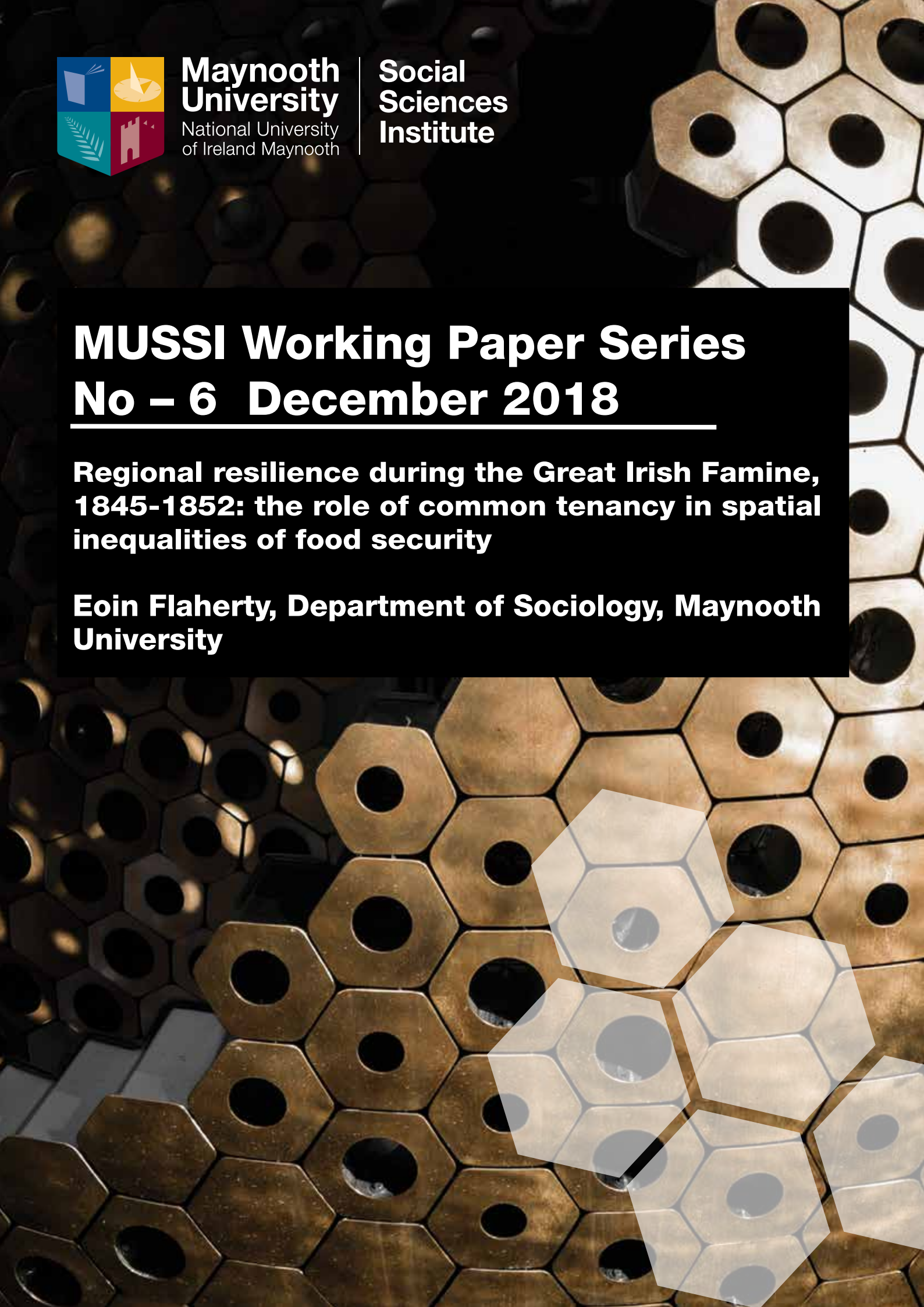

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This paper deals with two principal questions, drawing closely on the experience of Ireland. First, it addresses a deficit in our knowledge of resource governance institutions and land tenure systems as moderators of the impact of famine. We have known for some time of the extent and distribution of common tenancy systems in districts of 19th-century Ireland and across wider Europe, but little has been written about their role in determining levels of ecological risk exposure. Knowing that both distress and common tenancy were higher in marginal, impoverished Irish districts, this is an omission of some concern. Second, although current thinking on common-pool resource governance suggests such systems were potentially robust to ecological stress, why did this not translate into greater resilience in the Irish case? The paper argues that to make sense of this contradiction, we must consider both the local behaviour of ecological stressors, and the wider context of Irish colonialism. Using local clustering analysis and geographically weighted regression, it shows how the impact of key stressors varied geographically. It concludes by suggesting that narratives and analyses of the role of common-pool resource governance in conferring ecological resilience must be tempered with a fuller appreciation of geopolitical context.

Keywords: Ireland, nineteenth century, famine, commons, resilience

INTRODUCTION

Why does the Irish Famine of 1845-1852 continue to capture popular and academic imagination? Its status as the 'last great subsistence crisis in the Western world' begs questions of how such an event could occur in a colony of affluent industrial Britain. It also defies usual markers of recovery, as its population never recovered from an estimated excess mortality of 981,000 (Boyle and Ó Gráda 1986, 555), or 10-18% loss of total population due to combined mortality, and emigration. Whilst its sesquicentenary (1995) saw the release of a new wave of writing delving deeper into its proximate causes (Kinealy 2006), these questions are far from resolved. The respective role of the British State, its intentionality, the Malthusian nature of the event, and the role of landlordism remain open questions (Delaney 2012; Flaherty 2014; Ó Gráda and Kelly 2015). Similar questions on the role of colonial context come into play later in the 20th century in instances such as the Bengal Famine of 1943, where occupational restructuring under colonial rule set a disastrous context for the catastrophe which followed (Sen 1981). There is also recognition of the modest role Ireland may play in helping us to understand subsistence and ecological crises of modern times, such as Fraser's work on resilience to climate change (Fraser 2006, 2007). Meanwhile, the literature on common pool resource systems, or 'the commons' has grown, albeit independently, of work on the Irish famine. This work emphasises the potential role of common-pool systems in conferring ecological robustness, and resilience to shock events, and the relative merits of socially embedded vs market-based solutions to ecosystem management (Janssen, Anderies, and Ostrom 2007; Ostrom 1990; Ostrom et al. 2009).

There is good reason for bringing these two bodies of work together. First, renewed attention has been given to the extent of common-pool resource governance in Ireland during the mid-19th century has recently emerged (Anderson 2010; Flaherty 2013, 2014; Slater and Flaherty 2009). Given its potential coincidence with an ecological catastrophe of global significance, it provides an ideal testing ground for theories linking institutional resilience with ecological outcomes.

Second, the pan-European significance of common-pool and non-capitalistic agrarian systems (Anderson 2010) suggests that Ireland still has much to teach us about processes and mechanisms of social change, given the complex coexistence of feudal, primitive-communal, and putative capitalistic modes of production throughout this time. Finally, by bringing previously unexploited data to bear on the subject, we may clarify more pointedly the potential role common-pool systems may have played in determining regional distress rates during the Irish famine, thus enhancing our understanding of its causal factors. This paper provides such a test.

PROPERTY, LAND GOVERNANCE, AND MODELS OF FAMINE DISTRESS

Since the publication of Amartya Sen's (1981a) seminal work on the causation of famines, subsequent research has emphasised general factors underpinning instances of famine, coupled with a wider concern with issues of global food and resource security, and ecological sustainability. This is reflected in the current lexicon of human ecology, where concepts such as sustainability, resilience, and adaptive capacity dominate. Whilst these concepts are useful, there is a risk that - as with the concept of sustainability in recent decades – they lapse into metanarrative, in a manner which obscures their origins as useful 'middle range' methodological devices. Sen's entitlements model remains one of the most cited in the famine studies literature. According to Sen, lapses in resource security giving rise to famine ultimately come about through a confluence of 'entitlement collapses', where opportunities for food acquisition through subsistence growing (direct entitlements), purchase (indirect entitlements), and public welfare (transfer entitlements) simultaneously collapse. The immediate benefit of this model was its ability to easily transcend Malthusian arguments focusing on population as a prime mover, shifting attention instead to national contexts and political infrastructures underpinning the distribution of food. Although the model has come in for subsequent criticism, such as Devereux's charge of methodological individualism, and his lack of attention to non-market famine vectors (2001), it has remained markedly resilient. Central to its appeal amongst sociologists is its ability to undercut explanations which focus on food supply alone, toward those which emphasise socially-embedded resource systems. In this respect, one crucial deficiency identified by Devereux (2001) is that of the role of different institutionalised forms of resource governance in determining different levels of resource security. Whilst a methodological individualist approach might be blinded to such overarching institutional forms, evidence on their significance as moderators of resource security is substantial (Anderies, Janssen, and Ostrom 2004; Costanza et al 2001; Flaherty 2014; Futemma et al 2002; Janssen et al 2007; Ostrom 1990; Ostrom et al 2009).

