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Tree Cover Loss in the Mediterranean Region—An Increasingly Serious Environmental Issue

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Abstract: The Mediterranean Region currently faces major environmental issues that require constant analysis and monitoring. This study presents a thorough approach based on the application of Landsat imagery from Global Forest Change during 2001–2019. Spatial distribution mapping was one of the objectives of the study. We approached the analysis of tree cover loss areas by analyzing the cumulative tree cover loss and Tree Cover Loss Rate. This indicator offers information about the trend of tree cover loss in each Mediterranean country. A total of 581 Mha of deforested area was mapped during the analyzed period. Analysis was further supplemented by some statistical operations (distributions shown via histograms, validation via Shapiro–Wilk normality test, and testing via one-sample *t*-test). Agricultural expansion, intense forest fires, illegal logging, overgrazing (especially in the northern part of Africa), and extensive livestock farming have influenced the Mediterranean forest ecosystem's stability. The continuation of these activities could cause extreme climatic events, severe degradation, and desertification.

Keywords: tree cover loss; environment; degradation; Mediterranean Region

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1. Introduction

The effects of tree cover loss and forest degradation are critical environmental problems [1]. The fragility of forest ecosystems is an aspect intensely present in research in recent years, whether tropical forests, mangrove forests, or temperate forests [2–5].

Forest ecosystems are a critical component of the world's biodiversity, characterized more by diversity and unicity than other ecosystems of the world [6,7]. Forests cover 31% of the global land area, 4.06 billion hectares are natural forests or plantations, and approximately 15% are compact forest areas [8].

FAO estimated that, in 2015, across all Mediterranean countries, there were 88 million hectares of forest [9]. These forests represent biodiversity hotspots with around 60% endemic plant species from 25,000 species, but they are also very fragile ecosystems depending on variations in environmental conditions [10–12].

Several drivers determine tree cover loss: (i) commodity-driven deforestation, (ii) urbanization and demographic changes, (iii) shifting agriculture due to small- or medium-scale agriculture, (iv) forestry activities that through forest harvesting affect the forest stability, and (v) wildfires that determine the temporary loss of forests [13]. Anthropic activities have significantly altered biodiversity, and conservation efforts are needed to protect the mountains and coastal areas as a network of protected areas [14–16]. The long period of forest exploitation, significant socio-economic changes, rapid urbanization, and severe climatic events are important threats to the environmental stability of Mediterranean forests; a conservation strategy and sustainable forest management are thus required [17–19].

Human activities in forests also have a significant impact on the biodiversity of the Mediterranean Region. As a result, World Heritage Natural Sites have experienced a decrease in their degree of uniqueness and are subject to threats driven by climate change and increasing population in littoral areas [20–22].

Agricultural activities have influenced Europe's landscape through new crops and pastures, forest exploitation for fuel and wood processing, changes in soil properties, increasing temperatures in urban areas, and increased fire risk [23–27].

Additionally, natural hazards (storms, forest fires, strong winds) are strongly related to changes in land use and land cover, which fragment the landscape and result in environmental damage [28–31]. Large fires (>1000 ha) often claim human victims and cause greater burned forest areas and property damage [24].

Forest ecosystems are crucial in the fight against climate change, and reforestation can contribute to reducing the concentrations of greenhouse gases in the atmosphere [32–35].

For these major causes of tree cover loss, quantifying and documenting the extent of tree cover loss is a priority activity for environmental stability. The objectives of this study were (1) to explore tree cover loss rates in the Mediterranean Region; (2) to illustrate the spatial distribution of deforested areas; and (3) to show the evolution of the Tree Cover Loss Rate (*TCLR*) for the period 2001–2019 to illustrate the situation for this fragile environment.

The Mediterranean environment's stability is influenced by the tree cover loss in the context of actual global climate changes (increasing about 0.85 °C globally and 1.3 °C in the last century) [9]. That is why it is important to constantly monitor the evolution of tree cover loss, to observe the general trend. The tree cover loss is responsible for the present situation of flash floods and fires [36–38]. With the results presented in this paper, we aim to develop a better understanding of the impact of tree cover loss on the environment in the Mediterranean Region.

