Tools for participative prioritization of ecological restoration in the Region of Valencia (southeastern Spain)

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Summary

The effective integration of ecological restoration (ER) into land management requires the definition of priority areas and actions. At large spatial scales, priorities are commonly defined by experts in terms of ecological factors, particularly species distribution or a small set of ecosystem services. However, management decisions must deal with different habitats, and respond to society multiple demands and aspirations. New tools for identifying and analyzing priority criteria and determining best management alternatives, integrating ecological and socio-economic perspectives are needed. We developed a participatory approach to identify priority areas for restoration in a 224,472 Ha area in Crevillent Forest Demarcation, southeast semi-arid Spain. The challenge was to develop a rigorous yet accessible methodology that could be extrapolated to other regions. An 88-stakeholder platform was asked to identify and weight priority criteria for ER. Stakeholders identified five groups of criteria corresponding to natural and semi-natural environments, highly humanized environments, criteria related to ecosystem functions, criteria related to landscape-scale processes, and socio-economic and cultural criteria. The integrated weight of the studied criteria showed that highly humanized environments (landfills and waste dumps, river margins, unused quarries, rainfed crops, and irrigated crops) and criteria related to ecosystem function (key areas to reduce wildfire risk and vulnerability, key areas to reduce erosion, key areas to reduce water pollution) received the highest priority, together with areas with high cultural and ethnologic value. In contrast, the priority for natural and semi-natural environments and landscape-scale features was lower. We discuss these results and the feasibility of using this protocol to support decision making concerning ecological restoration actions in this Mediterranean landscape.

Introduction

The Mediterranean basin has been deeply altered by continued and intense land use. As a consequence, degradation processes have been triggered in the most vulnerable areas. Degradation has traditionally been combated by regulating particular land uses and planting trees in deforested areas (Navarro & Cortina, 2011).

Recent focus on ecological restoration has contributed to increase our knowledge on species ecology and management, and community assembly rules. It has also fostered social recognition of the benefits of restored ecosystems. In this context, socio-ecological restoration represent a means to integrate biophysical and socio-economic perspectives at large spatial scales (Murdoch, 2001) (Budiharta, Meijaard, Wells, Abram, & Wilson, 2016). However, most restoration projects fail to address interactions at landscape scale (Menz, Dixon, & Hobbs, 2013), and integrate them into a wider framework of ecologically and socially sensitive land-use planning and management (Dawson, Elbakidze, Angelstam, & Gordon, 2017). Consequently, the long-term sustainability of these actions may be compromised, and indeed, conflicting actions may be implemented in different sectors of the same landscape.

The effectiveness of restoration plans is currently compromised by: (1) the lack of tools to assess project suitability in a wide and changing socio-economic context, (2) the difficulty for integrating and weighting expectations of local stakeholders and technical staff, (3) the challenge of adopting and transferring innovative techniques and procedures, (4) the lack of a long-term perspective to promote biodiversity, through the creation of resistant and resilience landscapes, and (5) the absence of common metrics for the large diversity of scopes.

Planning and prioritization of restoration actions are commonly grounded on political decisions aside of the socio-environmental context, environmental risks, and the correct functioning of a few ecosystem processes and services (mostly related to erosion control and hydrological regulation). In contrast, few efforts have been devoted to identify areas with the greatest need to be restored using spatial multicriteria approaches, nor the type of restoration actions that could generate the greatest cost-effectiveness (but see exceptions in (Orsi, Geneletti, & Newton, 2011) (Vettorazzi & Valente, 2016).

The tools to perform these tasks are lacking. Linking economic and ecological information is an essential step towards making efficient investments in restoration with limited funding. Although our knowledge on the provision of ecosystem services in Mediterranean landscapes has progressed rapidly, it is still difficult to quantify the value of these services. Specifically, there is a clear demand for spatially explicit models to evaluate changes in the supply of multiple ecosystem services and their associated values with different land-use scenarios (Derak & Cortina, 2014) (Felipe-Lucia, Comín, & Bennett, 2014).

