenment Scotland," in *A History of Everyday Life in Scotland, 1600 to 1800*, ed. Elizabeth Foyster and Christopher A Whatley (Edinburgh: Edinburgh University Press, 2010); Bonnyman, *The Third Duke of Buccleuch and Adam Smith: Estate Management and Improvement in Enlightenment Scotland*.
[13] Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature*, 68.

improvement in Scotland in three ways: it provided a philosophical vision of socio-economic development; through the search for knowledge it produced a template for agricultural change; and it generated the ideological impetus behind its implementation.[14] Enlightened figures increasingly recognised agricultural progress as a form of civic good, grounded in their belief that humans had a duty to exploit natural resources to their fullest extent, and their conviction that this could be achieved through increasing the sum of knowledge about the world.[15] It is not possible, Devine argues, to understand economic change in Scotland without an appreciation of this new mindset permeating society, the idea that people could control and alter their environment to a greater extent than ever before.[16] Lands in a 'state of nature' were no longer tolerable and, for the first time, could in principle be comprehensively transformed.[17] This new understanding presented a radical reforming of the relationship of people to their environment: 'the rational, systematic and quasi-scientific systems of the improvers' were in stark contrast to older 'cooperative practices based upon disorderly tradition, habit, and the untutored folk knowledge of peasant husbandmen'.[18] Improvement was not confined to rural pursuits. Scotland's buildings, its towns and cities, and the conduct of public life, were all subject to new values and standards based on Enlightenment's rational principles.[19] The implementation of improvement, with its implications for the organisation and management of physical space, can thus be seen as the 'grounding' of Enlightenment ideas of 'order, advance, and proprietary'.[20]

[14] Davidson, "The Scottish Path to Capitalist Agriculture 3: The Enlightenment as the Theory and Practice of Improvement."
[15] Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature*, 68.
[16] Devine, *The Scottish Nation: A Modern History*, 67.
[17] Devine, *The Transformation of Rural Scotland: Social Change and the Agrarian Economy, 1660-1815*, 65.
[18] Barrett, *The Making of a Scottish Landscape: Moray's Regular Revolution, 1760-1840*, 64.
[19] Devine, *Improv. Enlight.*; Bob Harris and Charles McKean, "The Scottish Town in the Age of Enlightenment, 1740-1820" (Edinburgh : Edinburgh University Press, 2014).
[20] Charles W J Withers, "Towards a Historical Geography of the Enlightenment in Scotland," in *The Scottish Enlightenment: Essays in Re-Interpretation*, ed. Paul Wood (Rochester: University of Rochester Press, 2000), 85.

6.1.3 Useful knowledge

In recent years, the concept of useful knowledge has gained currency in the study of Enlightenment's impact on economic activity.[21] Joel Mokyr argues that the importance of useful knowledge in enacting the 'projects' of Enlightenment stemmed from a belief that 'material progress and economic growth could be achieved through increasing human knowledge of natural phenomena and making this knowledge accessible to all those who could make use of it'.[22] Knowledge of this kind encompassed the practical and the theoretical; from the design of ploughs to the ordering of the cosmos. Indeed, this connection between thought and practice is important: transforming economic activity, Davidson states, involved 'practice and practitioners, not only theory and theoreticians'.[23] In relation to specifically agricultural knowledge, Jones emphasises that this was 'simply a sub-set of general Enlightenment knowledge. Its producers and purveyors rarely passed for specialists and, generally speaking, their commitment to material improvement was not confined to the topics of agriculture and animal husbandry'.[24] In Scotland, a small number of motivated and well-connected improvers were most influential in the diffusion of useful knowledge relating to agriculture.[25] This diffusion was both formal and informal, and was comprised of both practical and ideological elements. Personal relationships, correspondence, and local emulation were all ways on which new techniques and ideas could be spread.[26] A number of more conscientious approaches were also employed, including the publication of agrarian manuals, the establishment of agricultural improvement societies, and the setting-up of national agricultural institutions.[27] Several of these modes of knowledge dissemination are discussed below in relation to lime burning.

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[21] Joel Mokyr, *Gifts of Athena: Historical Origins of the Knowledge Economy* (Princeton University Press, 2002).
[22] Joel Mokyr, *The Enlightened Economy: An Economic History of Britain 1700-1850* (London: Yale University Press, 2009), 41.
[23] Davidson, "The Scottish Path to Capitalist Agriculture 3: The Enlightenment as the Theory and Practice of Improvement," 10.
[24] Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature*, 57.
[25] Smout, "A New Look at the Scottish Improvers," 146.
[26] Adams, "The Agents of Agricultural Change"; Bonnyman, *The Third Duke of Buccleuch and Adam Smith: Estate Management and Improvement in Enlightenment Scotland*.
[27] Heather Holmes, "The Dissemination of Agricultural Knowledge, 1700-1850," in *Scottish Life and Society Volume 2: Farming and the Land*, ed. Alexander Fenton and Kenneth Veitch (Edinburgh: John Donald, 2011), 867–93; Boud, "Scottish Agricultural Improvement Societies, 1723-1835"; Brian Bonnyman, "Agrarian Patriotism and the Landed Interest: The Scottish 'Society of Improvers in the Knowledge of Agriculture', 1723-1746," in *The Rise of Economic Societies in the Eighteenth Century: Patriotic Reform in Europe and North*

Questions around the value and use of natural knowledge, and the rise of 'science as both technique and worldview' were central in the twin development of improvement and Enlightenment in Scotland.[28] Many of Scotland's brightest eighteenth century luminaries were operating together in scientific fields—Professor of Chemistry Joseph Black, Professor of Medicine William Cullen, Professor of Natural History John Walker—and were deeply embedded in influential social and professional networks.[29] Science drew large and well-connected audiences of landowners and improvers (often but not always one and the same), with figures like Cullen eager to argue its connection to their interests.[30] Increasingly, improvers turned to the sciences for both new knowledge itself and the method of acquiring it.[31] It is, of course, important to stress that what is referred to as 'science' in this period was not the same as science in the modern sense—it was not yet equipped to address the 'mundane details of production' involved in most economic activities.[32] In addition to its potential as a source of useful knowledge, the practising of science functioned as a form of 'social ornament', a signifier of 'access to polite culture'.[33] The work of Withers, Mathew Eddy and Jan Golinski have all brought to light the importance of natural philosophy and chemistry to Enlightenment discourse in Scotland. Withers provides insight into the lives and works of several key figures in the development of agricultural knowledge. In analysing the lectures, publications, correspondence and private experiments of men like William Cullen, John Walker and James Hutton, men whose agricultural and scientific—whether chemistry, geology, or natural history—interests were intimately connected, Withers highlights 'the intellectual alliance' between agriculture and the

America, ed. Koen Stapelbroek and Jani Marjanen (London: Palgrave Macmillan UK, 2012), 26–51; Holmes, "Sir John Sinclair, the County Agricultural Surveys, and the Collection and Dissemination of Knowledge 1793-1817, with a Bibliography of the Surveys: Part 1."

[28] Roger L. Emerson, "Science and the Origins and Concerns of the Scottish Enlightenment," *History of Science* 26, no. 4 (1988): 333–66; David N. Livingstone and Charles W. J. Withers, eds., *Geography and Enlightenment* (London: University of Chicago Press, 1999), 5.

[29] Bonnyman, *The Third Duke of Buccleuch and Adam Smith: Estate Management and Improvement in Enlightenment Scotland*.

[30] Steven Shapin, "The Audience for Science in Eighteenth Century Edinburgh," *History of Science*, 1974.

[31] Wilmot, *"The Business of Improvement": Agriculture and Scientific Culture in Britain, c.1700-1870*; Paul A Elliott, *Enlightenment, Modernity and Science: Geographies of Scientific Culture and Improvement in Georgian England* (London: I.B. Taurus & Co Ltd, 2010).

[32] Mokyr, *The Enlightened Economy: An Economic History of Britain 1700-1850*, 59.

[33] Jones, *Industrial Enlightenment: Science, Technology and Culture in Birmingham and the West Midlands 1760-1820*, 3,8.

earth sciences that was a fundamental part of Scottish improvement discourses.[34] Eddy's examination of James Anderson, a significant proponent of lime in Scotland, reveals much about how theoretical principles of university chemistry were interpreted and re-communicated to fit the practical interests of improvement-minded farmers.[35] Widespread interest in chemistry during the eighteenth century was largely tied to perceptions of its utility in a range of economically motivating fields (including agriculture, medicine, metallurgy, mining, bleaching, and dyeing).[36] On this basis, chemistry was accorded a degree of prestige, and was of growing interest among an interconnected network of natural philosophers and improvers. Thus, Golinski argues, chemistry became 'a public science in quite a specific sense, imbued with the civic values and aspirations prevalent in Enlightenment Scotland'.[37]

6.2 Knowledge dissemination

By examining the various ways in which knowledge was disseminated in Scotland, it is possible to observe the kinds of practical and theoretical information pertaining to lime burning that influenced the development of the industry. Practical methods, experience and theories regarding the use of lime and its suitability to different soils, crops and regions were widely shared during the eighteenth century, as was advice concerning its production. This knowledge was important in encouraging the 'universality' of liming across Scotland.[38] Improvement, and the dissemination of knowledge towards that goal, also became a means through which Scottish elites could engage in forms of

[34] Charles W J Withers, "On Georgics and Geology: James Hutton's 'Elements of Agriculture' and Agricultural Science in Eighteenth-Century Scotland," *Agricultural History Review* 42, no. 1 (1994): 47; Charles W J Withers, "A Neglected Scottish Agriculturalist: The 'Georgical Lectures' and Agricultural Writings of the Rev Dr John Walker (1731-1803)," *The Agricultural History Review* 33, no. 2 (1985): 132–46; Charles W J Withers, "William Cullen's Agricultural Lectures and Writings and the Development of Agricultural Science in Eighteenth-Century Scotland," *Agricultural History Review* 37, no. 2 (1989): 144–56; Charles W J Withers, "The Rev. Dr John Walker and the Practice of Natural History in Late Eighteenth Century Scotland," *Archives of Natural History* 18 (1991): 201–20.

[35] Eddy, "The Aberdeen Agricola: Chemical Principles and Practice in James Anderson's Georgics and Geology."

[36] Jan Golinski, "Utility and Audience in Eighteenth-Century Chemistry: Case Studies of William Cullen and Joseph Priestley.," *British Journal for the History of Science* 21 (1988): 2.

[37] Jan Golinski, *Science as Public Culture: Chemistry and Enlightenment in Britain, 1760-1820* (Cambridge: Cambridge University Press, 1999), 37.

[38] Smout and Fenton, "Scottish Agriculture before the Improvers - an Exploration."

'agrarian patriotism'.[39] Lime, and other agricultural topics entered polite conversation and were topics of interest and curiosity, with popular magazines occasionally featuring articles on agricultural techniques, inclulding lime burning, such as shown in Figure 60. The following section examines the various forms of practical knowledge pertaining to lime burning that were produced, shared, and put into practice at various 'sites of endeavour' throughout Scotland.[40] This discussion is divided by knowledge activity, dealing in turn with agricultural manuals, agricultural societies, the Annexed Estates, the Board of Agriculture, and interaction and emulation.

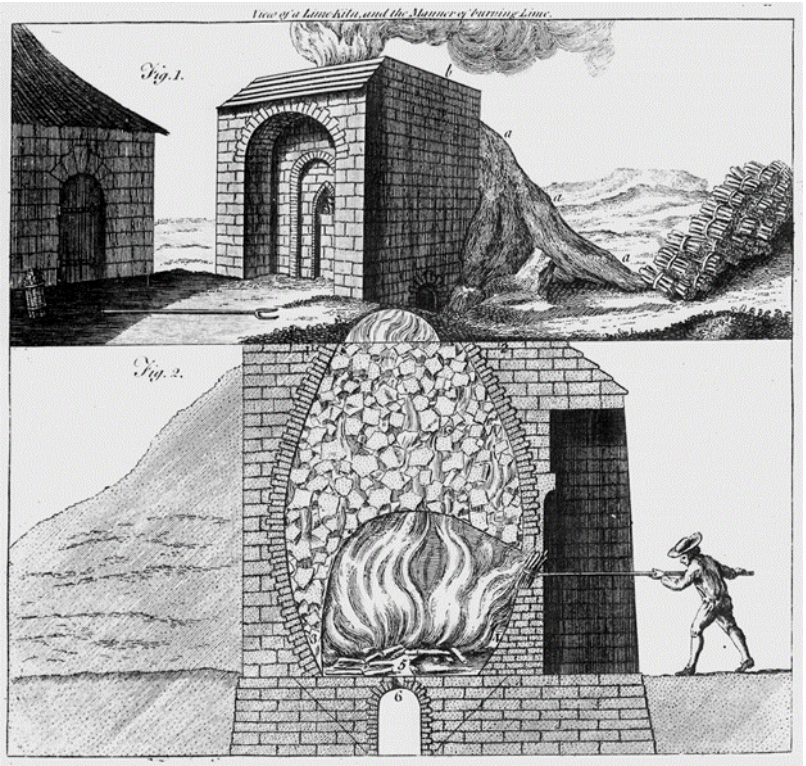

Figure 60 'Dissertation on the Nature, Properties and Uses of lime, illustrated with an elegantly engraved View of a Lime-Kiln, and the Manner of Burning Lime', *Universal Magazine of Knowledge and Pleasure*, Nov 1767, 41, p.286.

[39] Bonnyman, "Agrarian Patriotism and the Landed Interest: The Scottish 'Society of Improvers in the Knowledge of Agriculture', 1723-1746."
[40] Withers, *Placing the Enlightenment: Thinking Geographically about the Age of Reason*, 63.; Theoretical knowledges, and in particular the chemical study of lime and soils that gave rise to modern agricultural science, will be explored below.

6.2.1 Agricultural books

Books, according to historian Richard Sher, were 'the basic building blocks of the Enlightenment'.[41] During the eighteenth century, large numbers of agricultural books began to be published in Scotland, with their number swelling ever more quickly after 1750.[42] Since the material costs of publishing were so high, authorship was largely restricted to the upper classes: those with the money to publish as well as the literacy and leisure to write.[43] Holmes identified three main groups from which the texts were authored: members of the professions (not necessarily connected to agriculture); members of the agricultural community, comprising landowners and some tenant farmers; and those writing on behalf of the agricultural institutions.[44] Although some books were written by knowledgeable farmers, many of the early treatises were written by individuals with limited practical experience of agriculture and were compiled instead 'from the comfort of their reading cabinets'.[45] These were, to some extent, 'rich men playing at farming', individuals whose lives had little in common with the ordinary farmer.[46] Much of their writing was deeply polemical, castigating older farming practices in favour of modern, rational methods. The texts carried a tone of authority that reflected the elite status of many of the writers, regardless of the quality of the information. 'Even when they were talking nonsense, they assumed they always knew best', as Smout acerbically puts it.[47] Texts were usually written once agricultural improvement had been initiated so that the writers could demonstrate the successes of the methods they proposed.[48] They also, as Heather Holmes demonstrates, offered a means for gentlemen (and it was overwhelmingly men) to construct their identities and social status through their writing.[49] Through the use of book titles, pennames and the

[41] Richard B Sher, *The Enlightenment and the Book: Scottish Authors and Their Publishers in Eighteenth-Century Britain, Ireland and America* (University of Chicago Press, 2006), 597.
[42] Holmes, "A Bibliography of Scottish Agricultural Books to 1790."
[43] Robert Darnton, *The Business of Enlightenment: A Publishing History of the Encyclopédie, 1775-1800* (Harvard Univeristy Press, 1979), 521.
[44] This latter group are discussed separetely in sections relating to their associated bodies, see sections on agricultural societies (6.2.3), the Annexed Estates (6.2.4), and the Board of Agriculture (6.2.5) below. Holmes, "Scottish Agricultural Writers and the Creation of Their Personal Identities between 1697 and 1790," 90–91.
[45] Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature*, 62.
[46] Smout and Fenton, "Scottish Agriculture before the Improvers - an Exploration," 89.
[47] Smout, "A New Look at the Scottish Improvers," 130.
[48] Holmes, "The Circulation of Scottish Agricultural Books during the Eighteenth Century," 48–49.
[49] Holmes, "Scottish Agricultural Writers and the Creation of Their Personal Identities between 1697 and 1790."

author's own biographic descriptions, writers could choose to emphasise their expertise or patriotism, or to downplay their status so that their message might cut across social classes. Others sought to aggrandise their own standing through publication, a fact understood by some of the readership. One reviewer of William Dickinson's *Hints to Agriculturalists* scathingly remarked that the author had 'only introduced himself into the popular subject of agriculture, solely with the view of attracting attention to his other work'.[50]

The trend for improving literature also exhibited other Enlightenment compulsions—the urge to record, to classify and to educate—and they developed hand-in-hand with the emergence of another influential diffuser of knowledge, the agricultural society (attended to in the next section). Such literature performed several roles in the dissemination of agricultural knowledge. Not only did writers set out to impart their views on the best techniques, implements and systems for improving the productivity of land, they also propounded an ethos of improvement, a set of values and ambitions that set the template for change. Over time the character of this literature evolved, changing from a discursive encyclopaedic style towards more practical volumes informed by a growing agricultural orthodoxy.[51]

The extent to which agricultural books influenced practice is much debated. Scotland's relatively high levels of literacy in the eighteenth century have been cited as an important factor in the dissemination of various kinds of knowledge, and Holmes has shown that agronomic literature was accessible to the more substantial tenant farmers in Scotland by the end of the eighteenth century.[52] Most of this literature, however, was circulated among the landowning classes, and, since much of Scotland's agricultural change was driven by the landlords, this literature informed the character of this transformation.[53] Books were purchased with the express purpose of advancing methods.[54]

[50] C., 'Review of Hints to Agriculturalists', *The Farmer's Magazine*, 5(18), p.212.
[51] Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature*.
[52] Rab Houston, "Scottish Education and Literacy, 1600–1800: An International Perspective," in *Improvement and Enlightenment*, ed. Thomas M Devine (Edinburgh: John Donald Publishers Ltd, 1989), 43–61; Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature*, 79; Holmes, "The Circulation of Scottish Agricultural Books during the Eighteenth Century."
[53] Holmes, "The Circulation of Scottish Agricultural Books during the Eighteenth Century"; Devine, *The Transformation of Rural Scotland: Social Change and the Agrarian Economy, 1660-1815*, 60.
[54] Adams, "The Agents of Agricultural Change."

Accordingly, the useful knowledge regarding lime in these texts is an important factor to consider in understanding the development of the industry. Several examples of these books are examined below.

Sir Archibald Grant's anonymously published pamphlet *The Farmer's New-year's Gift to his Countrymen* in 1756 is an early example of the practical improving genre. Having taken up permanent residence on his Monymusk estate in Aberdeenshire in 1734 following an ill-fated political career spent in Edinburgh and London, Grant set about implementing a system of improvement modelled on English farming methods.[55] His short text, just 34 pages, that Grant stated was written 'to rouze [sic] my countrymen', contained practical advice regarding the use of lime.[56] This information, he proposed, would aid farmers through the 'refreshing of their memories', rather than by proposing some new programme of husbandry.[57] Where large quantities of lime were sought, Grant recommended the construction of a 'perpetual kiln' and gave detailed instructions as to its construction and operation:

> A wall of lime-stone is best for the kiln. It may be square or round at pleasure or as ground favours. It should be wide at top and narrow at bottom like a corn kiln, until two-thirds of the height, and gradually drawn in to about five feet wide. [58]

This draw kiln design could be adjusted depending on the available fuel. Grant described in some detail how limestone and fuel could be loaded in layers, how the burn could be managed through the use of vents, and how the pot could be stirred and unloaded using iron implements. Indeed, he was noted for taking a keen interest in the improvements on his estate, and it is possible his writing was drawn from first-hand observation of the kiln in use. The kiln is afforded greater attention in his text than the laying of lime, though he did attempt to set out some rules for the suitability of liming on certain soil types. The challenge of establishing clear guidelines for the laying of lime and gauging its usefulness on different soils would not be overcome until the establishment of agricultural science

[55] R. H. Campbell, 'Grant, Sir Archibald, of Monymusk, second baronet', *Oxford Dictionary of National Biography*, <https://doi.org/10.1093/ref:odnb/65016>; Alexander Dick, "'A Good Deal of Trash': Reading Societies, Religious Controversy and Networks of Improvement in Eighteenth-Century Scotland," *Journal for Eighteenth Century Studies* 38, no. 4 (2015): 592.
[56] [Sir Archibald Grant], *The Farmer's New-year's Gift to his Countrymen, Heritors, and Farmers, for the Year 1757*, (Aberdeen, 1756): 1.
[57] *Ibid.*
[58] *Ibid.* 29-30.

in the nineteenth century, a subject addressed in greater depth below. Grant's later pamphlet from 1766, *The Practical Farmer's Pocket-companion*, reiterated in an even more concise form much of his advice regarding the laying of lime.[59]

Another contribution to agrarian instruction was James Adam's *Practical Essays on Agriculture*, published in two volumes in 1789.[60] Adam's text includes a lengthy discussion of lime and lime burning, as well as a detailed account of the construction of a lime kiln. In the latter regard Adam alluded to a degree of variability among kiln designs: '[i]t is quite unnecessary, and would become very tedious, for me to describe the various constructions of kilns that have been used for the burning of lime'. Instead, like Grant, he instructed the reader on how to build 'a perpetual lime-kiln', which he believed 'to be the best'.[61] The kiln he proposed was of an obvious draw kiln type, of cylindrical construction, with an egg-shaped internal pot lined with 'hard bricks'. It was to be set into a raised bank for ease of loading. From his description, this kiln would have supported commercial lime production, being capable of continual use 'for six months together, without being once extinguished'. He also referred, in the course of describing the operation of the kiln, to the role of the lime burner, suggesting that his readership would have been able to employ labourers for the production of lime and the construction of the substantial kiln itself.

