land

MDPI

Article

# Anthropogenic Influences in Land Use/Land Cover Changes in Mediterranean Forest Landscapes in Sicily

**Donato S. La Mela Veca, Sebastiano Cullotta, Sebastiano Sferlazza * and Federico G. Maetzke**

Università Degli Studi di Palermo, Dipartimento Scienze Agrarie e Forestali, Viale delle Scienze, Edificio 4, Ingresso H, 90128 Palermo, Italy; donato.lamelaveca@unipa.it (D.S.L.M.V.); sebastiano.cullotta@unipa.it (S.C.); federico.maetzke@unipa.it (F.G.M.)

* Correspondence: sebastiano.sferlazza@unipa.it; Tel.: +39-3297372613

Academic Editors: Eduardo S. Brondizio, Jane Southworth and Andrew Millington

Received: 27 October 2015; Accepted: 19 January 2016; Published: 26 January 2016

**Abstract:** This paper analyzes and quantifies the land use/land cover changes of the main forest and semi-natural landscape types in Sicily between 1955 and 2012. We analyzed seven representative forest and shrubland landscapes in Sicily. These study areas were chosen for their importance in the Sicilian forest panorama. We carried out a diachronic survey on historical and current aerial photos; all the aerial images used to survey the land use/land cover changes were digitalized and georeferenced in the UTM WGS84 system. In order to classify land use, the Regional Forest Inventory 2010 legend was adopted for the more recent images, and the CORINE Land Cover III level used for the older, lower resolution images. This study quantifies forest landscape dynamics; our results show for almost all study areas an increase of forest cover and expansion, whereas a regressive dynamic is found in rural areas due to intensive agricultural and pasturage uses. Understanding the dynamics of forest landscapes could enhance the role of forestry policy as a tool for landscape management and regional planning.

**Keywords:** land use/land cover changes; landscape dynamics; climate changes; human-dominated landscape; socioeconomic factors; forest management models

## 1. Introduction

A landscape is a structural, perceptible and functional layout of an area that results from the complex interaction between its environmental and sociocultural assets. On the one hand, geomorphology, lithology, climate and soil have deeply influenced the entire territory of our countries; on the other hand, so have human activities related to forestry, agriculture, and wild and anthropic fires [1,2]. Land use/land cover (LULC) change, as a consequence of the human influence on the landscape, derived from significant modifications in ecosystems at local, regional and global scales and has consequently influenced global change [3–5], especially through its effects on temperature [6,7] and rainfall [8]. In light of the increasing awareness of such themes, recent international climate agreements stressed the importance of land use and land use change of forest ecosystems as a focal point for understanding the changes on global productions, harvested areas and prices of major crops, which are ultimately also taken into account by economists [9,10].

The entire Mediterranean basin is characterized by landscape patterns with compositions resulting from countless, long and complicated cultural and historical processes that developed in complex and varied environments [2,11,12]. Sicily, which is the largest island of the Mediterranean basin and the broader region of Italy (25,711 km$^2$), is characterized by huge variability in geological, climatic and biological assets, and was subjected to hundreds of years of human activities carried out by various cultures and people that shaped the local landscapes and maintained extraordinary vegetal biodiversity. The current typical Sicilian landscape is characterized mainly by agriculture [13], including extensive

active or abandoned farms, shrublands, pastures and grasslands. In Sicily, forests form a discontinuous patchwork mainly located along the slopes and at the top of the main northern and northeastern mountain ranges. They are also dispersed across territories now encompassed by regional natural parks (Mt. Etna, Madonie, Nebrodi and Sicani Mts.). Thus, forest and shrubland species composition and stand structure are typical of Mediterranean landscapes and exhibit a very high variability due to natural and anthropogenic influences [14,15]. In addition to these semi-natural forests, shrublands and woodlands, there are widespread reforested lands that are generally comprised of non-native species, such as conifer and eucalypt plantations.

The near-term projections of climate change for 2016–2035 in southern Europe, and Sicily in particular, from the Intergovernmental Panel on Climatic Change (IPCC), forecast a persistent change in the climate with an increase in mean seasonal temperature of up to 1.2 °C in summer and 0.9 °C in winter. Mean seasonal precipitation is expected to increase by up to 25% in summer, but drop by up to 20% in winter. Changes in the frequency, intensity, and duration of extreme events are likely to result in greater numbers of hot days, heat waves, and heavy precipitation events in addition to fewer cold days [16]. These last events may weaken or reduce forest and semi-natural ecosystems as well as exacerbate the potential desertification risk in Sicily, one of the Italian regions most threatened by this land degradation [17].

The aim of our study is to quantify and analyze the land use/land cover change of the main forest and semi-natural landscape types in Sicily between 1955 and 2012 using a diachronic survey and comparison, conducted through the interpretation of various historical and current aerial photos.

## 2. Materials and Methods

### *2.1. Study Areas*

The study analysis was carried out in six forest territories (the Sicani, Madonie, Nebrodi mountains and Mount Etna, the Calatino area and Pantelleria Island) (Figure 1) that are considered to be representative of the main ecological and sociocultural variations of the entire island, including Sicily's most representative forest and woodland forest types (approximately 60% of the whole forest cover) [18]. The sample areas were chosen using the following criteria: (1) encompassed in a protected area; (2) articulate sample of regional forest types; and (3) include the presence of selected silvicultural practices. On this basis, one or two sample areas for each territory (Table 1) were chosen in holm oak, cork oak, downy oak, turkey oak, corsican pine, beech and Mediterranean pine forests, as well as Mediterranean shrubland and plantations.

