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## Supplementary Materials

### Map S1 GeoTif of Habitat Critical Areas (HPA) at network level

The file is available for download (file name HPA2009, file size 85 MB, zip file 320 KB)

### Section S2 Multitemporal analysis of habitat status within test sites

Landsat-based multitemporal analysis was focused on the difference of the standardized NDVI (2009-1985) values with the aim of recognizing changes in the critical areas [96] with the support of ancillary data (see section 3.4).

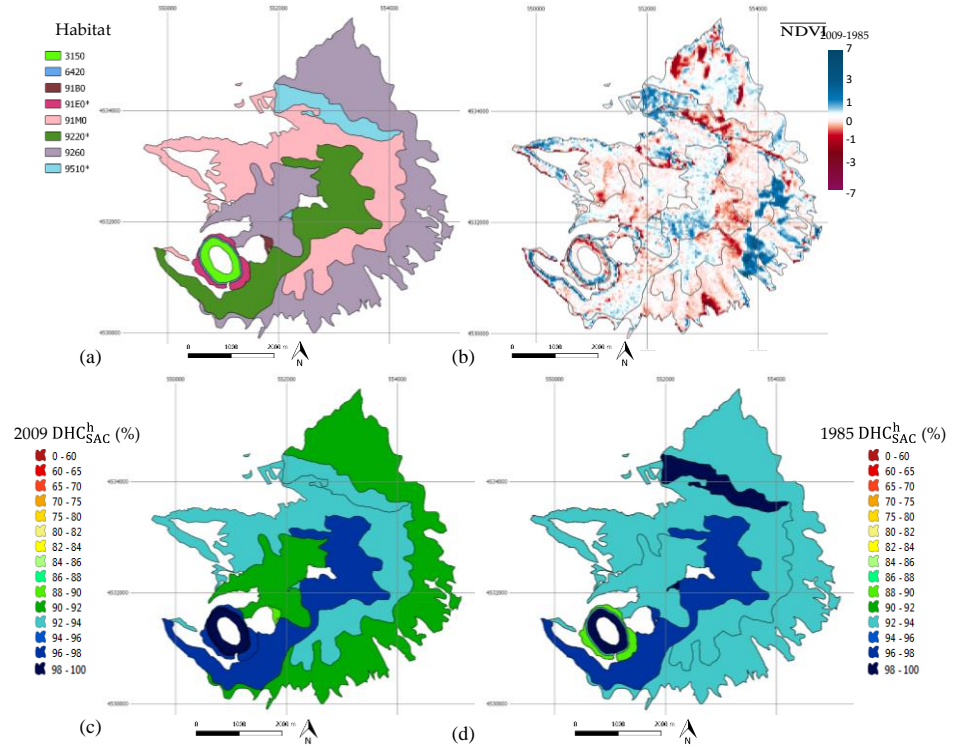
This analysis can help to better adjust the conservation measures to be adopted and to learn ecological lessons from past interventions.