Furthermore, social consensus concerning restoration priorities is strongly needed to properly manage the limited resources available. In this way, we may avoid potential conflicts arising from different stakeholder views, and economic, technical and land availability restrictions (Knight, Sarkar, Smith, Strange, & Wilson, 2011). A key aspect in this process is the participation of the multiple social agents concerned by the management of their environment (Couix & Gonzalo-Turpin, 2015); (Derak, Cortina, & Taiqui, Integration of stakeholder choices and multi-criteria analysis to support land use planning in semiarid areas, 2017). In spite of its importance, public participation in the planning and implementation of restoration actions is less clearly established than in other sectors (e.g., marketing consumer's goods). The lack of a general framework to prioritize ecological restoration actions, based on agreed and transparent criteria, limits its progress and acceptance. We believe that this deficiency may be overcome with the implementation of participatory processes and land-use planning techniques that take into account socio-economic and ecological constraints.

In this study we aim to map priority areas for restoration of a Mediterranean region by using a participatory approach. In this way, we want to develop a rigorous yet feasible participatory decision tool that can be used to discuss alternative actions and scenarios, and elicit public and private restoration initiatives. Biophysical and socio-economic conditions of the study area are common to other Mediterranean areas where the approach may be transferred and adapted.

Materials and methods

The study area is located Crevillent Forest Demarcation (Demarcación Forestal de Crevillent; CFD) an operational land unit in Alicante province, southern Spain (Fig. 1). It covers 224,472 Ha. It has dry sub-humid to semiarid Mediterranean climate. Based on maps provided by Plan de Acción Territorial Forestal (PATFOR, 2017), and Sistema de Información sobre Ocupación del Suelo en España (SIOSE, 2017), we identified nine combinations of land use and plant cover (hereafter referred as Homogeneous Environmental Units or HEU): forests, shrublands and steppes, river margins, wetlands, sand dunes, rainfed crops, irrigated crops, abandoned agricultural land and quarries. As much as 18.4% of the area is protected under different forms, including Sites of Community Interest (10 sites) and Special Protection Areas for birds (9 areas). Population is 829,980, including the town of Elx (228,647 inhabitants; INE, 2014). Most active population works in the service sector (69%) as compared to agriculture, cattle raising and fisheries (5%). Unemployment rate is 17.3%.

(Figure 1)

On April 2016 we established a 88-member multi-stakeholder platform by using the chain-referral method (Table 1). A group of six researchers from ecological and social sciences first defined a social map of the area, and identified the first group of stakeholders based on personal observations and previous experience (Derak & Cortina, 2014). These were contacted, and their advice used to identify further contacts, until all social profiles were represented. Our aim was to integrate all visions on the topic of ecological restoration in the area, rather than building a proportional representation of the different social profiles. When possible, we identified people representing organizations (e.g., farmers, NGO's, mining industry, etc.), as they may speak for the whole group and feel more prone to participation than single individuals.

Between April and July 2016 we asked stakeholders to identify (i) the services that HLU provided and (ii) the criteria that had to be taken into account to define priority areas for restoration. We do not present results concerning ecosystem services in this manuscript. However, this part of the methodology is worth mentioning, as the sequence of questions helped to bring interviewees into geographic and environmental context before we asked them for prioritization criteria. Interviews were presential, semi-structured, quasi-standardized, and used multiple-stimuli to obtain the information from individuals and small groups. They were pre-tested on three individuals not belonging to the platform, and the surveying protocol and contents refined accordingly. Then, we analysed stakeholder responses to the second question by unifying redundant criteria under a common name, suppressing criteria that were not responding to our questions, naming criteria in a way that could be understood by all stakeholders, and classifying criteria into five clearly differentiated and coherent groups (natural and semi-natural environments, highly humanized environments, criteria related to ecosystem functions, criteria related to landscape-scale processes, and socio-economic and cultural criteria; see below).

Between February and March 2017, we conducted an online survey using the software Qualtrics (Snow & Mann, 2017). Eighty-eight of the invited 109 stakeholders responded, of whom 73% had contributed in the first phase of the participatory process. We collected personal information on age, gender, education level, involvement in management and other explanatory variables, and asked stakeholders to make an ordinal classification of criteria in each criteria group. Criteria were scored from 1 (lower priority) to 5, 6, 7 or 8 (higher priority), depending on the number of criteria in each group. The same procedure was followed for the five groups of criteria.

The ordinal values obtained for each participant and criteria were then converted into cardinal values. We then re-scaled the cardinal values by dividing each one by the sum of all values of its corresponding scale (i.e., by dividing by 15, 21, 28 or 36 for groups with 5, 6, 7 or 8 criteria, respectivelly). In this way, we took into consideration the unbalanced number of criteria per group, which may cause overvaluation of some criteria and undervaluation of others. The re-scaled values, i.e. the weight of each criteria, summed 1 within the group and were comparable between the groups. Next, we estimated the integrated weight of each criteria by multiplying its weight within the group by the weight of the group. Collective weights of criteria and groups were computed by calculating the arithmetic mean of the 88 individual weights.

