

1 **Guest or pest? Spatio-temporal occurrence and effects on soil and vegetation of**
2 **the wild boar on the Elba island.**

3 Ilaria Greco¹, Ettore Fedele², Marco Salvatori^{1,3}, Margherita Giampaoli Rustichelli¹, Flavia
4 Mercuri¹, Giacomo Santini¹, Francesco Rovero^{1,3}, Lorenzo Lazzaro¹, Bruno Foggi¹, Alessandro
5 Massolo⁴, Francesco De Pietro⁵, Marco Zaccaroni¹

6 ¹ Department of Biology, University of Florence, Madonna del Piano 6, IT-50019 Sesto Fiorentino,
7 Italy;

8 ² Department of Genetics, University of Leicester, University Road, LE1 7RH, United Kingdom;

9 ³ Tropical Biodiversity Section, MUSE - Museo delle Scienze, Corso del Lavoro e della Scienza 3,
10 IT-38122 Trento, Italy;

11 ⁴ Department of Biology, University of Pisa, Via Volta 6, IT-56126, Pisa, Italy;

12 ⁵ Tuscan Archipelago National Park , Locality Enfola, IT-57037, Portoferraio, Livorno, Italy;

13

14 Corresponding author:

15 Zaccaroni Marco

16 University of Florence, Department of Biology, Madonna del Piano 6, IT-50019 Sesto Fiorentino,
17 Italy

18 marco.zaccaroni@unifi.it

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20 Running title: The wild boar on the Elba island

21

22 **Abstract**

23 In areas where allochthonous large mammals, such as the wild boars (*Sus scrofa*), occur in high
24 density, human-wildlife conflicts may arise. In these contexts, assessing spatio-temporal patterns of
25 the introduced population is paramount to its management. Here, we studied wild boars in the Elba
26 island, Italy, where they have been introduced and are perceived as pests. While crop-raiding has
27 been documented, no studies addressed the spatio-temporal occurrence, nor the impact of foraging
28 on natural habitat. We surveyed the Western part of the island with three camera trapping surveys
29 within one year. We found that the species' estimated occupancy probability was higher in summer-
30 autumn (0.75 ± 0.14) and winter-early spring (0.70 ± 0.10) than in late spring-summer (0.53 ± 0.15),
31 whereas detection probability did not vary. Occupancy was significantly associated with elevation
32 and vegetation cover, with preference for lower elevation and woodland. The lower site use of wild
33 boars during spring-summer might reflect lower food availability in this season, and/or movements
34 towards landfarms outside the sampled area. Detectability increased with proximity to roads during
35 spring-summer and decreased with humans' relative abundance in the other periods. Moreover,
36 boars were mainly nocturnal, with an overlap with human activity that decreased when human
37 presence was higher. Combined, these suggest behavioural avoidance of human disturbance by
38 boars. We also evaluated the impact of boars' foraging on the soil and vegetation and found that it
39 was higher in pine plantations than other covers, however, it was not associated with variation in
40 boars' occupancy across habitats. Our results indicate that the spatio-temporal activity of wild boars
41 on Elba island appears driven by seasonal preferences for food-rich cover and avoidance of human
42 disturbance. The lowered site use in months with lower resources could partially reflect increased
43 proximity to settled and farmed areas, which may, in turn, trigger crop-raiding and hence the
44 negative perception by residents.

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46 Camera trapping, *Sus scrofa*, occupancy modelling, allochthonous species, islands, Italian
47 archipelago.

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53 **Introduction**

54 The wild boar (*Sus scrofa*) is an ungulate that often triggers a wide range of human-wildlife
55 conflicts, whose demographic history in Europe is complex and affected by various reintroductions
56 and translocations. The species is native to the Eurasian continent (Barrios-Garcia and Ballari,
57 2012), with two native forms in central Italy (Apollonio et al., 1988; Iacolina et al., 2016), and it
58 carries out crucial ecological functions (Selva et al., 2005; Fonseca, 2008; Mori et al., 2017). Yet, it
59 is often associated to a broad range of socio-economic issues primarily related to its high abundance
60 (Bosch et al., 2016; Aguillar et al., 2018; Jägerbrand and Gren, 2018), the ability to colonize novel
61 environments, including suburban and urban areas, and its impacts on croplands and harvests
62 (Herrero et al., 2006; Schley et al., 2008). Its reputation as problematic wildlife is often exacerbated
63 where it is non-native, its natural predators are absent, or wildlife management is not properly
64 conducted (Bieber and Ruf, 2005; Toïgo et al., 2008). In the last 30 years, the distribution range of
65 the wild boar has largely expanded due to anthropogenic and environmental factors (Bieber and
66 Ruf, 2005; Geisser and Reyer, 2005; Hearn et al., 2014; Tack, 2018.), with the uncontrolled
67 restocking for hunting purposes being one of the major causes. This practice had led to the
68 introduction of such highly plastic and prolific species on islands, including the Tuscan Archipelago
69 before it became a national park in 1996 (Meriggi et al., 2015). Island ecosystems are particularly
70 vulnerable to the effects of introduced populations for geographic isolation and the higher
71 specialization of native species (Russel et al., 2017). In this context, wild boars can reach high
72 densities since natural predators and competitors are usually absent. As an important ecological
73 engineer (Jones et al., 1994), boars can trigger knock-off effects on biocenosis that span from the
74 extensive rooting of slopes and soils, ground aeration, uprooting and trampling of seedlings, the
75 creation of germination niches for plants, and the direct consumption of flora and fauna with
76 potential high conservation interest (Massei and Genov, 2004; Sendom et al., 2012).

77 In the Tuscan Archipelago National Park (TANP) wild boars have been introduced and occur only
78 on the Elba, where they have been recorded for the first time at the beginning of the 20th century
79 (Damiani, 1923). Subsequently, other individuals from eastern Europe were introduced in the 1960s
80 as a game species (Meriggi et al., 2015). The absence of natural predators and direct competitors on
81 the island allowed the new population to increase and expand over the whole area, taking advantage
82 of its generalist diet and high fecundity. In particular, the Western part of the island, designated as a
83 national park with prohibited hunting, is assumed to host a relatively higher wild boars' presence,
84 potentially impacting natural habitats and agricultural fields (Monaco, 2010). The Elba is also a
85 popular tourist destination, and the presence of boars often raises concerns for human safety,

86 especially in summer when incursions towards farmlands and residential areas are documented
87 (Giannini and Montauti, 2010). Their impacts on the island include collision with vehicles,
88 destruction of dry walls, crop damages, degradation of meadows and traditional agricultural systems
89 as well as native flora and fauna in general (Serra et al., 2001, Giannini and Montauti, 2010, Acosta
90 and Ercole, 2015, Meriggi et al., 2015). Its feeding behaviour, characterized by the typical rooting
91 activity, can alter and erode the soil substrate by removing the superficial vegetation stratum
92 (Siemann et al., 2009, Wirthner et al., 2012). At present, contrasting information is available
93 concerning the effect of the wild boars' feeding behaviour, although previous studies have
94 demonstrated that their rooting activity causes a decline of native flora and support plant invasions,
95 especially on islands where ungulates were not historically present (Aplet et al., 1991; Oldfield et
96 al., 2016). In a few decades, wild boars became so widespread and the socio-economic impacts so
97 severe that since 1997 the TANP has promoted a series of management actions with an average of
98 600 individuals captured each year and approximately 12,000 wild boars removed from the park
99 (TANP, 2018). However, while the economic damage caused by wild boars has been documented
100 for this island (Meriggi et al., 2015), no studies have assessed the spatial and temporal patterns of
101 wild boars' occurrence, nor the impact of foraging on natural habitat.

102 Here, we studied wild boars in the Western part of Elba using camera traps during three seasons; we
103 also sampled the status of soil and vegetation and aimed to i) assess wild boars habitat use in
104 relation to environmental and anthropogenic variables, and its variations across surveys in different
105 seasons; ii) determine its temporal activity and evaluate differences among seasons in relation to
106 human presence; iii) assess the rooting and grazing activity across macrohabitats to determine the
107 impact of foraging and its potential correlation with boars' occurrence.

108

109 **Methods**

110 *Study area*

111 The study was conducted on the Western part of the Elba island (42° 46'20.4"N, 10° 10'14.4"E), and
112 within the borders of the TANP, in Central Italy (Fig. 1). The island extends for 302 km², whilst the
113 park's area encompasses 206,3 km² (Meriggi et al., 2015). The Elba is characterized by a
114 Mediterranean climate, with a yearly mean temperature of 16.5°C, dry summers and mild winters,
115 and a localized colder microclimate with sporadic snowfalls on the top of the Mount Capanne,
116 which represents the highest peak with 1,016 m a.s.l. (Foggi et al., 2006). Mean yearly
117 precipitations amount to 595 mm, with periods of drought during the summer months, characterised

118 by scanty rainfalls (down to 13 mm), and temperatures exceeding 30°C during the hottest time of
119 the day (Meriggi et al., 2015). The study area is characterized by woodlands, on the northern slopes
120 and several types of maquis and garrigues; these last two result the most represented habitats on the
121 southern slopes. Patches of pine plantations (*Pinus sp.*) are also scattered along the mountain slopes
122 and derived from the reforestation policies of the 1950s. Thus, we distinguished five major
123 macrohabitats: holm-oak woods (*Quercus ilex*), chestnut groves (*Castanea sativa*), pine plantations,
124 low Mediterranean maquis, including garrigues, with characterised by rosemary (*Rosmarinus*
125 *officinalis*), lavender (*Lavandula stoechas*) and rockroses (*Cistus sp. pl.*) (hereafter "low maquis"),
126 and Mediterranean maquis with vegetation > 1 m characterised by strawberry trees (*Arbutus unedo*)
127 and tree heath (*Erica arborea*) (hereafter "tall maquis"). Urban and agricultural areas are located
128 just outside the borders of the TANP, with fields mainly cultivated as orchards and vineyards, and a
129 major paved road connecting the towns that rings the edge of the park.