#### S2.1. Monte Vulture

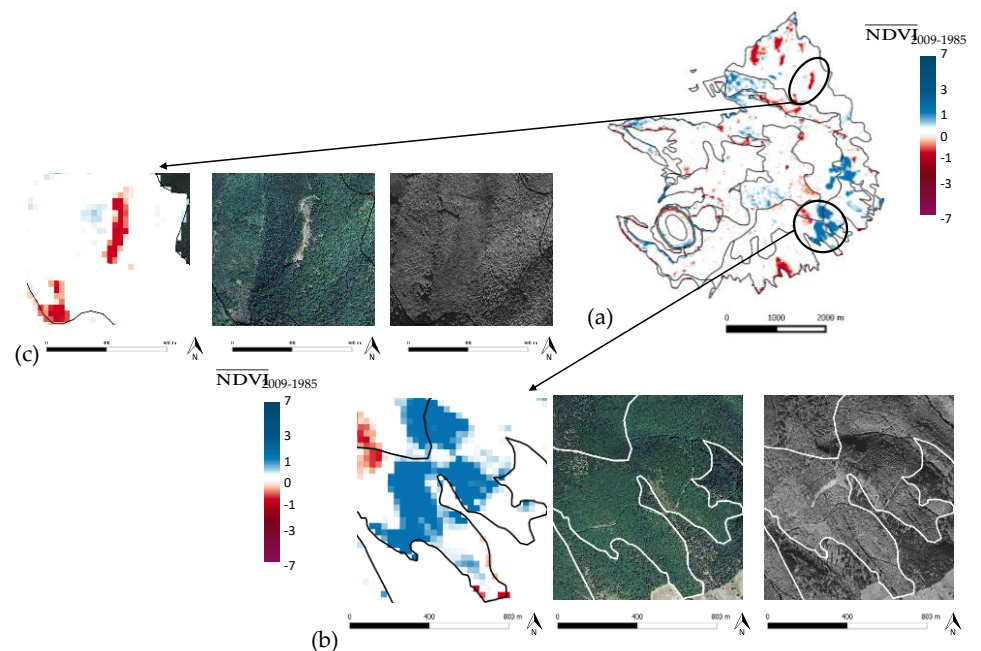
For the Monte Vulture SAC (IT9210210; Figure S1a), the difference maps of the standardized NDVI suggest a dichotomous behavior (Figure S1b): some areas (blue colored) exhibit very high positive values evidencing an overall better health status in 2009 with respect to 1985 conditions, whereas red areas identify potentially anomalous zones. Even though areas with positive values of the index are better clustered, the spatial occurrence of negative values is slightly prevalent producing general higher  $DHC_{SAC}^h$  values for all the habitats in 1985 (except for the habitat 91E0 - *Alluvial forests with Alnus glutinosa* and *Fraxinus excelsior*, see Figure S1c,d).

This worsening of conditions is well-represented by the habitat 9260 (*Castanea sativa* woods, light-purple in Figure S1a) which is characterized by heterogeneous populations resulting in different states of conservation. Areas with a strong increase in standardized NDVI differencing (Figure S1b) have generally experienced forest expansion under favorable site conditions and the contextual protection measures linked to the procedure for the establishment of protected areas (this site has been proposed as SCI since 1995 and classified as SPA in 1999). Figure S2a,b show this positive tendency for southern-eastern areas belonging to the major patch of the habitat 9260 as it emerges clearly from the comparison between 2008 and 1988 orthophotos.

Nonetheless, the prevalence of forest cover gain is partially counterbalanced by a decline of vegetation activity as occurred in some areas within the same habitat 9260 (in the northern part of the major patch, see Figure S2a,c). Here the progressive abandonment of forest management practices has not been stopped by the approval of stricter protection policies, causing over time an increasing presence of severely damaged trees (dead or dying) especially in state-owned areas (see <http://www.retecologicabasilicata.it/ambiente/site/portal/detail.jsp?sec=107281&otype=1012&id=109488>, last access on 18 March 2022). These areas, differently from private forests, require greater management efforts for the future because the analysis of the 1988 orthophoto reveals that their overall status could be considered not alarming in 1985.



**Figure S1.** Multitemporal analysis on the Monte Vulture SAC: (a) Map of habitats; (b) Map of  $\overline{\text{NDVI}}$  differencing (2009-1985); (c) Map of the  $\text{DHC}_{\text{SAC}}^{\text{h}}$  index (2009); (d) Map of the  $\text{DHC}_{\text{SAC}}^{\text{h}}$  index (1985).