(Table 1)

Results

Stakeholder profile and response

Success rate in the first phase of the participative process was relatively high (59% of the invited stakeholders). With few exceptions, stakeholders welcomed the initiative and showed empathy with the process and interest in the results. The success of the online survey was somewhat higher (87%). Most comments included in the stakeholder's observations section of the survey were positive. Three of them expressed concerns on providing the 'correct' answers. Most stakeholders were males (74%), between 36 and 65-year-old (88%) and with higher level of education (89% University graduates or higher level technical studies). As much as 79% of them considered that they had high levels of knowledge on environmental issues.

Selected criteria

Stakeholders proposed a list of 118 criteria for restoration. Further analysis of their selection reduced the number of criteria to 33 (Table 2). We classified criteria in 5 groups: natural and semi-natural environments, highly humanized environments, criteria related to ecosystem functions, landscape-scale criteria, and criteria related to socio-economic and cultural aspects. This classification aimed at defining coherent and comparable items, with low degree of ambiguity and overlapping, that could be easily understood by stakeholders. Homogeneity in the number of criteria per group (5-7) avoided bias in that respect.

(Table 2)

Partial weight

Criteria related to ecosystem functions and highly humanized areas were the most valued (Fig. 2). In comparison, the weight of natural and semi-natural areas was less than 50% of the first group. Coastal ecosystems, as sand dunes and wetlands, were prioritaire among natural and semi-natural ecosystems (Table 2). A similar partial weight was obtained by forests in semi-arid areas. The lowest priority in this group was given to North-faced forest slopes. Waste dumps obtained the highest priority amongst highly humanized areas, closely followed by river margins, whereas agricultural systems received the lowest scores. Two sets of functions represented a priority for stakeholders: those related to erosion, desertification and wildfires, on the one hand, and those related to water availability and quality. In contrast, carbon fixation and the control of exotic and invasive species, were not considered a priority for ecological restoration in the area. Protected areas, together with corridors and areas of particular interest for flora and fauna received the highest priority among landscape-scale criteria. Their priority almost doubled that of roadsides and other linear infrastructures. Finally, areas with high cultural value showed the highest partial weight among socio-economic and cultural criteria. They were followed at some distance by areas with high unemployment rates and recreational areas.

(Figure 2)

Integrated weight

Overall, five of the ten criteria receiving the highest priority for restoration, the highest integrated weight, corresponded to highly humanized environments as landfills and waste dumps, river margins and quarries. Criteria related to ecosystem functions (4 criteria) and socio-economic and cultural values (1 criteria) completed the top ten list. Criteria related to the control of desertification, water quality, water availability and wildfires completed the list of priority functions to be restored. Sites of high cultural value completed the list of criteria for prioritizing restoration actions. It is worth to note that the restoration of rainfed and irrigated agricultural systems was of high priority, despite that they ranked low within the group of highly humanized areas.

Discussion

We carried out a participative process to define criteria to prioritize restoration actions in a Mediterranean region. Our study area covers a wide range of climates and land-uses, and our protocol may be extrapolated to other drylands.

The participatory process was well accepted, as evidenced by the high success rate of the two phases of the survey. Stakeholders showed willingness to collaborate and appreciation for being consulted. The stakeholder platform showed bias of age, gender and education level. Additional stakeholders should be incorporated to correct this bias and incorporate innovative perspectives. Yet, we consider that in the way we established the platform, we captured social profiles that are relevant for decision-making under current socio-political conditions.

We obtained a long list of criteria, which illustrates the multiplicity of visions held by the different stakeholders. Reducing the surface area of study or focusing on single ecosystems could reduce the diversity of responses, but would fail to achieve the landscape-scale integration of restoration priorities sought. The wide range of criteria obtained also emphasizes the importance of interpreting stakeholders opinion by respecting their vision while maintaining a manageable list of criteria and services. In our case, we were responsible for this phase, but it may be alternatively carried out in a participative way to guarantee the legitimacy of the interpretations.

