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From religion to conservation: unfolding 300 years of collective action in a Greek sacred forest

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# 1 From religion to conservation: unfolding 300 years of collective 2 action in a Greek sacred forest

3 Valentino Marini Govigli<sup>1,2,3\*</sup>, Anthoula Efthymiou<sup>1</sup>, Kalliopi Stara<sup>1</sup>

4 <sup>1</sup> Laboratory of Ecology, Department of Biological Applications and Technology,  
5 University of Ioannina, Ioannina, 45110, Greece

6 <sup>2</sup> European Forest Institute - Mediterranean Facility (EFIMED), Barcelona, 08025  
7 Spain

8 <sup>3</sup> Department of Agri-Food Sciences and Technologies, University of Bologna,  
9 Bologna, 40127, Italy

10 \* *Correspondence to:* Valentino Marini Govigli, 2 Impasse Alexandre Aujas, 69003  
11 Lyon, France; +34668616844 ([valentino.marinigovigli@unibo.it](mailto:valentino.marinigovigli@unibo.it))

## 12 Keywords

13 Adaptive policies; Common Pool Resources; Forest commons; Ostrom framework;  
14 Sacred Natural Sites; Socio-ecological systems.

## 15 1.1. Abstract

16 2. Sacred Natural Sites are integrated-coupled systems with mutual social and natural  
17 interactions, and they exist within a variety of local cultures and regions of the world. In  
18 Europe and especially in the Mediterranean basin, changing land use patterns and  
19 population decline since World War II have had a dramatic impact on the socio-  
20 ecological structure and management practices of many of such sites. At the same time,  
21 old beliefs and taboos are often neglected due to modernization, rural depopulation, and  
22 change in community's structure, norms, and codes. Understanding how social,  
23 ecological, and policy processes changed through time becomes thus relevant to identify  
24 the main criteria for effective collective action and sustainability of the studied systems.  
25 In this paper, we applied Ostrom's social-ecological systems framework to model the  
26 main socio-ecological processes acting upon a sacred forest in Epirus (Greece) over a 300  
27 years' period. The multidisciplinary approach included collection of archival and  
28 ecological data and ethnographic research (semi-structured interviews). Results indicate

that significant changes have occurred in social, economic, political, and institutional terms since the creation of the settlement (17<sup>th</sup> century). However, the sacred forest has been of major importance to the adjacent local community that acts as its custodian guardian even nowadays. Collective action for the preservation of the forest has been achieved under various governance regimes that transformed through time traditional religious taboos into modern conservation approaches. This analysis revealed that local traditional management practices of commons can serve as successful socio-ecological conservation examples.

## 1. Introduction

Socio-Ecological Systems (SESs) are outcomes of long-term relationships between humans and natural processes. They can be defined as integrated-coupled human and natural systems (CHANS) in which “people and nature interact reciprocally and form complex feedback loops” (Liu et al., 2007). They are connected systems with multiple interactions and feedbacks at various spatial and temporal levels and scales (Berkes and Folke, 1998). SESs exist within a variety of local cultures and regions of the world, vestiges of the historical interactions which link human societies to their surrounding natural environment (Dudley et al., 2005; Lansing, 1991; McKean, 1992; Mwangi, 2005; Netting, 1976). Many of such sites are nowadays inscribed in the UNESCO World Heritage List, in an effort to preserve their biological, cultural, historical, and spiritual diversity (Mitchell et al., 2009).

Sacred Natural Sites (SNS) are outstanding SES examples as areas of spiritual significance for people and/or communities since they represent places of worship and memory. These sites are not static in time or space and can be either created or transformed in the context of changing socio-economic and/or environmental conditions (e.g. demographic crises, protection of scarce natural resources, etc.) (Oviedo et al., 2005; Verschuuren et al., 2010). Mapping SNS governance structure can thus become a complex task, requiring multidisciplinary approaches apt to capture the multiplicity of relations between actors, resource flows, socio-economic backgrounds, and institutions (Ostrom, 1990).

Sacred forests and groves constitute a common case of SNS. These spiritual sites are often governed by taboos, rules and bans, which regulate site access and resources exploitation (Dudley et al., 2005). Prohibitions are set by a variety of institutions (i.e. the custodians), which can be either an identifiable group of people with well-defined structures of power and leadership; or in other cases, multiple groups, scattered and diffused (Wild and McLeod, 2008). The reasons for establishing and regulating such forests can be both devotional (e.g. dedication to saints) and functional (e.g. managing the ecosystems for conservation purposes) (Byers et al., 2001). For the above-mentioned reasons, sacred forests and groves can be considered Common-Pool Resources (CPRs), as natural and human-made resource systems, whose access is restricted and regulated (Rutte, 2011).

In the case of Epirus, a mountainous region in northwestern Greece, sacred forests have been preserved either for the stability of slopes above settlements, and as natural reserves that hold important natural resources for times of need (e.g. water aquifers and feed for animal herds) serving at the same time cultural and aesthetic purposes. In these areas, sacred forests function as strictly controlled management systems. Following a common pattern, their retention is based on taboos, which are mostly related to trees' cutting. Activities such as grazing, collection of dry fallen branches, as well as non-wood forest products (mushrooms, hunting, etc.) are usually allowed. More infrequent are cases of absolute protection, including the prohibition of any provisioning behavior, such as grazing and harvesting of fruits or dead wood (Stara et al., 2016).

Changing land use patterns and population decline since World War II have had a dramatic effect on the social structure, management practices, and cultural landscapes of the region. Depopulation waves due to wars and subsequent rural exodus have impacted the socio-economic structure of mountainous rural areas, where many scattered small villages were left with few remaining permanent residents. The effects of these processes can be immediately observed in the landscape where sacred forests are located, formerly rich of agropastoral areas, now left abandoned with substantial forest expansion (Blondel et al., 2010). Simultaneously, old beliefs and taboos are gradually vanishing as many residents have moved

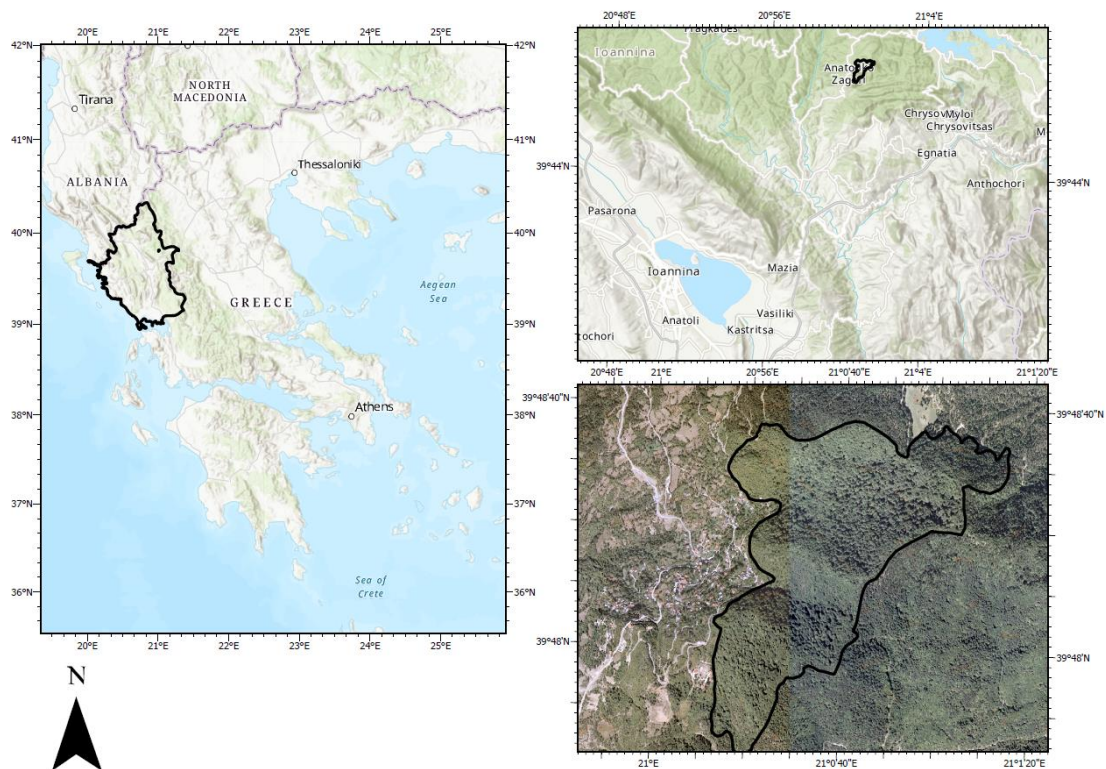
away from rural areas favoring larger urban agglomerates. Nonetheless, traditions linked to sacred natural areas remain alive for certain local communities, playing an important role in forging their cultural identity (Stara et al., 2016). It becomes thus relevant understanding how internal governance practices in sacred forests have responded to tumultuous socio-economic changes, to assist practitioners in defining efficient policy tools apt to maximize the potential of sacred forests' role in natural and cultural heritage preservation and modern rural economies.