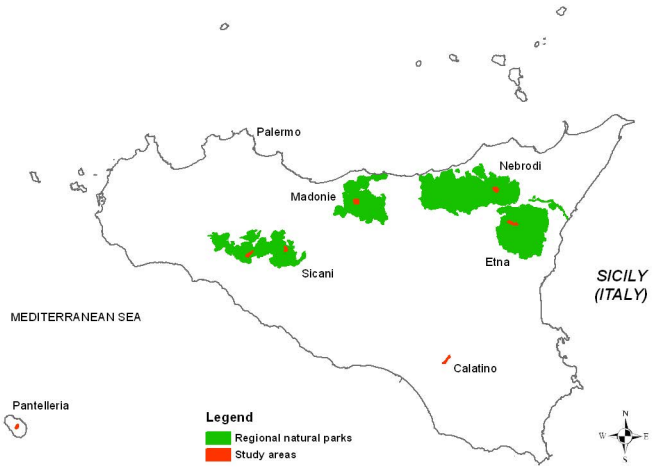



**Figure 1.** Geophysical map of Sicily with detail of the study areas.

**Table 1.** Forest types and main features of the study areas.

| Study Area | Main Geomorphology/Geography | Name of Municipality | Protected Area/Natura 2000 Site | Surface Area (ha) | Forest Type (Main) |
|---|---|---|---|---|---|
| Pantelleria | Circum-sicilian volcanic island (Sicilian Channel) | Pantelleria | SCI ITA010019 "Isola di Pantelleria: Montagna grande e Monte Gibele"; Riserva Naturale Orientata "Isola di Pantelleria" | 233.2 | Mediterranean pines (*Pinus pinaster, P. halepensis*) |
| Calatino | Flatlands and low rolling hills | Caltagirone | SCI ITA070005 "Bosco di S. Pietro" | 421.3 | Plantations (*Eucalyptus camaldulensis, E. globulus*); cork oak; Mediterranean shrubland (*Cistus sp. pl., Phillyrea latifolia, Pistacia lentiscus, Olea europaea var. sylvestris, Daphne laureola, Lonicera implexa, Calicotome infesta, Spartium junceum, Chamaerops humilis*) |
| Nebrodi | Mountain range | Tortorici | SCI ITA030043 "Monti Nebrodi"; Nebrodi Regional Park | 436.8 | Beech; turkey oak; supramediterranean shrubland (*Crataegus sp. pl., Rubus ulmifolius, Rosa sp. pl., Ilex aquifolium*) |
| Madonie | Mountain range | Isnello | SCI ITA020016 "Monte Quacella, Monte Cervi, Pizzo Carbonara, Monte Ferro, Pizzo Otiero"; Madonie Regional Park | 526.8 | Beech; holm oak |
| Etna | Volcanic mountain | Maletto | Etna Regional Park | 421.7 | Corsican pine (*Pinus nigra subsp. Laricio)*; holm oak; downy oak; plantations (*Cedrus atlantica, Pinus radiata*) |
| Sicani PA | Mountain range | Palazzo Adriano | SCI ITA020025 "Bosco di S. Adriano"; Sicani Regional Park | 317.7 | Plantations (*Pinus halepensis, P. pinea, Cupressus sempervirens, Eucalyptus camaldulensis, E. globulus, E. gomphocephala*); holm oak; downy oak |
| Sicani CS | Mountain range | Castronovo di Sicilia | SCI ITA020011 "Rocche di Castronovo, Pizzo Lupo, Gorghi di S. Andrea"; Sicani Regional Park | 261.2 | Plantations (*Pinus halepensis, Cupressus sempervirens)* |

The study areas (Pantelleria; Calatino; Nebrodi; Madonie; Etna; Sicani PA, abbreviation of Palazzo Adriano; Sicani CS, abbreviation of Castronovo di Sicilia) fall within seven municipalities: six villages (Pantelleria, Tortorici, Isnello, Maletto, Palazzo Adriano and Castronovo di Sicilia) and one town (Caltagirone) (Table 1).

### *2.2. Data Processing and Analysis*

In order to examine the anthropogenic influences on our forest landscapes, the two main anthropogenic activities of the last few decades—demographic trends and forest harvesting—were analyzed. Afterwards, given that landscape change studies can be only carried out on a long-term basis [19,20], especially in the central Mediterranean basin [14], the diachronic analysis was performed in a Geographic Information System (GIS) by interpreting aerial photos collected over a 57-year period (1955–2012), specifically from: 1955, 1968, 1988 and 2012. The 1955 and 1968 surveys were carried out by the Italian Military Geographic Institute (IGMI) using black and white film; the 1988 survey was carried out by the Sicily Regional Territory Service with orthoimages; and the 2012 images were obtained from free satellite remote sensing imagery (Bing Maps, Microsoft Corp.). To integrate these different sources, all the aerial images were digitalized and georeferenced in the UTM WGS84 system. The image interpretation and the following processing were conducted in a GIS environment as follows:

- clipping of the study areas and allocation of land use using the Sicily Regional Forest Map [21];
- labeling the non-woodlands not included in the Sicily Regional Forest Map, following the CORINE Land Cover III lev. legend;
- classifying historical land use (LU) using aerial photo interpretation of the 1955, 1968 and 1988 images and updating it to the 2012 layer;
- quantifying land cover (LC) for 1955, 1968, 1988 and 2012;
- map overlaying for the diachronic analysis of LULC changes for the whole period (1955–2012) and the sub-periods (1955 to 1968, 1968 to 1988, 1988 to 2012).

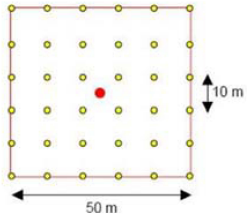
To classify land use, the Regional Forest Inventory 2010 legend [22] was adopted for 1988 and 2012 with the exception of the category "plantation," which was reclassified into two more categories ("exotic deciduous plantations" and "coniferous plantations") to permit comparison with anterior dates and to enlighten the importance of reforestation activities. Because of the low graphic resolution of the 1955 and 1968 images (flights IGMI GAI, panchromatic b/w, average flight height 5000 m, average image scale 1:33,000), only the CORINE Land Cover III lev. legend was suitable for use as a possible thematic relation with the Regional Forest Inventory 2010 legend, adapting even in this case the category "plantation" and implementing two categories ("deciduous plantations" and "Coniferous Plantations") (Table 2). The capacity to distinguish between plantations and forests is very significant because the plantations represent 36% of Sicilian forests [22] and their renaturalization is key for restoring Mediterranean forests.