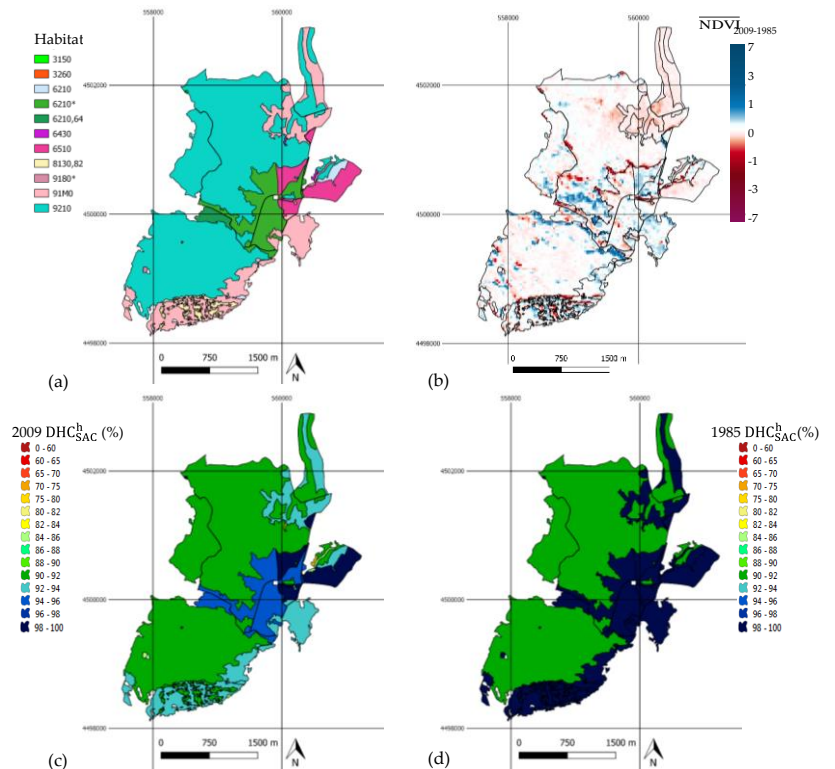


**Figure S2.** Examples of changes in vegetation matrix within the Monte Vulture SAC: (a) Map of  $\overline{\text{NDVI}}$  differencing (2009-1985); (b) recovering of vegetation conditions for the habitat 9260 (*Castanea sativa* woods) due to forest expansion under favorable soil and policy conditions; (c) vegetation decline in the same habitat 9260 due to improper management practices of forest areas.