In order to assess how governance practices in sacred forests change across time, we used the Ostrom's framework for SES to model the main social, ecological and institutional processes acting upon a sacred forest in Epirus (Ostrom, 2009). The Ostrom framework is a common and flexible analytical tool that helps scholars to identify the most important variables and their interactions, diagnosing the system outcomes at various levels and scales (Ostrom and Cox, 2010). Focusing on a large well-preserved sacred forest, we explore local stakeholders' perceptions concerning the resource (the sacred forest) and the related management practices (e.g. ban on tree cutting and grazing restrictions) responsible for its sustainability since the creation of the settlement (year 1668). Our research aims to investigate the social, economic, and ecological factors, which contributed to the formation and conservation of the sacred forest, and to detect any changes in the system's interactions and their outcomes across time. This analysis is relevant because it provides insights on how human-nature relationships are changing in rural areas. This is especially useful for national policy makers and conservation managers of SNS as it points out the extent to which faiths and traditional management practices can support natural conservation approaches (Dudley et al., 2009), and properly manage scenarios in which religious practices fall into disuse (Anyinam and Kalipeni, 1999). Furthermore, this analysis provides a novel adaptation of the E. Ostrom's SES framework to Sacred Natural Sites.

## 2. Methodology

### *2.1 Site selection*

The study area of this research is the sacred protective forest belonging to the village of Greveniti, northwestern Greece. Greveniti village is part of the Municipality of Zagori, located in the Epirus Administrative Region (Figure 1). According to the latest census (2011), Greveniti has a population of 193 people mainly dedicated to woodcutting and forestry activities. In 2005, the village area has been declared peripheral zone of Northern Pindos National Park. The area is in the proximity of the mountainous valley of Valia Calda, protected as a national forest since 1966.



**Figure 1:** Location of the Epirus region in Greece and (inset) location of the sacred protective forest of Greveniti. Source: ESRI, 2020 and Google Earth.

The sacred protective forest (geographic coordinates: 39°48'21.6''N, 21°00'13.6''E), covers an area of approximately 120 ha, with moderate slope. The working boundaries of the forest have been determined with the use of aerial photographs from 1945 (Tsiakiris et al., 2013). The forest's altitude is 1030 meters above sea level in its lower part, reaching up to 1505 meters in its top edge (Forestry Service of Metsovo, 2012). It is predominantly constituted by

126 beech trees (*Fagus sylvatica*). Patches of different vegetation types can be found around its  
127 edges, with black pine (*Pinus nigra*) in the NE and a mixed *Carpinus-Acer* stand around the  
128 W edges proximal to the village. The sacred forest is located at the fringes of the local  
129 community forest, where villagers have granted the right from the forestry service to extract  
130 timber resources. The site was selected for this analysis because it is one of the biggest and  
131 most well-preserved sacred forests among those studied so far in Epirus.

132 Greveniti sacred protective forest forms part of a local network of sites established through  
133 different ritual praxes, spanning from Saints dedication, community agreements, or  
134 excommunication regimes (Stara et al., 2016). In Greece, trees in the vicinity of churches or  
135 belonging to sacred forests are conceptualized as sacred and they are associated with cutting  
136 taboos. These are socio-religious norms, which associate the tree cutting with supernatural  
137 punishments ranging from warnings, little accidents or even death to the wrongdoers. Such  
138 beliefs are based on pre-Christian ideas, according to which mature trees have souls and thus  
139 can damage those who try to harm them (Stara et al., 2015).

140 Greveniti forest is located right above the settlement and plays an important role in protecting  
141 it from natural disasters, such as floods or landslides. To ensure the protection and longevity  
142 of the forest area, the local community had developed a religious practice, *aphorism* or  
143 *excommunication*, which historically threatened any potential trespasser or someone doing  
144 damage to the forest with direct exclusion from the Church and social stigmatization. These  
145 excommunication regimes differ, to a certain extent, to many worldwide examples of sacred  
146 forests which were protected for specific religious reasons, as the existence of shrines, homes  
147 of gods or spirits, or ceremonial places. Excommunication constitutes the heaviest sentence  
148 that can be imposed to Christians. In Greece, during the Ottoman Occupation (1479-1913), it  
149 was a practice often used for the resolution of private issues in areas — like Zagori — where  
150 the Church found herself in the special position to substitute political power, administration,  
151 and judicature (Mihailaris, 2004). In this context, excommunication was used in the Zagori  
152 area as an abstract threat and mechanism of production of fear, to protect the forest from



anthropogenic interferences. Testimonies report that excommunication rituals were characterized by certain degrees of officiality; in sacred forests it was practiced in situ. Participants used to execute the ritual through singing imprecatory psalms of David (e.g. Ps 59), bells ringing, and/or holding black candles. The symbolic number of priests that announced the excommunication was also of great importance (Mihailaris, 2004 Stara, 2012). As the forest's access and use is restricted and regulated, Greveniti sacred forest is considered an ideal CPRs case study to model with the Ostrom SES framework.

## ***2.2 Analytical framework***

The SES framework developed by Ostrom, provides a common set of variables that can be used to analyze forms of interactions in complex systems. The multi-level design of the framework, subdividing the system under study into a define set of explanatory variables and sub-variables, allows scholars to address the issues of self-organization and sustainability of governance institutions in the management of CPRs in a standardized manner (Ostrom, 2009). Ostrom SES framework challenges the supposition of simple and linear models of SESs, acknowledging the diversity of research methods used by different disciplines to describe SESs (Ostrom, 2007). This dynamic utility of the multi-level SES framework has been successfully applied to answer various questions about self-organization and sustainability of community institutions in forest ecosystems (Fleischman et al., 2010; Oberlack et al., 2015), irrigation systems (Cox, 2014; Meinzen-Dick, 2007), fisheries (Basurto et al., 2013; Guevara et al., 2016; Leslie et al., 2015; Partelow and Boda, 2015), lakes (Nagendra and Ostrom, 2014), marine settings (Schlüter and Madrigal, 2012) and protected areas (Palomo and Hernández-Flores, 2019; Williams and Tai, 2016).

So far, the Ostrom framework has never been applied to empirically study SNS. Nonetheless, the governance model of sacred forests can be assimilated to the one of early protected areas, established as "complementary measures" to promote the sustainability of ecosystem services in response to growing man-made pressures to natural ecosystems (Naughton-Treves et al.,

2005). Sacred forests can thus be conceptualized as CPRs, which can be threatened by exploitation (and/or abandonment) leading to congestion or even destruction of the resource itself and other related SESs (Rutte, 2011). The SES framework provides, therefore, a suitable approach for assessing the governance dynamics and their sustainability for sacred forests conservation in northwestern Greece.

Following McGinnis and Ostrom's (2014) modifications, the basic components or 1<sup>st</sup> tier variables of a SES are the Resource System (RS) which is the broader system under study, (i.e. the sacred protective forest of Greveniti in this case-study) and its sub-variables that summarize its characteristics. Resource Units (RU) are described both by the overall forest vegetation dynamics, and the specific characteristics of the individual tree species present in the forest. Actor groups (A) include the responsible people-stakeholders related to the forest's use (such as the community). Governance System (GS) components describe the governance framework in which A and RS mutually interact. These variables are also influenced by, and create feedback to, the external social, political, and economic environment (henceforth Settings: S) and Related Ecosystems (ECO). The framework also maps the Interactions (I) among the components, and their results as Outcomes (O) of the system (McGinnis and Ostrom, 2014; Ostrom, 2007). According to the proposed framework, these variables can be further unpacked in sub-variables of second, third etc. levels or tiers for a more comprehensive analysis of the action-situation as in Vogt et al., (2015). To capture the complexity of SNS (e.g. non-interaction as a form of management), the SES framework was duly redefined. The official framework published by E. Ostrom (2009) was thus adapted according to the latest additions of variables of Epstein and Kreitmair (2013), Vogt et al., (2015), modifications from Delgado-Serrano and Ramos (2015) and McGinnis and Ostrom (2014).

Taking into consideration that Greveniti sacred forest serves as a CPR for the community, the analysis is of vital importance because it maps governance changes in a broad temporal scale, proving that the collective action of local communities can serve to safeguard their common

resources. In addition, this research is one of few studies assessing the evolution of a specific CPR in time, as to determine the possible variations in the outcomes within consecutive periods (along with e.g. Basurto et al., 2013). This is a relevant comparative application of the Ostrom framework, which allows researchers to identify how variables and their related outcomes change as time passes.