Compounding the steady drift of social scientists away from substantive analyses of resource inequality, is an unhelpful methodological divide. Whilst debate continues amongst proponents of complexity regarding the validity of the linear model (Byrne and Callaghan 2013), geographers have been developing statistical models to better capture spatial heterogeneity, and more accurately model spatially-varying processes. The potential for mutual benefit here is obvious. As narratives of resource security move further from 'global' accounts of macro-level drivers, the growing capacity of statistical techniques to corroborate these more nuanced mechanisms offers a welcome pairing. Such is the objective of this paper. Ireland remains a concerning case in famine studies. It continues to violate one of the standard benchmarks of post-famine recovery with a population level below that of 1841, and remains an area of active debate and research as new datasets and source documents are exploited (Delaney 2012; Flaherty 2013, 2014; Kinealy 2001; Ó Grada and Kelly 2015). As we continue to uncover more about the extent of non-capitalistic modes of resource governance in pre-famine Ireland and beyond (Anderson 2010; Krader 1975), its ability to speak not only to the famine studies, but also to the growing literature on *the commons* is substantial. Finally, the quality of data available for this period allows us to explore new statistical techniques for the detection and modelling of spatial heterogeneity, in a manner not adequately

accounted for in existing quantitative models of famine impact. Before examining these specific issues further, the following sections clarify the conceptual foundations of this analysis.

THINKING GEOGRAPHICALLY: RESILIENCE, LOCAL DEPENDNCIES, AND TOBLER'S LAW

A resurgence of interest in Waldo Tobler's *first law of geography*, culminating in the publication of a discussion symposium in the *Annals of the Association of American Geographers* in 2004, saw renewed theoretical attention offered to a long-standing staple of human geography (Goodchild 2004; Miller 2004; Sui 2004; Tobler 2004). Tobler's law, claiming '...everything is related to everything else, but near things are more related than distant things' (Tobler 1970), may be interpreted in a number of ways. As a theory of spatially-varying relationships, it offers a basic defining principle for explanation in human geography: proximity and distance matter to the character of socio-spatial relationships. As a diagnostic criterion, it formalises the phenomenon of spatial autocorrelation into a simple methodological principle, where the first law becomes a condition to be modelled in quantitative geographical analysis. In the *Annals* debate, attempts were made to extend the law beyond its narrowly-defined use within spatial modelling, as a means of making sense of *mechanisms* of local dependency, rather than a descriptor of spatial autocorrelation alone. It was here suggested that the literature on complex adaptive systems could serve such a facilitating role (Miller 2004).

It is worth exploring this possibility further, considering the substantial volume of work in the fields of resilience and complexity which has emerged since the *Annals* discussion. The challenge however, is in reconciling the apparently simplistic idea of 'proximity' as a sufficient explanation of spatial relationships, with a body of theory which appreciates the complex nature of local spatial interactions. The wider social/ecological complexity literature may here be useful. This literature draws attention to the ways in which apparently simple local interactions can generate complex macro-geographies and emergent patterns, which transcend the properties of the units from which they are generated (Byrne 1998, 2005; Sawyer 2005). This does not imply that macro-complexity can be comprehended simply by studying the properties of constituent units as per the classic systemic paradigm (Skyttner 2005). Instead, it calls for careful attention to how we conceptualise systems themselves, and more importantly for this study, how we theorise the mechanisms which connect local behaviour to macro-structures and meso-institutions. This is as much the work of theory, as measurement and modelling, and is a staple concern of the resilience and complexity approaches.

At its core, complexity offers a means of conceptualising societies and social systems as multilevel entities embedded in specific ecological-geographical contexts, rather than viewing them as disparate assemblages of social institutions alone (manifest in the collections of variables which we typically, and necessarily, adopt as substitutes for more detailed information on system composition). As an epistemology of social-ecological systems, it offers a powerful account both of the actions of agents which give rise to wider social structures, and the emergent macro-properties which constitute our measurements as quantitative analysts. Complexity theory thus offers new opportunities to bring social theory back into dialogue with systems-based human ecology, from which it has long sought to distance itself. The general epistemology of complexity is complemented by the resilience approach, which views resource security not as a product of destabilising variables such as population growth alone, but because of patterns of cumulative risk exposure specific to the nature of local ecosystems. This approach works from the unique characteristics of food production systems themselves, to explain the causes of food and resource insecurity in specific contexts. (Berkes, Colding and Folke 2003; Cumming et al 2005; Fraser 2007; vanApelDoon et al 2011). Fraser (2006) for example, has suggested that measuring a system's

degree of species diversity, biomass volume, and connectivity, offers a means of operationalising resilience as a measure of robustness to ecological stress.

Together, these perspectives can serve as a means of reinvigorating both the first law, and the application of theory to the analysis of spatially varying relationships. By broadening the role of theory beyond that of law-like statements, to an appreciation of the generative mechanisms operating at local levels which give rise to spatial homogeneity and heterogeneity, the practice of geographical modelling can be brought closer into dialogue with wider theory in both human geography and human ecology. If we adopt as our basic principle the assumption that our units of analysis, at any given spatial scale, are complex open systems, comprised of emergent social, cultural, economic and ecological properties and levels, in a state of mutual interconnection (Capra 2005; Cillers 2001; Harvey and Reed 2004), our task is to interpret our models in terms of the interactions of these various dimensions. This can be accomplished by thinking through mechanisms of local dependency, in a manner which incorporates aspects of culture, economy, and ecology, and the ways in which they conspire to create unique geographies of local interaction which may then be detected through more formal means. In short, whilst not rejecting the presence of stable patterns and structures, we must remain sensitive to local context, and the underlying complexity of interacting agents and social structures, which give rise to geographical patterns. We can begin to articulate and operationalise this task more clearly by focusing on the specific properties and dynamics of common-pool resource systems, and the extent to which they may mediate local patterns of ecological risk exposure.

COMMON-POOL RESOURCE SYSTEMS AS MODERATORS OF ECOLOGICAL RISK

As the resilience approach is one inherently geared toward understanding the spatially-varying nature of social-ecological systems, forming a sufficient overview of the general properties of the system in question is vital. In the conceptual language of resilience, this involves delineating the system's identity, and using this information as a means of inferring the adaptive capacity of the systems institutions, or its ability to respond to disturbances in its environment. This resilience is a function of the institutional robustness of a system (i.e. the integrity of its governance institutions, its modes of resource management, demography, and economy) and contextual constraints placed upon the system (i.e. local ecology, climate, land ownership, state administration), which will tend to vary over space. Resilience may thus be provisionally defined as '...the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks' (Walker 2004 cited in Grimm and Calabrese 2011: 8). It is an invaluable heuristic for addressing shortcomings in structuralist systems theory, which has tended to search for general mechanisms giving rise to society-wide equilibrium, rather than case-specific conditions of systemic reproduction and sustainability. In methodological terms, classical systems theory is rooted in an implicit discarding of the spatial heterogeneity assumption, through its insistence on cross-sectional modelling. Here we invoke the concept of resilience as a means of reconciling the general properties of common pool resource systems, with specific mechanisms of local dependency.

There is much evidence suggesting that social-ecological systems with institutions that are adaptive to economic, political and ecological variability, experience heighted resilience to ecological stress through greater institutional robustness (Janssen, Anderies and Ostrom 2007; Wall 2014). This robustness is often explained as a function of cumulative experience internalised in institutions, whereby variations in local ecological conditions become adapted to within and between generations. Previous studies such as Ostrom (1990) have often observed '...that small-scale governance regimes that incorporate local knowledge, have clear rules that are enforced, and rely

on high levels of trust frequently perform well' (Janssen, Anderies and Ostrom 2007, 308). Resource pooling is often a viable option for non-capitalist agricultural systems, in the absence of stocks of capital amongst individuals, and as a means of bringing new tracts of land into cultivation. Common-pool systems are especially appropriate when land productivity is low, yield reliability is low, capital investment is absent, and where large territories are involved (Ostrom 1990, 63). Viability within common-pool agrarian systems was often kept in check by consensus-based mechanisms, such as the scattering of an individual's holdings in land strips of varying quality, restrictions on numbers of livestock in proportion to an individual's arable holdings, and periodic rotation of individual plots amongst commune members which discouraged resource and labour hoarding on specific portions of common lands.

According to Smith (2000), such common property regimes as exemplified by openfield agrarian systems, resolve several ecological difficulties engendered by the 'problem' of collective action, which has so occupied rational actor-oriented human ecology (Ostrom 1990). Within English, Swedish and German openfield systems of the seventeenth and eighteenth centuries, similar practices of strip dispersal as those later observed in Ireland prevailed, according to which each individuals' holdings (themselves merely usufruct) were scattered in a series of intermixed strips throughout the joint lands of the village. Such a system was interpreted by Seebohm as bound with requirements of grazing, whereby the size of each temporary holding was determined by the number of oxen contributed by each tenant to the village or manorial plough team (Goransson 1961, 83). Although some have been quick to idealise such arrangements as an archaic form of altruistic communality, others have pointed out that such scattering and redistribution functioned to permit combined tillage and grazing - otherwise impossible individually, owing to land and labour requirements - by maximising the grazing area available to the community after harvesting (Janssen et al 2007). These mechanisms of subdivision and plot scattering thus imposed collective ecological sanctions on excessive individual exploitation

Common-pool resource governance systems in Ireland

We suggested above that the rundale system in particular, and common pool resource systems generally, constitute a specific set of social-ecological properties and relations apart from those of pre-modern feudal and capitalist society. On the basis of comparative data, there is little doubt that common tenancy was widely distributed across many districts of mid-19th century Ireland, and even where it was a minority phenomenon, its presence marked it apart as a distinct mode of tenure and governance (McCabe 1991; McCourt 1955). The unique nature of common tenancy is well established in both documentary and statistical record. Early administrators were acutely aware of the residual influence of Gaelic legal code in local landholding practices, and as such, one of the first acts of Lord-Lieutenant Chichester in 1605 following the accession of James I, was to outlaw the practice of partible inheritance known as 'gavelkind'. The highly localised, and community-based nature of Irish landholding and kinship was also remarked upon by Sir. John Davies in *Of the Lawes of Ireland* (c.1610), where he noted that lands were often distributed amongst local *septs* headed by deputed chiefs, with lands periodically redistributed between sept members (Davies 1610 cited in Kelly, 1997: 430).