In contrast to those elite writers who lacked first-hand farming experience, David Young, author of *National Improvements upon Agriculture*, was able to draw from his time as a tenant farmer in Perth.[62] As a likely consequence of his first-hand knowledge, his writing covers many practical details of value to imitating farmers. For instance, he recounts the getting and laying of Lord Elgin's lime:

> The liming of pasture-grounds in the beginning of July, with Lord Elgin's powdered lime, as hot as you can lay it on, immediately from the ship, is an excellent improvement for the pasture, especially if the ground is sown with white clover, as lime is a great encourager to the growth of white and yellow clover. This lime is

[59] [Sir Archibald Grant], *The Practical Farmer's Pocket-companion, or a Brief Account of the Husbandry that Now Prevails in Scotland; in Which Errors are Pointed, and Better Methods Proposed in a Letter From a Gentleman in the South of Scotland, who had Long Experience of the Rules he Prescribes,* (Aberdeen, 1766).
[60] James Adam, *Practical Essays on Agriculture*, vol. 1 (London, 1789).
[61] Adam, *Practical Essays*, vol. 1, pp. 141-145.
[62] John Donaldson, *Agricultural Biography*, (London, 1854), 66.

> slaked at Limekilns; and, being the refuse, has a great quantity of coal-ashes in it, which makes it the better for pasture, being quite hot when it comes out of the ship.[63]

As Chapter Four has already shown, lime from Charlestown and Limekilns in Fife was readily available at ports up and down Scotland's east coast. By detailing his experience of this product, Young's practice could be readily replicated by anyone able to purchase from the same supplier. Like Grant and Dickson, Young recommended farmers construct their own lime kilns: '[i]t would be worth any person's while who has a good moss [of peat], to build a draw-kiln used for burning lime'.[64] However, his account contains no instruction on building them since, clearly, Young purchased lime rather than burn it himself. By restricting his writing to topics with which he was practically acquainted, the usefulness of Young's pronouncements on husbandry were probably enhanced. Indeed, in a recommendation for one of his later publications, Young's *National Improvements* was declared to be 'plain, practical, and suited to the capabilities of the Farmers, who ought to read and practice them'.[65]

Many more writers addressed only the use of lime, eschewing the subject of its production. Lime was included in agrarian volumes from the seventeenth century onwards.[66] John Reid's *The Scots Gardiner,* which was first published in 1683 and remained a widely-read textbook throughout the eighteenth century, was an early written advocate for the use of lime.[67] The intent of writers was often not to introduce lime or to convince people of its worth, but instead to elucidate the nature of its operation so as to give confidence to farmers and improve their handling of the substance. In a broader sense, improvement writers helped establish the primacy of lime within comprehensive programmes of agricultural improvement. Lord Kames' influential *The Gentleman Farmer,* first published in 1776, set out his vision for a national programme of improvement. Kames encouraged estate owners to ensure the ready supply of lime for agriculture and attempted to set out the 'proper

[63] Young, *National Improvements,* 106; the lime works at Charlestown and Limekilns, as well as other places, are known to have sold lower quality lime, the 'refuse', cheaply for agriculture and kept purer, higher quality lime for building and plastering.
[64] David Young, *National Improvements upon Agriculture, in Twenty-seven Essays*, (Edinburgh, 1785), p. 15.
[65] David Young, *Agriculture the Primary Interest of Great Britain,* (Edinburgh, 1789), x.
[66] John Donaldson, *Agricultural Biography*, (London, 1854).
[67] George E Fussell and H Fyrth, "Eighteenth-Century Scottish Agricultural Writings," *History* 35, no. 123 (1950): 50.

way' to lay lime on soil.[68] Kames' book also alludes to the ongoing tension between practical and theoretical knowledge around agriculture. Of lime he wrote:

> Philosophers differ widely about its nature, and the causes of its effects; and they talk so loosely as to convince a plain farmer that the matter is very little understood. But practice is our present theme; and the benefit of lime is so visible, that the use of it has become general, where the prices and carriages are moderate.[69]

The nature of lime remained elusive, and from the mid-eighteenth century several attempts were made to arrive at an understanding of lime based on a growing body of chemical knowledge. For example, Home's *Principles of Agriculture and Vegetation*, in 1756, published the results of some experiments with lime on soil, and sought more generally to connect the 'slow progress of agriculture' to chemistry. [70] He also proposed a method for determining the quality of quicklime that might be gained by burning different calcareous materials, information that was valued by those landowners seeking to gauge the potential profitability of mineral resources on their estates. Similarly, Adam Dickson attempted in 1762 to show how lime 'promot[ed] vegetation' based on 'what the Chemysts [sic] tell us'.[71] George Fordyce also sought to classify lime in his 1765 *Elements of Agriculture and Vegetation*, later editions of which contained an appendix 'for the use of Practical Farmers' that offered advice on over-liming the soil and ways to avoid this.[72] This addition perhaps acknowledges the duality of his readership, who sought both agrarian instruction and to engage in forms of 'gentlemanly science'.[73] Perhaps the most substantial treatment of lime came from James Anderson in an *Essay on Quicklime*, published in the first volume of his *Essays Relating to Agriculture and Rural Affairs* in 1775.[74] This text dealt with lime as a cement and as a manure, and set out in plain language the properties of lime 'that it imports the practical farmer fully to

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[68] Henry Home [Lord Kames], *The Gentleman Farmer. Being an Attempt to Improve Agriculture by Subjecting it to the Test of Rational Principles*, 3rd ed., (Edinburgh, 1788 [1776]).
[69] Kames, *Gentleman Farmer*, 259-60.
[70] Francis Home, *The Principles of Agriculture and Vegetation*, 3rd ed., (Edinburgh, 1763 [1756]): 68.
[71] Adam Dickson, *A Treatise on Agriculture*, (Edinburgh, 1762), 344.
[72] George Fordyce, *Elements of Agriculture and Vegetation*, 5th ed., (Edinburgh, 1796 [1765]), 105.
[73] Golinski, *Science as Public Culture: Chemistry and Enlightenment in Britain, 1760-1820*, 25.
[74] *Essay on Quicklime* was published in: James Anderson, *Essays Relating to Agriculture and Rural Affairs*, vol. 1, 2nd ed., (Edinburgh, 1777 [1775]). I have not been able to get a hold on another text relating to lime that was published at around the same time: James Alexander, *A Dissertation on Quick-lime: Pointing out its Origins, Properties, Use, and Application to Agriculture*, (Glasgow, 1779). John Donaldson, in his *Agricultural Biography*, also mentions a publication by amateur chemist Smithson Tennant from 1800 entitled *On the Different Sorts of Lime Used in Agriculture*. However, according to Donaldson, this text 'added nothing to the existing entertainments on the subject of these valuable bodies'.

understand'.[75] Anderson, based on the properties of lime, was able to confirm that calcining limestone was the 'easiest, and most efficious (sic) mode of reducing limestone to powder that ever was invented', dismissing calls by Kames and others for the mechanical grinding of limestone to be more thoroughly investigated.[76] He also gave detailed accounts of his own experience and experiments with lime, suggested means by which the value of limestones could be identified, and encouraged the most efficient ways of carrying and laying lime—all of which were outlined in plain language and employed implements likely to be to a farmer's hand. The relationships between lime, agriculture and Enlightenment science are explored below.

6.2.2 The Farmer's Magazine

By the start of the nineteenth century a large volume of printed agricultural information in the form of agricultural journals, magazines and newspapers was in circulation throughout Scotland.[77] These sources attracted contributions from a wider range of individuals than those who could afford to publish longer tracts themselves, let alone the time to write them. They contained a wealth of information, Goddard argues, to make farmers 'better qualified for the conduct of their affairs'—articles, often submitted by subscribers, covered discoveries, inventions, experience, techniques, and rural news.[78] One example was *The Farmer's Magazine,* published in Edinburgh between 1800 and 1825, with a focus on Scottish agricultural affairs.[79] The pages of the *Magazine* can be read as a kind of forum in which a community of engaged readers posed questions, challenged one another, and maintained dialogues. Submissions often encouraged readers to write to the author directly for further information or for personalised advice, hinting at networks of correspondence for which the *Magazine* acted as a fulcrum. Agronomic books were reviewed, indeed sometimes rebutted, and many of the essays show an awareness of the developing science of agriculture, including references

[75] Anderson, *Essay on Quicklime,* 286.
[76] Anderson, *Essay on Quicklime,* 395. The 'pounding' of limestone and Kames' interest in it are covered in Chapter Four.
[77] Holmes, "Scottish Agricultural Newspapers and Journals and The Industrialisation of Agriculture, 1800-1880."
[78] Nicholas Goddard, "The Development and Influence of Agricultural Periodicals and Newspapers, 1780-1880," *The Agricultural History Review* 31, no. 2 (1983): 129.
[79] Goddard, 130; Holmes, "Scottish Agricultural Newspapers and Journals and The Industrialisation of Agriculture, 1800-1880," 31.

to the work of Black, Anderson and other chemists.[80] Lime was a recurring subject of interest. As one anonymous contribution, submitted under the pseudonym Arator in 1802, wrote:

> Several useful papers, upon the application of lime, have recently appeared in your Magazine; and, with your permission, I propose to throw my mite of information into the general stock of practical knowledge already accumulated upon that very important branch of husbandry. Laying theory aside, I shall confine myself entirely to *facts*; and, without attempting to explain the manner in which lime operates on the ground.[81]

His paper was apparently well received by the *Magazine's* readership, since he was 'stimulate[d] . . . to continue the detail of his experiments' in a later issue.[82] Enduring uncertainty around the use of lime prompted numerous submissions from authors looking to share their experiences or to seek advice regarding management of their own land.[83]

Arator's statement also hints at ongoing debates conducted in the *Magazine's* volumes over the value of theoretical versus practical knowledge in the field of agriculture. Although practical information appears to have been favoured by many of the correspondents to the publication, some were evidently aware of the importance of theory, and indeed their role in diffusing it. A writer going simply by 'A', summed up the processes by which, in 1815, farmers in Scotland were 'profiting by information':

> Experiments, made by individuals, discovered properties and principals of universal, or, at least, of very extensive benefit; treatise were written, in which were collected the various points ascertained; the Board of Agriculture has diffused much useful knowledge; periodical publications have become the receptacles and vehicles of every new improvement; knowledge thus accessible to every one, enlightened the minds of farmers, inspired them with the ambition of excelling, and consequently was productive of the best results.[84]

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[80] A Yorkshire Farmer, 'Letter', *The Farmer's Magazine,* vol. 1(4), Oct 1800, pp387-389; C., 'Review of Hints to Agriculturalists', *The Farmer's Magazine,* vol 5(18), May 1804, pp.212-219.
[81] Arator, 'Experiments on Lime Husbandry', *The Farmer's Magazine,* vol. 3, Feb. 1802, pp. 76-82, original emphasis.
[82] Arator, 'Observations upon the Use of Lime and Compost Middens', *The Farmer's Magazine*, vol 3(11), Aug 1802, p.325; Most writers of agricultural texts and subscribers to publications during this period were male, and so the pronoun 'he' is assumed here, see Holmes, "Scottish Agricultural Writers and the Creation of Their Personal Identities between 1697 and 1790."
[83] Junior Novice, 'On the Use of Lime, and the Manageemtn of Dung', *The Farmer's Magazine*, vol. 2(8), pp.410-11; P., 'Observations on the Use of Lime', *The Farmer's Magazine*, 2(8), Nov 1801, pp. 407-410; A.C., 'Information requested concerning the Application of Lime', *The Farmer's Magazine*, vol. 8(30), May 1807, p. 168; 'On the Different Qualities of Lime', *The Farmer's Magazine*, vol. 15(58), May 1814, pp.163-165.
[84] A., 'A Knowledge of the Theory of Agriculture, necessary to its Practical Improvement', *The Farmer's Magazine*, vol. 16(62), May 1815, p.172.

As with other agricultural writing at this time, contributors to the *Magazine* felt that lime was an essential part of modern husbandry, one that was to be promoted throughout Scotland by means of improved knowledge and infrastructure.[85] The contributors themselves attached great social worth to the act of dissemination. To quote Arator again: 'if a single individual is benefitted by these statements [regarding lime], I shall account the time spent making them out, to be well employed'.[86] Many were quick to cast aspersions over those who did not embrace these new methods. One writer, after extoling the virtues of liming for improving pastures, lamented that in his neighbourhood many farmers had 'never [laid] one handful of lime upon their land', despite examples set before them and the nearby presence of fuel to burn it.[87] His conclusion: 'shepherds "canna be fashed"', adding 'their indolence is proverbial'.

Compared with the issue of using lime, contributors to the *Farmer's Magazine* seemed less concerned with the construction and operation of kilns. A writer using the epithet Fifensis remarked that, 'as a general engineer', it was equally unnecessary that he 'understand the practice of lime burning, as that an astronomer should find it necessary to build his own quadrant'.[88] In other words, he cared little for how it was made, only that he could be assured of a ready supply. Nevertheless, some submissions did cover aspects of lime production. Indeed, 'O-R-S' submitted a request specifically for information on 'the procedure of burning lime', including 'the form, the extent, and the height of the lime-kilns' required for 'perfect calcination'.[89] Unfortunately, however, he received no direct reply. In a later issue, Charles Menteath's elaborate Closeburn draw kilns were described

[85] P., 'Cursory Remarks on the present State of Agriculture and Rural Economy of the Highlands, &c', *The Farmer's Magazine,* vol. 8(32), Nov 1807, pp.500-518.
[86] Arator, 'Observations upon the Use of Lime and Compost Middens', *The Farmer's Magazine,* vol. 3(11), Aug 1802, pp. 325-331.
[87] Plebeian, 'On the Advantages of Liming Coarse Pastures', *The Farmer's Magazine,* vol. 13(50), Jun 1812, p.214.
[88] Fifensis, 'On the Perth and Fife Canals', *The Farmer's Magazine,* vol. 9(34), Jun 1808, p.210. The wider context of this revealing remark remains unclear. The paper in question concerns the construction of canals to facilitate transport of lime, and the statement quoted above appears to have been written in response to a Captain Frazer who, in some previous publication, gave a lengthy and detailed account of the practice and expense of burning lime. Unfortunately, I have not been able to find this earlier statement from Frazer—it does not seem to have been in the pages of *The Farmer's Magazine*.
[89] O-R-S., 'Observations on the Use of Lime', *The Farmer's Magazine,* vol. 11(43), pp.321-22.

admiringly, but, unusually among improvement writing, a few other contributors chose to advocate simpler burning methods using peats and kilns that were recognisably clamp kilns.[90]

A common theme running throughout the *Farmer's Magazine* was the importance of synthesising agricultural and chemical knowledge into practical information that would benefit the working farmer. A level of chemical understanding among the readership was often assumed. 'Every dabbler in chemistry', wrote one contributor, 'knows that the effect of burning is to expel the carbonic acid from lime', leaving it 'in a purely caustic alkaline state'.[91] One area of particular interest in this regard was the identification and valuation of limestones. An extended, and at times highly personal, correspondence was conducted through the *Magazine* on this topic between James Headrick, Sir George Mackenzie, and a writer using the initials 'A.S.'.[92] A.S. proposed that dissolving equal weights of limestone in muriatic (hydrochloric) acid and comparing the quantity of sediment left behind would quickly answer which of two rocks contained the highest proportion of lime. Mackenzie took exception to this basic approach, asserting that the properties of limestone could not be known without 'a regular analysis by a skilful chemist'.[93] Headrick, 'confessedly a practical and experienced mineral surveyor and chemist', interjected in support of A.S. and was at pains to lay out 'an easy process by which a farmer may judge comparative value of limestone' whilst avoiding 'complex and intricate analysis' which were 'foreign to the practical purposes of the farmer'.[94] This exchange (which latterly had become, Headrick suggested, 'tiresome to all') evidences several aspects of improvement and Enlightenment: the rigorous application of observation and experimentation; the desire to correspond and share information; the need to balance practical and

[90] P.H., 'On the Burning of Limestone with Peats', *The Farmer's Magazine*, vol. 3(10), May 1802, pp. 210-213; Robertson Buchanan, 'Account of the Limekilns at Closeburn, Dumfriesshire. With an Engraving', *The Farmer's Magazine*, vol. 16(62), May 1815, pp. 133-136; A Constant Reader, 'On Burning Lime without Kilns', *The Farmer's Magazine*, vol. 17(65), Feb 1816, p.61.
[91] C., 'Review of Hints to Agriculturalists', *The Farmer's Magazine,* vol. 5(8), May 1804, pp.217.
[92] A.S., 'On ascertaining the quality of Lime', *The Farmer's Magazine*, vol. 5(17), Aug 1804, pp. 27-29; Sir George S. Mackenzie, 'Thoughts on the Analysation of Lime, &c.', *The Farmer's Magazine*, vol. 5(19), Aug 1804, pp. 265-268; Alex Low, 'Extract of a Letter from the Reverend Mr Headrick to Mr Low of Annfield, Fifeshire', *The Farmer's Magazine,* vol. 5(20), Nov 1804, pp.451-452; James Headrick, 'On the Analysis of Limestone', *The Farmer's Magazine*, vol. 6(21), Feb 1805, pp. 11-18; A.S., 'On Lime. Answer by A.S. to Sir George Mackenzie, Bart.', *The Farmer's Magazine,* vol. 6(23), Aug 1805, pp.316-321.
[93] Mackenzie, 'Thoughts', p.266.
[94] A.S., 'On Lime', p.317; Headrick, 'On the Analysis of Limestone', p.12.

theoretical priorities; the increasing influence of chemical understanding; and the economic importance of lime.

6.2.3 Agricultural societies

Among the defining characteristics of Scottish agricultural improvement was the establishment of agrarian societies, membership organisations that encouraged participants to discuss a range of issues relating to agriculture and the rural economy.[95] More agricultural improvement societies existed in Scotland per head of population than anywhere else in the world, and collectively they had what Boud called an 'evangelising influence' on Scottish farming through their work in spreading both practical information and an ethos of improvement.[96] Indeed, the establishment of the Honourable Society of Improvers in the Knowledge of Agriculture in 1723 is considered by some to be the 'true beginning' of the improving movement in Scotland.[97] The Society's express aims were the pursuit of agrarian knowledge and the diffusion of that knowledge among the nation's landowners and tenantry.[98] Correspondence within and beyond its membership sought to ascertain the different methods of husbandry being practised so that 'what may be amiss may be corrected, and what is profitable initiated'.[99] Its membership was drawn from almost all parts of Scotland, giving the Society broad geographic reach.[100] Importantly, the Society acknowledged the need to be in contact with those who worked the soil, not just with the landed elites, and publications of essays and transactions, such as Maxwell's *Select Transactions* in 1747, were written in a deliberate 'Familiar Stile [sic]' such that farmers could comprehend and contribute to them.[101] Furthermore, the Society for Improvers actively encouraged replication of its model for knowledge gathering and diffusion at the local level; it proposed that members should form small societies of 'Gentlemen and Farmers' to

[95] Boud, "Scottish Agricultural Improvement Societies, 1723-1835."
[96] Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature*, 158; Boud, "Scottish Agricultural Improvement Societies, 1723-1835," 73.
[97] Smout, "A New Look at the Scottish Improvers," 130.
[98] Bonnyman, "Agrarian Patriotism and the Landed Interest: The Scottish 'Society of Improvers in the Knowledge of Agriculture', 1723-1746," 37.
[99] Maxwell, *Select Transactions*, p. 5
[100] Bonnyman, "Agrarian Patriotism and the Landed Interest: The Scottish 'Society of Improvers in the Knowledge of Agriculture', 1723-1746."
[101] Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature*, 68.; Maxwell, *Select Transactions*, p. 8

gather and share information.[102] This composition of membership is crucial since it proposes a method by which new knowledge and attitudes to agrarian subjects, including lime, could flow between those who owned and those who worked the land, those who wrote and read the kinds of agricultural treatise discussed above and those who would ultimately put them into effect. In this sense, Adams argues, societies were secondary rather than primary diffusers of knowledge.[103] Assessing the content of meetings of agricultural societies and the ideas they discussed is challenging since few produced written records of conversations held in-person and the topics to which they pertained. Several of the larger Scottish societies, however, published their transactions, which survive as a record of their interests, values and membership. Some of these are examined below.

Taking Robert Maxwell as an example, his influential volume *The Practical Husbandman*, published in 1757, was comprised largely of papers chosen from the Society of Improvers' Transactions, some of which had been revised and reformatted for publication.[104] Many of the articles it contained refer to liming among the various improvements discussed, while two papers directly address the construction of kilns for the liming of ground. The first, an essay submitted by an English farmer by the name of Mr Lummis, gave directions for 'burning Lime-stones, and manuring Ground with Marl, Lime, Water &c'.[105] Lummis described the construction of a kiln with a pot the 'shape of a Hogshead' made 'entirely within the surface of the ground', being, he argued, the 'most beneficial way' to burn lime.[106] In the case that the reader was unable to construct a such a kiln, due to a lack of materials or a suitable site, he also proposed that lime could be burned 'in the common way above ground'.[107] The details of this kilns's construction are not elaborated upon, but Lummis describes a method of clamping by covering it 'allover with sods or strong turf'.[108] His willingness to acknowledge different approaches underlines the pragmatism of his contribution to the Society. He also gave advice regarding the handling of lime, the detail of which suggests extensive first-hand experience. For

[102] Bonnyman, "Agrarian Patriotism and the Landed Interest: The Scottish 'Society of Improvers in the Knowledge of Agriculture', 1723-1746," 38.
[103] Adams, "The Agents of Agricultural Change."
[104] See: *Select Transactions of the Honourable The Society of Improvers in the Knowledge of Agriculture in Scotland*, (Edinburgh 1743).
[105] Robert Maxwell, *The Practical Husbandman: Being a Collection of Miscellaneous Papers on Husbandry &c*, (Edinburgh, 1757), 191.
[106] *Ibid.*
[107] *Ibid.* 192.
[108] *Ibid*, 192.

instance, he recommended that slaking the lime into a wet putty prevented the quicklime from blowing around in the wind and causing harm to people and animals, besides wasting much of the lime. Practical advice of this kind may have had greater relevance to ordinary farmers than the more theoretical tracts produced by other writers.

