Multi-faceted Characterisation of Spatial and Temporal Land Abandonment Patterns Using Descriptive Statistics and Massive Logistic Regression – A Norwegian Case Study.

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Introduction

Farmland abandonment is an increasingly common phenomenon across Europe with a range of consequences. Although there are certain effects which may be considered positive, the majority tend to be considered negative. Most common within grazed systems, it entails loss of bio-diverse pastoral habitats (Beilin et al. 2014), loss of pastoral vistas of cultural and economic value (Hunziker 1995), loss of soil quality (García-Ruiz and Lana-Renault 2011), and even threat to life due to increased avalanche risk in mountainous regions (Flury, Gotsch and Rieder 2005). Although it is understood that abandonment is not a simple term, many studies looking at its drivers tend to use just one particular definition, for example 'years out of use' (Beilin et al. 2014). In practice farm land is rarely abandoned permanently, at least in Norway, and we suspect the situation may be similar also in other countries. The impact of different periods of abandonment will vary depending on the level of maintenance when out of production and how local the habitat would reach a natural climactic state (Bryn et al 2012). Thus there is an important question as to whether abandonment should be defined by cause (lack of use) or effect (apparent degradation) or by some longer term trajectory (Munroe et al 2013). This study looks at how to classify land parcels in Norway with respect to type of abandonment, based on different potential metrics of abandonment derived from their pattern of usage over time.

Data Preparation

Every parcel of agricultural land in Norway (actively farmed or not) has a unique code. To receive agricultural subsidies Norwegian farmers have to annually submit detailed information to the Norwegian Agricultural Authority (NAA) about their respective products, as well as the land they manage (i.e. regardless of if it is rented or owned by the claimant).

The dataset consisted of 11 years of subsidy claim records (2000-2011) for c60,000 farms claiming for c200,000 land parcels. The LPID are part of the Norwegian cadastral system and are thus geo-referenced to a polygon map layer and a layer of those polygon's centroids.

The subsidy claim is made under the farm code of the farmer's 'home farm' (we use the term for convenience, there may in fact be no resident farmer), and the codes of any land claimed for (whether owed or rented) are included in each claim. The NAA database containing these subsidy claims are hereafter referred to as the production subsidy data and land parcels IDs as LPID. Individual land parcels may be sold or rented between farm businesses over the period, there is no referential database structure linking LPID, thus no simple database query could establish which years a particular LPID was present. A script was implemented in VBA for MS Access to sift the database for each LPID and then assign a "1" or "0" to a given year depending respectively on whether a match was found or not. The result was a binary string for the presence and absence of each LPID over the time period.

Patterns of Abandonment

Each land parcels binary string of presence/absence from the data set was categorised in 5 different ways as per table 1 :

Table 1

Type of Classification	Method
Average	The simple average between 0 and 1 from all years
Three year Shocks	The number of periods of three years or more where no claim was made, followed by a recorded return to production
Balance	The sum of the first six years, minus the sum of the last six years
Logistic Regression Line	The maximum likelihood a logistic regression line fitted through the time series
Long Term Outlook	The logistic regression line classification, with all those points for which a line could not be fitted classified to either 1 or 0 based on their majority state.

The five approaches reveal different aspects of the usage pattern of the land parcel.

Average : Gives a general impression of the overall productivity of the land during the period. However, a two year rotational fallow will give a similar value as regular use for the first 5 years followed by complete abandonment for the following 6.

Three Year Shocks : Three years is sufficient for the early stages of regrowth and soil degeneration which must be rectified for usage. So the absence of any usage for three or more years in succession implies some sort of issue has occurred for that land parcel such as change of ownership or unfavorable economic or weather conditions which render it vulnerable to longer term abandonment.

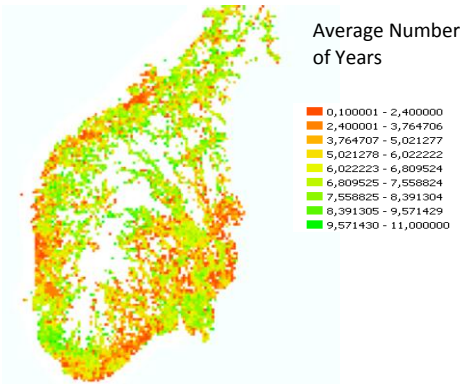
Balance : A large differential between the former and latter halves of the time period would suggest at the least a significant longer term downgrading of that land parcel's productivity compared to its potential as evidenced by the first half usage.

Logistic Regression : Regression shows how the probability that a land parcel will be used changes over the course of the decade. It has the advantage of providing confidence measures as to the co-efficient and thus the possibility to predict at what point in future likely hood of use will drop below a certain level.