### ***2.3. Data collection***

In-depth interviews were performed to collect stakeholders' view on the structure of the sacred protective forest, governance, management practices, and forest-stakeholders' interactions. An interview guideline was developed with mainly semi-structured questions based on the different components of the Ostrom SES framework. Pilot interviews were used to shorten and refine the interview guideline. 24 semi-structured questions were finally used during the interviews (Appendix A). Variables not inferred from interviews (i.e. S and ECO) were directly retrieved from bibliography and secondary sources. Beside identifying the variable occurrence, we also enquired about any perceived changes in time, if applicable, as to map how the system interactions and their outcomes evolved as time passed.

Field research was undertaken during August 2017, in parallel to the annual local celebration of the village dedicated to the Virgin Dormition (15<sup>th</sup> of August), which gathers both villagers and former residents now permanently residing in larger urban centers. A "snowball chain" method was used to draw the final list of key informants to interview, including elders, local policy makers, foresters, and rangers of the area (Nichols, 1991). 47 people (26 men and 21 women) participated in the study, 24% of the official census village population, and 78% of the actual permanent residents (ELSTAT, 2011)<sup>1</sup>. 17 informants were further excluded from the sample as they were merely aware of the protective role of the forest without having the

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<sup>1</sup> The official population data from the census should be treated carefully as often official Greek statistics do not match the real population living in villages, especially in rural areas. Official statistics are thus inflated by non-permanent residents there registered but living elsewhere in Greece. Retrieving the real population of rural villages in Greece requires complex ethnographic historical reconstructions (Green, 2016).

possibility of providing further details, while five informants refused to participate in the study. 25 face-to-face interviews (18 men, 7 women) were finally conducted, of which 22 were audio recorded, with the interviewee's permission, and therefore analyzed. Each interview lasted 45 minutes in average. Additional tools such as local tree names, photos of village locations and buildings, as well as maps of the region's sites, were used to facilitate the discussion with informants.

#### **2.4. Data analysis**

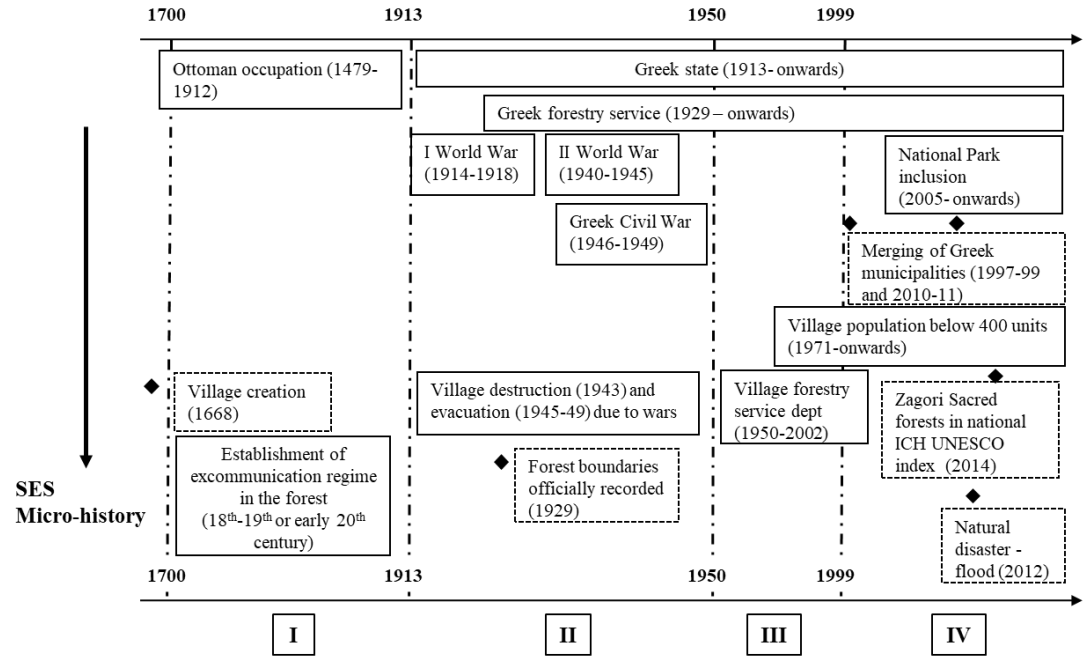
All semi-structured interviews recorded were transcribed with the help of the program Speechnotes (WellSource, 2017), and then analyzed using R's RQDA qualitative analysis package (R Core Team, 2017). The basic method of analysis was the assignment-linkage of each variable-code with each transcript of the informants to which they refer. The codes used in RQDA were the first and second tiers of Ostrom variables. None, one or more codes, could be assigned to each of the transcribed sentences, depending on the content and the judgment of the researcher. Additional codes were added, to capture emerging information relevant for the research, relating to temporal information, i.e. local toponyms, tree names and species, local values, non-interventional activities, as well as property-rights regime as proposed by Delgado-Serrano and Ramos (2015). During the analysis additional changes were made, removing variables for which no data were found (RS6b Frequency-Duration of Disturbances, RS6c Extent of disturbances and RS10c Human interventions), or which were found to have no effect on the system under-study (RU4ii Value of units, RU6ii Distinctive characteristics, I5 Investment activities, I6 Lobbying activities). The final variables selection includes 9 first tier variables 55 second tier variables, and 12 third tier variables (Full selection in Appendix B).

The information gathered was used to reconstruct relevant socio-economic and political events recorded in the local village's history. These events allowed identifying the main time periods of the SES, which were later used to assess eventual temporal changes of the SES

first-tier variables and their sub-components. Direct statements from the interviews (reported in italics and with the corresponding alphanumeric identifier of the interviewee) are also provided to support the findings.

### 3. Results

The collected data allowed the identification of the major local, historical, and environmental historical landmarks, which helped to conceptualize the SES under study in four consecutive time periods (Figure 2): (i) 1668-1913 (from the creation of settlement up until the end of the Ottoman occupation): (ii) 1913-1949 (from the annexation of Epirus region to the Greek state until the end of the Greek Civil War); (iii) 1950-1999 (Post-wars development period); (iv) 2000 onwards (current times, characterized by an increasing trend of population abandonment in rural areas). These four main demarcation periods are used in the following chapters to assess temporal changes in the SES under-study.



**Figure 2:** Timeline of the main events relevant to the history of the Greveniti Sacred Forest. Events are subdivided into national (SES Macro-history) and local (SES Micro-history). Latin

numbers indicate the four main demarcation periods selected for the analysis of the SES (I: 1700-1913, II: 1913-1949, III: 1950-1999, IV: 2000 onwards). Dashed-line boxes and black diamonds indicate punctual events; solid-line boxes indicate processes occurring across years.

Table 1 identifies the main occurring changes across the first-tier variables of the SES Ostrom framework applied to the sacred forest of Greveniti (years 1668-2017) according to the four intervals formerly introduced. In the following chapters, we highlight the main temporal changes and key aspects determining the successful collective organization and system's sustainability during each period elaborating on the main components of the SES framework.

**Table 1:** Comparison of key SES variables for the four distinct time periods (I-IV) in Greveniti village, Greece. The categorization of variables is mainly qualitative and indicates their occurrence in the SES under study (present, absent, na= not available) or their variability (high, moderate, low, very low, decreasing, na). Plus (+) and minus (-) indicate positive/negative developments for the SES. Data retrieved by ethnographic research for which supporting literature was not found is indicated with an asterisk (\*).