The second paper on lime burning was adapted from a letter sent to the Society by Robert Scott of Duninauld, advocate to Mr Hope of Rankilor. It describes in detail the design and operations of a 'reverberatory kiln', where the fuel and limestone are kept apart. Scott, in support of his design, also gave extended account of the operation of lime works in England. Maxwell's commentary on the paper began thus:

> This ingenious Gentleman, who is a notable Husbandman, has tried many experiments, made useful Observations where-ever he occasionally went, and has travelled all the best improved Counties in England, purposely to make further description of his Kill, and distinct Account of his Lime-work; which by his Knowledge, Assiduity and Industry, is come to be a very comfortable Improvement of his Estate.[109]

His statement reflects the high esteem in which he held English methods, as well as the deliberate effort made to import and imitate them in Scotland. Many travellers from England before and immediately after the Union of 1707 had remarked on the 'backward' nature of Scottish farming.[110] Scottish agriculturalists, eager to hasten the transformation of farming north of the border, became increasingly receptive to English ideas and techniques. This process was more than simply knowledge 'drifting northwards'; Scottish improvers actively sought out and then adapted English practices.[111] Improvement societies played an important role in spreading this ethos, holding up 'notable husbandmen' like Scott as examples to be followed. Nevertheless, Maxwell was not unquestioning in his advocacy of new methods, and he advised his readers 'I think proper to take Notice, that others build such Kills [sic] in different Forms'.[112] In other words, he diplomatically

[109] Maxwell, *Practical Husbandman,* 200.
[110] Smout and Fenton, "Scottish Agriculture before the Improvers - an Exploration," 86.
[111] Fussell and Fyrth, "Eighteenth-Century Scottish Agricultural Writings"; Bonnyman, "Agrarian Patriotism and the Landed Interest: The Scottish 'Society of Improvers in the Knowledge of Agriculture', 1723-1746"; Smout, "A New Look at the Scottish Improvers."
[112] *Ibid*

pointed out that Scott's kiln was uncommon and probably unfamiliar to most farmers, and that others had achieved success using more conventional kiln designs.

Even fewer records remain from smaller local societies, which may have numbered in the hundreds during the eighteenth century.[113] In a practical sense, these local societies may have been more influential than their more celebrated larger contemporaries.[114] A notice that appeared in the *Caledonian Mercury* in 1761 confirms that the construction of lime kilns was indeed of interest to local agrarian societies:

> The Members of the PERTH-SHIRE SOCIETY, for Agriculture, are desired all to attend the Meeting on the third Thursday of March, being the 19th inst. in order to concert proper measures for setting up lime-kilns in Cambusmichael, and it is hoped, many more Gentlemen and Farmers will join to promote so laudable an undertaking.[115]

Physical attendance at these kinds of events by landowning and tenant farmers was clearly an important means of disseminating practical knowledge and facilitating direct emulation. Indeed, such events would have been especially valuable to, as Boud put it, 'those towards the base of the agricultural pyramid, who sometimes could neither read nor had the means to travel'.[116] Local societies could also set up libraries or else circulate books among their members, providing access to agrarian literature of the kind discussed above.[117]

By the end of the eighteenth century and into the first decade of the nineteenth, lime, as a subject addressed directly, became less prominent among society Transactions. Nevertheless, liming had become ingrained in the established 'natural order and association of improvements in agriculture' espoused by the societies, and lime was routinely involved in the experiments and systems they proposed.[118] The societies also actively promoted liming as a part of a broad programme of improvements, particularly for breaking in new ground for arable farming. The system of premiums was their primary means of encouragement. For example, in 1799 the *Royal Highland and*

[113] Many were short-lived or informal, leaving little record, making precise totals difficult to calculate, see Boud, "Scottish Agricultural Improvement Societies, 1723-1835."
[114] Boud.
[115] *Caledonian Mercury*, Wed. 11 March 1761, p. 2.
[116] Boud, "Scottish Agricultural Improvement Societies, 1723-1835," 87.
[117] Holmes, "The Dissemination of Agricultural Knowledge, 1700-1850," 876.
[118] Rev. William Singers, 'Essay on the Principle Recent Improvements in Agriculture in Scotland', *Prize Essays and Transactions of the Highland Society of Scotland*, (1816) vol. 4, p. 172.

Agricultural Society of Scotland (RHASS) offered a premium of seven pounds to 'any Farmer or Tenant who, before the 1st of October next, shall have limed the greatest quantity of heathy, muir, or hill ground not arable . . . so as to produce a Grass crop'.[119] Premiums and prizes were also used to encourage the publication of agricultural books. In 1755, the *Edinburgh Society for the Improvement of Arts and Manufactures,* offered a prize for the 'best dissertation on vegetation on the principles of agriculture'. The gold medal was won in 1756 by Francis Home's *Principles of Agriculture and Vegetation,* which had been composed 'according to the rules laid down'.

The RHASS also advertised a premium for 'the best and approved Report, founded on experiment, on the Construction of Lime Kilns, comprehending the most recent improvements thereon, and pointing out the means by which the greatest quantity of lime may be obtained with the least quantity of fuel'.[120] This prize was awarded to Stuart Menteath of Closeburn in 1831 for an account of his extensive lime works in Dumfries.[121] Menteath's oval and egg-shaped designs were produced in response to the apparent inefficiency of 'kilns generally employed in Great Britain' and his report was pitched at those engaged in supplying agricultural lime to a 'limited district'.[122] His account also advises on controlling the burn and varying the scale of output to meet fluctuating demand. A scale model of his kilns was retained in the Society's museum, although tellingly these were not classified as being amongst the 'Division I' items ('considered as of universal application under the present system of farming') and were instead listed as Division III ('Miscellaneous Implements and Inventions').[123] Perhaps as testament to the esteem in which the RHASS was held, and its long reach within the British agriculturalist community, details of Menteath's Closeburn kilns were cited as notable examples of lime kiln design in J.C. Loudon's *Encyclopaedia of Agriculture* and Martin Doyle's *Cyclopaedia of Practical Husbandry,* as well as many subsequent histories of the industry.[124]

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[119] *Transactions of the Royal Highland and Agricultural Society*, vol. 1799, pp. xvi-xvii.
[120] *Prize Essays and Transactions of the Highland Society of Scotland*, vol. 8 (1831), 127.
[121] Stuart Menteath, 'On the Construction of Lime Kilns', *Prize Essays and Transactions of the Highland Society of Scotland,* vol 2, (1831), 127-31; see also Clarke, "The Closeburn Limeworks Scheme: A Dumfriesshire Waterpower Complex."
[122] Menteath, 'On the construction of lime kilns', 127-8.
[123] 'Catalogue of Models and Machines in the Museum of the Highland Society', *Prize Essays and Transactions of the Highland Society of Scotland,* vol. 3, (1832), 385-400.
[124] J C Loudon, *An Encyclopaedia of Agriculture*, 3rd ed., (London, 1835): 626; Martin Doyle, *A Cyclopaedia of Practical Husbandry and Rural Affairs in General*, (London, 1851): 348-54.

Menteath's kilns were not, however, met with universal acclaim. One contributor to the *Farmer's Magazine,* writing under the epithet 'A Constant Reader', announced that, having read the description of the Closeburn kilns in an earlier volume, he was 'pleased with their scientific construction, but at the same time surprised at the heavy expense necessarily incurred'.[125]

Other commentaries on kiln design appeared in the Transactions. Brigadier-General Alex Dirom presented a plan and description of lime kilns that he had constructed at Mount Annan that employed an unusual domed design.[126] Like Menteath, Dirom sought to demonstrate the improved fuel efficiency of his kilns and their ability to produce consistently high-quality lime. However, he also admitted that his tenant, who operated the kilns, found them too finicky to operate. Their domes made them difficult to load and the overall design required considerably more care and attention than other kilns in order to gain the benefits to efficiency. Shortly after featuring in the RHASS the kilns were abandoned, although Dirom maintained his interest in lime burning, keeping contact with Menteath and a lime burner in Dublin who reportedly improved on his original plans.[127]

Dirom's kilns were expensively built and therefore beyond the means, and indeed needs, of all but the larger commercial producers. Another essay by Jonathan Radcliff, on the other hand, offered advice on burning lime with peat in an essay published in 1803, an issue of great concern to those interested in extending improvements throughout the Highlands where coal was scarce (see Chapter Four).[128] His instructions were clear and the kiln he described could be cheaply made and adjusted to the needs of the farmer, yet Radcliff's contribution received little attention compared with the grander designs of Dirom and Menteath.

[125] This individual, who was Welsh, went on to recommend burning lime in clamp kilns (these kilns and his argument are disused in the previous chapter). Such derision highlights the fact that elaborate kilns of this type were relevant to a wealthy few, and that smaller, simpler kiln types, almost absent from later agricultural writing, were the more widely used. See, A Constant Reader, 'On Burning Lime without Kilns', *The Farmer's Magazine*, vol. 17(65), Feb 1816, p.61.
[126] 'Plan and Description of Lime-kilns Built in 1801 by Brigadier-General Dirom of Mount Annan', *Prize Essays and Transactions of the Highland Society of Scotland*, vol. 3 (1807): 110; Dirom's original plan from 1802, which was reproduced by the RHASS, can be found in the National Archives (NRS RHP35185).
[127] Major-General Dirom, *Account of the Improvements on the estate of Mount Annan,* (1811).
[128] Jonathan Radcliff, 'On burning lime with peat', *Transactions of the Royal Highland and Agricultural Society of Scotland,* (1803), p.160.

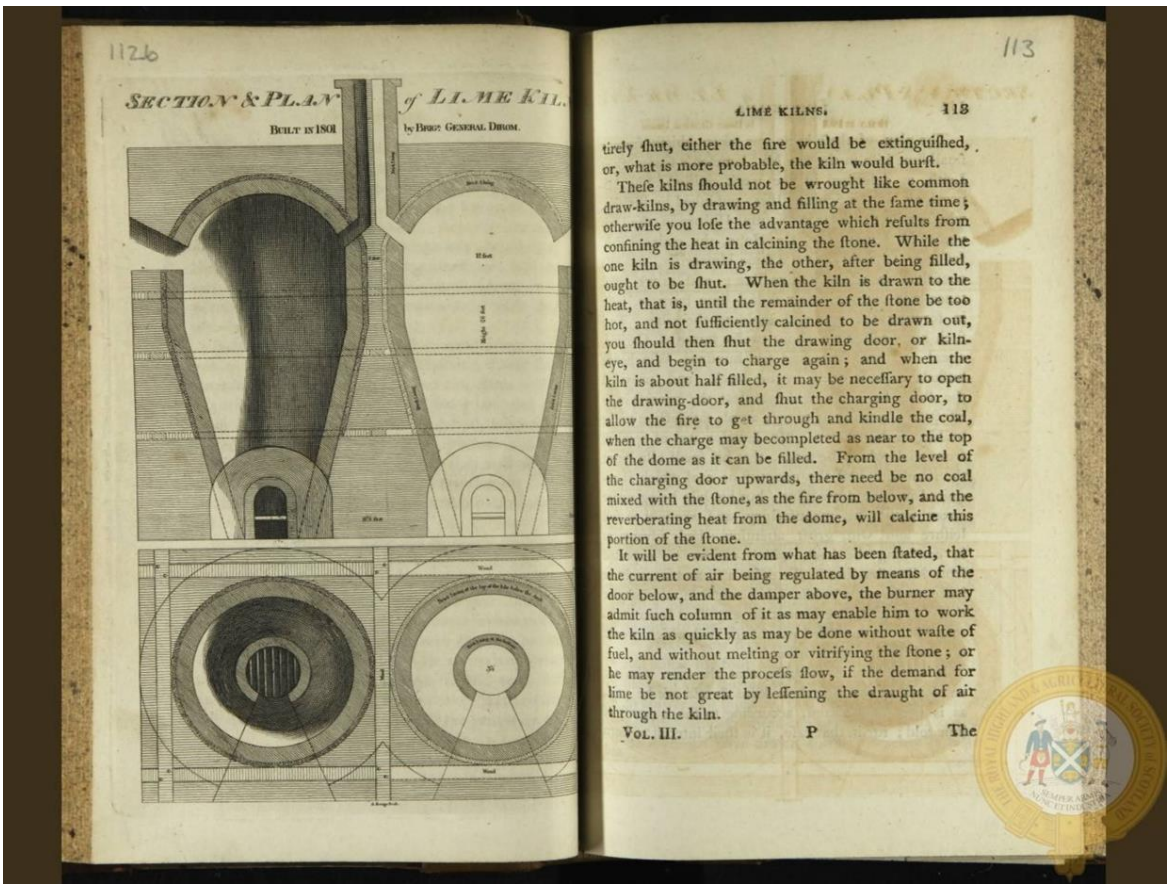

Figure 61 Description and section plan of Lime Kilns in 1801 by Brigadier-General Dirom, *Prize Essays and Transactions of the Highland Society in Scotland,* (1807), p. 113.

In 1831 the RHASS offered a premium for 'the best account of the principal Quarries in Scotland, detailing the mode and expense of working, the quantities produced, and other essential particulars'.[129] Several essays were received in response to this call, three of which were published in 1835.[130] None, however, described limestone resources, so, 'desirous of obtaining additional information', the society offered a second premium on the same topic in 1834, which was answered with two accounts of lime works in Scotland.[131] The gold medal prize was awarded to James Carmichael of Stirlingshire, while the silver was given to James Wallace of Ayrshire. Carmichael's account describes the operations of the largest commercial lime works in Lowland Scotland, detailing various aspects of their productivity and encouraging comparison between the sites. The range of

[129] *Prize Essays and Transactions of the Royal Highland and Agricultural Society of Scotland*, vol 11 (1837): 57.
[130] *Prize Essays and Transactions of the Royal Highland and Agricultural Society of Scotland*, vol 10 (1835): 53.
[131] *Prize Essays and Transactions of the Royal Highland and Agricultural Society of Scotland*, vol 11 (1837): 57.

factors described included: their associated geology; the quality of the lime produced; the selling price of lime; the source and price of fuel; the wages paid to quarriers and lime workers; the ownership of each site; the kinds of kiln used; and the quantity of lime produced annually.[132] He concluded by making some general pronouncements regarding the state of Scottish lime production. For instance, he felt that machinery, for quarrying and conveying limestone and fuel to the kilns, was under-utilised within the industry. He calculated that, based on his review of the major lime works, 5,060,000 bushels of lime were laid on the soil in 1833. At 120 bushels per imperial acre, this amounted to 42,166 acres of land limed over the year. Carmichael expressed concern at the apparent diminishing rate of liming compared with the total of 12,000,000 bushels previously calculated by Sir John Sinclair in 1814. This 'lapse', he argued, 'strongly enforces the necessity of redoubled exertion, to meet the change with courage'.[133]

Wallace's account followed much the same pattern as Carmichael's and was edited to avoid repetition between the two articles. He placed greater emphasis on the construction of kilns and called attention to the lack of formal knowledge regarding lime burning compared with other agricultural topics:

> The burning or calcining of limestone is one of the most important operations connected with lime-quarries, and it is one on which the least satisfactory information can be procured. Indeed very few great trials have been made to ascertain the best constructed lime-kilns, and the exact quantity of coal required to calcine a given quantity of lime. Prejudice in favour of the old plan exists to such a degree amongst lime-burners, that the truth, or even a trial, can only be obtained by chance, or with the greatest difficulty. In trials, much depends upon the construction of the lime-kiln, the quality of the coal, and the density of the limestone, yet it is the interest of every proprietor and every person connected with lime-quarries, to have satisfactory experiments made on a large scale with a view to economize fuel and have the limestone well and properly burnt.[134]

His account illustrates the *ad hoc* way in which lime production had developed in the preceding century, and that constructing efficient and effective kilns remained a subject of interest to

[132] James Carmichael, 'Account of the Principle Limestone Quarries of Scotland', *Prize Essays and Transactions of the Royal Highland and Agricultural Society of Scotland*, vol 11 (1837): 57-84
[133] Carmichael, 'Principle Limestone Quarries', 83.
[134] James Wallace, 'Account of the Method of Calcining Limestone in Some of the Limestone Quarries in Scotland', *Prize Essays and Transactions of the Royal Highland and Agricultural Society of Scotland*, vol 11 (1837): 455

agriculturalists. Indeed, that the Society saw fit to publish accounts of this nature, indeed reissuing their premium so that lime production was addressed, highlights continued interest in agricultural lime among their membership. Information on quality and pricing would have informed purchasers of lime, with Carmichael's comparative table perhaps serving as a catalogue of lime for sale around the most populous parts of Scotland.[135] Practical detail regarding the nature of quarry workings, kiln types, fuels and costs of production would have been valuable to landowners assessing the economic viability of mineral resources on their estates or else seeking to improve the profitability or scale of existing works. Carmichael's comments indicate that by the 1830s liming had begun to decline, but also that agriculturalists remained of the opinion that the project of improvement, in which lime was a crucial component, had not yet been completed. The Society, then, still had a role to play in promoting the use and production of lime through education and inducement.

6.2.4 The Annexed Estates

Adams argues that the Commissioners of the Annexed Estates in Scotland were among the most influential institutions in terms of disseminating knowledge and setting a template for agricultural change.[136] Following the Jacobite rebellion of 1745, estates forfeited by landowners sympathetic to the Jacobite cause were placed under the control of a board loyal to the British crown. These estates were managed by Commissioners whose remit was to improve their profitability whilst also quashing the clan structure that had been the context of the uprisings.[137] Since the profits from the estates were reinvested in further improvement, rather than simply deposited in the British treasury, Smith suggests that the annexed estates might be considered a 'first experiment in regional development'.[138]

The Commissioners published frequent reports on the state of the estates under their control and the progress of changes, leaving a written record of their knowledge and attitudes towards the management of land.[139] Many of the Commissioners were themselves committed improvers, several of whom, such as Lord Kames, published influential agrarian treatises of their own. Andrew Wight's

[135] Carmichael, 'Principle Limestone Quarries', 84.
[136] Adams, "The Agents of Agricultural Change."
[137] Annette M Smith, "Annexed Estates in the Eighteenth-Century Highlands," *Northern Scotland* 3, no. 1 (1977): 25–46.
[138] Smith, 46.
[139] Virginia Wills, *Reports on the Annexed Estates, 1755-1769* (Edinburgh: HMSO, 1973).

Present State of Husbandry in Scotland, published in three volumes between 1778 and 1784, was drawn from reports submitted to the Commissioners of the Annexed Estates. Wight shows the Commission to be conscious of its role in fostering knowledge diffusion, remarking that '[m]any ingenious farmers, dissatisfied with the common practice, would gladly attempt new modes; but are restrained by the uncertainty of success' and that such persons were 'unconnected, hav[ing] little opportunity to learn from each other'.[140] His account also shows that limestone resources or the availability of lime were considered important indicators as to the potential improvement of farms. The Commissioners were keen to introduce modern, fashionable ideas in the management of farmland and courses of liming were widely recommended, while the use of lime was an indicator of the progressiveness of lessees.[141] Among the other fashionable schemes that they promoted, Lord Kames' idea of grinding limestone using water power was trialled at Callander. A series of experiments regarding the use of ground lime were also proposed:[142]

> as there was plenty of limestone on different parts of the Estate of Perth and no coal the factor should be ordered to make comparative experiments of the effect of bruised lime and calcined lime on such parts of the estate as appears to him better for that end, some upon grass, some upon heath, some upon tilled land and taking an equal quantity by measure of lime shells and of lime stones with ½ part more of the latter, an allowance for the water that is in the unburnt stone.[143]

Such examples indicated the modern approach to agriculture favoured by the Board, and their commitment to innovation and experience. Unsurprisingly, draw kilns were recommended in favour of clamp kilns. Wight, and by extension the Commissioners', disdain for the latter is clear. When recounting the practice of a Mr Robertson in Clackmannanshire, who burned lime in clamp kilns in order to more easily lay lime on his soil while it was still hot, Wight remarked that 'he pretends to justify this method from experiments; whether so conducted as to be depended upon, may be doubted'.[144] The Board also felt that landowners should take responsibility for supplying lime to their tenants, as an essay submitted by Lord Justice Clerk regarding Barskimming, in Ayrshire, illustrates:

> Here is a glorious fund for improvement, a lime-stone rock and coal within two miles of it. His Lordship has erected a draw-kiln for burning it; and his tenants are made

[140] Wight, *Present State*, vol 1, viii-ix.
[141] Smith, "Annexed Estates in the Eighteenth-Century Highlands."
[142] Ground lime is discussed in Chapter Four.
[143] Letter, Lord Kames to Board of Commissioners, 31/01/1763 (NRS E777/262/1).
[144] Wight, *Present State of Husbandry*, vol. 2, p. 111.

> welcome both to the rock and kiln to burn as much as they please. This is a very proper encouragement to indolent tenants who stand in need of a spur. But his Lordship is too wise not to have the consequences in view. Lime is a two-edged weapon, and can be used as successfully to impoverish land as to improve it. The large crops it produces at first prove a violent temptation with low people, who mind only to present gain, to continue liming and cropping till they run out of ground, no less to their own hurt when bound by lease, than that of the landlord. It is necessary to put such men under restrictions against over-liming and cropping.[145]

The Board played an active part in facilitating those methods of which it approved as well as fostering examples of innovation. To encourage lime burning, for example, the Board would occasionally furnish the 'uncommon expense' of tools for quarrying or operating a kiln.[146] Clerk's comments also illustrate the attitude held by many of the Commissioners towards the indigenous population of the Highland estates. Indeed, the intention of the Commissioners to impart knowledge was ultimately indivisible from their purpose in extending forms of cultural colonialism.[147] Francis Grant, Inspector for the Commissioners of Annexed Estates, summarised his role in explaining the virtues of the new systems of husbandry thus: 'I endeavoured to demonstrate the particular benefit to themselves as well as the nation by enclosing and sowing grass for hay which might save many of their cattle's lives, planting trees, potatoes, liming, sowing hemp and flax and manufacturing the same, etc'.[148] To the largely Gaelic-speaking Highland population however, such improvements had to be conveyed through an interpreter.[149] The annexed estates thereby can be seen as an administrative structure that forcibly imparted knowledge through its management of the lands that it controlled.

