

On Georgics and Geology: James Hutton's 'Elements of Agriculture' and Agricultural Science in Eighteenth-Century Scotland*

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Abstract

In this article, the unpublished manuscript 'Elements of Agriculture' by the earth scientist James Hutton (1726–1797) is analysed to review both its content and its contextual significance in relation to contemporary knowledge on agricultural science in eighteenth-century Scotland. Examination of Hutton's agricultural manuscript shows him to have linked his geological and individual farming interests with matters of Scotland's husbandry. His work was part also of that improvement culture within eighteenth-century Scotland which sought to understand agricultural practice through science and to transform the agrarian economy through subjecting it, like the science on which it was based, to the test of 'rational principles'. The idea of continuing fertility and repair is seen to be essential to his geological *Theory of the Earth* and his *a priori* reasoning in the 'Elements of Agriculture'.

SEVERAL causal agencies may be identified in understanding the transformation of Scotland's agricultural economy during the eighteenth century. Broadly put, they may be identified as institutional, managerial, and contextual agencies of change.

The development of Scotland's agriculture through formal agricultural institutions is first evident in 1727 with the foundation of the Honourable the Society of Improvers. From that date other bodies were established, chiefly throughout Lowland Scotland, whose purpose was advancing knowledge through the practice and principles of new forms of rural management. It is true many such institutions were short-lived: others provided a means to the sharing of better practice and a forum for information exchange. Such was the concern of enlightening Scotland in

the later 1700s that societies whose purpose was 'improvement' more widely included agrarian topics in their business: this is true of the Edinburgh Society for Encouraging Art, Science, Manufactures and Agriculture (established in 1755), the Select Society (1754), the Philosophical Society (1737), and, notably, the Royal Society of Edinburgh, begun in 1783.¹

To these formally-constituted institutions should be added the impetus generated by the attention paid to Scotland's agriculture in her universities in the later eighteenth century. The Rev Dr John Walker's lecture courses at Edinburgh attracted a wide audience of persons committed to and engaged in Scotland's agrarian economy as well as students of medicine and law. Private courses of lectures in agriculture—by Robert Maxwell

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¹ On these points, see R C Boud, 'Scottish agricultural improvement societies, 1723–1835', *Review of Scottish Culture*, 1, 1984, pp 70–90; K Hudson, *Patriotism with Profit: British Agricultural Societies in the Eighteenth and Nineteenth Centuries*, 1972; S Shapin, 'The audience for science in eighteenth-century Edinburgh', *Hist Sci*, XII, 1974, pp 99–104; R I Black, 'The Gaelic Academy: the cultural commitment of the Highland Society of Scotland', *Scott Gaelic Studs*, XIV (II), 1986, pp 1–38; R L Emerson, 'The Philosophical Society of Edinburgh 1748–1768', *Brit Jour Hist Science*, 14, 1981, pp 133–76; J E McClellan, *Science Reorganised: Scientific Studies in the Eighteenth Century*, New York, 1985.

in the 1720s, for example, or more notably by William Cullen in 1748 and 1749 — added to the public attention given to promotion of improved agriculture.²

Building upon an earlier 'impetus to improvement' evident in the later seventeenth century,³ these changes were paralleled by new procedures of rural land management. Surveyors and landowners laid out new 'landscapes of improvement', and undertook new practices of crop rotation, different stocking rates, and the incorporation of breeds and crops into agricultural systems on scales not before considered. Many of these managerial changes were concentrated in the north-east and central southern Lowlands, and were often dependent upon the receptiveness of individual landowners to experiment, adopt, and persevere with new practices.⁴ Innovation in the Highlands in these ways was generally later in coming and, apart from the localized influence of the Board for Annexed Forfeited Estates between c 1752 and 1784, was not widespread in coverage throughout Scotland's north and west.⁵ In part, these new managerial practices were codified in an expanded range of published works on Scottish agriculture evident during the

eighteenth century.⁶ Texts that documented 'traditional' rural practices with a view to their vilification were complemented by works whose concern was the promotion of the new, either through personal experience, or national summary of best practice as in Wight's surveys of 1778–1784.⁷ Claims to national agrarian utility through the combined efforts of forward-thinking individuals were evident in men like James Donaldson whose 1795 book considered that 'The industrious husbandman not only enriches himself, but also advances the general prosperity of the community'.⁸

In part also, however, these texts and the practices they embodied represent what may be considered externally-derived or contextual changes affecting Scottish agriculture. The involvement of institutions with agricultural advance and with the promotion of new ways of working the land was shaped by those wider concerns of eighteenth-century Scotland with civic virtue, improvement and national 'cultivation'. The links between agricultural economic advance, the socio-cultural benefits of improvement, and the scientific bases to national utility were evident in the close links between agriculture and natural history and chemistry in the work of Walker and Cullen. Natural philosophy and medical discourse also informed the debates of the day. Many Scottish agrarian writers were members of those socio-scientific institutions in which these debates were commonplace. In these several ways, there was an evident 'utilitarian impulse' in later eighteenth-century Scotland as more generally in Britain. The earth sciences of geology, chemistry and natural history were central elements in what has