Variable	I: 1700-1913	II: 1913-1949	III: 1950-1999	IV: 2000-onwards
Settings (S)				
Economic development (S1)	High	Moderate	Moderate	Low
Demographic trends (S2)	High	Decreasing	Decreasing	Very low
Political stability (S3) <sup>1</sup>	Unstable	Unstable	Unstable	Stable
Government resource policies (S4)	Ottoman rule/community autonomy <sup>2</sup>	Greek State	Greek State	Greek State
Resource System (RS)				
Sector (RS1)	Excommunicated	Excommunicated	Excommunicated-protective	Mostly protective
Boundaries (RS2)	na	Stable	Stable	Stable
Predictability of system dynamics (RS7)	High*	Present	Present	High
Human use and disturbance history (RS10c)	Limited *	War shelter	Fringe disturbances; paths; fields; hunting;	Fringe disturbances; hunting; clearing water channels

			clearing water channels	
Actors (A)				
Number of relevant Actors (A1)	Community	Community & others	Community & others	Community & others (+)
Socioeconomic attributes (A2)	Farmers, merchants	Farmers, merchants	Farmers, woodcutters	Retired persons, woodcutters
Location (A4)	Settlement & further	Settlement & further	Settlement & further	Mainly further
Leadership (A5)	Community	Forestry service & community	Forestry service & community	Forestry service & community
Norms/social capital (A6)	na	na	Moderate	Moderate
Knowledge of SES (A7)	High*	High	High	High
Importance of resource (A8)	High	High	High	High
Governance System (GS)				
Government organizations (GS1)	Community*	Forestry service	Forestry service	Forestry service and national park
Property-rights (GS4a)	Community	Community	Community	Municipality
Access (GS4b)	No restrictions	No restrictions	No restrictions	No restrictions
Subtractability (GS4c)	Forbidden*	Forbidden	Forbidden (-)	Forbidden (-)
Operational rules (GS5a)	Excommunication	Excommunication	Grazing & dead branches collection permission; forestry service rules	Forestry service rules
Collective rules (GS5b)	Present*	Present	Present	Present
Constitutional rules (GS5c)	Present	Present	Present	Present (+)
Repertoire of norms and trends (GS6)	Excommunication	Excommunication	Excommunication & law	Excommunication (-) & law
Monitoring and sanctioning rules (GS7)	High*	High	High	High
Interactions (I)				
Harvesting (I1)	Absent*	Absent	Firewood collection only	Firewood collection only (-)
Self-organizing activities (I7)	Present	Present	Present (+)	Present
Monitoring activities (I9)	High*	High*	High	High
Outcomes (O)				
Social performance measures (O1)	High*	High	High	High

Ecological performance measures (O2)	High*	High	High	High
Externalities to other SESs (O3)	na	na	Absent	Present

<sup>1</sup>The S3 variable measures only stability.  
<sup>2</sup> During the Ottoman rule, the mountainous communities of Northern Pindos, as it is Zagori, enjoyed a considerable degree of autonomy .

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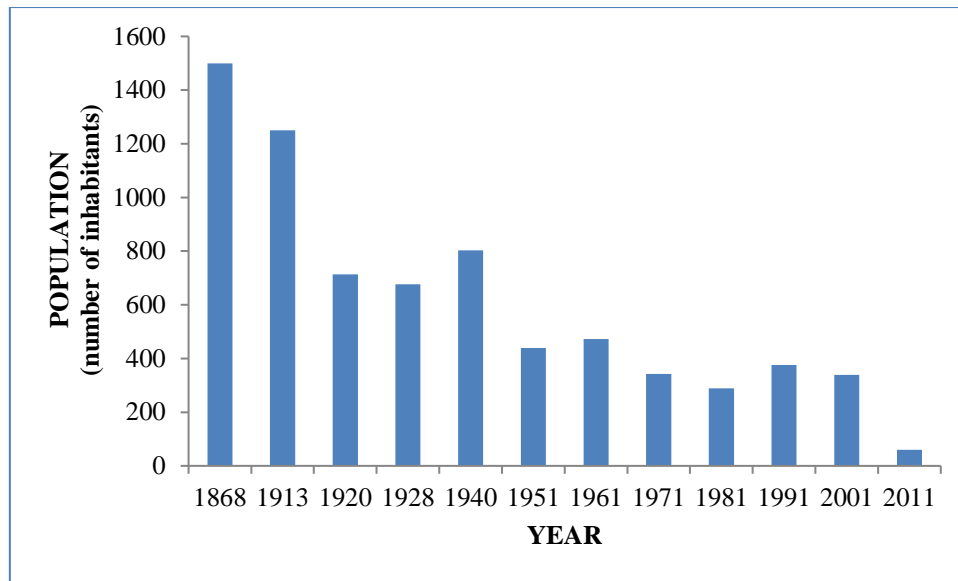
### 291 ***3.1. Socio-economic and political settings (S)***

292 The socio-economic and political background of Greece, including Greveniti village,  
293 underwent major changes during the previous centuries, (as depicted in Fig.2). Since the 15<sup>th</sup>  
294 century, many parts of the Hellenic area were under the Ottoman rule, which lasted until the  
295 beginning of the 20<sup>th</sup> century (1913 in Zagori) (**S4**). However, the mountainous communities  
296 of Northern Pindos, as it is Zagori, enjoyed a considerable degree of autonomy including,  
297 among others, absolute religious freedom, and the right of self-governance (**S3**) (Damianakos  
298 et al., 1997). During the 17<sup>th</sup> -18<sup>th</sup> centuries, the settlement of Greveniti consists of  
299 approximately 1500 people (**S2**). Agropastoralism was initially the basis of the local  
300 economy; Dasoulas (2009) reported the absence of an extended livestock farming sector, as in  
301 neighboring communities due to limited pastures. From the 17<sup>th</sup> century, village's men  
302 worked as carriers or migrated and worked elsewhere in cities and trade centers in  
303 Macedonia, Constantinople, Asia Minor, but mostly in Bucharest and other cities in  
304 Moldovlachia. During this period only elders, women, and children (boys until the age of 12-  
305 15) resided in the village maintaining the agropastoral activities, satisfying only 1/3 of the  
306 village population necessities. Remittances from the family members abroad greatly  
307 supported the village income, covering the construction of luxury private houses and  
308 community buildings. This brought cosmopolitan cultural and architectural styles in a rather  
309 rural and isolated settlement, which contributed to its educational and intellectual  
310 flourishing during the 18<sup>th</sup> and 19<sup>th</sup> centuries (Damianakos et al., 1997).

311 After the incorporation of Epirus region in the Modern Greek State (1913), agropastoral  
312 activities along with seasonal migration remained the basic economic activities, and the  
313 products from the village's fields were traded abroad with a great demand (**S1**) (Rogkotis,



1998). In 1922 temporary migrations of men ended and were slowly replaced by a permanent exodus to extra-European countries (e.g. U.S.A., Canada, Argentina, Egypt, Congo, and Ethiopia). An increasing political instability, peaking into the Second World War (1940-1945), and the subsequent civil war (1946-1949) led to an incessant decrease in the village population (Fig.3). During WWII, Greveniti was burnt to the ground several times, with all private houses (297) and community buildings destroyed, except of the village church. Losses in human lives were the second largest among all Zagori villages. During the civil war (1946-1949) the village was mandatory evacuated, and all villagers moved to the town of Ioannina. After the wars, most of village residents permanently flee to larger urban areas (Damianakos et al., 1997) (S3). Only 450 people came back to the village after the end of the civil war, compared to more than 1200 inhabitants recorded at the beginning of the 20<sup>th</sup> century (S2; Figure 3). In 1950, those who returned had to face a village with all houses destroyed and fields abandoned. This destruction was turned into an economic opportunity by shifting the local economic activity to logging of the community forest, located in the proximity of the sacred protective forest. About 30 foresters organized themselves in two forest cooperatives and this formed the basis of the local economy and social life during the post-war period and became the main occupation in the area until current days. (Damianakos et al., 1997) (S1) By 1991, only 376 people were recorded to reside in the village. Depopulation was worsened by modern public management changes (1999) which shifted most services from villages to larger towns (S2).



**Figure 3.** Real Population data of the Greveniti village (1868-2015). The definition of ELSTAT for real population means the number of people present at the census day in each prefecture, district, municipality/community, and independent settlement. This differs from official census data (Sources: Damianakos et al., 1997; ELSTAT 1913-2011).

### 3.2. Resource System (RS)

Most RS variables appear to be stable enough since the beginning of the 20<sup>th</sup> century (Table 1). The sacred forest boundaries were officially recorded in 1929 and their official formalization by the Forestry Service (1938) remains almost the same up until today. “No, nothing has changed. The boundaries, as it is said, have been set a few hundred years ago. (III)” (RS2). Even if the RS boundaries are perceived as stable, the ethnographic research shows that the abandonment of grazing has caused the infilling of vegetation in former open areas in its west boundaries and neighboring open areas, probably linked to the abandonment of local management and the reduction in population flows. (Additional information on RU is reported in Appendix C). This was confirmed by field observations on the forest structure (Marini Govigli et al., 2020). The key feature of the RS’ dynamics is natural gap regeneration processes (Cullen, 2015) (RS6; Appendix C). Informants confirm that this phenomenon occurs periodically every winter as trees fall due to age or weather events such as wind and snow.

Ethnographic research also identified that the forest contained certain plain areas, which villagers cultivated as fields until the '70s. (RS10c) Additional activities which are commonly performed in the wider area and within the sacred forest are hunting and the cleaning of water channels and tanks. No major human constructions were allowed and indeed none was recorded except for paths and a couple of water tanks to supply the village demand (RS4). This limited interference with the forest was probably linked to its protective function, sheltering the village from floods or landslides, and preserving water aquifers (RS7). *"This forest of ours will grow more and stronger over the years. And it will always protect the village, as long as the village lives."* (I15).