6.2.5 The Board of Agriculture

A national agrarian institution with a remit to collect information about the nature of British farming and disseminate the best standards of husbandry across the country was proposed by Lord Kames as early as 1766.[150] Eventually, following the efforts of the agriculturalist, writer and parliamentarian Sir John Sinclair, the Board of Agriculture and Internal Improvement was established in 1793. As an

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[145] [Andrew Wight], *Present State of Husbandry in Scotland. Extracted from Reports Made to the Commissioners of the Annexed Estates, and Published by their Authority,* vol. 3 (1), (Edinburgh, 1784)
[146] Letter, Alexander Cairns to commissioners, 28/07/1763 (NRS E777/138/2); Wills, *Reports on the Annexed Estates, 1755-1769*, 80.
[147] Colonial ideology may have underpinned much of the improvement movement, see Ross, "Improvement on the Grant Estates in Strathspey in the Later Eighteenth Century: Theory, Practice and Failure?," 297.
[148] Davidson, "The Scottish Path to Capitalist Agriculture 3: The Enlightenment as the Theory and Practice of Improvement," 29.
[149] Adams, "The Agents of Agricultural Change."
[150] Mitchison, "The Old Board of Agriculture (1793-1822)," 41.

institution, the Board was an unusual one. Part administrative body and part voluntary organisation, the Board drew its small membership from the landed gentry and aristocracy. Its key achievement was the initiation of a national survey of farming at the county level, with the aim of recording current practices, making recommendations for its improvement, and assessing the opportunities and barriers to making these improvements. The reports produced by this survey (often referred to as the *County Surveys* or *General Views*) were published in two series between 1793 and 1816.[151] The Scottish survey, which Sinclair presided over himself, produced fifty-four volumes which were written by forty-three authors. As was often the case with improvement literature, most of the reports were written by persons whose agrarian experience had been gained primarily as landlords rather than as farmers, and this fact likely coloured their accounts.[152]

As Holmes has shown, Sinclair's intention was for these reports to be widely circulated among farmers, landowners, and members of parliament; those, in other words, best able to effect change and encourage improvement. [153] Rosalind Mitchison suggests that, like other agrarian material, the volumes would have been purchased and read by a small number of landowners and aspiring tenant farmers.[154] Although the texts themselves might not be considered primary means through which practical information reached those working the land, they were held in high regard by the agriculturalist community—those already reading and writing improvement literature and participating in the agricultural societies—and thus contributed to the dissemination and codification of agrarian knowledge. Sir John Sinclair, in an 1808 address to the Board of Agriculture, quoted Dr. Coventry's commendation of the as-yet incomplete series of Scottish county surveys. Coventry, who was then Professor of Agriculture at the University of Edinburgh, had stated that 'in these late reports and publication, there is detailed more useful and distinct information on various branches of

[151] A complete bibliography and publication history of these surveys has recently been compiled by Holmes, see: Holmes, "Sir John Sinclair, the County Agricultural Surveys, and the Collection and Dissemination of Knowledge 1793-1817, with a Bibliography of the Surveys: Part 1"; Holmes, "Sir John Sinclair, the County Agricultural Surveys, and the Collection and Dissemination of Knowledge 1793-1817, with a Bibliography of the Surveys: Part 2."
[152] Mitchison, "The Old Board of Agriculture (1793-1822)," 43.
[153] Holmes, "Sir John Sinclair, the County Agricultural Surveys, and the Collection and Dissemination of Knowledge 1793-1817, with a Bibliography of the Surveys: Part 1."
[154] Mitchison, "The Old Board of Agriculture (1793-1822)," 52.

agriculture, and on rural concerns in general, than was in print before these were drawn up'.[155] Whilst Sinclair's intention was clearly to justify the substantial effort of compiling these reports, Coventry's endorsement illustrates the influential nature of the Board of Agriculture's publications. Coventry was an important agent in the circulation of agricultural knowledge since, through his lectures at the University, he could bring information held in institutions and texts into contact with audiences of men more likely to act upon the soil. The County Surveys also epitomise, as will be discussed below, the Enlightenment worldview that brought them into being—the notion that agricultural improvement could be achieved through the collection of data, the application of rational principles, and the diffusion of useful knowledge. Thus, as Mitchison states, the Board and its work were 'both a symptom and an instrument' of agrarian change.[156]

Soil fertility and therefore lime were of the utmost importance in the eyes of the Board. Indeed, Anderson, in his report on Aberdeen, called lime 'the basis of all essential improvements'.[157] At the end of the eighteenth century, when the first surveys were taking place, many of the authors concluded that lime was not yet being exploited to its fullest potential in many parts of Scotland, particularly those far from the prosperous Lothians and Ayrshire.[158] Liming was thus almost universally encouraged in the *County Surveys*. They also observed 'a difference of opinion and of practice with respect to its application' stemming from enduring uncertainty over its nature and best usage.[159] George Buchan-Hepburn, for example, observed in the Lothians that there was a long held 'fixed belief' that lime would have no effect on land that had been limed at any time in the past. However, he noted that 'a few experiments' conducted in the county disproved this notion and overcame the farmers' reticence, resulting in wider uptake of liming and illustrating how new knowledge could lead to better practice.[160] While the objective of the surveys was ostensibly to gather

[155] Address to the Board of Agriculture by Sir John Sinclair, Bart., the President, at the Conclusion of the Session, on the 7th of June 1808, *The Monthly Magazine; or, British Register*, (1808), vol. 26, part 2, p. 48.
[156] Mitchison, "The Old Board of Agriculture (1793-1822)," 41.
[157] James Anderson, *General View of the Agriculture and Rural Economy of the County of Aberdeen*, (1794): 58.
[158] John Smith, *General View of the Agriculture of the County of Argyll*, (1798): 199; James Donaldson, *General View of the Agriculture of the County of Elgin or Moray*, (1794): 20; Robert Douglas, *General View of the Agriculture of the Counties of Roxburgh and Selkirk*, (1798): 11.
[159] Patrick Graham, *General View of the Agriculture of Stirlingshire*, (1812), 254.
[160] G. Buchan-Hepburn, *General View of the Agriculture and Rural Economy of East Lothian*, (1794).

information about regional practice, the authors had licence to make recommendations for improvement and to articulate their own beliefs, experiences and knowledge. James Headrick, who compiled the report for Angus, had a keen interest in the natural sciences and was involved in the Glasgow Chemical Society.[161] His enthusiasm and understanding are evidenced in his lengthy and keenly-observed discussion of the action of lime.[162] He wrote, '[m]uch controversy has taken place, both among agriculturalists and chemists, regarding the mode by which lime operates as a manure', before making detailed and thoroughly argued pronouncements about the present state of knowledge regarding lime and the implications of these for liming various kinds of soils.[163] Charles Findlater's account of Peebles shows a similar interest in the science of lime, and made a number of suggestions regarding its best use on the soil. Findlater's information was drawn from his own observations, as well as published chemical works and the experiences of estate factors, the latter of which played a crucial role in implementing improvement on behalf of their proprietors.[164] Thus the *County Surveys*, depending on the interests, experience, and competence of their various authors, provided a conduit for collating and sharing practical and theoretical knowledge regarding the role of lime on soil.

In order to implement the programmes of liming recommended by the Board, farmers or proprietors were called upon to undertake lime burning themselves where lime was not locally available. Persuading farmers to burn lime was a matter of education and encouragement, as James Robertson observed in Inverness-shire: '[t]he lower class of farmer must have examples set before them, to excite their industry, and leases in their pockets to ensure the fruits of their labour.'[165] Leases in which tenant farmers were obliged to employ certain techniques were a well-documented means by which improvement could be incentivised or enforced by landowners (see Chapter Five).[166] This approach was endorsed in the County Survey as a way of increasing the uptake of liming. John

[161] J. H. Burns, 'Headrick, James (1759-1841)' in *The Oxford Dictionary of National Biography*, (Oxford, 2004).
[162] James Headrick, *General View of the Agriculture of the County of Angus, or Forfarshire,* (1813), 403-14
[163] *Ibid*, 406.
[164] Charles Findlater, *General View of the Agriculture of the County of Peebles, with Various Suggestions*, (1802), 165-6; Devine, *The Transformation of Rural Scotland: Social Change and the Agrarian Economy, 1660-1815*.
[165] Robertson, *General View Inverness,* (1808): 241.
[166] Devine, *The Transformation of Rural Scotland: Social Change and the Agrarian Economy, 1660-1815*.

Thomson's *General View* of Fife, for example, included the template of a lease, in which he proposed that tenants should 'have full power to apply a quantity of lime and marle so discovered', with the amount of lime they could use each year restricted to avoid damaging the soil.[167]

Recommendations extended to the manner of burning lime itself, and an orthodoxy regarding kiln design can be seen to emerge. Draw kilns were praised as the 'proper' kilns for burning lime, while James Macdonald, who surveyed the Hebrides, admired the numerous 'regular' lime kilns on Campbell of Shawfield's Islay estate.[168] Several of the accounts detail the construction of such kilns, which shared consistent features such as large rounded internal pots that narrowed to their base. John Smith for instance described the pot of his kiln as 'an inverted bottle', while James Robertson's was 'the shape of an egg, with the small end downwards'.[169] Robertson, whose enthusiasm for lime was evident in each of the three reports that he compiled for the Board, clearly understood both the value of knowledge for improvement and his role in diffusing it. Regarding lime kilns, he wrote in his Perthshire account:

> In many instances the kilns made by country people for burning limestone to be used on their own farms, are very awkward. We ought not, however, to brand them with opprobrious epithets, nor rail at them with acrimony of language; which is sometimes done; we ought rather to be glad that they make any kilns at all, and point out to them a better form of kiln.[170]

Not all authors restrained from criticism. For example, James Donaldson recounted with disdain the practice in Banffshire of tenant farmers burning lime in 'ill constructed open kilns'.[171] To ensure sufficient lime supplies, several of the *County Surveys* encouraged landowners to centralise lime production. William Marshall, who bemoaned the inefficiency of 'the Highland kiln', argued that in the Highlands, where lime was scarcely available, 'it behoves the proprietors of estates to devise; and put forward, every means of supplying the defect by internal productions', including establishing

[167] Thomson, *General View Fife*: 395-402.
[168] James Donaldson, *General View of the Agriculture of the County of Elgin or Moray,* (1794): 35; James Macdonald, *General View Hebrides:* 34.
[169] John Smith, *General View of the Agriculture of the County of Argyll,* (1798), 199; Robertson, *General View Perth*, 287.
[170] Robertson, *General View Perth,* 287.
[171] James Donaldson, *General View of the Agricutlure of the County of Elgin or Moray,* (1794): 41-2.

'sale kilns, for the use of small tenants'.[172] Similarly, Donaldson proposed that, 'in order to introduce the general use of this valuable manure . . . the proprietor should at his own expence [sic] erect proper kilns, and employ people experienced in burning lime stone'.[173]

The 'traditional' viewpoint regarding the 'backward state' of Scottish farming before improvement was to a large extent established by the institutional publications by the Board of Agriculture and the Statistical Accounts.[174] While this institution certainly did much to codify and disseminate knowledge that improved the productivity of farmers, this may have been at a cost to older ways of doing things. For instance, clamp kilns were roundly dismissed as inefficient, yet their use persisted and even expanded into the nineteenth century, evidencing their continued value in some situations.

From these published accounts can be seen the development of what Ian Adams referred to an 'established position' on the use of lime in agriculture.[175] Most authors addressed the subject of lime in the context of improving soil fertility, grappling to varying extents with the underlying question of how lime operated on soil. Yet answers to these questions remained elusive until the latter half of the nineteenth century. Where the production of lime is concerned, most accounts encouraged kilns that enabled 'perpetual' production, with designs varying only slightly. Thus, draw kilns became established within improving rhetoric as the pre-eminent means of lime burning—an attitude that finds itself articulated in many subsequent modern histories of the lime industry.

6.2.6 Interaction and emulation

It is widely acknowledged that a large proportion of knowledge diffusion in the Enlightenment took place via a range of ephemeral means that left little or no written record.[176] Personal and professional relationships, correspondence, lectures, formal and informal emulation, were all channels through which knowledge flowed.[177] Sir Archibald Grant alluded to the importance of informal social interaction in his decision to publish his 1756 pamphlet during the winter months, when farmers

[172] William Marshall, *General View of the Agriculture of the Central Highlands of Scotland*, (1794): 67.
[173] James Donaldson, *General View Elgin or Moray,* 35.
[174] Adams, "The Agents of Agricultural Change."
[175] Adams, 173.
[176] Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature*.
[177] Holmes, "The Dissemination of Agricultural Knowledge, 1700-1850," 868.

would have 'leisure to think and converse.'[178] Without overt written accounts, the extent to which emulation took place between farmers and landowners, and the bearing this may have had on the development of the lime industry, is ultimately conjectural. However, the development of other industrial and agricultural practices suggest such emulation likely did occur to some extent. Much agrarian innovation and knowledge came from 'unsung' efforts that took place before anything was recorded.[179] Given the long history of lime usage prior to the eighteenth century, and the variety of local practices that remained evident at the beginning of the nineteenth, it is likely that much of the early knowledge-making around lime could be characterised in this way. Farmers replicated what worked and discarded what did not. As Macdonald noted in his study of Northumberland, 'they learned from their neighbours, and particularly from those of their neighbours whose prosperity could be reasonably linked with the introduction of a new process'. [180] New methods often had to overcome initial resistance or scepticism, however, since most ordinary people, Mokyr argues, were not inclined to experiment or take risks, and they were even less willing to disrespect their teachers or ancestors by rejecting their ideas in favour of the new.[181] The *OSA* for West Kilbride, for example, recalls that 'very strong prejudices were long entertained against [lime]' and that 'no reasoning could prevail with the farmers to try it'. [182] The farmers 'pleaded their ignorance of its operation, the method of applying it, and the great expense [of carrying it from] a distant kiln'. Eventually, though, whether from 'observing the great advantages arising from it in neighbouring parishes', 'regulation by the late leases', or 'the more enterprising spirit of some new proprietors', 'vast quantities' of lime began to be laid in the parish from 1790. Thus, emulation, rather than being spontaneous, was more often accompanied by other forms of inducement.

Although innovation and emulation between farmers left little in the way of written evidence, more can be found among the landed classes. Landowners corresponded and interacted, influencing and learning from each other. Sir James Grant of Grant, who declared to his factor William Lorimer 'I

[178] Grant, *Farmer's New-year's Gift,* 1.
[179] Smout, "A New Look at the Scottish Improvers," 91.
[180] S. Macdonald, "The Diffusion of Knowledge among Northumberland Farmers, 1780- 1815.," *Agricultural History Review* 27, no. 1 (1979): 37.
[181] Mokyr, *The Enlightened Economy: An Economic History of Britain 1700-1850*, 23.
[182] *OSA*, Parish of West Kilbride, vol 7, p.408.

am determined to introduce [liming] in every part of my estate'.[183] Grant sent 'questionnaires' to other landowners with whom he was personally acquainted, enquiring about methods, prices, management, and so on.[184] Surveyor Peter May, who worked with Grant, corresponded on the subject of lime burning. In July 1767, he received a letter from Alexander Dirom (senior), with the latter offering detailed advice on the positioning, cost and construction of a large kiln:[185]

> I imagine a kiln 16 feet high, 16 feet wide within at the top and gradually brought in to 8 feet at the bottom would be a very proper size, but this will frighten your strylla [?] man, who will be prejudiced in favour of his own country kilns that burn from 10 to 16 boll only.[186]

Existing kilns served as a template for new kilns. When Robert Hogg, factor to Sir Hew Dalrymple of Drummore (Lord Drummore), set about establishing his proprietor's 'Lime affair' in 1754, the kilns belonging to Dalrymple's brother, Sir William Dalrymple, were used as a template. Writing to Lord Drummore in London, Hogg stated that he and two other men had visited the kilns with the purpose of 'taking a model from them' before marking out the ground at Sir Hew's own quarry.[187] From the end of the eighteenth century, with the onset of industrialisation, it became more common for gentlemen to visit the works of their peers or to correspond about their industrial endeavours.[188] Amongst the Duke of Gordon's papers relating to the operation of Ardonald Lime Works in Aberdeenshire is further evidence of conscious industrial observation. For example, a memorandum was written regarding Hedderwick lime works, the property of George Robertson Scott.[189] This account, which was compiled by Scott's factor James Kandow, details the expense of producing lime, including the geological situation, the arrangement of the works, labourers wages, and the selling price. Another slip of paper, simply headed 'note of queries and answers', indicates similar

[183] Adams, "The Agents of Agricultural Change," 164.
[184] *Ibid.*
[185] Dirom Senior in question was the father of Brigadier-General Alex Dirom who submitted his kiln design to the RHASS. Perhaps lime kilns were something of a family affair.
[186] Alexander Dirom of Muiresk, Sheriff-substitute of Banff, to Peter May, 11/07/1767, in Adams, *Papers on Peter May Land Surveyor, 1749-1793*, 78–80. The meaning of 'strylla man' is not known, but it is thought to relate to a local employee or labourer.
[187] Letter, Robert Hogg to Sir Hew Dalrymple, 30/12/1754 (NRS GD110/927/41); The occupation of the two other men is not stated, but one, a Mr Brown, is likely to have been the factor to William Dalrymple, while the other, James Greeve, may have been the mason hired to build the new kilns or otherwise in the employ of Robert Hogg.
[188] Donnachie, "A Tour of the Works: Early Scottish Industry Observed, 1790-1825."
[189] Memorandum of Hedderwick Limeworks belonging to George Robertson Scott esq. of Benholme near Bervie, from Mr James Kandow the Factor's information, undated [c.1810] (NRS GD44/39/30/14).

investigations having taken place regarding the state of the industry in the Lothians.[190] The questions related to the measures used, the quantity of slaked lime that each boll would yield, and the price.

The mobility of skilled labour has also been identified by Jones as an important way of spreading practical knowledge.[191] As Chapter Five has shown, labourers, masons and lime burners circulated in the rural economy, carrying with them valuable experience and skills, a model that had parallels in other aspects of improvement.[192] Masons in particular were afforded responsibility for building kilns, thereby influencing the designs that were carried forward. When farmers moved, they could also carry with them customary practices. An example of this can be seen in Southend parish in western Argyll, where Reverend David Campbell observed in 1792 that all the kilns used by farmers to burn lime were built of 'turf', except for one draw kiln 'built by an English farmer for his own use'.[193] Improvements, whether as a result of emulation or some other form of knowledge transfer, were influenced by more than commercial motivations.[194] Although, in most cases, 'profit would overcome prejudice', ideas and practices were subject to fashions or could be employed to convey some message about an individual or estate beyond simply increasing productivity.[195] These notions of status and cultural value are explored below.

6.3 Lime as status symbol

As Smout and others have shown, the programme of improvement and the technologies and practices that it promoted are linked to the cultural and intellectual values that produced it.[196] Agricultural improvement was closely tied to notions of civic virtue.[197] With the expansion of public fora for sharing agricultural exploits, including publishing and societies, farmers seen to be at the forefront of improvement, those so-called 'men of genius', could have their reputations enhanced by

[190] 'Note of queries and answers' (NRS GD44/39/30/7).
[191] Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature*, 111.
[192] Macdonald, "Agricultural Improvement and the Neglected Labourer."
[193] *OSA*, Parish of Southend (1792), p.364.
[194] Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature*, 158.
[195] Macdonald, "The Diffusion of Knowledge among Northumberland Farmers, 1780- 1815.," 38.
[196] Smout, "A New Look at the Scottish Improvers"; Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature*.
[197] Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature*, 68.

implementing new methods and techniques on their lands.[198] Those with the foresight to initiate programmes of liming in their areas through the building of roads, enforcement in leases, and the erection of kilns, were lauded as visionaries or pioneers.[199] Bringing new areas of land into production, a task for which lime was essential, was also particularly commended.[200] The earliest notable improvers were often the first to introduce lime burning to their area. George Dundas, for example, was keenly interested in modern farming methods, and the first kiln was in operation on the Dundas estate as early as 1624.[201] Lime's long history was well understood by the improvers, as evidenced by Adam Dickson's *Husbandry of the Ancients*, which cited Cato's writing regarding the construction of Roman lime kilns, and compared them favourably to those used in Britain at the time.[202] Despite its usage since 'time immemorial', lime was closely associated with progressive agriculture, being, as David Ure put it, 'the first and foremost step in this new system of husbandry'.[203] By association perhaps, liming and lime burning may have become symbolic of innovation, progressiveness or social stature.

Some farmers certainly took pride in implementing methods of modern husbandry, including the use of lime. This pride is evidenced in the following remark by Captain John Macpherson, a farmer in Invereshie in the Highlands: '[h]e [the boatman] and I, look upon ourselves as great farmers – I burn three lime kilns every fortnight now that the harvest is over – I have plenty of limestone and firing at hand'.[204] Elsewhere, lime could be used as a more direct proxy for the wealth and security of individual farmers. In Berwick in 1794, Alexander Lowe observed that

> So universally has the use of this manure been considered to contribute to the farmer's profit, and the improvement of the lands, that, to a bye-word in the county,

[198] Wight, *Present State of Husbandry*, vol 1: vii.
[199] Robert Douglas, *General View of the Agriculture of the Counties of Roxburgh and Selkrik,* (1798): 138-9
[200] George Robertson, *Rural Recollections; or, the Progress of Improvement in Agriculture and Rural Affairs*, (Edinburgh, 1829): 617.
[201] Ian Whyte, "George Dundas of Dundas: The Context of an Early Eighteenth-Century Scottish Improving Landowner," *The Scottish Historical Review* 60, no. 169 (1981): 1–13; Turnock, *The Making of the Scottish Rural Landscape*, 187.
[202] Adam Dickson, *The Husbandry of the Ancients*, vol I (Edinburgh, 1788), pp.330-343.
[203] *OSA*, Parish of East Kilbride (1792), vol. 3, 424; David Ure, *General View of the Agriculture of the County of Roxburgh,* (1794): 26.
[204] Letter, John Macpherson to William Macpherson, 22/10/1793 (NRAS 771/574).

> an entering tenant would get credit in proportion to the extent of his fallow field and the number and size of his lime heaps.[205]

Furthermore, failure to utilise lime when it was available was often considered a sign of laziness on the part of the farmer, an attitude reinforced by institutions such as the Board of Agriculture and the commissioners of the annexed estates. This attitude is alluded to in the following comment by the minister for Birse in Aberdeenshire in 1793:

> Some [tenants] aver, that to lime their ground is to no purpose as, say they, it has no effect, because the ground is on limestone: Whether this be a just remark, or only an excuse for indolence, is left to the skilful farmer to decide.[206]

Figure 62 Limekiln and other agricultural implements from plan of the Improvement of Bargany, the seat of John Hamilton, Esq., by George Robertson, 1774 (RHP1724)

The inclusion of a lime kiln in the vignette adorning John Hamilton's 1774 improvement plan, shown in Figure 62, for his farm in Bargany, Ayrshire, is an example of how liming could be incorporated

[205] Alexander Lowe, *General View of the Agriculture of the County of Berwick*, (1794), 34
[206] *OSA*, Parish of Birse (1793): 110.

into forms of agricultural display. Cartographic decoration of this kind conveys much about the status and values of the map-makers as well as the cultural meaning of the map itself.[207] By prominently positioning the kiln alongside other implements of modern agriculture, including an improved Scots plough and a five-barred harrow, the cartographer, George Robertson, clearly wished to convey a message about the supposed modernity of his proprietor's husbandry, regardless of whether the methods themselves were ever used.

