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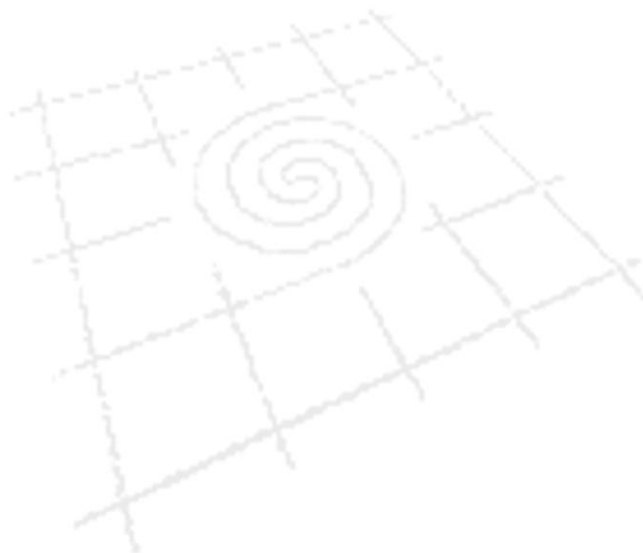
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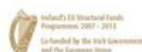


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The macro-context of communality in nineteenth century Ireland: toward a typology of social-ecological complexity

Eoin Flaherty¹

The rundale system has held a certain fascination for Irish historians due to its troublesome prevalence in the cartographic record and comparative absence from historical record. As a system of communal cultivation characterised by equality of land allocation through collective governance, popular conflicting accounts have interpreted it both as a functional adaptation to the ‘ecological niche’ of the Irish Western Seaboard or, controversially, as a modern survival of an archaic, embryonic mode of production of great antiquity. Beyond such empirical concerns with its origins and spatial distribution, the rundale system raises theoretical concerns of some antiquity (such as those concerning the place of communal modes of production as precursors to the development of capitalism within Marxist historical-materialism), and other issues permeating foundational debates of sociology, concerning the relationship between the natural and the social, and systems-based conceptualisations of societies and social order. These latter theoretical concerns have recently enjoyed a resurgence of interest under the interdisciplinary rubrics of resilience ecology and complexity theory, offering a means with which to discard old dualisms of nature-society, and the restrictions of normative stability assumptions and structuralism imposed by earlier variants of post-war sociological systems theory. The rundale system is here explored in the context of these informants both as an exercise in theoretical compatibility, and with a view toward establishing a more rounded perspective on rundale as a distinct social-ecological system. A macro-context for this subsequent investigation is thus established by subjecting a set of aggregate data on pre-famine Ireland to an optimisation clustering procedure, in order to discern the potential presence of distinctive social-ecological regimes. This resultant typology provides a contextual framework for subsequent quantitative and qualitative work at lower levels of aggregation.

¹ Department of Sociology and NIRSA, NUI Maynooth. Funded by the Irish Research Council for the Humanities and Social Sciences, excerpted from doctoral thesis ‘*Modes of production, metabolism and resilience: toward a framework for the analysis of complex social-ecological systems*’ [full thesis available at <http://eprints.nuim.ie/4389/>]

Typologies and models of settlement & productive activity in nineteenth-century Ireland

In assessing the geographical complexities of pre-famine Ireland, a range of existing typologies abound which have sought to reduce the undifferentiated unit of 'Ireland' to a number of distinctive zones or regions corresponding to particular economic, geographical, and demographic characteristics. Prominent amongst these endeavours is that of Kevin Whelan's four-fold typology of eighteenth century 'regional archetypes' (1991, 2000), with continuities extending into the nineteenth century as demonstrated by O' Grada (1994: 35). Whelan's division thus postulates a *pastoral* archetype, running from north-east Leinster to inner Connaught, driven by export price fluctuations, yielding patterns of periodic growth and decline. A *tillage* archetype of mixed farming may be observed extending across the Anglo-Norman coastlands from Cork to Wexford and northwards from Wicklow to Dundalk; this archetype approximating a form of mixed farming, experiencing pronounced periods of growth throughout the Napoleonic era of soaring grain prices, and subsequent contraction throughout periods of pre-famine price abatement. Thirdly, a *proto-industrialisation* archetype, spurred by favourable circumstances such as technological, infrastructural and competitive innovation may be observed, centred on key production zones of the Ulster linen trade (Whelan 2000). Whelan's fourth archetype of *small farming*, concentrated in a crescent running from Cork to North Donegal, is of greatest interest in light of its problematic influence on Irish historical geography throughout the twentieth century, as the exceptionalism of this Western 'peasant fringe' has long featured as a recurrent theme in both academic and popular discourse (Evans 1957; MacNeill 1921).

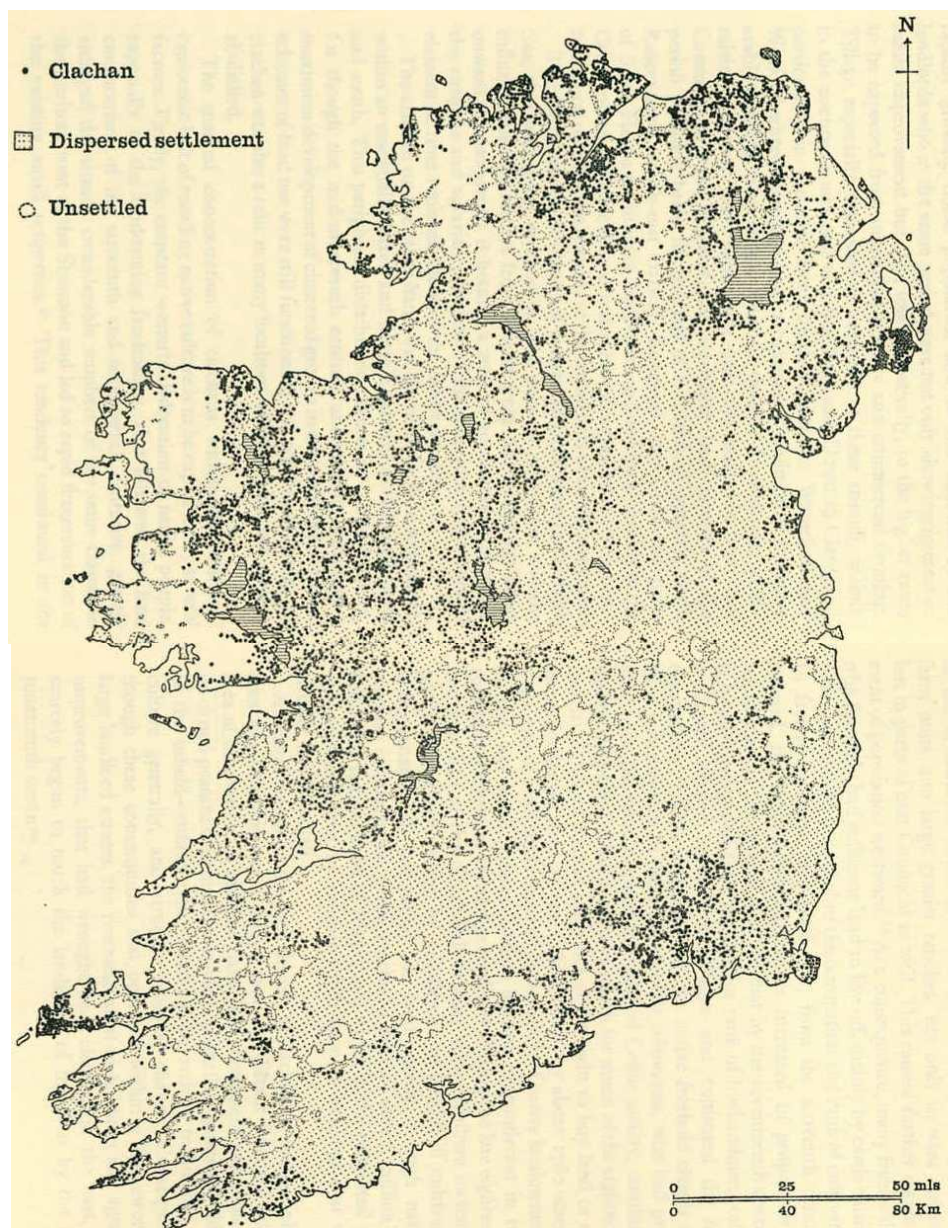
The contested nature of this *small farm* archetype owes much to the problematic reception of the work of the 'Queens' school' of historical geography². Much of this debate has centred on the widely contested notion of the antiquity and origins of the rundale system prevalent throughout this archetypal zone, its concomitant pattern of nucleated settlement, and associated communal social institutions and practices. An erroneous over-generalisation of this archetype thus formed the basis of a monolithic 'peasant subsistence' model of pre-famine Irish agriculture, which glossed over the internal complexities of Irish settlement distribution, social stratification, and agricultural-economic activity (Doherty 1999). Writing in 1939, Evans hypothesised that the rundale system constituted a system of great antiquity with potential origins in the Iron Age. In the decades since Evans' foundational pronouncements, many subsequent developments in historical geography and historiography, particularly the explanatory frameworks and regional typologies brought to bear on pre-famine Irish settlement, have proceeded in critical dialogue with the work of the Queens school, and its problematic hypotheses concerning the prevalence of such small, quasi-subsistence farming units.