Additionally, no major anthropogenic disturbances (e.g. timber harvesting) were identified by our research as occurring in the RS during the past century. Only few anthropogenic cuts and pollarded trees were detected, mainly clustered around the periphery of the sacred forest, the areas with the highest level of interfering as in the proximity of the village poorest families. (RS10). Similarly, no evidence of natural disasters was recorded in the forest until 2012, when an unprecedented flood occurred (ECO1).

### **3.3. Actor groups (A)**

Some variables of the Actors group have been identified as changing during the four time periods. These are: Number of Actors (A1), Socio-economic characteristics (A2), Location (A4). On the contrary three variables stand out as stable: Leadership (A5), Knowledge of the System (A7), and RS Importance (A8).

Concerning the Actors number, the data collected from bibliography shows that from the establishment of the settlement (1668) until the actual organization of the forestry service (1929), the only group responsible for the RS was the community itself (Dasoulas, 2009).

After that time, the Actor group enlarged including forest guardians and state foresters. Since 1999, the number of relevant groups drastically increased. This now includes: the community council, a logging cooperative (initially two established in the 80s), the village cultural

380 association, the village brotherhood<sup>2</sup>, the municipality of Zagori, forestry service employees,  
381 Northern Pindos National Park officers, academic researchers, and tourists (A1, A2). Most of  
382 the afore-mentioned Actors are located away from the system, (A4) as currently Greveniti is a  
383 depopulated village whose inhabitants are mostly summer and occasional residents. The  
384 interviews highlighted that the role of the local community is substantial for the long-term  
385 governance of the system (A5). The community has been the direct responsible of the forest  
386 through the years. This is a role which persists up until today, despite sharing responsibilities  
387 over the forest with official governing bodies (e.g. the forestry service and the national park;  
388 Section 3.4). *“But it is us, the woodcutters here who protect it. And when a stranger gets*  
389 *inside, we all notice who he/she is and what he/she is doing in there, you know. We all protect*  
390 *it, because it [the sacred forest] is the protection of the village. (I20)”*.

391 Ethnographic research confirms that no use of the RS was taking place until the 1970s, due to  
392 the enforcement of the supernatural fears associated with the religious practice of  
393 excommunication (A3). *“What is Eftapapado [efta = seven, papas = priest]: seven priests*  
394 *surrounded the forest with a candle from a church, spelling religious words (meaning curses).*  
395 *It was excommunicated, like cursed, whoever was going to cut down a tree or do something*  
396 *bad, he was excommunicated too. There was no other protection, people believed in religion*  
397 *back then, and it turned out to be very good. Because this forest was protected.” (I25).*  
398 Exceptionally, elder informants remember hiding inside this forest from the Nazi German  
399 army during the war (1940-1945) (A3). *“When the war began, I was 10 years old. Our homes*  
400 *were burned to the ground. We were hiding in the woods like wild beasts, like animals inside*  
401 *the forest. We were sleeping in the snow. We didn't have anything to eat.” (I9).*

402 Regarding the Actors' social capital (A6), field observations indicate the occurrence of  
403 several personal disputes among residents. Only one was identified as relevant to the RS, as it  
404 focused on the collection of firewood from the forest. Seven informants believe that this  
405 service degrades the RS: *“But what is good is not to be removed (the dead wood) because it*

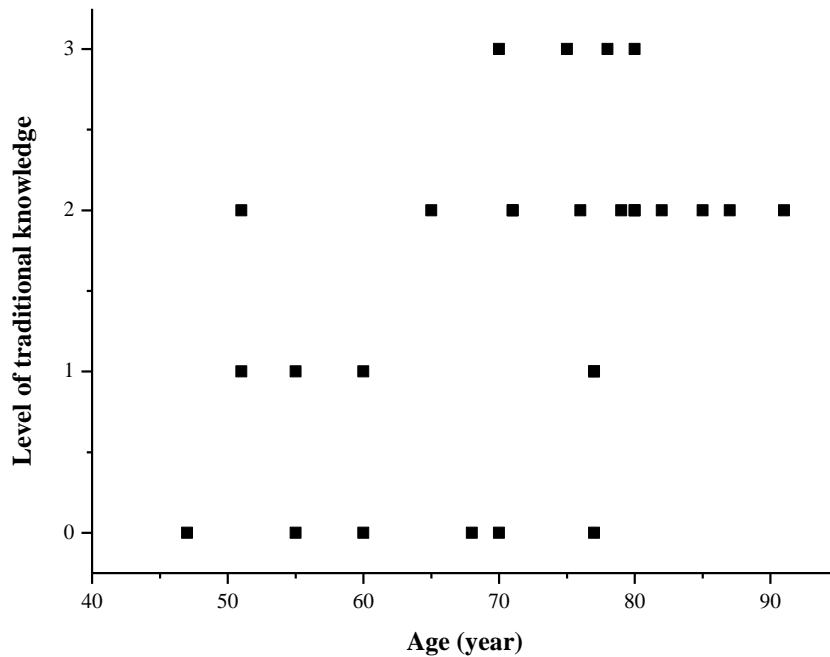
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2 the brotherhood is an assembly from people who descent from Greveniti but reside in Athens.

406 *rots and leaves, how to explain, something like manure, helping the tree to grow. Because if*  
407 *you remove it then you leave nothing for the tree so that it can grow” (I18), while few others*  
408 *support that it is beneficial for it: “Back then the authorities did not permit the collection of*  
409 *dead wood nor anything. Later, they allowed the collection of dead ones fearing of fires.”*  
410 *(I5). Some other interviewees support that there is trust and lack of disputes among the*  
411 *relevant Actors of the SES.*

412 What is more, the present case study shows that all Actor groups are aware of the existence of  
413 the RS (A7): *“Everybody knows about the protective forest, even the younger ones, everyone*  
414 *knows it” (I20), yet confirms the differences in mental models of people belonging to*  
415 *different generations (Figure 4). Youngest informants are amongst the 68% of the*  
416 *interviewees unaware of the excommunication ritual enforced at the time of the sacred*  
417 *forests’ establishment. On the contrary, those informants who still believe in the taboos*  
418 *associated to religious ritual of the forest correspond almost entirely to the oldest age class.*

419 Concerning the importance of the RS (A8), all the Actors state that the sacred protective  
420 forest is indispensable to their village: *“Because the forest protects the village from the floods*  
421 *and all this, keeps the rainwater, the snow, so that the village does not flood because of its*  
422 *downhill location.” (I7).*



**Figure 4:** Changes in the level of traditional knowledge concerning Greveniti's sacred forest according to the ages of the informants (N = 24). Levels legend: 0: Unaware of the sacred forest history, 1: Aware of the sacred forest existence, 2: Aware of the sacred forest existence and of its establishment tradition (excommunication ritual), 3: Aware of the sacred forest existence, its establishment tradition, and still actively believing in it.

### 3.4. Governance System (GS)

As elaborated in the Settings, during the 15<sup>th</sup>-19<sup>th</sup> centuries the community of Greveniti was granted the right to self-manage its natural resources without the intervention of the Ottoman rulers by simply paying a tax to the Ottoman authorities (Damianakos et al., 1997). Once the village was annexed into the Greek state (1913), the management of forest ecosystems is placed under the responsibility of the forestry service. After 1950, a local forestry department was created in Greveniti, but its function ceased in 2002 because of national administration

437 changes<sup>3</sup>: The fact that the village is declared a peripheral zone of Northern Pindos National  
438 Park (2005) seems to face positive responses from the community members (GS1) “*Yes, this*  
439 *is a good thing; it's an additional protection for the forest. The National Park's Management*  
440 *Agency patrols here, in all villages. And they see things, they will detect a fire, anything*”  
441 (I20).

442 Another relevant GS change is the ownership status of the RS. Formerly owned by the  
443 community, after the progressive merging of Zagori communities into a single municipality  
444 that ended in 1999, the municipal council becomes the RS official owner and manager  
445 (GS4a). Despite this major change of ownership, RS access (GS4b) and RS subtractability  
446 (GS4c) were not generally affected. The forest is still accessible to anyone as it was in the  
447 past, and the extraction of the forest's resources was and still is forbidden and remains a  
448 community prerogative (GS4c).

449 Since the Greek forestry sector in the area began to be centrally coordinated by the State  
450 (1924-1929), protective forests above settlements have been acknowledged and strictly  
451 protected by ad hoc legislation (GS5c) (L. 86/1969; PD 11/1928). Thus, any activity that  
452 could degrade protective forests such as Greveniti sacred forest (i.e. grazing and wood-  
453 cutting) is not allowed *de jure*. Greveniti community is still unanimously in favor of this  
454 restrictive legislation (GS5b), except a minor modification requested by the community  
455 council in the '70s (GS5a), related to obtaining permission in the collection of firewood and  
456 grazing domesticated animals in the forest periphery for the inhabitants residing on its  
457 foothills. This request was accepted, and it applies up until today.