The proliferation of small farm kilns into the nineteenth century, particularly in upland areas of Scotland where lime had a shorter history of use, raises the question of whether kilns themselves were used as forms of agrarian display by the farmers who built them. Johnson has alluded to this idea in relation to field kilns, suggesting that 'the intricate external design and solid built . . . testify to their owners' sense of pride and optimism'.[208] Perhaps an extreme example of this can be seen at Skye of Curr, in Invernesshire, shown in Figure 63. There each of the nine farms along a stretch of road less than a kilometre long shown is depicted in 1871 as having their own lime kiln. At the northern end of the road, at Dulnain Bridge, is a limestone quarry and larger draw kiln, which supplied lime commercially to the local area.[209] The farms at Sky of Curr were established after 1771, when an early plan identifies the area to be 'improvable moor ground covered with heath'.[210] Certainly in many areas farmers continued to burn their own lime until well into the nineteenth century, but in cases such as Skye of Curr it is difficult to imagine that doing so would have been cheaper or easier than carting it the short distance from an estate kiln.

[207] Harley, "Deconstructing the Map."
[208] David Johnson, 'Industrial Lime Burning', *Out of Oblivion*, http://www.outofoblivion.org.uk/ind_lime.asp, accessed 02/02/16.
[209] James Robertson, *General View of the Agriculture of the County of Inverness*, (1808), lvi.
[210] Plan of the lands of Curr, 1771 (NRS RHP89026).

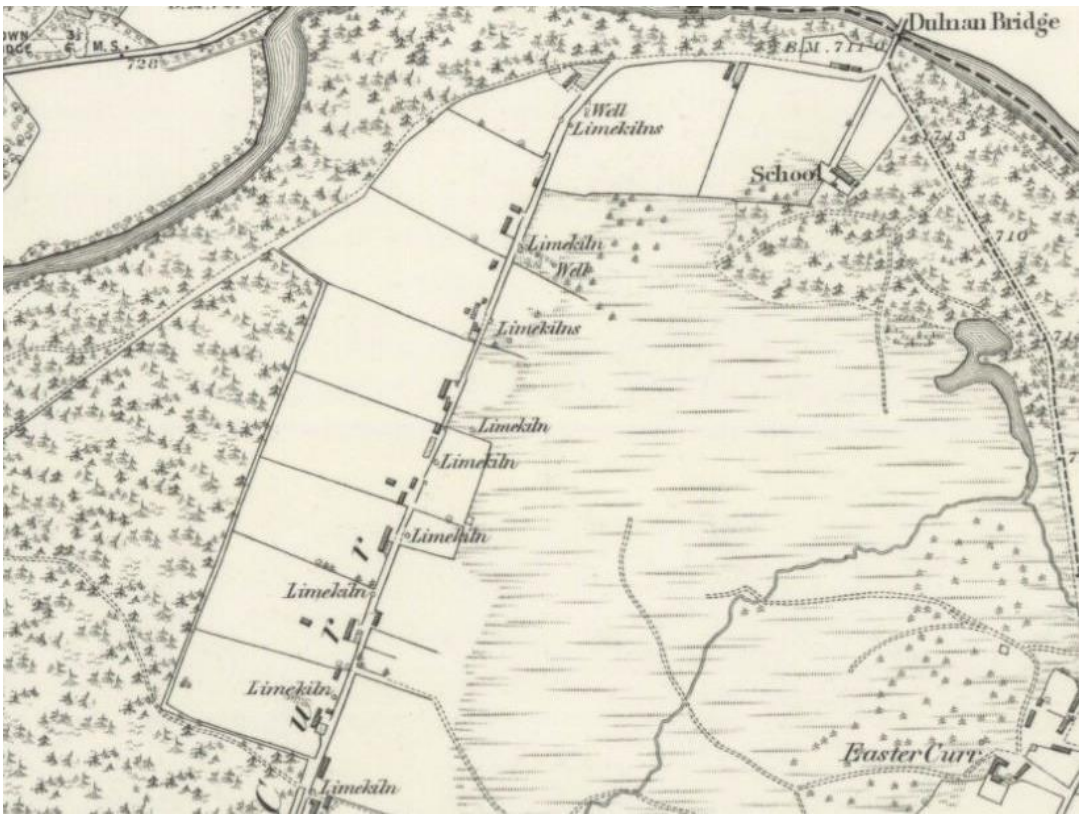

Figure 63 Lime kilns at Skye of Curr, OS 1st Ed. 6", Sheet no. 46, Inverness-shire (Mainland). Surveyed in 1871.

Some agriculturalists gained praise and prominence from their exploits in lime burning. Following the award of a gold medal by the RHASS in 1831, Stuart Menteath became established as something of an authority on lime burning in Britain. His lime works at Closeburn was widely lauded by agriculturalists for its innovation and featured in farming encyclopaedias for decades afterwards. In his praise for Closeburn, Carmichael stated that 'the penetration and perseverance of the *master* are everywhere apparent and applauded'.[211] Towards the end of the eighteenth century the nature of landed power was moving away from the feudal and towards the leveraging of land for economic gain.[212] Agri-industrial exploits, such as lime works, could reflect the economic strength, modernity, and even the benevolence of landowners. When ships carried lime from Charlestown up and down eastern Scotland, they also carried forth the name of the proprietor. Lord Elgin's lime, or lime from Lord Elgin's kilns, became a *de facto* product in agricultural improvement and building, becoming

[211] Carmichael, 'Principle Limestone Quarries', 78 (original emphasis).
[212] Davidson, "The Scottish Path to Capitalist Agriculture 2: The Capitalist Offensive (1747-1815)."

immortalised in several improving texts of the time.[213] In Inverness, James Robertson recounted admiringly the decision by Sir James Grant to supply lime free of charge to the tenants on his Urquhart estate. Not only would this prove fruitful in terms of the productivity of his land, Robertson proposed, but the arrangement also reflected the character and vision of the landowner himself: '[t]he effects of this bounty, which were visible on the face of that country by the appearance of the crop, will ultimately redound to the benefit, as it does now to the honour, of the generous proprietor'.[214] Elsewhere, ensuring a ready supply of lime became almost a duty of estate owners. In 1813 the Duke of Buccleuch received a letter from his factor, Will Keir, who had been contacted by eighteen 'of the most respectable tenants' complaining of unreliable lime supplies at the Duke's lime works at Harelawhill. Keir's letter to the Duke appealed to his agricultural pride as well as his compassion:

> You are too well acquainted with the management of land not to know that lime is an article of the first necessity to the farmer, without it or marle he cannot obtain from the ground above half the produce it is capable of yielding; and to oblige a tenant to improve waste ground, on a short lease, without one of these manures would be highly unreasonable.[215]

He continued by stating that '[t]he want of lime in this country is not only a serious loss to the tenants, but is also a great loss to his grace, and the country at large'.[216] Thus, maintaining a steady lime supply was considered among the duties of landowners, and their capacity to do so grounds on which they could be rated.

Alongside new agricultural practices, older building styles were systematically replaced by modern farmhouses built on of lime-mortared stone. Vernacular dwellings, such as the 'blackhouse', were considered outmoded and unhealthy. The prevailing attitude towards rural buildings held by most improvers by the start of the nineteenth century is illustrated by John Martin's description of the parish of Birnie, in Moray, in 1831:

> Nothing tends more to prejudice a visitor against a county and to impress upon him the idea of its poverty than the neglect of domestic comfort, and the want of adequate buildings. About ten years ago, it was not uncommon to see a range of buildings

[213] Charlestown lime works, despite its scale, was also notoriously unprofitable, so this stature may account in part for the continuation of this scheme, see Scottish Lime Centre Trust, *Charlestown Limeworks: Research and Conservation*.
[214] James Robertson, *General View of the Agriculture of the County of Inverness*, (1808), 241.
[215] Copy of letter, Will Keir to Duke of Buccleuch, 1813 (NRS GD224/522/81/2).
[216] *Ibid.*

> formed entirely of turf; and a tenant who had his dwelling-house built of stone and lime, was considered as possessed of superior means.[217]

Houses of stone and lime were clear signifiers of modern living, a sign of a prosperous estate and a judicious tenant. The rapid growth of Scotland's towns and cities during the eighteenth century was also built, quite literally, with vast quantities of lime mortar.[218] Edinburgh's New Town, which began construction in the 1760s, was famously referred to as an 'eternity of stone and lime' in 1824 by newspaper editor Robert Mudie.[219] During its construction, Carmichael notes that the proprietor of Blinkbonny Quarry, outside the city, had laid down a railway so that lime mortar could be 'laid down in town, in any quantity, at a moment's notice'.[220] This urbanisation had qualitative as well as quantitative dimensions. Stone replaced wood as the primary building material, offering reduced fire risk as well as aesthetic improvements. Harris and McKean emphasise the connections between urban development and Enlightenment thought, characterising this period of urban expansion as the search for 'greater amenity, efficiency and ornament'.[221] Lime-mortared stone buildings were thus symbols of more than just the increasing scale of Scotland's towns and cities.

The aesthetics of lime kilns themselves have also been remarked upon as potential status indicators. Skinner, observing the design characteristics of draw kilns in the Lothians, remarked that '[t]he resulting structures are always impressive, sometimes even aesthetically pleasing', and that rows of large, buttressed kilns built side-to-side had 'visual qualities reminiscent of some of the finest features in castle building'.[222] Such architectural appeal did not escape contemporary observers. Improved landscapes, as Tom Williamson has shown, often blurred the distinction between economic necessity and demonstrations of status.[223] Lime kilns were inextricably a part of that landscape, albeit one that could be either hidden or emphasised. Michael Havinden describes a case from Devon in

[217] John Martin, "A Description of the Parish of Birnie in the County of Moray," *Prize Essays and Transactions of the Highland Society of Scotland*, 8 (1831): 308–18.
[218] Thomas M Devine, "Urbanisation," in *People and Society in Scotland, Vol. I, 1760-1830*, ed. Thomas M Devine and Rosalind Mitchinson (Edinburgh: John Donald, 1988), 27–52.
[219] Harris and McKean, "The Scottish Town in the Age of Enlightenment, 1740-1820," 78.
[220] Carmichael, 'Principle Limestone Quarries', 64.
[221] Harris and McKean, "The Scottish Town in the Age of Enlightenment, 1740-1820."
[222] Skinner, *The Lime Industry in the Lothians*, 17–19.
[223] Tom Williamson, *Polite Landscapes: Gardens and Society in Eighteenth-Century England* (Stroud, 1995).

1769 when the grounds at Castle Hill were being developed. The agent overseeing the work wrote to the owner of the estate, Lord Fortescue, in London:

> Some preparations are making for the little Improvement of the old lime kiln – clearing the Rubbish and picking up some stone for it. It may have the appearance of a Fort given to it, and will fall into several principle Points of View, when a few Bushes in a Hedge Row are cut down, which at present obstruct the View from the Platform. I shall do myself the Honour to send your Lordship a sketch before I make the alterations.[224]

Having received the lord's approval, the agent followed up the completion of the works, noting in correspondence: 'I have taken the liberty to hang a Port-Cullis in the arch fronting the Meadow Park Wood which gives it a good deal of Spirit'.[225] While this is likely an atypical example, it hints at an appreciation for the kiln's aesthetic qualities, as well as a desire to preserve some value in the structure once its original purpose was no longer being served. More commonly kilns were kept at a distance from dwellings—they were smoky when in use, especially when burning sulphurous coal. For instance, an old lime kiln in the south east corner of the 'pleasure grounds' of Gosford House in East Lothian was masked with trees and hidden from view. Further viewshed analysis of estates might reveal the extent to which kilns were included or excluded from rural landscapes. However, given the weight of materials involved in lime burning, kiln location was probably dictated almost entirely by proximity to resources and transport rather than visual prominence. This consideration is especially true of the larger industrial kilns of the nineteenth century.

Expectations among landowners and their factors regarding the form and stature of lime kilns were likely informed by observation of their neighbours as well as through the various forms of improvement material discussed above. Comparisons between kilns were undoubtedly made. For example, in a letter to the Countess of Morton in 1805, William Douglas stated flatteringly that 'I made it my indavour [sic] to see all the kilns in the nibourhood [sic] of Gosfourd in my opinion there is not one equal to your Ladyships kilns'.[226] As the development of kiln design suggests, at least some proprietors took great care over the construction of lime kilns, with the aim of improving

[224] Hilliard, in Michael Havinden, "Lime as a Means of Agricultural Improvement: The Devon Example," in *Rural Change and Urban Growth*, ed. Christopher Chalkin and Michael Havinden (London: Longman Group Ltd, 1974), 129.
[225] *Ibid.*
[226] Letter, William Douglas to the Countess of Morton, 25/02/1805 (NRS GD150/2359).

efficiency, control and longevity. The fashion for these designs would have been influenced by the kilns described in agrarian texts as well as from the experience of neighbours and competitors. Some consideration too appears to have been given to the aesthetic qualities of these primarily utilitarian structures. For instance, at the Cambusbarron Lime Works in Stirlingshire, Mackay noted that red sandstone had been used in a regular pattern across the grey sandstone of the kiln face and to outline the arches.[227] This detailing, which appeared on the older section of a bank of kilns dating from around 1850, served no structural purpose, and appears no more than a stylistic choice on the part of the builders. It is not clear, however, if this decision was made by the proprietor of the kilns or the masons themselves.

Kilns could also fall short of their owner's expectations. This appears to have been the case in Fife, on the estate of James Sinclair-Erskine, later the first Earl of Rosslyn, as revealed in correspondence between his factor, John Jameson, and a mason employed to construct a draw kiln. In his estimate for the kiln, the mason, George Burns, agreed to construct it in a 'neet [sic] and substantial manner'.[228] When the kiln was completed, Jameson, upon first visiting found it 'in a situation [he] never expected to see her in', and immediately wrote to Burns complaining of its sorry state. He wrote 'it is shameful the little batter she has' and suggested that the completed structure was not fit for purpose.[229] In an earlier letter, perhaps anticipating the factor's reaction, Burns stated that the kiln had been built to a satisfactory standard. He included signed testimony from three other masons who had inspected the work, all agreeing that it had been 'executed in a workmanlike manner and in extent exceeding the plan' and that there was 'no danger of setting fire and lime immediately'.[230] Unsatisfied, Jameson sent several subsequent letters to Burns demanding that he rectify the kiln's 'very disagreeable appearance'.[231] Eventually, despite arguing that the factor had exaggerated the unsoundness of the kiln, Burns agreed to reinforce the foundations and walls.[232] From their exchange,

[227] Mackay, "Limestone Working: A Forgotten Stirlingshire Industry," 103.
[228] Estimate for Bulding a Lime Kiln at Endertil agrible to a Plan made owt for the same by George Burns, 3/09/1792 (NRS GD164/832/1).
[229] Letter, John Jameson to George Burns, 06/08/1793 (NRS GD164/832/5). 'Batter' refers to the outer wall cladding.
[230] Letter, George Burns to John Jameson, 31/07/1793 (NRS GD164/832/4).
[231] Letter, John Jameson to George Burns, 08/08/1793 (NRS GD164/832/7).
[232] Letter, George Burns to John Jameson, 10/08/1793 (NRS GD164/832/9); Letter from Masons Black, Hope and Anderson to John Jameson, 29/10/1793 (NRS GD164/832/12).

it is clear that, although the factor had practical concerns over the solidity and functionality of the kiln, its visual appearance was also considered inadequate, a conclusion reached before even a trial firing had taken place.

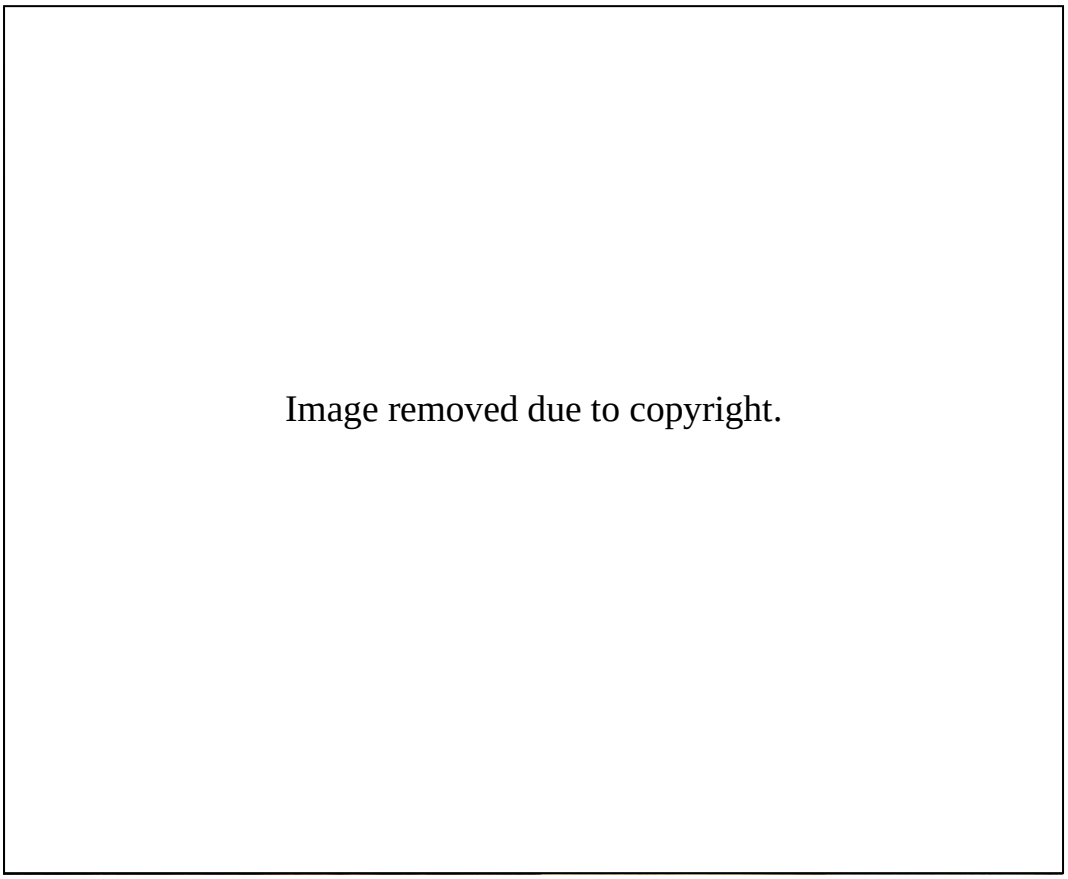

Figure 64 *A lime kiln and horse-gin*, attributed to Alexander Nasmyth (1787-1831), oil on panel. Museum of Barnstaple and North Devon.[233]

Beyond such scraps of evidence and modern appraisals of kiln remains, the extent to which kilns were viewed by landowners aesthetically as objects of display is hard to gauge. In a pre-photography age, depictions of kilns in landscape paintings might be considered revealing on this point, since it was the landowners, as the primary consumers of such art, that largely dictated artistic trends.[234] Indeed, livestock portraiture was a highly fashionable and revealing form of agrarian display during the late-eighteenth and early-nineteenth centuries. However, the manifestations of agricultural

[233] I have written in my notes somewhere that this was actually painted by English landscape painter Charles Towne, although I cannot now find the reference supporting this. Comparison of the two artists' styles supports the conclusion that it could have been Towne. However, searching through catalogues of his work have turned up nothing. The website artuk.org attributes this painting to Nasmyth, as does Basil Skinner, who used the image in *The Lime Industry of the Lothians*.
[234] Prince, "Art and Agrarian Change, 1710-1815," 115.

change during the latter half of the eighteenth century were generally spurned by artists. Landowners, Hugh Prince argues, 'did not want pictures of new enclosures or new machines or new farmstead and they certainly did not think of themselves as transforming the countryside'.[235] Lime kilns and other such rural industries were viewed as encroachments on the Arcadian visions preferred during the period. Paintings of lime kilns only really start to appear at the beginning of the nineteenth century, with few produced in Scotland or by Scottish artists, of which Alexander Nasmyth's painting of a lime kiln and horse gin is an example (Figure 64).[236] One notable exception to the neglect of lime kilns in art, albeit not a Scottish one, was W.M. Turner, who transcended romanticised landscape imagery to capture rural scenes that did not deny the 'essential drudgery' of farm work, but invested it with 'a divine and patriotic purpose'.[237] In the course of his celebrated career Turner was fascinated by light, fire and night scenes, and he produced several depictions of kilns alight at night. His paintings convey something of the materiality of lime burning—the physical labour of loading and unloading the kiln, and the noxious working environment experienced by lime workers (for example, see Figure 65).[238] In his *Limekiln at Coalbrookdale* (Figure 66, c.1795), Turner also evokes the ancient and modern aspects of lime, depicting the kiln as 'a blend of past and present, idyllic contemplation and industrial performance'.[239] Thus, for some artists at least, there was romanticism to be found in this ultimately unpleasant process.

[235] Prince, 115.
[236] A selection of paintings that do not appear elsewhere in the thesis is included in the Appendix.
[237] Prince, "Art and Agrarian Change, 1710-1815," 115.
[238] For example, see 'Llanstephen Castle by Moonlight, with a Kiln in the Foreground' (c.1795), *A Lime Kiln by Moonlight*, (c.1799).
[239] Klingender, *Art and the Industrial Revolution*, 90.