One school of thought which locates the origins of common tenancy in the pre-Gaelic era, suggests that such practices may have subsequently congealed over centuries into stable local identities giving rise to the geographical divisions of *townlands*, which remain in use to this day. Despite attempts by local landowners to subvert the system, by the 19th century, survey figures from the appendices of the *Devon Commission* (1845) show that 59%, 58%, and 29% of the lands of Counties Kerry, Mayo, and Clare respectively, were held in common or joint tenancy at the time of recording. Variance between unions within counties was more pronounced still, with 83% of the

union of Westport (Co. Mayo), 71% of the union of Scariff (Co. Clare), and 50% of the union of Kenmare (Co. Kerry) recorded as held in common. Local patterns thus appear to be of primary importance, and the omission of such from cross-sectional models presents a concerning degree of potential confounding. The specific characteristics of these areas were also quite distinct from those of wider Irish society at the time. As the following table shows (table 1), there were sharp qualitative differences in the composition of these common-pool systems along key dimensions.

Table 1. Composition of common-pool resource systems

Dimension	Common-pool system	Individualised system
Tenure	Joint or partnership	Individual
Property transmission	Partible inheritance	Primogeniture
Settlement morphology	Nucleated	Dispersed
Field system	Openfield (infield-outfield) system with communal share allocation	Enclosed fields, stable boundary demarcation
Local governance	Governance by communal council / headman	Solitary decision making
Legal reckoning	Customary law, usufruct entitlement	Civil / common law, private property
Village structure	Absence of services (public house or church)	Growth of township to include services
Demography	High fertility, high subdivision	Restricted subdivision, high migration, impartible inheritance

Whilst the presence of the above conditions is well noted in the wider literature on the Irish rundale, the productive activities of these areas, and in turn their potential resilience to ecological risk, was filtered through the wider country-wide context of colonialism. The non-capitalistic nature of the Irish rental system (to which all tenures were beholden under colonialism), is corroborated by the absence of a supply-and-demand price-setting mechanism for Irish rents. Irish rent was instead determined by the number of intermediary sub-tenancies, as landlords often sub-let their properties extensively to middlemen and land agents. Thus, whilst Ireland's level of outward trade in agricultural produce lent it the appearance of a putatively capitalistic society, the social relations of production remained rooted in a feudal rental regime with highly variable patterns and extents of direct local control. This system was interspersed with extensive tracts of common-pool resource governance where lands were held and administered in common, a situation which remained in some districts into the early 20th century. Because of the overarching feudal rental system, all common-pool regions operated under the auspices of a joint leasehold system geared as much toward rent production, as to subsistence. Rundale thus remained a highly constrained system, according to the specific nature of local colonial land administration. Our methodological task is thus to identify regional measures which best capture these degrees of constraint, and to formulate an appropriate modelling strategy.

DATA AND METHOD

Although some attempt was made to quantify regional patterns of risk exposure in the context of severe famine previously, (Flaherty 2014), this analysis relied on data measured at county level (N=32), thus limiting the scope for multivariate modelling. The following analysis draws on a set of aggregate data measuring a range of physical, social, economic, and agricultural conditions at Poor Law Union level (N=130), which allows for the specification of more complex models than previously possible. Owing to the importance of both the *extent of common tenancy*, and *ration uptake* (measured originally at union level), this level of analysis is most appropriate for maximising the availability of additional variables. The data are sourced from a range of publicly available reports and statistical abstracts compiled between 1841 and 1849. Summary statistics for all variables are provided below in table 2, and all sources are cited in the data appendix below (Appendix 1). This analysis draws on the decennial population census, and annual agricultural censes, Commission of Inquiry into the Occupation of Land in Ireland (Devon Commission), and the Reports of the Select Committee on Poor Laws. All relevant calculations are noted, and any applied transformations are noted in the figure titles and regression tables.

Table 2. Summary statistics

Variable	Mean	SD	Min	Max	Moran's I
Ration uptake (standardised rate of relief ration uptake, 1847)	0	1	-1.44	3.85	.685***
Population density (individuals per acre, 1841)	.49	.45	.14	4.02	.191***
Poor law valuation (£pounds per acre)	.87	1.43	.02	12.82	.298***
Consolidation of holdings (% change in proportion of farms over thirty acres, 1848-1849)	3.06	7.28	-17.06	38	.185***
Uncultivated land (% total cropland uncultivated, 1847)	71.44	12.29	40.72	97.08	.442***
Corn yield (% change in corn yield [kilograms per acre], 1847-1849)	-8.09	19.10	-45.39	75.64	.123***
Total crop area (percentage change in total crop area, 1847-1849)	1.54	2.27	-3.95	6.74	.182***
Flax cultivation (% area under flax, 1847)	1.14	2.03	0	9.52	.628***
Common tenancy (% lands held in common or joint tenancy)	8.00	15.25	0	83.88	.224***

*p<.05; **p<.01; ***p<.001

Table 3. Inter-item correlations

	Ration	Population	Valuation	Consolidation	Uncultivated	Corn	Crop	Flax
Population	-.184*							
Valuation	-.200*	.962***						
Consolidation	.226**	-.227*	-.237**					
Uncultivated	.515***	-.331***	-.309***	.085				
Corn	-.175*	-.130	-.137	-.181*	.109			
Crop	-.227**	.112	.058	-.194*	-.062	.006		
Flax	-.340***	-.044	-.100	-.158	-.161	.082	.248**	
Common (log)	.290***	.023	-.021	.161	.266***	-.069	-.038	.100

*p<.05; **p<.01; ***p<.001

The dependent variable is the rate of relief ration uptake, following the approach used by Kinealy (2006) in her appendix indicating areas suffering high levels of distress. Following initial discussion concerning the establishment of a system of rate-based poor relief in pre-famine Ireland, the famine relief activities of the *Select Committee on Poor Laws* were recorded in a series of reports presented to parliament in 1847. An important set of statistical tables in these reports tabulates the extent of mitigating activities undertaken by the relief commissioners in July of this year. Owing to increases in the import of foodstuffs throughout this time, a reduction in domestic food prices enabled the commissioners to subsidise outdoor relief in the form of rations (either gratuitously, or at reduced cost according to individual means), with characteristically liberal warnings of market interference, and the necessity of countering tendencies toward idleness. These issued rations consisted of 1&1/4lb of bread (or 1lb biscuit or meal), or 1 quart of soup thickened with a portion of meal along with ¼ ration of bread (Second Report of the Relief Commissioners... 1847). The first table of records concerning the issue of rations appears in the Second Report of the Relief Commissioners, and distinguishes between rations issued gratuitously to the registered destitute, and those sold to individuals of limited means at reduced cost (ibid). Statistics employed in the forthcoming analysis are limited to those concerning the issue of gratuitous rations, which in a majority of unions significantly outnumber those sold at subsidised rates. The data are drawn from six successive reports of May 8th, June 5th, July 3rd, July 31st, August 28th and September 11th, 1847. The largest number of rations issued on a single date across all reporting periods was selected for inclusion. The rate of ration uptake per head of population was first calculated, before z-score standardisation.

Our key independent variable is the extent of common tenancy, sourced from the statistical tables of the Devon Commission (1845), which records in Appendix 94 the 'Area of Union in Statute Acres', and 'Total Number of Acres Held in Common or Joint Tenancy', permitting calculation of a comparable rate. Figures at union level exhibit greater variation than those reported at county level in previous studies such (Almquist, 1977), and when aggregated to county level, such variation is lost owing to significant differences in the extent of *recorded* communal tenure within individual counties. For example, despite 50% of the lands of the union of Kenmare, Co, Kerry being noted as held in common, the union of Caherciveen – also falling within Co. Kerry - shows none. McCabe

(1991) suggests that joint tenancy may have been under-enumerated however, owing to the reliance of union clerks on union rate books. As such, any potential errors in the compilation of figures are likely to affect absolute levels within unions, rather than the variance, which is of primary concern. When corroborated with other estimates of the extent of common tenancy such as McCourt's clachán distribution map compiled from first edition six-inch ordnance survey maps (1971: 138-139), we can be confident that these figures are representative of between-union variation in rates of common tenancy. Further details on other variables used in this analysis are available in appendix one.

Our analysis proceeds in two distinct stages. First, preliminary descriptors of the clustering behaviour of spatial attributes are investigated using Moran's I and Getis-Ord Gi*. The challenge in these initial phases is of squaring the proscriptions of Tobler's law with the data-generating process giving rise to observed clustering effects. Here we draw on the theoretical insights of resilience and complexity theory to articulate these connections more clearly. This involves thinking carefully about the substantive mechanisms underpinning local dependencies across the range of included predictors. Moran's I measures the slope of a bivariate plot of a given variable against its *spatial lag* calculated from as the mean of both a unit, and its set of defined neighbours. Neighbours are here defined by 'Queen' contiguity, which includes the unit, and all proximate units in direct contact with any portion of its boundary. Accordingly, a positive slope indicates close correspondence between the variable and its spatial lag (i.e. its neighbours). In specification, Moran's I is an extension to the standard product-moment correlation, with the addition of a spatial weights matrix capturing dependencies between contiguous regions (Brunsdon and Comber 2015, 230). Variables are centred prior to plotting and calculation.