There is much evidence to warrant a closer inspection of the characteristics of this Western *small farm* archetype. According to the work of Desmond McCourt (1980), the existence of a

² Exemplified by the work of Estyn Evans, Ronald H. Buchanan and Desmond McCourt, through the Institute of Irish Studies at Queens' University Belfast. Its most prolific period extended from the 1940's to the 1970's, throughout which its methodology of combined ethno-archaeology (incorporating qualitative fieldwork and oral history) succumbed to a series of damning critiques by John Andrews (1974, 1977). The result of Andrew's series of critical papers was a discipline-wide dismissal of their generalisations regarding the prevalence of homogeneous peasant systems of Celtic descent in Ireland, which Andrews claimed were insufficiently grounded in empirical evidence (with thanks to Prof. Patrick Duffy for supplying facsimile copies of Andrew's original paper)

peripheral *small farm*, or distinctively Western archetype is substantiated by the first edition '6-inch' ordnance survey maps, which reveal a concentration of *clachán* settlement – the nucleated concomitant physical settlement form of rundale systems – concentrated within the areas bounded by Whelan's hypothesised *small farm* zone (see *figure 1* below).

Figure 1



Rural settlement patterns, 1832-1840 (McCourt 1971: 138-139)

There is little doubt that this western crescent was subject to the worst effects of the famine between the years 1845 and 1852. Although systematic estimation and comparison of mortality rates is impossible, owing to an absence of mandatory civil registration before 1864 (Vaughan and Fitzpatrick 1978), O' Grada (1986) has outlined a series of existing estimates ranging from 800,000 (Cousens 1960), to 1,000,000-1,500,000 (Mokyr 1980), the latter of which, based upon forward extrapolation of pre-famine growth trends is now considered an overestimate. Furthermore, it has proven difficult to ascertain the proportions of population decline attributable to starvation, death by disease and emigration respectively. Controlling for emigration, O' Grada's data yields an estimate of population loss due to excess death of 981,000 - with particular vulnerabilities noted amongst the young and elderly - throughout the famine period (1986: 555). Kinealys' (2006: 369) poor-law union level analysis of variability in the up-take of soup rations throughout the famine years, further reveals a concentration of high distress in the western counties of Galway, Mayo, Clare, Kerry and Limerick. Tabulation and mapping of the agricultural census data of 1851, recently completed by the National Centre for Geocomputation (National Centre for Geocomputation 2010), further underscores the presence and continuities of such regional distinctions (see *figures 2.1-2.4*, page 5³).

As may be observed in the below figures (2.1-2.4, page 5), profound regional distinctions present according to 1851 crop distribution patterns. Production of wheat (*figure 2.3*) remains centred along an Anglo-Norman tract extending from South Kerry through Cork, Kilkenny and Wexford, with extensive flax cultivation (*figure 2.2*) centring on the protoindustrial spinning and weaving districts of Ulster. Although a number of profound correlations present, most notably a comparative concentration of potato cultivation and lower land valuation across the Western fringe - in turn corresponding to the distribution of clachans as noted in *figure 1* - some reservations are warranted. Almquist (1977) and Gray (2005) have pointed out that such spatial distinctions are not representative of the true extent of proto-industrialisation throughout this period however, as significant proportions of rural households along the Atlantic seaboard engaged in spinning as a source of supplementary income (Gray notes over 50% of all occupied women in Donegal, Galway and Mayo were spinners, 2005: 52). Furthermore, patterns of high land fragmentation and early female nuptiality thought characteristic of this *small farm* zone, prevailed across much of Ireland throughout the early nineteenth century, resulting in 45% of all enumerated holdings across Ireland falling below five acres by 1841 (Connell 1950b: 284). An epistemological problem thus presents, whereby commonalities of process operating across regional boundaries are not readily represented by such spatial typologies.