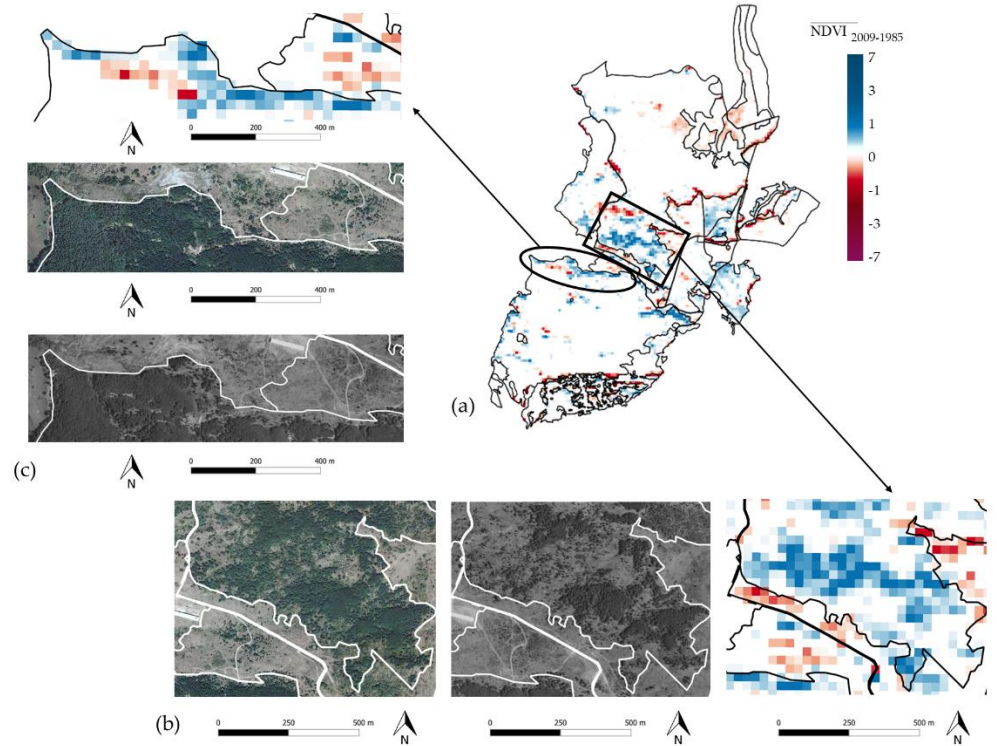
## S2.2. Monti Li Foi

The SAC of the Monti Li Foi (IT IT9210215; Figure S3a) shows a complex pattern of the  $\overline{\text{NDVI}}$  in the period 1985-2009 (Figure S3b). For all the habitats the 1985  $\text{DHC}_{\text{SAC}}^{\text{h}}$  is greater or equal to the 2009  $\text{DHC}_{\text{SAC}}^{\text{h}}$  (Figure S3c,d). This is mainly due to the presence of sparse anomalous areas in 2009 within habitats prevalently herbaceous such as 6510 (*Lowland hay meadows - Alopecurus pratensis, Sanguisorba officinalis*), 6210\* (*Semi-natural dry grasslands and scrubland facies on calcareous substrates - \*important orchid sites*), and 8130/8220 (*Western Mediterranean and thermophilous scree/ Siliceous rocky slopes with chasmophytic vegetation*). In addition, for the dominant habitat 9210 (*Apennine beech forests with Taxus and Ilex*), as it can be easily seen by looking at the Figure S3c, the standardized NDVI difference map suggests a variegated picture: a core of positive and high values are concentrated in the central belt of the site, counterbalanced by low-intensity negative values that are pervasively spread in the remaining part of the site. What changes is only the different geography of anomalies shaping the same  $\text{DHC}_{\text{SAC}}^{\text{h}}$  value for the years 1985 and 2009.

In particular, a tendency toward forest expansion associated to a reduction of glades was observed, presumably due to the recolonization of herbaceous areas, that were responsible for vegetation fragmentation in the Eighties (see Figure S4b,c comparing the 2008 and 1988 orthophotos), already observed in other similar studies [72]. Probably, the significant interest raised around this site since 1979, when the Italian Botanical Society put effort into conducting a census of vegetation species, has led to an increased attention to these areas that have been proposed as SIC in 1995. Contextually, a responsible management of natural and anthropic covers within the site (as in the case of the habitat 6510 - *Lowland hay meadows - Alopecurus pratensis, Sanguisorba officinalis*, magenta in Figure S3a) has led to sustainable environmental conditions.



**Figure S3.** Multitemporal analysis for the Monti Li Foi SAC: (a) Map of habitats; (b) Map of standardized NDVI differencing (2009-1985); (c) Map of the  $\text{DHC}_{\text{SAC}}^{\text{h}}$  index (2009); (d) Map of the  $\text{DHC}_{\text{SAC}}^{\text{h}}$  index (1985).



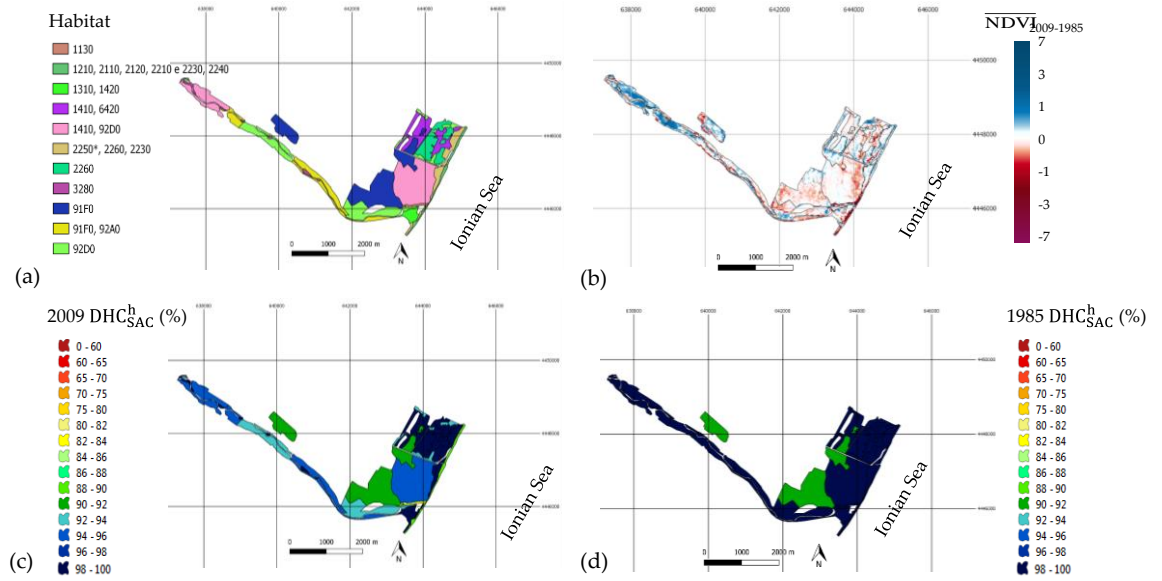
**Figure S4.** Examples of amelioration of vegetation matrix within the Monti Li Foi SAC: (a) standardized NDVI differencing map (2009-1985); (b) and (c) recolonization of sparsely vegetated areas over time in the habitat 9210 (*Apennine beech forests with *Taxus* and *Ilex**).