Stakeholders conferred the highest priority to criteria related to ecosystem functions and highly humanized areas. Even if they identified other priorities, particularly those related to natural and semi-natural environments, they still associated ecological restoration with dysfunctional ecosystems. We must bear in mind that large extents of natural and semi-natural environments in the Region of Valencia are currently protected (39.5% in the Region of Valencia; (ARGOS, 2017), and receive far more attention from the Environmental Administration than highly humanized environments.

Among natural and semi-natural areas, coastal ecosystems were considered prioritaire. The coastal fringe in Spain, and particular in the Mediterranean coast, has been intensively transformed in the last decades (García-Ayllón, 2013). In CFD, in particular, pressures to increase agricultural production and reduce health risks have been major drivers of historical wetland destruction. Thus, stakeholders probably linked degraded wetlands to the restoration of agricultural lands, rather than considering wetlands as a priority criteria for restoration.

Attention to semi-arid forests was not surprising, as semi-arid areas have been subjected to large-scale afforestation and in some way this represents the paradigm of actions to combat desertification in the region (Maestre & Cortina, 2004). Similarly, criteria related to areas affected by desertification and erosion were among those showing the highest priority. North-faced forest slopes were only mentioned by one stakeholder. At this stage, we preferred to include all criteria identified by stakeholders. However, in future exercises, it may be advisable to reduce the number of criteria and thus facilitate later phases of the participative process, by establishing thresholds (e.g., in the minimum number or proportion of interviewees identifying a given criteria).

In the area, there are 455 landfills and waste dumping sites covering 564 Ha (TERRASIT, 2017), and there is a large number of illegal sites that have not been registered. These small piles of trash, mostly construction waste, are dropped by private individuals to avoid landfill fees. Cleaning solid debris may cost between US$ 137 and US$ 364 for a household (Homeadvisor, 2017), but the price strongly depends on location and distance to the closest landfill site or recycling area. Mapping this source of degradation may be difficult, if not supported by volunteer work (Kubásek & Hřebíček, 2014). Clearly, the environmental Administration of CFD should consider this activity as a priority for restoration in the area.

Rivers and floodplains have been deeply modified in the region, resulting in habitat loss, excessive water use, eutrophication and invasion of exotic species. This is the reason why we included river margins within the group of highly humanized areas. The high score obtained by river margins suggests that this criteria would probably receive high priority, even if it was included in the list of natural and semi-natural areas.

Agricultural areas were not a priority for stakeholders when compared to other highly humanized areas. Yet, they were among the ten top priority criteria in the overal list, as a result of the high level conferred to this group. Ecological restoration has often been associated with the recovery of pristine ecosystems, leaving aside areas intensely affected by human activity, as agricultural fields and forest plantations, where current uses prevent this type of restoration. Yet, humanized areas cover large extents of land in the Mediterranean and have large environmental impacts. Recovering historic reference ecosystems may not be feasible or even possible in these highly altered areas, but still they offer ample opportunities to protect biodiversity and increase the provision of ecosystem services (Castro, et al., 2011). Furthermore, restored agricultural fields may provide additional cultural and naturalistic attraction to complement current touristic packages.

Wildfires are one of the main environmental problems currently affecting the Mediterranean basin (Pausas, Llovet, Rodrigo, & Vallejo, 2009), because of their high ecological and social impact, including their toll in human lives and the amount of resources invested in wildfire prevention and extintion. Forests in the dry sub-humid area in CFD are particularly prone to wildfires. Stakeholders were aware of this environmental problem, and perceived that it could be tackled by using ecological restoration. Restoration techniques to reduce vulnerability and increase ecosystem resilience to wildfires include the creation of discontinuities in fuel accumulation, the reduction in tree density and dead wood accumulation, and the planting of resprouting species (Alloza, et al., 2014).

Water availability and quality are big concerns among the population in southeatern Spain. Fresh water demands are largely covered by interbasin water transfers and aquifer depletion, which may result in salinization and ground subsidence (Pulido-Bosch, Morell, & Andreu, 1995), (Tomás, et al., 2005) (Grindlay, 2011). In addition, the Segura River basin is highly affected by eutrophication and pollution (García-Alonso, Gómez, & Barboza, 2015); (Micó, Peris, Sánchez, & Recatala, 2006). Both aspects were considered of high priority by the stakeholder patform.