² H W Scott, 'John Walker's lectures in agriculture (1790) at the University of Edinburgh', *Ag Hist*, XLIII, 1969, pp 439–45; S Richards, 'Agricultural science in higher education: problems of identity in Britain's first chair of agriculture, Edinburgh 1790–1831', *Ag Hist Rev*, 33, 1985, pp 59–65; C W J Withers, 'A neglected Scottish agriculturalist: the "Georgical Lectures" and agricultural writings of the Rev Dr John Walker (1731–1803)', *Ag Hist Rev*, 33, 1985, pp 132–56; *idem*, 'William Cullen's agricultural lectures and writings and the development of agricultural science in eighteenth-century Scotland', *Ag Hist Rev*, 37, 1989, pp 144–56.

³ On this point, see I D Whyte, *Agriculture and Society in Seventeenth Century Scotland*, Edinburgh, 1979; T C Smout and A Fenton, 'Scottish agriculture before the improvers — an exploration', *Ag Hist Rev*, 13, 1965, pp 73–93; R H Campbell, 'The Enlightenment and the economy' in R H Campbell and A Skinner, eds, *The Origins and Nature of the Scottish Enlightenment*, Edinburgh, 1982, pp 8–25.

⁴ G Whittington, 'Agriculture and society in Lowland Scotland, 1750–1870', in G Whittington and I D Whyte, eds, *An Historical Geography of Scotland*, 1983, pp 141–64; I Adams, 'The agents of agricultural change', in M L Parry and T R Slater, eds, *The Making of the Scottish Countryside*, 1980, pp 155–76.

⁵ A Smith, *Jacobite Estates of the Forty-Five*, Edinburgh, 1982.

⁶ J A S Watson and G D Amery, 'Early Scottish agricultural writers (1697–1790)', *Trans Highland Agric Society of Scotland*, XLIII, 1931, pp 60–85.

⁷ Andrew Wight, *Present State of Husbandry in Scotland* (6 vols), Edinburgh, 1778–1784.

⁸ J Donaldson, *Modern Agriculture; or, the Present State of Husbandry in Great Britain*, Edinburgh, 1795, I, p 4.

been considered for Scotland an 'institutionalized alliance between agricultural improvement...and the rationalizing impulse of scientific intellectuals'.⁹

One person who exemplified this connection in Scotland between the several earth sciences, who shared this concern for individual and national betterment through agriculture, and who was part of this socio-scientific alliance between these rationalizing discourses of improvement was James Hutton. Hutton, who was born in Edinburgh in 1726 and who died there in 1797, is best known for his contributions to the geological sciences. His notions of repair and the cyclical model of erosion-deposition-uplift repeating over and over through time — what McPhee has called Hutton's 'discovery' of 'deep time' — have established Hutton as one of the founding influences of modern geology.¹⁰ But Hutton was significantly involved with agricultural topics throughout his life. This is evident in several ways. He was a farmer in Slighhouses in Berwickshire for thirteen years, a student of agriculture in East Anglia, France and Flanders between 1752

and 1754, and he was elected in 1787 an 'Associé étranger' for his agricultural knowledge by the prestigious Société Royale d'Agriculture de Paris. More notably, he wrote a two-volume treatise entitled 'Elements of Agriculture' in which he sought to connect his experiences as an individual farmer with the earth science traditions and institutionalized utilitarian impulses of which he was part.

Early in these unpublished 'Elements', Hutton wrote how 'agriculture...has been in a manner the study of my life'.¹¹ As Jones has shown in her excellent summary of Hutton's agricultural research and life as a farmer, Hutton's agricultural and geological interests were intimately connected; in his views on soils, on the chemical utility of certain fertilizing and manuring practices designed to 'repair' the land, and in the empirical and deductive bases to both subjects. For Jones, '...it becomes clear that his geological and agricultural studies cannot be separated but that a change took place as they progressed. At the beginning of his period as a farmer his journeys were designed to collect agricultural information, with geology as something of a hobby. By 1764 geology had displaced agriculture as the principal subject of investigation, and for the rest of his life it remained paramount...'¹²

This paper is an attempt to extend our understanding of Hutton's place, and that of his unpublished 'Elements of Agriculture', in the agricultural scientific knowledge of his day. For reasons of space this paper cannot be the '...thorough study, which examines the whole text [of the MS 'Elements'] and compares Hutton's theories and methods with those of his contemporaries...' that Jones has called for. But what follows has intentions in this direc-