130 ***Data collection***

131 Boars' detections were collected using camera traps (CTs) deployed in the study area (from 160 to
132 1,000 m a.s.l.) between April 2018 and April 2019 (Fig. 1). The survey consisted of three separate
133 sampling periods, each deploying 80 camera stations: from the 27th of April to the 15th of July 2018
134 (spring-summer), from the 1st of September to the 18th of November 2018 (late summer-autumn)
135 and from the 18th of January to the 8th of April 2019 (winter-early spring). For each sampling
136 period, cameras were active in the field for a minimum of 19 days and, due to equipment and time
137 constraints, we used 20 motion-triggered camera traps of three different brands (Ltl Acorn MC-
138 6210 – Shenzhen, Guangdong, China; Spromise HD CAM – Shenzhen, Guangdong, China; and U-
139 way MB 500 – Vigilant Hunter®, Atlanta, Georgia, USA) deployed in four consecutive arrays of 20
140 CTs each. The devices had similar technical characteristics as they mounted IR flash and 0.8–1 sec
141 trigger speed. Due to the dense vegetation and the harsh terrain, CT stations were placed in
142 proximity of trekking trails, about 20 m off-trails, following the altitudinal gradient of the
143 mountains, with approximately 500 m spacing between cameras. Every camera trap was secured to
144 trees' trunks at approximately 50 cm from the ground, and in the proximity of signs of wildlife
145 presence (scats, footprint, etc.). We did not use baits or lure. Eight CTs were moved after the first
146 sampling period due to the inaccessibility of the terrain, whereas between sampling periods,
147 cameras were placed in a buffer of approximately 20 m around the selected CT station point yet
148 trying to be as close as possible to the original sampling location. For every CT station, we
149 collected environmental data to be used as covariates in the occupancy analyses. Thus, we recorded
150 the elevation, the macrohabitat (low maquis, tall maquis, pine plantation, chestnut groves, and

151 holm-oak wood), the dominant vegetation type (wood, understory, shrub), and visually estimated on
152 a continuous scale the percentage of tree, shrub and grass coverage in the area surrounding the CT
153 station.

154 To assess the impact of boar foraging on soil and vegetation, we followed the protocol in Lazzaro et
155 al. (2015). Thus, we deployed 80 plots of 10x2 m centred on the CT. The vegetation survey was
156 carried out from the 29th of April to the 5th of May 2019, and plots were distributed across all five
157 macrohabitats. Ground quality within each plot was assessed using a discrete scale from "1" (well-
158 preserved ground with high plant species richness) to "3" (highly degraded soil with highly-
159 damaged vegetation, signs of erosion and/or soil compactness). We also estimated the percentage of
160 torn-off ground within the plot, as a proxy of the intensity of wild boar rooting activity.

161 *Data analyses*

162 Camera trap images were annotated using the open-source software Wild.ID (Fegraus and
163 MacCarthy, 2016), which allowed for species classification using the IUCN taxonomy. From the
164 resultant file, we extracted all records related to the wild boar and estimated for each separate
165 season the number of independent events (with a 30 min threshold between photographs) to avoid
166 counting multiple times the same individual at the same CT station. With the independent events,
167 we estimated the Relative Abundance Index (RAI) for each sampling period calculated as events on
168 sampling effort and multiplied by 100. We also derived the naïve occupancy, i.e. the proportion of
169 sites occupied on sites sampled. With the site- and season-specific RAI values, we created a
170 proportional symbol map in the open-source software Quantum Gis (QGis Development Team,
171 2019) to display seasonal patterns of wild boars' raw detections and used the wild boar RAI as a
172 proxy for the intensity use of every CT station (Sollmann, 2018).

173 To estimate the wild boar "true" occupancy (\mathcal{P}) across the study area (i.e., with account for
174 imperfect detection p), we used the single-species occupancy modelling (MacKenzie et al., 2002),
175 implemented in R (R Core Team, 2019) using "unmarked" (Fiske and Chandler, 2011). We decided
176 to use single-season models instead of dynamic models as our aim was to determine habitat
177 association in each "season" rather than evaluating dynamic parameters. In addition, as described in
178 Data collection, we could not ensure complete consistency in sites samples across seasons. Thus,
179 we built detection histories for each season, arranging them as sites by sampling matrices, with a
180 resolution of 1 day. We built a number of models using site-covariates: besides the plot-level
181 environmental variables collected in the field (elevation, macrohabitat type, vegetation type, and
182 percentage of grass - shrub - tree coverage), we also measured the distance to the closest town and
183 the distance to the closest main road measured with the built-in tool in QGis, over a 1:10,000 scale

184 map. Additionally, we used as covariates the slopes of the mountain (North-South), the camera trap
185 model, and the RAI of human activity ("RAI humans") estimated at CT station-level with a 1-day
186 threshold, since human presence can affect activity patterns of large mammalian species (Oberosler
187 et al., 2017; see Suppl. Table 1 for a list of covariates). We excluded from the analyses the distance
188 from the closest main town to avoid collinearity since it resulted correlated to the distance to the
189 closest main road (we used $r = 0.5$ as reference threshold for the correlation coefficient). We
190 assessed model fit and compared models using the Akaike Information Criterion (AIC) and selected
191 as statistically best supported the models with $\Delta AIC < 2$. Using the package "AICcmodavg"
192 (Mazerolle, 2019), we averaged the best models and derived predictions for Ψ and p for each
193 sampling period in relation to the selected covariates.

194 To investigate the temporal pattern of wild boars' occurrence, we used a non-parametric Kernel
195 Density Estimation (KDE) function, using the package "Overlap" (Meredith and Ridout, 2014),
196 following the protocol in Ridout and Linkie (2009). For each sampling period, we used the
197 timestamp of each independent event, derived with a 30 min threshold to create an activity
198 distribution curve. In addition, to assess seasonal differences in boars' activities to the disturbance in
199 the park (i.e., human presence), we estimated the seasonal overlap coefficient Δ , ranging from 0 (no
200 overlap) to 1 (complete overlap), between the wild boars and humans by performing pairwise
201 comparisons of their diel activity patterns. We then generated distribution overlap values by
202 performing 999 bootstraps to estimate confidence intervals (Ridout and Linkie, 2009; Meredith and
203 Ridout, 2014). We expected the overlap to be smaller with greater disturbance and used a one-way
204 analysis of variance (ANOVA) to test significant differences between seasonal overlap values.

205 To evaluate the impact of boar grazing on soil and ground vegetation, we measured the level of soil
206 degradation across macrohabitats (i.e. vegetal species richness, ground compactness/erosion)
207 expressed as a discrete scale. Since torn-off ground resulting from wild boar rooting activity can
208 accumulate through time and can last for several months (Welanders, 2000; Horčíčková et al., 2019),
209 we estimated a yearly occupancy probability (ψ total) from the seasonal occupancy as a proxy of
210 the site-use intensity during the whole sampling period. This approximation is plausible given the
211 spacing between sampling locations and the high resolution of the wild boars' presence. Hence, to
212 assess spatial patterns in rooting activity, we implemented a Binomial Generalised Linear Model
213 (GLM) with the intensity of rooting activity (i.e. the percentage of torn-off ground) as the response
214 variable and macrohabitat type as the explanatory variable. Subsequently, to assess potential
215 differences of wild boar site use across macrohabitat, we performed a Gaussian GLM with yearly
216 site use probability as the response variable and macrohabitat type as the explanatory variable.

217 Lastly, we computed multiple Ordinal Logistic Regression models (Agresti, 2002) for testing
218 association between the degradation status of the ground, which was the response variable, and the
219 yearly wild boar site use, the intensity of the rooting activity and the type of macrohabitat as
220 explanatory variables. Model selection and ranking were then performed using the AIC. Binomial
221 and Gaussian GLMs were carried out using the built-in R package "stats", whereas Ordinal Logistic
222 Regression models were performed using the package "MASS" (Venables and Ripley, 2002).
223 Statistical assumptions were verified graphically.

224

225 **Results**

226 During the surveys, 9 cameras produced no data as they were either stolen or malfunctioning, yet
227 we reached a robust sampling effort in every season (> 1000 days, Table 1). We detected the
228 presence of 4 medium-to-large wild mammal species, 3 domestic species, several small mammals
229 and birds, and various human detections in the forms of trekkers/bikers and vehicles (see Suppl.
230 Table 2). Based on raw detection indices, wild boars appeared among the most photographed
231 wildlife on the island, with their raw detections and activity varying greatly across seasons (Table 2,
232 Fig. 2, see also Suppl. Fig 1 - 3).