2. Materials and Methods

2.1. Study Area

As the study area, we focused on Mediterranean countries; these are characterized by certain patterns of the climate, such as dry and hot summers and moist and cool autumns and winters. Sometimes, extreme climatic events can influence the forests [39,40]. The natural vegetation of the Mediterranean region is related to the Mediterranean climate, but it is influenced by the presence of mountainous areas [17]. The Mediterranean vegetation is adapted to its environmental conditions with a deficit of precipitation during the warm season. It comprises predominately xerophilous vegetation, shrublands, broadleaf forests (60%, with species *Castanea sativa*, *Quercus suber*, and *Quercus ilex*), and coniferous forests (*Pinus pinea*, *Cupressus sempervirens*, and *Castanea sativa)*, varying in proportion from Italy (76%) to Portugal (49%) [9,41,42]. The cork oak *(Quercus suber)* savannas in southwestern Europe and northwestern Africa have great conservation value and are characterized by shrub formations to grasslands with high biodiversity [43,44]. These countries are across three continents, most of them covering the European (13 countries), African (4 countries), and Asian (4 countries) territories (Figure 1).

2.2. Data Acquisition and Processing

The analysis of tree cover loss in the Mediterranean Region began with the collection of satellite images with a spatial resolution of 30 m from the Global Forest Change (GFC) dataset, courtesy of the Department of Geographical Sciences, University of Maryland (UMD), GLAD Laboratories in partnership with Google, United States of America from the Global Forest Watch, for a period of 19 years (2001–2019) [45]. The most suitable data to monitor forest cover changes are satellite images that can provide, through post-analysis, information about land use and forest changes. These images were used to extract the tree cover loss areas (annually from 2001 to 2019). The first step consisted of downloading the raster data. They were downloaded as individual, 21 (10 × 10 degree) granules, for the entire Mediterranean Region considering the geographical coordinates in Table 1. Using the function "extract by mask", the resulting merged raster image was cut according to the Mediterranean Region border (vector).