Getis-Ord Gi* compares the local mean of a feature and its defined neighbours against the global mean, producing a plot identifying statistically significant instances of 'high-high' and 'low-low' clusters. This approach identifies areas which represent a significant departure from the global norm, and are useful for gaining a visual appreciation of local clustering behaviour. As with the Moran diagnostics, we use contiguity definitions of neighbouring rather than fixed bandwidths. Together, both Moran's I and Getis-Ord Gi* permit closer investigation of the local and global behaviour of particular variables. Second, having explored the presence of geographical clustering effects, we present a geographically weighted multivariate regression model (GWR) of factors contributing to local distress rates. In this specification, independent variables become functions of both a location and its attribute, thus permitting variation in parameters over space (Brunsdon and Comber, 2015, p. 291). The standard regression model maintains fixed parameter estimates across the entire set of data. Adding a location represented by coordinates allows coefficients, intercepts, and diagnostics to vary as a function of different weighting methods – typically distance-based bandwidths/moving windows, or contiguity functions. In effect, this method estimates an iterative series of restricted models utilising cases falling within a given bandwidth, thus constructing a distribution of values from the standard regression output.

Parameters are estimated through ordinary least squares, and both fixed and adaptive bandwidths based on Akaike's Information Criterion (AIC) are provided. For comparison, these models are compared to cross-sectional OLS with cluster-robust standard errors. Interpretation of models is aided by the provision of mapped model output, allowing visual assessment of local parameter behaviour. This section argues that cross-sectional analyses which discard the potential for spatial autocorrelation introduce a critical source of potential error into their conclusions – substantive and theoretical. Consequently, by examining this local variation we come closer to understanding how this complex mix of contextual factors conspired to produce uneven rates of distress across the island throughout this time. We interpret these results in context of resilience theory's emphasis

on local adaptive capacity as a central property mediating the geography of ecological risk exposure.

UNDERSTANDING THE LOCAL GEOGRAPHY OF FAMINE

To what extent do these variables show local clustering? Are there regional disparities in the distribution of values, and if so, how can we account for this? The classic rendering of Tobler's law suggests proximity plays a key role in the patterning of social-geographical relations. Proximity alone is insufficient to account for observed autocorrelation however; this must be supported with a valid narrative of the mechanisms generating this effect. In terms of theorising, critical realism approaches this through a process of 'retroduction' or rational abstraction. This neither precedes, nor derives from the act of measurement, but is enacted as its complement. Its basic premise is that we must abstract from the concrete-empirical phenomenon itself, to identify the mechanisms through which its causal properties are activated (Roberts 2006: 70). Whilst the detection of associations through measurement constitutes an extensive form of inquiry, this process is intensive, insofar as it requires us to think conceptually about how a phenomenon comes to behave as it does (Roberts 2006: 73-74). The result is a combination of theory and method which transcends the typically positivistic primacy of measurement, and this is a guiding principle of the coming discussion.

From table 3, we see that our outcome variable shows moderate correlation with other predictors. These are intuitively signed, with higher valuation, crop yield, productive area, and flax growth associated with reduced ration uptake. The negative sign of population density is likely detecting the effect of urban concentration in areas such as Dublin, Cork, Waterford, and Belfast. As such, this is likely detecting the comparative affluence of certain areas particularly within Dublin. It is difficult to detect the impact of population density in Western districts however. Although we may hypothesise that it was substantial, it is more likely to have taken the form of high-density settlement pockets, within otherwise sparse and spacious regions. The presence of large tracts of grazing land, which in turn impacted on the ability of common-pool systems to expand under population pressure, is also likely to have diminished the sensitivity of this measure to smaller, more localised high-density settlement. Similarly, settlement consolidation, the presence of uncultivated land and the extent of common tenancy are associated with higher rates of ration uptake.

Turning to the autocorrelation figures (Moran's I) in table 2, we find substantive, and statistically significant degrees of spatial autocorrelation across all variables (see also figure 3 and 4). Ration uptake records a score of .685, the largest of all variables. This is easily accounted for visually as can be seen in figure 1 showing strong concentration in Western regions. Common tenancy also exhibits a modest degree of spatial autocorrelation, which is likely diminished by the presence of isolated pockets of common tenancy in the southeast and southwest as shown in figure 2. Those of the southwest – South Kilkenny in particular – represent a different form of commune to that described by the typical criteria of common-pool governance described above. These areas are mostly devolved manorial villages of the three-field system, which acquired their nucleated morphology during Norman occupation, but without accompanying communal institutions (Burtchaell 1988). Inspection of the spatial lag plots of these variables (figures 1 and 2) reveals more, with evident linearity in the lag of ration uptake, but a less certain trend in common tenancy. Finally, Getis-Ord Gi* plots for both variables reveal significant hotspots departing from the global average, and clustering along the Western seaboard - particularly in Western counties Mayo, Clare, and Kerry. Together, these indices provide strong corroboration of the importance of local dependency in the behaviour of variables, with clear patterns emerging between East-West, and

North-South. In all instances, Western regions associated with the 'small-farm' archetype (Whelan 2000) display especially strong clustering behaviour.