⁹ Shapin, *art cit*, p 102; see also K Blaxter, 'Agricultural science and practice', *Proc Royal Soc Edin*, 84B, 1983, pp 6-8; N T Phillipson, 'Culture and society in the eighteenth century province: the case of Edinburgh and the Scottish Enlightenment', in L Stone, ed, *The University in Society*, Princeton, 1974, II, pp 407-20; *idem*, 'The Scottish Enlightenment' in R Porter and M Teich, eds, *The Enlightenment in National Context*, Cambridge, 1981, pp 19-40; R Porter, *The Making of Geology: Earth Science in Britain 1660-1815*, Cambridge, 1977; A C Chitnis, 'Agricultural improvement, political management and civic virtue in enlightened Scotland: an historiographical critique', *Studies on Voltaire and the Eighteenth Century*, CCXLV 1986, pp 475-88; *idem*, 'The eighteenth-century Scottish intellectual enquiry: context and continuities versus civic virtue', in J Carter and M Pittock, eds, *Aberdeen and the Enlightenment*, Aberdeen, 1987, pp 77-92; on these issues for Britain as a whole, see S Wilmot, *'The Business of Improvement': Agriculture and Scientific Culture in Britain, c 1700-1870*, Cheltenham, 1990.

¹⁰ For a more complete background to Hutton, see S I Tomkief, 'James Hutton and the philosophy of geology', *Trans Edin Geol Soc*, 14, 1948, pp 253-76; D A Bassett, 'James Hutton the "Father of Modern Geology": an anthology', *Geology*, 2, 1970, pp 55-76; D R Dean, 'James Hutton and his public, 1785-1802', *Annals of Science*, XXX, 1973, pp 89-105; *idem*, 'James Hutton's rôle in the history of geomorphology' in K J Tinkler, ed, *History of Geomorphology*, 1989, pp 75-84; *idem*, *James Hutton and the History of Geology*, Harvard, 1992; G L Davies, *The Earth in Decay: a History of British Geomorphology 1578 to 1878*, 1969, pp 154-99; S J Gould, *Time's Arrow Time's Cycle: Myth and Metaphor in the Discovery of Geological Time*, Cambridge, Mass, 1987, pp 61-98.

¹¹ 'Elements of Agriculture', Royal Society of Edinburgh MS C 5, f 3.

¹² J Jones, 'James Hutton's agricultural research and his life as a farmer', *Annals of Science*, 42, 1985, pp 573-601 (quote from p 573).

tion. More specifically, the paper has three aims. The first is to bring to the attention of a wider audience the range, content, structure, and purpose of Hutton's unpublished manuscript. Amongst historians of Scotland's agriculture, Hutton has received little attention, his 'Elements' none. Handley, for example, notes only how Hutton 'has sometimes been credited' with the introduction of the Norfolk system of drill husbandry into Scotland, and sees him as an innovator in south-east Scotland in the way Adams has noted of leading individuals in the North-East.¹³ 'His methods excited curiosity among his neighbours, many of whom, attracted by the profitable outcome of his efforts, were led to imitate him'.¹⁴

The second and principal aim is to begin consideration of the relationships between Hutton's 'Elements', their geological basis and georgical content, and the views and published works of his contemporaries, chiefly in Scotland. A number of texts are examined, but particular attention is paid here to the scientific and chemical basis to agriculture in Francis Home's 1757 *The Principles of Agriculture and Vegetation*. Hutton's work and his utilitarian views are compared with Kames' *The Gentleman Farmer being an attempt to improve Agriculture, by subjecting it to the Test of Rational Principles* (1776). Kames' improvement philosophy, evident in his claim that 'Agriculture justly claims to be the chief of arts: it enjoys beside the signal pre-eminence, of combining deep philosophy with useful practice',¹⁵ was shared by Hutton. In his 'Elements', Hutton noted that his concern was 'to make philosophers of husbandmen and husbandmen of philosophers'.¹⁶ The third aim is to illustrate through this consider-

ation of Hutton something of the institutional, managerial and contextual complexity of those intellectual and material alliances that underlay advances in agricultural knowledge in late eighteenth-century Scotland.

I

Jones has suggested that Hutton '...began to write his treatise on agriculture as soon as the first two volumes of the *Theory of the Earth* appeared in print in 1795', and that the work was based on earlier unpublished essays on agricultural topics (now lost) by Hutton.¹⁷ Playfair's 'Biographical Account' of Hutton, published in 1805, notes that Hutton first '...resolved to apply himself to agriculture' in the summer of 1750 (after abandoning plans for a career in medicine) and was, from 1752 and his visits to Norfolk, seriously committed to ideas of improvement: 'As he was never disposed to do any thing by halves, he determined to study rural economy in the school which was then reckoned the best'.¹⁸ But as Hutton's geological interests overtook his agricultural ones, so his writings on rural economy took second place and remained incomplete upon his death in March 1797. As Playfair notes

After the publication of the work just mentioned, [*Theory of the Earth*] he began to prepare another for the press, on a subject which had early occupied his thoughts, and had been at no time of his life entirely neglected. This subject was husbandry, on which he had written a great deal, the fruit both of his reading and experience; and he now proposed to reduce the whole into a systematic form, under the title of *Elements of Agriculture*. This work, which he nearly completed, remains in manuscript. It is written with considerable perspicuity; and though I can judge but very imperfectly of its merits, I can venture to say, that it contains a great deal of solid and practical knowledge, without any of the vague

¹³ Adams, *op cit.*

¹⁴ J E Handley, *Scottish Farming in the Eighteenth Century*, Edinburgh, 1953, p 147.

