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How Ecosystem Services Can Strengthen the Regeneration Policies for Monumental Olive Groves Destroyed by *Xylella fastidiosa* Bacterium in a Peri-Urban Area

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Abstract: The Apulian Region (Italy) is a socio-ecological system shaped by the millennial co-evolution between human actions and ecological processes. It is characterized by monumental olive groves protected from Regional Law 14/2007 for the cultural value of the landscape, currently threatened by the spread of a devastating phytopathogen, the bacteria *Xylella fastidiosa*. The aim of this paper is to apply landscape resilience analysis focusing on ecosystem services to understand the potential effects and trade-offs of regeneration policies in a peri-urban area characterized by monumental olive groves land cover. The study involved land-cover and land-use analysis, supported by a survey on the inhabitants and an ecosystem services analysis. The results showed a mismatch between the agroecosystem and the social and economic use linked to leisure or hospitality. The study area was defined as a peri-urban landscape characterized by tourist use. From the interviews of the users, the cultural heritage of olive groves seems linked to the presence of olive trees like a *status quo* of the landscape and olive oil productions. The culture aspect could thus be preserved by changing the type of olive trees. In addition, the analysis showed that the microclimate could be preserved and enhanced in terms of air temperature and thermal comfort, by replacing the olive trees with varieties resistant to *Xylella*, such as cv. Leccino. Therefore, regeneration policies that promote replacing dead olive groves with new olive trees could be efficient to stimulate social components of the landscape and improve the resilience of ecosystem services in peri-urban areas in the interest of the cultural heritage of the users and benefits that they provide. An ecosystem services analysis at a local scale could be a strategy for an integrated regenerate approach between land-use and land-cover with social, ecological, and economic evolutions vision orientated to a sustainable and desirable future.

Keywords: landscape; socio-ecological system; resilience; ecosystem services; microclimate; cultural value

1. Introduction

Many European landscapes express the millennial interactions between natural processes and anthropic activities that transform ecosystems in order to adapt them to human needs [1–3]. The landscape is thus a Social–Ecological System (SES) resulting from the co-evolution of human societies with their environment through change, instability, and mutual adaptation [4–6]. Land use and land cover are the result of the mutual interactions between socio-economic and ecological processes [7–9]. The people's perception of the result of interaction between nature and human needs is at the basis of the concept of the cultural landscape [10–12].

This is the case of the monumental olive groves in Apulia (Italy) regulated by the Regional Law 14/2007 for the cultural value of the landscape (B.U.R. Puglia—N. 83, 7 June 2007) [13]. Currently, cultivated and monumental olive trees are threatened and destroyed by the spread of a devastating phytopathogen, the bacteria *Xylella fastidiosa*. At the moment, no practical solutions are available to save infected plants of the most common varieties, which are particularly sensitive and undergo rapid death [14,15]. The problem of olive grove destruction is not limited to agricultural production but concerns areas that extend for tens of thousands of hectares, penetrating urban contexts [16]. Therefore, it is a complex reality, creating a critical problem for the landscape and non-agricultural production interest, affecting thousands of people who live in close contact with the dying trees. For some citizens, however, it is not just an economic-productive issue but also a cultural one, linked to the people's psycho-physical well-being [2,16,17].

Resilience should be considered in a specific context, and, as discussed by Carpenter et al. [18], it is necessary to define "the resilience of what concerning what" that is, the resilience of "which system concerning which disturbance". The social and institutional ability to manage resilience represents the "adaptability of a landscape", which depends on the social power to avoid an undesired change in land cover and land use to maintain the capacity of the landscape to support ecosystem services for human well-being [3,19–22].

The Italian National and Regional administration has been working to find new regeneration strategies to recover the agricultural land cover affected by the dying and subsequent uprooting of olive trees, many of which are deemed to be monumental (centennial plants) [2]. The current defense strategy includes the replanting of *X. fastidiosa*-resistant olive tree cultivars [23,24] as well as non-host plants (Regione Puglia, 2021).

Though agroforest ecosystems are critical in terms of the ecosystem goods, services, and benefits they provide in peri-urban areas [16,25–28], to date, a lack of attention has been paid to the agroforest–urban interface and complex linkages between landscape resilience and forest biomass [25,29]. Several studies have shown that vegetation has beneficial effects on the microclimate and thermal comfort. Green areas play a beneficial role in the microclimate by reducing the air temperature thanks to shading and evapotranspiration [16,28,30,31]. Moreover, the regeneration processes of olive groves in the peri-urban area is important considering the resident perceptions of the bio-cultural heritage threatened by the *X. fastidiosa* spread [32–34].

The policy of olive grove regeneration has not considered the potential effect of ecosystem services in the peri-urban area that can drive the landscape change in specific scenarios of applications to preserve the cultural value of the landscape. The inclusion of ecosystem services could represent the base approach for promoting landscape evolution to guaranty the well-being of humans with a societal, ecological, and economic transformation orientated to a sustainable and desirable future [35–38]. To better support the regeneration processes of the landscape, more evidence-based assessments with trade-off analyses and policy validations have to be developed with the help of ecosystem services modeling, improving locally detailed information [39–41].

Thus, this research aims to provide a socio-ecological approach to evaluate and design policy instruments and adaptive strategies for the regeneration and management of the social-ecological landscape affected by *X. fastidiosa*. in the peri-urban area. This study focuses on the relations between agroecosystems and society [42–44].

We thus developed the approach to landscape resilience analysis that focuses on managing and providing ecosystem services over time. We analyzed ecosystem services' resilience of the Social–Ecological Landscape to *X. fastidiosa* considering the land-cover and land-use change that characterized the peri-urban landscape and evaluated potential landscape scenarios as adaptative strategies that can be derived by a regeneration policy.

2. Materials and Methods

2.1. Study Area

The study area is located in the rural landscape of Carovigno (UTM coordinates: 40° 43′46″ N, 17°41′01″ E), province of Brindisi (Apulia region, Southern Italy). The climate is mild, with the medium temperature of the coldest month being 9.6 °C, while in the summer, the average temperature value is around 25 °C, with peaks approaching 40 °C (http://stazionemetobrindisi.altervista.org/wxtrends.php, accessed on 7 May 2021). The area is included in the Regional Landscape Plan "Rural Landscape" representative of the Apulia region (Figure 1), characterized by olive groves' monoculture with monumental trees. Among all the provinces of Puglia, Brindisi is the area where olive tree presence is more intensely spread (https://www.istat.it/it/archivio/32618, accessed on 15 June 2021) [45]. The site is located within the area classified by the EU as infected with *X. fastidiosa* subsp. *pauca*. This rural landscape is threatened by the bacterium sprawl that caused the olive trees' death and that already destroyed many monumental plants. However, this territory is characterized by a sprawl of urban settlements, a condition typical of many areas currently infected or threatened by the presence of the bacterium. Therefore, our study focused on a portion of the territory in which scattered houses in an agricultural context (Figure 1) represent the current predisposition to use of the land, no longer strictly linked to agricultural production but rather to recreational and tourist activities.

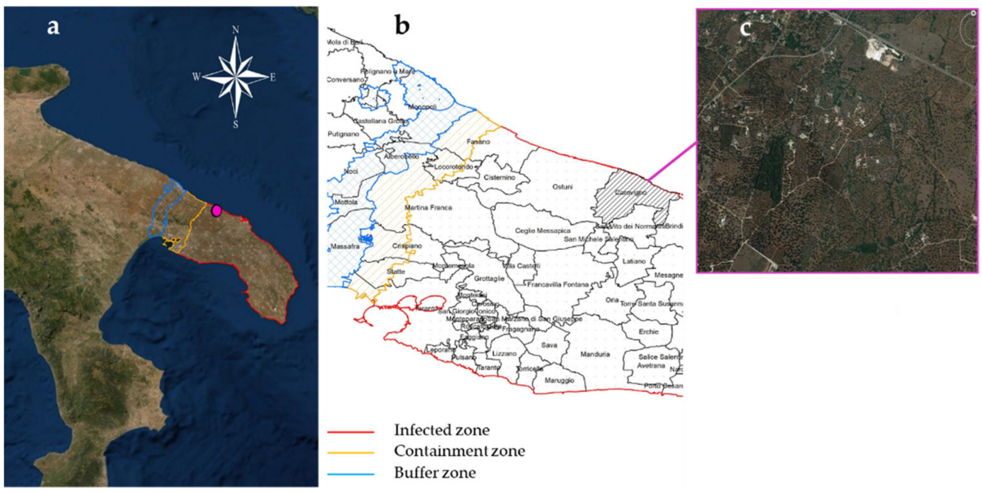

Figure 1. The study area is located in the municipality of Carovigno, the province of Brindisi (Apulia region in southern Italy (**a**,**b**); the study area (**c**).

2.2. Methodology

The land-cover and land-use resilience of the landscape are evaluated by considering potential vegetation that can replace the current olive trees to regenerate the rural landscape. Three steps have been followed: (i) Land cover and land-use characterization, (ii) cultural value and disease severity assessment of the olive groves, and (iii) analysis of the ecosystem services resilience, considering different scenarios (Figure 2).

2.2.1. Land-Cover and Land-Use Characterization

In this study, the land-cover refers to the biophysical attributes of the landscape that affect ecosystem functions [8,46], which can influence the capacity of the landscape to produce ecosystem services [35]. Whereas land-use refers to how and why humans use the land [46] and is therefore linked to social and economic interest that can benefit from direct use and impact the ecosystem services [47,48].