233 For every season, the "null" model (i.e. no covariates) was the least supported. For each sampling
234 period, multiple models resulted best-supported ($\Delta AIC < 2$); hence we estimated Ψ and p by
235 averaging them (Table 3). Models results showed that the wild boars had different occurrence levels
236 in the study area across seasons, with the spring-summer period displaying the lowest occupancy
237 probability ($\Psi = 0.53 \pm 0.15$ SE) compared to late summer-autumn ($\Psi = 0.75 \pm 0.14$) and winter-
238 early spring ($\Psi = 0.70 \pm 0.10$). Conversely, average detectability was similar across seasons ($p_1 =$
239 0.19 ± 0.05 ; $p_2 = 0.16 \pm 0.03$; $p_3 = 0.12 \pm 0.03$). Habitat characteristics associated with the wild
240 boar's Ψ and p varied slightly according to the sampling season (Table 4). Elevation and vegetation
241 types were the covariates significantly associated with its occupancy probability (Fig. 3, Fig. 4). In
242 particular, the wild boar occupancy significantly decreased with increasing elevation during spring-
243 summer (-1.06 ± 0.46 , $P < 0.05$) and winter-early spring (-1.08 ± 0.45 , $P < 0.01$), whilst occupancy
244 increased significantly with woodland as main vegetation type for both spring-summer (3.33 ± 0.42 ,
245 $P < 0.05$) and late summer-autumn (2.67 ± 0.91 , $P < 0.01$). During this latter period, also the
246 understory (tall maquis) had a significant positive association with the occupancy probability (2.28
247 ± 1.01 , $P < 0.05$). Only in spring-summer, the low Mediterranean maquis was negatively associated
248 with Ψ (-2.89 ± 1.57 , $P = 0.07$), whilst a higher percentage of shrub coverage was positively

249 associated to a higher occupancy probability (1.21 ± 0.63 , $P = 0.05$), although both effects were
250 only marginally significant. The distance to the closest road, the percentage of shrub cover, the
251 habitat types, the human RAI, and camera models were the covariates affecting the wild boar
252 detection probability, though with a seasonal variation. During spring-summer, wild boar detection
253 probability increased significantly in proximity to the main road (0.67 ± 0.16 , $P < 0.001$), whereas it
254 was significantly lower with higher shrub coverage (-0.53 ± 0.18 , $P < 0.01$). The detection
255 probability had a significant negative association with greater human activity in the study area
256 (human RAI) during both summer-autumn (-0.36 ± 0.10 , $P < 0.001$) and winter-spring ($-0.50 \pm$
257 0.17 , $P < 0.01$). A similar pattern was found also for both the tall Mediterranean maquis (-0.82 ± 23 ,
258 $P < 0.001$ for the second sampling season and -0.80 ± 0.32 , $P < 0.01$ for the third one) and the low
259 maquis (-1.95 ± 0.72 , $P < 0.01$ for the second season and -1.28 ± 0.37 , $P < 0.001$ for the third one)
260 (Table 3). Detection probability was also affected by camera models with U-way trail camera (1.79
261 ± 0.62 , $P < 0.01$ during spring-summer) and Spromise (0.69 ± 0.25 , $P < 0.01$ during summer-
262 autumn) determining higher detectability.

263 The diel activity pattern of wild boars appeared consistent across sampling periods, with the
264 intensity of the activity decreasing after sunrise and increasing during sunset hours (Fig. 5a). On the
265 other hand, the overlap between wild boars and humans activity patterns were significantly different
266 between seasons, with overlap being smaller during late summer-autumn ($\Delta = 0.29$; $0.22 - 0.36$),
267 compared to spring-summer ($\Delta = 0.36$; $0.25 - 0.48$) and winter-early spring ($\Delta = 0.32$; $0.18 - 0.46$)
268 (Fig. 5b).

269 We found a significantly higher percentage of overturned soil within the pine plantation patches (P
270 < 0.04), and lower erosion in the low maquis ($P = 0.06$, Table 5, Fig. 6a). While the latter cover was
271 the least intensively used, pinewoods were not the most frequently-used macrohabitat (Fig. 6b). The
272 degradation status of the ground appeared affected by the wild boar's site-use intensity, in
273 conjunction with their rooting activity at a site, as well as by the macrohabitat-specific
274 characteristics (see Suppl. Table 3), although the effect of interaction between wild boars'
275 occurrence and rooting activity is questionable as the difference in AIC between the two models is
276 less than 2. Furthermore, pinewoods and a higher presence of overturned soil were the factors
277 significantly associated with higher levels of degradation. In contrast, a high wild boar presence,
278 which translated in a more intensively-used site, did not coincide with a greater degraded ground
279 (Table 6).

280

281 **Discussion**

282 We studied the spatio-temporal activity of wild boars on Elba island and found that the species is
283 widespread across the study area, with an estimated occupancy that seasonally reaches average
284 values of 0.75. Variations in spatial occurrence and diel activity pattern among seasons appear
285 driven by seasonal preferences for food-rich cover and avoidance of human disturbance. In
286 particular, the lowered site use in months with lower resources could partially reflect increased
287 proximity to settled and farmed areas, which may, in turn, trigger crop-raiding and hence the
288 negative perception by residents.

289 Seasonal movement patterns associated with the availability of food resources are compatible with
290 the "food exploitation hypothesis" proposed by Larter and Gates (1994), with animals adjusting
291 their distribution range to optimize the use of trophic resources in the area. Wild boars exhibit
292 strong responses toward food pulse (Cutini et al., 2013), hence their foraging activity can affect
293 their home ranges, with the use of different areas in different seasons. Our findings, in particular,
294 are consistent with Meriggi et al. (2015), that report increased damage to orchards and meadows
295 caused by wild boars on the Elba island during summer. Moreover, lower abundance of food
296 resources in summer, associated with low precipitation and droughts, has been reported (Gianniani
297 and Montauti, 2010). Indeed we recorded the higher intensity of habitat use, as proxied by RAI
298 values, in the southeastern part of the study area, where small agricultural parcels are present.

299 The relatively higher occurrence of wild boars within the park that peaks during both the late
300 summer-autumn and winter-early spring suggest a firm association with woodland cover. Several
301 studies have shown that woodlands represent the optimal habitat for wild boars across the year (e.g.
302 Abaigar et al., 1994; Rodriguez et al., 2016; Keuling and Leus, 2019), as associated to food
303 provisioning (e.g. chestnuts, acorns, mushrooms, tubers, and wild asparagus), humid and cool
304 microclimate, shadowy coverage from heat and presence of streams and pools. We also found that
305 the Mediterranean low maquis was the least preferred cover, especially during late spring-summer.
306 In fact, this latter macrohabitat mainly develops on the southern slope, and at a higher elevation of
307 the Mount Capanne, it is a very dry and exposed environment dominated by the poisonous
308 *Calicotome spinosa* and offers limited resources for wild boars. That occupancy of wild boars
309 generally decreased with elevation suggests a preference for lower elevation zones, except in late
310 summer-autumn. This both appears consistent with the presence of the low Mediterranean maquis at
311 a higher elevation and supports Meriggi et al. (2015) findings that damage to crops was higher
312 between 100 and 300 m a.s.l.. In contrast, during late summer-autumn, wild boars' occurrence was

313 not related to elevation, indicating a stronger association with woodlands along the mountain
314 slopes, potentially driven by fruiting chestnut groves occurring between 600 and 800 m a.s.l.

315 Wild boars' detection probabilities were negatively influenced by the anthropogenic disturbance in
316 late summer-autumn and winter-early spring, translating into a marked elusive behaviour when
317 relative human abundance peaked in the park. Similar trends have been reported for other medium-
318 to-large mammals in alpine contexts (Oberosler et al., 2017), confirming the pivotal role of
319 anthropogenic disturbance in detection probability. However, we also found that wild boars can
320 adjust their elusiveness and tolerance to human disturbance when trophic resources are scant since
321 boars' detection probability increased in late spring-summer with decreasing distance to the main
322 road. This latter rings the border of the national park, where boars' detection can be easier at its
323 edges and connects adjacent towns and agricultural fields. Thus, in a context of food scarcity, the
324 ungulate can adopt a bolder behaviour to sources of disturbance, while tendentially avoid human
325 interaction and encounters in periods of high trophic abundance.

326 The wild boars' nocturnal and crepuscular activity pattern is consistent with the literature from a
327 range of areas (Lemel et al., 2003; Keuling et al., 2008). Moreover, Podgórski et al. (2012)
328 highlighted the behavioural plasticity of this species, with an ability to shift its activity from diurnal
329 to almost exclusively nocturnal in response to different levels of human disturbance. Thus, our
330 findings might reflect increased boars' elusiveness in areas with higher chances of human
331 encounters. Elba island is a human-dominated landscape, with towns surrounding the borders of the
332 park and many recreational activities within it across seasons, with a peak in late summer-autumn,
333 when we detected the highest human activity (Suppl. Table 2) and the overlap coefficient between
334 human and wild board had the lowest value. Further support to such pattern of human avoidance is
335 given by the map of the intensity in the habitat use, which highlighted that no raw detections were
336 recorded near the most used trekking trails. Besides, the nocturnal/crepuscular behaviour can also
337 ensure access to food resources provided by agricultural fields (Keuling et al., 2008; Podgórski et
338 al., 2012), at times when human control is low.

339 The higher intensity in rooting activity associated with pine plantations confirmed the patterns of
340 habitat selection for wild boar, with pinewoods that are among the preferred macrohabitats (Abaigar
341 et al., 1994, Rodriguez et al., 2016). This is also positively associated with a high abundance of
342 cicada larvae, which can explain the greater percentage of the overturned ground caused by wild
343 boars' foraging activity (Massei and Genov, 1995). Here, the diggings produced to extract
344 invertebrates may be more evident/persistent due to a possibly harder surface of the ground. On the
345 other hand, the low maquis resulted in being the most intact macrohabitat, with fewer signs of
346 erosion associated with a rooting behaviour. We have found that a greater presence of overturned

347 soil corresponded to higher erosion, more degraded vegetation stratum, and potentially lower
348 vegetal species richness. Conversely, we did not find an association between the occurrence
349 probability of wild boars and soil degradation, indicating that higher intensively-used sites may not
350 be more degraded. Boars can indeed use a site for activities (i.e. resting) that do not imply the
351 mechanical degradation of the ground. This result might indicate that the wild boars' presence alone
352 is not an exclusive cause of soil degradation, but rather the intensity of their feeding activity in a
353 combination of the specific characteristics of the macrohabitat.