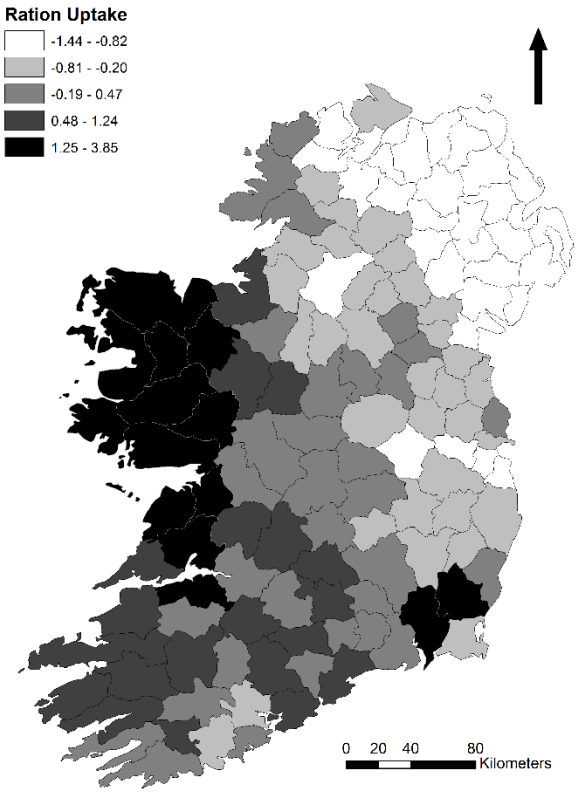

Figure 1. Ration Uptake

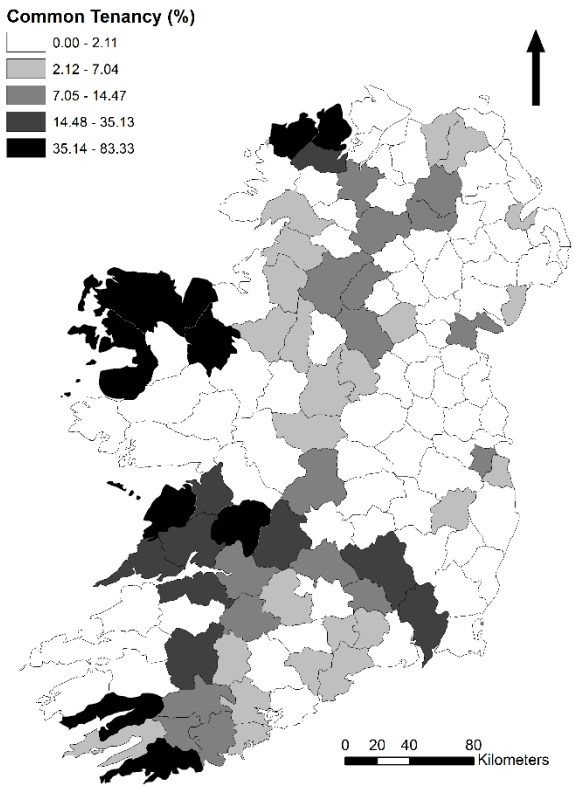

Figure 2. Lands held in Joint or Common Tenancy

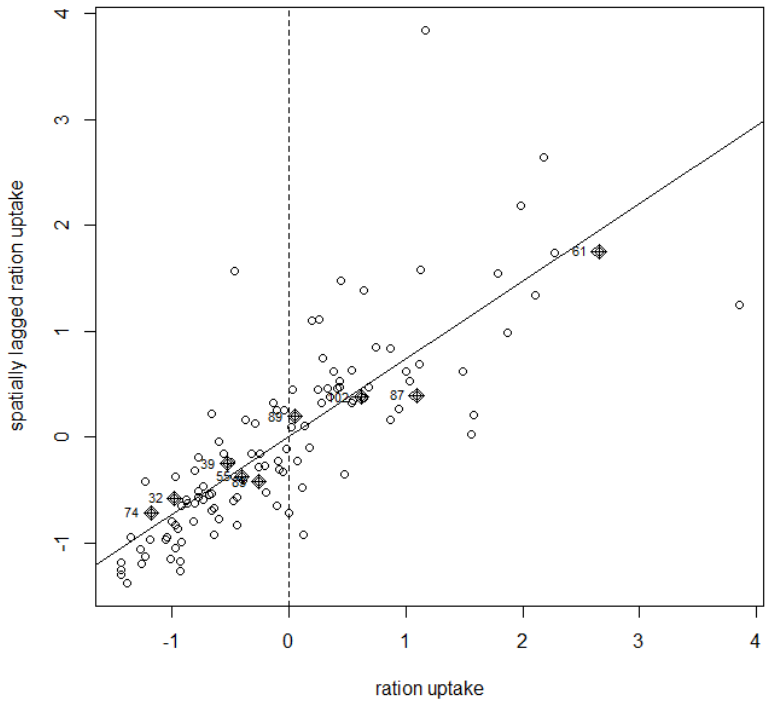

Figure 3. Spatial lag plot, ration uptake

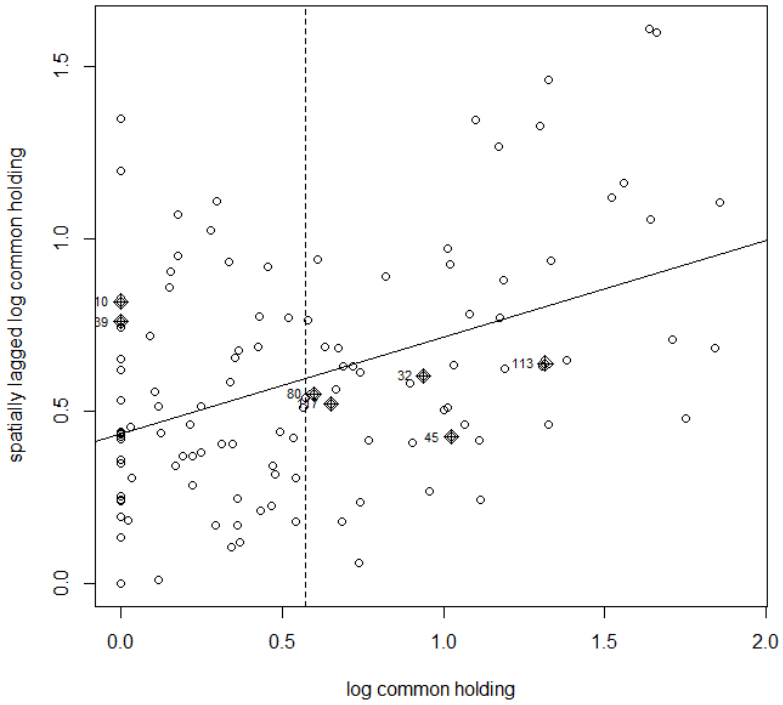

Figure 4. Spatial lag plot, common tenancy

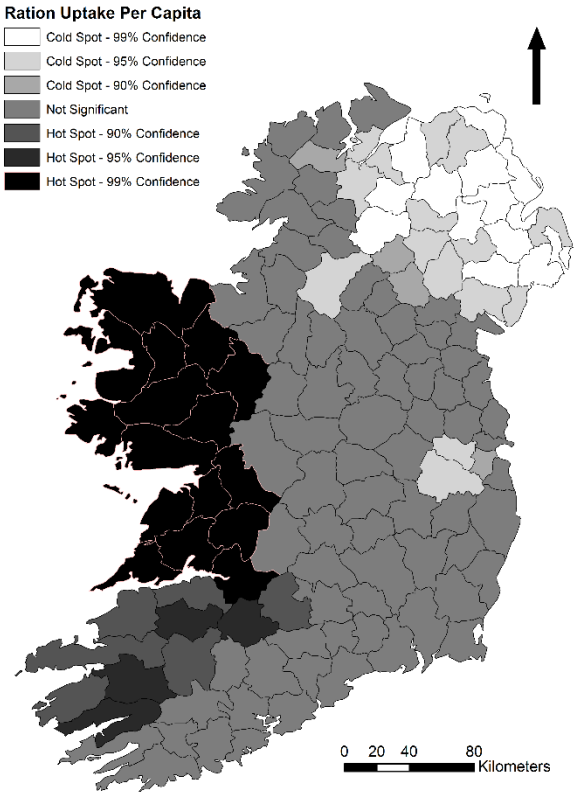

Figure 5. Getis-Ord Gi*, Ration uptake

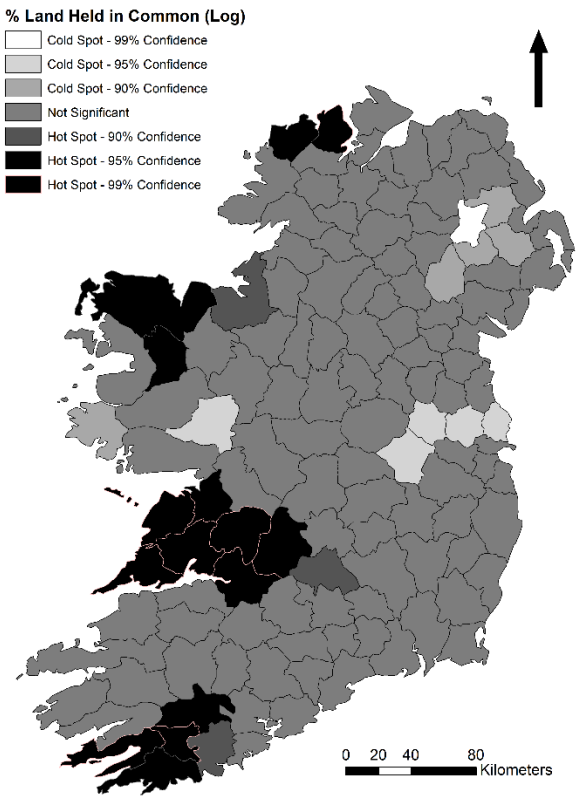

Figure 6. Getis-Ord Gi*, Common tenancy

Mechanisms of local dependency

How can we account for this clustering beyond surface measurement? How did these patterns arise, and how might they be reinforced by the institutional structures of common-pool governance? Mindful of the restrictions on inference to lower-order units inherent in any ecological analysis, we can nonetheless begin to detail several mechanisms (also summarised below in table 4). *Poor law valuation* is a measure closely linked to potential land productivity and profitability. As such, it is closely linked to a range of factors such as predominant regional economic activities, the positions of unions within regional archetypes (whether tillage, pastoral, or quasi-subsistence), and local geology (Collins 2008). Thus, we find a characteristic East-West bias in the distribution of valuation, with a concentration of low valuation in Western peripheries. The mechanisms underpinning this include a predominance of low capital-intensity in Western small-farm production (characteristic of labour-intensive common-pool systems), an underlying geology which confers a characteristically shallow, heavily-leached soil bed (Evans 1979), and higher extents of land subdivision which diminished the introduction of plant and capital to the labour process. The geography of valuation may indeed be underpinned by more thoroughgoing historical processes. The hypothesised post-17th century westerly migration of a dispossessed peasantry in the wake of the Cromwellian plantation for example, which may have created an immediate need for labour pooling to break in new lands for cultivation (Braa 1997).

The process of *consolidation of holdings* displays a more intuitive regional signature. In the post-Napoleonic period, grain and stock price fluctuation dictated much of the character of regional restructuring, as landlords sought to move away from high density tillage production, toward land-intensive grazing in response to rising stock and wool prices. Local styles of land administration also played a role; hence we find contradictory mass evictions on the Nixon estates of Donegal, the Mahon estates of Roscommon, and the Walsh estates of Mayo, yet investment, improvement,

and resettlement on the Hill estates of Donegal (Mac Aoidh 1990; Yager 1996). The post-Napoleonic years marked a watershed in this respect, insofar as the key channels of profitability for landlords shifted from increasing the supply of tenantry engaged in tillage, toward clearing estates to make way for capital-intensive grazing. Approximately 37,286 evictions were carried out between 1846-1849, marking a key stressor on the capacity of common-pool districts to maintain their essential structures (Orser 2006). The result was a spatially uneven pattern of redistribution, with varying degrees of direct local intervention by landowners.

Our four measures of productive activity, *uncultivated land*, *corn yield*, *total crop area* and *flax production* map well onto the processes described for valuation and consolidation, and constitute a key factor in local resilience and adaptive capacity. The availability of wasteland was a key factor facilitating the expansion of the Irish common-pool rundale system. On peripheral lands, the systems' tendency toward demographic expansion through subdivision, facilitated by the encroachment of communes onto new marginal lands was an essential factor of its resilience. This was an unfortunate precondition of the Great Famine, as the prolific potato allowed smallholders to settle comparatively smaller plots of land, thus enhancing the concentration of biomass, and lowering species diversity in the pre-famine years (Fraser 2006). Considering Ireland's rate of population growth in early 19th century Ireland, which rose 72% from 4,753,000 in 1821, to 8,175,124 in 1841, the capacity of individual settlements to incorporate new members whilst retaining its delicate balance of tillage and grazing, was essential – wasteland played a crucial role in this regard. Villages often grew exponentially, with noted instances of unchecked settlements evolving from a handful of homesteads to over thirty within a single generation (Aalen, Whelan and Stout 1997). In the absence of external constraints, expansion was often limited primarily by local geography and geology, but under colonialism, the calculus of international markets played a dominant role in the annexation of neighbouring lands by landlords for capital-intensive activities. The result was a heightened strain on communes who were now forced to accommodate new members by further subdividing their existing space, or by colonising parts of their grazing ground for tillage, thus upsetting the balance of pasture and tillage central to the systems' identity.