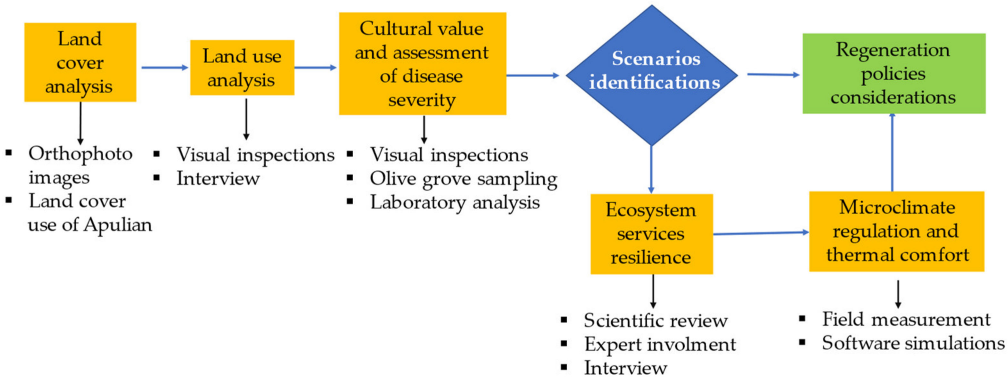

Figure 2. Workflow applied in the study.

The land-cover pattern changes of the study area were evaluated in terms of composition (type and extension of the patches of land-cover type) and configuration (spatial arrangement of the land-cover patches) in 2010–2018. The land-cover map for the year 2010 and the orthophoto images available on the webGIS of the Apulia region for the years 2010 and 2016, as well as Ving Maps and Google Earth for the year 2018 were employed. Visual field inspections were carried out in 2020 to verify the recent land cover.

Land use was analyzed considering the type of owner characteristics and typologies of settlements characterizing the area, identifying the stakeholders and the priority benefits these areas provide. For this purpose, the information retrieved by the National Land and Houses Registry was employed to analyze the owners' provenance and the possible change of ownership in recent years (www.agenziaentrate.gov.it, accessed on 15 June 2021) [49].

Moreover, during the visual inspections, an interview was performed with owners in the study area to record their opinions about potential landscape regeneration actions and their land-use perspective. The questionnaire was aimed at understanding: (i) The use of the housing and the olive groves, (ii) if the owner produces oil (directly or indirectly), (iii) if the presence of monumental olive groves was significant in the choice of housing and (iv) the human benefit that they obtain from the current land use and the possible interventions that they would consider in the face of a total compromise of their olive groves due to *X. fastidiosa*.

2.2.2. Cultural Value and Assessment of Disease Severity

The cultural value of monumental olive groves was analyzed through objective measures concerning the trunk diameter and visual analysis of the shape of the trunk following indications provided by the Regional Law 14/2007 (B.U.R. PUGLIA—N. 83, 7 June 2007) [13].

Specifically, the estimation of disease severity and the analysis of symptoms associated with *X. fastidiosa* infection e.g., leaf scorching and wilting of the canopy, was carried out by visual inspections [50,51]. Furthermore, samples of olive leaves were collected (Figure 3 shows sampling points) and analyzed to confirm the pathogen presence. Approximately 1g of leaf petioles (a pooled sample from 60 leaves collected from six branches) was transferred to an extraction bag (BIOREBA, Reinach, Switzerland) and treated as previously described by Luvisi et al. (2017) [51]. DNA extraction was carried out by the protocol of Edwards et al. (1991) [52] and used as a template for *X. fastidiosa* detection by the TaqMan real-time PCR protocol with XF-F/R primers and an XF-P probe [53]. Reactions were performed in the thermal cycler QuantStudio™ 3 System (Applied Biosystems, Foster City, CA, USA).

Figure 3. Distribution of trees subjected to disease severity assessment and sampling (represented as green dots) within the study area (base image taken from Google Earth).

2.2.3. Ecosystem Services Resilience

The resilience of ecosystem services has been analyzed assuming the loss of monumental olive trees and their replacement with different vegetation types, also assessing microclimate ecosystem services. Initially, an overview of the resilience of ecosystem services was carried out considering different scenarios compatible with the current land-use and also considering the information obtained from the interview activity (Figure 4) and through bibliography analyses [15,35,54].

The different scenarios were also submitted to an external panel's opinion made up of botanists, agronomists, and faunists. After that, the recovery capacity of the microclimate ecosystem services was assessed by applying potential new land covers based on the regional policy or owners' desiderata (Figure 4).

We consider the potential scenario of intensive olive groves land cover (plants located using a mesh-square of 6 m × 6 m) using cv Leccino to analyze microclimate resilience and thermal comfort.

2.2.4. Microclimate Regulation and Thermal Comfort

To assess the local microclimate and thermal comfort in terms of air temperature and predicted mean vote, PMV [16,55] effects generated by olive groves land-cover change, we performed simulations considering three different scenarios: (i) The "current scenario" with trees in good-health status, (ii) the "no trees scenario" without olive trees, which represents a transition to uncultivated soil caused by the presence of *X. fastidiosa,* which led to the death of the tree, and (iii) potential "new land-cover" with olive groves of cv. Leccino. The built constructions' height was estimated by comparison with known objects.

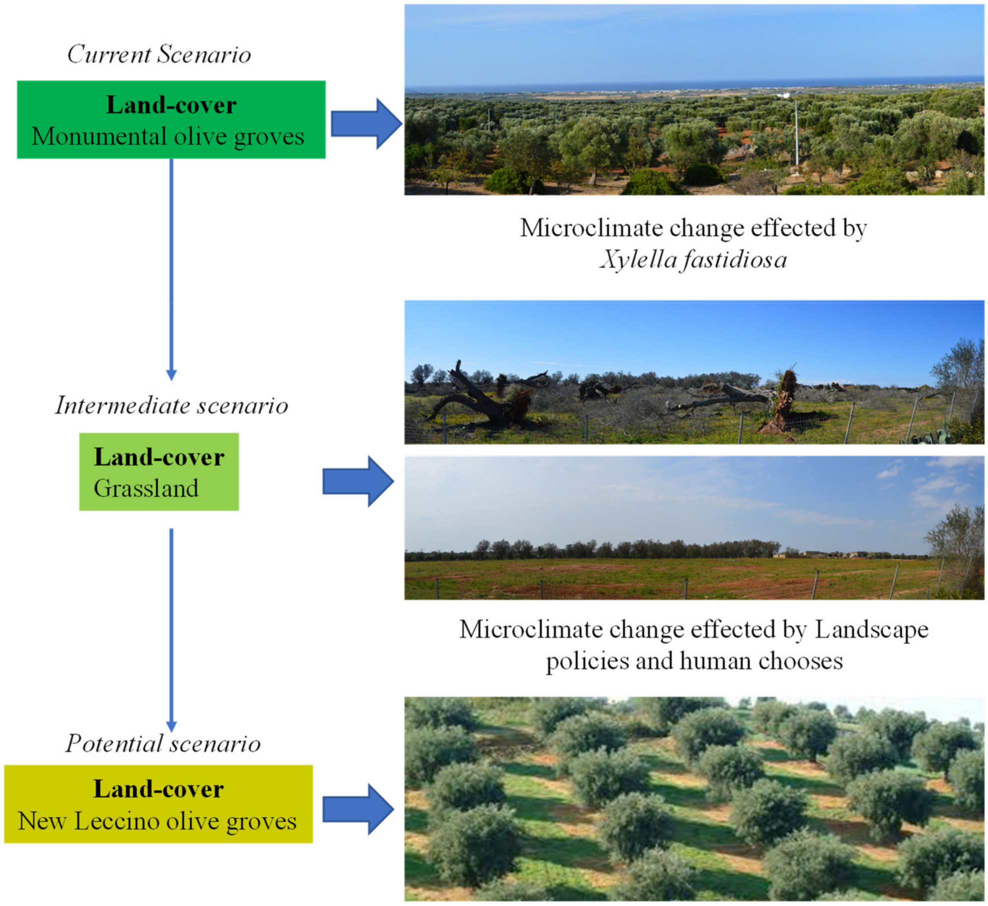

Figure 4. Scenarios considered for the analysis of the ecosystem services resilience.

Specifically, PMV considers both meteorological parameters and personal factors, such as heat resistance of clothing and human activity. Outdoor PMV ranges from −4 (very cold) to 4 (very hot), with 0 indicating the neutral condition. Vegetation measurements in the area were initially carried out to obtain information regarding the characteristics of the species. The "Leaf Area Index" (LAI) of the olive trees was estimated with the AccuPar LP80 ceptometer by measuring the "Photosynthetically Active Radiation" (PAR). By dividing the LAI by the width of the trees' crown, the Leaf area density (LAD) was calculated, which allowed for reconstructing the trees with the ENVI-met "Albero" tool. The value of the LAD is equal at 0.30 (m2/m3) for the 155 trees counted throughout the study area (belonging to cultivars susceptible to *X. fastidiosa* infection), whereas 0.60 (m2/m3) was esteemed for the resistant cv. Leccino that was considered as a substitute for currently infected plants.

The microclimate model ENVI-met was employed to simulate complex surface–vegetation–air interactions in the urban environment (www.envi-met.com, accessed on 7 May 2021). It is a holistic, prognostic, three-dimensional, grid-based microclimate model. The study area has a dimension of 700 m × 700 m, which was discretized with 350 (x-direction) × 350 (y-direction) × 30 cells (z-direction) with a spatial resolution of dx = dy = dz = 2 m, except for the lowest (close to the ground) five cells whose vertical resolution was 0.4 m (i.e., the equidistant option was employed in ENVI-met). Along the perimeter of the area, seven nesting grids were used, i.e., empty cells, which have the function of minimizing errors during the simulation and therefore allow to get more reliable output data. The set-up is similar to that employed in Semeraro et al. [16]. The day selected to start the simulations was 7 July 2019, a typical scorching summer day. The relative humidity and air temperature (Tair) data were obtained from the ARPA-Puglia meteorological station located about 40 km from the study area (http://www.arpa.puglia.

it/web/guest/serviziometeo accessed on 17 June 2021) [55]. For each scenario, 14 h were simulated, from 07:00 to 21:00. The time interval analyzed is the one that, due to the high diurnal air temperature, shows the most critical thermal comfort issues, and for this reason, it has been considered the most interesting for the study. Two receptor points (Point 1 and Point 2) were identified, one along the path and the other near a building (Figure 5). Temporal data in the receptor points and spatial maps (shown in Section 3.2.1.) were extracted at the pedestrian height of 1.4 m.