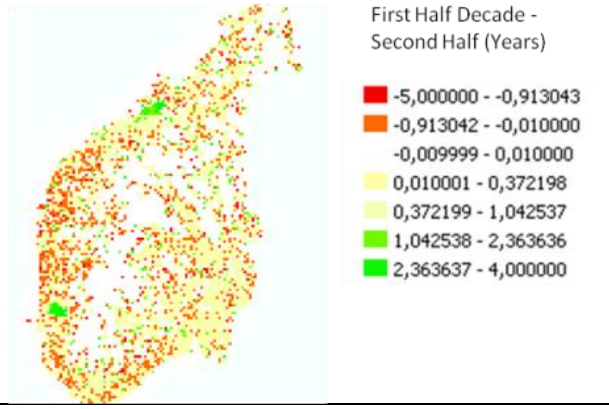
Long Term Outlook : Logistic regression only functions when the probability is not too extreme. As the probability approaches 0 or 1, the function fails, which was true in about half of the cases. However, in those circumstances the outlook of the parcel is clear, either it is in regular use and showing little evidence of that changing, or it is rarely if ever used. Thus a composite index may be developed showing the likely outlook for all the land parcels,

Results

Figure 1 : Simple and More Complex Metrics of Farm Land 'Abandonment'

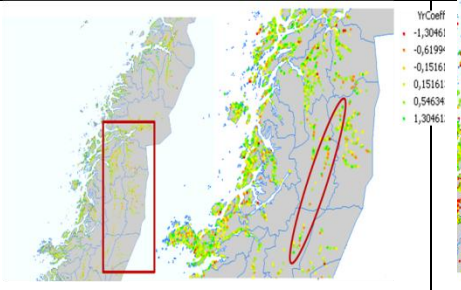


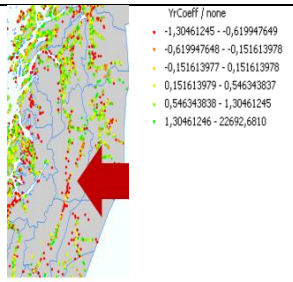
Average



Balance

(a)





(b) **NB : Red includes land parcels with no claim in 10 years, Green includes land parcel in constant use.**

Logistic Regression Coefficient

(c)

Long term outlook

(d)

Figure 1 shows some of the patterns produced by the dimensions selected. Figures 1a and 1b show the data aggregated to 5km grid squares as point patterns at this scale tend to reflect drawing order more than actual value. A simple chromatic stretch shows considerable clustering between land in regular usage (green), and land in partial usage (yellow orange) or rarely used (Red). It does not however give much indication of future prospects of these areas. Red areas may simply be those where land is only used rarely due to limited capacity, or where abandonment is already established due to a prior process of change.

Balance helps pick out areas of decline but does not consider when the land was last used. Presented on a map it gives a perhaps unduly negative picture since those areas in use every year would get a value of 0, and very few land parcels are completely new to production[1]. On the other hand, areas entirely abandoned throughout the period are also 'balanced' so it does not present historic loss of land.

The Logistic regression coefficient (figure 1c) is given for individual land parcels, with c100,000 parcels providing a value, and focuses attention on land parcels where the intensity is changing. The red oval highlights land parcels along a large valley. Land parcels such as that of the orange point

[1] The two clusters of green are new data.

sitting somewhat isolated to the lower center is an example of the type of land parcel which might be considered of particular concern. It appears to have a steep decline in use. Slightly to the north is a land parcel still in regular usage, but beyond that further parcels in declining use. When land parcels which cannot be fitted with a logistic trend are included, the picture again becomes dominated by the extreme cases (figure 1 d), but it shows that these particular points (indicated by the red arrow) are surrounded by previously abandoned farmland. Thus they form the 'dots' of farmland which when looking along the valley still provide a visible sense of continuity in management along the valley.

Next Steps

Since the dataset is relatively short and individual decision makers often confound the evidence it would be unwise to attempt to seek to correlate drivers of abandonment with these metrics at the parcel level. However, one might add statistical weight to such approaches through spatial aggregation. The authors are exploring the possibility to use multi-dimensional scaling to cluster the land parcels by these 5 dimensions of abandonment, and then look for spatial clustering of the results. That should allow environmental explanations to be identified through multiple local regression analyses which would be less susceptible to auto-correlation than global approaches but better able to represent discrete boundaries in systems that geographically weighted approaches.

Conclusion

Agricultural land abandonment is not a binary state. There are grades of management both in terms of intensity and frequency, and multiple dimensions to the patterns of usage. Temporal patterns of usage can provide a more nuanced picture of specific types of abandonment with, perhaps, different driving forces.

Acknowledgements : This work was funded by the Norwegian Forest and Landscape Institute

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