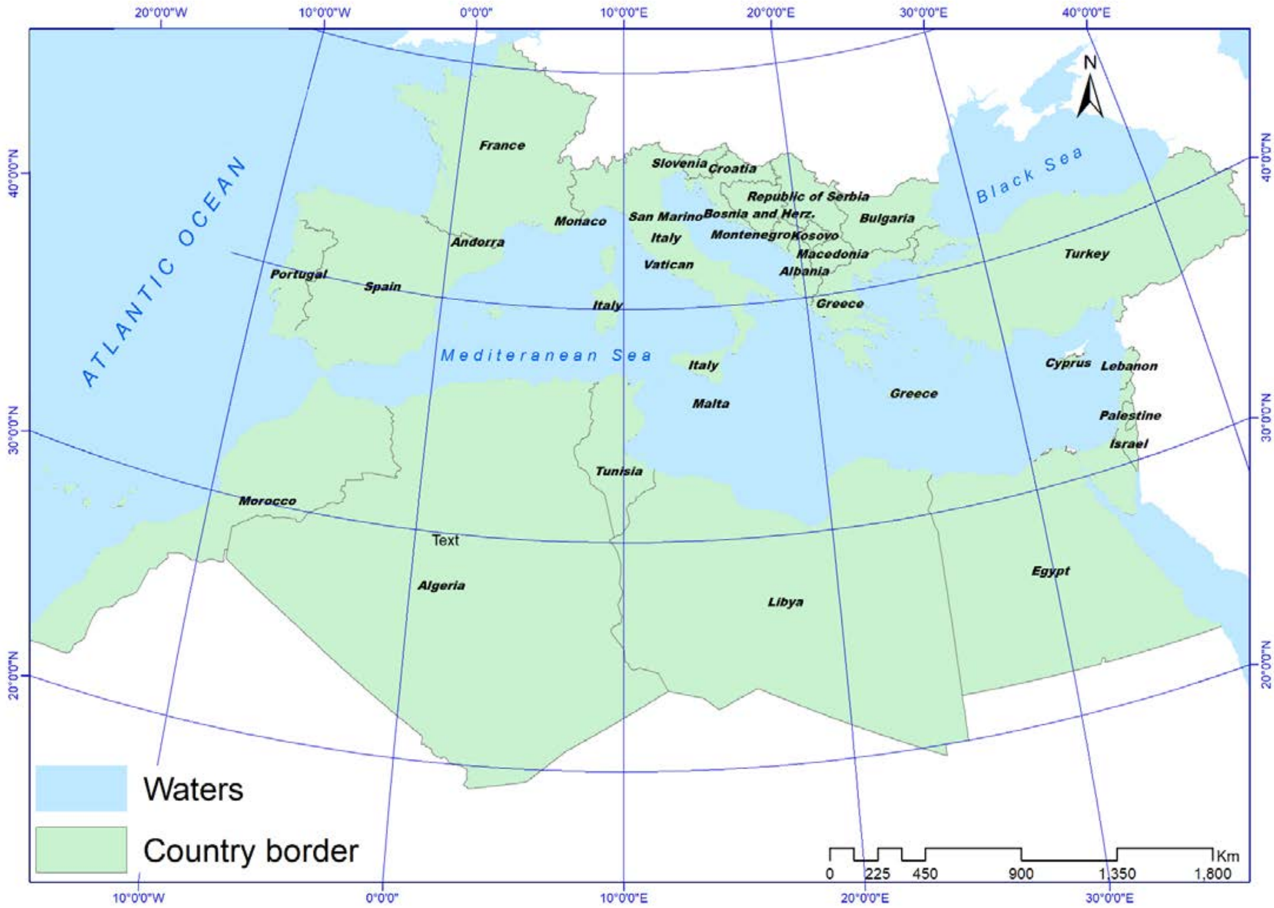

Figure 1. The geographical positions of countries in the Mediterranean Region.

Then, the data were merged to produce a single raster image. The conversion into points of the raster image was performed using the function "raster to points" to extract the annual tree cover loss for each country (Figure 2). Each pixel had a different color representing a different year (e.g., for the period 2001–2019, 19 different colors were used for each year).

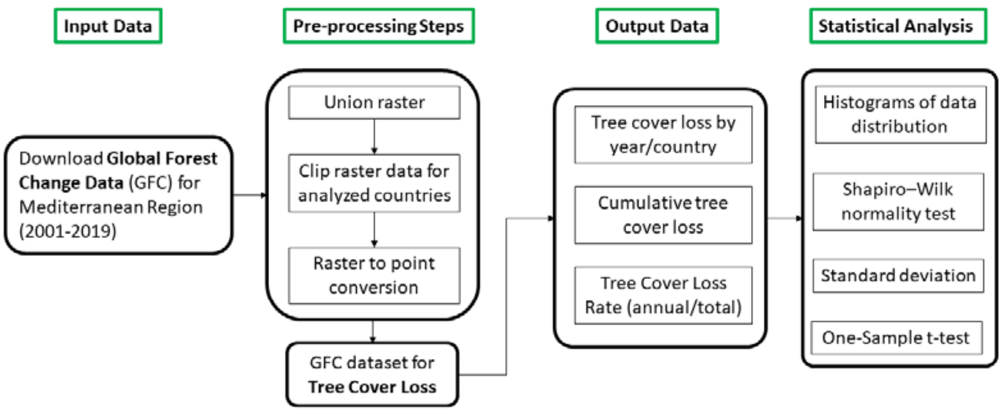

Figure 2. Flowchart including input data, pre-processing steps, statistical analysis, and output data to determine the tree cover loss in the Mediterranean Region.

Table 1. Landsat-7 ETM+ geographical coordinates covering the study area (Data obtained from the Global Forest Change platform [45]).