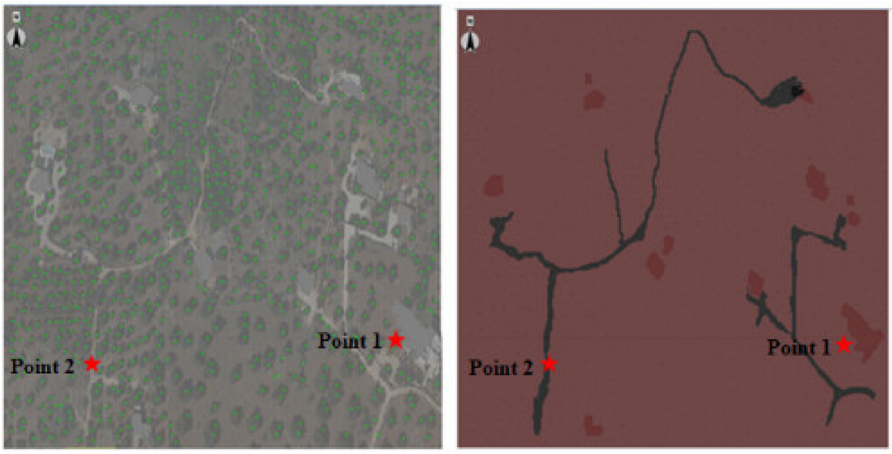

Figure 5. Current (**left**) and future (**right**) scenarios, with an indication (red) of the points where data were extracted for the evaluation of air temperature and PMV. Point 1 (**right**) is the one close to a building and Point 2 (**left**) is the one located along the path.

3. Results

The study area's land-cover pattern is characterized by an agricultural matrix where sprawl-built constructions and roads create fragmentations in the agricultural pattern, as shown in the maps for 2010 and 2018 (Figure 6). This time window was chosen because the orthophotos available before 2010 (e.g., 1989) show the same landscape pattern as 2010. The figure shows an increase in built constructions (17 in total) in 2018. Five other buildings are under construction.

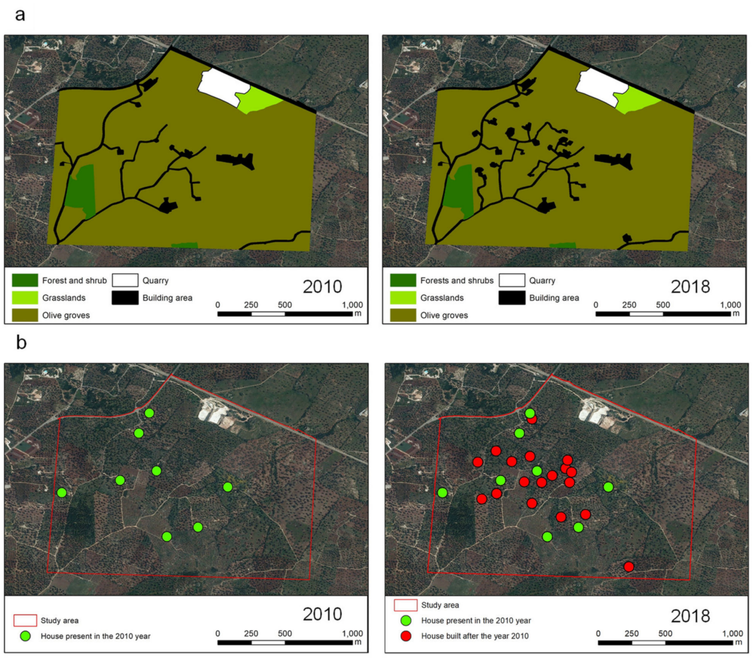

Figure 6. Maps of the study area showing the land-cover in 2010 and 2018 with an indication of olive groves and built constructions (**a**); position of the built constructions present before and after 2010 (**b**).

Table 1 shows that the primary use of the area is for agricultural purposes, mainly olive production for oil. The land cover is, in fact, mainly characterized by the presence of olive groves in both 2010 (89% of the total surface area) and 2018 (88% of the total surface area), with a reduction of just 2 ha. The area occupied by built constructions (buildings and roads) increased by about 2 ha, from 8 ha in 2010 (4% of the total surface area) to 10 ha in 2018 (5% of the total surface area).

Table 1. Land-cover classes that characterized the study area in 2010 and 2018.

	2010		**2018**		**Changes from 2010 to 2018**	
	ha	**%**	**ha**	**%**	**ha**	**%**
Forest and shrub	5	3	5	3	0	0
Grasslands	3	2	3	2	0	0
Olive groves	162	89	160	88	−2	−1.2
Quarry	5	3	5	3	0	0
Built constructions	8	4	10	5	2	25
Total	182	100	182	100		

The buildings present in this area are mainly prestigious villas characterized by good finishing and equipped with a swimming pool (Figure 7). The buildings under construction are also villas. Analyzing the National Land and Houses Registry, it is possible to highlight some aspects related to land use. In fact, the owners of buildings located in the area are not residents, but they are mainly from other Italian regions or other European countries.

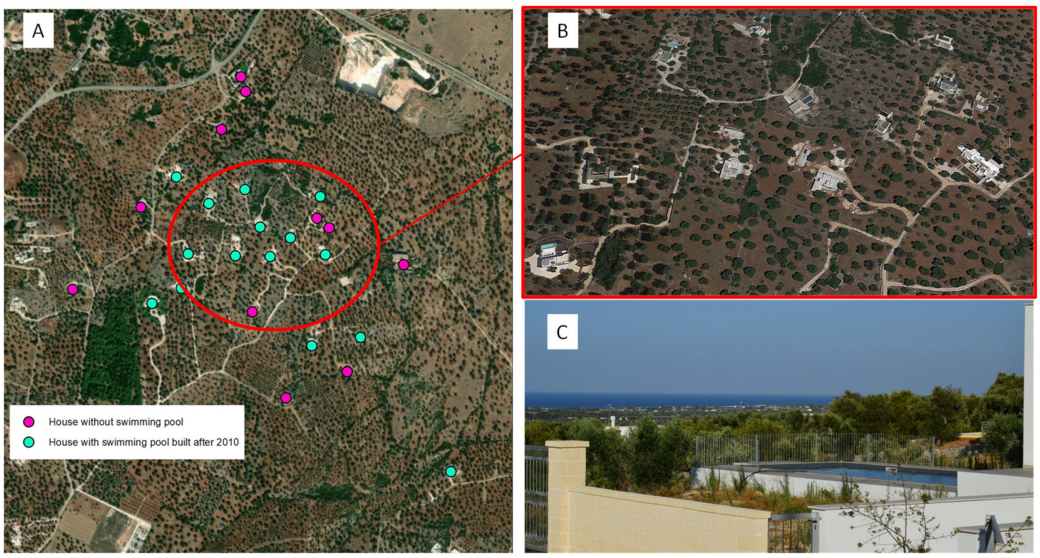

Figure 7. Houses with a swimming pool built in recent years within the study area considering (**A**,**B**); Example of a house with swimming pool (**C**).

Furthermore, the questionnaires showed that the owners live in the houses only for short periods, mainly during holidays or weekends, or rent the villas during the summer months to holidaymakers.

To date, the area seems more predisposed to welcoming tourists and for carrying out recreational activities rather than for carrying out productive activities related to the agricultural sector. Answers to questionnaires confirm the continuous use of homes in the summer (20% of owners) while being limited to weekends in the rest of the year. Consistent with these habits, the recreational attitude of maintaining the olive groves is also confirmed, as no owners are professional farmers and do not directly produce oil and, in some cases, the olives are given to third parties for processing. It should be noted that tourists rented

11% of the houses for the summer holidays and that 23% of the houses were still under construction, so it was not possible to proceed with the administration of the questionnaire.

3.1. Cultural Value and Disease Severity Analysis

The area analyzed is characterized by monumental olive groves, representing an important cultural landscape. From the visual inspections, over 50% of the olive groves have monumental trees inside them and are therefore classifiable as 'monumental olive groves'. Such trees present trunk sizes larger than 80 cm in diameter and a typical sculptural shape defined by the Regional Law 14/2007 (Figure 8) [13]. All the sampled trees did not show symptoms associated with *X. fastidiosa* infection, and the laboratory PCR-based analyses performed on randomly collected samples gave negative results. Therefore, even if the study area falls within the area classified by the EU as infected, the olive groves currently have a good health state concerning *X. fastidiosa* threat.

Figure 8. Example of monumental olive trees present in the study area.

3.2. Analysis of the Ecosystem Services Resilience

The loss of ecosystem services generated by the desiccation or death of monumental olives can be restored, as summarized in Table 2. For instance, gas regulation ecosystem services can be supplied regardless of the tree cultivar because these are mainly influenced by the plant's biophysical structure more than the genotype itself. Therefore, using plants that can produce a biophysical structure similar to monumental olive trees can restore these ecosystem services. With regards to habitat functions, a different structure can also support biodiversity but can change the type of biodiversity, e.g., other fruits produced by trees can influence the presence of specific species, and the endemic pathogens, in the medium to long term, can be subject to change. However, the olive grove does not represent a natural ecosystem. Therefore, the replacement with other species or varieties already cultivated in the Mediterranean area should determine a sustainable structure in terms of biodiversity as much as that defined by olive groves. The carrier functions can also be considered resilient because the owner can enjoy the house and the area in the same way, independently of the types of vegetation. Indeed, as evidenced by the questionnaire responses, the owners do not seem worried about different uses of the house considering the loss of monumental olive groves.

