4. Geophysics, tillage and the ghost ridges of County Galway, c. 1700–1850

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Illus. 1—Archaeologist Ronan Jones recording features observed in machine-cut test excavations at Rahally on the N6 Galway to Ballinasloe scheme (Galway County Council).

Geophysical survey and national road schemes

Intuition, experience and observation are among the ingredients in a successful field investigation. At the outset of a big development project, the field archaeologist uses all three in trying to predict what might be found on the development site. The sources of evidence include historic maps, aerial photographs, museum records, published local histories and anecdotal information from landowners. The archaeologist's own observations, from site inspections, are very important, but even the keen eyes of an experienced fieldworker cannot penetrate the soil. Ultimately, ground-breaking test excavations, by hand or machine (Illus. 1), are the most effective means of finding new archaeological sites, and such excavations are performed on the routes of all new national road schemes in advance of construction. (For more information on the archaeological assessment of road schemes see O'Sullivan 2007a.) There is one non-intrusive method, however, that has been described as 'seeing beneath the soil' (Clark 1990). This method employs geophysical survey equipment (Illus. 2) and has been widely used in Environmental Impact Assessments (EIAs) on road schemes in Galway and adjoining counties in recent years.

Illus. 2—Geophysical survey at archaeological reconnaissance stage on a national road project, using an FM256 Dual System Magnetometer (Earthsound Archaeological Geophysics, James Bonsall).

The geophysical survey methods deployed in our EIAs have included magnetic susceptibility, magnetic gradiometry and electrical resistivity, using a corresponding range of equipment in specialist hands. The common theme is that each of these methods measures some characteristic of the soil's natural electromagnetic field—or an induced field—in a search for anomalies that might have been caused by past events. These anomalies result from events that disturbed the ground or changed its characteristics. Buried hearths, wall foundations, boundary ditches or souterrains and other large voids can all be found by these means if conditions are favourable. Pyrotechnic features—like iron-smelting pits or pottery kilns—can give especially clear signals. Metal objects also give a very strong response, but these often turn out to be lost or discarded modern objects, ranging from old zinc buckets to an entire car that was buried in a field on the N6 Galway to Ballinasloe road scheme!

The specialists who performed or advised on these surveys for Galway County Council and the NRA did not agree about the best combination of methods or instruments to use. As a result, there was a degree of experimentation as our technique evolved from scheme to scheme. The schemes surveyed to date have a combined (centreline) length of 187 km and extend over an aggregate area of 1,856 ha. Taken all together, this is the basis for a fairly large experiment. In the end, we agreed that a centreline strip of recorded magnetic gradiometry, amounting to not less than 30% of the footprint of the road scheme (e.g. a continuous strip 15 m wide within a road corridor 50 m wide), was the optimum method at reconnaissance stage. Following the reconnaisance stage, on all schemes, we used magnetic gradiometry or electrical resistivity for detailed surveys in selected areas (Table 1). (We did not use ground-penetrating radar, although, with hindsight, this could have been very useful in some locations.)

So far, the results of this grand experiment have been variable and sometimes disappointing. Often, sites that were afterwards discovered by archaeological test excavations were not detected as geophysical anomalies at EIA stage. Conversely, many of the anomalies that were identified by geophysical survey proved to be non-archaeological in origin or could not be identified at all when tested afterwards by excavation. The largest of the surveys was also the most successful. On the N6 Galway to Ballinasloe scheme, areas amounting to 27.7% of the footprint of the scheme were surveyed using recorded magnetic gradiometry (Roseveare & Roseveare 2004a). The selected survey areas were chosen because there were known archaeological sites and monuments in the immediate vicinity, or historic population centres nearby, or simply because they lay within areas of good farmland that would also have been attractive to prehistoric and medieval settlers. Of the 202 geophysical anomalies that were detected by this survey, 63 were thought likely to be of archaeological origin, but as 14 of these were also known from other sources (e.g. map evidence or visible surface features) the number of anomalies of likely archaeological origin discovered exclusively by geophysical survey was 49. In the end, only eight (Table 2) of these turned out to be significant archaeological sites (i.e. sites where full archaeological excavation of a burial-ground, a settlement or industrial features took place).