No.	Satellite Images and Spatial Resolution	Longitude	Latitude	Data Source
1	LANDSAT 7 ETM+, 30 m	10°–20° N	0°–10° E	GFC
2		10°–20° N	20°–30° E	
3		20°–30° N	0°–10° E	
4		20°–30° N	10°–20° E	
5		20°–30° N	0°–10° W	
6		20°–30° N	20°–30° E	
7		20°–30° N	10°–20° W	
8		20°–30° N	30°–40° E	
9		30°–40° N	0°–10° E	
10		30°–40° N	10°–20° E	
11		30°–40° N	0°–10° W	
12		30°–40° N	20°–30° E	
13		30°–40° N	30°–40° E	
14		30°–40° N	40°–50° E	
15		40°–50° N	0°–10° E	
16		40°–50° N	10°–20° E	
17		40°–50° N	0°–10° W	
18		40°–50° N	20°–30° E	
19		40°–50° N	30°–40° E	
20		40°–50° N	40°–50° E	
21		50°–60° N	0°–10° E	

The data are expressed in hectares, and for our analyses, the tree cover loss by year from 2001 to 2019 and the canopy cover levels from ≥10 to ≥75 (≥10, ≥15, ≥20, ≥25, ≥30, ≥50, ≥75) seemed to be remarkably interesting. The recommendation is to select the desired percent canopy cover level and use it consistently throughout any analysis, but the Global Forest Watch website uses a ≥30% canopy cover threshold as a default for all statistics, the same canopy level used by us in the present study. The processing of the data was performed by using descriptive statistics and was materialized in graphic and cartographic materials and boxplots, made using the ArcGIS (ESRI, Redlands, CA, USA), Microsoft Excel, and R Software platforms.

2.3. Methodology

To observe the distribution of data, histograms by country were made with all the tree cover loss. Then, some specific operations and tests were applied: the standard deviation for each country and one-sample *t*-test, also by country. To check the normality of the tree cover loss distribution, the Shapiro–Wilk statistical test was applied, due to the small amount of data (2001–2019). The data displayed in Table 3 indicate, for most of the countries analyzed, a normal distribution (*W* values are over 0.75). This hypothesis is also sustained by the *p*-values, which are above 0.05 in most cases. Among all the 30 countries, there were 9 that did not report any information about tree cover and tree cover loss areas, by year or by canopy cover level. That is why they were excluded from our analyses (Figure 2).

The *TCLR* was calculated to observe the trend in the tree cover loss evolution by year and for the entire period. The annual evolution was marked in blue, and the upward trend, for the entire period, was marked in red (meaning a negative aspect—a high tree cover loss rate) or green (meaning a positive aspect—a low tree cover loss rate).

It was calculated by using the following equation:

$$TCLR\ (\text{annual}) = \left(\frac{TCL\ n - TCL\ n-1}{TCL\ n-1}\right) \times\ 100.$$

where $TCL \rightarrow$ tree cover loss; $n \rightarrow$ year.

$$TCLR\ (\text{entire period}) = \left(\frac{TCL\ n - TCL\ n - 19}{TCL\ n - 19}\right) \times 100$$

where $TCL \rightarrow$ tree cover loss; $n \rightarrow$ year.

3. Results

Tree Cover Loss in the Mediterranean Region

In Figure 3, showing the tree cover loss by country in the 2001–2019 period, there are differences from one country to another; these are due, on the one hand, to their total areas, tree cover areas, and timber needs and, on the other hand, to other natural or anthropogenic factors such as wildfires, diseases, the expansion of urban areas, and so on. The biggest tree cover loss areas were registered in Spain (1,231,065 ha), France (1,142,699 ha), Portugal (1,027,175 ha), and Turkey (499,959 ha). On the opposite side, the countries with low tree cover loss included Palestine (18 ha), Malta (13 ha), and Jordan (7 ha). These countries have forest areas that are large but fragile to main threats: climate change, extreme temperature, human activities, urbanization, and the need for agricultural land. The smallest values were recorded in countries with small administrative territories.

