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‘Man is But a Worm’
History, Ecology and Invertebrate Agency: A study of the environmental impact of the earthworm in natural and human history 1881-1992

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‘Man is But a Worm’

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Introduction

Figure 1. 'Man is But a Worm', *Punch's Almanack* (6th December 1881), London, Wellcome Library.

Shortly before the death of Charles Darwin in 1882 *Punch Magazine* printed an image referencing his most famous legacy, the theory of the origin of species. The picture satirically expressed the evolution of humans from earthworms, representing 'chaos', in the bottom left, to Darwin, as 'modern, civilised' man, sitting in 'Father Time's chair at the centre. The magazine mocked the eminent naturalist for becoming preoccupied in his later years with an 'obsessive' study of the 'humble' earthworm. Darwin's 1881 treatise on '*The Formation of Vegetable Mould through the Action of Worms with Observations on their Habits*' was the first work to study earthworms so intimately and at such length. It was also, in its time, a

greater commercial success than his 1859 publication *On the Origin of Species*.[1] Darwin raised the profile of earthworms considerably, asserting that 'worms have played a more important part in the history of the world than most persons would at first suppose'.[2] However, the work's popular appeal was fleeting. The earthworm remained physically detached from people, restricting its cultural reach. [3] It was (and remains) a creature of the soil in an age of industrialism and chemistry. Amongst the contemporary scientific community Darwin received a mixed reception, which delayed the vocational significance of his work.[4] Today, the treatise, like its animal protagonist, is largely ignored, with the exception of soil scientists, and even they now believe that Darwin overstated the earthworm's role in global natural history.[5] Nonetheless, 'The Formation of Vegetable Mould' had a significant impact on the profile of the earthworm in the twentieth century. Earthworms became a legitimate subject for scientific research, if one that remained under-exploited. Darwin's work has been considered the *tour de force* on the subject of oligochaetology and a pioneering work in the soil sciences.[6] However, perhaps for reasons of methodology, earthworms have been ignored as a subject for historical research.

This dissertation asks how earthworms shaped twentieth-century human history as 'independent ecological agents', their own natural history transcending human history and analyses two case studies to achieve this aim. Agency is a term riddled with varied assumptions and many historians assert that it can only be applied to the human species. According to William Sewell, drawing upon ideas from Bruno Latour, to have agency 'means being capable of exerting some degree of control over the social relations in which one is enmeshed, which in turn implies the ability to transform those social relations to some degree'.[7] Because animals are unable to directly transform human structures, according to

[1] D. Quammen, *Flight of the Iguana: A Sidelong View of Science and Nature* (London, 2012).
[2] C.R. Darwin, *The Formation of Vegetable Mould through the Action of Worms with Observations on their Habits* (London, 1881/1945), 145.
[3] D.R. Montgomery, *Dirt: The Erosion of Civilizations* (Berkeley, 2007), 9-14.
[4] O. Graff, 'Darwin on earthworms – the contemporary background and what the critics thought' in J.E. Satchell (ed.), *Earthworm Ecology: From Darwin to Vermiculture* (London, 1983), 5-18.
[5] C. Feller, G.G. Brown, E. Blanchart, P. Deleporte and S.S. Chernyanskii, 'Charles Darwin, Earthworms and the Natural Sciences: various lessons from past to future', *Agriculture, Ecosystems and Environment*, vol.99, no.1 (Oct 2003), 29-49.
[6] Oligochaetology – see glossary p.32.
[7] W.H. Sewell, 'A Theory of Structure: Duality, Agency and Transformation', in W.H. Sewell, *The Logistics of History: Social Theory and Social Transformation* (Chicago, 2005), 143.

Sewell they cannot be historical agents.[8] However, animals have been present in and impacted upon human history, not as commodities (objects) but as living creatures (subjects), and are written about and presented in a multitude of sources. This paper forms part of a growing literature suggesting that the definition of agency should be expanded to include non-human organisms, emphasising their influence upon their environment. 'Agency' and 'influence' are used synonymously throughout the work. The dissertation redefines Sewell's definition so that to be an agent means 'to be capable of exerting some degree of control over the *environmental conditions* in which one is enmeshed, which in turn implies the ability to transform the inter-species relations *connected with that environment* to some degree'. It discounts any existing requirement of historical consciousness and calls for an ecological approach to history, recognising environmental change as being at the centre of human and non-human experience. Specifically, it suggests that a multi-disciplinary methodology should be undertaken: ecological analysis of the physical impact an organism has on its environment, embedded within historical analysis of anthropogenic sources connected with that ecological change.

Integrating animals into the discipline of history requires a fundamental rethinking of the traditional divisions between natural history and the humanities as well as the epistemological divisions between 'nature' and 'culture'. The prevailing view in animal studies is that the only way to successfully integrate animals into history is via representation, by analysing human representations of and discourse on animals and our relationships with them.[9] This principle is however flawed on the premise that historical representation is an insufficient medium in which to present animals as independent agents. By 'representing' animals human perception remains central, the animal is lifted from its environmental context and the physical identity of the 'real animal' is lost. Non-human animals should be seen as historical actors of environmental process and agents of ecological change, rather than postmodern symbols within an anthropocentric historical narrative.

One of the fundamental methodological problems animal historians face is in communicating animal agency. Some have tackled this problem by writing 'histories from below', focusing upon two interconnected factors: agency and class. The problem with such histories is that

[8] D. Brantz, 'Introduction', in D. Brantz (ed.), *Beastly Natures: Animals, Humans and the Study of History* (Charlottesville, 2010), 3.
[9] Brantz, 'Introduction', 5.

animals continue to be perceived using anthropogenic linguistic constructions, entities foreign to animal capacities. Jason Hribal has argued that in such histories the agents (the animals) 'dissipate into a vacant, theoretical category', rather than being presented as living, biologically complex organisms.[10] Another method to 'access' animal agency was proposed by Gilles Deleuze and Felix Guatteri in 1987, who argued that humans should 'become animal' when writing animal studies.[11] Deleuze and Guatteri suggested that human-animal relationships should be based more on 'affinity' than 'identification, imitation or resemblance' and should therefore reflect a sense of 'mutual similarity'.[12] 'Becoming animal' means an undoing of identity, dealing with anthropocentrism by removing the human from the agenda.[13] However, despite positive intentions, this approach is methodologically dubious. The problem lies in insufficient interdisciplinary approaches to methodology. Through integrating ecological methods in their study, animal historians can observe the physical impact animals have on their environment and explain the physical and environmental reasons for animal action, better placing them as agents of environmental change in human history.[14] Sources should be analysed with regards to the human response to such objectively observed environmental influence. Using this methodology makes analysis of non-human animal influences on human history more objective, excluding neither human nor animal and moving away from Aristotelian notions of intellectual hierarchy in describing and perceiving nature.[15] Ecological animal histories offer an innovative interpretation of understanding the past, bridging the gap between empiricism and post-structuralism.

The dissertation aims to raise the profile of the earthworm, an ecologically important yet largely ignored animal, and asks how earthworm ecological agency affected human land management practices between 1881 and 1992. The principle focus of the dissertation is on methodology, not chronology. However, the chronological parameters should be explained. The publication of Darwin's treatise in 1881 expanded the profile of the earthworm like never before and inspired earthworm research. In 1992 the British government banned the

[10] J.C. Hribal, 'Animals, Agency, and Class: Writing the History of Animals from Below', *Human Ecology Review*, vol.14, no.1. (2007), 102.
[11] G. Deleuze and F. Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, trans. B. Massumi (Minneapolis, 1987).
[12] L. Kalof, *Looking at Animals in Human History* (London, 2007), 161.
[13] S. Baker, 'What Does Becoming-Animal Look Like?', in N. Rothfels (ed.), *Representing Animals* (Bloomington, 2002), 68.
[14] See R.W. Sims and B.M. Gerard, *Earthworms* (London, 1985); C.A. Edwards, 'Earthworm Ecology in Cultivated Soils', in J.E. Satchell (ed.), *Earthworm Ecology: From Darwin to Vermiculture* (London, 1983).
[15] J. Serpell, *In the Company of Animals: A study of human-animal relationships* (Cambridge, 1996).

application of the organochlorine chlordane in turf environments, ending earthworm 'ecocide' on the sports field, a key subject in this paper and therefore a relevant temporal boundary.[16]

Earthworms have been little touched upon historically. Jerry Minnich stands alone in writing a general history of the earthworm although his work is more descriptive than analytical, writing as a horticulturalist, not an historian.[17] Janelle Schwartz has written an extensive historical work linking eighteenth and early nineteenth century discourses of decay and generation in romantic literature with natural history explorations of the biological properties of worms.[18] Further, geologist David Montgomery, entomologist Mercury Ghilarov and zoologist Otto Graff have all engaged to some extent in discussing attitudes towards Darwin's work on an historical level.[19] However, there has been nothing written suggesting earthworm 'agency' in human history, which highlights a cultural distance from the soil. Their greater study within the field of animal history would enable improved insight to the changes in human distance and attitudes towards the soil and soil ecosystems, a phenomenon vital to understand if humans are to place sufficient value on soil systems in the future, the ultimate source of future food security: a critical concern for an increasing human population.