Table 1—Geophysical survey methods on road schemes at Galway County Council NRDO.

Road scheme *Surveyors*	**General reconnaissance**	**Targeted area surveys**
N6 Loughrea Bypass *Roseveare & Roseveare 2003*	Magnetic susceptibility over 100% of the scheme	Magnetic gradiometry
N6 Galway to Ballinasloe *Roseveare & Roseveare 2004a*	Magnetic gradiometry over large areas amounting to 27.7% of the scheme	N/A
N6 Ballinsaloe to Athlone *Bonsall & Gimson 2004a*	Magnetic susceptibility centreline transects	Magnetic gradiometry
N6 Galway City Outer Bypass *Bonsall & Gimson 2006a*	Magnetic susceptibility centreline transects; magnetic gradiometry centreline ribbon	Magnetic susceptibility Magnetic gradiometry Electrical resistivity
N18 Oranmore to Gort *Krahn 2005*	Magnetic susceptibility centreline transects	Magnetic susceptibility Magnetic gradiometry
N18 Gort to Crusheen *Bartlett 2005*	Magnetic susceptibility Magnetic gradiometry	Magnetic gradiometry
N17 Tuam Bypass *Roseveare & Roseveare 2005b*	Magnetic susceptibility centreline transects; magnetic gradiometry centreline ribbon	Nil survey
M17 Galway to Tuam *Bonsall & Gimson 2006b*	Magnetic gradiometry	Magnetic gradiometry Electrical resistivity
N17 Castletown Realignment *Roseveare & Roseveare 2004b*	Magnetic gradiometry over 100% of the scheme	N/A
N84 Luimneagh realignment *Roseveare & Roseveare 2005a*	Magnetic susceptibility Magnetic gradiometry	Nil survey

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Table 2—Assessment methods and their results on the N6 Galway to Ballinasloe scheme.

Scheme details	
Area of road scheme	588 ha
Length of road scheme (centreline)	56 km
Number of fully excavated archaeological sites	37
Methods of discovery of significant excavation sites	
Test excavation	16
Desk study	8
Geophysical survey	8
Field inspection	4
Construction monitoring	1
Geophysical survey	
Combined areas of geophysical survey	163 ha (27.7%)
Criteria for selected survey areas	Good land Adjacent monuments Adjacent historic population centres
Survey method	Recorded magnetometry
Survey results	202 geophysical anomalies of all sorts 63 possible archaeological sites 49 sites identified by anomalies alone 8 significant excavated sites = net result

Table 3—Archaeological geophysical survey results on road schemes at Galway NRDO.

Scheme	**Potentially significant anomalies**	**Significant anomalies confirmed**	**Percentage anomalies confirmed**
M17 Galway–Tuam (27 km)	77	Testing pending	n/a
N84 Luimneagh realignment (2 km)	9	Testing pending	n/a
N6 Galway City Outer Bypass (20 km)	22	Testing pending	n/a
N17 Castletown realignment (2 km)	4	0	0%
N17 Tuam Bypass (5 km)	12	0	0%
N6 Loughrea Bypass (5 km)	14	2	14%
N6 Galway–Ballinasloe (56 km)	63	8	13%
N6 Ballinasloe–Athlone (20 km)	10	1	10%
N18 Gort–Crusheen (22 km)	40	0	0%
N18 Oranmore–Gort (28 km)	19	0	0%
Totals	158	11	7%

Note—the figures in the ‘Significant anomalies confirmed’ column refer to archaeological sites discovered primarily by geophysical survey and do not include sites that appeared in geophysical survey results but that were also known from other sources of information.

