RURAL DEPOPULATION AND LAND COVER CHANGE IN WESTERN SPAIN

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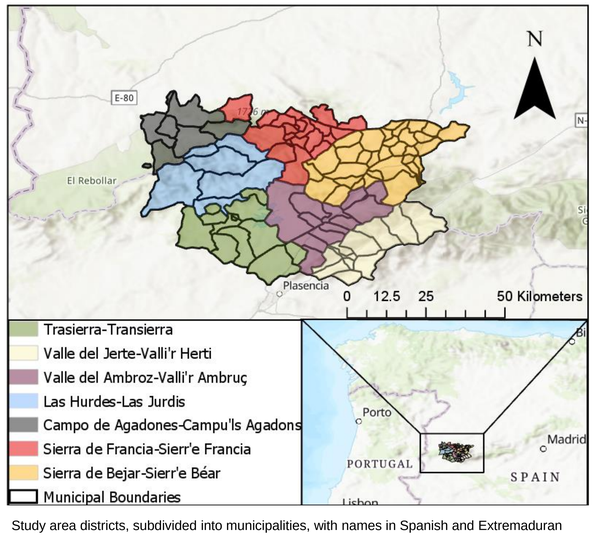
ABSTRACT

Various models based on the application of demographic transition theory predict a post-industrial phase of population decline. In various areas of the world, such depopulation has already materialized and has been particularly pronounced in rural areas. Simultaneously, it is well understood that human population densities as well as cultural factors have an impact on land use and land cover types in a given area. Thus, depopulation in the rural context provides an ongoing study area for the effects declines in human populations can have on land-use and land cover change (LULCC). In the present study, a rural area in western Spain with an enduring, chronic demographic decline was assessed for LULCC using remote sensing methodologies. Statistical linear regression analyses were then used to determine the nature of the relationship between population decline and LULCC. The results concluded that, in this study area, rural population decline has had varying degrees of impact on a multitude of land cover types, including natural, naturalized, and anthropogenic. Continued study, aimed at discerning other potential factors in this LULCC as well as the impacts on other land cover types, is warranted.

BACKGROUND

A thorough investigative engagement with human-environment interactions and their dynamics comprises, amongst other research foci, understanding land-use and land cover change (LULCC). As part of demographic transition theory, human population numbers and densities are expected to decline in various societies, thereby effecting varying degrees and types of LULCC. In the Iberian Peninsula, depopulation – specifically rural depopulation – has been an observed trend influenced by low natality, high life expectancy, historically high emigration to urban centers, and other social factors. The study area consisted of a total of seven *comarcas* and *mancomunidades* (traditional jurisdictional districts) located on the border between the Spanish autonomous communities of Extremadura and Castile-and-Leon, on either side of a sub-range (primarily the Sierra de Gredos) of the Sistema Central mountain chain. These districts comprise a total of 99 municipalities, from which publicly-available population data (1950-2010) was extracted.

Several land cover types predominate in this study area. Besides bodies of water, the most evident land cover types are natural: 1) Mediterranean savanna, 2) *matorral* shrubland, 3) deciduous and coniferous forests, and 4) sub-alpine shrub/bare rock. Agricultural land uses included 6) olive groves and orchards (primarily cherry trees) and 7) other agricultural fields, including wheat and rye cultivation. A final, but critical and idiosyncratic, land cover type in this study area is the *dehesa*, a diverse, naturalized, anthropogenic mixed-use cork oak woodland ecosystem used for Iberian black pig rearing, chestnut and cork harvesting, as well as traditional hunting and other gathering activities. The *dehesa* represents a silvicultural thinning of indigenous cork oak forests – which still comprise a significant proportion of the study area's deciduous/coniferous forest land cover class – but additionally constitute an important habitat for endemic species and an economic and cultural bedrock for local communities.



Study area districts, subdivided into municipalities, with names in Spanish and Extremaduran

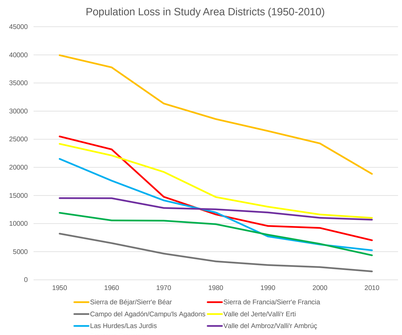
DATA

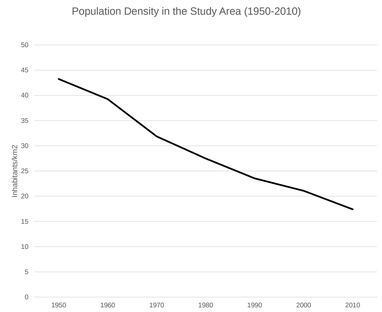
Municipal population data 1950-2010

Landsat 5 scenes from September 1984 and September 2010

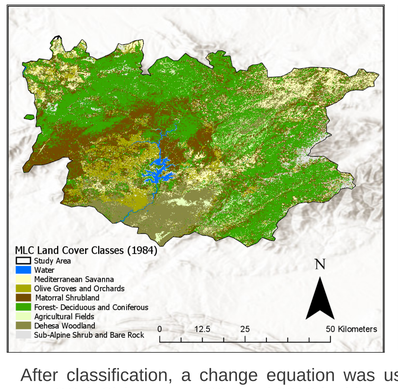
METHODS

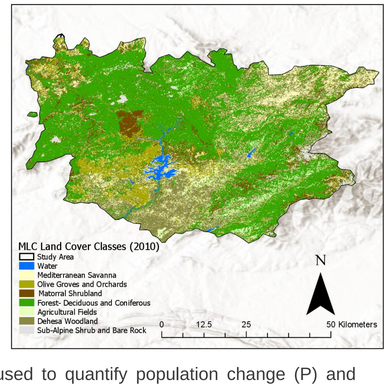
For the depopulation analysis, population data (1950-2010) for the seven districts' 99 constituent municipalities was acquired from the Spanish National Statistics Institute (INE, for its acronym in Spanish). In all, the seven districts experienced a marked loss of population as well as population density, as measured by proportion of the population living outside of the district's largest municipality. This shows a chronic, ongoing, and constant depopulation trend in this area, with few exceptions at the municipal level.