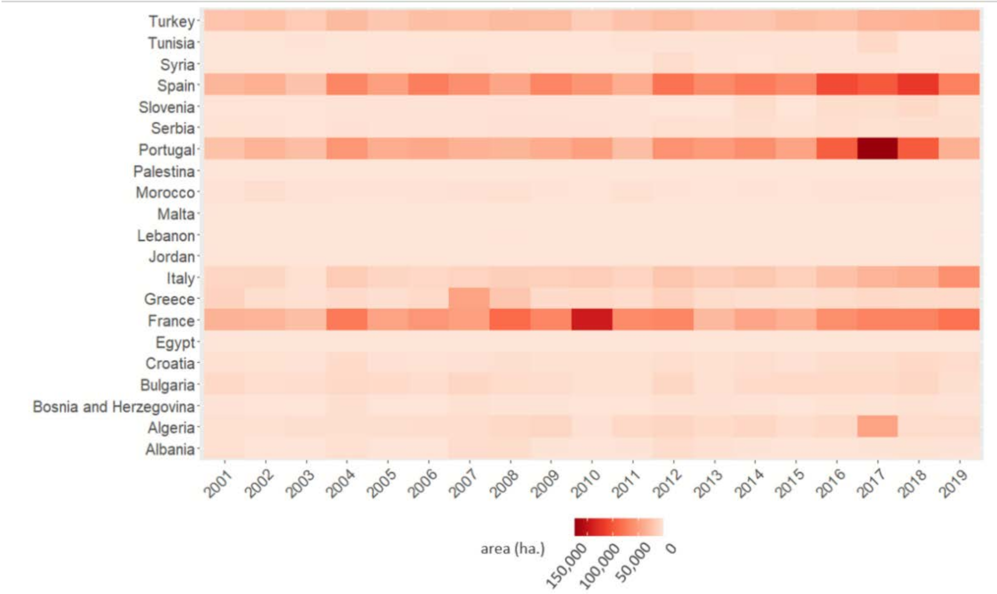

Figure 3. Tree cover loss by country (2001–2019).

To see the importance of the tree cover loss, it is particularly useful to analyze the distribution of the tree cover loss. By ordering all the countries alphabetically, we obtain the most relevant and non-discriminatory view of all the countries in the whole territory considering a canopy level of $\geq$30, the same level taken in all analyses [27] (Table 2).

To identify the shape of the tree cover loss data and see whether tree cover loss process changes occurred from one year to another, some descriptive statistic operations were applied. The first step was to determine the simple distribution of them by constructing a histogram for each country of the tree cover loss in the period 2001–2019. The histograms in Figure 4 show a very different distribution of the data for each country, and they can be grouped into only two main categories. Most of the countries (15 countries) have a skewed-right distribution; among these, Albania, Algeria, Egypt, Greece, Portugal, and Tunisia can be mentioned as representatives. In the second category (symmetric/normal distribution), there are only six countries (Bulgaria, Lebanon, Morocco, Serbia, Spain, and Turkey).

The normality of the tree cover loss data distribution for each country was checked using the Shapiro–Wilk test in the present study. The data in Table 3 indicate a normal distribution for most of the countries (W values over 0.75), but not in some cases (Algeria, 0.48; Egypt, 0.56; Greece, 0.59; Jordan, 0.65; and Portugal, 0.71). This hypothesis is also sustained by the *p*-values, which are above 0.05 in most cases (Lebanon, 0.1503; Morocco, 0.1335; and Serbia, 0.9262). The standard deviation exhibits significant variation, ranging from 0.60 (Jordan) and 0.91 (Palestine) to 35,264.54 (Portugal), 26,971.25 (France), and 13,047.56 (Italy).