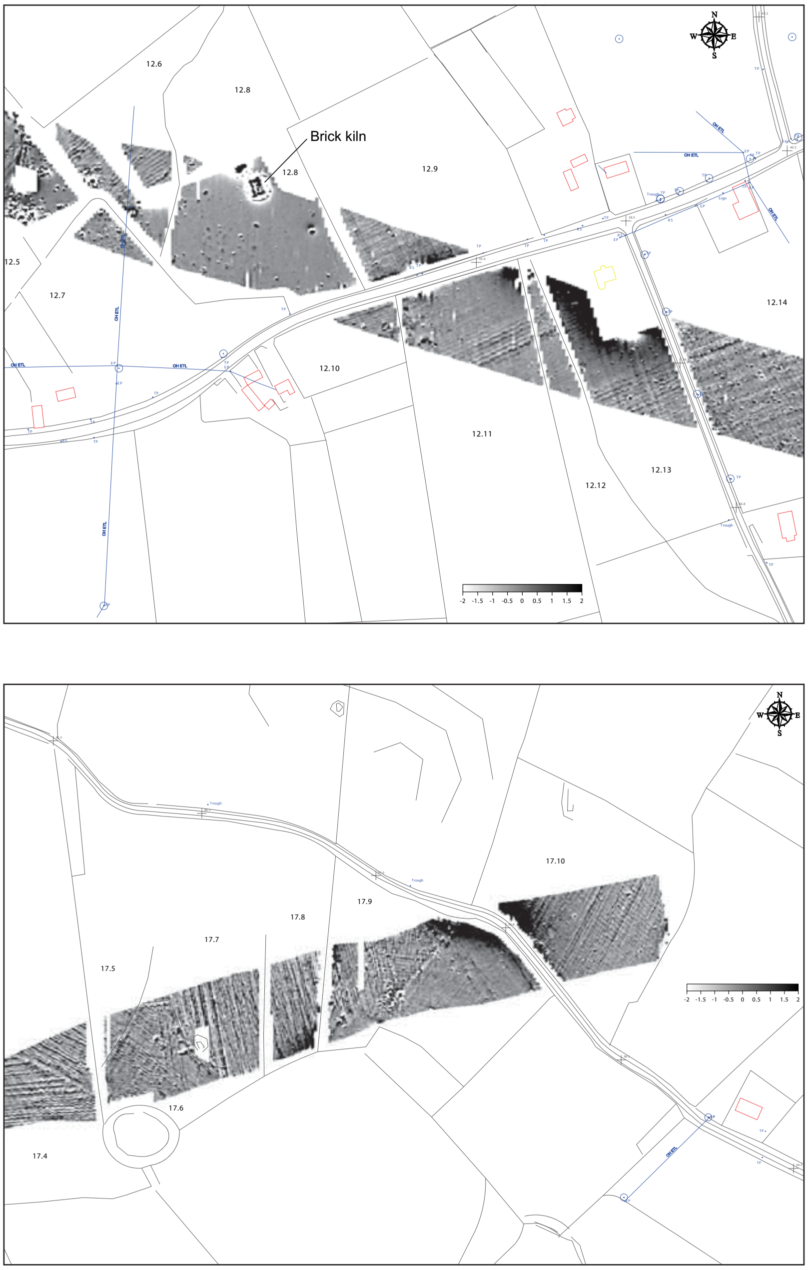
Eight excavated archaeological sites may seem a poor return from 202 anomalies, but as only 30 other significant sites were excavated (i.e. sites discovered from desk-based sources, field inspection, test excavations or construction monitoring) these eight sites amounted to 21% of all of the archaeological sites discovered on the scheme. Arguably, the proportion would have been higher if all of the scheme had been surveyed and not merely the most promising 27.7% of its total area. On the other hand, it must be conceded that the results of surveys on other schemes have been much less impressive, with the number of significant archaeological sites discovered exclusively by geophysical survey being as low as two, or one, or none (Table 3). This is partly due to the methods used (it is acknowledged that magnetic susceptibility was a poor choice for the reconnaissance stage of the surveys) but also relates to ground conditions. Some of the lands traversed by these schemes include large tracts of peatland or peaty soils that have been reclaimed for pasture, especially on the N6 Ballinasloe to Athlone scheme in south Roscommon (Bonsall & Gimson 2004a). Elsewhere there are large tracts of improved pasture with thin soils overlying karstic limestone bedrock or unimproved boulder fields with expanses of protruding bedrock, especially on the N18 Oranmore to Gort and N18 Gort to Crusheen schemes (Krahn 2005; Bartlett 2005).