The two main chapters in this paper explore specific earthworm case studies, practising the 'ecological historical' methodology outlined above. Earthworms, as soil agents, have ecologically impacted below and above the ground and both phenomena are assessed, firstly in organic agriculture and horticulture and secondly in golf course management. The source base is diverse in each section, primarily using pamphlets, articles and letters relating to earthworm activity. Sources in the 'organic' case study include articles from *Mother Earth*, the journal of the Soil Association, as well as Albert Howard's 'rival' journal *Soil and Health* and its successor *Health and the Soil*. Greenkeeping handbooks form the basis for the chapter regarding earthworm agency above the ground. In both cases the ecological activity of

[16] See A.R. Thompson, 'Effects of nine insecticides on the numbers and biomass of earthworms in pasture', *Bulletin of Environmental Control Toxicology*, vol.5, no.6 (1971).; M.E. Cook and A.A.T. Swait, 'Effects of some fungicide treatments on earthworm populations and leaf removal in apple orchards', *Journal of Horticultural Science*, vol.550 (1975).

[17] J. Minnich, *The Earthworm Book* (Emmaus, 1977).

[18] J.A. Schwartz, *Worm Work: Recasting Romanticism* (Minneapolis, 2012).

[19] Montgomery, *Dirt*; M.S. Ghilarov, 'Darwin's Formation of Vegetable Mould – its philosophical basis', in J.E. Satchell (ed.), *Earthworm Ecology: From Darwin to Vermiculture* (London, 1983), 1-5; Graff, 'Darwin on Earthworms'.

earthworms is outlined alongside analysis of relevant historical sources, allowing for a combination of ecological and historical methodologies.[20]

Earthworm agency 'below the ground' (the subject of the first case study) had significant repercussions in human activity. In the 1930s and 1940s research as to the earthworm's capacity for inducing soil renewal expanded, based on the ideas Darwin had highlighted. Earthworms suited the cause of organic pioneers such as Albert Howard, becoming political symbols for organic methods whilst remaining independent 'ecological agents'. Organic practitioners' awareness of earthworm influence differed from that of the audience of Darwin's treatise because of their contrasting agendas. Instead of simply reading about earthworm impacts, organic practitioners physically connected with earthworms, harnessing their 'agency' whilst recognising their ecological role. As this 'return to the soil' took place, human actors connected with earthworms, becoming agents in earthworm histories and harnessing them as 'man's best friend'.[21]

The second chapter scrutinises earthworm agency 'above the ground' and focuses specifically upon castings (bioturbation) and the reaction from sports greenkeepers.[22] The key sources analysed in this chapter are British and American 'greenkeeping' handbooks, written circa 1910-1928. [23] Greenkeepers were concerned because of the unappealing aesthetic of castings and the practical problems they created for golfers. Although the focus in this chapter is on golf, worm killing was undertaken in a number of lawn sports from croquet to tennis and polo.[24] From the nineteenth century scientific and technological research gave humans greater influence over ecosystems once out of reach, including soil environments. Greenkeepers used chemicals to 'control' earthworm influence by preventing it, removing earthworms when their 'agency' did not complement human activity and becoming 'masters over life and death' in the process.

This dissertation is pioneering in writing earthworms into history but critically also argues a case for a new methodology in animal history, focusing on a post-postmodern deconstruction

[20] See C.R. Darwin, *The Formation of Vegetable Mould through the Action of Worms with Observations on their habits* (London, 1881/1945); C.A. Edwards and J.R. Lofty, *Biology of Earthworms* (London, 1972).
[21] Minnich, 'The Earthworm - Man's Best Friend', 127-129.
[22] Worm castings are the excreted materials of earthworms, often forming a viscous structure on the soil surface.
[23] See R. Beale, *The Practical Green Keeper* (London, 1908); P.W. Lees, *Care of the Green* (New York, 1918).
[24] J.R. Escritt and J.H. Arthur, 'Earthworm Control- a resume of methods available', *Journal of the Board of Greenkeeper Research*, vol. 7 (1948).

of the boundaries between natural and human histories. Animal historians need to be ecologically aware of the wider implications of their work and the paper further raises awareness of the dangers of speciesism, anthropomorphism, 'becoming animal' and wider society's neglect of soil systems, healthy soils being vital components for a flourishing human civilisation. Earthworms have been ignored by historians, reflecting wider attitudes within human society towards life in the pedosphere. Erica Fudge has written that 'for a history of animals to be distinctive it must offer what we might call an ''interspecies competence''; that is, a new way of thinking about and living with animals'.[25] Ecological histories, drawing upon Fudge's 'holistic history', offer a method to achieve this, especially used as a tool within the growing sub-discipline of animal history. The dissertation raises awareness of earthworm agency as a fundamental part of human experience, integrating the animal into human history and the human into animal history, returning humans to nature.

[25] Fudge, 'A Left Handed Blow', 11.

Chapter 1

'Man's Best Friend'?

Agriculture, Horticulture and Ecological Impacts within Soil Systems

Initial praise for Darwin's earthworm treatise was limited. Russian soil scientist Vasily Dokuchaev, commonly acclaimed as 'the father of pedology', discounted Darwin's findings in his 1883 thesis on the Russian Chernozem soils, regarded as a founding work in the discipline of soil science. He considered Darwin's observations as either 'exaggerated' or as 'having only local significance'.[26] His observations in the Russian steppe region, where earthworm activity is rarely evident, did not match Darwin's English account and therefore his critique was negative. Darwin received little more support in Europe. The German soil scientist Ewald Wollny reviewed the German translation of Darwin's treatise in 1882 and concluded:

> 'Summarized, what has been said above, shows that the author has by far overestimated the role which worms have played and are still playing in the formation of vegetable mould. He relies far too much on the prejudices of gardeners and farmers.'[27]

It is specifically those 'prejudices of gardeners and farmers' that this chapter will analyse. It looks at both the ecological impact of earthworms within the soil and the human response to that impact, arguing that earthworms became 'agents' in human history through a human recognition of their capacity to influence soil profiles.

In 1945 Faber and Faber republished Darwin's earthworm treatise and asked the agricultural scientist and organic pioneer Sir Albert Howard to write the introduction for the new edition. The timing of the publication was astute due to renewed interest in 'alternative' approaches to land management, promulgated by Howard and others. This 'paradigm shift' towards organics resulted from the mistrust of some scientists towards 'chemical approaches' to agriculture and horticulture.[28] Howard himself noted his delight of 'reintroducing' Darwin's work:

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[26] Ghilarov, 'Darwin's Formation of Vegetable Mould', 1.

[27] E. Wollny, 'Besprechung von Charles Darwin ''Die Bildung der Ackererde durch die Tätigkeit der Würmer'' deutsch von V. Carus, Stuttgart 1882', *Forschungen auf dem Gebiete der Agriculturphysik*, vol.5 (1882), 50-55.

[28] See P. Conford, *The Origins of the Organic Movement* (Edinburgh, 2001).