354

355 **Conclusions and management recommendations**

356 Variations in the spatio-temporal activity of wild boars on Western Elba island appear driven by the
357 availability of trophic resources, as proxied by habitat cover, and avoidance of anthropogenic
358 disturbance. We provided evidence that these patterns are compatible with perceived conflicts due
359 to crop raiding by boars and proximity to farmland and urban areas which are elevated in the
360 summer months when food resources in the park are limited. In this scenario, protecting agricultural
361 fields and orchards located close to the park's borders with electric fences could mitigate the impact
362 caused by wild boars during summer, given the high success rate in keeping wild boars out reported
363 in the literature (Monaco et al., 2010; Massei et al., 2011). The use of dissuasive feeding, meant as a
364 short-term food supply within the core areas of the park, might be a complementary management
365 tool (Calenge et al., 2004; Meriggi et al., 2015), to be used in conjunction with the management
366 policies currently in force on the island. This could keep boars within the park during the summer
367 and prevent movements towards residential areas and croplands in combination with electric
368 fencing. However, we note that applying this mitigation technique needs careful evaluation since
369 too prolonged dissuasive feeding can increase wild boar reproductive output (Monaco et al., 2010).
370 On the other hand, the high density of wild boars' in the park appears to impact the soil and
371 vegetation. However, this may determine substantial damage only in the pine plantations, which are
372 of low conservation interest as they do not represent an autochthonous habitat on the island
373 (Gatteschi and Arretini, 1989; Maestre and Cortina, 2004). Hence, wild boars may not be as
374 impactful as previously thought in relation to their foraging activity. However, we acknowledge that
375 further research would be required to better understand the magnitude of wild boars' ecological
376 effect on soil properties and plant species diversity.

377

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Tables

Table 1 Survey specification conducted on the Western Elba island, Italy, during the three sampling seasons. Table reports the total number of damaged and working camera traps (CTs), sampling effort indicating the total number of active camera days, mean number of days with CTs active in the field, and number of detected species.

Sampling Season	Damaged CTs	Working CTs	Sampling effort	N. of active days	N. of detected species
April - July	6	74	1387	19	8
September - November	3	76	1771	23	10
January - April	0	80	1520	19	10

Table 2 Raw indices of detections, as well as occupancy (Ψ) and detection probabilities (p) for the wild boar during each separate sampling season, using camera trapping on the Elba island. Table reports the number of independent events with a threshold of 30 min, season-specific Relative Abundance Index (RAI – events/100 camera days), and naïve occupancy. The last two columns report the seasonal mean occupancy probability which accounts for imperfect detection, and seasonal mean detection probability.

Sampling season	Events (30 min)	Survey effort	RAI (30 min)	naïve occupancy	Ψ	p
April - July	88	1387	6.34	0.45	0.53 ± 0.15	0.19 ± 0.05
September - November	355	1771	20.05	0.70	0.75 ± 0.14	0.16 ± 0.03
January - April	144	1520	7.50	0.61	0.70 ± 0.10	0.12 ± 0.03

Table 3 Model selection and ranking for the estimation of occupancy (Ψ) and detection probability (p) of the wild boar for each separate sampling period. Wild boars were detected by means of camera traps on the Western Elba island, central Italy. Models were ranked using the Akaike Information Criterion (AIC), and those with $\Delta AIC < 2$ were considered as supported.

Sampling period	Models	AIC	ΔAIC	AIC wt	cumltvWt
Spring - Summer	p (Camera model + Distance to closest road + % Shrub coverage) $\sim \Psi$ (Elevation + Vegetation type + % Shrub coverage)	474.86	0.00	3.60E-01	0.36
	p (Camera model + Distance to closest road + % Shrub coverage) $\sim \Psi$ (Elevation + Habitat + % Shrub coverage)	476.35	1.50	1.70E-01	0.52
	p (Camera model + Distance to closest road + % Shrub coverage) $\sim \Psi$ (Elevation)	477.02	2.16	1.20E-01	0.64
	p (Camera model + Distance to closest road + % Shrub coverage) $\sim \Psi$ (Elevation + Vegetation type)	477.06	2.20	1.20E-01	0.76
	p (Camera model + Distance to closest road + % Shrub coverage) $\sim \Psi$ (Elevation + Habitat)	478.23	3.37	6.60E-02	0.83
	p (Camera model + Distance to closest road + % Shrub coverage) $\sim \Psi$ (Elevation * % Shrub coverage)	478.58	3.73	5.50E-02	0.88
	p (Camera model + Distance to closest road + % Shrub coverage) $\sim \Psi$ (Elevation + % Shrub coverage)	479.00	4.15	4.50E-02	0.93
	p (Camera model + Distance to closest road + % Shrub coverage) $\sim \Psi$ (Distance to closest road)	481.83	6.97	1.10E-02	0.94
	p (Camera model + Distance to closest road + % Shrub coverage) $\sim \Psi$ (Vegetation type)	482.14	7.28	9.30E-03	0.95
	p (Camera model + Distance to closest road + % Shrub coverage) $\sim \Psi$ (Mountain side)	482.21	7.35	9.00E-03	0.96
	p (Camera model + Distance to closest road + % Shrub coverage) $\sim \Psi$ (% Tree coverage)	482.51	7.65	7.80E-03	0.97
	p (Camera model + Distance to closest road + % Shrub coverage) $\sim \Psi$ (% Grass coverage)	482.59	7.74	7.40E-03	0.98
	p (Camera model + Distance to closest road + % Shrub coverage) $\sim \Psi$ (% Shrub coverage)	482.64	7.78	7.30E-03	0.99
	p (Camera model + Distance to closest road + % Shrub coverage) $\sim \Psi$ (RAI humans)	482.69	7.83	7.10E-03	1.00
	p (Camera model + Distance to closest road + % Shrub coverage) $\sim \Psi$ (Habitat)	485.42	10.57	1.80E-03	1.00
	p (Camera model + Distance to closest road + % Shrub coverage) $\sim \Psi$ (Elevation + Distance to closest road)	485.42	10.57	1.80E-03	1.00
	p (1) $\sim \Psi$ (1)	505.05	30.20	9.90E-08	1.00
Summer - Autumn	p (Camera model + Habitat + RAI humans) $\sim \Psi$ (Vegetation type)	1320.19	0.00	1.30E-01	0.13
	p (Camera model + Habitat + RAI humans) $\sim \Psi$ (Elevation + % Shrub coverage)	1320.25	0.06	1.30E-01	0.26
	p (Camera model + Habitat + RAI humans) $\sim \Psi$ (% Shrub coverage)	1320.77	0.59	9.70E-02	0.35
	p (Camera model + Habitat + RAI humans) $\sim \Psi$ (Vegetation type + % Shrub coverage)	1320.79	0.60	9.60E-02	0.45
	p (Camera model + Habitat + RAI humans) $\sim \Psi$ (Elevation * % Shrub coverage)	1320.82	0.63	9.50E-02	0.54
	p (Camera model + Habitat + RAI humans) $\sim \Psi$ (% Tree coverage)	1321.56	1.38	6.50E-02	0.61
	p (Camera model + Habitat + RAI humans) $\sim \Psi$ (Elevation + Vegetation type + % Shrub coverage)	1321.63	1.44	6.30E-02	0.67

p (Camera model + Habitat + RAI humans) $\sim \psi$ (Mountain side)	1321.72	1.54	6.00E-02	0.73
p (Camera model + Habitat + RAI humans) $\sim \psi$ (RAI human)	1322.22	2.03	4.70E-02	0.78
p (Camera model + Habitat + RAI humans) $\sim \psi$ (Elevation)	1322.82	2.63	3.50E-02	0.82
p (Camera model + Habitat + RAI humans) $\sim \psi$ (% Grass coverage)	1323.00	2.81	3.20E-02	0.88
p (Camera model + Habitat + RAI humans) $\sim \psi$ (Distance to the closest road)	1323.05	2.86	3.10E-02	0.91
p (Camera model + Habitat + RAI humans) $\sim \psi$ (Habitat)	1323.77	3.58	2.20E-02	0.93
p (Camera model + Habitat + RAI humans) $\sim \psi$ (Elevation + Distance to closest road)	1323.77	3.58	2.20E-02	0.95
p (Camera model + Habitat + RAI humans) $\sim \psi$ (Elevation + Habitat)	1323.86	3.67	2.10E-02	0.98
p (Camera model + Habitat + RAI humans) $\sim \psi$ (Elevation + Habitat + % Shrub coverage)	1324.68	4.49	1.40E-02	0.99
p (Camera model + Habitat + RAI humans) $\sim \psi$ (Habitat * Elevation)	1325.11	4.92	1.10E-02	1.00
p (1) $\sim \psi$ (1)	1481.95	161.86	9.70E-37	1.00