Other services, however, could undergo significant changes depending on the choices made. For instance, production functions are subject to more or less pronounced changes depending on the type of plant, significantly influencing the area's economic potential. As for information functions, they can mainly be considered not resilient for the loss of the monumental olive groves' cultural aspect in the medium time, just as we appreciate it today. Maybe, in the long term, this aspect can be restored but in different cultural landscapes than the current state.

The owners interviewed declared to be interested in replanting olive trees to replace the dying monumental olive groves. That approach could be influenced by mutual evolution between the landscape and human perspective and vision, in which olive groves are the landscape's main cultural production (Table 3).

Table 2. Summary of ecosystem services resilient changing from monumental olive groves into land-cover of Leccino olive groves and other cultivars [16,35,54]. "Resilience" indicates the capacity to reinforce ecosystem services keeping the ecological function and human benefits. "Adaptation" suggests the ability to reinforce ecosystem services keeping the ecological function but changing the way to obtain or perceptive the human benefits.

Functions		Ecosystem Services	New Olive Groves	Others Agricultural Varieties	References
"Regulation functions"	Gas regulation	"UVB-protection by O_3 (preventing disease). Maintenance of (good) air quality Influence on climate."	Resilient	resilient	[16,56–62] Local Expert Involvement
	Climate regulation	"Maintenance of a favorable climate (temp., precipitation, etc.) for human habitation, health, cultivation."	resilient	resilient	
	Disturbance prevention	"Storm protection (e.g., by coral reefs Flood prevention (e.g., by wetlands and forests)"	resilient	resilient	
	Water regulation	"Drainage and natural irrigation."	resilient	resilient	
	Water supply	"Provision of water quality (e.g., drinking, irrigation, and industrial use)"	not applicable	not applicable	
	Soil retention	"Maintenance of arable land Prevention of damage from erosion/siltation."	resilient	resilient	
	Soil formation	"Maintenance of productivity on arable land. Maintenance of natural productive soils."	resilient	resilient	
	Nutrient regulation	"Maintenance of healthy soils and productive ecosystems."	resilient	resilient	
	Waste treatment	"Pollution control/detoxification; Filtering of dust particles (air quality) Abatement of noise pollution."	not applicable	not applicable	
	Pollination	"Pollination of wild plant species Pollination of crops."	not applicable	not applicable	
	Biological control	"Control of pests and diseases Reduction of herbivory (crop damage)"	not applicable	not applicable	
"Habitat functions"	Refugium function	"Maintenance of biological and genetic diversity"	adaptation	adaptation	[16,58,60,62] Local Expert Involvement
	Nursery function	"Maintenance of commercially harvested species"	adaptation	adaptation	

Table 2. *Cont.*

Functions		Ecosystem Services	New Olive Groves	Others Agricultural Varieties	References
"Production functions"	Food	"Hunting, game, fruits, etc. Small-scale subsistence"	resilient	adaptation	[16,58,60,62,63] Local Expert Involvement
	Raw materials	"Building and Manufacturing (e.g., lumber) Fuel and energy (e.g., fuelwood)"	resilient	resilient	
	Genetic resources	"Improve crop resistance to pathogens and pests. Other applications (e.g., health care)"	adaptation	not resilient	
	Medicinal resources	"Drugs and pharmaceuticals; Chemical models and tools; Test and essay organisms."	not applicable	not applicable	
"Information functions"	Aesthetic information	"Enjoyment of scenery (scenic roads, housing, etc.)"	not resilient	not resilient	[15,58,62,63] Interview of the owner
	Re-creation	"Travel to agroecosystems for eco-tourism and (recreational) nature study."	resilient	resilient	
	Cultural and artistic information	"Use of nature as motive in books, landscape symbol and arts."	adaptation	not resilient	
	Spiritual and historical information	"Use of nature for religious or historical purposes (i.e., the heritage value of natural ecosystems and features)."	not resilient	not resilient	
	Science and education	"Use of natural systems for education. Use of nature for research."	adaptation	adaptation	
"Carrier functions"	Habitation	"Living space (ranging from small settlements to urban areas)."	adaptation	adaptation	Interviews to the owners
	Tourism-facilities	"Tourism-activities (outdoor sports, walking, etc.)."	adaptation	adaptation	

Table 3. Responses of interviews to preferred plant for replanting.

Scenarios	Degree of Agreement
New olive trees	80%
Ornamental plants typical of the place	-
Agricultural plants of any type, even exotic	-
Only agricultural plants typical of the place	-
Ornamental trees plants, also exotic	-
Plants, regardless of the type, which over time can take on a pleasant appearance, such as historic-monumental olive trees	20%

3.2.1. Analysis of Microclimate Regulation and Thermal Comfort Lost from Monumental Olive Groves Land-Cover to Grassland Land-Cover

Figure 9 shows that Tair temporal profiles follow the same trend at two receptors: Tair increases in the early hours of the day until it reaches a peak between 15:00 and 16:00, subsequently slowly decreases until evening. In particular, at Point 1 in the current scenario, a maximum Tair of 36.02 °C at 16:00 is found, while in the "no trees" scenario, it reaches 36.27 °C. The minimum Tair in the current scenario is 29.55 °C at 08:00, while it is 29.86 °C in the "no trees" scenario. The higher air temperature decrease in the current scenario compared to the "no trees" scenario is at 18.00 at both extraction points and is equal to 0.39 °C (Point 1) and 0.47 °C (Point 2). On average, during the considered period, Tair is 0.24 °C higher in the "no trees" scenario. At Point 2, in the current scenario, Tair reaches a maximum value of 36.24 °C at 15:00. An increase of 0.43 °C is found in the "no trees" scenario. The minimum Tair as at Point 1 is experienced at 08:00 and is equal to 29.85 °C and 30.41 °C for the current and "no trees" scenarios, respectively. On average, an increase of 0.35 °C is found in the "no trees" scenario.

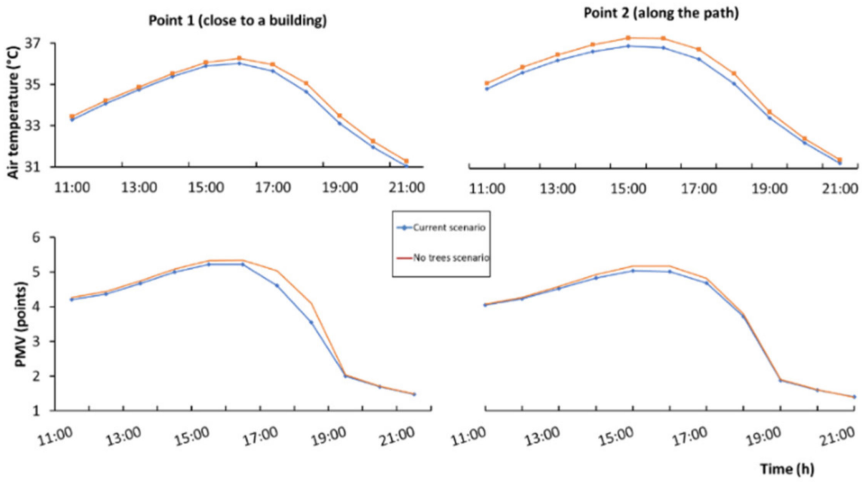

Figure 9. Temporal profiles of air temperature and PMV for the "current scenario" and "no trees scenario". Data for the first hours of the day, where there are no significant differences, are not shown.

To assess the effect on thermal comfort, Figure 9 further shows that even PMV in the presence of olive groves experiences lower values than those in the "no trees" scenario, thus suggesting a better thermal condition of the surrounding environment. In general, PMV is higher during the hottest hours of the day and reflects the same behaviour of the Tair profile. In particular, at Point 1 during the early hours of the morning (from 08:00 to 12:00), the profiles tend to increase, reaching a peak at 16:00 in which it is estimated to be 5.22 for the current and 5.34 for the "no trees" scenario. Then a decrease occurs reaching values close to the unity in the evening. This suggests that close to the buildings, on a typical summer day, there is a discomfort condition with high PMV values. Only in the evening is a neutral condition found in both scenarios. Point 2 shows similar profiles to those found at Point 1. Similar to air temperature profiles, the higher PMV decrease in the current scenario compared to the "no trees" scenario is at 18.00 at Point 1 and it is equal to 0.55; at Point 2, this occurs at 16:00 and it is equal to 0.16. On average, for the time period considered, PMV is 0.14 higher in the "no trees" scenario, and this confirms that the thermal comfort improves in the presence of olive trees, especially during the hottest hours of the day.

Figure 10 shows Tair contour maps at 11:00, 15:00 and 18:00. In the whole area, at 11.00, there is a noteworthy spatially averaged decrease of 0.13 °C in the presence of olive trees, with a maximum value equal to 35.42 °C, while in the no-trees scenario, the Tair maximum value is equal to 35.77 °C (an increase of 0.35 °C is estimated). At 15:00, the spatially averaged decrease in the presence of olive trees is equal to 0.45 °C, up from 11.00. The maximum value is equal to 37.20 °C in the current scenario and 37.42 °C in the no-trees scenario. Finally, at 18:00, in the presence of olive trees, a spatially averaged decrease of 0.40 °C is found. The maximum Tair value in the current scenario is equal to 35.42 °C and 0.35 °C in the no trees scenario.