To quantify the land cover (LC) (%), a special tool called the "Neighbor analysis plot" was used [23]. This tool was constructed from a 50 × 50-meter square frame with a 10-meter regular grid of superimposed points; by placing this mask on the images, the percentage of coverage was easily calculated by counting the number of points that fell on a tree or shrub canopy, and their absolute percentages were calculated by checking the value in a dedicated table (Table 3).

**Table 2.** Thematic relation between the Regional Forest Inventory 2010 legend and Corine Land Cover III-level legend.

| Regional Forest Inventory 2010, legend [22] | | Corine LC, III-level legend |
|---|---|---|
| Beech forest<br>Chestnut forest<br>Turkey oak forest<br>Downy oak forest<br>Cork oak forest<br>Holm oak forest<br>Orno-ostrietum forest<br>Riparian vegetation<br>Other deciduous forests<br>Pioneer vegetation | | Deciduous forests (311) |
| Corsican pine forest<br>Mediterranean pine forest | | Coniferous forests (312) |
| Supramediterranean shrubland<br>Mediterranean shrubland | | Shrubland (323) |
| Plantations | exotic deciduous plantations<br>coniferous plantations | Deciduous plantations<br>Coniferous plantations |
| Natural grasslands and pastures | | Natural grasslands and pastures (321) |

**Table 3.** Neighbor analysis plot design for the estimation of land cover (LC) (%) and related conversion table.




| LC (%) | Number Points |
|---|---|
| <5% | 1 |
| 5%–10% | 2–3 |
| 11%–20% | 4–7 |
| 21%–50% | 8–18 |
| 51%–80% | 19–28 |
| 81%–100% | 29–36 |

Landscape changes were analyzed and quantified through the diachronic analysis of the LULC changes: each study area was compared to the LULC maps by identifying the changes in the study areas over time by considering the whole period (1955–2012) and sub-periods (1955 to 1968, 1968 to 1988, 1988 to 2012).

With regard to the LU, thee *ad hoc* classes were identified to reclassify the changes: "unvaried," "evolution," and "degradation" (Table 4). The first one ("unvaried") was assigned to the areas where no change had occurred in the considered time span; "evolution" was assigned to the areas where successional dynamics resulted in a more complex structure or composition of the forest type; and the class "degradation" encompassed regressive dynamic cases with a clear simplification of structure and composition of the forest and shrubland landscapes. This classification did not include the plantations in which the former LU could not be positively identified.

**Table 4.** Land use (LU) change classification.

| Land Use Change | | Classes |
|---|---|---|
| **from** | **to** | |
| no change | | Unvaried |
| grassland | shrubland | Evolution |
| shrubland or grassland | deciduous or coniferous forest | |
| shrubland | grassland | Degradation |
| deciduous or coniferous forest | shrubland or grassland | |
| shrubland or grassland | exotic deciduous or coniferous plantations | |

The diachronic analysis was also extended to the land cover (LC) change (%) character, and four classes of change were identified (Table 5):

- "unvaried";
- "less significant," where the change in observed LC was less than or equal to 20%;
- "increase" or "decrease," where a progressive or regressive change, respectively, of over 20% was recorded for LC.

The 20% threshold is considered the minimum significant value that can detect regressive or progressive LC. This threshold was chosen on the basis of a general overview of this type of phenomenon observed in Sicilian forests and woodlands, together with the general knowledge of forest stand cover dynamics according to the mean Mediterranean climatic and ecological driving factors [14,24].

**Table 5.** Land cover (LC) change classification.

| Land Cover Change | Classes |
|---|---|
| no change | Unvaried |
| $\leqslant \pm 20\%$ | Less significant |
| $>+20\%$ | Increase |
| $>-20\%$ | Decrease |

Finally, the relationship between the land use/land cover change (LULC) and the desertification risk in Sicily was evaluated through the overlapping of the available Desertification Sensitivity Map of Sicily [25] and the maps of "unvaried" and "degradation" areas identified in this study. The latter areas are forest and semi-natural ecosystems that are characterized by stability, integrity and complexity, and should therefore be the categories with the lowest level of sensitivity to desertification.

## 3. Results

The number of residents of all municipalities clearly reflects the general demographic trend of the last few decades in Sicilian rural areas (Figure 2): the overall population has decreased since 1950 due to emigration to other countries and internal migration.

The analysis of forest statistics [26] has provided a complete picture of the phenomenon of forest harvesting in Sicily (Figure 3). In absolute terms, forest harvesting was reduced by half, which is related to the depopulation of the common Sicilian rural area, represented by the seven selected sample areas. Regarding the dynamics of the harvested products (cut timber and fuel wood), the trend of the two curves well reflects changes in the usages and practices of the population. In fact, until 1965, the predominant product was fuel wood, thereby indicating the high demand of wood for heating and domestic purposes; the opposite trend was observed from 1965 to the late 1970s, *i.e.*, the use of

fuel wood reached a minimum because it was replaced by gas and electricity. Since 1980, an increase in the production of fuel wood has been observed, due to the growing demand for wood fuels and innovative alternatives to traditional products (e.g., biomass, pellets).