### S2.3. Bosco Pantano di Policoro

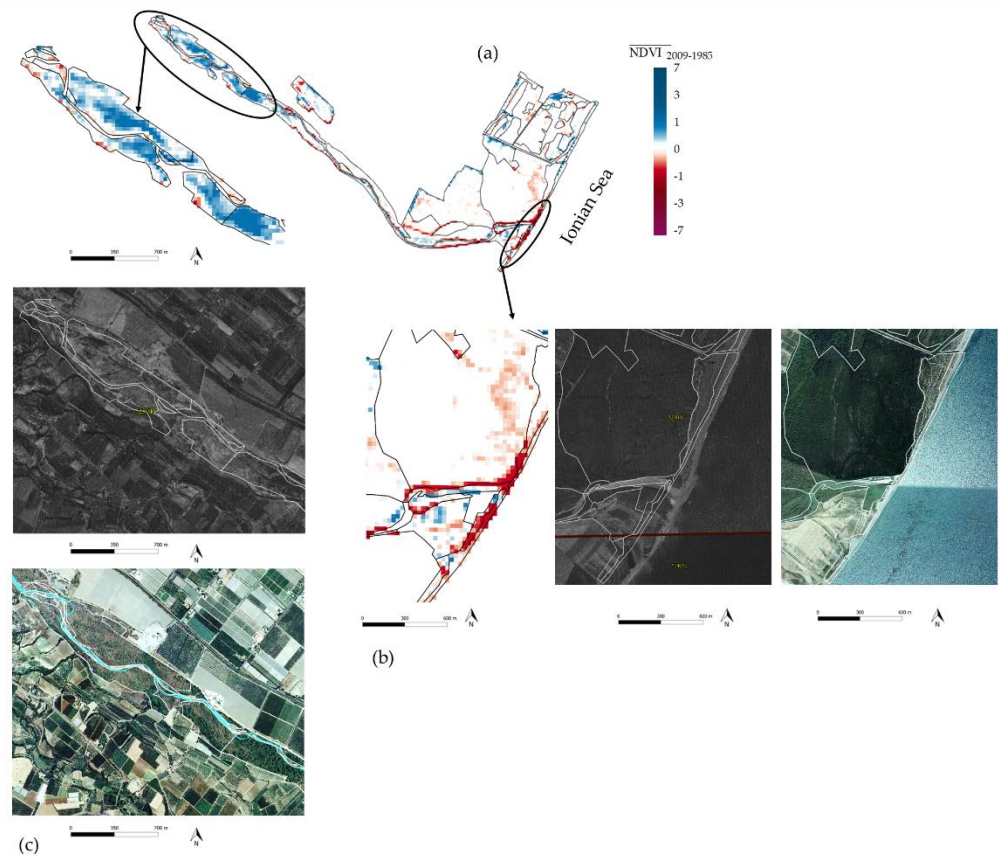
The site of Pantano di Policoro and Costa Ionica Foce Sinni (IT9220055, Figure S5a) shows a prevalence of vegetation recovery especially for forest habitats. In Figures S5b the long and narrow riparian corridor along the Sinni River, expanding northwestwards from the mouth to the inner areas, is characterized by high values of the standardized NDVI differencing. On the contrary, dune and meadow habitats (especially the habitat 2260 - *Cisto-Lavanduletalia dune sclerophyllous scrubs* and the association between the habitats 1410 and 6420 - *Mediterranean salt meadows and Mediterranean tall humid herb grasslands of the *Molinio-Holoschoenion**, respectively bluish-green and purple in Figure S5a) appear affected by negative values of the standardized NDVI differencing (Figures S5b). This does not imply necessarily the emerging of anomalies that appear very sparse with a slightly higher number in 2009 resulting in greater values of the 1985  $DHC_{SAC}^h$  (Figure S5c,d).