> 'At a period when present-day agricultural and horticultural teaching and research are being critically examined with a view to their speedy reform, only good could result from the republication of the results of some forty years observation, experiment and thought devoted by our greatest naturalist to the part played by the earthworms in the history of the world.'[29]

The work inspired a new generation of farmers, already aware of Howard's work. This younger generation were willing to explore new methods, particularly, in this case, by exploiting earthworm activity to increase soil fertility. Agricultural student J.K. Wheatley was one such pioneer on whom the republication impacted, expressed in a letter to Howard in 1946:

> 'I have recently read the new edition of Darwin's book which, with your most interesting introduction, gives meaning to many personal observations. On this farm, where I am a student, heavy dressings of fertilizers are used, but earlier experiments with artificials and compost have given me no reason to approve of this...What strikes me is that farmers mostly ignore the earthworm. Some credit it with ability to keep the soil open, but none mention its effect upon the chemical content of the soil.'[30]

Wheatley's letter supports the argument that, in the early to mid-twentieth century, soil biology was side-lined in agricultural science, in favour of soil chemistry and physics. This trend resulted from an industrial revolution in agriculture which took place in the nineteenth century, the views of chemists such as Justus von Liebig being heralded above those of biologists such as Darwin. The organic movement was a counter revolution to the 'high farming' industrial agricultural revolution of the nineteenth century, critically engaging with the importance of 'humus' in plant growth and soil health, a material discounted by Liebig and his disciples. Darwin's earthworm treatise heavily influenced Howard's work because of the relationship it drew between earthworms and humus, suggesting that there was an alternative to the 'chemical agriculture' being imposed by the agricultural research institutes and colleges.

Darwin asserted that earthworms have significant biological and physical effects on soil ecosystems. Different species, of which there are around three thousand globally (28 in Britain), are present in different soil profiles and are generally divided into four groups:

[29] A. Howard, 'Introduction', in C. Darwin, *The Formation of Vegetable Mould through the Action of Worms with observations on their Habits* (London, 1945), 1.
[30] J.K.W. Wheatley, 'Correspondence: Darwin on Humus and the Earthworm', *Soil and Health*, vol.1, no.3 (Autumn 1946), 175.

compost worms, epigeic worms, endogeic worms and anecic worms.[31] Together they provide key ecosystem services. Firstly, they ingest and decompose plant litter. Secondly, they mix and turn soils within the soil profile, thus helping to maintain weathering by repeatedly introducing soil materials to new weathering environments. Thirdly, they produce castings and partially digested material, that not only stabilise soil aggregates but are stable substances themselves, containing concentrations of many nutrients vital for germination and plant growth.[32]

Understanding these ecological impacts clearly had a profound influence upon Howard. As a soil scientist, he recognised the role of earthworms as a major actor of environmental change within soil ecosystems. Howard was determined to raise awareness of their impact on soil chemistry and physics, suggesting that it had the potential to ground organics in something other than the 'muck and magic' it was accused of being. As Philip Conford has written, 'that the organic movement is 'anti-science' has been a criticism levelled by its opponents since its earliest days. 'Muck and Magic' is the most familiar of the phrases which proponents of 'progressive', 'efficient' industrial agriculture have used to dismiss organic husbandry's claim to any serious consideration'.[33] Scientific study of the earthworm, shown especially through the work of Darwin, offered an opportunity to ground the work of organics in biology and ecology; one reason why Howard was so enthusiastic about the republication of Darwin's work in 1945.

Howard's ambition was to shift the focus of agricultural research, and ultimately practice, from an 'NPK mentality' to recognition of soil as 'a vast biological complex in which myriads of active organisms are competing with one another for the available supplies of food material'.[34] For Howard, earthworms, as 'active organisms', played a part in forging this paradigm shift in food production methodology. A number of organic practitioners answered Howard's call and bred earthworms to mix their compost. R.B. Canever from Hampshire, a prolific earthworm breeder, argued for 'intensive earthworm breeding' in Britain. He contended that, on all scales of farming or gardening, the influence earthworms have on the soil could be exploited to increase both the rate of breakdown and the overall amount of

[31] See appendix 4 for full explanations of these ecotypes.
[32] D. Briggs, *Soils* (London, Butterworth, 1977), 150.
[33] P. Conford, 'Science, Organic Husbandry and the Work of Dr David Hodges', *Agricultural History Review* vol.59, no.11 (2011), 217.
[34] A. Howard, 'The Work of the Soil Population', *Soil and Health*, vol.2, no.1 (Spring 1947), 3.

organic matter in soils. He called on Soil Association members to 'domesticate' earthworms for human benefit:

> 'By using domesticated earthworms in boxes or compost beds, even the smallest amounts of organic waste can be converted satisfactorily into perfect organic fertilizer. Even the flat-dweller growing lettuce in a window-box, or tomatoes in pots on a veranda, can thus utilize his kitchen waste.'[35]

However, Canever's vision and interest was rare. Despite Howard's determination to base organics in science through earthworm research, organic writers did not explore the path sufficiently to ground organic agriculture in 'scientific' earthworm experimentation. Despite the Soil Association's insistence that the earthworm was 'a creator of soil fertility without equal', earthworm research received very little prominence in the Soil Association journal *Mother Earth*.[36] In all publications of *Mother Earth*, from its founding in 1946, only twenty six articles and letters contained references or material related to earthworms.[37] Further, eighteen of the references to earthworms in *Mother Earth* were concentrated between spring 1947 and summer 1952, after which the earthworm is rarely mentioned, suggesting its study diminished as the organic movement moved away from the agendas of its pioneers, Balfour and Howard. Albert Howard's journal *Soil and Health* contained four articles in the eight publications it ran for, ceasing publication upon Howard's death in October 1947 and evolving into *Health and the Soil*.

Some organic magazines were careful to disregard the language that lent itself to the labelling of organic proponents as 'practitioners of muck and magic'. Arthur Campbell, the editor of *Health and the Soil* was particularly wary of this. For the 'Highland Show Special' of 1955 he commissioned W.J. Guild, a biologist at Edinburgh University, to write an article supporting ideas of earthworm ecology as being beneficial to the soil, giving credence to organic proponents for embracing the earthworm, as Howard had wished. Guild's independence as a scientist helped *Health and the Soil* forge a credible reputation, crucial for organics to be taken seriously within the scientific community. He summarised the earthworm's 'varied role' in the soil, declaring that:

> 'There is little space here to detail the activities of the earthworm as a soil agent or to discuss its effects, but by the very nature of its activities, i.e. burrowing, casting and turning-over of soil, ingesting and speeding the

[35] R.B. Canever, 'Can Domesticated Earthworms Help the Small Composter?', *Mother Earth*, vol.4, no.2 (Spring 1950), 48.
[36] E.B. Balfour, 'An Acquaintance worth cultivating', *Mother Earth*, vol.3, no.1 (Winter 1948-1949), 45-46.
[37] See appendices.

> breakdown of organic matter, the earthworm group must have a profound effect upon the ecology of the soil, and it is difficult to see how they can be anything but mainly beneficial.'[38]

Guild's mentioning of the earthworm as 'a soil agent' suggests that earthworms were regarded by contemporary biologists as critical members of soil ecosystems, despite being disregarded by 'conventional' agricultural scientists, who were heavily influenced by chemists. The association between Guild, earthworms, *Health and the Soil* and the wider organic movement, helped lift earthworms into wider debate on the nature of agriculture and therefore allowed the subject to transcend the historical-ecological boundary, affirming earthworms in human history as ecological agents.

'Scientific' understanding of earthworm influence was particularly profound in dividing land management policy of 'conventional' and 'organic' practitioners, placing earthworm agency at the very centre of the debate regarding the nature of agricultural science and practice. The two camps in this debate were polarised by 1939. The 'conventional' lobby discounted the role of soil fauna as a 'minor element' in soil processes, despite the contemporary understanding that earthworms themselves alter the chemical profile of the soil. In an essay written in 1939 J.A. Scott-Watson, a 'conventionalist', argued for a 'chemical' approach to soil management and stated that 'we have now so large a body of scientific knowledge about the chemistry of soil fertility that the farmer, in his efforts to produce better crops, can and does rely very largely upon the chemist.'[39] Clearly, knowledge of soil chemistry aided contemporary agricultural management but the political proclamation of 'chemistry as king', a consequence of Liebig's preaching in the age of 'high farming', side-lined soil biology and ostracised patrons of agricultural systems governed by soil biology and ecological management.