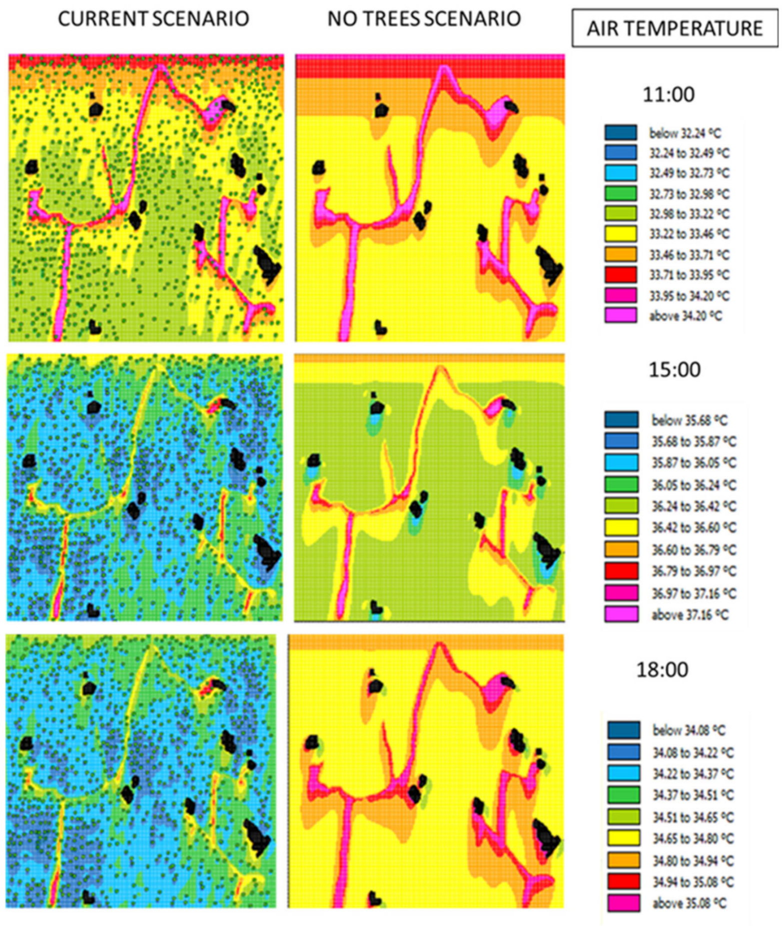

Figure 10. Contours of air temperature (T_{air}) for the current (**left**) and no trees (**right**) scenarios at 11:00 (**top**), 15:00 (**middle**) and 18:00 (**bottom**).

Finally, Figure 11 shows PMV contour maps at 11:00, 15:00 and 18:00. As expected, since the simulations were performed on a typical hot summer day, all the maps show an uncomfortable condition, as indicated by relatively high values of PMV. The spatial distribution of PMV shows the same positive effect already evident from the spatial distribution of Tair. At 11:00, the spatially averaged decrease of PMV in the current scenario in comparison with the "no trees" one is equal to 0.10; the maximum value is 4.56 in the current scenario and 4.62 in the no trees scenario. At 15:00, the spatially averaged decrease of PMV in the current scenario is equal to 0.18. The maximum value is 5.51 in the current scenario and 5.56 in the no-trees scenario. At 18.00, the spatially averaged decrease of PMV in the current scenario is equal to 0.25 points. The maximum value is 4.35 in the current scenario and 4.49 in the no-trees scenario.

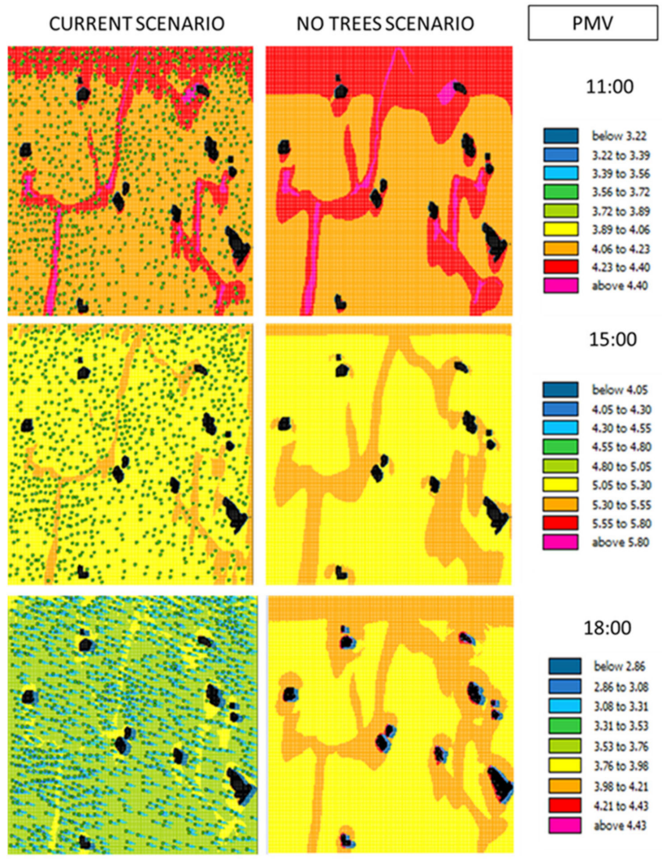

Figure 11. Contours of PMV for the current (**left**) and no trees (**right**) scenarios at 11:00 (**top**), 15:00 (**middle**) and 18:00 (**bottom**).

3.2.2. Analysis of Microclimate Regulation Resilience from Land-Cover with Monumental Olive Groves to New Land-Cover of Leccino Olive Groves

In this section, the microclimate effect of the land-cover change from monumental olive to new plants of the *X. fastidiosa*-resistant cv. Leccino is reported, evaluating the effects generated by potential landscape regeneration scenarios compared with the "no trees" scenario. The analysis was performed only on a small portion of the study area (157 m × 167 m), which can be considered a repetition unit of the whole area (Figure 12).

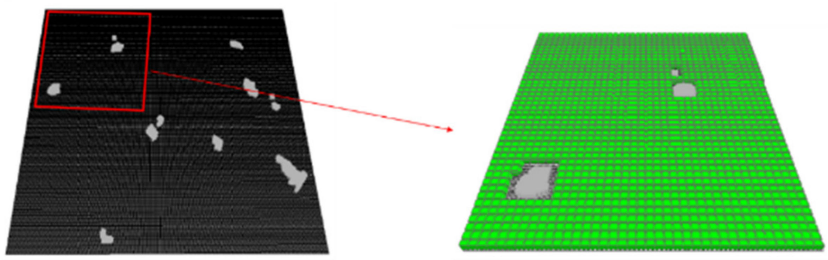

Figure 12. Portion of the study area considered for new landcover of Leccino olive groves (new scenario with Leccino).

By analyzing the contours in Figure 13, it is noteworthy that the thermal comfort is better in the new scenario compared to the "no trees" and current scenarios. Looking at the average values of PMV, it is evident that the thermal comfort, according to the PMV ranges (see Section 3.2.1), moves from "Hot" conditions (current scenario and "no trees" scenarios) to "Warm" conditions. Specifically, compared to the current and no trees scenarios, at 11:00, there is an average reduction of 1.43 and 1.50 points, respectively. The average maximum reduction is at 15:00 with a difference of 2.28 and 2.43 points, respectively. At 18:00, there is a reduction of 1.98 and 2.48 points.

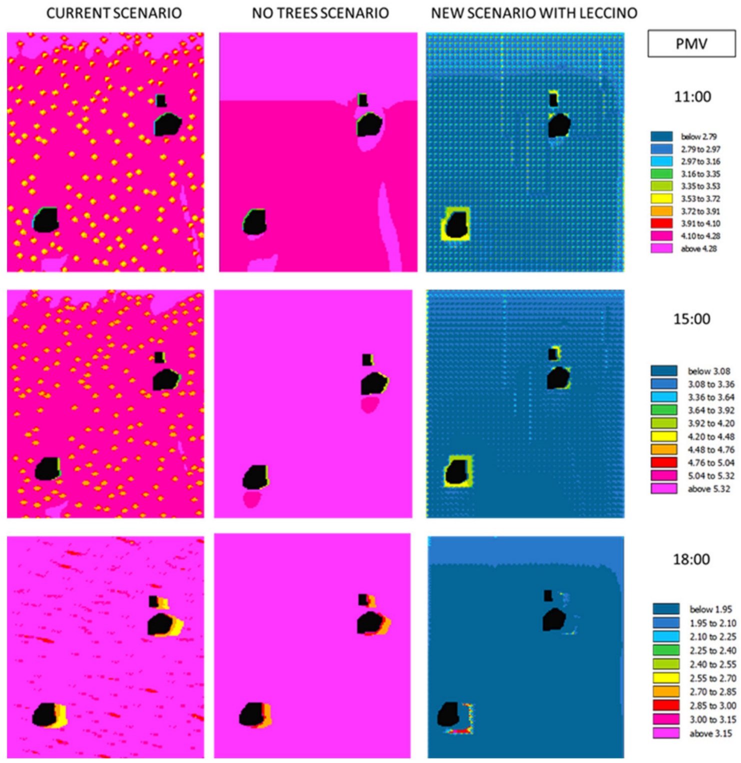

Figure 13. Contours of PMV for the current scenario (**left**), no-trees scenario (**middle**) and new scenario with Leccino (**right**) at 11:00 (**top**), 15:00 (**middle**) and 18:00 (**bottom**).

4. Discussion

The study showed that the differences in land-cover and land-use information in the Social-Ecological Landscape are not trivial. Indeed, the small change of olive groves land cover from 89% to 88% of the total land cover (see Table 1) represents a great change in land use in the investigated study area. The strong presence of monumental olive groves is currently not strictly connected to raw materials and to food production, but mainly to the psycho-physical well-being and relaxation that the owners draw from them during their holidays and free time.

Therefore, in the Peri-urban area, the analysis of differences in land-cover and land-use is relevant to not produce a mismatch between land-cover policy development and land-use perspectives that can produce results undesired and unpredictable in the regeneration of the landscape.