³ <http://ncg.nuim.ie/content/projects/famine/Agriculture.htm>

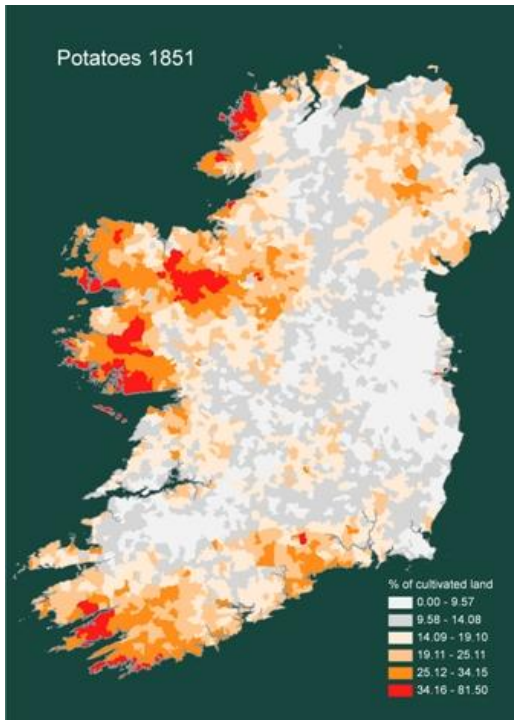


Figure 2.1

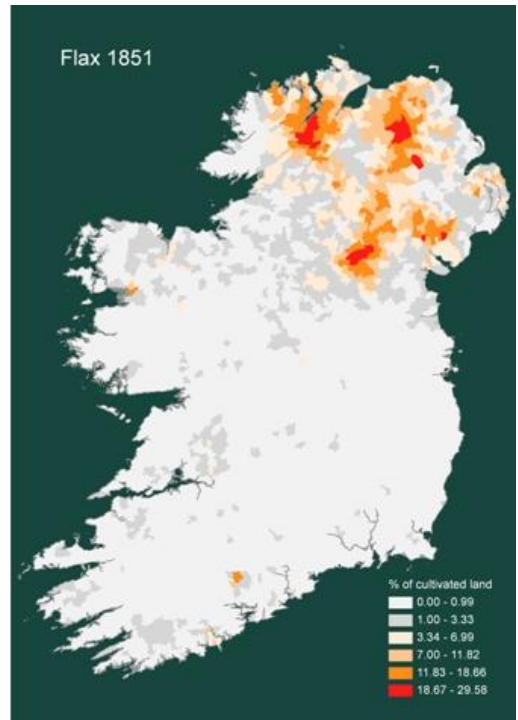


Figure 2.2

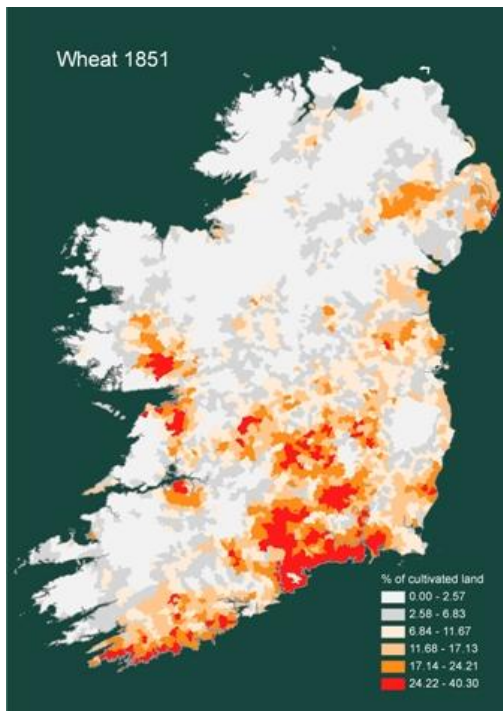


Figure 2.3

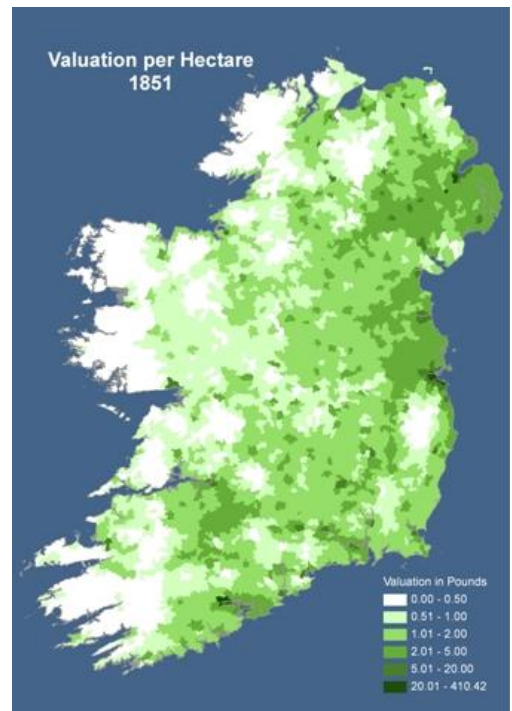


Figure 2.4

Despite such concerns, the exceptional and consistent characteristics of these Western areas warrant consideration, as the nucleated rundale settlements distributed across this area (*figure 1*) have courted much academic attention⁴. For County Mayo, McCabe (1991), estimated up to 831,000 acres – or 63% of the total area of County Mayo – was held in rundale in the 1840's. There is much qualitative evidence to support such a contention; Knight (1832), in his published travel memoirs, remarked on the prevalence of rundale throughout the Mayo Barony of Erris, and the documents of the *congested districts board* repeatedly cite the residual influences of fragmentation in these regions - in part engendered by the rundale system - as a barrier to land reform and redistribution efforts at the turn of the century (Breathnach 2005). Previous hypotheses positioning the rundale system as one of great antiquity have since given way to those interpreting such systems of communality as ones of adaptation to particular ecological niches, such as the marginal conditions of the West of Ireland (Aalen et al 2002; Whelan 1995, 1999). Indeed classical pronouncements on Ireland's unique demographic regime, such as those of K.H. Connell, have identified the critical role of wasteland reclamation, and the ability of the potato both to prosper in poor soils and yield a diet of calorific adequacy on small acreages, as key factors in the removal of barriers to early conjugal union, and consequently, higher fertility (1950b, 1962)⁵.

What is required therefore is an alternative typological approach which permits a closer examination of the presence of such distinctions and consistencies at a greater level of abstraction, albeit in a manner capable of transcending the epistemological confines of space imposed by the preceding forms of distribution mapping, and reliance on productive activity alone. Turning to the informants of complexity theory and resilience ecology, we may thus begin to develop an analytical framework capable of addressing this question of multilevel systemic complexity.

⁴ Although significant outliers of clachans may be observed in the South and North-East of *figure 1*, these may be considered distinct from those of the West. Burtchaell (1988) has suggested that those of the South, due to the influence of Anglo-Norman cultivation systems, represent devolved manorial systems previously operating under the medieval *three-field* rotation system. Consequently, they bear only structural similarities to those of the west, lacking their social institutions of collective governance, periodic reallocation, seasonal herding, and crucially, their poverty – buoyed as they were by the presence of speculative capital, and proximity to the prosperous market centre of Waterford. Centralisation of tillage in such areas, giving rise to their nucleated settlement patterns is thus attributable not to subsistence or reclamation partnership imperatives (as per those of the West), but the inherent centralisation of tillage engendered by the manorial three-field tillage system. Those of the North-East demonstrate differences in line with those of Kilkenny, due to their proximity to the linen centres of Ulster. Northern counties, due to the presence of 'Ulster custom', and the encouragement of husbandry practices distinct from those of Irish pastoralism enjoyed conditions conducive to fixed improvements such as drainage and enclosure. According to the 'Ulster custom', a tenant retained the right to uninterrupted sale of his lease, a security not present in the South (Gray 2005: 51). Consequently, fixed capital investments in the South were effectively discouraged, due to the inability of a tenant to realise the monetary value of his improvements through sale, and inevitable upward rental revisions incurred under systems of rackrent. Consequently, such territories are not readily comparable with those of the south (see Bell and Watson 2006 for a comprehensive study of clachans in the Glens of Antrim).

⁵ Ireland's population grew fourfold between the years 1687 (2,167,000) and 1841 (8,175,124) (Vaughan and Fitzpatrick 1978)

Social-ecological systems and systemic complexity

Systems and complexity theory

Consensus regarding the current standing of systems theory in sociology depicts the field as a remnant of the ‘grand narrative’ excesses of post-war American sociology, with clear origins in Talcott Parsons’ appropriation of the works of Weber, Durkheim and Pareto, within the emerging multidisciplinary fields of cybernetics and general systems theory (Doyle 2008; Johnson 2008; Hammond 2003; Holmwood 2008). Through its preoccupation with the explanatory powers of reductionism and systemic conceptualisation, the homeostatic mechanism of normative socialisation thus emerged as a central concept within Parsonian structural functionalism, through a process of biological analogising with clear antecedents in the works of Spencer and Durkheim (Barry 2007; Delanty 2009; Sciortino 2009). Notwithstanding problematic restrictions of agency and intentionality associated with equilibrium and optimal state assumptions, subsequent work has sought to disambiguate the question of *structure* from that of *function*, and to locate the source of Parson’s shortcomings in a critical misappropriation of Pareto’s concept of thermodynamic equilibrium (Buckley 1967, Bailey 1984, 1994, Gerhardt 2002). Owing in part to discipline-wide reactions against such biological analogising, subsequent dialogue between the social and natural sciences has remained limited.

Advancements in sociological-systemic approaches subsequent to the major works of Parsons (1991 [1951]) have largely abated, yielding a problematic legacy of ‘Durkheimian exceptionalism’ in environmental sociology, whereby integration of the social and the natural has proven elusive both empirically and ontologically (Benton 1991, 1994, 1996; Castree and MacMillan 2001, Dunlap 1980, 1997; Gerber 1997, McNaughton and Urry 1998; Murdoch 2001; Murphy 1995; Franklin 2002; Gammon 2010; Swyngedouw 2010). Much of this post-Parsonian debate on the nature-society problematic has spuriously centred on the ontological separatism of *the social* as a distinct object of social-scientific investigation. Other prominent contributors have forwarded epistemic critiques of knowledge hierarchies through which the primacy of scientific knowledge in public discourse is challenged. Authors working within the rubric of Actor-Network Theory have thus developed alternative co-constructionist epistemologies of nature-society which carry implicit rejections both of structural regularities, and abstract consistencies of process (Dickens 1996; Latour 2004, 2005; Murdoch 2001; Swyngedouw 2004; Yearley 2005).

More recently, others operating within mainstream sociology have sought alternative means of addressing such shortcomings in natural-social scientific dialogue and systemic theorising. Drawing upon the concepts of positive feedback and non-linearity associated with complexity theory, such authors have sought to rework systems analysis by emphasising the role of small changes in inducing path-dependent systemic change, thereby overcoming prior assumptions of negative feedback-conditioned equilibrium and normative socialisation, associated with more restrictive variants of Parsonian functionalism (Urry 2005; Walby 2007)⁶. Furthermore, widespread acceptance within this paradigm of the assumptions of ontological depth associated with critical realism and complexity, have addressed the structuralist shortcomings of earlier variants of general systems theory (Byrne 1998). Systems, according to the

⁶ According to the *Gulbenkian Commission on the Restructuring of the Social Sciences*, to which Immanuel Wallerstein and Ilya Prigogine contributed, complexity as a unifying paradigm promised a ‘...breaking down of the division between ‘natural’ and ‘social’ science through seeing both characterized by ‘complexity’ (Urry 2005: 3)

informants of complexity, are thus viewed not as ordered hierarchies of nested sub-systems conditioned by higher-order processes, nor may they be understood atomistically through the study of their agents; instead, they are conceptualised as complex open systems, comprised of emergent social, cultural, economic and ecological properties and levels, in a state of mutual interconnection (Alhadeff-Jones 2008; Capra 2005; Cillers 2001; Harvey and Reed 2004, Miller & Miller 1992; Walby 2007).