Further support for a 'chemical approach' came from the Director of the Rothamsted Research Station Sir Edward Russell. However, he was not so forthright in his conclusions. Russell acknowledged that 'the most serious problem of modern times is the destruction of soil fertility' and wrote that 'a close watch must be kept on the lime status of the soil because of the great importance of maintaining a high preponderance of calcium in the cations of the

[38] W.J. Guild, 'Earthworms and the Soil', *Health and the Soil*, vol.4, no.2 (Highland Show Special 1955), 56.
[39] J.A. Scott-Watson, 'The Art of Husbandry', in A.W. Ashby (ed.), *Agriculture in the Twentieth Century: essays on research, practice and organization to be presented to Sir Daniel Hall* (Oxford, 1939), 126-127.

clay and of the humus'. [40] However, he ignored the 'evidence' provided by organic practitioners and Darwin, that the earthworm, as an ecological agent, fixes this problem through the secretion of alkaline material from its calciferous glands, in effect liming the soil.[41]

Organic practitioners similarly failed to recognise earthworm research from 'conventionalists'. From the late 1950s it was known that high doses of inorganic nitrogenous fertilizers (applied by 'conventional' farmers) favoured earthworms, particularly species that live close to the surface, due to a subsequent increase in plant biomass and, upon death, an increase in the amount of decomposed organic matter available, returning carbon to the soil and boosting earthworm populations.[42] Organic proponents claimed that all inorganic fertilizers were harmful to earthworm populations, without evidence, for many years before and after this 'discovery'. Not until 1959, referencing a contemporary article by J.E. Satchell of the Nature Conservancy, did the Soil Association acknowledge that not all inorganic fertilizers are harmful to earthworm populations, stating that 'the effect of fertilisers is considered to depend on whether they increase or decrease soil acidity'.[43] Albert Howard had long argued that 'chemical' agriculture 'murdered the earthworm' and that conventional agriculture provided 'no effective substitute' (for healthy food production). [44] However, he never experimented regarding the effects on earthworm populations of applying inorganic nitrogen to the soil. By the 1950s earthworms had become a cultural and political symbol for organic methods. The realisation in the 1960s and 1970s that applying inorganic nitrogen to soils actually benefited earthworm populations significantly affected the number of references to earthworms in organic journals.[45] It was not until the late 1970s that the Soil Association once again included articles on earthworms in official literature.[46]

[40] E.J. Russell, 'Soil Science in England 1894-1938', in A.W. Ashby (ed.), *Agriculture in the Twentieth Century: essays on research, practice and organization to be presented to Sir Daniel Hall* (Oxford, 1939), 184.
[41] Darwin, *The Formation of Vegetable Mould*, 36-39.
[42] Edwards, 'Earthworm Ecology in Cultivated Soils', 133.
[43] J.E. Satchell, 'Earthworms and Soil Fertility', *Mother Earth*, vol.10, no.5 (January 1959), 444.
[44] A. Howard, *Farming and Gardening for Health or Disease* (London, 1945), 80.
[45] See S.P. Davey, 'Effects of chemicals on earthworms. A review of the literature', *Special Scientific Report*, Wildlife, no.74 (USA Fish and Wildlife Service, 1963).
[46] J.G.B. Vivian, 'Earthworms and the Gardener', *Soil Association Quarterly Review*, vol.1, no.1, (September 1975), 8-10; R.H. Averley, 'Gardening with Earthworms', *Soil Association Quarterly Review*, vol.3, no.3 (September 1977), 14-15.

Following the publication of Rachel Carson's *Silent Spring*, increasing amounts of research were carried out regarding the influence of pesticides on soil ecology. Pesticides have different effects on earthworm populations to those of most fertilizers. For example, it has been shown that copper fungicides are toxic to earthworms and some herbicides, including chlorpropham and triazine, decrease earthworm populations to an extent.[47] Of the organochlorine insecticides, chlordane, which will be explored in detail in the next chapter, is severely toxic to earthworms. However, aldrin, dieldrin, dichlorodiphenyltrichloroethane (DDT), heptachlor and endrin have little effect.[48] Organic proponents recognised this but, again, did not carry out scientific research to back up their claims. In the USA Jerome Rodale claimed that DDT was 'instant death' to earthworms, but supplied no supporting data to back up his claim.[49] Claims such as this kept 'conventional' scientists sceptical as to the legitimacy of organic methods with, for example, Dr Thomas Dukes, Professor of Medical Physics at the University of California, Berkeley branding organic farming a 'shabby fraud' and 'off grade junk', labelling DDT 'the safest of all pesticides'.[50] Earthworms were caught within a polarised political debate about the possibilities of soil biology in agriculture. Whilst invertebrate populations suffered due to excessive pesticide applications, politics governed the agenda. With 'conventionalists' claiming the 'science' brand and controlling the major agricultural research institutes as well as state funding, it was difficult for proponents of soil biology to argue a case for shifting the emphasis of agricultural science from chemistry to biology.

The international organic lobby was far from united as to the scientific 'truth' behind earthworm impact in the soil. Percy Wright, an organic nurseryman from Saskatchewan, was prominent in his attacks of supporters of earthworm ecological impact. He argued that earthworm influence was harmful to the soil because 'humus is released too suddenly in a soil in which the earthworm is active and that because of this suddenness, there is a percentage of leaching and waste which could have been avoided.'[51] Further critique came from *Soil Magazine* editor S Marian who argued against the orthodox view of the compost

[47] Edwards and Lofty, *Biology of Earthworms*, 181.
[48] Edwards and Lofty, *Biology of Earthworms*, 182-183.
[49] Edwards and Lofty, *Biology of Earthworms*, 183.
[50] T.H. Jukes, 'Scientific Agriculture at the Crossroads', *Nutrition Today*, vol.8, no.1 (January/February 1973), 31.
[51] J.H. Burman, 'Is the Earthworm and Enemy', *Mother Earth*, vol.9, no.9 (January 1957), 798.

school, claiming that worm castings actually reduced soil fertility and that earthworms caused more problems in the soil than they offered benefits.[52]

Wright and Marian's views were rare within the organic lobby but noting their existence is important as it suggests that disagreements regarding earthworm soil agency did not just rest on agricultural political persuasion. Through the twentieth century, earthworms were propelled from a soil animal studied by few naturalists to a species associated with a particular agricultural paradigm. Organic supporters claimed earthworms as a political symbol for their own philosophy, although this claim was arguably based more on metaphysics than objective scientific study. Further, not all organic supporters were interested in earthworm influence and Howard failed in his attempts to fully ground organics in active scientific research. Nonetheless, earthworms' association with the wider debate regarding the role of soil biology in food production lifted them into human history as independent ecological agents. Earthworm research ultimately suffered due to the animal's association with the politicisation of food production. Nonetheless, it was only as a result of the counter-revolution to soil chemistry in the form of the organic movement, that earthworms were recognised as soil agents 'worthy' of study. They were lifted from the subject of an unorthodox obsession of an elderly naturalist, albeit the naturalist who suggested the theory of the origin of species, to an animal at the forefront of the counter-revolution against the 'conventional' agricultural paradigm. Such recognition ultimately changed attitudes regarding human land management philosophies, albeit governed more by politics than by ecological data.

[52] S. Marian, 'The Earthworm as Gardener', *Soil Magazine*, vol.10 (November 1949), 18.

Chapter 2

Earthworm Ecocide:

Golf Courses, 'Pest' Management and Ecological Impacts above the Soil Surface

Figure 2. 'Watering in the Earthworm Irritant', R. Beale, *Lawns for Sports: Their Construction and Upkeep* (London, 1924), 201.

In the 1890s Peter Lees, the English golf course architect, developed an earthworm management control to deal with the 'problem' faced by greenkeepers of earthworm casts on the soil surface. [53] His control method is shown in figure two and involved applying a powdered irritant to the soil surface, in the form of mowrah meal, made from the seeds of *Bassia latifolia*, the Indian butter tree, and watering it in. As a result of combining the irritant and excessive amounts of water, earthworms came to the surface, were raked into piles and then shovelled on to wheel-barrows and physically removed from the site. [54] Earthworm removal, as a direct response to their influence on the soil environment, was common on golf courses throughout the twentieth century in both Europe and the United States, although

[53] J. Beard, 'Invention Era in the Early Evolution of Turfs 1830-1952 Part 1', *Turfgrass Bulletin*, vol.217 (July 2002), 33.