In any case, this area is classified as infected by *X. fastidiosa* and potentially prone to the death of olive trees. Of course, the monumental olive grove's land cover in the current state cannot be more resilient because it is linked to a specific olive cultivar (no longer usable due to being highly susceptible to *X. fastidiosa*) and cultivation practices not possible anymore (sculpturing of the trunk linked with past plant care practices). While the land use linked to touristic activity and holidays of the owners could be not affected by *X. fastidiosa*, the well-being change that the landowners experience can affect the area's future land cover. Mainly focusing on ecosystem services, we can propose an adaptation strategy for the potential land-cover transformation generated by the spread of *X. fastidiosa* infection, replacing agro-forest land-covers from monumental olive trees with the resistant varieties of olive trees such as cv. Leccino (already present in the infected areas) and/or cv. FS17 (newly introduced) [14,23,64] without altering the land use. Focusing on the resilience of different ecosystem services groups, the system can show resilience for "gas regulation". It simultaneously can show less resilience regarding the cultural landscape and the productions that depend on the capacity of social components to adapt to new landscape transformations. The conversion of the current olive groves with other olive tree cultivars (e.g., cv Leccino) can also produce a change in the food oil production chain (quality, quantity, agricultural practices). However, in the SES, the resilience in ecosystem services can include an intrinsic change; indeed, changing the cultivar olive tree can keep ecosystem services linked with olive productions, but can produce changes in crop management and agricultural biodiversity [63,65]. Of course, the historical aspect of the monumental olive landscape, as it is currently known, is not resilient, especially in the medium time. A new agricultural landscape probably develops with a new vision of cultural aspects to adapt to future generations in the long term.

Furthermore, these areas cannot be managed as just agricultural areas, but rather as peri-urban areas where the interests of use are strongly connected to the physical well-being of the individuals who live in or use them. Therefore, analyzing the land cover and land use benefits that the owners obtain from them is essential to ensure the landscape's regeneration after *X. fastidiosa* pandemics. Mainly, homeowners favor replacing potentially infected plants with young olive trees, suggesting that olive tree seems to represent a *status quo* characterizing the study area regardless of the trees' monumentality. They are less interested in planting other types of agricultural tree.

Therefore, in this area, the main objects of the landscape regeneration plan should not focus on the resilience of monumental land-cover olive trees but, *vice versa*, on priority ecosystems services, like the presence of the olive trees, olive oil production and allied cultural aspects, and microclimate regulations to maintain a comfortable and relaxing habitat for the users.

In this way, the development of regeneration policies that promote economic support to replace dead olive trees with new resistant olive trees at *X. fastidiosa* can reinforce the current land use without losing the landscape's cultural value linked to olive presence. Therefore, this can be intended as a profitable conservation action of the olive grove landscape's, read evolutionarily, or adaptation strategy. In so doing, the risks connected to a traumatic jump towards completely new agricultural systems (such as fruit trees or the introduction of new exotic lants) would be minimized [66].

This somewhat highlights the value of the regional policies that push for the (re)planting of new olive trees in the infected areas. So, even if the legislation was developed to ensure the olive grove landscape's resilience in agricultural production, it also seems to make sense in tourist valuable areas, where the production aspect is less prominent.

An essential aspect of the Italian National and Regional policies is calibrated on the sole ownership of the trees, taking its economic role for granted, while in the peri-urban context, the interest or the ability to access support actions may not be sufficient. Indeed, if the owners did not have the financial strength to replant, the area's regeneration action would slow down or produce a landscape driven by the lower cost of vegetation replacement. Therefore, in the absence of regional policies capable of fully supporting the costs of replanting, only non-economic owners with a cultural sensitivity towards a landscape traditionally characterized by olive groves will be inclined to restore actions.

Of course, there are different legal and bureaucratic situations of landowners in peri-urban areas, and some of these cannot give access to these regeneration processes developed like agriculture policy. Therefore, it necessary to develop a complementary landscape policy to improve the regeneration processes of olive groves in the landscape to support the owners that have a strong sensibility of the cultural heritage of the olive groves to replace the dead plants, in case it is not possible to apply the current Regional Policy.

In the context of the Apulian olive grove landscape, this aspect is crucial because it is not limited to this study area but is widespread at a regional level. Figure 14 shows how our study area can be representative of a much more extensive situation. Moreover, the interaction between urban areas and the agricultural landscape and their development policies is a problem that characterizes the socio-ecological landscape in the Mediterranean area [67–69].

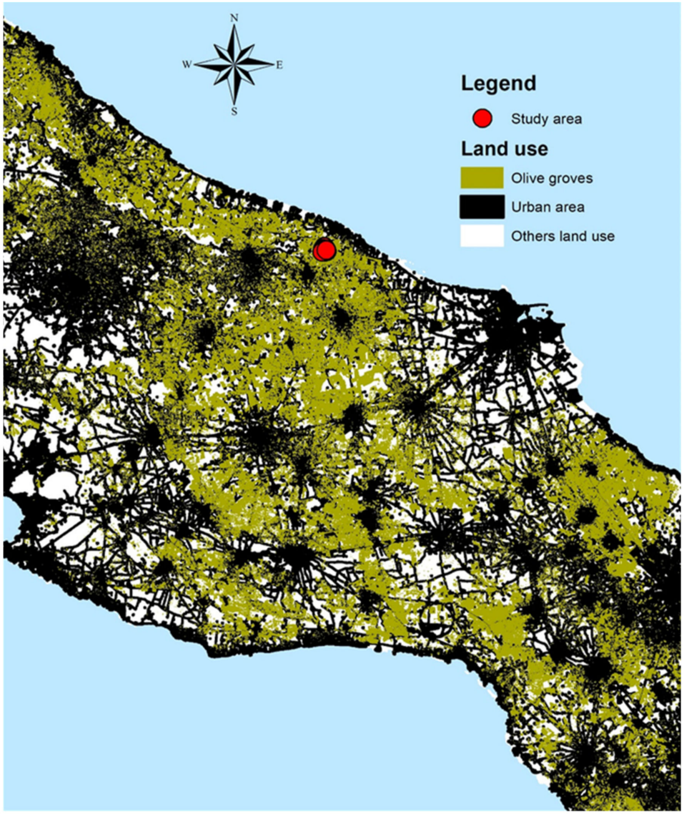

Figure 14. Representation of the urban areas and olive groves land-cover at the province scale.

Moreover, the ecosystem services approach used in the study areas can be applied to all peri-urban areas characterized by the dominant presence of olive trees. Indeed, considering that *X. fastidiosa* is able to infect several Mediterranean vegetation species and cultivars, the question can be extended to all Mediterranean Bio-geographical Region. The main difference would be to focus on priority ecosystem services.

5. Concluding Remarks

The paper highlights how analyzing and modeling SES with simple linear and reductionist land-cover or land-use dynamics can misinterpret how the system works, with substantial implications for management and policy. Regional regeneration policies should not be based only on the restoration of the land cover because they may not meet the needs of those who use and manage it.

The regeneration policy that sustains the conversion of olive groves destroyed by *X. fastidiosa* with new olive groves can be a good strategy to improve the landscape's resilience in the peri-urban area where the agricultural economy has a limited impact. In this case, the policy should support not only the economic operators but also the subjects inclined to regeneration actions for the cultural and historical value of the intervention. In the vision of the landscape, how "the perceived value of the population", this strategy has to develop independently of the economic land use while also considering the priority ecosystem services that we want to preserve. In this sense, the cultural ecosystem services can represent a valuable strategy to connect society and institutions for developing incentives for conservations policy like payment of ecosystem services tools [70], and not as personal income sustain. Therefore, the landowners can be considered the sellers of ecosystem services that can be compensated for replacing the olive trees destroyed, whereas the regional institutions should be considered as buyers that represent the interest of the local societies. We believe that the ecosystem service approach in SES regeneration can provide solutions that overcome the difficulty generated by the dichotomy between land cover development and land use and find good connections between societal, ecological, and economic evolutions orientated to a sustainable and desirable future. This could be useful for approaching the concept of resilience in the landscape, interpreting some changes produced by human choices, such as an adaptation strategy for disturbance events. This study is represented by restoring ecosystem services using cv. Leccino to replace the olive trees destroyed by *X. fastidiosa* bacterium.

However, priority ecosystem services need to be established for each landscape. This case study shows that the cultural aspect of olive oil production and the symbol of the local landscape, as well as the microclimate regulation ecosystem services, can be directly linked with human benefits in peri-urban areas characterized by monumental olive groves.

The ecosystem services approach could also focus on the cultural value of the landscape more pragmatically. In this study, it emerges that the landowners link the ecosystem services of olive oil production to important aspects of the agricultural landscape culture where they live, regardless of plant monumentality. Therefore, replacing monumental olive trees with new olives in order to maintain olive oil production helps to preserve the cultural aspect of the landscape, even though this does not have a primary productive purpose considering the land use transition from use in terms of agriculture to tourism.

The regeneration scenario evaluated with ENVI-met is limited to the use of *X. fastidiosa*-resistant cv. Leccino. Future studies in the same area may, for example, evaluate the effect of different vegetation scenarios on the microclimate. In addition to testing the effect of different species and their different spatial arrangement, other meteorological conditions (wind direction, wind speed, air temperature, etc.) or particular water stress or flooding conditions (e.g., arid or too wet soil) can be investigated.

Therefore, to implement the power of the result, it is necessary to analyze different places that can describe specific situations to have a complete vision of the issues.