458 The ethnographic research proves that from 1913 until the '70s no activity was allowed inside  
459 the sacred forest and that its actors would entirely comply with it (GS6). The “institution”

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<sup>3</sup> A major reform in the local administration of Greece was initiated in 1997 (L. 2539/97, the Ioannis Kapodistrias Programme). According to this law, all existing municipalities and communities were obliged to form new enlarged municipalities. With this legislation, decision-making responsibilities of communities' local councils were replaced by a larger municipal council (Lalenis & Liogkas, 2002). Another similar reform occurred in 2010 (L. 3852/2010, the Kallikratis Programme) which additionally reduced the overall number of municipalities.

responsible for CPR governance used to be the local community represented by the Church, which substituted political and juridical power through the establishment of religious rituals for the protection of fragile ecosystems during the Ottomans times (Stara et al., 2016). *“If you were to do anything illegal for example, there was no one to punish you, you had to believe in religion. To the fact that it is excommunicated and somehow indeed the people were more religious, they believed back then, they believed it.”* (I5). After the Second World War, many villages replaced their fear on religious bans with the ecosystem service value of the RS (i.e. the fact that the forest shelter the village from extreme weather events and replenish water supplies) *“They protect it, and there is a tradition, we don't intervene in this forest, we don't touch it. It is a protective forest, it protects us.”* (I12).

Lastly, there is no clear evidence about the existence of monitoring and sanctioning institutions before the 20<sup>th</sup> century, although the religious excommunication ritual might have acted itself as a tacit sanctioning instrument. (GS7). After 1913, the protection of the forest was under the responsibility of state forest guardians along with the community itself. Nonetheless, after the merging of municipalities in 2010, only few forest guardians were left responsible for the whole area in which Greveniti is located (YPEKA, 2014) in addition to some wardens of the Management Agency of the National Park who do not have the authority to impose penalties to trespassers.

### **3.5. Interactions (I) and Outcomes (O)**

No written evidence was found about Interactions (I) with the RS during the Ottoman years. The only available evidence came from the ethnographic research pointing out that all Actors refused to damage trees within the forest during those years, fearing the consequences of the excommunication (I1). Most of the informants argue that this is the main reason why the RS was preserved in the first place. The research shows that except the collection of firewood after 1970s, no other harvesting activity ever took place inside the sacred forest (I1). *“No one goes inside it, no one does damage. They wouldn't even go in the past when they needed it*



most" (I16). A documented evidence confirming the findings of the ethnographic research was found in a descriptive report of the forest. There it is stated that: "*The removal of very old beech trees is possible, assuring the lack of negative consequences to the protective effect of the system. However, such an intervention was not desirable from the community for moral reasons, so it [the sacred forest] is exempted of any management plans*" (Forestry Service of Metsovo, 1982). After the reconstruction of the village in 1950, new self-organized activities of the community with the RS were developed, consisting in forest paths repairing to attend the annual feast at the Prophet Elias chapel (July 20<sup>th</sup>), located in the neighboring, non-protective, communal forest area, and marking of new mountain trails (I7). After the municipalities' establishment, control by the State in the area is still undertaken by forest guardians from the Metsovo Forestry Service, located 40 km away from the village. The community itself, however, carries out additional guard duties concerning its protective forest (I9).

The above interactions have resulted in a successful collective performance (O1) and a positive ecological state of the forest, which continues to regenerate naturally (O2), since the creation of Greveniti settlement. However, the lack of care in cleaning water channels and tanks for storing the water coming from the forest since 2000, has contributed to the occurrence of landslide in the settlement of Greveniti (Paschos and Nikolaou, 2010). This also creates certain shortage of water supply in the village, especially in the summer months where water management is rendered necessary (O3).

#### 4. Discussion

The purpose of this research is to assess the degree to which collective action was successful in preserving the sacred protective forest of Greveniti across time, identifying the main social, economic and ecological factors, which contributed to the forest formation and conservation. Our results overall indicate that changes in the socio-economic context and the wider governance system recorded over time and the different forms of interactions between its

actors do not appear to have affected in a negative way the collective management of the system, which has been maintained under different multi-centered governance regimes.

The first main finding of this research is that the studied SES was subjected through centuries to dramatic socio-economic, political, and governance changes. These included migration, wars and subsequent destructions, depopulation as well as a changing ownership status of the forest. The latter meaning that the SES regime gradually shifted from a monocentric (community-based) to a polycentric decision-making system (community-municipality-forestry service; state driven). That is to say, the decision-making center has been gradually shifted away from the community itself since 1999.

Frequent socio-economic and governance changes are typical of long-term SES (Skulska et al., 2020), and in certain cases deteriorating conditions, such as political instability and an absence of economic development can affect negatively the outcomes of an action situation (Guevara et al., 2016). Moreover, SESs where communities are deprived of their former property rights on CPR have been showing symptoms of collapse (Basurto et al., 2013; Mutekwa and Gambiza, 2017).

Nevertheless, in our case study, it appears that such changes have not impacted the success of collective action neither the sustainability of the sacred forest for at least 300 years. Most of the village inhabitants are still aware of the sacred forest's existence and of its protective role, despite the experienced turmoil. This is an outstanding finding, which contrasts other SNS literature where the changes in the social and political background of the country are considered the main factors for the degradation of sacred forests: i.e. China (Zeng and Reuse, 2016), India (Osuri et al., 2014), and Africa (Alohou et al., 2016; Mutekwa and Gambiza, 2017). We link the success of the collective action in preserving the sacred forest to four main drivers: (i) adaptive governance, (ii) simplicity of the adopted rules, (iii) combined formal and informal institutions, (iv) community role.

For 200 years (18<sup>th</sup> and 19<sup>th</sup> century) the basic collective rule for the management of the sacred forest of Greveniti was the fear of excommunication. Since the beginning of the 20<sup>th</sup>

century, the fear of excommunication has been gradually supplanted by the ecosystem service value of the resource, *i.e.* the protective role of the forest in replenishing village's aquifers and mitigating flood risks. This shows how the villagers have adopted an alternative vision for the conservation of the forest future; adapting and rationalizing the traditional governance system (preserve the forest via spiritual taboos) to modern governance tools (preserve the regulating and provisioning value of the forest with the support of forestry service activities). However, no matter the method in use, the central role of the sacred-protective forest in community's life remains active. In most sacred forests across the world sacredness is a one-dimensional value, that is to say, local populations believe primarily in the spirituality of the forest itself and not in conservation values, despite major social, economic and political changes (Allendorf et al., 2014; Allendorf and Yang, 2013; Orłowska and Klepeis, 2018; Strauch et al., 2016). Yet, additionally to our case study, community strategies evolution to conserve sacred forests has been also noted in e.g. SNS in India and Sri Lanka (Weerasinghe, 2011).

In addition, CPR surveys' findings confirm that locally based rules that are easy to understand, to enforce, and to help to resolve conflicts, are more likely to lead to effective governance (Basurto et al., 2013). For this reason, they are also considered a very important variable for collective action (Chhatre and Agrawal, 2008). This is the case for the sacred forest of Greveniti, where a simple rule (prohibition of tree cutting) managed to withstand centuries of social, economic, and political changes in the SES.

Moreover, laws established by the Greek state for protective forests have acted as supplementary enforcement for the *de facto* community customary rules. Self-management in the years of Ottoman occupation and Zagori's autonomy, is replaced by the co-management of the community and the Greek state management policies after 1913. These state mechanisms appear to have enhanced the protection of the ecosystem and contributed to the implementation and monitoring of community rules, ensuring the success of collective action until today, as it has happened in the sacred ecclesiastical forests of Ethiopia (Klepeis et al.,

2016). This is an extraordinary prerogative of this sacred forest thanks to the active role played by the local community. This finding contrasts other neighboring sacred forests in Zagori, where forests were at logging risk because no agreements were reached between the forestry service and local communities.

In the case of Greveniti sacred forest, we believe that the clear ownership status and collective rules originally set up by the community for the community itself, are two vital factors responsible for the sustainability of this ecosystem. Yet, the absence of strong enforcement mechanisms of these rules as well as proper monitoring can lead to a degradation of resources (Ostrom and Nagendra, 2006) or poaching of the RS from outside actors (Basurto et al., 2013; Fleischman et al., 2010). The lack of such mechanism for the sacred forest of Greveniti seems to not have caused any negative consequence yet on the SES governance.