Was this grand experiment a success? Can we justify persisting with these extensive surveys on every new scheme? The answer is certainly yes, and for several reasons. Firstly, the surveys are not expensive. The value for money in any archaeological investigation is measured by its results. The cost of an extensive geophysical survey on a road scheme will typically be about 1.5% of the total archaeological costs, so that even a modest result can justify the outlay and, in at least one instance, on the N6 Galway to Ballinsaloe scheme (above), the results have been very good indeed. Secondly, any experimental results are reliable in proportion to the volume of data on which they are based. To break off a procedure midway in the process merely because one is disappointed by the results is poor science. Thirdly, it may be a mistake to think that geophysical anomalies do not correspond to archaeological features merely because they cannot afterwards be confirmed by test excavation. One thing that we discovered is that the soil is full of ‘ghost’ features that are only detectable as geophysical anomalies and by no other means. It would be rash to dismiss them from the record merely because their definition is not improved by probing with the bucket of a 20-tonne tracked excavator. Indeed, it can be argued that a survey method that identifies features not susceptible to any other means of detection is the most valuable of all assessment methods, because it hints at stories that would otherwise be overlooked. The ‘ghost ridges’ of this paper will illustrate the point.

Ghost ridges

A type of feature identified by all of the surveys is the distinctive corduroy striping of cultivation furrows (Illus. 3 & 4). These occur very widely in the study areas, on every hillside and valley bottom that was surveyed. This ‘striping’ of the landscape by tillage, in our geophysical survey plots, seems odd to contemporary eyes, because Galway and the adjoining counties are predominantly pastoral places today. Older country people remember a time, not more than 35 years ago, when farming in the West involved a mixed regime of cattle, sheep and pigs, with fruit, root and cereal crops being grown for the market, for the table or for exchange with neighbours. Since that time, changing agriculture policy, EC/EU grants and market demand have combined to transform the farming landscape of the West into a monoculture of improved grass pasture for livestock—predominantly dry cattle and some sheep. These days, a person could walk all day through the countryside in County Galway and not see a tilled field or a standing crop (Illus. 5).

So what are these tillage features seen everywhere in our surveys? When were they formed? Why are they found so extensively? And what sort of tillage regime do they represent? Physically, they can be defined as broad-ridge remnants, at intervals of c. 2–4 m, forming straight or parallel groups and extending over large areas. Sometimes they are found to respect the existing field boundaries (usually drystone field walls of 18th- or 19th-century date) and sometimes they pre-date them. Frequently they form a palimpsest of



Illus. 3—Pyrotechnic features, like this Victorian brick kiln at Brusk (top), appear as strongly defined anomalies in geophysical survey results, but the corduroy striping of early modern cultivation ridges, like this example from Rahally (bottom), occurs very extensively in all of the surveys from Galway and adjoining counties. Both examples are from a survey of the N6 Galway to Ballinasloe scheme (Roseveare & Roseveare 2004a).

Illus. 4—Broad, mounded, spade-dug ridges can still be seen here and there in lands that have now reverted to pasture (above) or in marginal lands that have not been ploughed in the modern period (below) (Galway County Council).

Illus. 5—Pasture for drystock farming (above) has almost entirely replaced tillage in modern farming in the West, so that it is possible to walk all day across country in County Galway today (below) and not see a tilled field or standing crop (J O'Sullivan).

superimposed groups, where the ridges have evidently been laid out first in one direction and then in another in successive seasons. Remnant ridges are sometimes visible as surface features, but never to the extent revealed in the geophysical surveys. And very often the furrows cannot be detected as 'cut' features in the soil profile, even when they are exposed by machine-testing—hence their description as 'ghost ridges' in this paper, adopting an expression used by some geophysical surveyors in describing anomalies that are detectable but not visible (Schleifer 2004; Bonsall & Gimson 2004b). Possible causes of our ghost ridges are organic manures, which would have influenced the iron content of the soils, and ashes arising from sod or stubble burning, which would have increased the soil magnetic susceptibility of ashy silt deposits forming in furrow bottoms.