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References

1. Antrop, M. Landscape Change: Plan or Chaos? *Landsc. Urban Plan.* **1998**, *41*, 155–161. [CrossRef]
2. Maggiore, G.; Semeraro, T.; Aretano, R.; De Bellis, L.; Luvisi, A. GIS Analysis of land-use change in threatened landscapes by *Xylella fastidiosa*. *Sustainability* **2019**, *11*, 253. [CrossRef]
3. Dean, G.; Rivera-Ferre, M.G.; Rosas-Casals, M.; Lopez-i-Gelats, F. Nature's contribution to people as a framework for examining socio-ecological systems: The case of pastoral systems. *Ecosyst. Serv.* **2021**, *49*, 101265. [CrossRef]
4. Wu, J.; Hobbs, R.J. Key Issues and Research Priorities in Landscape Ecology: An Idiosyncratic Synthesis. *Landsc. Ecol.* **2002**, *17*, 355–365. [CrossRef]
5. Virapongse, A.; Brooks, S.; Metcalf, E.C.; Zedalis, J.G.; Kliskey, A.; Alessa, L. A social-ecological systems approach for environmental management. *J. Environ. Manag.* **2016**, *178*, 83–91. [CrossRef] [PubMed]
6. Mao, Z.; Centanni, J.; Pommereau, F.; Stokes, A.; Gaucherel, C. Maintaining biodiversity promotes the multifunctionality of social-ecological systems: Holistic modelling of a mountain system. *Ecosyst. Serv.* **2021**, *47*. [CrossRef]
7. Turner, B.L.; Meyer, W.B. Land-use and land-cover in global environmental change: Considerations for study. *Int. Soc. Sci. J.* **1991**, *130*, 667–669.
8. Brown, D.G.; Pijanowski, B.C.; Duh, J.D. Modeling the relationships between land-use and land-cover on private lands in the Upper Midwest, USA. *J. Environ. Manage.* **2000**, *59*, 247–263. [CrossRef]
9. Haines-Young, R.; Potschin, M. Valuing and assessing multifunctional landscapes: An approach based on the natural capital concept. In *Multifunctional Landscapes: Theory, Values and History*; Brandt, J., Vejre, H., Eds.; WIT Press: Southampton, UK, 2004; pp. 181–192.
10. Antrop, M. Background concepts for integrated landscape analysis. *Agric. Ecosyst. Environ.* **2000**, *77*, 17–28. [CrossRef]
11. UNESCO. Operational Guidelines for the Implementation of the World Heritage Convention Copia whc.unesco.org. *UNESCO World Heritage Centre. Paris.* 2005, p. 83. Available online: https://whc.unesco.org/archive/opguide05-en.pdf (accessed on 4 August 2021).
12. Cumming, G.S.; Epstein, G. Landscape sustainability and the landscape ecology of institutions. *Landsc. Ecol.* **2020**. [CrossRef]
13. Regione Puglia. 2021. Available online: https://www.regione.puglia.it/web/rigenerazione-olivicola (accessed on 24 June 2021).
14. Saponari, M.; Boscia, D.; Nigro, F.; Martelli, G.P. Identification of DNA sequences related to *Xylella fastidiosa* in oleander, almond and olive trees exhibiting leaf scorch symptoms in Apulia (Southern Italy). *J. Plant Pathol.* **2013**, *95*, 668.
15. Martelli, G.P. The current status of the quick decline syndrome of olive in Southern Italy. *Phytoparasitica* **2016**, *44*, 1–10. [CrossRef]
16. Semeraro, T.; Gatto, E.; Buccolieri, R.; Vergine, M.; Gao, Z.; De Bellis, L.; Luvisi, A. Changes in Olive Urban Forests Infected by *Xylella fastidiosa*: Impact on Microclimate and Social Health in urban areas. *Int. J. Environ. Res. Pub. Health* **2019**, *16*, 2642. [CrossRef] [PubMed]
17. Semeraro, T.; Zaccarelli, N.; Lara, A.; Sergi-Cucinelli, F.; Aretano, R. A Bottom-Up and Top-Down Participatory Approach to Planning and Designing Local Urban Development: Evidence from an Urban University Center. *Land* **2020**, *9*, 98. [CrossRef]
18. Carpenter, S.; Walker, B.; Anderies, J.M.; Abel, N. From metaphor to measurement: Resilience of what to what? *Ecosystems* **2001**, *4*, 765–781. [CrossRef]
19. Walker, B.; Holling, C.S.; Carpenter, S.R.; Kinzig, A.P. Resilience, Adaptability and Transformability in Social-Ecological Systems. *Ecol. Soc.* **2004**, *9*, 5. Available online: http://www.ecologyandsociety.org/vol9/iss2/art5/ (accessed on 17 July 2021). [CrossRef]
20. Broderstad, E.G.; Eythorsson, E. Resilient communities? Collapse and recovery of a social–ecological system in Arctic Norway. *Ecol. Soc.* **2004**, *19*, 1. [CrossRef]
21. Ahern, J.; Cilliers, S.; Niemelä, J. The concept of ecosystem services in adaptive urban planning and design: A framework for supporting innovation. *Landsc. Urban Plan.* **2014**, *125*, 254–259. [CrossRef]
22. Hughes, T.P.; Barnes, M.; Bellwood, D.R.; Cinner, J.; Cumming, G.; Jackson, J.B.C.; Kleypas, J.; Van De Leemput, I.A.; Lough, J.M.; Morrison, T.; et al. Coral reefs in the Anthropocene. *Nat. Cell Biol.* **2017**, *546*, 82–90. [CrossRef] [PubMed]
23. Vergine, M.; Meyer, J.B.; Cardinale, M.; Sabella, E.; Hartmann, M.; Cherubini, P.; De Bellis, L.; Luvisi, A. The Xylella fastidiosa-Resistant Olive Cultivar "Leccino" Has Stable Endophytic Microbiota during the Olive Quick Decline Syndrome (OQDS). *Pathogens* **2019**, *9*, 35. [CrossRef] [PubMed]
24. Sabella, E.; Moretti, S.; Gärtner, H.; Luvisi, A.; De Bellis, L.; Vergine, M.; Saurer, M.; Cherubini, P. Increase in ring width, vessel number and δ18O in olive trees infected with Xylella fastidiosa. *Tree Physiol.* **2020**, *40*, 1583–1594. [CrossRef]
25. Kelly, C.; Ferrara, A.; Wilson, G.A.; Ripullone, F.; Nolè, A.; Harmer, N.; Salvati, L. Community resilience and land degradation in forest and shrubland socio ecological systems: Evidence from Gorgoglione, Basilicata, Italy. *Land-Use Policy* **2015**, *46*, 11–20. [CrossRef]
26. Morton, J.F.; Solecki, W.; Dasgupta, P.; Dodman, D.; Rivera-Ferre, M.G. Cross chapter box on urban–rural interactions—Context for climate change vulnerability, impacts, and adaptation. In *Climate Change: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*; Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Eds.; Cambridge University Press: Cambridge, UK; New York, NY, USA, 2014; pp. 153–155.
27. Carrasco, L.; Papworth, S.; Reed, J.; Symes, W.; Ickowitz, A.; Clements, T.; Peh, K.-H.; Sunderland, T. Five challenges to reconcile agricultural land use and forest ecosystem services in Southeast Asia. *Conserv. Biol.* **2016**, *30*, 962–971. [CrossRef]