In summary, areas belonging to the old planitial woods show a positive trajectory toward healthier conditions (Figure S6a,b), although the 2009  $DHC_{SAC}^h$  is lower compared to that of 1985 mainly because the positive values of the index are compensated by the occurrence of widespread negative values characterizing the same habitat located in front of the coast (this is the case of the habitat 92D0 with 1410 - *Southern riparian galleries and thickets with Mediterranean salt meadows with *Juncetalia maritime** – pink in Figure S5a). In any case, for this forest area, the increase of photosynthetic activity is probably due to the establishment of the site as SCI since 1995 and the following classification as SPA in 1999 (contemporaneously with the establishment of the Natural Oriented Reserve of the Bosco Pantano di Policoro by the Regional Law no.28).





**Figure S5.** Multitemporal analysis for the Pantano di Policoro and Costa Ionica Foce Sinni SAC: (a) Map of habitats; (b) Map of standardized NDVI differencing (2009-1985); (d) Map of the  $DHC_{SAC}^h$  index (2009); (e) Map of the  $DHC_{SAC}^h$  index (1985).



**Figure S6.** Examples of changes in vegetation matrix conditions (2009-1985) within the Pantano di Policoro and Costa Ionica Foce Sinni SAC: (a) Standardized NDVI differencing map (2009-1985); (b) Habitats included in the ancient planitial wood (91F0 - Riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia*; 92D0 with 1410 - Southern riparian galleries and thickets with Mediterranean salt meadows with *Juncetalia maritime*; 92A0 - *Salix alba* and

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*Populus alba* galleries; 91F0- Riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia*) showing a good recovery with respect to 1985 under stricter environmental policies; (c) The impressive retreating coastline (compare 2008 and 1988 orthophotos and follow the boundaries of habitats to understand the severity of the issue) and its impacts on dune habitats, especially 1410 - *Mediterranean salt meadows* with 92D0 - *Southern riparian galleries and thickets* (pink in Figure S5a), and 1310 - *Salicornia* and other annuals colonizing mud and sand with 1420 - *Mediterranean and thermo-Atlantic halophilous scrubs* (light green in Figure S5a).

These habitats, damaged by past land reclamation works and intensive agricultural activities [95] and having the shape of barren riverbeds in 1985 (Figure S6b), have probably benefited from the application of the National Law no. 431/1985 (the so-called Galasso Law). This policy has promoted landscape conservation schemes for areas of particular natural and cultural interest (coastal areas, rivers, lake, volcanic areas, archeological sites, etc.) limiting modifications in land use within a belt of 150m from the banks of rivers and 300m from coasts. In this case, national/regional regulations have allowed a general improvement of the vegetation conditions for the preservation of hygrophilous woods.

Differently, most of herbaceous habitats (mainly dunes), located close to the coast and playing a notable role in modelling landscapes as crucial elements within the transition ecosystem between land and sea, have undergone a continuous alteration. This is due to the significant and progressive coastline withdrawal caused by the increasing erosive action of the sea and the drastic reduction of sediment transport produced by hydraulic-engineering measures (dams and small barrages) adopted both in mountainous areas and in floodplains (Figure S6c, see [79,80,96,97]). This translates in negative values of the  $\overline{NDVI}$  and in lower values of the  $DHC_{SAC}^h$ .