[54] D. A. Potter, C. T. Redmond and D.W. Williams, 'Coursecare: controlling earthworm casts', *USGA News* (4th October 2011) available at http://www.usga.org/news/2011/October/Course-Care--Controlling-Earthworm-Casts/ (accessed 18.02.14).

methods changed over time. Whereas organic farmers and gardeners saw earthworm ecological impact as beneficial, greenkeepers saw it as a nuisance.

In many ways earthworm influence on the soil profile was favourable for greenkeepers. Their role in the decomposition process as well as in nutrient recycling and consuming dead plant material, including thatch, was beneficial for the quality of grass. Their tunnelling aided drainage and aeration, preventing courses from waterlogging. However, greenkeepers' key complaints were based on a judgement of the value of surface casts, the result of anecic and epigeic earthworms excreting waste material on the soil surface. Of the common field species only three, *lumbricus terrestris, allolobophora longa* and *allolobophora nocturna* (anecic species) cast on the surface, others (endogeic species) excreting in soil crevices.[55]

Greenkeepers were more concerned by the aesthetic value of castings than their chemical profile, which they deemed negative to golf courses. Castings caused practical problems for the golfer and greenkeeper and remain so today. According to a recent article in *Pitchcare Online Magazine* casts can 'interfere with the roll of the ball, create an uneven playing surface, damage lawnmower blades, smear across the surface reducing water infiltration, encourage weed invasion and spoil the look of the turf'. [56]

This chapter explains how the twentieth century golfing industry deliberately targeted and exterminated earthworms because of their ecological influence (agency) on the soil, arguing that it was their ecological agency that instigated a human reaction and propelled earthworms into human history. The majority of sources in the first half of the chapter are greenkeeping handbooks from circa 1910-1928. The chapter explains greenkeepers' attitudes towards earthworms, the reasons for these attitudes, and the actions taken to 'control' earthworm populations. The second part of the chapter looks briefly at the wider cultural perceptions of lawns and turf as well as the use of organochlorines as a 'weapon' against earthworms on the golf course, especially the use of chlordane, from the late 1950s.

Peter Lees despised earthworms. His 1918 handbook *Care of the Green* dedicated a chapter to his personal struggle against them and he regularly labelled them his 'enemy', suggesting a

[55] Satchell, 'Earthworms and Soil Fertility', 441.
[56] D.T. Jones, 'Return of the Worm', http://www.pitchcare.com/magazine/return-of-the-worm.html [accessed 19.02.2014].

strategy of 'war' against them.[57] His feelings towards earthworms developed early in his career when he was greenkeeper to the Edinburgh Burgess Golfing Society. In his efforts to destroy earthworm populations he experimented with many substances, suggesting his determination to rid his course of earthworms, no matter the wider consequences.

> 'I was almost at my wits' end, but was by no means beat in the battle, so looked about for another weapon to circumvent my enemy. At last I hit on something that was really of some good. I got on the right side of one of the members, who was a wholesale druggist and I persuaded him to give me a quantity of corrosive sublimate.'[58]

Although the use of 'corrosive sublimate' (*mercuric chloride* $HgCl_2$) ultimately failed to kill earthworms Lees persisted in his 'war', trying lime-water among other irritants, but continuously failed in his attempts. When he worked at Mid Surrey Golf Club near London he noted that, 'I soon found myself face to face with my old enemy', suggesting that, for Lees, earthworm eradication became a personal obsession.[59] It was at Mid Surrey that he was successful in his efforts with mowrah meal. He noted that 'after I had thoroughly convinced myself that I was at last on the right course, I set about to exterminate the common enemy on every putting green on both courses (ladies' and gentlemen's courses)'.[60] More than any other golfing handbook writer Lees is the most explicit in his use of language regarding earthworms. Earthworms transcended the human animal Cartesian divide in Lees' imagination, the animal anthropomorphised as a 'common enemy' and the golf course translated into a battle field.

Lees received much rebuff from the club membership, perhaps due to the influence of Darwin's relatively recent work. He was aggrieved so much by one particular instance that he recorded it in his 1918 handbook, writing 'I well remember one of the best known golfers, one who has held both amateur and professional championships coming up to me when I was busy on the work of general extermination and offering to make a bet that in six months' time I would not have a putting green on the two courses worth playing on.'[61] However, upon seeing Lees' results, 'a fine, clean, dry and firm carpet on which it was possible to play all the year round without the slightest chance of doing harm to the grass plants', members stopped all criticism. Earthworm impact was clearly a negative trait for golfers as well as

[57] P.W. Lees, *Care of the Green* (New York, 1918), 37-41.
[58] Lees, *Care of the Green*, 38.
[59] Lees, *Care of the Green*, 39.
[60] Lees, *Care of the Green*, 40.
[61] Lees, *Care of the Green*, 40.

greenkeepers and their removal a 'positive' thing for the sport, even though the demand for earthworm eradication initially came from greenkeepers, not golfers.

Lees' attitudes were shared by several of his peers, not least Reginald Beale, manager of the 'Golf and Sports Department' at Messrs James Carter and Company, London. Beale recognised the 'problems' earthworms presented greenkeepers with and designed an earthworm killing programme to remove them from the soil and reduce their impact on the sport. He dedicated a whole chapter of his handbook to earthworms, declaring that 'worms are the worst pest that attacks turf; they riddle the soil and turf to such an extent that it becomes unnaturally muddy and soft, which cannot be corrected by rolling and otherwise strong turf is made so tender that it soon wears out.'[62] By labelling earthworms 'the worst pest' Beale ranked earthworms in an anthropocentric hierarchy of species, created in relation to the golfing culture at the centre of his life experience. By 1924 debate amongst greenkeepers regarding earthworm influence on the soil surface had developed substantially and most greenkeeping handbooks contained at least one reference to worm killing. An ecocide was underway on the golf course, driven by a greenkeeping obsession to remove any 'problems' that nature presented golfers.

The early chemical control methods not only impacted upon earthworm populations but had significant impact upon the wider ecosystem. For example, rotenone (derris dust) and mowrah meal are toxic to fish and therefore applications near water courses affected aquatic ecosystems.[63] Potassium permanganate and formaldehyde killed or stained grass, which was not only unappealing aesthetically but poisoned species through the food chain.[64] Ecology as a scientific study was relatively youthful in the 1920s. Frederic Clements and Henry Gleason had only recently introduced their theories of succession and association, well known today, but greenkeepers of the early twentieth century showed little regard for soil ecology in their management plans. Instead, focus was placed on the aesthetic of the course itself, as an environment of superb sporting potential.

The aggressive language used by British greenkeepers towards earthworms was reflected across the Atlantic. The American R.A. Oakley wrote that 'whether or not earthworms may

[62] R. Beale, *Lawns for Sports: Their Construction and Upkeep* (London, 1924), 198
[63] http://www.surrey-bigga.co.uk/downloads/Earth%20worms.pdf (accessed on 28.02.14), 5.
[64] See P.D. Sachs and R.T. Luff, *Ecological Golf Course Management* (Hoboken, 2002).

be regarded as a beneficial factor in soil making, is beside the point. They are a nuisance on putting greens, and should be removed'.[65] Whilst accepting the ecological viewpoint suggested by Darwin's thesis, Oakley suggested that earthworm agency on the golf course could only be negative and their removal did not require justification. In a 1924 article Oakley presented the wide range of contemporary chemicals for killing earthworms. Ammonium chloride (NH_4 Cl) and ammonium sulphate ($(NH_4)_2SO_4$) were sometimes added to mercuric chloride (HG_2Cl_2) to decrease the 'burning effect' of the latter on the grass by making it more soluble.[66] Further, 'Bordeaux mixture', a combination of copper sulphate ($CuSo_4$) and slaked lime ($CA(OH)_2$), often used as a fungicide, sodium cyanide (NaCN), ammonium hydroxide (NH_4OH) and ammonium sulphate ($(NH_4)_2SO_4$) were all further mentioned as being used in the 1920s to control populations, with mixed success. It is clear that greenkeepers were willing to use any substance that could potentially destroy earthworm populations, regardless of the environmental consequences. Destruction of earthworm 'ecological agency' was their aim. The means to reach that goal were numerous and for many greenkeepers, irrelevant.