One-sample *t*-tests were applied for the sample of 21 countries to test whether the mean tree cover loss in each country was different from a specific value; statistical significance was observed for all countries as indicated by the *t*, *df* and *p* values registered. In all cases, the degree of freedom was 18, which means that the power of the test is high. The obtained values of t varied from 2.689 (Jordan) to 20.211 (Turkey) and the probability level *p* in all cases is under 0.05 (from 0.00001 for Bosnia and Herzegovina, Bulgaria, Croatia, Italy, Lebanon, Morocco, Portugal, Spain, and Turkey to 0.01500 for Jordan) (Figure A1). The evolution of the *TCLR* for the 21 countries shows three situations: one where the tree cover loss increases (represented in red color—negative aspect), one where the surfaces decrease (green color—positive aspect), and one country with no evolution (0%, Jordan) (Figure 5). For most countries, the tree cover loss area as a percentage for the period 2001 to 2019 increased; the highest values (more than 100%) were registered in Italy (504.85%), Slovenia (461.95%), Syria (340.82%), Tunisia (148.05%), France (136.2%), and Spain (116.46%). Other countries encountered negative evolution rates for the same period; among them were Palestine and Malta (−100% for each), Egypt (−85.81%), and Albania (−71.20%).

Table 2. Tree cover loss areas in countries in the Mediterranean Region [Data obtained from the Global Forest Change platform and online documentation [45].

Country	Country Area	Tree Cover Loss 2001	Tree Cover Loss 2005	Tree Cover Loss 2010	Tree Cover Loss 2015	Tree Cover Loss 2019	Cumulative Tree Cover Loss (2001–2019)
				(ha)			
Albania	2,873,537	3729	695	656	284	1074	39,047
Algeria	124,831,323	3469	4470	2606	5707	6291	158,275
Andorra	46,800	*NA* *	*NA* *	*NA* *	*NA* *	*NA* *	*NA* *
Bosnia and Herzegovina	5,106,883	1496	574	911	581	1232	30,073
Bulgaria	11,158,731	8202	6567	3569	7293	4125	123,569
Croatia	5,707,840	3378	2747	3499	2669	5978	76,297
Cyprus	925,100	*NA* *	*NA* *	*NA* *	*NA* *	*NA* *	*NA* *
Egypt	98,376,439	148	53	98	32	21	1732
France	54,951,498	34,421	46,391	143,265	37,293	81,304	1,142,699
Greece	13,257,505	12,617	4181	7785	3840	7604	182,913
Israel	2,077,000	*NA* *	*NA* *	*NA* *	*NA* *	*NA* *	*NA* *
Italy	30,075,443	9871	10,896	15,806	14,124	59,705	358,569
Jordan	8,911,879	1	0	0	0	1	7
Kosovo	1,088,700	*NA* *	*NA* *	*NA* *	*NA* *	*NA* *	*NA* *
Lebanon	1,023,804	299	300	115	174	390	4147
Libya	176,000,000	*NA* *	*NA* *	*NA* *	*NA* *	*NA* *	*NA**
Macedonia	6,700,000	*NA* *	*NA* *	*NA* *	*NA* *	*NA* *	*NA* *
Malta	32,335	1	0	1	0	0	13
Monaco	202	*NA* *	*NA* *	*NA* *	*NA* *	*NA* *	*NA* *
Montenegro	1,381,200	*NA* *	*NA* *	*NA* *	*NA* *	*NA* *	*NA* *
Morocco	41,348,767	1868	1526	988	952	1250	37,419
Palestine	621,997	2	0	1	0	0	18
Portugal	8,955,506	24,405	38,934	48,401	46,097	36,886	1,027,175
San Marino	6120	*NA* *	*NA* *	*NA* *	*NA* *	*NA* *	*NA* *
Serbia	7,823,140	2380	1551	2462	2815	3962	52,807
Slovenia	1,998,091	615	1951	1434	1025	3456	45,059
Spain	50,604,279	32,811	48,955	56,093	65,414	71,022	1,231,065
Syria	18,691,800	267	792	241	2393	1177	20,681
Tunisia	15,486,458	231	633	398	1880	573	26,937
Turkey	78,070,341	22,910	20,411	17,008	27,735	39,118	499,959
Vatican	44	*NA* *	*NA* *	*NA* *	*NA* *	*NA* *	*NA* *

* *NA*—countries with no tree cover loss data.