¹⁵ H Home, *The Gentleman Farmer being an attempt to improve Agriculture, by subjecting it to the Test of Rational Principles*, Edinburgh, 1776, p v.

¹⁶ 'Elements', f 2.

¹⁷ Jones, *op cit.*, p 574.

¹⁸ J Playfair, 'Biographical account of the late Dr James Hutton F.R.S. Edin.', *Trans Royal Soc Edin.*, 5, 3, 1805, pp 39-99. Quote from pp 42-43.

and unphilosophic theory so common in books on the same subject.¹⁹

Attempts were made in 1806 to publish what was called Hutton's *Principles and Practice of Agriculture* (*sic*) but these were never realized. The manuscript circulated between custodians in the Royal Scottish Geographical Society and the Edinburgh Geological Society before being housed from 1949 in the Royal Society of Edinburgh.²⁰

The 'Elements' is a lengthy and, in places, ill-connected work. It is 1070 folio pages long, in two volumes, and is chiefly in the hand of an amanuensis together with some pencil marginalia by Hutton. The work is structured into a series of sections and chapters, not always consecutively numbered. It begins with a 'General view of husbandry and agriculture, what they are and how to be treated of' in two chapters: 'What husbandry properly is, and how it may be rendered scientific' (chapter 1) and a 'General view of the principles of agriculture as they are now to be treated of' (chapter 2). Approximately half of volume I is taken up with discussion of the links between soils, climate, and vegetation. Hutton shows himself concerned with the application of these issues to contemporary contexts in his discussion of the 'Application of the theory of climate, in comparing the most distant countries with regard to the power of vegetation and the means of population' (vol I, ff 271-314). The remainder of the first volume is taken up with discussions of seeds '...or the science of propagating useful plants' (vol I, ff 315-345) and of the 'Botanical and Chymical Philosophy of vegetable reproduction', together with consideration of the efficacy of different agricultural implements. Volume II begins with 'the general Principles by which the reproduction of Animals is conducted, with

application to the Husbandry of Britain' before turning to considerations of crops and cropping practices which, whilst scattered, form the great bulk of the second volume. Attention is also paid to the 'Moral and Political View of the labour and skill employed in Agriculture' (vol II, ff 667-717) and to several sections on systems in rural and political economy 'for the improving of a country' (vol II, ff 875-927).

Hutton was in no doubt as to the overall purpose of his 'Elements'. After considering the Board of Agriculture's work essentially comparative, he writes

The present undertaking has another object in view; this is to examine agriculture in general and to treat of it scientifically, in order to enable husbandmen to judge how far any particular practice is conformed to the general principles. It is this that constitutes the science of the art, or that generalization of our knowledge which is to direct our conduct & practice in particular instances. In order to attain this end I have endeavoured to explain the principles of Agriculture, both philosophical and oeconomical; and I have supported and illustrated those principles by the actual practice of the most successful husbandmen of this kingdom, that is by the general experience of the art.

The object of this work is, in short to make philosophers of husbandmen and husbandmen of philosophers; to unite as far as may be, or is proper, those two valuable characters, for the general benefit of the country as well as the particular interest of those immediately concerned. What could be more advantageous to this country than that the wealthy farmers, who are to take the lead in what concerns the rural oeconomy to be men of science in their profession, that is, men judging of every thing upon the most just and general principles, consequently, acting most advantageously upon all occasions? — What more for the benefit of our landed interest, than for gentlemen of education to understand their immediate concern in the general practice of agriculture & husbandry, that art by which a nation is to be made both powerful & happy?²¹

There are a number of related issues of interest to us in Hutton's view of his own enterprise and in the structure to his work. Firstly, and perhaps most importantly, the 'Elements' are informed by a concern for

¹⁹ Playfair, *op cit*, p 87.

²⁰ Jones, *op cit*, p 575.

²¹ 'Elements', ff 1-3.

the philosophical and scientific treatment of agriculture. The chosen means are as essentially empirically verifiable practices, with deductive methods principally employed: 'It is this that constitutes the science of the art, or that generalization of our knowledge which is to direct our conduct & practice in particular instances'. Secondly, to complement such knowledge is 'the actual practice' of successful husbandmen. Through the conjunction of rational principles and direct observation, agriculture could develop as scientific practice understandable to all, philosophers and husbandmen both. It is significant in this respect that Hutton did not explicitly distinguish, in his preface at least, between practising farmers and theorizing philosophers. They were in this context one and the same thing and properly so, given thirdly his concerns for utility, and national and individual advance via a rationally managed agriculture. In general terms, these concerns with utility, with philosophical and scientific principles, and with economic betterment place Hutton firmly in his contemporary context, in Scotland and beyond. It would have been surprising had they not. In more detail, however, Hutton's unpublished 'Elements of Agriculture' merits attention in its own right precisely because of this context and because it would appear to substantiate in its connections between georgics and geology the claims of those who have argued for that conjunction of scientific and intellectual discourses and socio-scientific institutional alliances as principal agencies behind the development of agricultural science in this period.