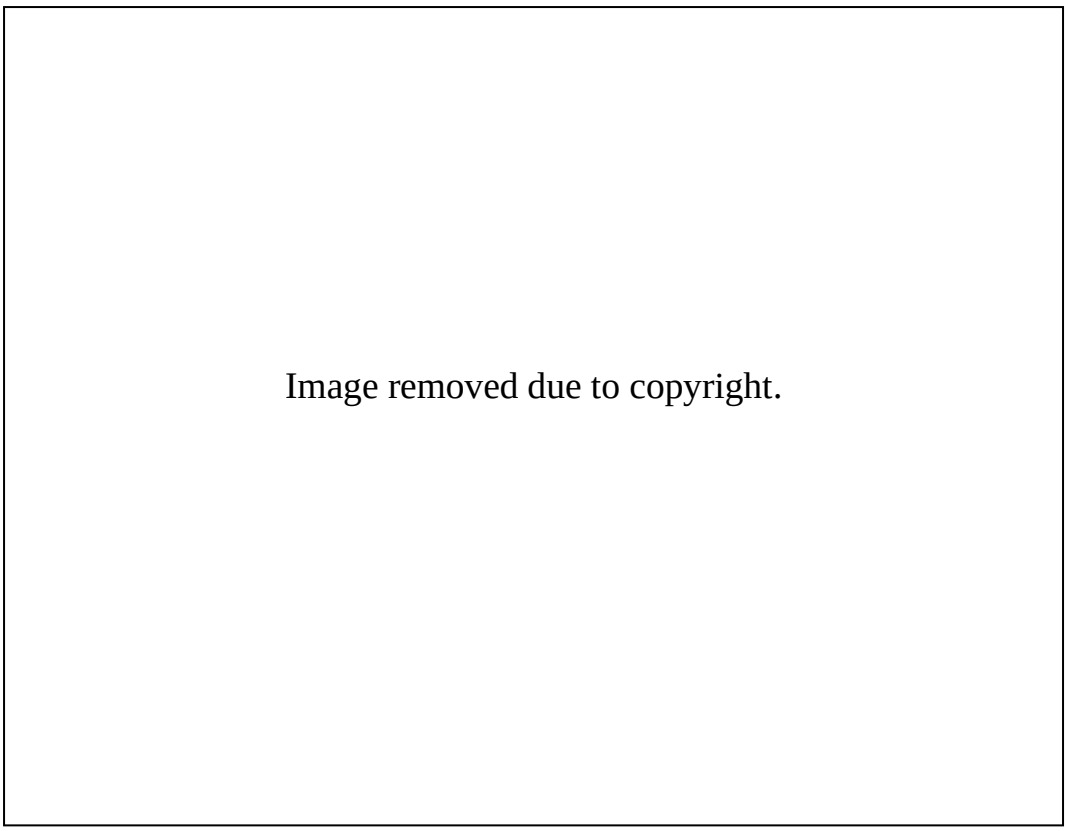

Figure 65 Joseph Mallord William Turner, *Llanstephan Castle by Moonlight, with a Kiln in the Foreground*, c.1795, graphite and watercolour on paper. Tate, London.

Historian Richard Moore-Colyer has speculated on a further role of lime kilns as nodes in the local folk culture of an area. He writes:

> If, as is frequently alleged, the folk culture of the area was nurtured and sustained on the farm, it might be further argued that a readily available source of those off-farm inputs necessary to ensure the success of husbandry would play an important role in the maintenance of cultural activity. On the basis of this argument, the limekiln and its product might perhaps be accorded a significance beyond the mere considerations of husbandry. This apart, the limekiln was a warm and rather friendly place which, on a cool evening in the lime burning season, might attract all manner of people to its precincts so, like the smithy and pub, becoming a focal point for the local community.[240]

This thinking is supported by the occasionally quaint scenes depicted by painters of people relaxing beside lime kilns (see Figure 53 and Figure 59 in Chapter Five). Certainly, kilns were important to the rural economy and would have been places where people met on a semi-regular basis, whether delivering materials or purchasing lime. As such, they could well have been places where news and ideas were exchanged. The likelihood of them being sites of more leisured congregation would have

[240] Moore-Colyer, "Coastal Limekilns in South-West Wales," 24.

depended on things like the location of the kiln and the nature of its operation. While ultimately plausible, these notions are hard to prove, barring some serendipitous account from a written source.

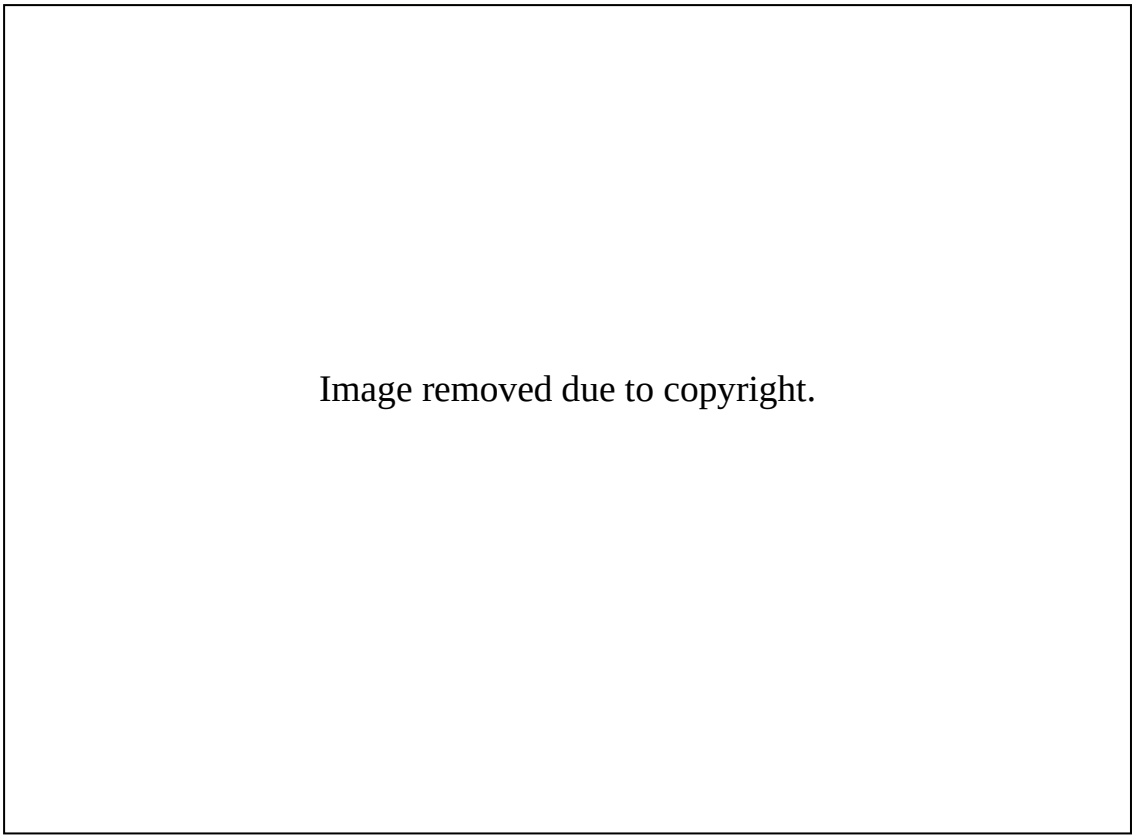

Figure 66 Engraving of Limekiln at Coalbrookdale, after J.M.W. Turner. Mezzotint on paper. Tate Gallery.

In terms of their position as status symbols, lime kilns, although they could constitute impressive and imposing industrial structures, remained primarily utilitarian in nature. The material constraints of their construction and operation probably precluded their use as objects of overt agricultural display, particularly as they grew larger and more industrialised. Design choices appear to have been driven chiefly by efficiency, or at least the *perception* of efficiency. Improvement discourse, as highlighted above, established draw kilns as almost the *de facto* mode of burning for progressive agriculturalists. Similarly, the operation of lime works by landowners for the benefit of their tenants became not only a source of revenue and a means of improving productivity (and thereby rents), but also part of the duty of an attentive and agriculturally-informed lord. Lime itself, perhaps more than kilns, appears to have held some symbolic value as a resource of modern agriculture and even as a barometer of economic security among farmers.

6.4 Lime and Enlightenment science

> Lime and other calcareous substances are an important material of manure to the farmer. But although they were used by the Romans in that way as early as the time of Pliny . . . it is only since the new improvements in the science of chemistry (in which our schoolboys now think themselves adepts) that any attempts have been made to distinguish accurately what of these substances are most deserving of the farmer's notice.[241]

When Lord Kames set out in the pages of *The Gentleman Farmer* his ambitions for a programme of national improvement, he stated in its introduction that he drew confidence in his pronouncements from the encouragement of his so-called 'imprimatur', the chemist Joseph Black.[242] Kames' model of agriculture, in which lime was a vital component, drew on natural philosophy and chemistry centred on the University of Edinburgh during the middle decades of the eighteenth century. He himself had encouraged, through friendship and patronage, figures like William Cullen and Joseph Black to turn their attentions to agricultural questions. These linkages between economic and philosophical interests, social networks and personal motivations, highlight that any discussion of knowledges relating to lime and its social value in eighteenth and early nineteenth-century Scotland cannot ignore its Enlightenment context. As a resource for improvement, an economic entity, and as a subject of theoretical curiosity, lime was closely embedded in the mesh of cultural values, personal connections and intellectual concerns that constituted Enlightenment Scotland. Figures occupying the overlapping worlds of estate management, science and polite society took interest in the material properties and utility of lime, seeking to harness it in aid of various goals. By the mid-eighteenth century, large quantities of lime had been used on the land in Scotland for generations without anyone fully understanding the ways in which it operated on the soil.[243] This imbalance between theory and practice did not escape the attentions of notable improvers and natural philosophers alike. Part of this interest was taxonomic: much of Enlightenment science was concerned with the classification and ordering of nature.[244] However, there were practical implications too. Discrepancies of practice were thought likely to occur if farmers could not be certain how lime worked, while others were keen to

[241] A.S., 'On Lime', p.319.
[242] Kames, *Gentleman Farmer*, xiii.
[243] Clow and Clow, *The Chemical Revolution: A Contribution to Social Technology*, 472.
[244] Matthew D Eddy, "Scottish Chemistry, Classification and the Late Mineralogical Career of the Ingenious Professor John Walker (1779-1803)," *British Journal for the History of Science* 35, no. 4 (2002): 411–38.

discover reliable means of testing the suitability of limestones for economic exploitation.[245] This interest in mineral knowledge appears at first an obvious one. As Emerson put it:

> There are clear connections between the enlightened scientists and the *virtuosi* which can be illustrated if one wishes to play a version of "animal, vegetable or mineral". The knowledge of useful minerals in a society with mines will be kept up and it was.[246]

Lime was certainly a useful mineral, but its importance to both scientists and the *virtuosi* extends beyond the simple maintenance of practical knowledge. Lime, lying at the intellectual intersection of chemistry, industry and agriculture, theoretical and practical knowledge, presented an inviting subject through which agriculturalists, gentlemen scientists and landowners could all engage with an emerging scientific public culture.

As briefly mentioned above, theoretical questions around lime's utility to agriculture was increasingly the purview of early chemists. The universities of Edinburgh and Glasgow have long been identified as notable sites in the development of chemistry throughout the Scottish Enlightenment.[247] The medical faculties at these universities, under which chemistry as well as mineralogy were housed, often attracted students and audiences whose interests extended beyond the corporeal. Indeed, the renowned geologist and agriculturalist, James Hutton, reputedly only studied medicine in order to continue his studies in chemistry.[248] Eddy argues that experiments on mineral and chemical classification being carried out by professors at Edinburgh's Medical School during the eighteenth century provided a key service to mineral industries that elsewhere in Europe was typically served by mining academies.[249] Thus, equipped with chemical knowledge and with connections to the gentlemen scientists of Glasgow and Edinburgh, medical men were often at the forefront of the move to scientific agriculture.[250]

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[245] Patrick Graham, *General View of the Agriculture of Stirlingshire*, (1812), p. 254.
[246] Emerson, "Science and the Origins and Concerns of the Scottish Enlightenment," 344.
[247] Golinski, *Science as Public Culture: Chemistry and Enlightenment in Britain, 1760-1820*.
[248] Jean Jones, "James Hutton's Agricultural Research and His Life as a Farmer," *Annals of Science* 42, no. 6 (1985): 577.
[249] Eddy, "Scottish Chemistry, Classification and the Late Mineralogical Career of the Ingenious Professor John Walker (1779-1803)," 432.
[250] Fussell and Fyrth, "Eighteenth-Century Scottish Agricultural Writings," 60.

Although William Cullen is most widely remembered for his contributions to medicine, his agricultural work emerged out of a 'shared enthusiasm' with Lord Kames.[251] Kames believed that, by applying his chemical knowledge to questions of soil nutrition and farming practice, Cullen would contribute to a 'scientific revolution in agriculture that would benefit the whole nation'.[252] Cullen himself had a profound belief in making science useful and educating gentlemen to the betterment of society as a whole.[253] The two corresponded extensively on agricultural subjects and Cullen performed practical experiments on bog reclamation and soil chemistry on his own farms, as well as those of his friends and associates.[254] The properties of lime, as a widely used yet relatively simple compound, posed particularly tantalising theoretical questions that chemistry could, in theory, answer.[255] In searching for answers to these questions, the chemistry faculty at Edinburgh developed a 'fascination for experiments with lime'.[256] Although neither Kames nor Cullen could derive any comprehensive agricultural theory from these exchanges, by attempting to discover new means of enriching soil, they were, Donovan argues, 'engaging in a problem of major importance', while their efforts also helped to instil a scientific mindset in subsequent improvement discourse.[257]

Cullen lectured widely on his agricultural theories. Having previously taught medicine at the University of Glasgow, he became professor of chemistry at Edinburgh in 1756.[258] The chemistry chair was unsalaried, meaning that most of Cullen's income came from fees paid by lecture attendees. Consequently, he tailored his lecture content to draw larger audiences.[259] In these lectures he satisfied the needs of medical students whilst also appealing to the interests of men from outside the university

[251] Golinski, *Science as Public Culture: Chemistry and Enlightenment in Britain, 1760-1820*, 31.
[252] Arthur L Donovan, *Philosophical Chemistry in the Scottish Enlightenment* (Edinburgh: Edinburgh University Press, 1984), 69.
[253] Withers, "William Cullen's Agricultural Lectures and Writings and the Development of Agricultural Science in Eighteenth-Century Scotland," 154.
[254] Withers, 149; Roger L. Emerson, "The Scientific Interests of Archibald Campbell, 1st Earl of Ilay and 3rd Duke of Argyll (1682-1761)," *Annals of Science* 59, no. March (2002): 21–56.
[255] Donovan, *Philosophical Chemistry in the Scottish Enlightenment*, 87–88.
[256] Eddy, "The Aberdeen Agricola: Chemical Principles and Practice in James Anderson's Georgics and Geology," 142.
[257] Donovan, *Philosophical Chemistry in the Scottish Enlightenment*, 87–88.
[258] Withers, "William Cullen's Agricultural Lectures and Writings and the Development of Agricultural Science in Eighteenth-Century Scotland," 149.
[259] Golinski, "Utility and Audience in Eighteenth-Century Chemistry: Case Studies of William Cullen and Joseph Priestley.," 4–5.

with a cultural or commercial interest in chemistry.[260] In touching on practical subjects through his experiments and lectures, Cullen encountered some of the limitations of contemporary scientific understanding as well as the inherent tensions involved in applying new knowledges to long established practices. As Golinski writes,

> The sheer intractability of the material difficulties involved in arts such as agriculture and bleaching severely limited his freedom of manoeuvre. He also had to negotiate such social and cultural constraints as the unwillingness of workers to alter their practices and the need to avoid imputations of projecting.[261]

Through these efforts, as well as through his connections to other members of the Edinburgh intelligentsia, Cullen and his disciples presented chemistry as a form of 'gentlemanly science', one that became deeply integrated into Scottish public culture.[262] Scientific knowledge and theoretical speculation, especially in connection to improvement, became increasingly seen as acceptably genteel activities for elites, one from which there was considerable prestige to be gained.[263] This was to be Cullen's legacy. Indeed, a student of his remarked that 'chemistry owes but little to Cullen as discoverer, but much to him as a clear and philosophical expounder'.[264] Cullen's influence can also be seen in the esteem in which others held his agricultural and chemical work. James Anderson, who studied under Cullen, after the success of the first edition, added a dedication to his former professor in the preface of the second and subsequent volumes of his *Essays Relating to Agriculture and Rural Affairs*, which contained his *Essay on Quicklime*.[265]

Cullen's most famous student, Joseph Black, also engaged in agricultural subjects and performed experiments with lime. Like Cullen, Black's chemical studies were driven by the spirit of improvement.[266] From a theoretical perspective, Black directly examined the properties of lime in the course of his work on limewater and uncovered the nature of the lime burning reaction in the

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[260] Donovan, *Philosophical Chemistry in the Scottish Enlightenment*, 64.
[261] Golinski, *Science as Public Culture: Chemistry and Enlightenment in Britain, 1760-1820*, 31.
[262] Golinski, 25.
[263] Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature*, 57; Golinski, *Science as Public Culture: Chemistry and Enlightenment in Britain, 1760-1820*; Emerson, "The Scientific Interests of Archibald Campbell, 1st Earl of Ilay and 3rd Duke of Argyll (1682-1761)"; Shapin, "The Audience for Science in Eighteenth Century Edinburgh," 99.
[264] Donovan, *Philosophical Chemistry in the Scottish Enlightenment*, 64.
[265] James Anderson, *Essays Relating to Agriculture and Rural Affairs*, vol. 1, 2nd ed., (Edinburgh, 1777), ii.
[266] Golinski, *Science as Public Culture: Chemistry and Enlightenment in Britain, 1760-1820*, 12.

development of his theory of 'fixed air' (carbon dioxide).[267] Neither Cullen nor Black produced any substantial written treatise on chemistry or agriculture topics (although Cullen did produce an outline for a book entitled 'Agriculture' which never came to fruition) and so their theories and doctrines were spread through lectures, correspondence and subsequent publications by other writers.[268] As the so-called 'preeminent man of science in the Scottish Enlightenment', Black was highly influential through his work and personal relationships with members of the Scottish elite, such as Adam Smith, James Watt, David Hume, and James Hutton.[269] He was frequently consulted on agricultural matters.[270] George Dempster, for example, wrote to Black enquiring as to the use of calcareous manures on his Dunnichen estate. Black's reply included details of a kiln design—one superior, he argued, to the 'vulgar' lime kilns used in much of the country—that could be adapted to burn marl, revealing him to be well acquainted with agrarian practice as well as theory.[271] Evidence of the dissemination and, importantly, *comprehension* of Black's teachings, as well as their further propagation by other means, can also be seen in Colonel William Fullarton's 1793 account of the county of Ayr for the Board of Agriculture. Fullarton's agricultural observations appear strongly influenced by Black, particularly in his classifications of soils and use of lime. He wrote,

> It is asserted by some improvers, that the burning of the lime, and the caustic quality it thereby acquires, are not requisite to call forth its ameliorating powers; being, as they say, equally efficient when merely pulverized, without burning and spread in powder. Dr Black, indeed, positively maintains, that lime is equally applicable in its mild, as in its caustic state; that it should remain 12 months on the sward before the ground be ploughed, by which it sinks into the earth, is incorporated with the soil, and corrupts the vegetable matter, so forming a manure. [272]

This passage is footnoted simply 'see Dr Black's Lectures', confirming the source of the information. Not only does this signal Fullarton's attendance and comprehension of the public lectures delivered

[267] Eddy, "The Aberdeen Agricola: Chemical Principles and Practice in James Anderson's Georgics and Geology."
[268] Golinski, *Science as Public Culture: Chemistry and Enlightenment in Britain, 1760-1820*; Withers, "William Cullen's Agricultural Lectures and Writings and the Development of Agricultural Science in Eighteenth-Century Scotland," 149.
[269] David B Wilson, *Seeking Nature's Logic: Natural Philosophy in the Scottish Enlightenment* (Penn State University Press, 2009), 133.
[270] Emerson, "The Scientific Interests of Archibald Campbell, 1st Earl of Ilay and 3rd Duke of Argyll (1682-1761)."
[271] *OSA*, Parish of Forfar, vol. 1 (1791), p. 427; Fredrik Albritton Jonsson, *Enlightenment's Frontier: The Scottish Highlands and the Origins of Environmentalism* (Yale University Press, 2013), 220–21.
[272] Col. William Fullarton, *General View of the Agriculture of the County of Ayr*, (1793), 50-51.

by Black (and presumably others), but it illustrates how a scientific understanding of soils and agriculture began to influence the language and guidance offered by improving writers.

The growing desire to apply chemical knowledge to agriculture can be read in several works of the latter half of the eighteenth century. Edinburgh physician Francis Home, in his 1757 publication, attributed what he called the 'slow progress of agriculture' to a lack of chemical understanding, and complained that farming was an art 'in general, carried on by those whose minds have never been improved by science.'[273] Although his conclusions were held back by an adherence to the antiquated chemistry of the elements, his work arguably signalled a turning point towards what might be considered scientific agriculture or experimental farming.[274] The publication, in 1765, of *The Elements of Agriculture and Vegetation*, by another Scottish physician, George Fordyce, constituted a further step in this direction. Fordyce's work brought together the most recent chemical knowledge being produced in Edinburgh and Glasgow, as well as the results of a series of deliberate experiments with manures conducted himself on land owned by his friend John Hunter. Both Home and Fordyce sought to establish the properties of lime and its relationship to soil fertility, and saw a degree of chemical understanding as being 'necessary . . . for the explanation of the principles of agriculture'.[275] James Anderson took to heart Cullen's philosophy of chemistry's practical applications and sought in his *Essay on Quicklime* to convey these principles to audiences of landowners and practical farmers.[276] Anderson's work was influential and his treatments of chemical topics were well received by his contemporaries. Charles Findlater, for example, in his account of Peebles, cited Anderson as informing his understanding of lime, while William Aiton called his work 'certainly the best marks that can be given' and suggested that 'every experienced and intelligent farmer will judge the quality of lime by them'.[277]

[273] Home, *Principles of Agriculture and Vegetation*, 1-2.
[274] Jones, "Making Chemistry the 'science' of Agriculture, c. 1760-1840," 173.
[275] Fordyce, *Elements of Agriculture*, 5.
[276] Eddy, "The Aberdeen Agricola: Chemical Principles and Practice in James Anderson's Georgics and Geology."
[277] Findlater, *General View Peebles*, 165-6; William Aiton, *General View of the Agriculture of the County of Ayr* (1811), p.579.