Corn yield and *total crop area* both capture changes in production from 1847-1849, the peak years of hardship. Although both exhibit low degrees of spatial autocorrelation, they constitute key components of regional resilience. These measures are arguably preferable approximations of resilience, as they deal with longitudinal change, sourced as they are from the annual agricultural censes which began in 1847. It is telling in this regard, that both corn yield and crop area are negatively correlated with consolidation and ration uptake (table 3). These measures capture seasonal yield consistency during the peak famine months, and declines in cultivated space, potentially linked to lower labour input and forced land enclosures. Corn yield is of interest as, despite the depiction of Western regions as wholly potato-dependent, grains featured prominently in the production process owing to the necessity of rent payments – sales of grain typically meeting these obligations. Thus, whilst potatoes were largely consumed, or their surplus used as stock fodder, grains were essential to avoid falling into arrears and losing tenure. The net effect of physical restrictions on the capacity of rundale to expand, coupled with continuing rent obligations despite the hardship of the peak famine years, meant surrendering an ever-greater proportion of tillage area to non-subsistence crops. This particularly affected peripheral areas, especially common-pool regions, which depended on a delicate balance of tillage and stock for their viability. As such, we find a concentric diminishing of yield from East to West, consistent with the predominance of intensive tillage along the Southern to North-Eastern Anglo-Norman tillage crescent. The pattern is less pronounced for changes in crop area, consistent with its low degree of spatial autocorrelation, although large pockets are to be found toward West-Connaught, and south-westerly toward Limerick and Kerry.

Our outcome, and key predictor (*ration uptake* and *common tenancy*) display clearer spatial patterning, visually and diagnostically. Whilst evidence of autocorrelation for common tenancy is low owing to the haphazard intermixing of high-low density areas, it correlates positively with ration uptake. Figures 5 and 6 show results from the Getis-Ord procedure, which reveals clear concetrations of hotspots in Western counties. Consistent with evidence governing the distribution of flax production in the North, we also find concentrations of lower ration uptake in Northern unions. The mechanisms underpinning this characteristic geography are rooted in the factors of production and productivity outlined above, as well as historical circumstance, and public policy (Delaney 2012). Our range of contextual variables describes well the conditions which facilitated higher densities of rundale – marginal lands of low productivity, regions with high volumes of direct producers subsisting on a narrow range of root crops (chiefly the potato), a characteristic dependence on an openfield system with customary subdivision, and a demographic boom from the early-mid 19th century. With the removal of barriers to early family formation, fertility soared amongst smallholder. Common-pool systems facilitated this through internal subdivision of commune lands, facilitated by the prolific nature of the potato. Such was the pace of fragmentation, that by 1841, 45% of all holdings in Ireland were under five acres, with higher regional rates such as 64% recorded in Connaught (Connell 1950: 284).

The concept of panarchy from the resilience literature connects these factors well to the decline of adaptive capacity at settlement level, and their vulnerability to ecological stress. According to Fraser's formulation, a tri-axial model of connectivity, biomass volume, and species diversity provides a quick index of an ecosystem's resilience. As connectivity (settlement fragmentation) heightens, coupled with a reduction in species diversity (monoculture), and an increase in biomass, the magnitude of disturbance required to induce systemic collapse becomes ever smaller. Such were the circumstances in Ireland on the eve of the famine, however models to date have note taken adequate account of the uneven geography of resilience. As our diagnostics show, these factors were both locally correlated, and spatially distributed, such that a general model cannot be applied universally to the entire territory. Institutional structures – particularly the unique dynamics of Irish common-pool governance played a crucial role in the construction of this geography, mediating the impact of the specific antagonist - in the Irish case, the blight strain which decimated crops over multiple seasons. Consequently, explanation is not to be found in the character of colonialism, nor single stressors such as population alone, but rather in their interactions, and spatial distribution. Our final piece of analysis thus examines the impact of common tenancy, controlling for these contextual factors.

Table 4. Mechanisms of local dependency

Variable	Mechanism
Population density	Classic mechanism of rundale expansion: high fertility, partible inheritance, endogenous expansion, and clachan morphology engendered high density settlement. Density also played a role in the spread of communicable disease. Our data are detecting higher urban densities.
Poor law valuation	Valuation linked closely to productivity and productive capacity of land, and in turn, the profitability of particular activities corresponds with wider economic circumstances such as the relative prices of produce (i.e. grain vs wool vs stock).
Consolidation of holdings	Strong regional differences in estate reconfiguration post-Napoleonic war, moderated by price of produce, extent of direct control over estates and labour within settlements.
Uncultivated land	Availability of wasteland a key contextual variable in the growth of rundale both through outward reclamation from within, and new settlement colonisation. Elevation is also important, as such settlements tended to thrive on higher, marginal lands.
Crop yield	Strong patterning of production and yield according to 'regional archetypes', with particularly strong output in certain specialised areas (i.e. the Anglo-Norman Southern-Eastern tillage tract). Yield consistency reflects regional ecological and economic resilience.
Flax production	Regional clustering of linen production in the Ulster linen triangle, in certain districts of West Mayo, with proximity to linen markets, household divisions of labour, and availability of labour a key factor. Linen production reflects a diversity of income streams beyond sole dependence on single crops, and is a key factor in settlements resilience to external stress.
Common holding	Settlements constituting rundale identity (table 1, 'common pool system') thrived in marginal land-poor districts, at higher altitudes, and under favourable grain prices where landlords encouraged tillage.
Ration uptake	Together, these factors conspired to lower resilience to distress amongst common-pool, and land-poor regions. With the balance of openfield production disrupted, continuing rent obligations, restrictions on expansion, monoculture of dietary potato dependence, low species diversity, disease in turn thrived.

Table 5. Regression Output (OLS and Geographically Weighted)

	OLS (cluster-robust errors)			GWR (Fixed Bandwidth)	GWR (Adaptive Bandwidth)
Common (log)	.544***	.284**	-	.290* (.073)	.300* (.059)
Population	-	1.54***	1.508**	1.323* (.536)	1.472** (.409)
Valuation	-	-.541***	-.510***	-.477** (.140)	-.511** (.109)
Consolidation	-	.004	.006	.007 (.009)	.008 (.008)
Uncultivated	-	.035***	.031***	.030*** (.009)	.031*** (.010)
Corn yield	-	-.010***	-.009	-.011** (.003)	-.011** (.002)
Crop area	-	-.064**	-.069***	-.040 (.032)	-.041 (.037)
Flax cultivation	-	-.150***	-.148***	-.096* (.076)	-.091* (.068)
Common (Group 1)	-	-	reference	-	-
Common (Group 2)	-	-	-.109	-	-
Common (Group 3)	-	-	-.153	-	-
Common (Group 4)	-	-	.694**	-	-
Constant	-.312***	-2.743***	-2.369***	-2.448*** (.540)	-4.235*** (.608)
F	(1, 128) 21.95***	(8, 121) 13.25***	(10, 119) 11.49***	(8, 121) 41.894	(8, 121) 44.482
Adj R^2	.1397	.4318	.5115	.605	.593
AIC	360.476	304.1097	296.793	268.379	270.519
Mean VIF	-	4.90	4.31	-	-
Neighbours	-	-	-	-	117
Bandwidth	-	-	-	149 km	-
N	130	130	130	130	130

*p<.05; **p<.01; ***p<.001
In the GWR column, coefficient standard deviations are in parentheses.

Table 5 displays parallel results from a set of cross-sectional, and geographically weighted models, and visual diagnostics (residual plots and R^2) are provided in figures 7-10. Across all cross-sectional specifications, coefficients are signed intuitively according to the mechanisms detailed above. Common holding displays strong positive association with ration uptake, recording one of the strongest effect sizes aside from population density. Population density is signed positive in all specifications, and strongest of all predictors, however it must be interpreted with caution. While the impact of population density is intuitive in terms of the mechanisms outlined above – particularly in high-density common pool regions - the variable is itself only weakly correlated with common holding (table 3). As such, the positive effect of population is likely due to high-density urban regions into which numbers of destitute flooded during the peak famine years. Rather than marking a departure however, urban areas were themselves sites of vast inequality (in the case of Dublin) and high mortality, especially in high-density tenement districts.

Additional stressors of ration uptake include consolidation (of small magnitude), and uncultivated lands. In line with our discussion of the role of productivity above, consistency of yield and productive area are both associated with lower ration uptake. Corn yield is particularly interesting, as although recorded potato acreages were provided through the agricultural censes, the widespread destruction of crops makes systemic comparison of true yield estimates impossible, whilst turnips are of too small a count to substitute. As corn production is widely distributed across the island, the capacity of regions to maintain output - itself dependent not only on ecological circumstance but also institutional robustness – is a useful resilience indicator. Flax cultivation captures not only the comparative resilience of Northern Ulster, but of the importance of economic diversification. According to Sen's classic entitlements model, the collapse of indirect entitlements constitutes one of three key sustenance channels in a healthy economy. One avenue toward widening indirect entitlement channels at settlement level is economic diversification, and our results suggest that the diversity of income streams offered by cottage industries engaged in flax production and 'putting-out', played a key role in enhancing their resilience to ecological stress.