Winter - Spring

p (Distance to closest road + Habitat + RAI humans) $\sim \psi$ (Elevation)	752.79	0.00	3.20E-01	0.32
p (Distance to closest road + Habitat + RAI humans) $\sim \psi$ (Elevation + % Shrub coverage)	754.29	1.50	1.50E-01	0.48
p (Distance to closest road + Habitat + RAI humans) $\sim \psi$ (Elevation + Distance to closest road)	754.59	1.80	1.30E-01	0.61
p (Distance to closest road + Habitat + RAI humans) $\sim \psi$ (Mountain side + Elevation)	754.66	1.87	1.30E-01	0.73
p (Distance to closest road + Habitat + RAI humans) $\sim \psi$ (Elevation + Vegetation type)	755.92	3.13	6.80E-02	0.80
p (Distance to closest road + Habitat + RAI humans) $\sim \psi$ (Elevation * % Shrub coverage)	756.05	3.26	6.30E-02	0.86
p (Distance to closest road + Habitat + RAI humans) $\sim \psi$ (Elevation + Habitat)	757.10	4.31	3.70E-02	0.90
p (Distance to closest road + Habitat + RAI humans) $\sim \psi$ (Elevation + Vegetation type + % Shrub coverage)	757.54	4.75	3.00E-02	0.93
p (Distance to closest road + Habitat + RAI humans) $\sim \psi$ (Elevation + Habitat + % Shrub coverage)	757.96	5.17	2.40E-02	0.96
p (Distance to closest road + Habitat + RAI humans) $\sim \psi$ (Distance to closest road)	760.25	7.46	7.80E-03	0.96
p (Distance to closest road + Habitat + RAI humans) $\sim \psi$ (Mountain side)	760.36	7.57	7.30E-03	0.97
p (Distance to closest road + Habitat + RAI humans) $\sim \psi$ (RAI humans)	760.99	8.20	5.40E-03	0.98
p (Distance to closest road + Habitat + RAI humans) $\sim \psi$ (% Tree coverage)	761.04	8.25	5.20E-03	0.99
p (Distance to closest road + Habitat + RAI humans) $\sim \psi$ (Elevation + % Shrub coverage)	761.79	9.00	3.60E-03	0.99
p (Distance to closest road + Habitat + RAI humans) $\sim \psi$ (% Shrub coverage)	761.87	9.08	3.40E-03	1.00
p (Distance to closest road + Habitat + RAI humans) $\sim \psi$ (Vegetation type)	762.88	10.10	2.10E-03	1.00
p (Distance to closest road + Habitat + RAI humans) $\sim \psi$ (Habitat)	763.25	10.46	1.70E-03	1.00
p (1) $\sim \psi$ (1)	799.16	46.37	2.80E-11	1.00

Table 4 Parameter estimates for each sampling season from the averaging of the best models. Models test the effect of covariates on the probability of detection (p) and probability of occupancy (Ψ) of the wild boar (*Sus scrofa*) on the Western part of the Elba island, central Italy.

Sampling period	Model	Estimate	SE	Z	P(> z)	
Spring - Summer						
	Ψ Intercept	-1.4	1.31	1.07	0.29	
	p Intercept	-2.23	0.41	5.51	< 0.001	
	Ψ Elevation	-1.06	0.46	2.31	0.02	*
	Ψ Vegetation type (Wood)	3.33	1.42	2.34	0.02	*
	Ψ % Shrub coverage	1.21	0.63	1.92	0.05	•
	Ψ Habitat (Low maquis)	-2.89	1.57	1.83	0.07	•
	p Distance to closest road	0.67	0.16	4.29	< 0.001	***
	p % Shrub coverage	-0.53	0.18	2.90	< 0.01	**
	p Camera Model (Uway)	1.79	0.62	2.87	< 0.01	**
	Ψ Vegetation type (Understory)	0.61	1.20	0.51	0.60	
	Ψ Habitat (Holm oak wood)	1.10	1.04	1.06	0.29	
	Ψ Habitat (Tall maquis)	-1.99	1.45	1.37	0.17	
	Ψ Habitat (Pine plantation)	2.39	1.98	1.21	0.123	
	p Camera Model (Spromise)	-0.03	0.40	0.09	0.93	
Summer - Autumn						
	Ψ Intercept	0.62	1.28	0.48	0.63	
	p Intercept	-0.69	0.43	0.63	0.1	
	Ψ Vegetation type (Wood)	2.67	0.91	2.92	< 0.01	**
	Ψ Vegetation type (Understory)	2.28	1.01	2.26	0.02	*
	p Habitat (Tall maquis)	-0.82	0.23	3.55	< 0.001	***
	p RAI humans	-0.36	0.10	3.68	< 0.001	***
	p Habitat (Low maquis)	-1.95	0.72	2.72	< 0.01	**
	p Camera Model (Spromise)	0.69	0.25	2.80	< 0.01	**
	Ψ % Shrub coverage	-0.69	0.42	1.63	0.10	
	Ψ % Tree coverage	0.59	0.45	1.31	0.19	
	Ψ Elevation	0.38	0.38	0.99	0.32	
	Ψ Mountain side (south)	-0.87	0.73	1.19	0.23	
	Ψ Elevation * % Shrub coverage	0.68	0.42	1.61	0.11	
	p Camera Model (Uway)	0.18	0.28	0.64	0.52	
	p Habitat (Pine plantation)	-0.09	0.23	0.38	0.70	
	P Habitat (Holm oak wood)	-0.26	0.20	1.30	0.19	
Winter - Spring						
	Ψ Intercept	1.04	0.44	2.34	0.02	
	p Intercept	-1.43	0.21	6.9	< 0.001	
	Ψ Elevation	-1.08	0.45	2.37	0.01	*
	p Habitat (Holm oak wood)	-0.94	0.33	2.83	< 0.001	***
	p Habitat (Tall maquis)	-0.80	0.32	2.49	0.01	*
	p Habitat (Low maquis)	-1.28	0.37	3.47	< 0.001	***
	p RAI humans	-0.50	0.17	2.88	< 0.01	**
	p Distance to closest road	0.19	0.11	1.76	0.08	•
	Ψ % Shrub coverage	-0.24	0.34	0.71	0.48	
	Ψ Distance to closest road	-0.16	0.35	0.45	0.66	
	Ψ Mountain side (south)	0.27	0.74	0.36	0.72	
	p Habitat (Pine plantation)	-0.02	0.39	0.05	0.96	

Table 5 Summary of the Generalised Linear Models (GLMs) results, assessing the spatial patterns of the wild boars' rooting activities (% of torn-off ground) and its yearly occurrence probability (ψ) across the macrohabitats present on the Elba island, Italy.

Dependent variable	Independent variable	Estimate	SE	t value	P value	
% torn-off ground	Chestnut groves (Intercept)	-0.59	0.52	-1.14	0.25	
	Hom-oak woods	0.12	0.71	0.16	0.87	
	Tall Maquis	0.13	0.69	0.18	0.85	
	Low Maquis	-2.10	1.13	-1.87	0.06	•
	Pine plantation	2.40	1.20	1.99	0.04	*
Yearly ψ (site-use intensity)	Chestnut groves (Intercept)	0.80	0.05	16.90	< 0.001	***
	Hom-oak woods	-0.13	0.06	-2.03	0.04	*
	Tall Maquis	-0.23	0.06	-3.58	< 0.001	***
	Low Maquis	-0.32	0.07	-4.81	< 0.001	***
	Pine plantation	-0.18	0.09	-2.12	0.04	*

Table 6 Estimated coefficients of the Ordinal Logistic Regression of the best model testing the degradation status of the ground in relation to the macrohabitat type, the percentage of torn-off ground, and the annual occupancy probability of the wild boar on the Western Elba.

	Value	SE	t value	P value
% torn-off ground	0.15	6.27E-02	2.37E+00	0.02
ψ total	-0.86	1.74E+00	-4.94E-01	0.62
Habitat (Holm oak wood)	1.06	7.99E-01	1.33E+00	0.18
Habitat (Tall maquis)	0.76	8.26E-01	9.25E-01	0.36
Habitat (Low maquis)	0.30	9.27E-01	3.19E-01	0.75
Habitat (Pine plantation)	15.30	2.81E-05	5.44E+05	< 0.001
% torn-off ground * ψ total	-0.14	8.06E-02	-1.75E+00	0.08
Moderately degraded ground	-1.20	1.51E+00	-6.67E-01	0.50
Highly degraded ground	3.21	1.58E+00	2.04E+00	0.04

Figures

Fig. 1 Study area located on the Western part of the Elba island, on the Mount Capanne (1,019 m a.s.l.), central Italy. Dots represent camera trap locations.

Fig. 2 Proportional symbol map representing the spatial activity pattern of the wild boars on the Western part of the Elba island, Italy, during three separate sampling seasons from April 2018 to April 2019. Circles represent the site-specific Relative Abundance Index (RAI) with size varying according to value intervals, whilst colours represent the different sampling seasons.

Fig. 3 Estimated occupancy probability (Ψ) of the wild boar (*Sus scrofa*) on the Elba island, Italy, from April 2018 to April 2019. Occupancy was predicted in relation to the elevation during the three sampling periods.

Fig. 4 Estimated occupancy probability (Ψ) of the wild boar (*Sus scrofa*) on the Elba island, Italy. Occupancy was predicted in relation to the three vegetation types (Shrub, understory and wood), during the second (late summer-autumn) and third (winter-early spring) sampling periods, that is when this covariate was statistically supported ($\Delta AIC < 2$) to be include in the average model.

Fig. 5 Temporal pattern of wild boars (*Sus scrofa*) on the Western Elba island, Italy, from April 2018 to April 2019. On the left, yearly activity pattern with independent events (< 30 min) divided into time slots (0 – 23) and numbers on the x-axis representing total independent events detected during the same hour (b). On the right, seasonal Kernel density distributions of wild boars and humans, and overlaps in their diel activity patterns during each sampled season (b). Figure shows overlap coefficient (Δ) and upper-lower limits for each season.