The combined use of historical aerial images and current remote sensing images in a specific GIS environment was used to trace the land use and land cover changes from 1955 until the present, by examining seven significant forest and shrubland landscapes in Sicily. With reference to land use, the most important variations were observed in the Mount Etna, Calatino and Sicani areas, while in the remaining study areas, less significant changes were recorded (Figure 4). Specifically, the land use changes observed in the Etna area is driven by the successional dynamics of natural vegetation, whereas they are related to plantation activities in the Sicani and Calatino areas. This result clarifies the ongoing natural processes on Mount Etna, one on the most important natural sites in Sicily and the recipient of widespread human intervention for increasing the forest cover of the island. For the sake of synthesis, in this work, the most representative results for only the Etna and Sicani-CS study areas are presented (Figure 5; Supplement 1, Tables S1–S9). Across the study areas, land cover increases were observed in all forest types. Remarkable increases in land cover were observed in the Pantelleria Island pine forest on Mount Etna and in the Sicani and Madonie forests, with density increases greater than 50%. The only reduction in land cover, was a loss of 25% recorded in the Calatino area (Figure 6; Supplement 1, Table S9).

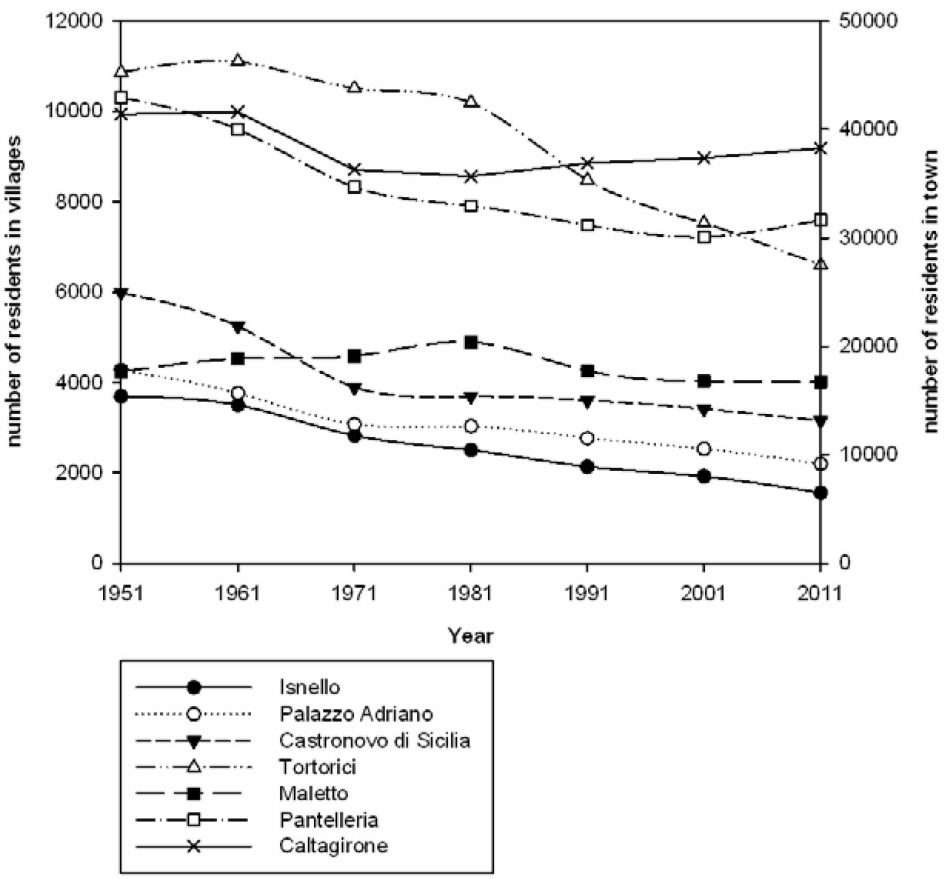



**Figure 2.** Number of residents of the municipalities over which the study areas extend (Source: processing of data from ISTAT) [26]. Data for the six villages are plotted on the primary y-axis; data for the town (Caltagirone) are plotted on the secondary y-axis.