Model three, from the first set of cross-sectional specifications is of particular interest, as it decomposes common tenancy into four discrete categorical groupings. This is desirable, as the variable is negatively skewed, with a cluster of high-value cases toward the right tail of the distribution. Categorisation was performed through k-means clustering, with an input condition of four, yielding a set of comparator groups for which group 4 displayed the highest group mean. Group four is here associated strongly and positively with heightened ration uptake, suggesting the bulk of the global positive effect was borne by regions of high common tenancy, as other groupings show negative values relative to the reference. Whilst this is somewhat to be expected, its magnitude is striking, further suggesting that the neglect of common tenancy to date has led to oversight of a key dynamic in rural social structure.

Both geographically weighted models offer some improvement on the overall explanatory power of the included variables, with the fixed and adaptive specifications improving the R^2 substantially. While this is also due in part to the inclusion of additional parameters in the GWR specification, the AIC also records a reduction, and this figure is itself adjusted for the complexity of the model, suggesting the GWR is the preferred specification. Whilst the fixed bandwidth performs marginally better diagnostically, the adaptive is a more intuitive fit with the research problem, as it adjusts the number of neighbours according to our chosen contiguity criteria. It is likely that the moderating effect of common tenure on distress manifested in a variety of ways. Firstly, although our theoretical informants suggest heightened resilience effects associated with greater extents of common holding, this depends on the flexibility of members to respond to environmental feedback. Clearly this was severely hampered in the immediate famine period by extensive enclosures, both in response to financial distress amongst landowners, and falling grain prices

which incentivised consolidation, and the clearing of smallholders. Secondly, excess mortality during this period was not attributable to direct starvation alone. Communicable diseases, particularly cholera, dysentery, and typhus, played the largest role in fatalities (Clarkson and Crawford 2001), and it is likely that the high-density settlement associated with rundale, including communal living with livestock and multiple generations in a single household, contributed to the rapid spread of disease amongst an already immune-compromised population. These factors also played a significant role in previous disease outbreaks such as the smallpox epidemic of 1739. Examining the distribution of local R^2 in both fixed and adaptive specifications (figures 7 and 8) shows substantial regional variation in explanatory ability across regions – particularly the north and west, although this may be a function of the large bandwidths excluding influential cases.

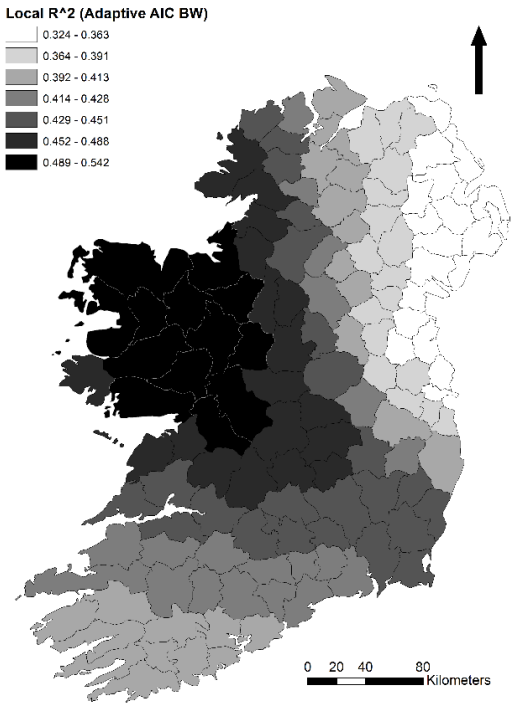

Figure 7. Local R^2 (adaptive)

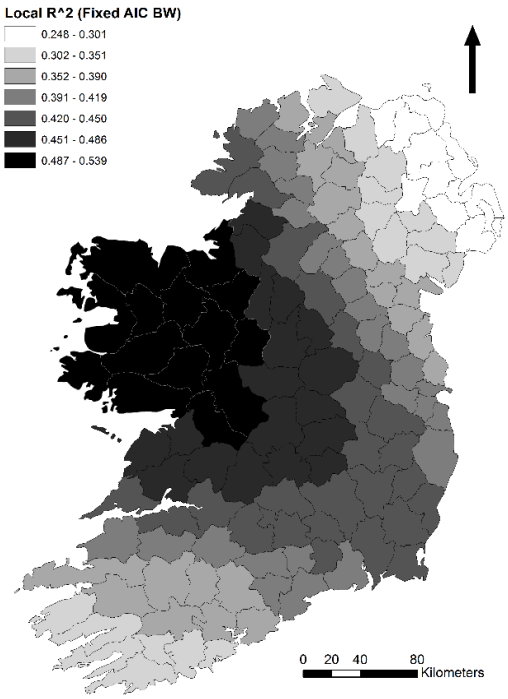

Figure 8. Local R^2 (fixed)

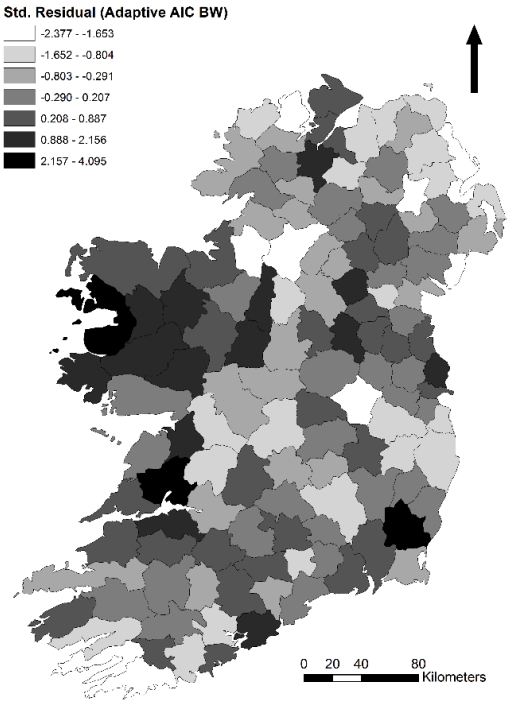

Figure 9. Standardised residuals (adaptive)

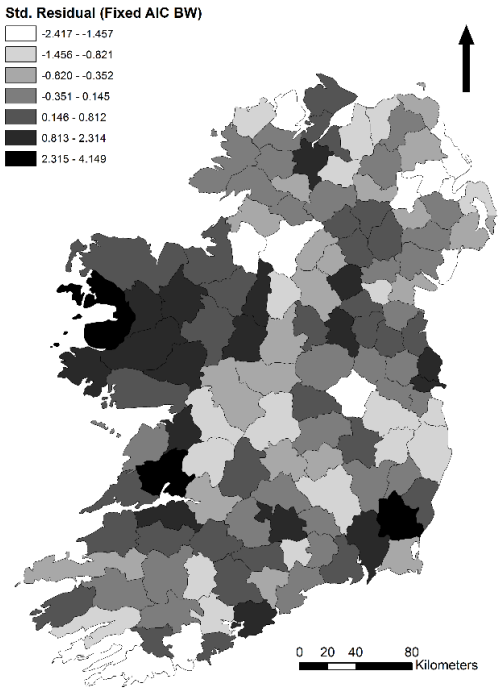

Figure 10. Standardised residuals (fixed)

CONCLUSION

The complexity of these factors and their close interconnectedness confronts a common perception surrounding the causes of the Irish famine – and indeed other instances of food scarcity. To fully appreciate the impact of famine, we must factor not only its regional impact, but the moderating role of resource governance systems in generating this uneven distribution. These results map well onto Ostrom's emphasis on the role of institutional adaptive capacity, and in turn, confront several common charges levelled against other meso-level models such as Sen's entitlements model. First, by investigating more fully the structures and institutions which characterised the settlements in question, we are better able to account for the complex channels through which environmental stressors translated into inequalities of outcome. The preceding models verify not only the significance of local modes of governance as predictors of distress rates, but their uneven impact across the Island. This question of spatial variance has been largely absent from much quantitative work on the impact of famine. Second, in addressing Devereux's (2001) criticism of the methodological individualism of work in famine studies, we might argue that a more reasonable approach is to turn to ecological models such as this, to more fully tease out the role of contextual effects. Finally, these results demonstrate the need for sociologists to pay greater attention to geographical variability in their analyses. Rather than 'controlling out' spatial heterogeneity through regional fixed effects, or treating them as confounding factors to be adjusted through standard errors, instead we should use the descriptive abilities of spatial diagnostics, and the analytical capabilities of weighted modelling, to enhance our understanding of the behaviour of meso-level social structures and institutions.

References

Aalen, F. H. A., Whelan, K., & Stout, M. (1997). *Atlas of the Irish Rural Landscape*. Cork: Cork University Press.

Almquist, E. L. (1977). *Mayo and Beyond: Land, Domestic Industry and Rural Transformation in the Irish West*. (Doctoral dissertation). Retrieved from Boston University.

Anderies, J. M., Janssen, M. A., & Ostrom, E. (2004). A Framework to Analyze the Robustness of Social-ecological Systems from an Institutional Perspective. *Ecology and Society, 9*(1), 18-35.

Anderson, K. (2010). *Marx at the Margins: On Nationalism, Ethnicity and Non-western Societies*. Chicago: University of Chicago Press.

Berkes, F., Colding, J., & Folke, C. (Eds.). (2003). *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*. Cambridge: Cambridge University Press.

Boyle, P. P., & Ó Gráda, C. (1986). Fertility trends, excess mortality, and the Great Irish Famine. *Demography, 23*(4), 543-562.

Braa, D. M. (1997). The Great Potato Famine and the Transformation of Irish Peasant Society. *Science and Society, 61*(2), 193-215.