II

Hutton's major geological work *Theory of the Earth* (1795)²² is precisely what it says:

²² The work was originally published in 1788 in *Trans Royal Soc Edin*, 1, 1788, pp 209–305, but was written in a dense and often misleading prose. The 1795 version, much improved by the

a *theorization*, an exploration of those abstract principles — time, heat, decay, repair, cyclicity — that underlay the nature of the Earth. The emphasis he lays in that work upon rational principles and upon reasoned speculation as to relationships of cause and effect is evident throughout the 'Elements' as Hutton discusses the application of theory to the practical arts of agriculture.

In the opening sections, Hutton writes 'Without theory or general rules no art can be brought to any degree of perfection; for art is not founded immediately upon matters of fact or events but upon the generalization of them & and this generalization is a scientific observation which leads to theory'.²³ He goes on to consider the relationships these theoretical constructions have with utilitarian motives (agriculture as a profoundly *useful* science) and with the practical experiences of those actually engaged in agriculture. In so doing, and despite his intention to make philosophers of husbandmen and vice versa, it is clear Hutton placed much greater weight on contemporary theoretical discourse than upon the knowledge of the husbandmen of the day.

If for the purpose of the teaching mankind any art every artist were to give an account of his own experience, the first thing to be done with that information would be to employ a man of science to form a theory by generalizing the matters of fact. But so inaccurate in general are practical men in reporting their experience that much misrepresentation of the facts would enter into the mass of information from whence, by generalization, the science was to be collected. The theory thus formed would therefore be extremely imperfect or erroneous however accurate the generalization might be. For in this case the man of science in generalizing the knowledge derived from experience would have no opportunity of verifying the results by comparing the various circumstances or conditions in which the events had taken place.

In the art of agriculture the events to be looked

attentions of Playfair, appeared under the full title *Theory of the Earth with Proofs and Illustrations*, Edinburgh. I have used the later version here.

²³ 'Elements', f 4.

at are influenced by the most variable circumstances, such as the practitioners are but little qualified to judge of. Therefore to form a science of agriculture, and to give general rules for the practice of that art, would require that men of science, well instructed in natural philosophy, should apply to the art as generally practiced in order to see the truth of experience, and to avoid being misled by the vanity of opinion. Nothing is more fallacious than what husbandmen call their experience; for they attempt to generalize without being properly qualified for that scientific operation and they give as matter of fact, or as truth learned from their experience, that which is only their inaccurate, & often false conclusion drawn from the whole of a complicated train of causes and effects.²⁴

Hutton's intentions to illustrate '...the great difference between a husbandman founding the practice of his art upon principle and his following blindly that practice which he has taught, without knowing the principle or general truths on which it is founded'²⁵ in part ally him with contemporaries like Francis Home and Henry Home (Lord Kames). In turn, they distance him from the work of people like Andrew Wight, Adam Dickson, and James Donaldson whose focus was more in the recorded collection of best agricultural practice throughout Scotland. This is not to suggest that contemporary understanding of scientific agriculture in later eighteenth-century Scotland may be reduced to formal 'traditions' or 'paradigms' — the philosophical or theoretical school and the school of practical observation. Such labels impose distinctions on this intellectual context and institutionalized alliance that neither Hutton nor his fellow writers would have understood. But it is to highlight here the scientific (philosophical) emphasis to Hutton's 'Elements', and to suggest that this stemmed from Hutton's own theoretical leanings and belief in the virtues of reasoned speculation upon general principles rather more than it did from the ideas of his contemporaries. In this sense, we may consider Hutton's emphasis

to be both influenced by his geological *theory* and to be different from the claims of others.

In 1757, Francis Home had argued that the by then '...slow progress of husbandry may be accounted for from more obvious reasons':

This art is, in general, carried on by those whose minds have never been improved by science, taught to make observations or draw conclusions, in order to attain the truth...

...It [husbandry] had yet a greater [obstacle] to struggle with. It does not, like most arts, lead to an account of itself; or depend on principles which its practice can teach.²⁶

For Home, established principles lay in understanding agriculture's 'dependence on chymistry' and upon reducing the art of agriculture to 'a system' through knowledge gained via experimentation. Home's work is essentially a record of experiments on soil types; for him 'Agriculture does not take its rise originally from reason, but from fact and experience. It is a branch of natural philosophy, and can only be improved from the knowledge of facts, as they happen in nature'.²⁷ Such an inductive and empiricist stance as underlying methodology was in distinction to Hutton but it was a view echoed by Henry Home (Lord Kames) in his 1776 *The Gentleman Farmer*, whose subtitle (*being an attempt to improve Agriculture, by subjecting it to the Test of Rational Principles*) belies the attention given to those rational principles as, essentially, the result of practical observation and experience. Modern scholars have claimed of Kames that he 'contributed more than any other man to the development of a scientifically-based agriculture'.²⁸ This is true if we consider his understanding of rational principles to be based heavily on inductive empiricism: 'Fortunately,

²⁴ 'Elements', ff 4–5.