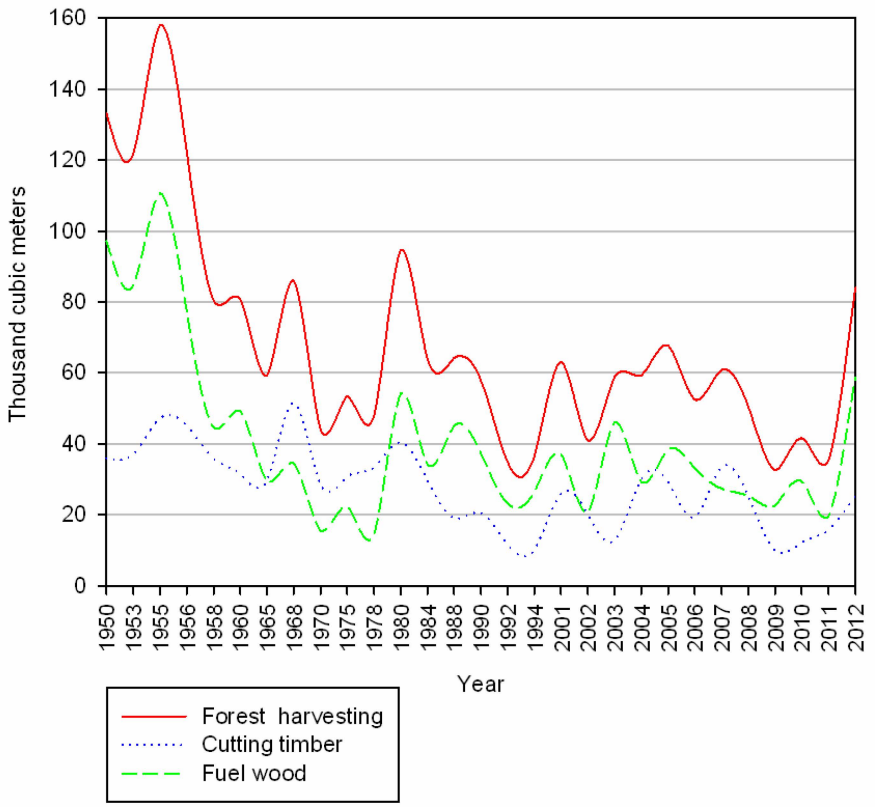



**Figure 3.** Dynamics of forest harvesting and products in Sicily (Source: processing of data from ISTAT) [26].

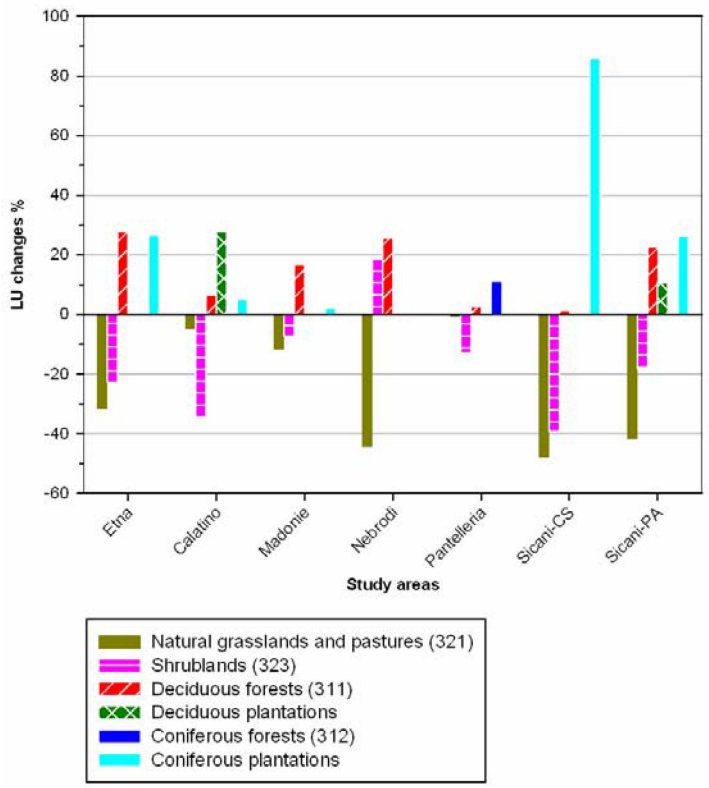



**Figure 4.** Dynamics of land use (LU) change (%) in the seven study areas for the period 1955–2012.

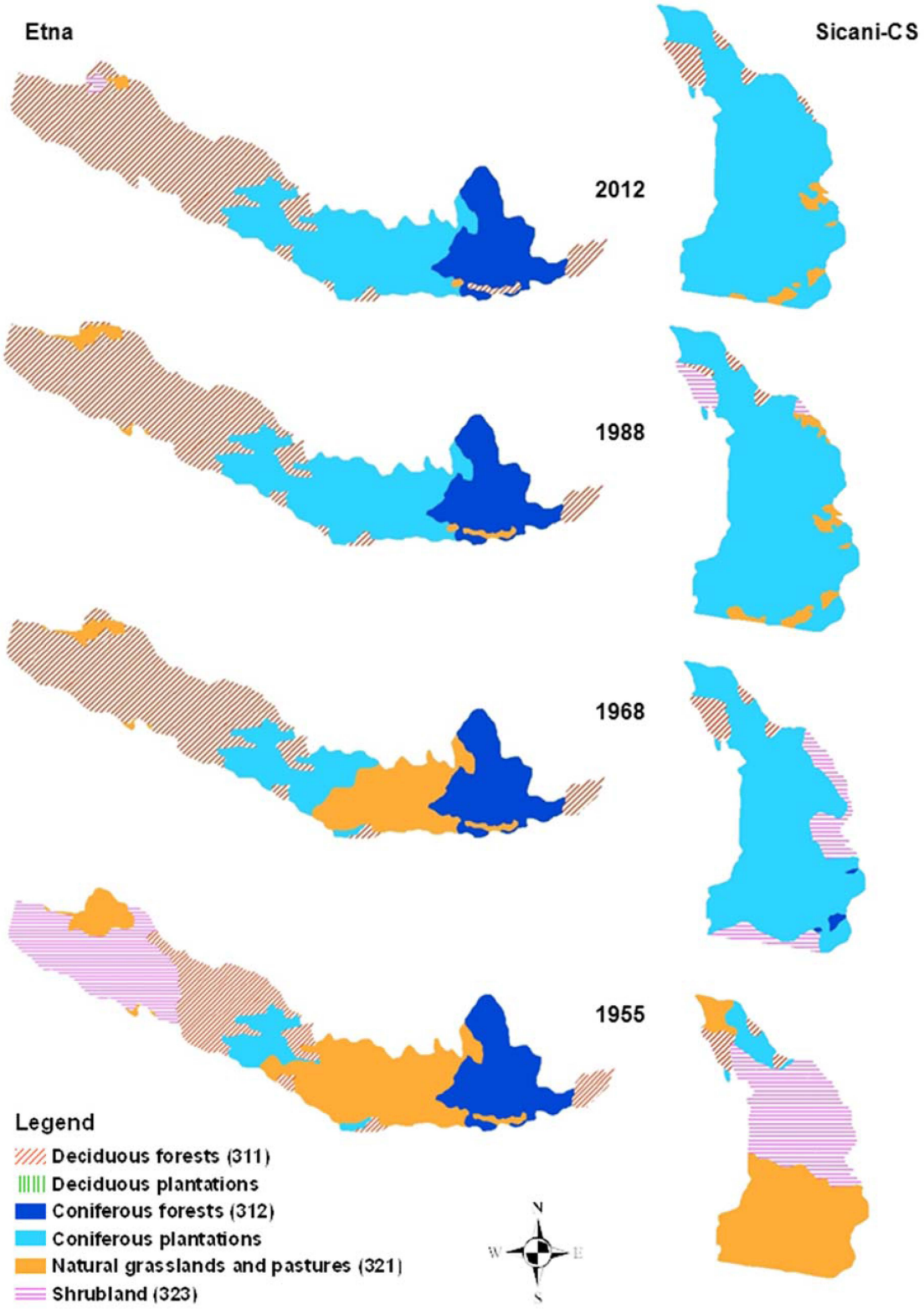



**Figure 5.** Land use classifications for 1955 and 2012 of the most significant areas: Etna and Sicani-CS.

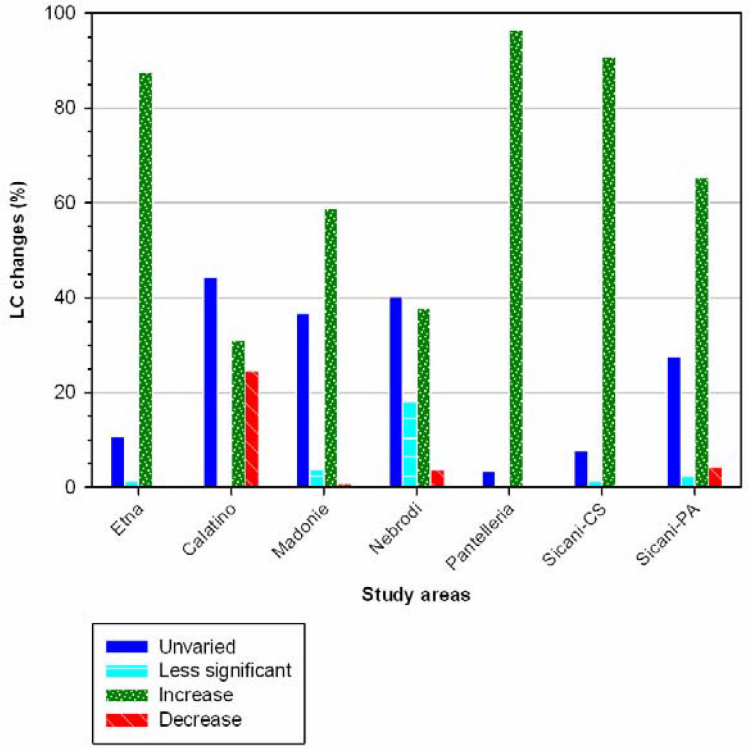



**Figure 6.** Dynamics of the land cover (LC) change classes (%) in the study areas from 1955 to 2012.

Specifically, on Mount Etna, the surface of grasslands and shrublands decreased, while broadleaved woodlands, holm oak, beech and deciduous oak forests increased, as did mountain conifer plantations. The area of Corsican pine (*Pinus nigra* spp. *laricio*) did not vary during the considered time span (Figure 4). With regard to the LC, there was a general increase for both plantation activities and shrubland expansion. It is remarkable that in 1955, the latter had less than 10% coverage and was therefore not classified as "other wooded land" (OWL) under the FRA 2010 standard [27].

In 1955, the Calatino landscape was mainly characterized by Mediterranean shrublands (65% coverage) and cork oak (*Quercus suber*) forest. Currently, the landscape pattern is clearly diversified given the widespread plantations and, to a lesser extent, the increase in the cork woodland area. Eucalyptus plantations were established on grassland (3.5%) and mainly on Mediterranean shrubland (34%). In this study area, the LC remained largely the same or increased slightly in some parts. In many nearby areas, however, a reduction in LC occurred due to wildfires (see the values in Figure 6). Regardless, this area is strongly characterized by heavy human influence as the introduction of uncontrolled grazing cattle, human-caused wildfires due to social tensions, and illegal removal of cork from the cork oaks.