Resilience ecology

Although such developments have proceeded apace within sociology, parallel works in ecology and human ecology - which have advanced the general systems programme to a productive analytical integration of the natural and the social - have passed largely unheeded by environmental sociologists. This stunted dialogue has produced a field of complexity-based research divided into two distinct orientations; those engaging with complexity metaphorically as a narrative of social order and change (Cillers 1998; Smith & Jenks 2006; Urry 2005; Walby 2007), and those who have co-opted the analytical concepts of complexity with a view to their practical application (Byrne 1998, 2005; Castellani and Hafferty 2009; Fisk & Kerhevre 2006; Harvey and Reed 2004; Sawyer 2001, 2005). The interdisciplinary work of this latter grouping is best represented by those operating within the paradigm of resilience ecology, with its emphasis on the study of combined social-ecological systems (Abel et al 2006; Adger 2000; Buchmann 2009; Cumming et al 2005; Cumming & Collier 2005; Cumming 2011; Fabricius & Cundill 2011; Fraser 2003; Holling 1973, 2001; Janssen et al 2007; Kinzig et al 2006; Matthews and Sydneysmith 2011; Ostrom 2009; Peterson et al 1998; Walker et al 2006).

Resilience first emerged as a corrective to restrictive assumptions prevalent in ecological analysis associated with the concept of stability, in a series of debates demonstrating notable similarities with those concerning the theoretical deficiencies of functionalism in sociology (Holling 1973). Contrasted with *engineering* resilience as a measure of a systems' return time to 'base state' parameter values following disturbance, *ecological* resilience assesses the amount of disturbance a system may undergo before transition to an alternate state is induced (Gunderson 2003). The probability of a particular system crossing this threshold is determined by its *adaptive capacity*, as a heuristic assessing the systems capability to appropriately respond to feedback (Berkes et al 2003; Fabricius and Cundill 2011).

The utility of an ecological resilience approach, as opposed to a 'stability' or engineering resilience approach, rests in its use of the concepts of *regime* and *identity*, as opposed to equilibrium and structure. Drawing upon the techniques and terminology of complexity theory, a *regime* may be conceptualised as a '...locally stable or self-reinforcing set of conditions that cause a system to vary around a local attractor; the dominant set of drivers and feedbacks that lead to system behaviour; a 'basin of attraction' (Cumming 2011: 14). Localized concrete social-ecological systems may be conceptualised as specific arrangements of actors, components and their interactions, constituting a particular *identity* (ibid). Thus we may state that a social-ecological system of particular *identity* occupies a specific *regime* insofar as fluctuations in the conditions or variables constituting its identity do not result in significant changes or critical losses. In the terminology of resilience and complexity, such a change as results in a loss of *system identity* constitutes a *regime shift*.

Resilience ecology is thus concerned with the assessment of such *regime shifts*, which may be observed as systems move within particular value-ranges of identity parameters, and with

system change or collapse as measured by loss of identity. The assessment of system change, as a consequence of a loss of resilience, necessitates ‘...a shift in focus from numerical values of state variables to ‘relationships’, i.e. to the internal organization of ecosystems which gives rise to their properties’ (Grimm and Calabrese 2011: 8). *Adaptive capacity* is the essential property mediating regime shift or identity loss, as differing configurations of social-ecological variables - representing multiple components of system identity such as demography, economy, labour strategies and modes of resource governance - interact to confer resilience in the form of institutional robustness to external shocks. Crucially, this resilience approach is inherently amenable both to qualitative *and* quantitative operationalisation, and further avoids restrictions previously imposed by the requirements of ‘equilibrium state’ input values (such as with engineering resilience), and the identification of homeostatic mechanisms (as with sociological functionalism).

Resilience is thus not a rigid ‘metric’ according to traditional quantitative definitions, but is instead a property which permits the assessment of ‘...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 on a range of fronts, not least for countering extant shortcomings in structuralist systems theory as discussed above. Cumming suggests that a resilience-based approach may be implemented by operationalising *identity* as; “...a set of elements...that interact with one another in a shared environment... Identity derives from the maintenance of key components and relationships, and the continuity of these through time” (2011: 10 - 13). This approach displays numerous similarities, with other theoretical and methodological approaches in sociology, such as ideal-typical modelling (Ragin 1989; Harvey and Reed 2004)⁷, and more abstract typological approaches to social-ecological systems, such as those of Marxian historical materialism, the latter of which explicates economic epochs of combined *forces* and *relations* of production into an abstract typology of successive modes of production, or dominant ways by which humans collectively engage in the appropriation of natural resources (Benton 1991, 1996; Foster 1999).

Although our research interests rest with a particular localised social-ecological system known as the *rundale system*, prevalent across the Western fringe of pre-famine Ireland as illustrated above in *figure 1*, these systems are themselves nested within the broader geographical territory of Ireland. Consequently, before moving to examine the specific dynamics of *rundale* as a localised social-ecological system, we must begin with an assessment of the macro-systemic complexities of 19th century Ireland, by exploring the potential presence of macro-level distinctions – or, in the terminology of resilience and complexity, the presence of particular social-ecological *regimes*, as attractors within which such *rundale* systems are located. Given that localised systems are themselves embedded within broader spatial units (such as townlands, counties and countries), and trans-boundary social systems (such as economic, legal, climatological, demographic and cultural systems), imposing such a degree of typological order appears a logical starting point. This approach is substantiated within the complexity literature, particularly by Byrne (1998, 2005), who has suggested the use of cluster analysis as a means of identifying such attractors, or cases located in n-dimensional space, with ‘...the dimensionality of that space equal to the number of variables used for the clustering procedure’ (1998: 80).

⁷ Ragin refers to such approaches as ‘case-oriented’ comparative (1989: 34), although the principles of this process of abstraction and generalisation are well established in classical theory - particularly Weberian and Marxian

Drawing upon these theoretical informants, a methodology may thus be implemented, comprising;

1. Identification of a parsimonious set of *macro-systemic* variables within which particular regimes may be identified
2. Application of optimisation clustering techniques to develop a typology of such social-ecological regimes, or domains of attraction
3. Identification of regimes within which individual settlements may be susceptible to increased probabilities of ecological stress, or diminished resilience
4. Implementation of this macro-classification as a framework permitting the regional contextualisation of localised systems
5. Identification of identity components specific to the *localised* systems of interest, and a qualitative assessment of their adaptive capacity

Choice of clustering variables

The following discussion presents the results of an exploratory *k*-means cluster analysis, conducted with the intention of extracting a latent typology of *cases* from a set of county-level variables measuring physical, economic and demographic attributes. Although cluster analysis techniques are comparatively under-utilised in sociological research, other exploratory techniques such as factor analysis are relatively common, and the nature of cluster analysis may thus be outlined analogously⁸. Whereas factor analysis techniques are variously used for confirmatory validation (i.e. to validate the relatedness of groups of variables as scale components), or in an exploratory manner (i.e. to extract latent variables from sets of existing variables without predictive direction), cluster analysis is employed when the latent category of interest is that of *groups* rather than *variables*. Numerous commentators have drawn attention to the risks of succumbing to naive empiricism inherent in such exercises, and as with all such exploratory techniques, careful discrimination is required on the part of the analyst. Aldenderfer and Blashfield (1984) suggest that this empiricist tendency may be checked by grounding one's selection of variables within relevant theory;

“The basic problem is to find that set of variables which best represents the concept of similarity under which the study operates. Ideally the variables should be chosen within the context of an explicitly stated theory that is used to support the classification. The theory is the basis for the rational choice of variables to be used within the study” (1984: 20)

In the context of the preceding discussions, and on the basis of prior empirical research, particularly that of Eric Almquist (1977), who has subjected many of the following variables to regression modelling with productive results, the following variables were selected (see *table 1*, page 12). These variables thus represent a parsimonious range of social, demographic

⁸ For a recent example of applied cluster analysis in sociological research, see Edgell and Tranby (2010)

and physical attributes of the n-dimensional (state) space of Ireland, in which potential attractors or regimes may be discerned⁹. The inclusion of demographic variables in the form of *land-labour ratio* and *females 26-35 married/widowed* is substantiated by existing literature on Ireland (as discussed above), and within broader works in human ecology. In a comprehensive review conducted by Axinn and Ghimire, the authors conclude that existing literature identifies *population* as a key determinant of resource consumption trends, controlling for levels of affluence and technology (2011: 215). Van Wey et al (2005) discuss the ‘IPAT identity,’ as a land use outcome model frequently utilised as a comparative device in development literature. In this model ‘...population in one form or another plays the role of the villain’ (Ehrlich and Ehrlich 1991 cited in Van Wey et al 2005: 26), taking the form ($I = P*A*T$) where I = impact on environment, P = population, A = affluence (consumption, per capital GDP, level of living) and T = technologies employed. The inclusion of a range of classificatory variables beyond these ‘Malthusian’ parameters alone is therefore justified as a counter to simple ‘population determinism’; hence the inclusion of *land held in common or joint tenancy* as a crude index of the presence of particular social-institutional modes of local governance. The role of wasteland as a proximate determinant of rundale expansion is also well established, and many have drawn attention to the benefits inherent in collective leasing, particularly as they permit reclamation, and consequently, accommodations of new commune members (Connell 1950b; Currie 1986; McCourt 1955, 1971; Slater and Flaherty 2009). Summary statistics, correlations, and a scatterplot matrix are provided below in *tables 2 & 3*, and *figure 3* (pages 12 and 13).