The local community emerges as being the main custodian of the Greveniti sacred forest, as in many other SNS (Dudley et al., 2009; Virtanen, 2002; Byers et al., 2001). Although its socio-economic attributes have changed radically compared to previous centuries, the community council maintains the role of the leader for the system preservation. The presence of recognized and collectively elected leaders/representatives from the community is indeed another factor identified as important in achieving collective action among the actors of a CPR system (Guevara et al., 2016; Williams and Tai, 2016; Onyx and Leonard, 2011). The clear identification and small size of the group, their interdependence, the existence of leadership, the existence of a common identity and common social norms, are some of the elements the literature has pointed out as important for successful collective governance. In the studied system, the two most important variables to ensure positive results are, in our opinion, that all stakeholders in the system know about its existence (A7) and that the community's direct dependence on resource is universally accepted (A8). Both variables remain stable at high levels in each time period (Table 1). These variables have been

highlighted by other researchers as of paramount importance for preserving a common resource through time (Orlowska and Klepeis, 2018; Basurto et al., 2013).

An additional result of the performed analysis is the perceived stability of the sacred forest by the informants, in contrast to its actual ecological dynamics. Even older informants perceive the sacred forest as a static, unaltered system since its creation. A similar result is confirmed by other sacred forest surveys, where fewer than half of the informants perceive observable changes in the sacred forest (Allendorf et al., 2014). However, the analysis shows that tree units have increased inside the sacred forest because of the lack of human intervention. Furthermore, the tree cover seems to be “expanding” towards the village former open neighboring areas because of minimum human-induced pressures during the past 30 years, like grazing. The existence of temporal and spatial variability in vegetation coverage has been also recorded in the sacred church forests of Ethiopia (Cardelús et al., 2017) but Klepeis et al., (2016) proved that such changes are hard to perceive within the span of one human generation. Further research on the temporal variability of sacred forests boundaries and the way they are perceived by their neighboring communities is currently underway.

#### ***4.1. Conclusions and policy implications***

The present research confirms that the studied mountainous communities in Northern Greece, have developed an intimate century-long interaction with their sacred forests and related ecosystem services, framed by collective decision-making and customary forms of protection. This enables us to consider sacred forests in northwestern Greece as complex SESs, being natural systems governed through community rules and religious and social taboos, which have evolved as time passes and through subsequent ecological and societal changes. Our application of the Ostrom’s SES framework showed that socio-ecological, political and governance changes have not affected the sustainability of the resource for more than 300 years. Moreover, Actors’ solutions for the collective management of the system proved to be evolving, as time passes. Traditional religious taboos for protecting the resource thus persist, although molded into environmental awareness and heritage preservation reasonings. This

finding has multiple implications relevant from a policy perspective. First, it indicates how SNSs require adaptive policy measures, which can comply with local circumstances and their socio-ecological changing context (Schultz et al., 2015; Undaharta and Wee, 2020). In the field of SNS, this can correspond to adaptive policy frameworks that depart from static sacredness to dynamic conservation strategies for the SNS and its socio-ecological values. Secondly, policies on SNSs need to consider the interconnectedness between all element systems and between the micro-scale (each individual site, with its own specificities) and the macro, landscape, scale. This essential modularity of the policy framework dealing with SNS is necessary to allow the various actors and decision-making centers (e.g. communities, local administrations) to operate in a grid, but without hampering each other work (Anderies and Janssen, 2013). Lastly, policies should aim at being diversified and plurals. SESs rely upon multiple actors' interactions. Maintaining alive the plurality of visions in SNSs is extremely important as it increases chances of social confrontations, possibly leading to the emergence of innovative ideas and practices supporting effective management of SNSs in changing socio-economic contexts.

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## 6. Appendices

**Appendix A:** English translation of the interview guideline used to support the semi-structured interviews.

<b>RESOURCE SYSTEM (RS)</b>	
Sector: What is the name of your Sacred grove?	
1. Clarity of system boundaries	(What are its boundaries?) Have they changed?
2. Ecologically defined boundaries	Is there some ecological sign to define forest's boundaries? (e.g., watershed, changes in vegetation, rocks)  How do they distinguish it from the community forest?
3. User-defined boundaries	Any other signs such as chapels? How would they personally know forest's boundaries? What is their opinion about them?
4. Location	What was there in the past? Have they noted any changes?  Is there a path inside the forest? Where does it go? How often it was used in past? How often is it used now and by whom? Have they ever used it personally? When was the last time? Do people make any use of it nowadays and why?
5. Size of resource system	Has the size of the forest changed over time?
8. Ecosystem History	[Which historical/physical events affected its structure and how?]  How was it used during the war?
9. Natural disaster history	Did any natural disasters take place? Do people relate them to the forest protection?
10. Human disturbance history	Do they remember any major disturbances caused by humans?  When was the pasture-land and grazing abandoned?
Equilibrium properties	Which disturbances exist and how do they affect the system?
11. Frequency/timing of disturbance(s)	How often do they notice disturbances? What are the most usual ones?
24. Predictability of system dynamics	What do they believe about its future development?
<b>ACTOR GROUPS (A)</b>	
6. History or past experiences	Any local or personal stories concerning the forest?
7. Importance of resource (dependence)	How is the sacred forest important for their livelihood? In what way? In the past?
12. Location	Has it ever changed? Any stories about smaller communities that united? Any communities inside the forest?

<b>RESOURCE UNITS (TREE SPECIES) (RUII)</b>	
13. Value	To what tree species do they attribute more value and why? Is it the same they like the most?
14. Distinctive characteristics	Does any tree species have some distinctive characteristics for them?
15. Spatial and temporal distribution	Which species is dominant in the forest today? Is it the dominant sp. in every part of it? What about the community forest and the forests of near villages? Why do they think this is taking place?
16. Growth or replacement rate	Do they notice any change in species? What about canopy tree sp.? Are they the same?
<b>POPULATION OF RESOURCE UNITS (THE FOREST) (RUI)</b>	
17. Growth or replacement rate	Do they believe their grove keeps growing? Do you know the ages of older trees? Comparing to the past ones?
18. Number of units	Do they see more trees in the forest now than the past?
19. Spatial and temporal distribution	Do they believe the composition of the forest has changed compared to previous time periods?
<b>GOVERNANCE SYSTEM (GS)</b>	
20. Government organization	Who owns the forest? Who takes decisions about it? Do they know if it is part of National Park? What would they think of that?
21. Property-rights systems	Who had access to the forest? Does that apply to every member of the community?
23. Repertoire of norms and trends	Do actors comply with them or have a different way of managing things? What was the case before/during the war?
Rules in use	What are the rules and how often are they modified?
22. Monitoring and sanctioning rules	Are there any monitoring rules? Any sanctions in case of illegal activities?

876

877

878 **Appendix B:** First (bold), second and third (*italics*) tier variables selected initially for the current  
879 study. \* indicates the existence of more than one tiers. Variables defined according to Epstein &  
880 Kreitmair (2013) and Delgado-Serrano & Ramos (2015). RU is decomposed in two components, with  
881 the aim of including the forest as a single system (RUI) and the units from which it is composed  
882 (RUII). RU4-Economic Value was renamed to Resource Value (Delgado-Serrano & Ramos, 2015)  
883 because the ecosystem is protected and there is no economic exploitation.  
884

#### **SOCIO-ECONOMICAL AND POLITICAL SETTINGS (S)**

S1	Economic development
S2	Demographic trends
S3	Political stability
S4	Government resource policies
S7	Technology

RS6c *Extent of disturbance(s)*

RS7 Predictability of system  
dynamics\*

RS9 Location

RS10 Ecosystem History\*

RS10a *Relevant geologic history*

RS10b *Natural disaster history*

RS10c *Human use and disturbance  
history*

#### **RELATED ECOSYSTEMS (ECO)**

ECO1	Climate patterns
ECO3	Flows in &out of SES

#### **ACTORS (A)**

A1	Number of relevant actors
A2	Socioeconomic attributes
A3	History or past experiences
A4	Location
A5	Leadership/entrepreneurship
A6	Norms (trust- reciprocity)/social capital
A7	Knowledge of SES/mental models
A8	Importance of resource (dependence)
A9	Technologies available

#### **RESOURCE SYSTEM (RS)\***

RS1	Sector
RS2	Clarity of system boundaries*
RS2a	<i>Ecological defined boundaries</i>
RS2b	<i>User-defined boundaries</i>
RS3	Size of resource system*
RS3a	<i>Different ecosystem types within the RS</i>
RS4	Human-constructed facilities
RS6	Equilibrium properties*
RS6a	<i>Successional stage/trajjectory</i>
RS6b	<i>Frequency/timing of disturbance(s)</i>