Brunsdon, C., & Comber, L. (2015). *An Introduction to R for Spatial Analysis and Mapping*. London: Sage.

Burtchaell, J. (1988). The South Kilkenny Farm Villages. In W. J. Smyth and K. Whelan (Eds.), *Common Ground, Essays on the Historical Geography of Ireland* (pp. 110-123). Cork: Cork University Press.

Byrne, D. (1998). *Complexity Theory and the Social Sciences*. London: Routledge.

Byrne, D. (2005). Complexity, Configurations and Cases. *Theory, Culture and Society, 22*(1), 95-111.

Byrne, D., & Callaghan, G. (2013). *Complexity Theory and the Social Sciences: The State of the Art*. London: Routledge.

Capra, F. (2005). Complexity and Life. *Theory, Culture and Society, 22*(1), 33-44.

Census of Ireland. (1841). *Report of the Commissioners Appointed to Take the Census of Ireland, for the Year 1841*. 1843 [504] xxiv

Cillers, P. (2001). Boundaries, Hierarchies and Networks in Complex Systems. *International Journal of Innovation Management, 5*(2), 135-147.

Clarkson, L.A., & Crawford, M. E. (2001). *Feast and Famine: Food and Nutrition in Ireland* 1500-1920. Oxford University Press.

Collins, J. F. (2008). *Quickening the Earth: Soil Minding and Mending in Ireland*. Dublin: UCD Press.

Connell, K. H. (1950). Land and Population in Ireland, 1780-1845. *The Economic History Review, 2* (3), 278-289.

Costanza, R., Low, B., Ostrom, E., & Wilson, J. (Eds.). (2001). *Institutions, Ecosystems and Sustainability*. London: Lewis Publishers.

Cumming, G. S., & Collier, J. (2005). Change and Identity in Complex Systems. *Ecology and Society, 10*(1), 29-32.

Delaney, E. (2012). *The Curse of Reason: The Great Irish Famine.* Gill and Macmillan.

Devereux, S. (2001). Sen's entitlement approach: critiques and counter-critiques. *Oxford Development Studies, 29*(3), 245-263.

Devon Commission. *Appendix to minutes of evidence taken before Her Majesty's Commissioners of Inquiry into the state of the law and practice in respect to the occupation of land in Ireland.* Part IV. 1845 [672] [673] xxii.

Evans, E. E. (1979). *Irish Folk Ways*. London: Routledge.

Flaherty, E. (2013). *Modes of production, metabolism, and resilience: toward a framework for the analysis of complex social-ecological systems.* (Doctoral Dissertation). Maynooth University.

Flaherty, E. (2014). Assessing the distribution of social-ecological resilience and risk: Ireland as a case study of the uneven impact of famine. *Ecological Complexity, 19*, 35-45.

Fraser, E. (2006). Food system vulnerability: Using past famines to help understand how food systems may adapt to climate change. *Ecological Complexity, 3*(1), 328-335.

FraserD. (2007). Travelling in antique lands: using past famines to develop an adaptability/resilience framework to identify food systems vulnerable to climate change. *Climatic Change, 83*, 495-514.

Futemma, C., De Castro, F., Silva-Forsberg, M. C., & Ostrom, E. (2002). The Emergence and Outcomes of Collective Action: An Institutional and Ecosystem Approach. *Society and Natural Resources, 15*, 503-522.

Goodchild, M. F. (2004). The Validity and Usefulness of Laws in Geographic Information Science and Geography. *Annals of the American Association of Geographers, 94*(2), 300-303

Goransson, S. (1961). Regular Open-Field Pattern in England and Scandinavian solskifte. *Geografiska Annaler, 43*(1/2), 80-104.

Grimm, V., & Calabrese, J. M. (2011). What is Resilience? A Short Introduction. In G. Deffuant and N. Gilbert (Eds.), *Viability and Resilience of Complex Systems: Concepts, Methods and Case Studies from Ecology and Society* (pp. 3-14). Berlin: Springer.

Harvey, D. L., & Reed, M. (2004). Social Science as the Study of Complex Systems. In L. D. Kiel and E. Elliot (Eds.), *Chaos Theory in the Social Sciences: Foundations and Applications* (pp. 295-323). Ann Arbor: University of Michigan Press.

Janssen, M. A., Anderies, J. M. & Ostrom, E. (2007). Robustness of Social-Ecological Systems to Spatial and Temporal Variability. *Society and Natural Resources, 20*, 307-322.

Kelly, F. (1997). *Early Irish Farming*. Dublin: Dublin Institute for Advanced Studies.

Kinealy, C. (2001). *The Great Irish Famine: Impact, Ideology and Rebellion*. Palgrave Macmillan.

Kinealy, C. (2006). *This Great Calamity: The Irish Famine 1854-52*. Dublin: Gill and Macmillan.

Krader, L. (1975). *The Asiatic Mode of Production: Sources, Development and Critique in the Writings of Karl Marx*. Assen: Van Gorcum.

Mac Aoidh, S. (1990). Nixon: A Tyrant Landlord. *Donegal Annual, 42*, 45-48.

McCabe, D. (1991). *Law, Conflict and Social Order in County Mayo 1820-1845*. (Doctoral Dissertation). Retrieved from University College Dublin.

McCourt, D. (1955). The Rundale System in Donegal: Its Distribution and Decline. *Donegal Annual, 3*, 47-60.

McCourt, D. (1971). The Dynamic Quality of Irish Rural Settlement. In R. H. Buchanan, E. Jones, and D. McCourt (Eds.), *Man and His Habitat: Essays Presented to Emyr Estyn Evans* (pp. 126-164). London: Routledge.

Miller, H. J. (2004). Tobler's First Law and Spatial Analysis. *Annals of the American Association of Geographers, 94*(2), 284-289.

Ó Grada, C., & Kelly, M. (2015). *Why Ireland Starved* after Three Decades: The Great Famine in Cross-Section Reconsidered. *Irish Economic and Social History, 42*(1), 53-61.

Orser Jr, C. E. (Ed). (2006). *Unearthing hidden Ireland: Historical archaeology at Ballykilcline, County Roscommon*. Wicklow: Wordwell.

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge University Press.

Ostrom, E. et.al. (2009). A General Framework for Analyzing Sustainability of Social-Ecological Systems. *Science, 325*, 419-422.

Returns of Agricultural Produce in Ireland, in the Year 1847. 1847-48 [923] lvii.

Roberts, J. M. (2006). Method, Marxism and Critical Realism. In K. Dean., J. Joseph., J. M. Roberts., & C. Wight (Eds.), *Realism, Philosophy and Social Science* (pp. 65-98). New York: Palgrave.

Sawyer, K. R. (2005). *Social Emergence: Societies as Complex Systems*. Cambridge University Press.

Second Report of the Relief Commissioners, constituted under the act 10th Vic., cap. 7. 1847 [819] xvii.

Sen, A. (1981). *Poverty and famines: an essay on entitlement and deprivation*. Oxford University Press.

Skyttner, L. (2005). *General Systems Theory: Problems, Perspectives, Practice*. World Scientific Publishing.

Slater, E., & Flaherty, E. 2009. Marx on primitive communism: the Irish rundale agrarian commune, its internal dynamics, and the metabolic rift. *Irish Journal of Anthropology, 12*(2), 5-26.

Smith, H. (2000). Semicommon Property Rights and Scattering in the Open Fields. *The Journal of Legal Studies, 29*(1), 131-169.

Sui, D. Z. (2004). Tobler's First Law of Geography: A Big Idea for a Small World. *Annals of the American Association of Geographers, 94*(2), 269-277.

Tobler, W. (2004). On the First Law of Geography: A Reply. *Annals of the American Association of Geographers, 94*(2), 304-310.

van ApelDoon, D. F., Kok, K., Sonneveld, M. P. W., & Veldkamp, T. A. (2011). Panarchy Rules: Rethinking Resilience of Agroecosytems, Evidence from Dutch Dairy-Farming. *Ecology and Society, 16*(1) [online first: http://www.ecologyandsociety.org/vol16/iss1/art39/]

Wall, D. (2014). *The Sustainable Economics of Elinor Ostrom: Commons, Contestation and Craft*. London: Routledge.

Whelan, K. (2000). Settlement and Society in Eighteenth-Century Ireland. In T. Barry (Ed.), *A History of Settlement in Ireland* (pp. 187-205). London: Routledge.

Yager, T. (1996). Mass Eviction in the Mullet Peninsula During and After the Great Famine. *Irish Economic and Social History, 23*, 24-44.

Appendix A. Data Sources

Variable	Source
Ration uptake (standardised rate of relief ration uptake, 1847)	*Second Report of the Relief Commissioners...* 1847
Population density (individuals per acre, 1841)	Census of Ireland, 1841
Poor law valuation (£pounds per acre)	Almquist (1977)
Consolidation of holdings (% change in proportion of farms over thirty acres, 1848-1849)	Devon Commission (1845)
Uncultivated land (% total cropland uncultivated, 1847)	*Returns of Agricultural Produce in Ireland, in the Year 1847*
Corn yield (% change in corn yield [kilograms per acre], 1847-1849)	*Returns of Agricultural Produce in Ireland, in the Year 1847*
Total crop area (percentage change in total crop area, 1847-1849)	*Returns of Agricultural Produce in Ireland, in the Year 1847*
Flax cultivation (% area under flax, 1847)	*Returns of Agricultural Produce in Ireland, in the Year 1847*
Common tenancy (% lands held in common or joint tenancy)	Devon Commission (1845)