²⁵ 'Elements', f 18.

²⁶ F Home, *The Principles of Agriculture and Vegetation*, Edinburgh, 1757, pp 3–5.

²⁷ F Home, *op cit*, pp 174–75.

²⁸ W C Lehmann, *Henry Home, Lord Kames, and the Scottish Enlightenment*, The Hague, 1971, p xvii.

agriculture depends not much on theory. If it did, baneful it would be to the human race: skilful practitioners would be rare; and agriculture, upon which we depend for food, would, by frequent disappointments, be prosecuted with little ardour'. Later in the same work, Kames writes 'But admitting experience to be our only sure guide, theory ought not to be rejected, even by a practical farmer'.²⁹ Kames, Home, and Hutton all share a concern to benefit Scotland's rural economy through combining (in Kames' words) 'philosophy with rural practice'. For the first two, the means lay in understanding through practical experience the varieties of that practice: for Hutton rationality as method lay in deductive natural philosophy, in *a priori* theoretical formulation. In this, he was different, too, from the work of John Walker whose means to promoting agriculture as useful science were more directly pragmatic: via university and public lectures, in correspondence with Scotland's farmers, and via tours of the Highlands and Islands with a view to planning their improvement.³⁰ William Cullen's attention to agriculture as both an enlightening part of university medical education and as bound up with '...the elements of chemistry applicable to arts in general' was, like Walker's, promoted via lecture courses.³¹ Hutton never taught others his views on agriculture, though like Cullen and unlike Walker, he learned much from his own farming interests. The point of significance here is to see these intentions as degrees of emphasis within a shared discourse of agriculture as both natural philosophy and useful social practice, not as differences in fundamental purpose.

III

Over 150 folio pages of Hutton's 'Elements' are directly taken up with discussions on soils, and attention is also given to this topic elsewhere—in sections on crop rotation, the chemical bases to fertility and vegetable reproduction. Discussion of soil types and their capacity in natural states or after forms of artificial fertilization to improve agricultural productivity is a central concern of eighteenth-century agricultural scientists, particularly men like Cullen with his chemical lectures, Francis Home's 'chymical principles' and experimentation, or others like Fothergill, Cochrane, and Fordyce.³² Donovan has shown how a concern with philosophical chemistry was an essential component of the rationalizing impulses in the Scottish earth sciences.³³ The chemical and philosophical principles of heat were of central importance, for example, to Hutton's close friend Joseph Black, as well as to William Cullen. All three men were members of the Poker Club and Oyster Club amongst other socio-scientific groups of the time.³⁴ Cullen's focus was on chemistry as part of the materia medica taught to medical students, but it is also true that his agricultural lectures examined agricultural chemistry in detail; the chemical bases to plant nutrition, the chemical means of improving soil quality, and the question of what Cullen termed the 'chief object of Husbandry', obtaining the proper temperature in soils for optimum plant growth.³⁵ Black's studies of

²⁹ H Home, *op cit*, pp 290–91.

³⁰ C W J Withers, 'Improvement and enlightenment: agriculture and natural history in the work of the Rev. Dr. John Walker (1731–1803)' in P Jones, ed, *Philosophy and Science in the Scottish Enlightenment*, Edinburgh, 1989, pp 102–16.

³¹ Withers, *op cit*, (1985); see also A Doig, ed, *William Cullen and the Eighteenth-Century Medical World*, Edinburgh, 1993.

³² A Fothergill, 'On the application of chemistry to agriculture', *Letters and Papers of the Bath Society*, 3rd edn, v, 3, 1791, pp 54–62; A Cochrane, *A Treatise shewing the intimate Connection that subsists between Agriculture and Chemistry*, London, 1795; G Fordyce, *Elements of Agriculture and Vegetation*, Edinburgh, 1765. On the connections between agricultural theory and scientific culture more generally, see Wilmot, *op cit*, pp 31–38.

³³ A L Donovan, *Philosophical Chemistry in the Scottish Enlightenment*, Edinburgh, 1975; Blaxter, *op cit*, pp 2–7; G E Fussell, 'Science and practice in eighteenth-century British agriculture', *Ag Hist*, XLIII, 1969, pp 7–18; Wilmot, *op cit*, pp 31–38; A Clow and N L Clow, *The Chemical Revolution*, 1952, pp 456–514.

³⁴ R G W Anderson, 'Joseph Black' in D Daiches, P Jones, and J Jones, eds, *A Hotbed of Genius: the Scottish Enlightenment 1730–1790*, Edinburgh, 1986, p 93.