#### **POPULATION OF RESOURCE UNIT (THE WHOLE FOREST) (RUI)**

RU2i	Growth or replacement rate
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RU3i	Interaction among resource units
RU4i	Resource value
RU5i	Number of units
RU7i	Spatial and temporal distribution

**RESOURCE UNIT (TREE SPECIES) (RUII)**

RU2ii	Growth or replacement rate
RU4ii	Resource value
RU6ii	Distinctive characteristics
RU7ii	Spatial and temporal distribution

**GOVERNANCE SYSTEM (GS)\***

GS1	Government organization
GS2	NGOs
GS3	Network structure
GS4	Property-rights systems
GS5	Rules in use*
<i>GS5a</i>	<i>Operational-choice rules</i>
<i>GS5b</i>	<i>Collective-choice rules</i>
<i>GS5c</i>	<i>Constitutional-choice rules</i>
GS6	Repertoire of norms & trends

GS7	Monitoring and sanctioning rules
GS8	Regime type
GS9	Historical continuity

**INTERACTIONS (I)**

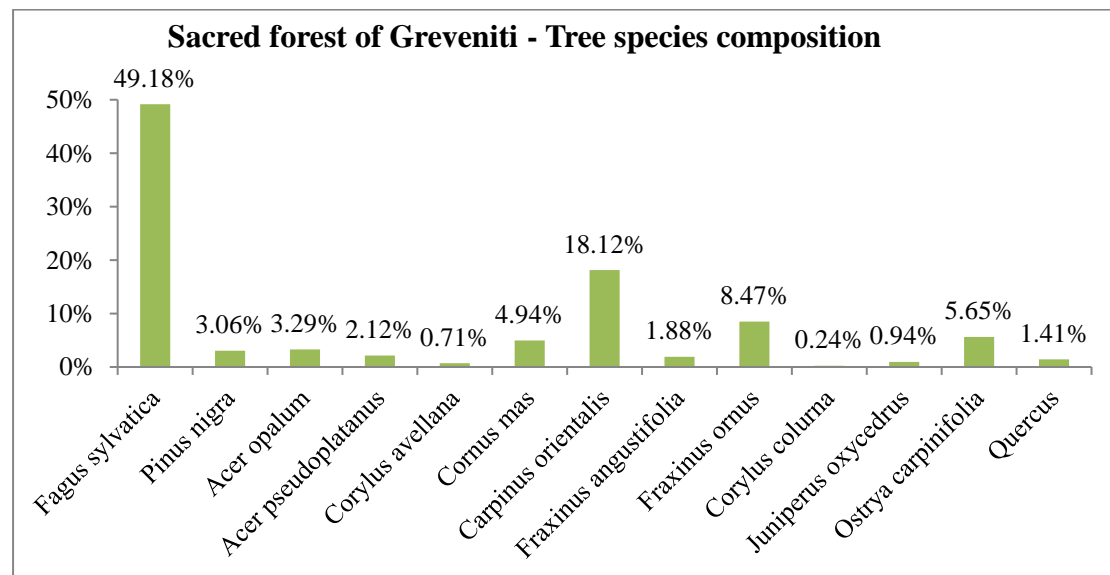
I1	Harvesting
I2	Information sharing
I3	Deliberation processes
I4	Conflicts
I5	Investment activities
I6	Lobbying activities
I7	Self-organizing activities
I8	Networking activities
I9	Monitoring activities
I10	Evaluative activities

**OUTCOMES (O)**

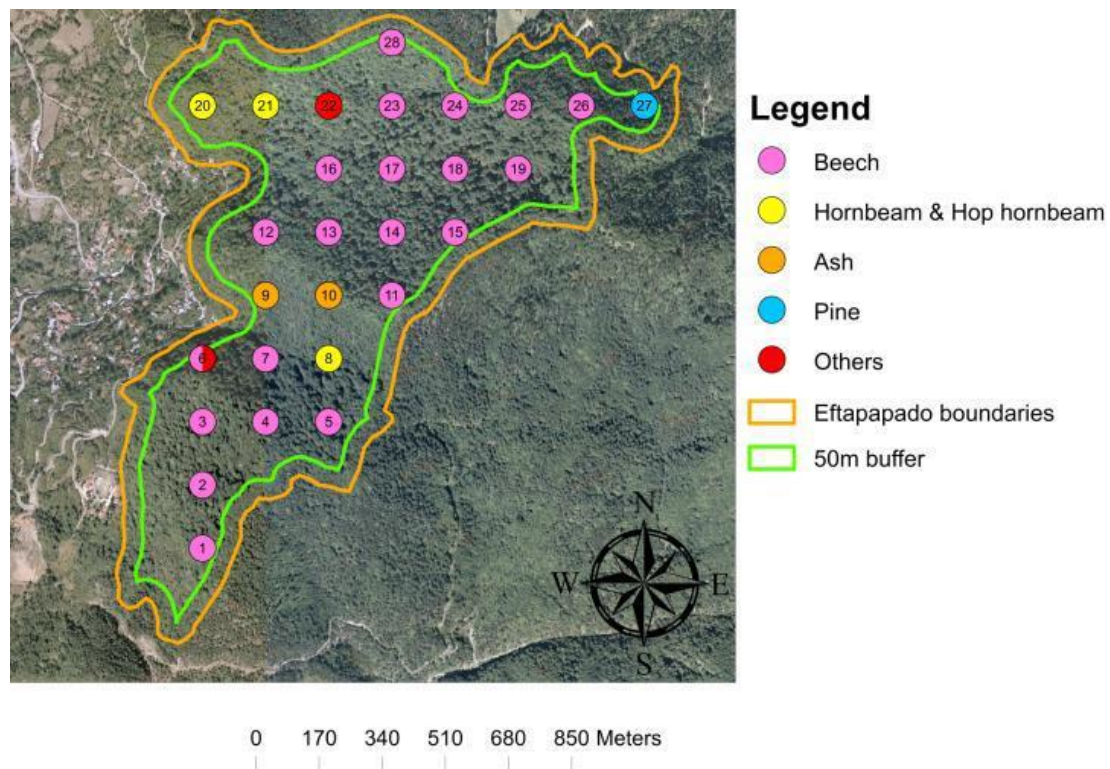
O1	Social performance measures
O2	Ecological performance measures
O3	Externalities to other SESs

**Appendix C:** RU data collected for the sacred forest of Greveniti. Sources: (Cullen, 2015; Marini-Govigli et al., 2015; Marini-Govigli et al., 2020; Metsovo Forestry Service, 2012).

I. POPULATION OF RESOURCE UNIT (THE WHOLE FOREST) (RU <sub>i</sub> )		
<b>RU2i</b>	Growth/replacement rate	Natural regeneration, gap dynamics
<b>RU2ia</b>	Age of forest	Up to 310 years old
<b>RU3i</b>	Interactions among units	Competition does not appear to affect the growth rate of mature trees,, although further research needs to be conducted (Cullen, 2015)
<b>RU4i</b>	Resource value	Aesthetic, recreational, spiritual, conservation, research, utilitarian
<b>RU5i</b>	Number of trees	Increasing (according to informants)
<b>RU7i</b>	Spatio-temporal distribution	Dominant tree species is beech, spreading in an area of approx. 66 ha. The ethnographic research conducted did not detect any changes in the current species distribution.
II. RESOURCE UNITS (INDIVIDUAL TREE UNITS) (RU <sub>ii</sub> )		
<b>RU2ii</b>	Growth/replacement rate	The number of individuals decreases exponentially as size classes increase. Beech trees dominates understorey vegetation, with exception to the W side where the regeneration layer is more diversified with other broadleaves
<b>RU2iia</b>	Tree species	Fig. C.1
<b>RU2iib</b>	Tree ages	<i>Fagus sylvatica</i> was found in all size classes (except 100-125years old), <i>Pinus nigra</i> trees correspond only to medium-large sized trees (approx..100-150 years old)
<b>RU7ii</b>	Spatio-temporal distribution	Two distinct beech dominated forests, separated by a belt of lower understorey vegetation ( <i>F. ornus</i> , <i>F. angustifolia</i> and <i>C. orientalis</i> ) (Fig.1). Pine ( <i>P. nigra</i> ) in the NE and a mixed <i>Carpinus-Acer</i> stand around the W edges proximal to the village of Greveniti (Fig. C.2).



**Figure E.1** Tree species composition in Greveniti sacred forest. Values are percentages of the total identified individuals at tree level. (Due to identification issues, juveniles of deciduous oaks were pooled at *Quercus spp* level). Source: Marini-Govigli *et al.*, 2020.



**Figure E.2** Dominant tree species by plot stems number. Presence of two colors shows a case of co-dominance. (Source: Marini-Govigli *et al.*, 2015.)

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