⁹ The principle of parsimony must be adhered to in order to minimise the risk of ‘overfitting’ resulting from inclusion of an excessive number of input variables, with a consequent reduction in explanatory power or excessive statistical noise (Agresti and Finlay 2009).

Table 1. Description of input variables

Variable	Unit	Source	Theoretical/empirical justification
Land-labour ratio	Statute acres per individual	Census of Ireland, 1841	Hypothesised by Chayanov as key determinant of household labour strategies. Elevated/diminished ratios associated with probability of uptake in subsidiary domestic industry / labour intensive crop cultivation (O' Neill 1984)
Poor law valuation	£(pounds) per individual	Almquist (1977)	Reliable index of poverty – lower valuations associated with lower potential land productivity
Females 26-35 marries/widowed	% all females	Vaughan and Fitzpatrick (1978)	Cited as key independent variable in land-use outcome explanation. Often-hypothesised component of pre-famine Irish demographic expansion (Connell 1950a), closely related to subdivision, and viability of potato
Holdings 1-5 acres	% of all holdings	Almquist (1977)	Rundale systems are characterised by fragmentation of holdings through subdivision
Waste (course pasture) below 800ft above sea level	% of all county wasteland	Devon Commission appendices (1845)	Wasteland / course pasture encroachment cited as characteristic of rapidly expanding rundale settlements. Wasteland availability conducive to resilience of communal systems through spatial expansion
Land held in common or joint tenancy	% of all county land	Devon Commission Appendices (1845)	Key indicator of potential presence of rundale

Table 1. Description of input variables

Table 2. Input variable summary statistics

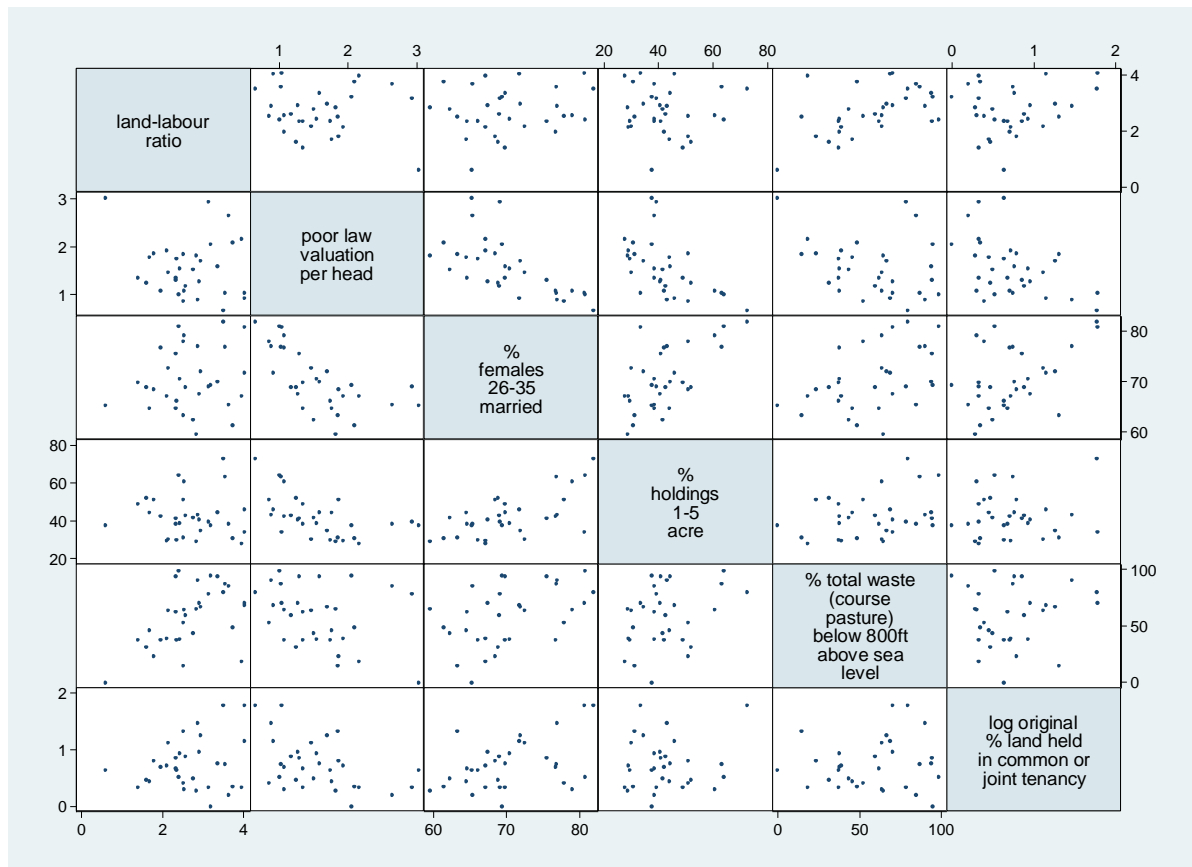
Variable	Unit	Mean	SD	Min	Max
Land-labour ratio	Statute acres per individual	2.68	0.81	0.61	4.04
Poor law valuation	£ (pounds) per individual	1.56	0.58	0.66	3.03
Females 26-35 married	% all females	70.35	6.03	59.49	81.85
Holdings 1-5 acres	% of all holdings	42.33	11.12	27.9	72.6
Waste (course pasture) below 800ft above sea level	% of all county wasteland	57.9	26.00	0	98.46
Land held in common or joint tenancy	% of all land	8.91	12.42	0	58.7

Table 2. Input variable summary statistics**Table 3. Correlation matrix (* $p \leq 0.05$)**

	Land-Labour	Poor law	Married	1-5 acre	Waste	Common
Land-labour	1.000					
Poor law	-0.1308	1.000				
Married	0.1466	-0.6568*	1.000			
1-5 acre	-0.0346	-0.5368*	0.6351*	1.000		
Waste	0.5134*	-0.3276	0.4500*	0.3276	1.000	
Common	0.1989	-0.4648*	0.4393*	0.0842	0.1038	1.000

Table 3. Correlation matrix

Figure 3



Input variable scatterplot matrix

As may be observed across the preceding tables and figures (and as discussed previously by Almquist 1977), our chosen input variables exhibit suitably broad ranges (*table 2*, min & max). Furthermore, a number of significant correlations present within *table 3* and *figure 3*. Consistent with existing theory, the key demographic variable of *females 26-35 married* demonstrates strong, significant correlations with others including *holdings 1-5 acres* ($r = 0.6351$, $p \leq 0.05$), *waste* ($r = 0.45$, $p \leq 0.05$) and *common* ($r = 0.4393$, $p \leq 0.05$). Thus we observe strong positive associations between the broad demographic regime of high early female nuptiality, classical predictors of population growth (availability of wasteland), and a number of consequent effects of demographic expansions such as fragmentation of holdings, and the presence of common holding. Of note also are strong, negative associations between valuation (*poor law*) and *females 26-35 married* ($r = -0.6568$, $p \leq 0.05$), *holdings 1-5 acres* ($r = -0.5368$, $p \leq 0.05$) and *common* ($r = -0.4648$, $p \leq 0.05$). Such associations point toward a diminished probability of early marriage, fragmentation and common holding within more affluent districts.