³⁵ Glasgow University Library, MS Box 7.3.2, Cullen lecture 2, f 3.

heat during his position as lecturer in chemistry and then as professor of medicine at the University of Glasgow were also part of his agricultural and utilitarian views. Lord Kames considered of Black (who never formally produced an agricultural treatise or lecture programme on the topic) that '...the principles of agriculture will in your hands make one of the most interesting articles of a course of chymistry'.³⁶ Given this social and intellectual context, it is not surprising that Hutton's 'Elements' should contain work on chemistry, in both a practical sense on matters of different manures, for example, and in a more theoretical sense on those notions of 'chymical philosophy', latent heat and heat capacity that so concerned men like Black and Cullen and Francis Home.³⁷ But the attention he paid to soil is only in part understandable as a reflection of wider contemporary concern amongst agricultural writers.

For Hutton, as a deist and someone concerned with final causes, soil was part both of destructive and the regenerative processes informing his theoretical reasoning on earth processes. In the principles of his agricultural thinking and through his observations as a practising farmer, Hutton understood that a soil must be both fertile enough and constantly so to maintain the Earth's final cause as an abode for life. In this georgical view, soil was the means to agricultural production through its fertility. This was widely recognized, although the attention given to soil by Scottish agricultural theorists varied from the classificatory as in Donaldson and Dickson, for example, to its chemical bases as for Home and Cullen, or in what geographically different soil types permitted by way of local agricultural practice as in Wight's survey. For Hutton the soil had profound geological importance as well as georgical significance.

The soil was the conceptual clue to that dynamic model of cyclicity and repair which underlay his *Theory of the Earth*. His 'Elements' bring this conceptual rôle into the rôle of means for the rational practices of everyday farming experience, including his own.

Bailey has considered that Hutton in his geological work '...wrote of the Earth as of a well-managed agricultural estate with a rotation designed to maintain continuing fertility'.³⁸ In his *Theory of the Earth*, Hutton wrote how 'For this great purpose of the world, the solid structure of this earth must be sacrificed; for, the fertility of our soil depends upon the loose and incoherent state of its materials'.³⁹ Over time, however, such sacrifice would lead, without the restorative notion of uplift and repair, to the destruction of life, of which agriculture was part: 'The washing away of the matter of this earth into the sea would put a period to the existence of that system which forms the admirable constitution of this living world'.⁴⁰ In his 'Elements' likewise, Hutton considered 'the constitution of this world has been designed infinitely superior to that of man' and argued, too, that attention to the soil lay at the heart of maintaining (the Earth's) fertility:

He [humankind] chases what shall grow upon the surface of the earth, appropriated for his use; and not content with what the ground is able to produce, this intelligent ruler in the world improves the quantity and quality of his soil in order to increase the natural fertility of the earth; nothing is so much under his disposal as the soil which is to feed the vegetable and animal creation. But this he cannot do without science; and his science he acquires [*sic*] in studying nature...

...Here then in the constitution of this earth, we shall see a final cause for that various and universal production of soil by means of which there is a bounteous provision made for such a diversity of organised living bodies.⁴¹

³⁶ Edinburgh University Library, MS Gen. 873/1/83-84.

³⁷ For Hutton on botanical and chemical philosophy and the vegetating heat of soils, see 'Elements', ff 157-91, 346-50.

³⁸ E B Bailey, *James Hutton — the Founder of Modern Geology*, 1967, pp 6-7.

³⁹ Hutton, *Theory*, II, 1795, p 89.

⁴⁰ Hutton, *Theory*, I, 1795, p 510.

⁴¹ 'Elements', ff 51, 52-3.

For Hutton as agricultural and geological theorist, the soil had a central importance as part of the cyclical restoration of the Earth, in terms of the growing season and over 'deep time'. For Hutton, the eighteenth-century improvement philosopher, the notion of proper constitution also extended to ideas of political economy: 'Let us never lose sight of this great principle, that the produce of the earth is the means of population, and the bond of union to a people. Let us not forget that while the husbandry of a country is promoting the prosperity of the state, there is a reciprocal duty which the state owes to the husbandry of the country'.⁴² For Hutton, '...the art of Agriculture promotes the social state of human society, and sows the seeds of order, empire, government'.⁴³ Early in his 'Elements' he argued how, through the scientific improvement of agriculture '...the natural and social state of a country, becomes rich and the political state becomes strong. How much then is it the interest of the governing power to encourage that art by which it is to be so well supported!'.⁴⁴ Similar sentiments are echoed by his close friend Adam Smith who considered in his *Wealth of Nations* (1776) how '...the complete improvement and cultivation of the country...was the greatest of all public advantages'.⁴⁵ In this context, Hutton's 'Elements' were a reflection of that more widespread concern with agricultural advance as an essential element both of a nation's economy — 'the first of all political objects' as Sir John Sinclair termed it⁴⁶ — and of individual's betterment. Kames saw in agricultural improvement a moral economy: 'agriculture is of all occupations the most consonant to our nature; and the most productive

of contentment, the sweetest sort of happiness'.⁴⁷ Yet for Kames, Francis Home, James Donaldson, Adam Dickson and others as for Hutton, the political economy of improvement was usually seen as the end in view, for agricultural philosophers and practising husbandmen both. Similarly, the metaphors of cyclicity and natural fertility, and the dependence of geological and georgical theorization upon them were not lost upon contemporaries like Smith, whose own focus was more upon human activity and natural productivity in order to gain useful reward: 'The most important operations of agriculture seem intended not so much to increase...as to direct the fertility of nature towards the production of the plants most profitable to man'.⁴⁸