Application of this multitude of chemicals, coupled with an obsession by greenkeepers to eradicate earthworms and, as a result, castings, cannot be separated from the wider cultural value granted to lawns in the twentieth century, particularly in American society. In his book *American Green: The Obsessive Quest for the Perfect Lawn* Ted Steinberg went further than any other historian in illustrating the complexities behind the American obsession with turf. In plotting a history of the domestic lawn he outlined, in his own words, 'one of the most profound transformations of the landscape in American history.'[67] Management of golf courses is integral to the history of the lawn and it is clear that earthworms not only impacted upon the golf course landscape in a physical sense, but in excreting casts on the surface earthworms assaulted the very essence of American culture.

By the late 1950s playing golf was synonymous with higher social status. Lawns were intimately involved in this class association, constructing the perfect lawn an expectation for both the golf course and the suburban household. As Steinberg writes, 'semiskilled

[65] R.A. Oakley, 'Earthworms', *Bulletin of the Green Section of the USGA*, vol.4 (1924), 115.
[66] Oakley, 'Earthworms', 115.
[67] T. Steinberg, *American Green: The Obsessive Quest for the Perfect Lawn* (New York, 2006), 9.

workers, now entering the ranks of the middle class, took up golf for much the same reasons they adopted lawns, once the landscape of the aristocracy: it provided a measure of status in a world of tremendous social and economic fluidity.'[68] Such association between social status, golf and lawns as well as more people watching the televised Masters series at Augusta increased golfers' expectations of greenkeepers to achieve the highest standards. This led to greenkeepers increasing the assault on earthworms through application of increasingly deadly pesticides.

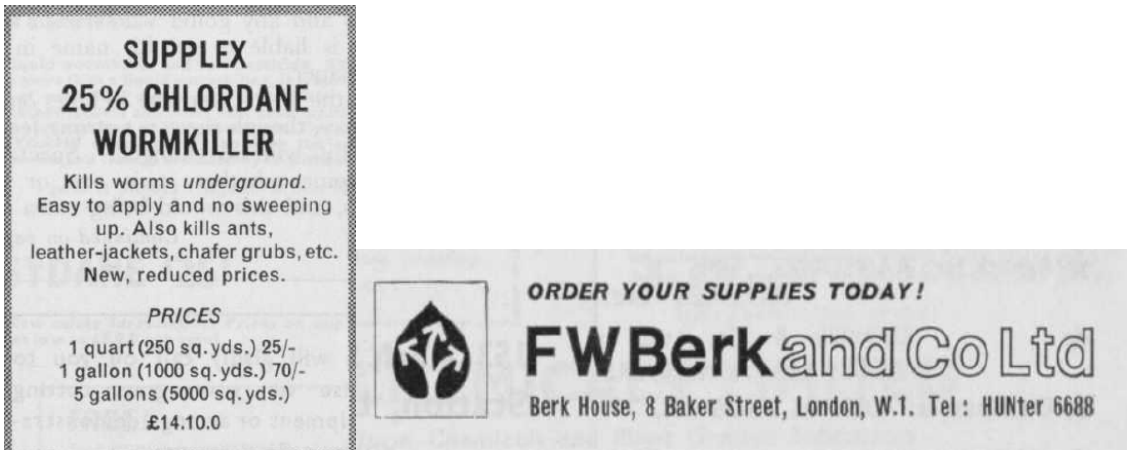

Figure 3. 'FWBerk and Co Ltd advertisement for Chlordane Wormkiller', *The British Golf Greenkeeper*, no.229 (April 1964), 5.

From the late 1950s the chemical campaign against earthworms intensified, principally due to the widespread use of the organochlorine chlordane, a mixture of 120 structurally related chemical compounds. It was registered in the United States in 1948 and sold widely within the United Kingdom from about 1962. Greenkeepers accepted it quickly and it was popularly heralded as being able to eliminate casting 'problems' for up to seven years following the first application.[69] Chemical companies were keen to seize the business opportunity and numerous advertisements were placed in greenkeeping magazines and journals to market chlordane products. The chemical company FWBerk and Co Ltd were particularly prolific advertisers of chlordane products, an example of which is shown above in figure three. Advertisements such as this appealed to greenkeepers particularly because of the reference to 'no sweeping up'. Raking up

[68] Steinberg, *American Green*, 92.
[69] D.T. Jones, 'Return of the Worm', http://www.pitchcare.com/magazine/return-of-the-worm.html [accessed 19.02.2014].

earthworm bodies was a highly labour-intensive consequence of using other earthworm removal products such as mowrah meal and any alternative was tempting.

It is likely however that the mania surrounding the chemical was driven more by marketing than by science. Although chlordane was successful in destroying earthworm populations on some courses, success rates were more variable than chemical companies wished to present. In August 1965 H.J. Lidgate, a chemist at the British Sports Turf Research Institute (STRI) accepted that 'chlordane is very popular at present' but then warned greenkeepers against blindly accepting its credibility, stating that 'we get odd reports of complete failure even when the right amount of chlordane has been used'.[70] Roger Evans, Advisory Officer to the STRI, confirmed this view two years later, writing that 'somewhat variable results have been obtained with chlordane up and down the country'.[71] However despite preaching their views in publications widely read by greenkeepers, scientists such as Lidgate and Evans had little influence on changing behaviour.

In addition to its erratic success on golf courses, following the wave of research that followed after the publication of Carson's *Silent Spring*, it was found that chlordane was particularly environmentally harmful. It has a half-life of about four years meaning it is incredibly persistent in soils, taking a long time to break down and often dissipates through soils into water courses, affecting aquatic life. It also bioaccumulates in animals, meaning that it persists and strengthens as it moves through the food chain. The Environmental Protection Agency in the United States recognised these effects and banned its registration for use on turf in the late 1970s, finally achieving this goal in 1983. [72] The British government waited until 1992 until putting a ban in place, unofficially ending the 'earthworm ecocide'.

Since the chlordane ban no viable alternative has been suggested for controlling earthworm casts. In 2003 a survey of British greenkeepers suggested that earthworms

[70] H.J. Lidgate, 'A Perennial Problem', *The British Golf Greenkeeper*, vol.245 (Aug 1965), 6.
[71] R.D.C. Evans, 'Earthworms and their Control', *Sports Turf Bulletin*, vol.77 (April/June 1967), 8.
[72] D.A. Potter, C.T. Redmond and D.W. Williams, 'Coursecare: controlling earthworm casts', *USGA News* (4th October 2011) available at http://www.usga.org/news/2011/October/Course-Care--Controlling-Earthworm-Casts/ [accessed 18.02.14].

were still regarded as their most common 'pest'.[73] Indeed, attitudes of golfers and greenkeepers towards earthworms have remained persistently negative throughout the twentieth century and in to the twenty-first century. The obsession with creating a 'perfect' lawn environment for golf was caught up alongside the wider phenomenon regarding lawns in the western imagination as well as changing attitudes towards 'controlling' nature and rising social status. These facets combined to result in golf courses riddled with structurally complex chemicals and a mind-set conducive to an earthworm ecocide, earthworms being labelled 'the common enemy' and greenkeepers working to eradicate earthworm species by any means possible, despite the potential ecological effects. However, this narrative was only possible through the ecological influence of earthworms on their environment.

[73] D.T. Jones, 'Return of the Worm: Earthworms in the Post-Chlordane Era' http://www.bigga.org.uk/about-us/news/return-of-thhlordane-era/00274.html [accessed 5.03.2014].