On the Nebrodi mountains, from 1968 until now, the shrubland, turkey oak (*Quercus cerris*) and beech (*Fagus sylvatica*) woodland areas increased, occupying former grassland, and the LC increased across the entire study area (by an average of 38%).

The landscape of the Sicani-PA mountains original study area (Palazzo Adriano) was mainly characterized by holm oak (*Quercus ilex*) and deciduous oak (*Quercus pubescens*) woodlands (46% of the whole surface) and conifer plantations (*i.e.*, *Pinus halepensis*, *Pinus pinea*) (37%). Here, over the 1955–1968 time span, a deciduous oak woodland expansion on grazing land was observed, due to the general abandonment of Sicily's marginal areas by its inhabitant. However, over the 1968 to 2012 time span, widespread (65% increase in surface area) plantation activity deeply changed the layout of the local landscape. Furthermore, in the other Sicani-CS study area (Castronovo di Sicilia), similar widespread reforestation activities from 1955 to 1986 were conducted in former grazing, grassland and shrubland areas (85% increase in terms of surface), mainly through the planting of Mediterranean

conifers (*Pinus halepensis*, *Pinus pinea*, *Cupressus sempervirens*). This caused a consequent LC increase (Figure 6) in the area.

With regard to the "unvaried" areas and the woodlands where no variation of LULC was observed, and the few "degradation" areas where the LULC is degraded, their intersection with the Desertification Risk Sensitivity Map of Sicily showed that these woodlands are generally categorized as having no or low sensitivity to desertification, *i.e.*, they fall within the first risk classes (unaffected, potential, fragile 1), which confirms the efficiency and resilience of forest and semi-natural ecosystems (Figure 7).