Sites of high cultural value was the only criteria from the socio-economic and cultural list of criteria included in the final list of priorities for restoration. There are many natural areas simultaneously being cultural references in CFD, including Fondo NP, Santa Pola and La Mata-Torrevieja wetlands, Santa Pola fossil reef, Guardamar sand dunes, etc. While many of these natural areas have been protected, their status of conservation is diverse, and they are frequently in conflict with other land-uses. Thus, Guardamar sand dunes, an early 20th century example of sand dune restoration, are now threatened by a diversity of interacting drivers, including coastaline modification and regresssion, frequentation, urbanization, pine senescence and climate change, which results in massive pine mortality, lack of pine regeneration and empoverished sand dune communities (Aldeguer, 2008).

None of the criteria related to carbon fixation and biodiverity were included in the list of high priority criteria. Other studies in the area have shown that criteria related to biodiversity were highly valued as indicators of forest restoration success, at the same level as soil organic matter and below water retention (Derak & Cortina, 2014). The scarce importance given by stakeholders to carbon fixation may reflect decoupling between local and global environmental problems, and the perception that restoration in this type of environment may not substantially contribute to mitigate climate change.

Through a participatory approach we have been able to identify and weight criteria for the prioritization of restoration actions at a landscape scale. By aggregating cartographic indicators of all or a subset of criteria, we will provide an integrated value of priority for the different sectors of the study area. However, there is no correspondence between the level of priority, as defined in this study, and the state of a particular location, as some criteria (e.g., river margins or areas of high cultural value) may not necessarily be in need of restoration. This map should be combined with cartographic estimations of the degree of integrity (e.g., in terms of the status of biodiversity and the provision of ecosystem services), and the potential cost of restoration to identify priority areas with the highest cost:effectiveness ratio. Finally, the study presented here is based on the aggregation of 88 visions that may not be coincident (Derak, Taiqui, Aledo, & Cortina, 2016). Further exploration may reveal divergent opinions in different stakeholder groups and increase the power of our participative protocol in the decision making process.

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Table 1. Composition of the stakeholder platform to identify priority areas for ecological restoration in Crevillent Forest Demarcation (southeastern Spain).

Professional profile	Number of Individuals
Regional Administration	9
Province Administration	1
Local Administration	8
Farmers	5
Agricultural watering organizations	8
Commerce and Services	3
Eco-cultural and rural development	6
Hunting	3
Eco-commerce	3
Neighbourghs organizations	5
Mining industry	4
Agricultural industry-nurseries	1
Real-state and building	2
Active-adventure leisure	5
NGO’s	4
Natural Park Administration	4
Politicians	5
Trade Unions	2
Tourism	4
University and research centers	6

Table 2. Criteria for the prioritization of restoration actions in Crevillent Forest Demarcation identified and weighed by a stakeholder platform. Criteria are sorted by their across groups scores.

Criteria group	Criteria	Partial weight (within group)	Integrated weight (across groups)
Humanized environments	Landfills and waste dumps	0.25	0.061
Humanized environments	River margins	0.24	0.060
Humanized environments	Unused quarries	0.20	0.051
Ecosystem functions	Key areas to reduce erosion	0.17	0.043
Ecosystem functions	Key areas to reduce water pollution	0.16	0.043
Socio-economic and cultural	Areas with high cultural and ethnologic value	0.20	0.041
Humanized environments	Rainfed crops	0.16	0.039
Ecosystem functions	Key areas to reduce wildfire risk and vulnerability	0.15	0.038
Humanized environments	Irrigated crops	0.15	0.037
Ecosystem functions	Kay areas to retain water	0.14	0.037
Landscape scale features	Protected areas and important conservation areas	0.20	0.033
Landscape scale features	Areas with rare, endemic and endangered species of flora and fauna	0.19	0.032
Socio-economic and cultural	Areas with potential for job creation, dynamization of vulnerable populations	0.16	0.032
Landscape scale features	Corridors connecting natural areas of high value	0.19	0.031
Socio-economic and cultural	Recreation and highly frequented natural areas	0.15	0.031
Ecosystem functions	Key areas to reduce the risk of	0.11	0.030