In 1795, the eccentric landowner and chemical manufacturer Archibald Cochrane, 9th Earl of Dundonald (or "Daft Dundonald", as he was occasionally known), published *A Treatise Shewing the intimate connection that subsists between agriculture and chemistry*.[278] This text, Jones argues, signalled one of the first successful attempts to marry chemical theory with agrarian practice.[279] Drawing on the work of Cullen and Black, Dundonald sought to prove that chemistry could meet the practical challenges of improvement, basing much of his advice on 'actual experiments, attentively carried out in Scotland'.[280] The lingering influence of medicinal chemistry was also evident; lime, Dundonald suggested, 'should be considered in a chemical and medical point of view'[281] He proposed that 'cultivators of the soil' should have a degree of chemical knowledge, should be able to distinguish the proportion of various materials and substances in soil by practical test, understand acids and alkalis, and should be 'well acquainted with the powers of lime'.[282] On this last point Dundonald was emphatic. Farmers, he argued, needed to understand lime's role as a stimulant rather than a source of plant nourishment in itself. He continued,

> This fact has been well ascertained, and if proper attention be paid to it, in regulating the conduct of the agriculturalist, in the future application of lime, it will prove more satisfactory than all the chemical reasonings adduced in this Treatise.[283]

Thus, lime can be seen as a central question around which nascent forms of agricultural science were developed in Scotland during the eighteenth century. Indeed, the work Scottish chemists and agriculturalists was a considerable contribution to that understanding. Publications by Scottish natural philosophers were widely reported and discussed elsewhere in Europe.[284] Humphrey Davy, writing on the subject of liming in his *Treatise on Soils and Manures*, drew on what he referred to as the 'gathered wisdom of the school of Scottish agriculture'.[285] Although it would not be until the late-

[278] Campbell, Alec. 2009 "Cochrane, Archibald, ninth earl of Dundonald (1748–1831), chemical manufacturer." *Oxford Dictionary of National Biography.*
[279] Jones, "Making Chemistry the 'science' of Agriculture, c. 1760-1840," 173–74.
[280] Eddy, "The Aberdeen Agricola: Chemical Principles and Practice in James Anderson's Georgics and Geology," 149.; Archibald Cochrane, Earl of Dundonald, *A Treatise Shewing the intimate connection that subsists between agriculture and chemistry*, (Edinburgh, 1795).
[281] Dundonald, *Intimate connection*, 119.
[282] *Ibid*, 152.
[283] Dundonald, *Intimate connection*, 119.
[284] Jones, "Making Chemistry the 'science' of Agriculture, c. 1760-1840," 174.
[285] Humphrey Davy, *Agricultural Chemistry in a Course of Lectures for the Board of Agriculture, to which is added A Treatise on Soils and Manures as Founded on Actual Experience*, (Philadelphia, 1821), p.46.

1850s that agricultural chemistry would emerge as a professionalised European discipline, the notion of applying chemical reasoning and experimental methods had significant impact on the mindset of Scottish agriculturalists.[286] The antecedents of this process were evident in Maxwell's declaration at the beginning of *The Practical Husbandman*: 'I have treated [agriculture] as a Science, making Nature my Guide'.[287] By the mid-eighteenth century a scientific outlook on agriculture had gripped many improvers, and by the end of the century had become deeply ingrained in the attitudes of institutions such as the Society of Improvers and the Board of Agriculture.[288] The wisdom of chemists became highly valued in improvement circles, consulting on matters practical and theoretical. Alex Dirom, for example, when constructing his lime kilns (the designs for which would later be presented to the *Highland Society*) sought advice from Dr Hope, then Professor of Chemistry at the University of Edinburgh.[289] Lime was already closely associated with the improvement of new ground: '[t]o a country in a state of nature, lime [was] of the first necessity to bring it into cultivation'.[290] Many improvers, imbued with a strong 'faith in the chemical basis of reclamation', felt that scientific agriculture was the key to unlocking the economic potential of the land, especially in the Highlands where it could, it was believed, enable previously marginal areas to be brought into modern systems of husbandry.[291] Such ambitions were never fully realised, as improvement came up against the limitations of the Highland climate.[292] Nevertheless, it was to, to a large extent, lime that sparked this new way of thinking. In this sense, lime was central in the formation of the scientific mindset that was so influential among the ideologies that were to shape the development of Scottish agriculture and the rural landscape into the nineteenth century.

[286] Jones, "Making Chemistry the 'science' of Agriculture, c. 1760-1840."
[287] Maxwell, *Practical Husbandman,* vi.
[288] Emerson, "The Scientific Interests of Archibald Campbell, 1st Earl of Ilay and 3rd Duke of Argyll (1682-1761)."
[289] 'Plan and Description of Lime-Kilns', *Prize Essays and Transactions of the Highland Society of Scotland,* (1807): 114.
[290] Rev. William Donaldson, 'An Account of the Southern District of Ayrshire (1811)', *Prize Essays and Transactions of the Highland Society of Scotland*, (1816) vol. 4, p. 479.
[291] Jonsson, *Enlightenment's Frontier: The Scottish Highlands and the Origins of Environmentalism,* 221; Neil MacGillivray, "Dr John Mackenzie (1803–86): Proponent of Scientific Agriculture and Opponent of Highland Emigration," *Journal of Scottish Historical Studies* 33, no. 1 (2013): 81–100.
[292] Jonsson, *Enlightenment's Frontier: The Scottish Highlands and the Origins of Environmentalism*.

6.5 Conclusion

This chapter makes several arguments relating to the influence of useful knowledge in the development of the lime industry, the valuing of liming and lime kilns, and the relationship of lime to science in Enlightenment Scotland. The development of the lime industry was a product of several factors. Alongside improvements to infrastructure and the expansion of markets, increased awareness of the value of lime and greater expertise in its use and production was driving demand and encouraging more enterprising individuals to burn it themselves.[293] One writer in the *Farmer's Magazine*, looking on thirty years of farming in East Lothian in 1810, noted that 'lime has for many centuries been used . . . though, of late years, the husbandry of that article has undoubtedly been much improved . . . under the guidance of rational principles'.[294] Indeed, such statements evidence Mokyr's argument that the greater exploitation of mineral resources in the eighteenth century was not simply due to demand-side pressures, but rather because 'the knowledge needed to extract, transport, and utilise minerals was growing'.[295] A great deal of what can be identified as useful knowledge relating to lime was circulated among the various 'prophets and practitioners' of improvement in eighteenth century Scotland.[296] Towards the end of the eighteenth century most improving literature and institutions can be seen to support an 'established position' on agrarian matters, one in which lime was a crucial component.[297] This position promoted certain practices, such as the construction of draw kilns and centralised models of lime production. Much of this knowledge was aimed at those who owned land, rather than those who worked it. Although the practical guidance on burning and using lime offered by improving writers and agrarian societies may well have found its way to the more literate farmers, the greatest influence of such material was on the organisation of the rural landscape by the landowning classes. On a related point, the carriers of this useful knowledge evidence the ways in which lime, and other improvements, were propagated

[293] John Wilson, *General View of the Agriculture of Renfrewshire … and an Account of its Commerce and Manufactures*, (1812): 24.
[294] N., 'Comparative View of East Lothian Husbandry in 1778 & 1810', *The Farmer's Magazine*, vol. 12(48), Dec 1811, p.518-19.
[295] Mokyr, *The Enlightened Economy: An Economic History of Britain 1700-1850*, 6.
[296] Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature*, 73.
[297] Adams, "The Agents of Agricultural Change," 173.

along with other forces of internal colonisation. This is evident in references to the need to educate and control 'indolent tenants' and 'low people' regarding the use of lime, or the attitude of several of the county survey authors to traditional farming practices.[298] This connection between lime and the extension of British improvement values across particularly northern Scotland should not be dismissed.

Science is always informed by its cultural context, and consequently the nature of scientific knowledge regarding lime, and the ways in which this knowledge were valued and shared in the eighteenth century, reflects the unique cultural setting of Enlightenment Scotland.[299] The ethos of improvement, and the desire to find new ways of 'turning nature into capital' through the accumulation and application of knowledge, underpinned experimentation with lime.[300] Golinski has shown that, compelled by the civic spirit of the time and owing to the work of figures like Cullen, chemistry became an important part of Scottish public culture. It is possible to speculate that lime was one of the key subjects around which this culture could coalesce. 'That important branch of rural science', as Arator called to it, lime straddled industries and was of economic interest to many landowners and industrialists.[301] It was also of intellectual interest to chemists, mineralogists, natural historians and geologists, and provided an accessible subject through which agriculturalists and gentlemen scientists could explore theoretical and practical questions. Thus, lime might be thought of as perhaps a material node in the Enlightenment networks of improvement, science, and polite society. Jones has shown how chemistry emerged in the eighteenth century to eventually become the 'science of agriculture'.[302] Given its importance to improved farming and its obvious relationship to soil nutrition, lime posed important theoretical questions around which early agricultural science could form.

The case of lime, with its long history of use, also reveals something of the continual making and remaking of modernity that took place in the Enlightenment. There is an apparent contradiction in

[298] Wight, *Present State of Husbandry*, vol 3., 205.
[299] Shapin, "The Audience for Science in Eighteenth Century Edinburgh," 95.
[300] Jonsson, *Enlightenment's Frontier: The Scottish Highlands and the Origins of Environmentalism*, 81.
[301] Arator, 'Observations', 325.
[302] Jones, "Making Chemistry the 'science' of Agriculture, c. 1760-1840."

the various framings of lime in the improvement period as something both 'ancient and universal' but also integral to 'the new system of husbandry'.[303] The early chemical work on lime, then, might be considered an example of new knowledge breathing life and interest into a long-established practice, a theme explored by Keene in relation to nineteenth century science.[304] These notions of lime's supposed modernity are closely linked to the question of whether social status was attached to liming or lime kilns. In certain settings, particularly in the earlier part of the eighteenth century and in areas where liming had been newly introduced, lime appears to have been considered an indicator of modern agriculture, or at least agriculture that adhered to the progressive norms established by improvement discourses. Whether lime kilns themselves were similar indicators of status is harder to interpret. Figures like Menteath certainly enhanced their reputation through accounts of their lime burning, while the care and attention afforded to many kilns suggests a level of pride and optimism in their construction. It is unlikely, however, that their construction was ever overly influenced by aesthetic concerns, such was the importance of efficient movement of resources (see Chapter Four).

The production and circulation of knowledges both theoretical and practical highlights some of the already well-documented connections between rural and urban spaces in Enlightenment Scotland. Ideas written about and discussed by members of elite society in 'polite' settings would eventually have bearing on the management of rural space and the practices of labouring farmers, not to mention the quarry men and lime burners who fed the growing demand.[305] Knowledge relating to lime and its production was developed, shared and diffused in range of settings: lecture halls; reading rooms; society meeting places; even at kilns themselves. Much of what was known about lime was gained quite literally in the field, initially through generations of experience and later through experimental methods and close observation. Through the circulation of this useful knowledge a fuller understanding of the nature of lime was developed, bringing with it greater confidence in its efficacy, codification of techniques, and the ever closer marrying of theory and practice. In turn, the act of

[303] Graham, *General View Stirling,* p.254; Ure, *General View Roxburgh*, p.26.
[304] Melanie Keene, "Familiar Science in Nineteenth-Century Britain," *History of Science* 52, no. 1 (2014): 53–71.
[305] Withers, "Towards a Historical Geography of the Enlightenment in Scotland," 85.

thinking about lime arguably influenced the nature of agricultural discourse in Scotland. Thus, not only was lime an essential innovation in the improvement of agriculture, debates around its use and production embody many key aspects of Enlightenment thought and discourse, revealing in turn the ways in which these became grounded in practice.[306]

[306] Smout and Fenton, "Scottish Agriculture before the Improvers - an Exploration," 65.

7 Conclusion

To conclude this thesis, this chapter pieces together the national historical geographies of lime burning in Scotland. It begins by assessing the research findings against the research objectives set out in the Introduction. Reflecting on these objectives serves to highlight the historical geographies of lime burning revealed by this work and underlines the contribution that it makes to several areas of scholarship. Following this analysis, some opportunities for further research are discussed. The chapter closes with a short summary that articulates the thesis of this thesis.

7.1 An historical geography of lime burning

The objectives set out in the Introduction to this thesis provide useful reference points from which to ultimately consider the research findings.[1] Taking each research objective in turn, this section discusses, the main conclusions of the thesis, its contributions to relevant disciplinary fields, and the extent to which it has met its aims.

7.1.1 Broaden the geographic scope

This thesis makes several contributions to the present understanding of the lime industry in Scotland. One aspect of this contribution is geographical. Through the mixed-methods approach employed in the research, attention is drawn to parts of Scotland where lime burning has yet to be examined in detail, such as the Central Highlands and the far north. By presenting data digitised from the OS maps, the thesis achieves a new and valuable overview of nineteenth-century lime burning across Scotland and a gazetteer of sites with which to support further studies. Although the OS maps reflect their own set of values and inconsistencies, this data constitutes a 'fresh' perspective on the industry. These data particularly emphasise the far greater proportion of low-order lime burning sites across Scotland compared with larger, more conspicuous draw kilns that have hitherto received the bulk of scholarly attention. This evidence also supports Nisbet's argument that investigations into lime

[1] See Research Objectives, pp.39-41.

burning in formerly overlooked areas would bear results if only researchers were willing to go looking.[2]

Throughout this thesis, the use of historical sources has attempted to maintain an even-handed approach in considering lime burning at a range of scales and from all around Scotland. Care has been taken to source examples and evidence from beyond the traditional heartlands of lime burning research. Any study of lime burning, or indeed any other rural industry, is inevitably led, to some degree, by the availability of historical material. Although map evidence reveals small-scale lime burning to be practiced nearly everywhere in Scotland, it was the larger commercial works that have left the greatest trace in the archives. The conditions and situation of such producers likely do not reflect the nature of lime burning as it was practiced on most farms or at small quarries. As with other aspects of agriculture, those with the greatest hands-on experience of lime production—such as the tenant farmer, the quarry labourer, the mason, or the lime burner—are largely silent in the written historical record, forcing the researcher to rely on fragments and clues to reconstruct their practices.[3]

Not only does this research extend the history of lime burning to new places, it also follows lime burning into new spaces. In Enlightenment Scotland, lime is revealed to have been a subject that crossed several knowledge spaces, including laboratories, lecture halls and the writing desks of improving landowners. Contributions in forums such as agricultural journals and societies, on subjects including constructing kilns, selecting fuels and using lime, set a template for lime production in Scotland. The extent to which this template was followed, however, remains open to debate.

7.1.2 Analyse spatial patterns

Nearly 3,000 kilns were digitised from the OS first edition six-inch map, giving unique insight into the spatial distribution of the lime industry in the mid-nineteenth century. These data will be handed-off to my partner institution, HES, to support future historical and archaeological research, as well

[2] Nisbet, "The Archaeology of the Lime Industry in Renfrewshire."
[3] Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature*.

as the conservation of previously unknown sites. As such, the data constitute a clear and valuable contribution to the archaeological and historical study of Scotland's rural industries.

To some extent analysis of the digitised kilns has confirmed several existing conceptions of the lime industry. Commercial production is concentrated in the Central Belt, close to supplies of coal and limestone. Clamp kilns appear also to be a feature of this area, with particular concentrations in Fife, Lanarkshire, Stirlingshire, and Renfrewshire, supporting findings by Bishop, Nisbet and Mackay. One new aspect highlighted by the mapping work is the number of kilns found in the Highlands, following glens along the southern and north-eastern fringes of the Cairngorm massif. These kilns, most of which were recorded by the OS between 1860 and 1875, were, based on the classification system used throughout this thesis and supported by their number and situation, determined to be field kilns. Nevertheless, the limitations of this classification must be acknowledged, especially when attempting to determine function from map symbology alone. Upland field kilns of this type require differentiation from the larger, continuously running draw kilns found on commercial sites and some estates, as well as from the elongated clamp kilns found primarily in the Central Belt. Further archaeological fieldwork, in the manner of Cruickshank *et al.*, is required to gather evidence and inform more robust kiln typologies for Scotland.

Comparisons between mapped kilns and evidence from archaeological work and written historical sources also suggests that the total number of kilns in Scotland was much higher at previous times in history. The kilns recorded by the OS indicate that domestic lime burning was in decline across Scotland by the mid- to late-nineteenth century, a finding consistent with previous narratives of the industry. Nevertheless, the proliferation of small kilns shows that small-scale lime burning had not yet been fully usurped by larger commercial interests and may have remained important in many areas until the beginning of the twentieth century.

7.1.3 Explore the role of clamp kilns

This thesis has paid close attention to the role of clamp kilns in Scottish lime burning. The use of clamps appears widespread, as evidenced by the cartographic record, historical accounts, and archival materials. Commercial use of clamps, involving banks of several kilns operating cyclically,

was concentrated in the Central Belt region (as noted above). The extent to which this concentration was the product of resource distribution (particularly those areas where coal and limestone could be extracted together), or else local preferences or expertise, is a matter for further study.[4]

The case of clamp kilns also allows examination of improvement ideologies and the extent to which these were implemented. As Chapter Six has shown, an 'orthodoxy' of lime production was established in the later part of the eighteenth and the beginning of the nineteenth century, one that largely marginalised clamp kilns. Evidence from a range of sources nevertheless shows that clamp kilns continued to be valued by some lime burners on account of their ease of construction and, perhaps, the control afforded to the burner. Tarlow has argued that improvement was never a fully coherent ideology, and in practice was prone to contradictions and contestations.[5] Thus clamp kilns fell outside of the improver's rhetoric but persisted in use on account of their enduring utility.

This thesis has not attempted to resolve any of the archaeological debates around kiln types and nomenclature. Indeed, by offering more examples of diverse lime kilns from historical sources, it may only have served to highlight the ambiguity of kiln classifications in practice and further complicate the picture of lime burning. The simplified kiln types employed throughout—clamp, draw and field kilns—enabled high-level analysis, but patently cannot capture the full complexity of lime kilns in Scotland. As Chapter Four argues, kiln structures exist on a spectrum, with at one end the simplest heaped kilns and at the other the large banks of draw kilns. Kilns should not, however, be interpreted as having developed on a linear path. The continued difficulty of establishing robust typologies suggest that kilns were singular constructions, the product of local experience, user preference, site conditions, and the availability of materials and capital, rather than conforming to idealised plans.

[4] Bishop has already conducted a valuable study of the western Central Belt (see "Lime Burning in Clamp Kilns in Scotland's Western Central Belt: Primitive Industry or Simple But Perfectly Adequate Technology?"). Further comparisons with clamp kiln usage in Fife, Lanarkshire and the Lothians may prove illuminating.
[5] Tarlow, *The Archaeology of Improvement in Britain, 1750–1850*, 192.

7.1.4 Investigate social status

The extent to which social status was attached to lime kilns is challenging to prove. Within the archives used in this research there was no proprietor bragging about the size of his pot; no landowner requesting architectural embellishment; no Mr and Mrs Andrews painted proudly beside their newly erected draw kiln. Nevertheless, there are clues to suggest lime kilns held positive associations for their owners, particularly in the pre-industrial phase of lime burning. Subtle details in the construction of individual kilns imply that someone at some point took pride in their appearance, whether that be the mason responsible for building the kiln or the person who commissioned it. Indeed, some artists found a romantic appeal in the burning of lime (another example of which can be seen in Figure 67), despite its noxious and dangerous reality. It is unlikely, however, that kilns were ever constructed principally for their architectural or symbolic value.

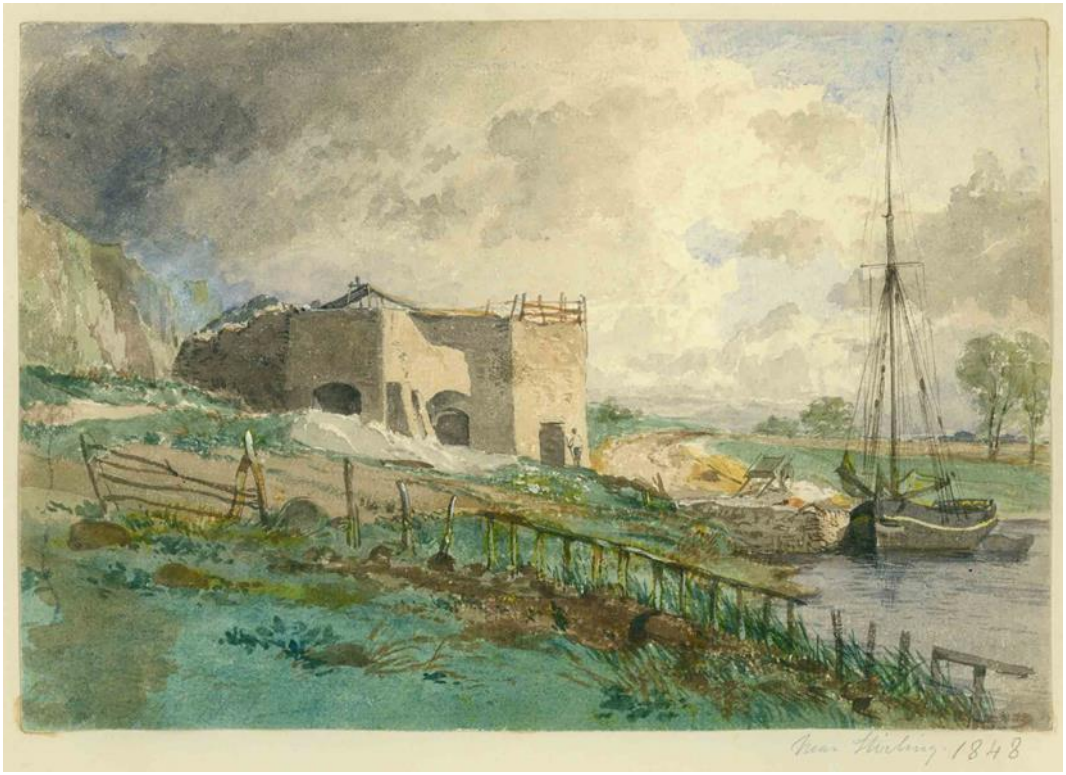


Figure 67 *Limekilns at Abbey Craig*, 1848, John Adam Houston. Watercolour on paper. The Stirling Smith Art Gallery & Museum, Stirling. The image depicts a lime kiln on the River Forth at Causewayhead, Stirling, just below the Abbey Craig

The use of lime in farming during the period of improvement does, however, seem to have been an indicator of a modern husbandry. Improvers were keen to evangelise the nation to liming, lauding as 'visionaries' those who first introduced it to new parishes or laid roads to facilitate its travel. For the

landowner in Enlightenment Scotland, harnessing the potential of mineral resource on their lands was of the utmost imperative. Making lime available to their tenants was almost tantamount to their patriotic duty. By the nineteenth century, lime production was becoming an increasingly economic concern, a chance for landowners to leverage revenues from their estate with the expenditure of little effort on their own part. Considerable attention was paid to calculating the financial merit of current and proposed works, rather than the opportunities that they might present for further improvement. Several elements of industrialisation and modernisation within the industry accompanied this shift, such as can be seen in the debates around standardisation and metrology that became prominent during the nineteenth century. Similarly, the role of the skilled journeyman lime burner—himself a valued agent of the rural economy—also wanes in this period, replaced by the manager of the lime works responsible for directing teams of labour in the loading and unloading kilns.