For the forthcoming cluster analysis, all variables were z-score standardised (to mean 0, standard deviation 1) prior to application of the clustering algorithm, consistent with Everitt et al's recommendations, given that optimization methods are inherently scale dependent (Everitt et al 2011: 115). A boxplot of the above z-score standardised variables is included below under *Appendix 1*. A log transformation was also applied to the variable *common* prior to clustering,

in order to correct a profound positive skew. Consistent with Field's guidelines, a simple ln10 (log to base 10) transformation was applied, with the addition of a constant of 1 (due to the presence of '0' values in the original dataset). A comparison of histograms pre and post-transformation for this variable is provided below as *Appendix 2*. Preceding correlations are reported for the log-transformed version of *common*, whereas subsequent summary statistics are reported using the untransformed variable for ease of interpretation.

Clustering method and results

As stated above, the purpose of exploratory cluster analysis is to extract latent typologies of *cases*. For *k*-means optimization techniques as utilised below, *k* denotes the number of groups required by the clustering procedure, and is a user-defined input parameter (unlike hierarchical procedures which progressively match cases on the basis of similarity/distance measures). *k*-means clustering may thus be viewed as a kind of maximum likelihood technique, with trace (W) minimization as its optimization criteria (see Everitt et al 2011: 126)¹⁰. Although a number of formal procedures exist for the estimation of potential group numbers for optimisation clustering methods, such as the Calinski and Harabasz pseudo *F*-statistic (Rabe-Hesketh 2004: 276), and the Duda and Hart index (Everitt et al 2011: 127), Landau and Everitt (2004) suggest that many of these techniques are necessarily ad-hoc. Mardia et al suggest a more useful rule of thumb, in the form of $[k = \sqrt{(n/2)}]$ which for our data yields $[\sqrt{(32/2)} = 4]$ (1979: 365). This estimated value of *k* agrees with previous classifications of Ireland, which have tended to emphasise four distinct socio-economic zones (O'Grada 1994, Whelan 2000, National Centre for Geocomputation 2010).

Further benefits of employing a *k*-means method in the context of this research, are that such techniques '...seek to minimize the variability within clusters and maximise variability between clusters' (Landau and Everitt 2004: 312), thus yielding a set of groups optimally distinct from each other, yet retaining a significant degree of internal homogeneity. This process is thus theoretically consistent with the concept of *regimes*, as informed by complexity theory and resilience ecology, whereby each cluster group may be interpreted as a distinct *regime* or *attractor* (Byrne 1998). Complete output generated from the clustering procedure is provided in *Appendix 3*, although this output is less intuitively interpreted owing to necessary standardisations employed prior to running the clustering algorithm. The reader may however, discern cluster centroids more intuitively through the following tables (3 and 4, pages 16 and 17), which tabulate final cluster solution group members (*table 3*) and input variable summary statistics according to derived cluster group membership (*table 4*).

¹⁰ According to Everitt et al, 'The basic idea...is that associated with each partition of the *n* individuals into the required number of groups, *g*, is an index $c(n, g)$, the value of which measures some aspect of the 'quality' of this particular partition' (2011: 111).

Table 3. Cluster solution group members

Group 1	Group 2	Group 3	Group 4
Antrim	Armagh	Carlow	Clare
Down	Cavan	Kildare	Donegal
Dublin	Cork	Meath	Galway
Kilkenny	Fermanagh	Queen's	Kerry
Louth	King's	Westmeath	Mayo
Tipperary	Leitrim	Wexford	
Waterford	Limerick	Wicklow	
	Londonderry		
	Longford		
	Monaghan		
	Roscommon		
	Sligo		
	Tyrone		

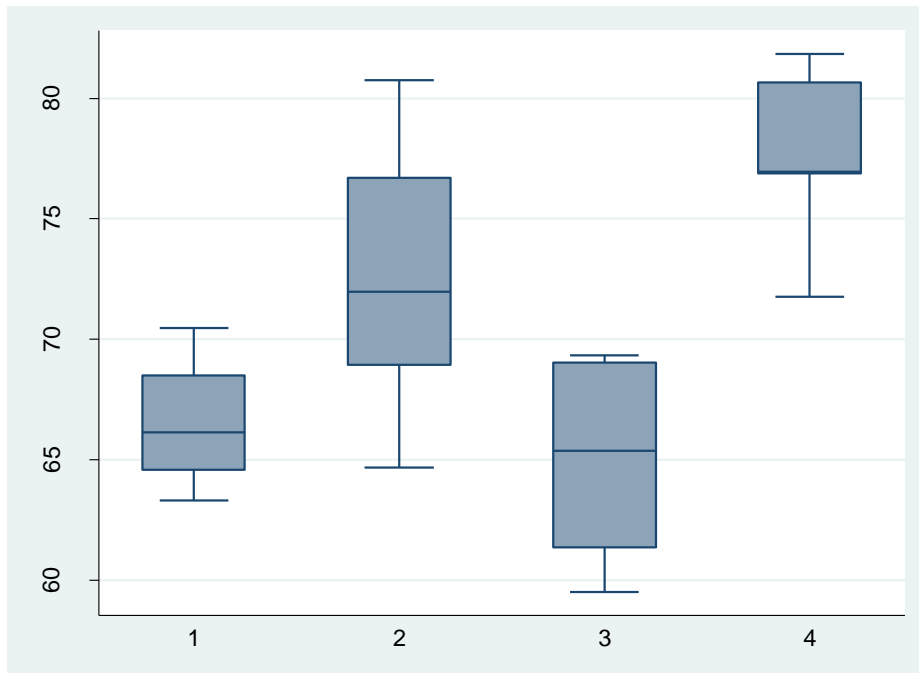
Table 3. Cluster solution group members

On the basis of these results, a number of manifest social-ecological regimes may be observed. Commensurate with a complexity account of systems as constituted by multiple ontological levels and trans-boundary properties, the above typology is not limited by restrictions of space, but rather designates an abstract set of typological characteristics indicating probable tendencies operating at lower levels of aggregation. Consequently, in light of the summary statistics presented in *table 4* (page 17), we may observe a distinct social-ecological regime described by the territories of **Group 4** (Clare, Donegal, Galway, Kerry and Mayo); the consistency of this group as a distinct social-ecological regime is defined by its high *land-labour ratio* (3.6), low *poor law valuation* (£0.91), high proportions of *females 26-35 married* (77.62%), high fragmentation of holdings *1-5 acres* (51.72% of all holdings), high availability of *wasteland* (78.99%), and greater prevalence of *common landholding* (32.66%). This may in turn be compared to the regime described by **Group 1**, characterised by significantly higher *valuation* (£1.96), lower fragmentation of holdings *1-5 acres* (37.31%), limited *wasteland* (28.13%), and comparative absence of *common landholding* (6.44%). The magnitude of these between-group differences may be observed by examining the following boxplots generated by cluster group membership for variables *female 26-35 married* (*figure 4*) and *land held in common or joint tenancy* (*figure 5*).

Table 4. Input variable summary statistics by cluster group membership

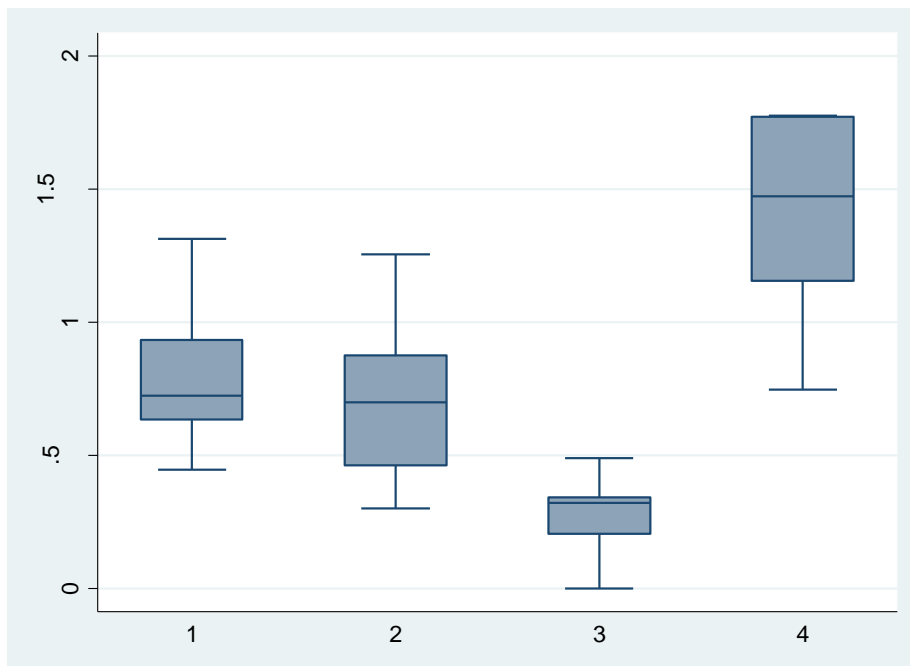
Variable	Unit	Group 1		Group 2		Group 3		Group 4	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Land-labour ratio	Acreage per head of population	1.93	0.67	2.40	0.54	3.33	0.47	3.60	0.47
Poor law valuation	£ (pounds) per head	1.96	0.49	1.27	0.23	2.17	0.48	0.91	0.15
Females 26-35 married	% all females	66.47	2.44	72.61	4.94	64.84	3.89	77.62	3.95
Holdings 1-5 acres	% all holdings	37.31	8.14	45.43	9.69	34.90	5.62	51.72	15.78
Waste (course pasture) below 800ft above sea level	% total county waste	28.13	16.34	63.78	21.81	61.70	26.74	78.99	9.67
Land held in common or joint tenancy	% all land	6.44	6.08	5.39	21.81	1	0.64	32.66	24.99