IV

This paper set out to examine the unpublished agricultural manuscripts of one of the most influential of all earth scientists. Several points may be made in conclusion. The notions of decay and repair were central to James Hutton's *Theory of the Earth* and the Earth's final purpose as the abode of humans and a basis to agriculture. For Hutton, 'This is the view in which we are now to examine the globe; to see if there be, in the constitution of this world, a reproductive operation, by which a ruined constitution may be again repaired, and a duration or stability thus procured to the machine, considered as a world sustaining plants and animals'.⁴⁹ In his 'Elements of Agriculture' and in the attention paid to soils and to the deductive establishment of rational principles (theory), it is possible to see in the work of one man a particular expression of that general intellectual alliance between agriculture and the earth sciences that was

⁴² 'Elements', ff 697–98.

⁴³ 'Elements', f 688.

⁴⁴ 'Elements', ff 22–23.

⁴⁵ A Smith, *The Wealth of Nations*, edited and with an introduction by A Skinner, Harmondsworth, 1986, p 334.

⁴⁶ J Sinclair, *An Account of the Systems of Husbandry adopted in the more improved districts of Scotland*, 2 vols, Edinburgh, 1813, I, p vii.

⁴⁷ H Home, *op cit*, p xvi.

⁴⁸ Smith, *op cit*, p 462.

⁴⁹ Hutton, *Theory*, 1788, I, (2), p 216. Quoted in Davies, *op cit*, p 171.

central to discourses upon agrarian improvement in eighteenth-century Scotland. As an agricultural philosopher, Hutton was one of many arguing for the need to adopt rational principles in agrarian management, and the contents of his 'Elements' reflect the subject matter dealt with by a wide range of contemporary agricultural writers. Quite how differently his peers considered improvement and utility to be understood in terms of agricultural knowledge has been reviewed above: Walker was practical, agriculture's didactical promoter; Cullen, like Francis Home, a theorist upon the chemical principles necessary for the better management of Scotland's husbandry. Others shared similar notions on Scotland's improvement and expressed them in texts, institutional membership, and practical management. This would suggest a strong continuity in the ideology of improvement and in the place of agriculture as useful science, but vari-

ation in the material forms taken in promoting and sustaining that belief.

Hutton's 'Elements of Agriculture' should be properly considered, however, as a profoundly theoretical survey rather than advance via practical observation, lecture course, or comparative survey. Like his contemporaries, Hutton viewed the utility of agricultural advance as its final purpose, the ultimate cause. The systematic relationships he explored between soil, climate, seed and labour in his 'Elements' were to understand better what he called agriculture's 'end in view' in serving the human race. In his geological thinking, the *a priori* characteristics underlying the cyclical model and theory he advanced were also concerned with the same final cause: the Earth as the abode of humans. Such connections demonstrate, however briefly, the complexity of those agencies underlying the development of a scientific agriculture in eighteenth-century Scotland.

Notes and Comments

FIRST GUIDE TO THE HISTORY OF TECHNOLOGY IN EUROPE

This essential companion to the study of the history of technology has been published by the Science Museum. It lists about 800 individual researchers, 600 institutions, and 130 journals within a relatively new discipline. Researchers are grouped by academic interest: the guide provides the means to survey the field as well as look up names, addresses, telephone, fax and E-mail numbers. Relevant libraries, museums and universities across Europe are included as well as key journals. Individual entries can be located using the indices. Copies are available price £8.00 from Dillons at the Science Museum, Exhibition Road, South Kensington, London SW7 2DD, Tel 071 938 8355. Sterling cheques should be made payable to Dillons Bookstores. Dillons accept Mastercard, Visa and American Express cards.

XIXth INTERNATIONAL CONGRESS OF THE HISTORY OF SCIENCE

The International Union of History and Philosophy of Science, Division of History of Science will be

holding its XIXth Congress on 22-29 August 1994 in Spain, at the University of Zaragoza. Further details of this meeting can be obtained from the Congress Office, Facultad de Ciencias (Matemáticas), Ciudad Universitaria, 50009 Zaragoza (Spain), Tel. 34-76-35 7180, Fax 34-76-56 5852, Telex 58198 EDUCI-E, E-Mail ICHSA@cc.UNIZAR.ES

1994 CONGRESS ON THE HISTORY OF VETERINARY MEDICINE

The 1994 Congress on the History of Veterinary Medicine will be held in Copenhagen on 21-25 August. Further details can be obtained from Dr Peter Koolmees, Faculty of Veterinary Medicine, Utrecht University, P.O. Box 80.175, 3508 TD Utrecht, The Netherlands Fax 31-30 532365.

THE 1994 SPRING CONFERENCE

The 1994 Spring Conference will be held at Trevelyan Hall, University of Durham organized

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