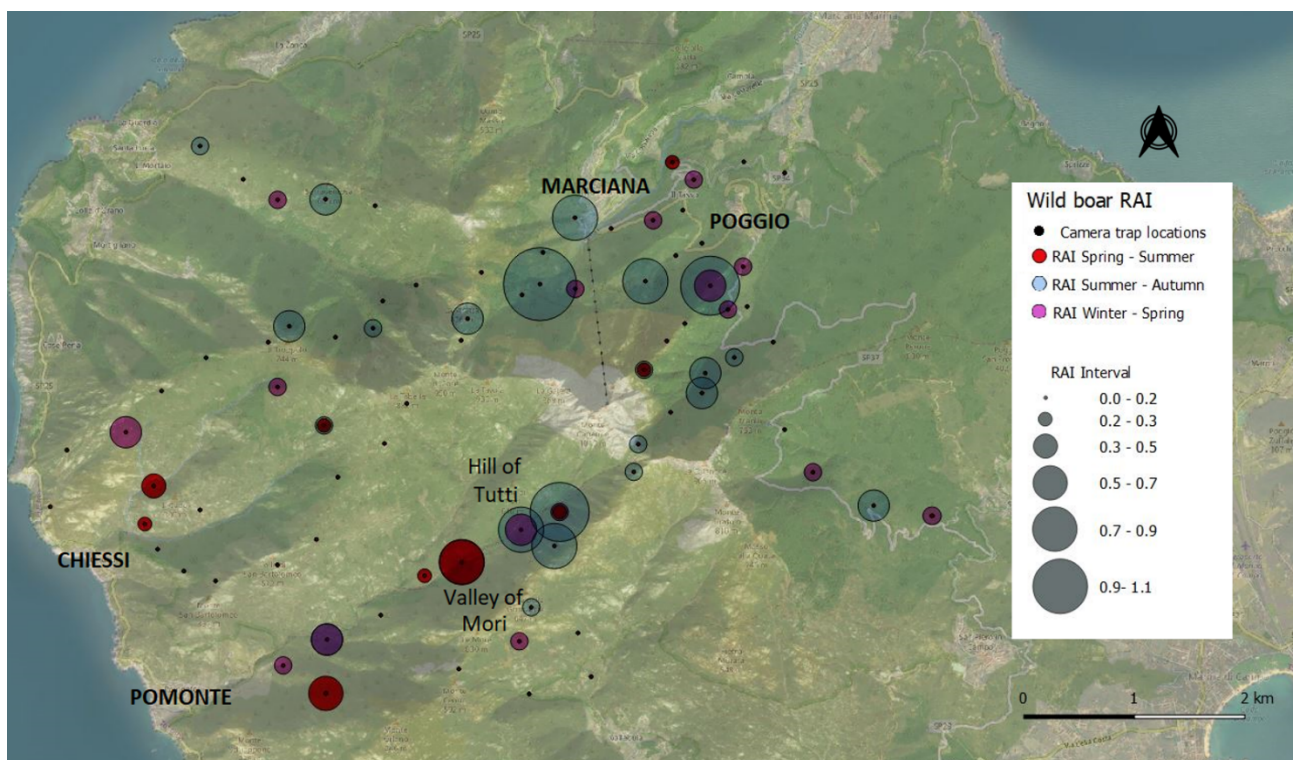
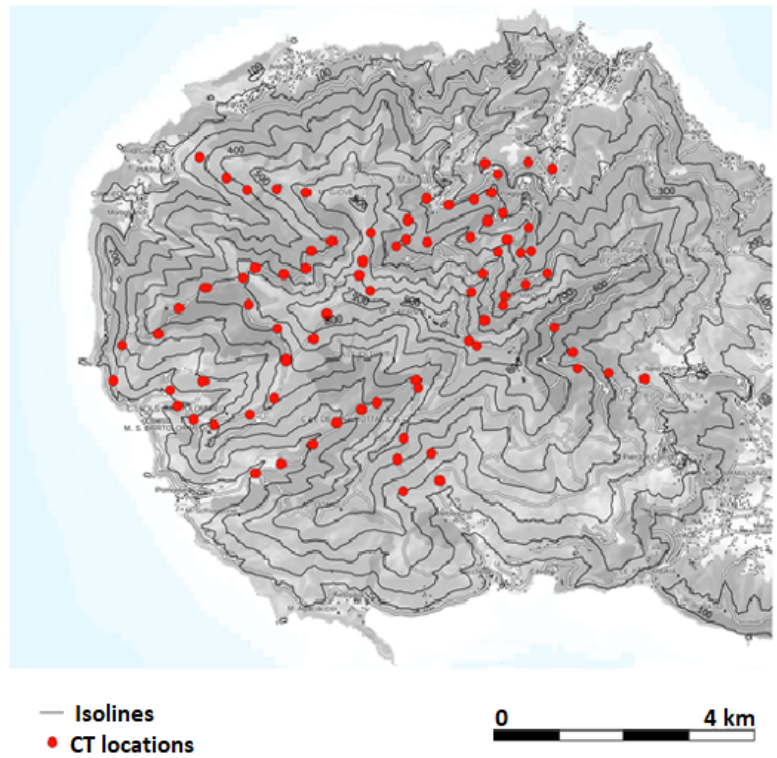
Fig. 6 Percentage of torn-off ground by wild boars in relation to the macrohabitats present on the Western part of the Elba island, central Italy (a). Wild boar yearly occupancy probability as a proxy of site-use intensity in relation to the five macrohabitat types present on the island (b). Data were collected from April 2018 to April 2019.

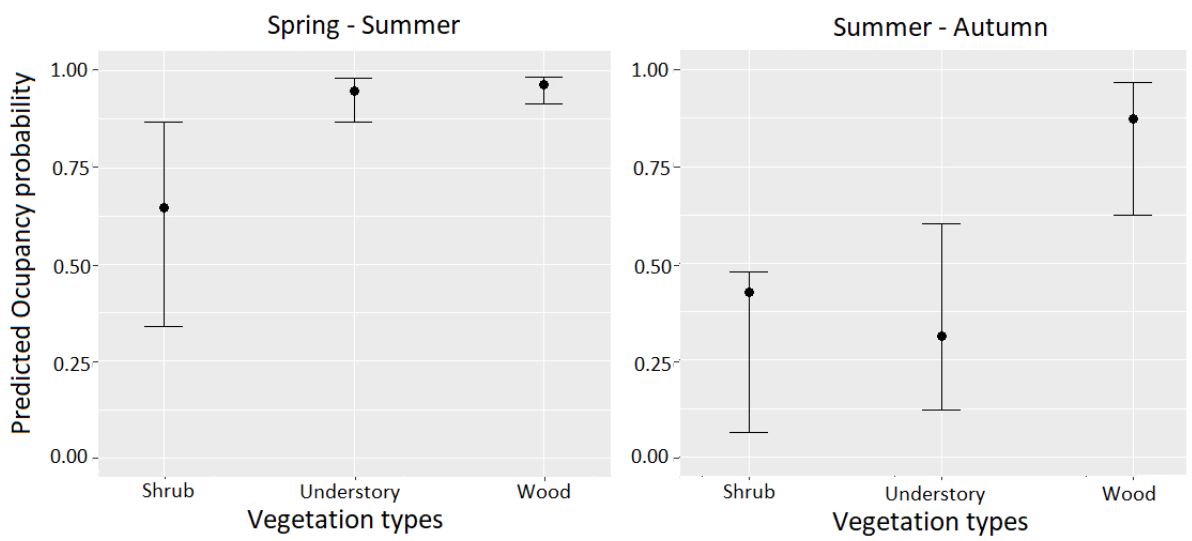
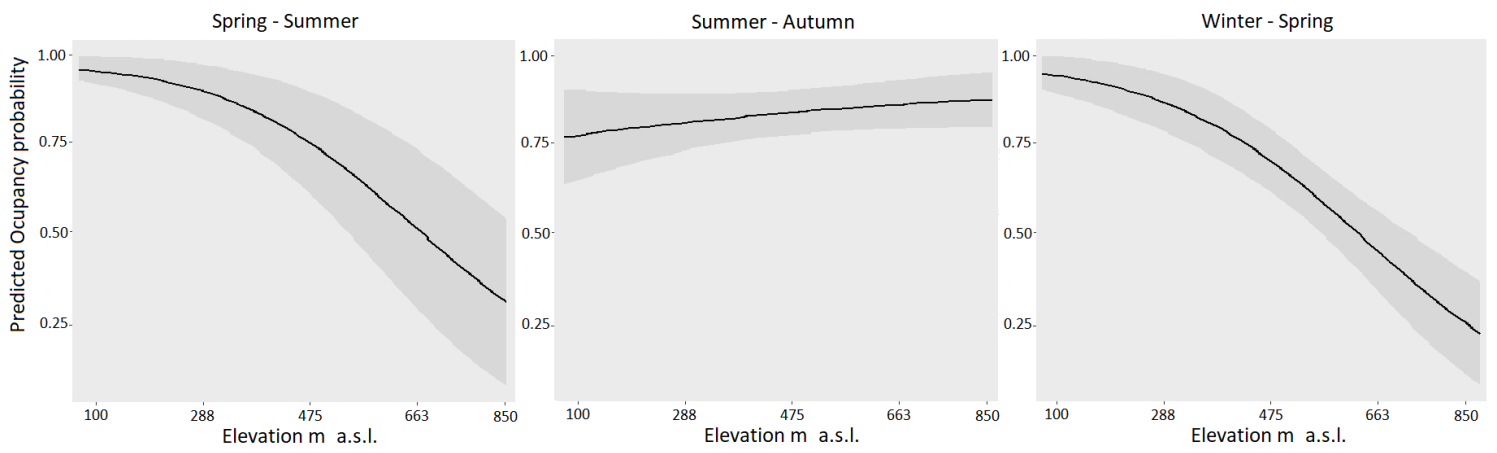
Conflict of interest: None declared