From their extent, form and relationships with extant field boundaries, it can be concluded that the ridges and furrows most frequently seen in our geophysical survey results are not ancient features but date broadly from the early modern period (c. 1700–1850), when there was a tremendous increase in the amount of arable farming in Ireland. Several authorities have written about the methods and equipment used in early modern Irish farming, including Evans (1957), Lucas (1970), Ó Danachair (1970), Gailey (1982) and Bell (Bell 1984; 2008; Bell & Watson 1986). What follows here, in the short space available, is necessarily a superficial treatment of a complex subject. Readers are strongly recommended to these authorities for a more detailed treatment, and to the early modern writers from whom today's scholars derive much of their information—like Arthur Young (1776–9), Hely Dutton (1824) and Horatio Townshend (1810); and also to *Feast and Famine*, an excellent book on the history of Irish food by L A Clarkson & E Margaret Crawford (2001).

Tillage in the West, c. 1700–1850

The most striking feature of the tillage regime represented in our surveys is that it was extremely labour-intensive. The population of Ireland grew from an estimated one million in 1650 to 8½ million in 1845. Labour was cheap and easily available. Arable land in the West was commonly worked not by ploughing with teams of draught animals but by hiring gangs of agricultural labourers—both men and women—who broke the ground with heavy, long-handled spades and mounded the soil into long, straight, broad ridges (Illus. 6). They sometimes worked collectively, going all together from farm to farm to hire themselves out as a team. Hely Dutton could report to the Royal Dublin Society in his *Statistical and Agricultural Survey of the County of Galway* (1824, 62–3): 'Some of the better kind of farmers use the plough for this purpose, but the general mode is by the spade or loy. When labourers work by the day, it may probably take from thirty to forty men per acre.'

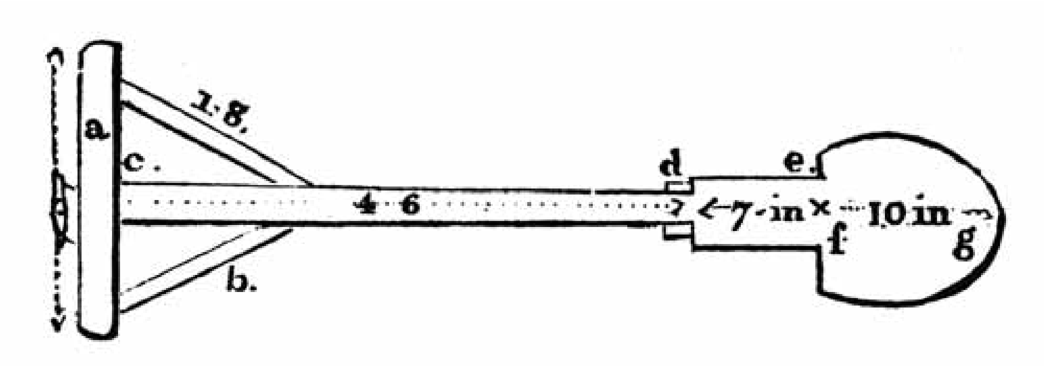
The straight sets of ridges that typically result from spade-dug tillage are not to be confused with medieval broad ridges. Some very broad, curvilinear ridges are recorded in Ireland in the early modern period, but straight ridges were the norm by c. 1800 (Bell 1984, 23). In general, broad S-shaped ridges are the signature of lowland medieval estate farming, and these were permanent features, built up over the years by repeated traverses with a mould-board plough. Likewise, our ridges are not to be confused with 'lazy beds', a very particular kind of ridge that was formed by turning the sod upon itself to form the ridge, thus leaving a very wide furrow between each planting bed. This kind of ridge was used especially for potatoes—both in subsistence cultivation by the poorest folk and also, more

Illus. 6—Women at work in 1901 on cultivation ridges in Glenshesk, Co. Antrim (R J Welch Collection RW.1164, Ulster Museum).

extensively, to 'clean' the weeds from fallow land with a potato crop before subsequent seasons of cereal-planting. The differences between one kind of cultivation ridge and another are seldom clear-cut, however, and Bell (ibid., 21–2) is worth quoting at length in this regard:

> Techniques of making ridges varied widely throughout Ireland, as did their dimensions when complete. The latter applied even when the same crop was being cultivated. In 1774, for example, Hyndman discussed the cultivation of flax on ridges ranging from three feet to twenty-three feet in width. Very broad ridges were recorded in Kilkenny, where some 'gentlemen' farmers practised a technique of ploughing 'in balk' for corn crops. The ridges made were up to 16 yards wide. In the mid 19th-century, however, the agriculturalist Martin Doyle claimed the commonest Irish practice was to make 'extremely narrow' ridges, about four feet in width. Unfortunately, the width of trenches or furrows, separating ridges, was more rarely noted by observers. Arthur Young recorded ridges six feet wide, which were separated in one instance by furrows two feet in width, in another, two and a half feet. It seems to have been fairly common for narrower ridges to be accompanied by furrows which were between one third and one half the ridges' breadth. Ridges also varied in height. The rather fragmentary evidence suggests that the centres of ridges might be anything from six inches to three feet higher than the adjoining furrow bottoms.

This was a very aggressive regime in its treatment of the soil profile. The sets of ridges in a field were not permanent. From season to season their orientation might be changed or,



Illus. 7—A 'flatcher' from County Tyrone: this heavy instrument was in effect a breast plough, used to pare the sod from fallowed land in preparation for spade-dug cultivation ridges (reproduced from McEvoy 1802, 51).

after a fallow period, the sod might be pared off the surface then piled, dried, burned and spread again as fertiliser. The furrows between the ridges might be deepened to bring up mineral-rich subsoils, which were also spread on the ridges as fertiliser, and drains were sometimes set between the ridges in the deepened furrows. (As an aside, this aggressive treatment of the soils in the early modern period may partly explain why earth-cut features from earlier periods—like the post-pits of a prehistoric roundhouse, for instance—are so seldom found by test excavations in the West.)

Intensive manual tillage required a distinctive set of tools. The instrument for paring sod (a 'flatcher') was a kind of heavy, wooden breast-plough with a wide curved blade (Illus. 7). At harvest time sickles were preferred to scythes. A large scythe in experienced hands is five times more efficient than a sickle but is not convenient for use on rounded, steep-sided ridges. The local forges known as 'spade mills'—where agricultural tools were manufactured or finished—flourished in this period (Rynne 2006, 268; O'Sullivan et al., forthcoming). Spades themselves varied considerably in their design, not only from region to region but from one district to another, and different sorts of spade might be used in the same field for breaking the ground, ditching a furrow, raising a ridge and working the tilth on its surface. Sometimes the spade and plough were combined, as in this modern instance reported by Jonathan Bell (correspondence 29/10/2004): 'We have recorded one man in Monaghan who made one side of the ridge using a horse plough, going downhill, and the other side using a spade, and a lot of ridges were started by ploughing and finished by spades'.

Why was this seemingly archaic way of tilling the land preferred in the West? The answer is in the sky and in the soil. Then, as now, the West of Ireland can experience up to 60% more rainfall—and correspondingly less sunshine—than the driest parts of the South and East. Wet soil is cold, and the crops it supports are more prone to disease and failure. The 'Improvers' of the day—agricultural innovators and applied theorists—railed against what they perceived as archaic methods. Horatio Townshend, in his *Statistical Survey of the County of Cork* (1810, 247), complained that: 'An experienced agriculturalist cannot behold without surprise, a farmer with half a dozen labourers, toiling for a fortnight (while his horses are doing nothing), to perform a piece of work, which his plough and harrow could accomplish in a couple of days'. Yet it is a fact that soil in mounded ridges is warmer and drier than the same soil spread in a flat tilth. Also, ridges expose the crop to more light and air, which is an added benefit in a damp climate. A cost-benefit analysis by the Devon

Commission in 1847 determined that the labour used to make ridges could more profitably be diverted to drainage work instead, with the aim of making ridges redundant within a period of 20 years (quoted in Bell 1984, 27). But in the absence of public monies to bring about these improvements, the first concern of farmers was with immediate profit and not with the fortunes of the next generation. They understood, from experience, that they could recoup the high cost of making ridges from the bigger yield obtained at harvest time, and this was sometimes acknowledged by the 'improvers' too.