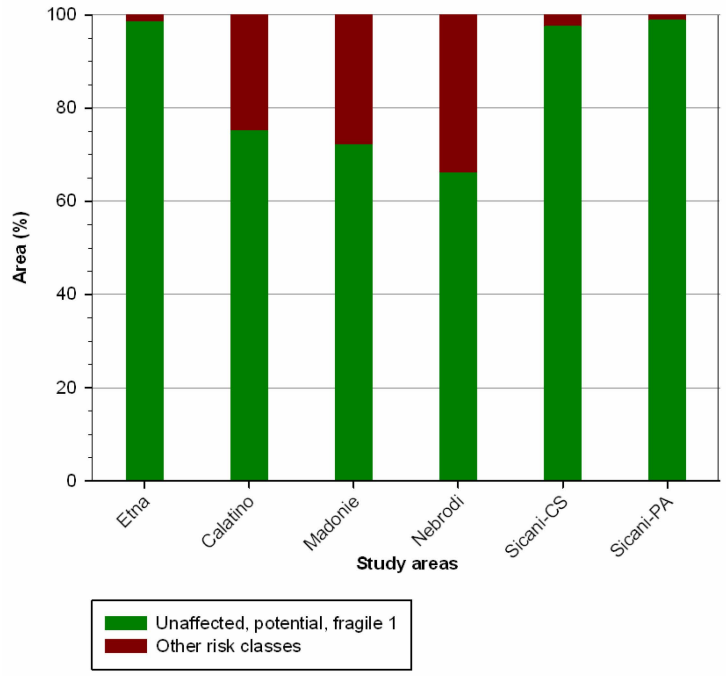



**Figure 7.** Distribution of "unvaried" and "degradation" areas for classes of desertification risk. Data not available for Pantelleria because the Desertification Risk Sensitivity Map of Sicily does not include the smaller islands.

## 4. Discussion

The study results mainly highlight two different trends observed in the studied areas: first, the strengthening and expansion of forests in many of the study areas (Etna, Sicani, Madonie and Pantelleria), and second, a clear reduction or degradation in the woodland area (example given, Calatino). With regard to the first change type, increasing cover and complexity processes were observed in the forest and shrubland stands situated in the Mount Etna, Sicani and Madonie areas, as well as on Pantelleria Island, where significant increases in the structural complexity, composition and canopy coverage have been proved. Such events can be interpreted as a result of historical socioeconomic problems of the Italian south and inner mountain territories. After World War II, widespread emigration, the use of new energy sources (gas, electricity) and the consequent reduction in cutting activities in the forest areas fostered the natural evolutionary dynamics of forest and shrubland, thus causing a decline in pasture and grassland. These latter open habitats are extremely important for the preservation of rare plants and the feeding habitats of many birds, and the maintenance of biodiversity and landscape diversity. Moreover, the growing awareness of the importance of forests as ecological assets of a territory and the establishment of protected areas that generally encompass the most important forest territories of the island entailed a further reduction in wood logging. In addition, about one fourth of the forest area of the region is owned by the regional authority and managed in order to foster renaturalization of conifer stands and natural forest complexity. Furthermore, in the

Sicani areas, widespread reforestation, which was conducted on abandoned pastureland, increased the local wood asset. In the Mount Etna area, a large part of the forest area has been designated a regional natural park, resulting in a substantial increase of forest density due to the reduction or suspension of logging activities and the increase of shrublands and woodlands due to the abandonment of agricultural activities over large areas.

In the Calatino territory, however, intense human activities, such as the expansion of pasture and agriculture, as well as the abandonment of cork production and logging, caused a general reduction in the extent of the cork oak woodlands. Furthermore, the dry and hot climate combined with social tension resulted in an increase in wildfire events with a consequent loss of complexity and diversity, in addition to the decrease in the forest surface area.

In conclusion, this work highlights the consolidated trend of successional processes across almost all of the Sicilian forest case studies considered. The majority of the forest and other woodlands in the study areas are increasing in structural complexity as a result of complex socioeconomic and ecological factors that foster these evolutionary trends.

**Acknowledgments:** This study was supported by grants of the Project LIFE11+ ENV IT 000215 Resilformed—Climate change resilience of Mediterranean forests (http://www.resilformed.eu). All authors contributed to analyzing and discussing the results and wrote the manuscript.

**Author Contributions:** All authors contributed to analyze the results and to write the paper.

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

1. Barbera, G.; Cullotta, S.; Rossi-Doria, I.; Ruhl, J.; Rossi-Doria, B. *I paesaggi a Terrazze in Sicilia. Metodologia per l'analisi, la Tutela e la Valorizzazione*; Collana Studi e Ricerche dell'ARPA Sicilia: Palermo, Italy, 2010; p. 214.
2. Grove, A.T.; Rackham, O. *The Nature of Mediterranean Europe: An Ecological History*; Yale University Press: New Haven, CT, USA, 2001; p. 384. Available online: http://doi.org/10.1002/ldr.475 (accessed on 10 March 2015).
3. Feddema, J.J.; Oleson, K.W.; Bonan, G.B.; Mearns, L.O.; Buja, L.E.; Meehl, G.A.; Washington, W.M. The importance of land-cover change in simulating future climates. *Science* **2005**, *310*, 1674–1678. [CrossRef] [PubMed]
4. Foley, J.A.; DeFries, R.; Asner, G.P.; Barford, C.; Bonan, G.; Carpenter, S.R.; Chapin, F.S.; Coe, M.T.; Daily, G.C.; Gibbs, H.K.; *et al*. Global consequences of land use. *Science* **2005**, *309*, 570–574. [CrossRef] [PubMed]
5. Kueppers, L.M.; Snyder, M.A. Influence of irrigated agriculture on diurnal surface energy and water fluxes, surface climate, and atmospheric circulation in California. *Clim. Dyn.* **2012**, *38*, 1017–1029. [CrossRef]
6. IPCC. *Mitigation of Climate Change: Contribution of Working Group III to the Fourth Assessment Report of the Inter-governmental Panel on Climate Change*; Metz, B., Davidson, O.R., Bosch, P.R., Dave, R., Meyer, L.A., Eds.; Cambridge University Press: Cambridge, UK, New York, NY, USA, 2007; p. 863.
7. Wang, M.; Yan, X.; Liu, J.; Zhang, X. The contribution of urbanization to recent extreme heat events and a potential mitigation strategy in the Beijing-Tianjin-Hebei metropolitan area. *Theor. Appl. Climatol.* **2013**, *114*, 407–416. [CrossRef]
8. Woldemichael, A.T.; Hossain, F.; Pielke, R.; Beltrán-Przekurat, A. Understanding the impact of dam-triggered land use/land cover change on the modification of extreme precipitation. *Water Resour. Res.* **2012**, *48*, 1–16. [CrossRef]
9. Avetisyan, M.; Baldos, U.; Hertel, T. Development of the GTAP version 7 land use data base. *GTAP Res. Memo.* **2011**, *19*, 1–17.
10. Hertel, T.W.; Rose, S.K.; Tol, R.S.J. *Economic Analysis of Land Use in Global Climate Change Policy*; Routledge Explorations in Environmental Economics, Taylor & Francis Group: New York, NY, USA, 2009; p. 343. Available online: http://www.routledge.com/books/details/9780415773089/ (accessed on 06 April 2015).
11. Barbera, G.; Cullotta, S. The Halaesa landscape (III B.C.) as ancient example of the complex and bio-diverse traditional Mediterranean polycultural landscape. *Landsc. Hist.* **2014**, *35*, 53–66. [CrossRef]
12. Braudel, F. *Civiltà e imperi del Mediterraneo nell'età di Filippo II*; Einaudi: Torino, Italy, 1986; Volume 1.