28. Wilkerson, M.L.; Mitchell, M.G.; Shanahan, D.; Wilson, K.; Ives, C.D.; Lovelock, C.; Rhodes, J. The role of socio-economic factors in planning and managing urban ecosystem services. *Ecosyst. Serv.* **2018**, *31*, 102–110. [CrossRef]
29. Soto-Montes-De-Oca, G.; Bark, R.; González-Arellano, S. Incorporating the insurance value of peri-urban ecosystem services into natural hazard policies and insurance products: Insights from Mexico. *Ecol. Econ.* **2020**, *169*, 106510. [CrossRef]
30. Salmond, J.A.; Tadaki, M.; Vardoulakis, S.; Arbuthnott, K.; Coutts, A.; Demuzere, M.; Dirks, K.N.; Heaviside, C.; Lim, S.; MacIntyre, H.; et al. Health and climate related ecosystem services provided by street trees in the urban environment. *Environ. Health* **2016**, *15*, S36. [CrossRef]
31. Santamouris, M.; Ding, L.; Fiorito, F.; Oldfield, P.; Osmond, P.; Paolini, R.; Prasad, D.; Synnefa, A. Passive and active cooling for the built environment-Analysis and assessment of the cooling potential of mitigation technologies using performance data form 220 large scale projects. *Sol. Energy* **2017**, *154*, 14–33. [CrossRef]
32. Plieninger, T.; Bieling, C.; Fagerholm, N.; Byg, A.; Hartel, T.; Hurley, P.; López-Santiago, C.A.; Nagabhatla, N.; Oteros-Rozas, E.; Raymond, C.; et al. The role of cultural ecosystem services in landscape management and planning. *Curr. Opin. Environ. Sustain.* **2015**, *14*, 28–33. [CrossRef]
33. Chen, W.Y.; Hua, J. Heterogeneity in resident perceptions of a bio-cultural heritage in Hong Kong: A latent class factor analysis. *Ecosyst. Serv.* **2017**, *24*, 170–179. [CrossRef]
34. Cheng, X.; Van Damme, S.; Li, L.; Uyttenhove, P. Evaluation of cultural ecosystem services: A review of methods. *Ecosyst. Serv.* **2019**, *37*, 100925. [CrossRef]
35. De Groot, R.S.; Alkemade, R.; Braat, L.; Hein, L.; Willemen, L. Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. *Ecol. Complex.* **2010**, *7*, 260–272. [CrossRef]
36. Costanza, R.; De Groot, R.; Braat, L.; Kubiszewski, I.; Fioramonti, L.; Sutton, P.; Farber, S.; Grasso, M. Twenty years of ecosystem services: How far have we come and how far do we still need to go? *Ecosyst. Serv.* **2017**, *28*, 1–16. [CrossRef]
37. Semeraro, T.; Radicchio, B.; Medagli, P.; Arzeni, S.; Turco, A.; Geneletti, D. Integration of Ecosystem Services in Strategic Environmental Assessment of a Peri-Urban Development Plan. *Sustainability* **2020**, *13*, 122. [CrossRef]
38. Vallecillo, S.; La Notte, A.; Ferrini, S.; Maes, J. How ecosystem services are changing: An accounting application at the EU level. *Ecosyst. Serv.* **2019**, *40*, 101044. [CrossRef]
39. Rall, E.L.; Kabisch, N.; Hansen, R. A comparative exploration of uptake and potential application of ecosystem services in urban planning. *Ecosyst. Serv.* **2015**, *16*, 230–242. [CrossRef]
40. Turkelboom, F.; Leone, M.; Jacobs, S.; Kelemen, E.; García-Llorente, M.; Baró, F.; Termansen, M.; Barton, D.N.; Berry, P.; Stange, E.; et al. When we cannot have it all: Ecosystem services trade-offs in the context of spatial planning. *Ecosyst. Serv.* **2018**, *29*, 566–578. [CrossRef]
41. Dang, A.N.; Jackson, B.M.; Benavidez, R.; Tomscha, S.A. Review of ecosystem service assessments: Pathways for policy integration in Southeast Asia. *Ecosyst. Serv.* **2021**, *49*, 101266. [CrossRef]
42. Collins, S.L.; Carpenter, S.R.; Swinton, S.M.; Orenstein, D.; Childers, D.; Gragson, T.L.; Grimm, N.; Grove, J.M.; Harlan, S.L.; Kaye, J.P.; et al. An integrated conceptual framework for long-term social–ecological research. *Front. Ecol. Environ.* **2010**, *9*, 351–357. [CrossRef]
43. Bodin, Ö.; Tengo, M. Disentangling intangible social–ecological systems. *Glob. Environ. Chang.* **2012**, *22*, 430–439. [CrossRef]
44. Berrouet, L.; Machado, J.; Villegas-Palacio, C. Vulnerability of socio—Ecological systems: A conceptual Framework. *Ecol. Indic.* **2018**, *84*, 632–647. Available online: https://www.istat.it/it/archivio/32618 (accessed on 15 June 2021). [CrossRef]
45. Turner, B.L.; Skole, D.; Sanderson, S.; Fischer, G.; Fresco, L.; Leemans, R. Land-Use and Land-Cover Change Science/Research Plan. In *Joint Publication of the International Geosphere-Biosphere Programme (Report No. 35) and the Human Dimensions of Global Environmental Change Programme (Report No. 7)*; Royal Swedish Academy of Sciences: Stockholm, Sweden, 1995.
46. Bishop, J. *The Economics of Ecosystems and Biodiversity in Business and Enterprise*, 1st ed.; Routledge: London, UK, 2021. [CrossRef]
47. Houdet, J.; Ding, H.; Quétier, F.; Addison, P.; Deshmukh, P. Adapting double-entry bookkeeping to renewable natural capital: An application to corporate net biodiversity impact accounting and disclosure. In *Ecosyst. Serv.*; 2020; 45, p. 101104. Available online: https://www.agenziaentrate.gov.it/portale/home/ (accessed on 15 June 2021). [CrossRef]
48. Nicolì, F.; Negro, C.; Nutricati, E.; Vergine, M.; Aprile, A.; Sabella, E.; Damiano, G.; De Bellis, L.; Luvisi, A. Accumulation of azelaic acid in *Xylella fastidiosa*-infected olive trees: A mobile metabolite for health screening. *Phytopathology* **2019**, *109*, 318–325. [CrossRef] [PubMed]
49. Luvisi, A.; Aprile, A.; Sabella, E.; Vergine, M.; Nicolì, F.; Nutricati, E.; Miceli, A.; Negro, C.; De Bellis, L. Xylella fastidiosa subsp. pauca (CoDiRO strain) infection in four olive (*Olea europaea* L.) cultivars: Profile of phenolic compounds in leaves and progression of leaf scorch symptoms. *Phytopathol. Mediterr.* **2017**, *56*, 259–273.
50. Edwards, K.; Johnstone, C.; Thompson, C. A simple and rapid method for the preparation of plant genomic DNA for PCR analysis. *Nucleic Acids Res.* **1991**, *19*, 1349. [CrossRef] [PubMed]
51. Harper, S.J.; Ward, L.I.; Clover, G.R.G. Development of LAMP and real-time PCR methods for the rapid detection of Xylella fastidiosa for quarantine and field applications. *Phytopathology* **2010**, *100*, 1282–1288. [CrossRef] [PubMed]
52. De Groot, R.S.; Wilson, M.; Boumans, R. A typology for the description, classification and valuation of Ecosystem Functions. *Goods Serv. Econ.* **2002**, *41*, 393–408.

53. Gatto, E.; Buccolieri, R.; Aarrevaara, E.; Ippolito, F.; Emmanuel, R.; Perronace, L.; Santiago, J.L. Impact of Urban Vegetation on Outdoor Thermal Comfort: Comparison between a Mediterranean City (Lecce, Italy) and a Northern European City (Lahti, Finland). *Forests* **2020**, *11*, 228. Available online: http://www.arpa.puglia.it/web/guest/serviziometeo (accessed on 17 June 2021). [CrossRef]
54. Rui, L.; Buccolieri, R.; Gao, Z.; Ding, W.; Shen, J. The impact of green space layouts on microclimate and air quality in residential districts of nanjing, China. *Forests* **2018**, *9*, 224. [CrossRef]
55. Burkhard, B.; Kroll, F.; Nedkov, S.; Müller, F. Mapping ecosystem service supply, demand and budgets. *Ecol. Indic.* **2012**, *21*, 17–29. [CrossRef]
56. Strohbacha, M.W.; Haaseb, D. Above-ground carbon storage by urban trees in Leipzig, Germany: Analysis of patterns in a European city. *Land. Urban. Plan.* **2012**, *104*, 95–104. [CrossRef]
57. Kandziora, M.; Burkhard, B.; Müller, F. Mapping provisioning ecosystem services at the local scale using data of varying spatial and temporal resolution. *Ecosyst. Serv.* **2013**, *4*, 47–59. [CrossRef]
58. Whitmarsh, J.G. The Photosynthetic Process. In *Concepts in Photobiology*; Singhal, G.S., Renger, G., Sopory, S.K., Irrgang, K.-D., Eds.; Springer: Dordrecht, The Netherlands, 1999. [CrossRef]
59. Petrosillo, I.; Zaccarelli, N.; Semeraro, T.; Zurlini, G. The effectiveness of different conservation policies on the security of natural capital. *Landsc. Urban Plan.* **2009**, *89*, 49–56. [CrossRef]
60. Vallés-Planells, M.; Galiana, F.; Torrijos, I.D. Agricultural abandonment and resilience in a Mediterranean periurban traditional agroecosystem: A landscape approach. *Ecol. Soc.* **2020**, *25*, 5. [CrossRef]
61. Crane, T. Of Models and Meanings: Cultural Resilience in Social–Ecological Systems. *Ecol. Soc.* **2010**, *15*, 16. [CrossRef]
62. Sabella, E.; Luvisi, A.; Aprile, A.; Negro, C.; Vergine, M.; Nicolì, F.; Miceli, A.; De Bellis, L. Xylella fastidiosa induces differential expression of lignification related-genes and lignin accumulation in tolerant olive trees cv. Leccino. *J. Plant Physiol.* **2018**, *220*, 60–68. [CrossRef] [PubMed]
63. Folke, C. Resilience (Republished). *Ecol. Soc.* **2016**, *21*, 44. [CrossRef]
64. Holling, C.S. The resilience of terrestrial ecosystems local surprise and global changeSustainable Development of the BiosphereClark, W.C., Munn, R.E., Eds.; Cambridge University Press: Cambridge, UK, 1986; pp. 292–317.
65. Cecchini, M.; Zambon, I.; Pontrandolfi, A.; Turco, R.; Colantoni, A.; Mavrakis, A.; Salvati, L. Urban sprawl and the 'olive' landscape: Sustainable land management for 'crisis' cities. *GeoJournal* **2019**, *84*, 237–255. [CrossRef]
66. Robert, S.; Fox, D.; Boulay, G.; Grandclément, A.; Garrido, M.; Pasqualini, V.; Prévost, A.; Schleyer-Lindenmann, A.; Trémélo, M.-L. A framework to analyse urban sprawl in the French Mediterranean coastal zone. *Reg. Environ. Chang.* **2019**, *19*, 559–572. [CrossRef]
67. Salvia, R.; Halbac-Cotoara-Zamfir, R.; Cividino, S.; Salvati, L.; Quaranta, G. From Rural Spaces to Peri-Urban Districts: Metropolitan Growth, Sparse Settlements and Demographic Dynamics in a Mediterranean Region. *Land* **2020**, *9*, 200. [CrossRef]
68. Fujita, R.; Lynham, J.; Micheli, F.; Feinberg, P.G.; Bourillón, L.; Sáenz-Arroyo, A.; Markham, A.C. Ecomarkets for conservation and sustainable development in the coastal zone. *Biol. Rev.* **2013**, *88*, 273–286. [CrossRef] [PubMed]
69. Waylen, K.; Martin-Ortega, J. Surveying views on Payments for Ecosystem Services: Implications for environmental management and research. *Ecosyst. Serv.* **2018**, *29*, 23–30. [CrossRef]
70. Brathwaite, A.; Pascal, N.; Clua, E. When are payment for ecosystems services suitable for coral reef derived coastal protection?: A review of scientific requirements. *Ecosyst. Serv.* **2021**, *49*, 101261. [CrossRef]