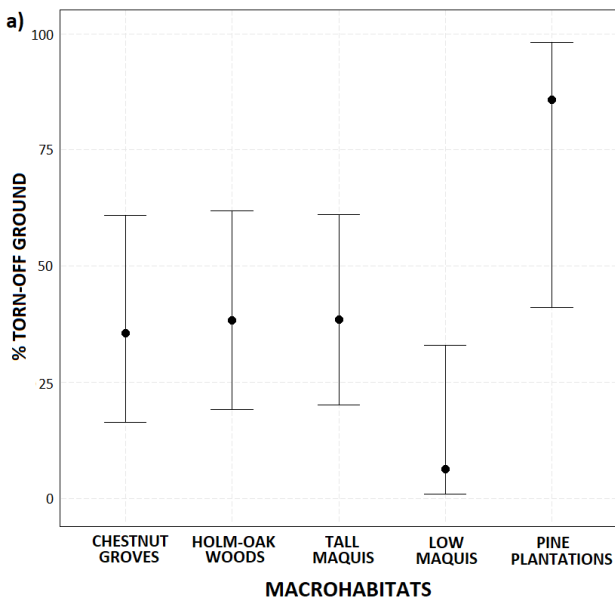
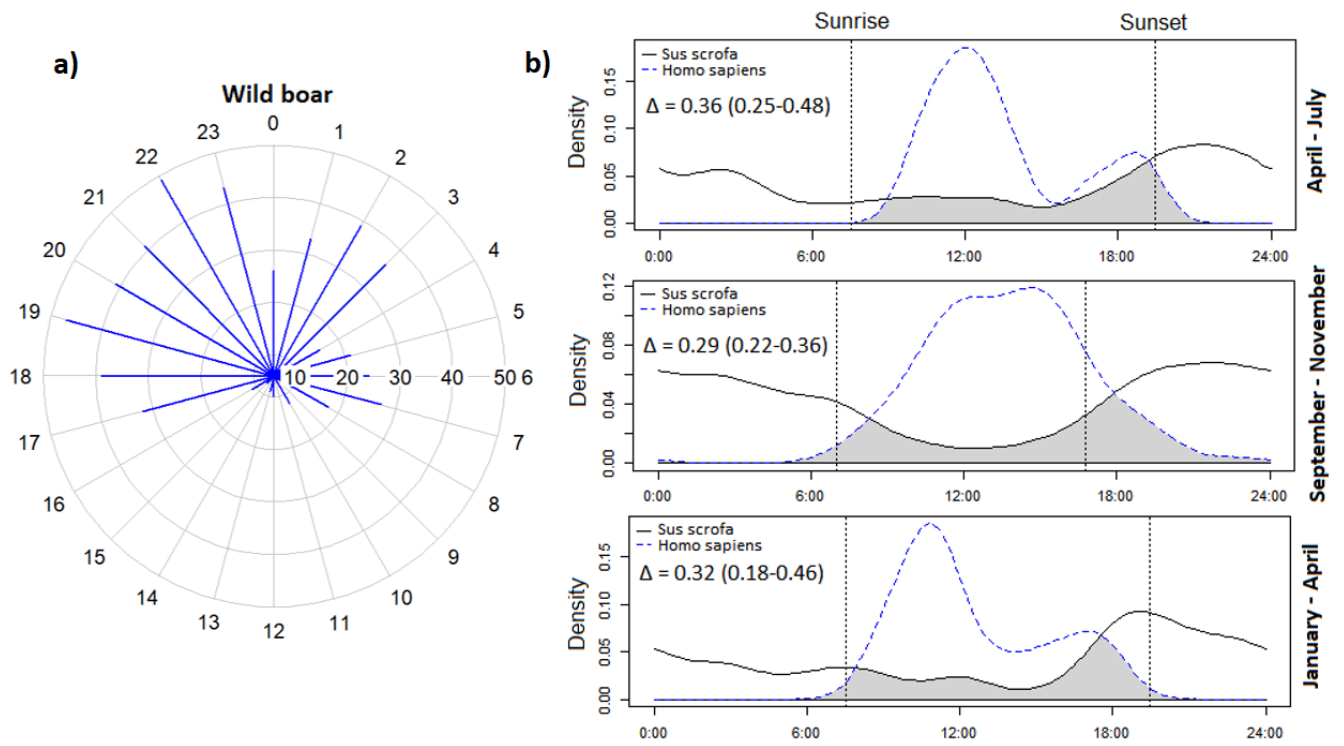
Authors contribution: MZ conceived the idea and together with FR, GS, EF, IG, BF and LL designed the study. IG, MZ, EF, MGR, AM, FDP and FM collected the data. IG, EF, MGR and FM processed and identified camera trap data. IG and MS analysed the data, with the contribution of GS, MZ and FR. IG wrote the manuscript and all authors contributed critically to the drafts and gave final approval for publication.

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Supplementary Materials

Suppl. Table 1 Spatial and environmental covariates list used for the occupancy and vegetation analyses.

Covariate	Categories	Variable description	Variable type
Occupancy analyses			
Environmental covariates			
Elevation	-	from 160 to 110 m a.s.l.	continuous
% Grass coverage	-	from 0 to 100%	continuous
% Shrub coverage	-	from 0 to 100%	continuous
% Tree coverage	-	from 0 to 100%	continuous
Vegetation type	Shrub Understory Wood	vegetation < 1 m 2 m < vegetation > 1 m vegetation > 2 m	categorical
Macrohabitat type	Low maquis Tall maquis Pine plantation Chestnut grove Holm-oak wood	Mediterranean vegetation < 1 m Mediterranean vegetation > 1 m dominated by pine trees dominated by chestnut trees dominated by holm and oak trees	categorical
Mountain side	North South	North side in relation to the mountains' peak South side in relation to the mountains' peak	categorical
Spatial covariates			
Dist. to closest town	-	expressed in meters	continuous
Dist. to closest road	-	expressed in meters	continuous
Other covariates			
RAI human	-	Human Relative Abundance Index with 1-day threshold	continuous
Camera trap model	Spromise U-Way Acorn	Brands	categorical
Vegetation analyses			
Environmental variable			
Macrohabitat type	Low maquis Tall maquis Pine plantation Chestnut grove Holm-oak wood	Mediterranean vegetation < 1 m Mediterranean vegetation > 1 m dominated by pine trees dominated by chestnut trees dominated by holm and oak trees	categorical
Soil degradation		from 0 to 100% of torn-off ground	continuous
Ground quality	1 2 3	Well preserved ground with high vegetal species richness Soil moderately eroded with presence of vegetal species Highly degraded soil with signs of erosion	discrete
wild boar ψ		Site-specific occupancy probability of the wild boar	continuous

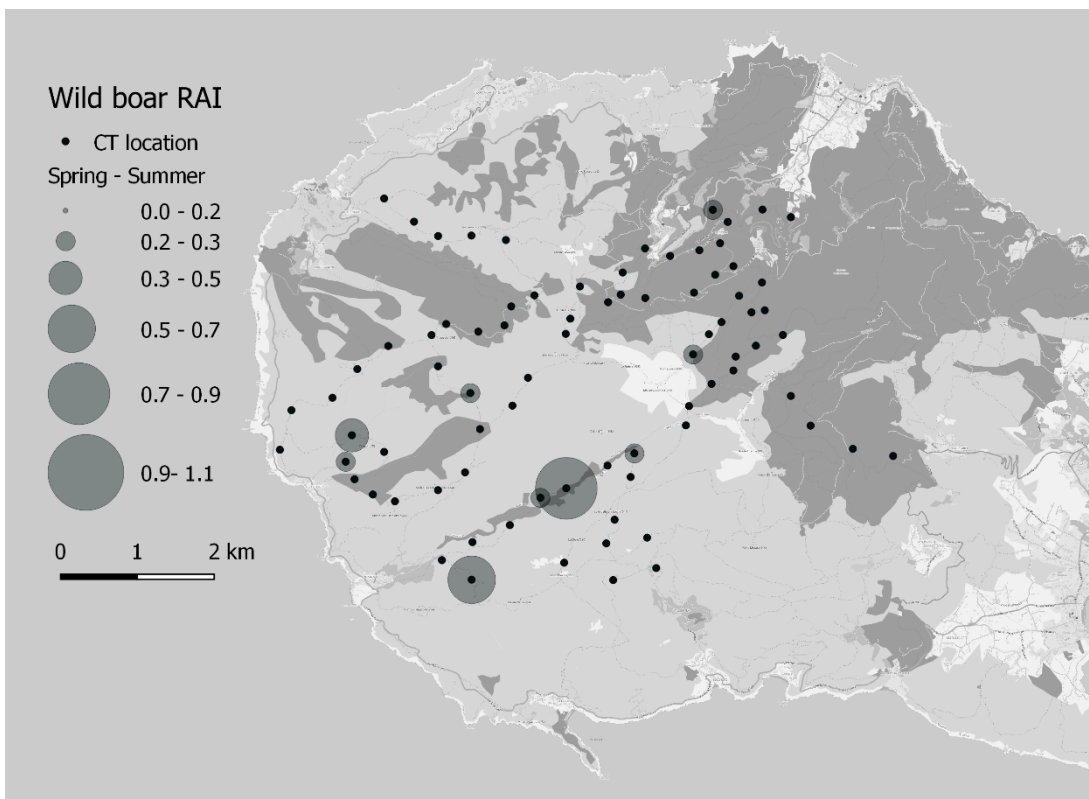
Suppl. Table 2 Species list detected on the Western Elba island during the three sampling periods: I period (April to July), II period (September to November) and III period (January to April). Table reports raw detection indices for each recorded species, in particular the number of independent events with 30 min threshold, the Relative Abundance Index (RAI) and the naïve occupancy which indicates the proportion of occupied sites.