Conclusions

Earthworms and Agency

'Humanity knows little about its most important commensals. We are unaware of the nocturnal, hidden, subterranean activity of the most important animal biomass that shares with us the earth's land surface. ... If we compare, for example, the significance accorded to ornithology and the multitude of birdwatchers studying about one kilogram of birds per hectare, with the extremely limited number of research workers' interest in the hundreds of kilograms or tons per hectare of earthworms, we must conclude that our knowledge of ecosystems is fundamentally distorted by our above-ground, visual perception of nature and our ignorance of life below-ground.'[74]

This paper is broadly in agreement with the conclusions of Peter Tompkins and Christopher Bird, outlined above. It is clear that a species hierarchy remains within the western imagination. Studies of 'charismatic megafauna', particularly in the discipline of animal studies, dominate the literature, with 'minifauna', including soil invertebrates, largely ignored. This paper does not claim that earthworms are more important than other animals but argues that historians should rethink how humans value invertebrates more broadly. Earthworms (and other invertebrates) open up a presently untapped potential for innovative historical research. This paper has presented earthworms as having influenced the path of specific human histories and by envisioning earthworms as exhibiting 'ecological agency', humans and animals have been placed next to each other. The human role in shaping the environment has been acknowledged but it is also accepted that the environment (and non-human animals) has shaped human experience. It now moves towards a number of conclusions that, whilst seemingly disparate, connect under the umbrella viewpoint that if animals are to be seen as historical actors they should be seen 'not separate from humanity, but rather partners in our species' biological and historical transcendence', to use the language of Brett Walker.[75]

Julia Adeney Thomas, in her innovative approach to understanding history alongside the biological sciences, has suggested that 'biologists can help historians broaden our understanding of the human and demonstrate the possibilities and limitations within which humans operate and historians can help biologists understand the varied political and cultural resources, economic systems, forces of agency and multiplicity of ends which leave their

[74] P. Tompkins and C. Bird, *Secrets of the Soil* (London, 1989), 47-48.
[75] B. Walker, 'Animals and the Intimacy of History', *History and Theory*, vol.52, no.4 (December 2013), 67.

imprint on land, air, water and bodies'.[76] Thomas argues that biology and history should stand independently, whilst each recognising the particular attributes of the other discipline in moving their own intellectual framework forward. However, this paper has suggested that, whilst in agreement that history should stand as an independent discipline, animal history could move closer towards biology and ecology in methodological approach, resulting in a disciplinary methodology specific to animal history. Animal historians (and environmental historians) should not shy away from engaging with the methodologies and findings of the natural sciences but use biological research to approach analysis of human culture and society. Such an interdisciplinary approach would result in more nuanced and 'ecologically alive' research, making historical approaches to the study of non-human animals more true to biological reality.

Although a slow process, invertebrates have begun to crawl their way into the intellectual portmanteaus of animal historians. Janelle Schwartz has recently written a study of literal and metaphorical worms in the eighteenth and early nineteenth centuries, arguing that natural-history explorations of the biological properties of worms, combined with literary authors' interest in their symbolic presence, evoked discourses of decay and generation in the period.[77] However, in focusing on human 'ideas' of worms, in which she includes not only earthworms but maggots, caterpillars, polyps and others, the 'real animal' is lost in her poststructuralist critique. In order to focus on the animal itself as a subject of historical research, not an object within it, the animal's ecological influence must form the main focus of the work, requiring ecological analysis, set within an historical framework.

The third conclusion regards the role of ecological histories in enforcing reflection within wider society, in this case regarding our attitudes towards soil systems. Soil erosion and the depletion of soil nutrients remains one of the key global issues that humankind faces, which, if it continues to deteriorate, will result in insufficient capacities for growing food and sustaining the human population. For example, in 2007 28 percent of all cropland in the United States was eroding at a rate at which farming cannot be sustained.[78] Other soil problems include contamination from heavy metals, the effects of pesticides on soil

[76] J. Adeney Thomas, 'The Scales of History and Biology in the Age of Climate Change' (*forthcoming, American Historical Review*), 2.
[77] C. Burton, 'Review of Worm Work: Recasting Romanticism', *Keats-Shelley Journal*, vol.62 (2013), 157.
[78] M. Empson, *Land and Labour: Marxism, Ecology and Human History* (London, 2014).

biodiversity, soil compaction and acidification and threats from climate change.[79] By raising awareness of earthworms this paper has drawn focus towards not only their ecological role but towards their soil environment, extending a much needed historical debate regarding attitudes towards that particular environment and the values humans place upon it. Food activists have long argued that people should rethink their attitudes towards the soil and become 'lovers of the soil'.[80] However, historians, with a few exceptions, notably the British environmental historian Chris Smout, have neglected the soil as a subject of historical research. This paper suggests a rapprochement with soils and calls upon animal and environmental historians to engage with both this precious resource and the fauna within it.

Perhaps the most significant conclusion of this study is recognising the need to reassess understanding of historical agency. The philosophical concept of agency has already become more widely encompassing than traditional concepts of historical agency, epitomised by the work of Donald Davidson, which suggested that only humans could exhibit agency because of their ability to communicate using language, implying intention.[81] However, history is not a single narrative of intention but a series of multiple narratives, simultaneously coexisting and colliding in conjunction with one another. For example, the work of the ecologist Frederic Clements, the agricultural scientist Albert Howard and the greenkeeper Peter Lees occurred within the same generational paradigm. However, the work of each failed to directly influence the others during their lifetimes. It is the historian who constructs the narrative, containing disparate, perhaps contemporaneously unrelated, sources, resulting in a narrative unlike the reality of the contemporary subjects' lives. If contemporary intention can be removed from historical understanding, pushing instead towards a multi-stranded narrative of chaos, then we can move towards an understanding of agency in which it is not the intention behind the impact that is important but the impact itself. Non-human animals, like human animals, clearly impact upon their environments and this impact affects human experience and therefore human history.

It has been made clear that earthworms have significant impact on their soil environment and are 'ecological agents' on the basis that, whilst we may not be able to 'prove' intentionality,

[79] J. Miles, 'The Soil Resource and Problems Today: An Ecologist's Perspective', in S. Foster and T.C. Smout (eds) *The History of Soils and Field Systems* (Aberdeen, 1994), 145-154.
[80] F. L. Kirchenmann, 'On Becoming Lovers of the Soil', in C.L. Falk (ed.), *Cultivating an Ecological Conscience* (Berkeley, 2010), 285-289.
[81] D. Davidson, 'Rational animals', *Dialectica*, vol. 36, no. 4 (1982), 317–27.

they have various biological needs that they must satisfy in order to survive individually and collectively: consumption, digestion, excretion and reproduction being the most basic of these needs. This fits with Helen Steward's approach to understanding animal agency that we should 'allow the animal...a certain freedom and control over the precise movements by means of which it satisfies those instinctual needs and desires.'[82] By claiming freedom of control over their bodies as animate beings, earthworms exhibit control over the ecological framework in which they exist. By influencing this framework, they consequentially influence the human historical framework which is intimately bound to changing environments.

Anthropocentrism, which has long encouraged us to make clear separations between ourselves and non-human animals, is largely to blame for why attitudes have conspired against earthworms and animals more broadly as exhibitors of historical agency. It accounts for so few historians thinking about the ground beneath their feet. Anthropocentric doctrine has combined with the Cartesian dualism separating mind from body, disregarding animate potential as a variable for exhibiting agency and instead focusing upon specifically human notions of intelligence and intention in claiming agency. Steward points further afield to Kantianism, privileging rationality over body possession and control as well as an 'empiricist epistemology which has encouraged, throughout the biological sciences, a huge distrust of the spontaneous codings of the mind module and has supported the insistence that they be treated as nothing more than misplaced anthropocentrism.'[83] A range of options have therefore led to a feeling that humans are separate from nature, most notable when we place this notion within the soil. By placing earthworms next to humans in an overlapping historical narrative this sentiment can be deconstructed.

Darwin's earthworm treatise remains relevant and is consequentially useful as an historical source to help historians understand societies. As Janelle Schwartz has written 'it (Darwin's treatise) advocates for a kind of land ethic that treats what Aristotle called ''the intestines of the earth'' as some of the most influential organisms in/for the world.'[84] This paper suggests that historians need to research soil fauna to raise awareness of people's past, often intimate, connection with soil systems. A lack of intellectual engagement with such connections

[82] H. Steward, 'Animal Agency', *Inquiry*, vol.52, no.3 (2009), 225.
[83] Steward, 'Animal Agency', 228.
[84] Schwartz, *Worm Work*, 197.

suggests a wider cultural disconnect, resulting in human actors being less likely to connect with the soil, tangibly and intellectually. Human and earthworm histories have coincided and both earthworms and humans have influenced the changing nature of soil ecology. By recognising earthworms as both ecological and historical agents we begin to integrate them into a multi-species historical narrative, albeit one that is complex, multi-linear and chaotic.

Word count: 9,780

Glossary

N.B. all definitions are from the Oxford English Dictionary (OED)

Anecic – A habitat classification term referring to earthworms that live in deep vertical burrows but feed at or near the soil surface.