	flooding		
Socio-economic and cultural	Touristic areas	0.14	0.028
Landscape scale features	Vicinity of Natural Parks and other protected areas	0.17	0.028
Socio-economic and cultural	Areas with potential for development of the tourist industry	0.13	0.027
Ecosystem functions	Key areas to reduce anthropogenic salinization	0.10	0.026
Socio-economic and cultural	Public properties	0.12	0.025
Ecosystem functions	Key areas to fix carbon	0.09	0.024
Landscape scale features	Peri-urban areas which are highly visible and accessible	0.14	0.024
Ecosystem functions	Key areas to control exotic and invasive species	0.08	0.022
Semi-natural environments	Coastal sand dunes and other coastal ecosystems	0.17	0.021
Semi-natural environments	Wetlands	0.16	0.020
Semi-natural environments	Forests with very scarce precipitation (semi-arid)	0.16	0.020
Semi-natural environments	Forests affected by massive dieback	0.16	0.020
Socio-economic and cultural	Vicinity of residential areas, second residences	0.09	0.018
Landscape scale features	Vicinity of transport infrastructures: roads, highways, railways, dirt roads, etc.	0.11	0.018
Semi-natural environments	Forests with scarce precipitation (dry sub-humid)	0.14	0.017
Semi-natural environments	Shrublands and steppes	0.13	0.016
Semi-natural environments	North-faced slopes	0.08	0.010

Fig. 1. Location of Crevillent Forest Demarcation in southeastern Spain and overlook of the diverse land use mosaic. Most prominent land uses are irrigated crops (yellow), rainfed crops (orange), forests (dark green), shrubland and steppes (light green), continental waters (blue) and urbanized (grey). From (PATFOR, 2017) and (SIOSE, 2017).

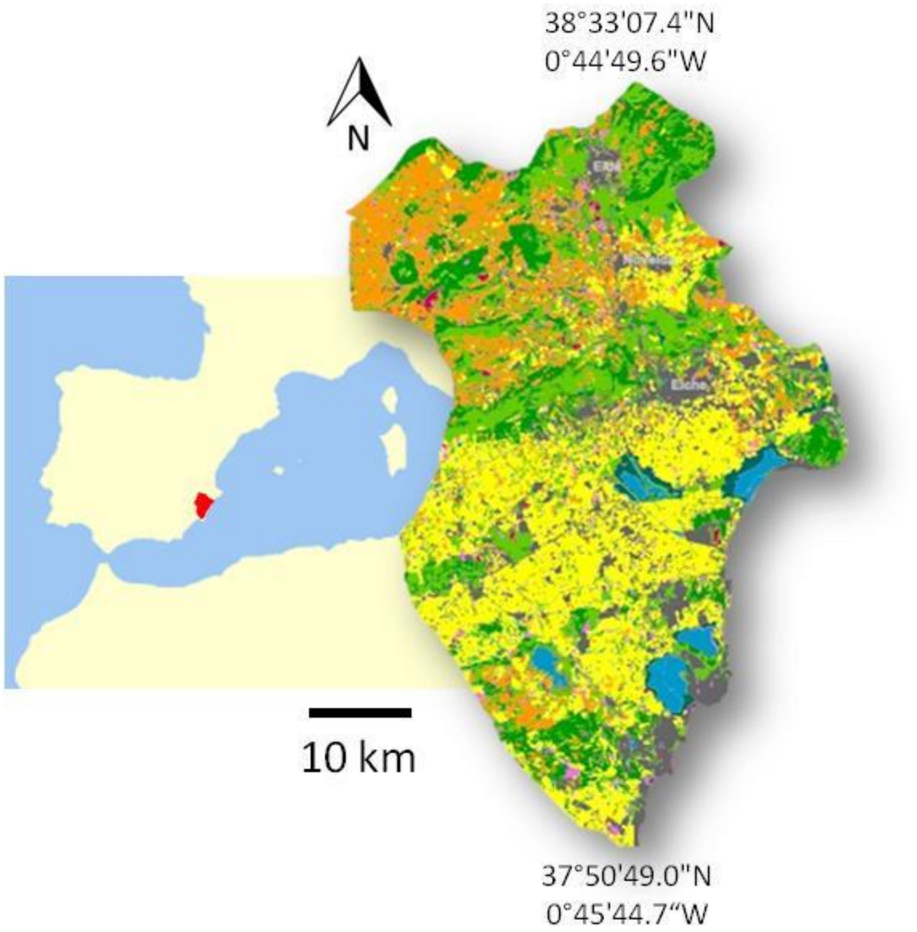

Fig. 2. Results of the participative evaluation of the five groups of criteria to prioritize restoration actions in Crevillent Forest Demarcation (southeastern Spain).