Latin name	Common name	Events			RAI			Naïve ψ		
		I period	II period	III period	I period	II period	III period	I period	II period	III period
<i>Ovis aries</i>	Mouflon	231	456	256	16.65	25.75	16.84	0.75	0.73	0.65
<i>Sus Scrofa</i>	Wild boar	88	355	144	6.34	20.05	7.50	0.45	0.70	0.61
<i>Martes martes</i>	European pine marten	130	115	76	9.37	6.49	5.00	0.53	0.45	0.48
<i>Muridae sp.</i>	Small mammals	56	86	316	4.04	4.86	20.78	0.22	0.31	0.35
<i>Aves sp.</i>	Birds	3	83	131	0.22	469	8.61	0.04	0.30	0.44
<i>Felis silvestris</i>	Cats	34	37	77	2.45	2.09	5.07	0.25	0.23	0.31
<i>Homo sapiens</i>	Humans	23	68	13	1.66	3.84	0.86	0.09	0.25	0.11
<i>Canis lupus familiaris</i>	Dogs	3	6	5	0.22	0.34	0.33	0.04	0.08	0.07
<i>Capra hircus</i>	Goats	-	2	2	-	0.11	1.31	-	0.01	0.01
<i>Lepus europeus</i>	Hares	-	2	1	-	0.11	0.07	-	0.23	0.01

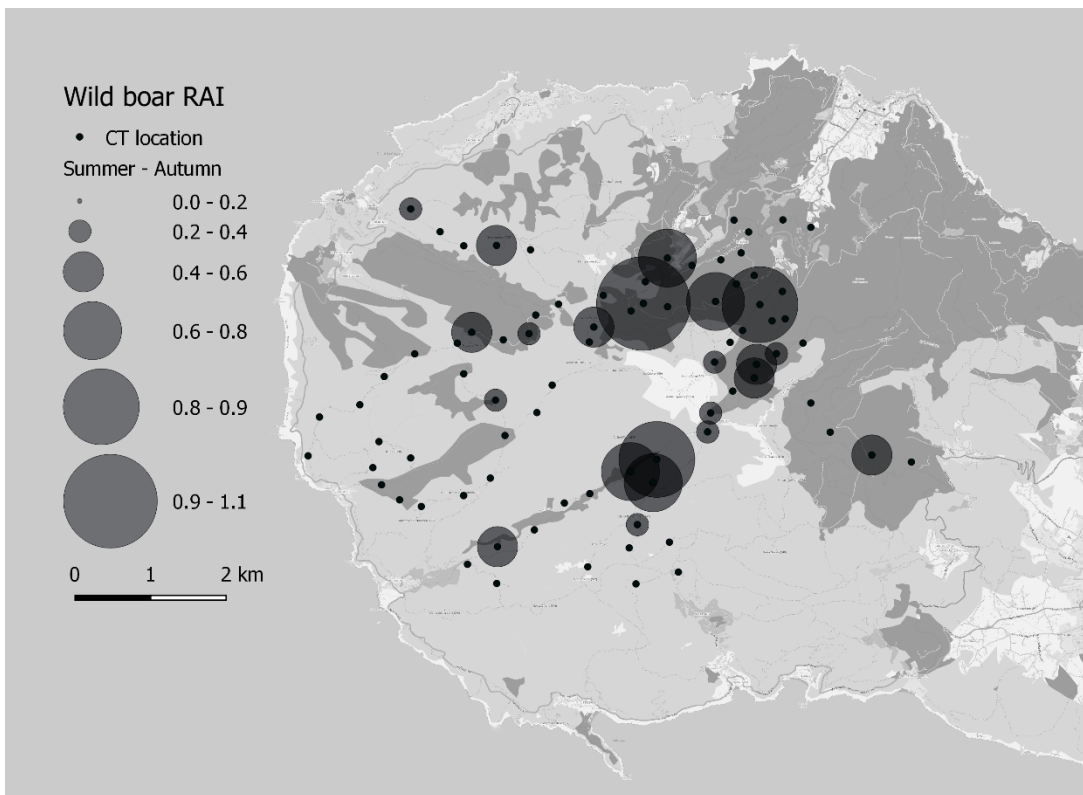
Suppl. Table 3 Model ranking for the selection of the best supported model explaining the degradation status of the ground caused by wild boar on the Western Elba island. Models were ranked using the Akaike Information Criterion (AIC).

Model	AIC
Soil degradation ~ % torn-off ground * ψ total + Habitats	110.04
Soil degradation ~ % torn-off ground + ψ total + Habitats	111.97
Soil degradation ~ % torn-off ground + Habitats	112.80
Soil degradation ~ % torn-off ground * ψ total	113.17
Soil degradation ~ % torn-off ground * Habitats	113.90
Soil degradation ~ % torn-off ground + ψ total * Habitats	114.25
Soil degradation ~ % torn-off ground + ψ total	114.60
Soil degradation ~ % torn-off ground	116.58
Soil degradation ~ % torn-off ground * ψ total * Habitat	117.01
Soil degradation ~ ψ total + Habitat	138.73
Soil degradation ~ Habitat	142.74
Soil degradation ~ ψ total * Habitat	143.74
Soil degradation ~ ψ total	157.58
Soil degradation ~ 1	158.52

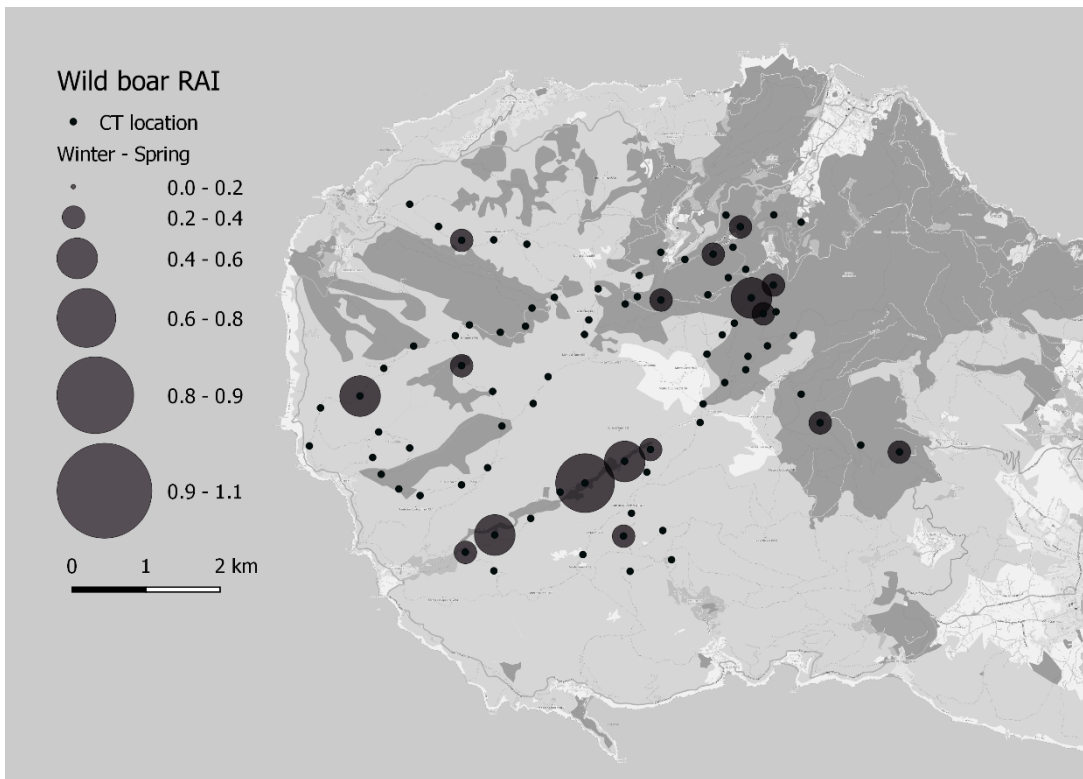
Suppl. Fig. 1 Relative Abundance Index (RAI) for wild boar (*Sus scrofa*) on the Western part of the Elba island, central Italy, during late spring – summer. RAI values indicate the intensity of the activity of the wild boar.



Suppl. Fig. 2 Relative Abundance Index (RAI) for wild boar (*Sus scrofa*) on the Western part of the Elba island, central Italy, during late summer – late autumn. RAI values indicate the intensity of the activity of the wild boar.



Suppl. Fig. 3 Relative Abundance Index (RAI) for wild boar (*Sus scrofa*) on the Western part of the Elba island, central Italy, during winter – early spring. RAI values indicate the intensity of the activity of the wild boar.



Suppl. Fig. 1 Relative Abundance Index (RAI) for wild boar (*Sus scrofa*) on the Western part of the Elba island, central Italy, during late spring – summer. RAI values indicate the intensity of the activity of the wild boar.

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