Remote sensing methodologies were incorporated into the subsequent LULCC analysis. Two cloud-free Landsat 5 scenes, one from September 1984 and the other from September 2010, were acquired in order to observe LULCC across this time period. Because of the chronic and constant depopulation trend observed in the study area, obtaining imagery from a certain year was not necessary; however, September was chosen because of the lack of snow cover and the timing of the harvest. The imagery was processed, and then underwent two different forms of land cover classification: an unsupervised classification and a supervised maximum likelihood classification (MLC). Using satellite imagery as a truth sample and an error matrix, it was revealed that the MLC analysis produced a more accurate classification of the actual land cover types:





After classification, a change equation was used to quantify population change (P) and LULCC (LC) between 1984 and 2010 in this study area:

$$\Delta LC = \frac{LC_{2010} - LC_{1984}}{LC_{1984}} \quad \& \quad \Delta P = \frac{P_{2010} - P_{1984}}{P_{1984}}$$

Subsequently, a linear regression was performed aimed at ascertaining what the relationship between LULCC and population decline has been in regards to three particular land cover classes thought to be highly dependent on human-environment interactions : forests, *dehesa* woodlands, and agricultural fields.

RESULTS

Overall population in the study area's seven districts declined by 59.75% between 1950 and 2010, which is a decrease from 145,784 to 58,680. Population density, *including* each district's most populous municipality, decreased from 43.34 people/km^2 in 1950 to 17.4 people/km^2 in 2010. However, excluding each district's most populous municipality in the density calculations – to account for intra-district migration and the consequent concentration of inhabitants in each district's most advantaged municipality – reveals that the real population density outside such municipalities decreased by 76.7% to 10.1 people/km^2. For the regression analysis, 1985 population data was used.

Changes were also evident in the extents of the study area land cover types, including the deciduous/coniferous forests (16.1% increase, accounting for 47.7% of the total surface in 2010), *dehesa* woodlands (2.9% increase, with 13.5% total surface in 2010), agricultural fields (96.7% increase, with 4.5% total surface in 2010), and *matorral* shrubland (52.8% decrease, with only 10.8% total surface in 2010).

The linear regression analyses helped clarify the nature of the LULCC and its relationship to depopulation in this study area. At the district level, the only land cover class which was significantly affected by the depopulation was the "forest" class; a moderate negative correlation was established between the two variables. (Note: RMSE is Root Mean Square Error)

$$Forest\ R^2 = -.383 \text{ (RMSE: } 0.225)$$

$$Dehesa\ R^2 = -.085 \text{ (RMSE: } 0.416)$$

$$Fields\ R^2 = -.079 \text{ (RMSE: } 0.682)$$

A surprising result of the LULCC quantification and the regression was that the extent of the agricultural fields land cover class increased significantly (almost doubling) *despite* the roughly proportional halving of the population between 1985 and 2010. It is suspected that this can be attributed to the consolidation of smallholdings and family farms into the hands of wealthier farmers operating under a more land-extensive, capital-intensive agricultural model. In contrast, the *matorral* shrubland class decreased significantly – not in proportion to depopulation directly but seemingly in relation to the decline of traditional transhumance, which formerly maintained the existence of this land cover class. District-specific LULCC included the expansion of olives and orchards in the Valle del Jerte/Valli'r Erti district, in which the cultivation of protected-denomination cherries has grown significantly in the last few decades. Finally, the important *dehesa* ecosystem grew marginally, despite becoming more fragmented as agricultural fields and orchards grew alongside it. *Dehesas* remain an important cultural-economic-natural ecosystem for local communities.

CONCLUSIONS

LULCC continues to be an area of focus for researchers worldwide, including in those parts of the world affected by processes of depopulation and decreased rural activities. In this study, it became clear that rural depopulation can have widely-differing effects on LULCC. The effects of depopulation are contingent on not just the ecology of the study area but the cultural factors influencing human-environment interactions, such as land tenure, nature of agricultural activity, transhumance and the influence of livestock, and institutional revitalization attempts. Anthropogenic, species-rich ecosystems such as the *dehesa* cork oak woodlands may have a positive correlation with population growth (i.e., decreasing alongside the rural population that maintains them) unless they have become naturalized. An additional unexplored variable in this study's LULCC analysis is climate change; the subalpine shrub land cover class, existing at high altitudes and necessitating low temperature thresholds, saw significant reductions between 1984 and 2010. A continued engagement with this kind of research is crucial if geographers, ecologists, zoologists, and many others wish to continue to understand the rich, dynamic, and interpenetrative relationship between humans and their cultural and natural environments.

REFERENCES

Available upon request (ablancoc@uccs.edu)

Special thanks to:
Dr. Cerian Gibbes, GES Department, University of Colorado-Colorado Springs
Dr. Emily Skop, GES Department, University of Colorado-Colorado Springs
Dean Peter Braza, College of LAS, University of Colorado-Colorado Springs
Ms. Margie Oldham, College of LAS, University of Colorado-Colorado Springs