In general there was a big increase in the amount of land brought under cultivation in Ireland in this period and a corresponding increase in the volume of root and cereal crops produced. Partly the increase in tillage was led by market demand. Over 200 breweries and about 2,500 grain mills are recorded in Ireland by the mid-19th century (Rynne 2006, 241, 256), but Irish oats, barley and wheat were also being exported on a large scale to mills and breweries in Britain in this period. Tillage did not supplant livestock husbandry in western counties but they did participate in the general increase in arable production at this time. The crops grown in Galway were much as elsewhere in the country. Hely Dutton's *Survey* (1824, 12) recorded that: 'The soil of this county generally produces every crop in abundance. The wheat, particularly that which is produced to the southward of Galway, is amongst the best in Ireland, producing that fine bread to be found in Galway, Tuam and other towns, and in almost every gentleman's house.'

The increase in tillage was also led by subsistence needs. Spade-dug cultivation techniques were used on a large scale in the West, alike by tenant farmers on 10 acres and gentlemen farmers on landed estates. But as the population grew, more and more land came under cultivation, so that remnant ridges can still be seen today in the most unpromising locations, on steep-sided hills, dry knolls in bogs and cleared patches in boulder fields, where marginal land was broken and planted by the poorest folk, to grow food for themselves. Oats had been the staple of the ordinary Irish in the post-medieval period but gave way to potatoes as the early modern period advanced; buttermilk was their drink in both periods. The poor ate very little else. But subsistence and the market did not represent separate, unrelated economic worlds. They were interwoven by labour in a manner starkly described by Robert Bell in the 1790s:

> Bread made of flour of wheat was a luxury; but whenever, by any uncommon effort [the labourer] was able to cultivate that species of grain, it bore a price at market so comparatively high, that ruin would to him be the consequence of not selling the whole of it. Hardly ever in the possession of any sort of flesh meat, but pork or bacon, he always considered this as an article of too much value to be converted to the use of himself or his family. The butter, the poultry, and the eggs, were equally his property, and the miserable family by whose care they were produced, were equally prohibited to use them. What did these people live on? They lived on those things for which little or no money could be procured at market: potatoes constituted their chief food. The next article which he retained for his own use was one of still less value, it was that part of the milk which remained behind after butter had been extracted from it [quoted in Clarkson & Crawford 2001, 86; after Bell 1804].

Hely Dutton (1824, 70) complained that he had heard Galway's landlords too often say of their tenants: "I do not care a damn what they do, or how dirty their houses are so [long as] I receive my rents". By the eve of the Famine, 40% of Irish farms were less than 10 acres in extent and almost none were owner-occupied (Rynne 2006, 187). Cottars lived on much less. So long as potatoes were plentiful, labour was cheap and the land was tenanted, not owned, by the people who farmed it, the increases in demand for arable products did not spur on either innovations in technique or investments in improvements.

So what brought the archaic and labour-intensive regime of manual tillage to an end? A constellation of factors combined to make the gangs of hired labourers with their heavy, long-handled spades a thing of the past. Extensive drainage schemes were got under way in the West as the 19th century advanced, with corresponding improvements in the soils. In tandem with drainage schemes, roads and trackways were developed, so that farmlands became accessible to mechanised equipment and wheeled vehicles. Mechanical equipment, like steam-driven ploughs and harrows, became available to estates and larger farms, and on smaller holdings the light, iron, Scottish 'swing plough'—which could be operated efficiently by a ploughman with a single draught horse—was universally adopted. (This is the light, elegant iron plough most often seen today blocking gaps in hedgerows or discarded in farmyards, but still used by its aficionados in exhibitions at ploughing matches.) Scythes or reaping machines replaced the sickle. Market demands changed too, so that dairy and meat products increasingly displaced cereals in the Irish export market. (In the later 19th century Ireland became for the first time a net importer of cereals.) But critically, the great Famine of 1845–8 brought an end to the plentiful supply of cheap labour on which, above all, spade-dug tillage had depended.

Today, it is still possible to see fugitive patches of broad ridges in parts of County Galway—usually in marginal land that was brought into cultivation by the poorest people, at a time of peak population, but that has only been used since then for rough grazing. Elsewhere, the swathes of corduroy-striped cultivation ridges that once covered the land, and the people too who made them, have become ghosts in the landscape, and are only made visible again in the greyscale images of our geophysical survey reports.

Acknowledgements

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