Anthropocentric – Centring in man; regarding man as the central fact of the universe, to which all surrounding facts have reference.

Anthropogenic – Having its origin in the activities of man.

Anthropomorphism – Attribution of human form or character to anything impersonal or irrational.

Bioaccumulation – Accumulation of (typically toxic) chemicals in the tissue of organisms, esp. so that their concentration increases in individuals with time.

Bioturbation – The disturbance of sediment by burrowing or other activity of living organisms; the disturbed state that results.

Ecology - The branch of biology that deals with the relationships between living organisms and their environment. Also: the relationships themselves, esp. those of a specified organism.

Endogeic – A habitat classification term referring to earthworms that form a network of burrow channels, some vertical, some horizontal in the rhizosphere.

Entomology – That branch of natural history which deals with the physiology, distribution, and classification of insects.

Epigeic – A habitat classification term referring to earthworms that live in the uppermost layers of the soil or litter layer forming shallow vertical burrows.

Humus – Vegetable mould; the dark-brown or black substance resulting from the slow decomposition and oxidization of organic matter on or near the surface of the earth, which, with the products of the decomposition of various rocks, forms the soil in which plants grow.

Oligochaete – Of or relating to annelid worms of the class Oligochaete, which includes earthworms, characterized by simple setae on each segment and a lack of sensory appendages on the head; characteristic of or designating such worms.

Oligochaetology - That branch of zoology that deals with the oligochaete worms.

Pedosphere - The Earth's soil layer.

Phylum - Originally: any large group of organisms considered to have originated from a common ancestral form in the distant past; an evolutionary lineage, a major taxonomic group. Now usually: *spec.* a fundamental taxonomic grouping ranking above class and below kingdom, generally comprising organisms which share a basic body plan or pattern of structural organization.

Speciesism **-** Discrimination against or exploitation of certain animal species by human beings, based on an assumption of mankind's superiority.

Appendices

Appendix 1 - Articles in *Mother Earth* on earthworms (listed chronologically)

E.B. Balfour, 'Earthworm Experiments at Haughley', *Mother Earth*, vol.1, no.2 (Spring 1947), 29.

E.B. Balfour, 'Earthworm Experiments at Haughley', *Mother Earth*, vol.1, no.4 (Harvest 1947), 23.

E.B. Balfour, 'Tying up Loose Ends', *Mother Earth*, vol.2, no.2 (Spring 1948), 11-16.
- (esp12-13 for earthworms)

E.B. Balfour, 'An Acquaintance worth cultivating', *Mother Earth*, vol.3, no.1 (Winter 1948), 45-46.

F.C. King, 'A Non-Digger Answers Some Comments', *Mother Earth*, vol.3, no.3 (Summer 1949), 43-45.

O.J. Russell, 'Correspondence: Observations on Earthworms', *Mother Earth*, vol. 3, no.3 (Summer 1949), 46.

N.P. Burman 'Phosphate Availability', *Mother Earth*, vol.4, no.1 (Winter 1949), 15-18.
– (section on earthworms p16.)

F.C. Tattersall, 'A Great Naturalist on Earthworms', *Mother Earth*, vol.4, no.1 (Winter 1949), 52.

E.M. Walrond, 'Contrast between two glasshouse growers', *Mother Earth*, vol.4, no.2 (Spring 1950), 43-45.

L.E. Ford, 'Preserve these earthworm nurseries', *Mother Earth*, vol.4, no.2 (Spring 1950), 46-47.

R.B. Canever 'Can Domesticated Earthworms Help the Small Composter?', *Mother Earth*, vol.4, no.2 (Spring 1950), 48.

B.A. France, 'Correspondence: An Earthworm's Burrowings', *Mother Earth*, vol.4, no.2 (Spring 1950), 55.

Anon, 'East Malling Research Station', *Mother Earth*, vol.4, no.3 (Summer 1950), 38.

Anon, 'Earthworms in Grassland', *Mother Earth*, vol.4, no.3 (Summer 1950), 41.

Anon, 'Mechanical Cultivation and Earthworms', *Mother Earth*, vol.4, no.3 (Summer 1950), 50.

Elizabeth Frank, 'An Experiment with Earthworms', *Mother Earth*, vol.5, no.3 (Summer 1951), 26.

E.W. Russell, ‘Soil Structure: Is Importance in Crop Production’, *Mother Earth*, vol.5, no.3 (Summer 1951), 27-29.

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Appendix 2 - Articles in *Soil and Health* on earthworms (listed chronologically)

J.K.W. Wheatley, ‘Correspondence: Darwin on Humus and the Earthworm’, *Soil and Health*, vol.1, no.3 (Autumn 1946), 175-176.

A. Howard, ‘Harnessing the Earthworm’, *Soil and Health*, vol.1, no.4 (Winter 1946), 203-205.

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Winter 1947 (vol2 no.4) was Sir Albert Howard’s final issue before he died. Spring 1948 brought the memorial number. Afterwards it became ‘Health and the Soil’ (ed. Angus Campbell) (first issue Summer 1948)

Appendix 3 - Articles in *Health and the Soil* on earthworms (listed chronologically)

F.W. Sadler, 'Ode to the Great Little Worm', *Health and the Soil*, vol.4, no.1 (Spring 1951), 11-12.

A. Campbell, 'Breeding Earthworms', *Health and the Soil*, vol.4, no.2 (Summer/Autumn 1951), 60.

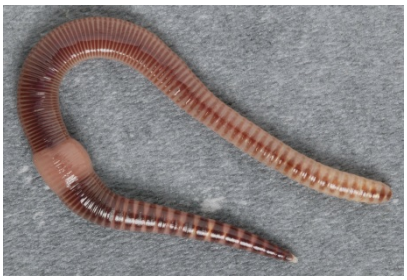
W.J. Guild, 'Earthworms and the Soil', *Health and the Soil*, vol.4, no.2 (Highland Show Special 1955), 54-56.

Appendix 4 – Descriptions of earthworm ecotypes

(The information below is sourced from http://www.earthwormsoc.org.uk/earthworm-information/earthworm-information-page-2 (accessed on 12.02.2014)

Earthworms are divided into **four groups**, called **ecotypes**.

Compost earthworms



As their name would suggest, these are most likely to be found in a compost bin. They prefer warm and moist environments with a ready supply of fresh compost material. They can very rapidly consume this material and also reproduce very quickly. Compost earthworms tend to be bright red in colour and stripy.
Image right: Eisenia veneta, a compost earthworm
Compost earthworm species include *Eisenia fetida* and *Eisenia veneta*

Epigeic earthworms

Epigeic earthworms live on the surface of the soil in leaf litter. These species tend not to make burrows but live in and feed on the leaf litter. Epigeic earthworms are also often bright red or reddy-brown, but they are not stripy.
Image right: Lumbricus castaneus, an epigeic earthworm
Epigeic earthworm speices include *Dendrobaena octaedra*, *Dendrobaena attemsi*,*Dendrodrilus rubidus*, *Eiseniella tetraedra*, *Heliodrilus oculatus*, *Lumbricus rubellus*, *Lumbricus castaneus*, *Lumbricus festivus*, *Lumbricus friendi*, *Satchellius mammalis*

Endogeic earthworms

Endogeic earthworms live in and feed on the soil. They make horizontal burrows through the soil to move around and to feed and they will reuse these burrows to a certain extent. Endogeic

earthworms are often pale colours, grey, pale pink, green or blue. Some can burrow very deeply in the soil.
Image right/above: Allolobophora chlorotica, an endogeic earthworm
Endogeic earthworm species include *Allolobophora chlorotica, Apporectodea caliginosa, Apporectodea icterica,Apporectodea rosea, Murchieona muldali, Octolasion cyaneum* and *Octolasion tyrtaeum*

Anecic earthworms

Anecic earthworms make permanent vertical burrows in soil. They feed on leaves on the soil surface that they drag into their burrows. They also cast on the surface, and these casts can quite often be seen in grasslands. They also make middens (piles of casts) around the entrance to their burrows. Anecic species are the largest species of earthworms in the UK. They are darkly coloured at the head end (red or brown) and have paler tails.
Image below: Apporectodea longa, an anecic earthworm
Anecic earthworm species include *Lumbricus terrestris* and *Apporectodea longa*

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