7.1.5 Analyse the relationship to science, improvement and Enlightenment

This thesis makes a scholarly contribution to the historical geographies of improvement and agricultural change in Scotland. Between 1750 and 1840, a great deal of information was circulated regarding lime and lime burning through the various channels of improvement discourse, including books, journals, the work of institutions and societies, and the small acts of emulation between individuals. This information and its diffusion constitutes the kind of 'useful knowledge' that was at the heart of what Jones conceives as Scotland's Agricultural Enlightenment.[6] The process of dissemination had two key audiences and impacts: landowners were alerted to value of the minerals on their estates and the means of their exploitation; and farmers were imbued with the understanding and confidence required to effectively lime their soils. By addressing the interests of both groups, this knowledge stimulated both the production and consumption of lime. In terms of kilns, the 'established position' that emerged into the nineteenth century was one that promoted draw kilns and centralised models of production, over smaller instances of lime burning. Although not entirely unchallenged at the time—some voices, for example, argued for the merits of clamp kilns—this position can continue to be read in subsequent modern histories of the lime industry.

[6] Mokyr, *The Enlightened Economy: An Economic History of Britain 1700-1850*; Jones, *Agricultural Enlightenment: Knowledge, Technology, and Nature*.

An important theme emergent in this thesis is the relationship between lime and the development of a scientific mindset among the improvers and, later, the emergence of agricultural science. This aspect constitutes an important contribution to the histories of science and Enlightenment in Scotland. Given the interconnectedness of earth sciences (particularly chemistry), agricultural improvement and public culture in Enlightenment Scotland, discourse around the nature and properties of lime sat at the heart of a lattice of entwined personal and professional interests.[7] Lime was seen as a valuable resource for a range of economic pursuits and an example of the utility that could be drawn from the earth by the application of reason. In this sense lime might be considered a (perhaps *the*) quintessential Enlightenment *material* in Scotland, one whose connections with nearly all areas of economic and intellectual activity embodied the very connectedness of Enlightenment itself. There also exists an interesting contradiction between, on one side, knowledge and practice regarding lime that, by contemporary estimates, had existed since 'time immemorial' and, on the other, a national spirit of learning that was invigorating this not-so-ancient practice.[8] Lime burning, and with it lime use, was, in the historical imagination, both timeless and a symbol of 'modern' farming.

7.1.6 Evaluate diverse methodologies

This research employed a diverse range of methods and sources in seeking to tell a broad narrative about lime burning in Scotland, giving opportunity to evaluate the extent to which these elements can all be combined within the context of a historical geographical project. Archival research and HGIS, for instance, are not typically applied to the same research questions. This marriage of methods presented both advantages and disadvantages. Some of the most problematic aspects relate to the OS maps as a spatial data source. As Chapter Two highlighted, the specific timescales and spatial resolution of the mapped kilns make integrating them with other spatial datasets (such as Canmore) problematic. Different data sources have different spatial resolutions and features observed on the ground may not reflect what the OS recorded in the nineteenth century.

[7] Golinski, *Science as Public Culture: Chemistry and Enlightenment in Britain, 1760-1820*.
[8] Withers, *Geography, Science and National Identity: Scotland since 1520*.

The six-inch first edition maps also were produced significantly later than, arguably, the period of greatest interest to scholars of Enlightenment, industrialisation or agrarian change. From around 1750 to the opening decades of the nineteenth century, lime burning underwent considerable growth, spurred on by the ideologies and demands of improvement. The kilns recorded by the OS thus reflect a relatively late stage lime industry, one that developed after the period of expansion. Conversely, many written sources relating to lime and lime kilns, including agronomic books and improvement publications, date from the late-eighteenth and early-nineteenth centuries, resulting, to some extent, in a disconnect between the two sources. Furthermore, sites identified by mapping did not always signify existent associated archival material. Indeed, the opposite could be the case—some kilns discussed in written sources were not mapped by the OS. This problem was particularly pronounced for smaller mapped kilns. While major lime works produced large volumes of financial records and related correspondence, written accounts of small-scale lime burning are thin on the ground, a difference that likely reflects the contrasting statuses of their respective proprietors.

Another perspective on the previous point is that small kilns, given their lack of representation in written sources and low 'archaeological visibility', could be easily overlooked in accounts of the lime industry were it not for their presence in the OS 'paper landscape'.[9] This alternative perspective was just one of the advantages of the mixed methodology employed. Mapping the kilns from the six-inch first edition provided a unique empirical insight into the industry on a scale never before achieved. Analysis of these points supported several conclusions (discussed above). By taking into account lime kiln symbology, an approach pioneered by Bishop, this already valuable dataset is imbued with important qualitative information, highlighting the diversity of scales and methods of lime production and the distribution of different kiln types.[10] Of course, HGIS analysis can only inform certain kinds of research questions. As David Bodenhamer argues, 'technology cannot speak to the contingent nature of cultural processes or to the agents of change or transformation'.[11] Thus,

[9] J H Andrews, *A Paper Landscape: The Ordnance Survey in Nineteenth-Century Ireland*, 2nd ed. (Dublin: Four Courts Press, 2002).
[10] Bishop and Thomson, "How OS Depicted Limekilns in Scotland's Central Belt."
[11] David J Bodenhamer, "Beyond GIS: Geospatial Technologies and the Future of History," in *History and GIS: Epistemologies, Considerations and Reflections*, ed. Alexander von Lünen and Charles Travis (Dordrecht: Springer, 2013), 10.

maps of lime kilns serve as a useful jumping off point for other kinds of more traditional research. To some extent they serve as a practical aid: named sites enabled targeted database searches, while knowing where kilns were concentrated could direct the selection of archives and records. Issues raised in archives or published sources, such as the importance of infrastructure connections or the relationship between a kiln and its resources, can be illustrated and contextualised by returning to cartographic sources. Site visits were also valuable in this regard, serving to ground the research findings in a coherent understanding of physical space.

Many of the insights gained in this thesis, and the national perspective it provides, are made possible by the diverse sources upon which it draws. It is important, therefore, to recognise that many of the resources available to me as a researcher, such as GIS software, electronic databases, digitised and georeferenced historical cartography, search engines, aerial photography, and digitised publications, were not available when the first modern histories of Scotland's lime industry were written by Skinner, Donnachie, Mackay and others.[12] That these have had such a lasting influence on our understanding of lime burning, especially Skinner, most certainly speaks to the quality of their research. The goal of this thesis, then, has been to expand on their work, rather than to expose any shortcomings of their conclusions.

7.2 Limitations and opportunities

This study of lime burning shows that improvement, agricultural change, and industrialisation remain salient themes in Scottish historical geography. Future studies addressing these subjects may wish to make use of certain aspects of the research approach employed here to investigate other industries or practices. In particular, and in light of the widespread use of digitised cartographic sources, this work has demonstrated the analytical potential of incorporating map symbology into the data capture process.

In drawing on a wide-ranging set of sources and methods, each with their own granularities, temporalities and subjectivities, this thesis contends with several questions of time, place and scale.

[12] Neither were many other techniques not employed in this thesis but used in other studies of lime kilns: laser scanning, radiocarbon dating, etc.

This work does not bracket the history of lime burning into arbitrarily defined periods to create a neat sequence of development, nor does it attempt to document the industry at a particular moment in time. Instead, the knitting together of local experiences allows for spatial as well as temporal variation (and commonality) to emerge. This approach enables different conclusions to be reached than would a more narrowly defined study of a singular place, region or time. While research outputs such as the national map of lime burning sites provide a valuable and novel perspective on the industry, their analytical value is ultimately restricted by the level of detail required to account for patterns of kiln usage, infrastructure development and resource movement at that site-scale. Regional or site-based studies of lime burning thus have an essential role to play in deepening understanding of how kilns were operated in relation to local markets, resources and knowledge. Indeed, in revealing the presence of lime kilns in previously overlooked parts of Scotland, this thesis increases the scope for new local and regional historical or archaeological investigations into lime burning.

Related to the national scale and the use of map data, the structure of this thesis has implications for the ordering of methods, concepts and the conclusions that can be reached. Just as broad geographical narratives sacrifice depth, the thematic structure employed here arguably sacrifices some of the potential for chronological interpretation and arguments around causality. Nevertheless, the decision to forefront the spatial data served its purpose in geographically informing subsequent thematic analysis. By demonstrating the spatial coincidence of different forms of lime kiln, for example, this thesis is able to contest standard chronological narratives of modernisation and industrialisation, thereby serving as a caution against simplistic and sweeping assumptions. Future papers arising from this work will serve to further address chronological questions.

Several issues remain unresolved. Nomenclature and kiln classification, a long-standing area of debate among industrial archaeologists, continue to make robust comparisons between regions and countries challenging. Further archaeological work focusing on recording the structure and dating of clamp and field kilns will help to establish a clearer picture of the development of kiln technology of Scotland besides that of the large commercial draw kilns. Nevertheless, such work should be mindful

of slipping into 'piecemeal empiricism'.[13] In other words, local studies should always consider the wider social, cultural and intellectual contexts in which industries and practices were constituted.

7.3 Conclusion

In summary, lime burning was vital for the development of Scotland's agriculture and industry during the eighteenth and nineteenth centuries—this much was already well understood. This thesis has shown how lime burning was shaped by twin forces, neatly encapsulated in John Wilson's remark from 1812 that appeared in the Introduction. On one hand, practical factors, 'the improved state of the roads', allowed lime to reach new markets and lime burners to be supplied with resources from more distant sources, thereby allowing lime to be burnt in ever greater volumes and in more parts of Scotland.[14] On the other, 'a more complete knowledge of agriculture', diffused through the efforts of agrarian societies, institutions, and the example of individual improvers, was both showing lime to be an indispensable ingredient in modern husbandry and providing the template from which to enact its production.[15] The crucial, perhaps unique, thing about lime burning, however, was the way in which it intersected numerous intellectual and practical concerns. Improvers, natural philosophers, chemists, industrialists, already people with interconnected interests, social lives and professional endeavours, took interest in understanding and harnessing lime and encouraging its production. Thus, 'ancient and universal', lime embodies a nation striving for modernity by re-examining and improving upon the practices of the past.[16]

This thesis ends with a moment of levity—the only known joke about lime kilns, dating from 1849:

> Why is a dandy like a lime kiln?—
> He is generally given to smoking.[17]

[13] Morrell, "Reflections on the History of Scottish Science," 86.
[14] Wilson, *General View Renfrewshire*, 24.
[15] *Ibid.*
[16] Graham, *General View Stirlingshire*, p.254
[17] *John o'Groat Journal,* Friday 9th November 1849, p.4

Appendix

Glossary

Boll	A unit of measurement (see Weights and Measures)
Bushel	A unit of measurement (see Weights and Measures)
Chalder	A unit of measurement (see Weights and Measures)
Clamp kiln	Form of kiln, rectangular or U-shaped in plan and dug into the ground. Covered over (‘clamped’) with earth or turf to control the burn (see, p.169)
Clinker	Overburned lime
Draw kiln	A kiln in which fuel and limestone can be continuously added to the top and the burned lime drawn out of the bottom. Usually masonry built. See p.181
Field kiln	Kiln intended for intermittent use, most commonly associated with agriculture. Masonry or earthen built (see p.175).
Firlot	A unit of measurement (see Weights and Measures)
Hogshead	A barrel of agreed dimensions, often used as a local unit of measurement
Kill (as in ‘lime kill’)	Common variation of ‘lime kiln’
Marl	Lime rich mud or mudstone, with similar properties to lime. Often spread on fields to reduce acidity and improve soil texture.
Moss	A marsh, bog or tract of soft wet ground.
Pye kiln	A type of earthen intermittent kiln (see Leach 1995)
Shells (see also ‘lime shells’)	Unslaked lime.
Slake (see also ‘slack’ or ‘slock’)	Verb; to add water to quicklime. See page 2.
Sod	A piece of turf
Strake (see also ‘straik’ or ‘streak’)	Verb; to level something, such as grain, in a measure using a ‘strake’ or straight edged implement.
Tirr	Verb; to break the surface of the earth

Weights and measures

Until the middle of the nineteenth century a range of weights and measures were used in Scotland. The complexity and inconsistency of historical pre-metric weights and measures has long presented an obstacle to scholarly research.[1] English Imperial measures were not imposed until 1824. Lime was typically sold by volume rather than by weight. The most commonly used measure for lime was the boll. There were many locally defined bolls, with the most widely used being the Linlithgow peas boll.[2] The smallest unit lime was sold in was the firlot. Occasionally, other local measures were used such as the hogshead, a barrel of agreed volume. Inconsistencies regarding measuring lime quantities are discussed further in Chapter Five (see p.208).

Table 16 Scottish dry capacity measures and their respective Imperial and metric equivalents.[3]

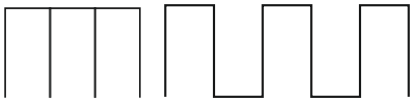
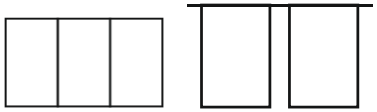
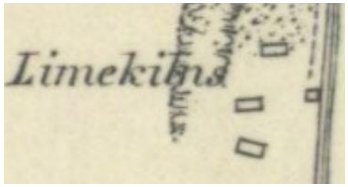
Scots	Imperial	Metric (litres)
1 firlot = 4 pecks	3 pecks, 1.986 gallons	36.286
1 boll = 4 firlots	3 bushels 3 pecks, 1.944 gallons	145.145
1 chalder = 16 bolls	7 quarters 7 bushels, 1.615	2322.324

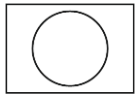
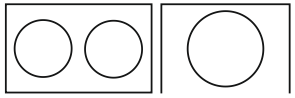
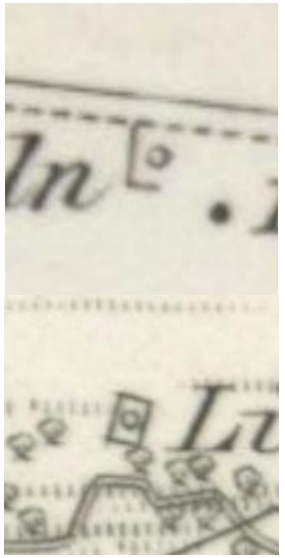
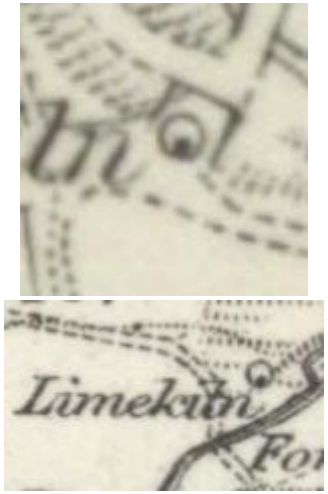
Site visits

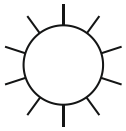
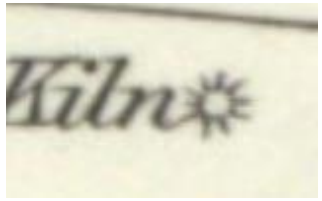
Site	Location	Map Ref	Date
Ard Neakie Lime Kilns	Loch Eiriboll	NC446597	Sep-15
Charlestown	Fife	NT063835	Jun-16
Queenzieburn	Stirlingshire	NS684784	Jul-16
Whitfield Quarry	West Lothian	NT171539	Aug-16
Campsie kiln	Stirlingshire	NX089597	Oct-16
Benarty Forest	Fife	NT159972	Oct-16
Skaill kiln	Orkney	HY233186	Oct-16
Maryhill lime kiln	Glasgow	NS572690	Nov-16
Ardonald Lime Works	Aberdeenshire	NJ460446	Mar-17
Dulnain Bridge & Easter Laggan	Invernesshire	NH998249	Mar-17
Skye of Curr	Invernesshire	NH991244	Mar-17
Loch an Eilean	Kingussie	NH897083	Mar-17
South/North Mine Limeworks	Linlithgow	NS992717	Mar-17
Wildshaw Lime Works	Lanarkshire	NS876283	Mar-17
Glencotho	Peebleshire	NT087297	Mar-17
Whim	West Lothian	NT216532	Apr-17
Kilmory kiln	Lochgilphead	NR868869	May-17
Harehill	Lothian	NT163621	Feb-18
Left Law Lime Works (Dunsyre)	West Lothian	NT046507	Sep-18

[1] Zupko, *A Dictionary of Weights and Measures for the British Isles: The Middle Ages to the Twentieth Century*, ix.
[2] Many of these local variations for lime and for other goods are documented by Zupko.
[3] Scottish Archive Network Weights and Measures Guide, https://www.scan.org.uk/measures/index.asp

Symbol schema

Symbol group	Basic symbol	Description	Key Variations	Examples
A		Curve end clamp kiln		
B		Square end clamp kiln		
C		Rectangular kiln		
D		Circular kiln symbol		

D2-7		Kiln pot within stone structure		
E		Dot on circumference; generic kiln symbol	[may also be within polygon, as above]	

F		Dot within circle; generic symbol variant	[may also be within polygon, as above]	
G		Circle with radial lines		
H		Standard OS roofed-structure symbol		
U		Other / Unknown		

Symbol codes and classifications

Symbol Group	Description	Symbol Code	Classification	Count
A	Curved clamp	A1	Clamp	103
A	Curved clamp	A2	Clamp	4
A	Curved clamp	A3	Clamp	2
A	Curved clamp	A4	Clamp	1
A	Curved clamp	A5	Clamp	1
A	Curved clamp	A6	Clamp	1
A	Curved clamp	A7	Clamp	2
B	Curved clamp	B1	Clamp	115
B	Square-end clamp	B2	Clamp	1
B	Square-end clamp	B3	Clamp	1
B	Square-end clamp	B4	Clamp	4
C	Rectangular clamp	C1	Clamp	293
C	Rectangular clamp	C2	Clamp	7
C	Rectangular clamp	C3	Clamp	1
C	Rectangular clamp	C4	Other / Unknown	1
D	Circle	D1	Field	895
D	Circle, enclosed	D2	Draw	49
D	Circle, enclosed	D3	Draw	38
D	Circle, enclosed	D4	Draw	11
D	Circle, enclosed	D5	Draw	10
D	Circle, enclosed	D6	Draw	5
D	Circle, enclosed	D7	Draw	1
E	Dot on circumference	E1	Field	440
E	Dot on circumference, enclosed	E2	Draw	9
E	Dot on circumference, enclosed	E3	Draw	16
E	Dot on circumference, enclosed	E4	Draw	6
E	Dot on circumference, enclosed	E5	Draw	5
E	Dot on circumference, enclosed	E6	Draw	7
F	Dot within circle	F1	Field	72
F	Dot within circle, enclosed	F2	Draw	2
G		G1	Other / Unknown	10
H	Roofed structure	H1	Draw	40
H	Roofed structure	H2	Draw	1
H	Roofed structure	H3	Draw	1
U	Kiln Obscured	U1	Other / Unknown	25
U		U2	Other / Unknown	1
U		U3	Other / Unknown	1
U		U4	Other / Unknown	2
U		U5	Other / Unknown	1

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DR2/1	Poltalloch Papers, Duntrune Estate lime workings and improvement, c. 1796
DR4/2	Duncan Colville Papers, Askomill Lime Works, c.1847-1854

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T-LX6	Scullingour Working Papers 1816-1981
T-LX7	Scullingour Coal and Lime Works, Alex Galloway papers
T-LX14	Kaimhill Working Papers c.1801-1826, T-LX14

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GD44	Duke of Gordon Papers, Ardonald lime works and Highland improvements c.1796-1809
GD112	Campbell Family, Earls of Breadalbane, Improvements on Perth and Argyll estates, c.1716-1862
GD150	Earls of Morton Papers, Raw Camps Lime Works, West Lothian, c.1792-1813
GD220	Grahams Family, Dukes of Montrose papers, Murrayshall Lime Works, c.1787-1861
GD224	Dukes of Buccleuch Papers, Haskomill and Canonby lime works, Stirlingshire, weights and measures, c.1780-1813
GD293	Macbiehill Estate Papers, c.1837
RHP282	Mackrihanish, 1757
RHP627	Plan of Skaterow Harbour, East Lothian, William Mason 1771
RHP1199	Plan of the Estates of Lainswood and Kirkwood, W Crawford, 1779
RHP1438	Macbiehill Estate Plan, 1835
RHP1628	Plan of Limestone Quarry, Craighead, Ayrshire, 1797
RHP1807	Strathavon, Banffshire, 1839
RHP1826	Auchindown, Banffshire, 1838
RHP1859	Plan of the Lands of Pitmain and Kingussie, by William Taylor, 1771
RHP1724	Plan for the Improvement of Bargenny, George Robertson, 1774
RHP1766	Forest of Glenfiddich, 1766
RHP2743	Plan of the extension of the lime road, Bargenny, c.1800
RHP4004	Rude Draught of Mundole Commonty, 1814
RHP8926	Plan of the Lands of Curr, George Taylor, 1771
RHP35185	Plan elevation of lime kilns, 1802
RHP37700	Closeburn Estate, 1845
RHP82890	Plans of the Low Grounds of Rothiemurchus, H Morrison,1842-1847

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