Figure 4



Boxplot (% females 26-35 married or widowed) by cluster group membership

Figure 5



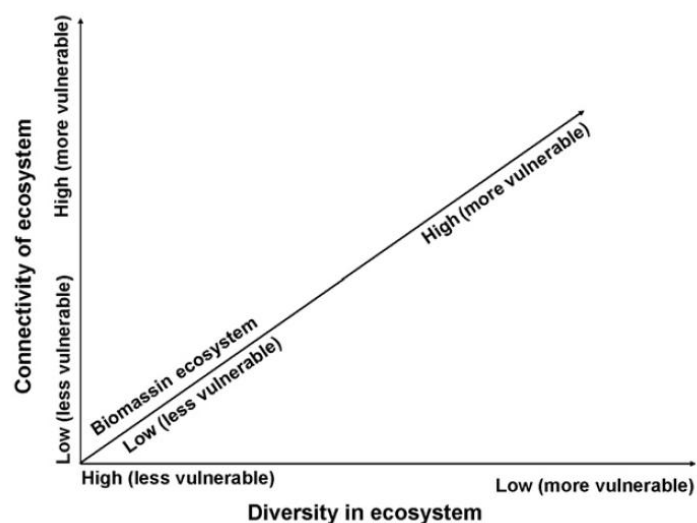
Boxplot (log % land held in common or joint tenancy) by cluster group membership

Theoretical and methodological implications

Although this exercise bears numerous theoretical implications, they must be advanced with a measure of caution, as the preceding exercise has relied upon data drawn from ecological units (i.e. counties). As units in which ‘individuals’ such as settlements or specific actors are contained, individual data points here denote the attributes of broad containment units, and should not be interpreted as proxy measures of association at lower levels of aggregation; this is potentially problematic for a number of reasons, and discussions assessing the validity of individual-level inferences derived from ecological correlations are extensive (Goodman 1959, Piantadosi et al 1988, Schwarz 1994, Freedman 1999, Robinson 2009). Although the computation of correlation coefficients is relatively commonplace in quantitative sociology, comparatively less attention is given to the validity of correlations computed on ecological units (i.e. counties, as are utilised above). Such practice is not without long historical precedent; sociology owes a significant debt to the ecological correlations of Durkheim, whose pronouncements on the explanatory power of the social were constructed from aggregate data on suicide rates and religious affiliation in Prussia (Piantadosi 1988: 893). The use of such units is extensive and unproblematic within sociology, and cross-national comparative work typically proceeds by employing data measured at particular levels of aggregation (such as cross-national comparative human ecology, or studies in ecological modernisation - Bradshaw et al 2010). Consequently, despite the limited downward-predictive validity of such approaches, particularly in the context of complex open systems such as societies, the explanatory power of such emergent attributes as social-ecological regimes is no less diminished *a priori* by the mere utilisation of aggregate units by the analyst, with whom blame must also reside when the explanatory limitations of ecological units are breached, and projected downward onto individuals.

It is therefore critical not to over-generalise such associations, (i.e. to assume that the characteristics of individual settlements within such containment units will necessarily display similar association). Given a comparative lack of data at lower levels of aggregation, such limitations are unfortunately unavoidable. This exercise does however confront certain existing pronouncements on the social-ecological complexity of pre-famine Ireland, particularly those of Fraser (2003, 2006) whose implementation of a resilience approach in the context of pre-famine Ireland has drawn attention to the critical outcome of perturbation exposure engendered by high systemic connectivity, both in terms of settlement, and biomass concentration. A tri-axial model of this relationship is provided by Fraser (2006), illustrating the relationship between connectivity, biomass, diversity and resilience (reproduced below as *figure6*).

Figure 6



Panarchy framework (reproduced from Fraser 2006: 330)

Connectivity - as measured by settlement density - when coupled with high concentrations of biomass and low species diversity, functions to lower resilience, and to increase exposure to perturbation (see Peterson et al 1998). As systems ascend the respective axes toward critical risk exposure levels, the magnitude of disturbance required to induce collapse becomes increasingly smaller. Pre-famine Ireland is therefore cited as a prime example of this critically diminished resilience (as a function of gradual ascension of the above axes), resulting of limited adaptive capacity at local levels. This diminished adaptive capacity encompasses reductions in biodiversity and increases in connectivity and settlement density incurred through population growth and surplus production (rent), pre-famine subdivision, and both spatial and monetary restrictions on external subsidy imports (Fraser 2003, 2006, 2007, Kinealy 2006). Initially, such ecocentric conclusions were borne out by K.H. Connell's identification of the potato as a dominant independent variable accounting for expanding pre-famine fertility and population density. The classical narrative of biodiversity reduction through monoculture subsistence - somewhat authenticated, albeit with significant regional variation (Bourke, 1959, Downey 1996) - in turn led Connell (1950a) to hypothesise the potato as a key agent facilitating wasteland colonisation, subdivision through subsistence on smaller acreages, with a consequent removal of barriers to early reproductive union as discussed above.

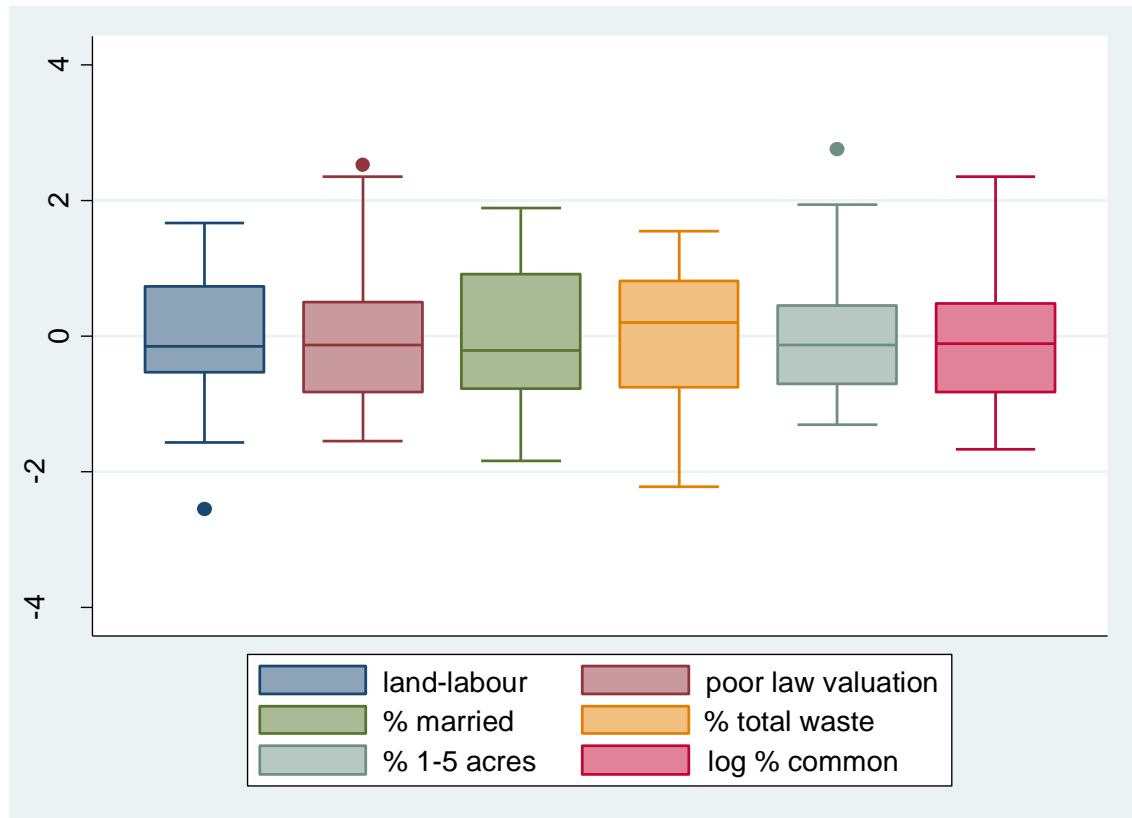
Clearly there is much possible heterogeneity across various trajectories of systemic development and collapse, and caution must be exercised in mapping any such model (i.e. *figure 6*) onto particular case studies. It is thus a critical oversight of studies such as Fraser's that do not further consider the internal diversity of Irish social-ecological regimes, distinguished by the preceding analysis according to demography, tenure and geography. There is clearly much merit in complicating such generalised frameworks, which in turn serves to direct us away from sweeping statements such as '...the agro-ecosystem in Ireland progressed from a relatively complex system of mixed livestock, grain and potato production to a system that was wholly based on the potato' (Fraser 2003: 4). Works such as Currie (1986), Slater