13. Barbera, G.; Cullotta, S. An inventory approach to the assessment of main traditional landscapes in Sicily (Central Mediterranean Basin). *Landsc. Res.* **2012**, *37*, 539–569. [CrossRef]
14. Mazzoleni, S.; di Pasquale, G.; Mulligan, M.; di Martino, P.; Rego, F. *Recent Dinamics of the Mediterranean Vegetation and Landscape*; John Wiley & Sons Ltd.: West Sussex, UK, 2004; p. 320.
15. Ruhl, J.; Chiavetta, U.; La Mantia, T.; La Mela Veca, D.S.; Pasta, S. Land cover change in the Nature Reserve "Sughereta di Niscemi" (SE Sicily) in the 20th century. In *Remote Sensing & GIS for Environmental Studies*; Erasmi, S., Cyffka, B., Kappas, M., Eds.; Gottinger Geographische Abhandlungen: Gottingen, Germany, 2005; Volume 113, pp. 54–62.
16. Kirtman, B., Power, S.B., Adedoyin, J.A., Boer, G.J., Bojariu, R., Camilloni, I., Doblas-Reyes, F.J., Fiore, A.M., Kimoto, M., Meehl, G.A., *et al*, Eds.; Near-term climate change: Projections and predictability. In *Climate Change 2013: The Physical Science Basis; Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*; Cambridge University Press: Cambridge, UK; New York, NY, USA, 2013; pp. 953–1028. Available online: http://doi.org/10.1017/CBO9781107415324.023 (accessed on 16 September 2014).
17. Costantini, E.A.C.; Urbano, F.; Bonati, G.; Nino, P.; Fais, A. *Atlante Nazionale Delle aree a Rischio di Desertificazione*; INEA: Roma, Italy, 2007; p. 108.
18. Camerano, P.; Cullotta, S.; Varese, P. *Strumenti Conoscitivi per la Gestione delle Risorse Forestali Della Sicilia. Tipi Forestali*; Regione Siciliana: Palermo, Italy, 2011; p. 192.
19. Foster, D.R.; Motzkin, G.; Slater, B. Land-use history as long-term disturbance: Regional forest dynamics in Central New England. *Ecosystems* **1998**, *1*, 96–119. [CrossRef]
20. Vos, W.; Stortelde, A.H.F. *Vanishing Tuscan Landscapes: Landscape Ecology of A Sub-Mediterranean-Montane Area (Solano Basin, Tuscany, Italy)*, 2nd ed.; Pudoc Scientific Publishers: Wageningen, The Netherlands, 1992.
21. Regione Siciliana. *Carta Delle Categorie Forestali Della Regione Sicilia*; Assessorato Territorio e Ambiente, Comando del Corpo Forestale Della Regione Sicilia: Palermo, Italy, 2011; Available online: http://sif.regione.sicilia.it (accessed on 23 September 2013).
22. Hofmann, A.; Cibella, R.; Bertani, R.; Miozzo, M.; Fantoni, I.; Luppi, S. *Strumenti Conoscitivi per la Gestione Delle Risorse Forestali Della Sicilia. Sistema Informativo Forestale Regionale*; Assessorato Territorio e Ambiente, Regione Siciliana: Palermo, Italy, 2011; p. 208.
23. AA VV. *Sistema Informativo Forestale Della Regione Siciliana*; Istruzioni per il Rilievo Degli Attributi di Seconda Fase: Palermo, Italy, 2008; p. 261.
24. Quézel, P.; Médail, F. *Ecologie et Biogéographie des Forêts du Bassin Méditerranéen*; Elsevier, Collection Environnement: Paris, France, 2003; p. 573.
25. Regione Siciliana. *Carta Della Sensibilità Alla Desertificazione Della Regione Sicilia*; Assessorato Territorio e Ambiente: Palermo, Italy, 2011; Available online: http://www.artasicilia.eu/old_site/web/desertificazione (accessed on 23 September 2013).
26. ISTAT. Istituto Nazionale di Statistica, Roma. Available online: http://istat.it (accessed on 09 March 2015).
27. FAO. *Global Forest Resources Assessment. Terms and Definitions*; Forest Resources Assessment Programme, Working Paper 144/E; FAO: Rome, Italy, 2010; p. 27.