(1988), O'Grada (1994), O' Hearn (2001), Slater and McDonough (2005) have revealed profound internal variability in factors such as rental regimes, modes of tenure, regional economies and landholding distributions; points which demand a closer examination of how resilience may be distributed across regions and settlement types, in turn augmented by specific local practices.

This typology fast outlives its limited functionality however; by serving merely as an orienting device, it confirms something of the exceptionalism of the peripheral locations in which rundale abounds, quantifies such regional macro-characteristics, and offers a basis for subsequent qualitative inquiry. From the preceding results, we observe merely a *potential* differential distribution of social-ecological resilience across the state-space of Ireland, by noting areas subject to greater probabilities of ecological stress. This tells us little of the dynamics of *localised* social-ecological systems (i.e. individual settlements) however. Consequently, our focus must now move toward a qualitative examination of such localised settlements themselves, in order to observe the strategies by which they confronted their encroaching ecological limitations, by augmenting adaptive capacity through the mechanism of collective governance. In service of this analysis, appropriate conceptual frameworks permitting the assessment of combined social-ecological relatedness and activity must be employed. On the basis of the preceding heuristics offered by complexity and resilience, this is an exercise that may now proceed without the use of normative assumptions. Subsequent exercises thus examine more closely, through the use of multiple regression and data at lower levels of aggregation, the relationship between communality, demography and local agricultural production. Having established such a quantitative basis, an empirically-grounded ideal-typical model of the rundale system is subsequently offered based on existing documentary data.

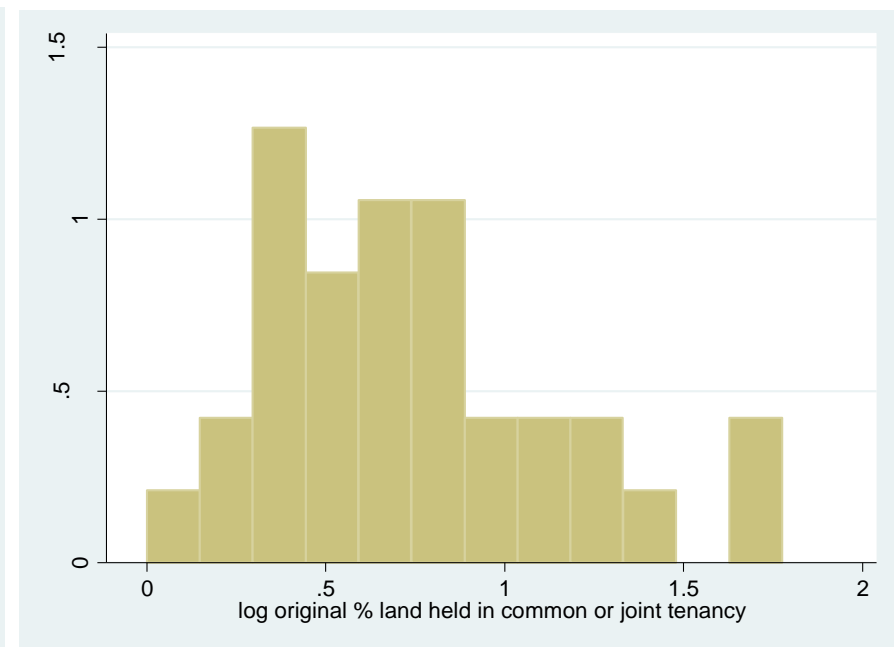
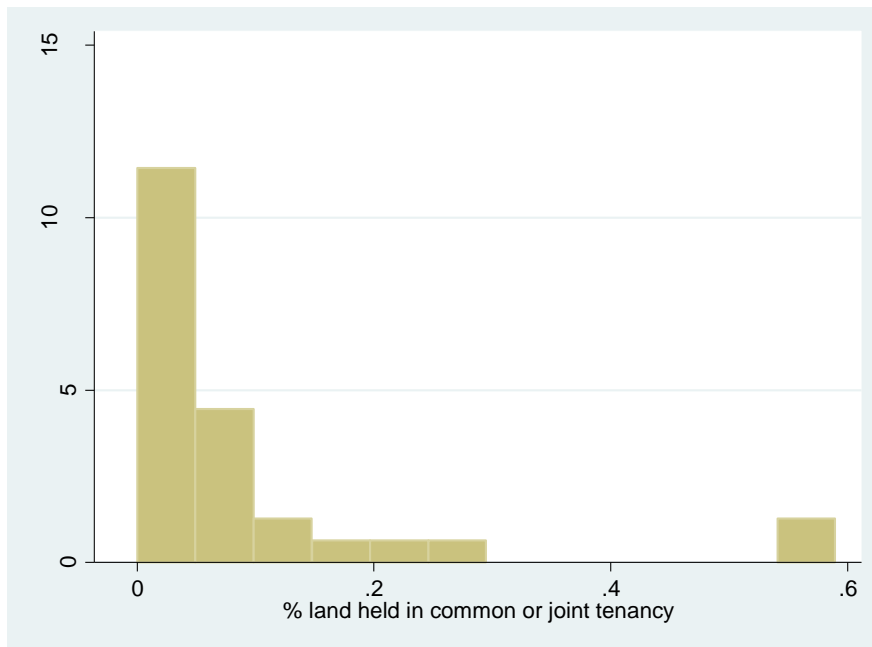
Appendix 1

Boxplot of z-score standardised input variables



Appendix 2

Comparison of distribution pre and post-transformation (variable 'common')



Appendix 3

Cluster analysis output

Initial Cluster Centers				
	Cluster			
	1	2	3	4
zscore: population density	-2.55204	-.19206	1.18460	1.01252
zscore: poor law valuation per head	2.52063	-1.20268	1.8517	-1.54584
zscore: % females 26-35 married	-.86642	1.24137	-.86642	1.88992
Zscore: % total waste (course pasture) below 800ft above sea level	-2.22270	-.22563	1.04174	.84972
Zscore: % holdings 1-5 acres	-.40549	.76592	-.31538	2.74829
Zscore: log original % land held in common or joint tenancy	-.23244	-.76598	-1.20503	2.34405

Iteration History				
	Change in cluster centers			
Iteration	1	2	3	4
1	2.164	1.523	1.501	1.828
2	.756	.213	.340	.616
3	.205	.174	.000	.492
4	.000	.175	.000	.451
5	.000	.000	.000	.000

Final Cluster Centers

	Cluster			
	1	2	3	4
zscore: population density	-.92779	-.36225	.79303	1.13052
zscore: poor law valuation per head	.68962	-.50447	1.04749	-1.12032
zscore: % females 26-35 married	-.63480	.38079	-.93591	1.20894
Zscore: % total waste (course pasture) below 800ft above sea level	-1.14187	.22637	.14196	.81131
Zscore: % holdings 1-5 acres	-.45698	.27379	-.65006	.83800
Zscore: log original % land held in common or joint tenancy	.10568	-.06584	-1.03279	1.46913

Number of cases in each cluster

Cluster	Cases
1	7
2	13
3	7
4	5
Valid	32
Missing	0

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