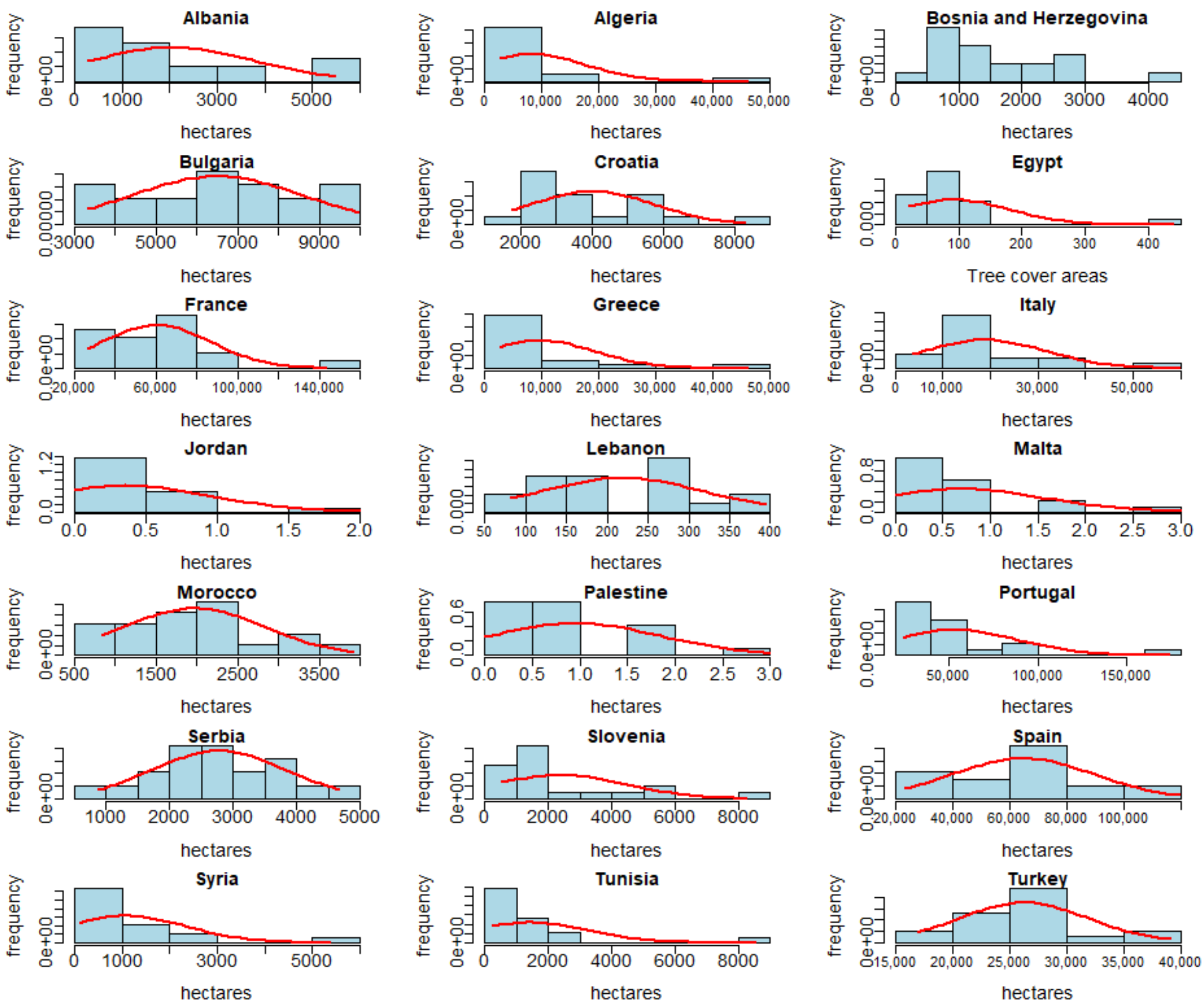

Figure 4. Histograms of tree cover loss by country (2001–2019).

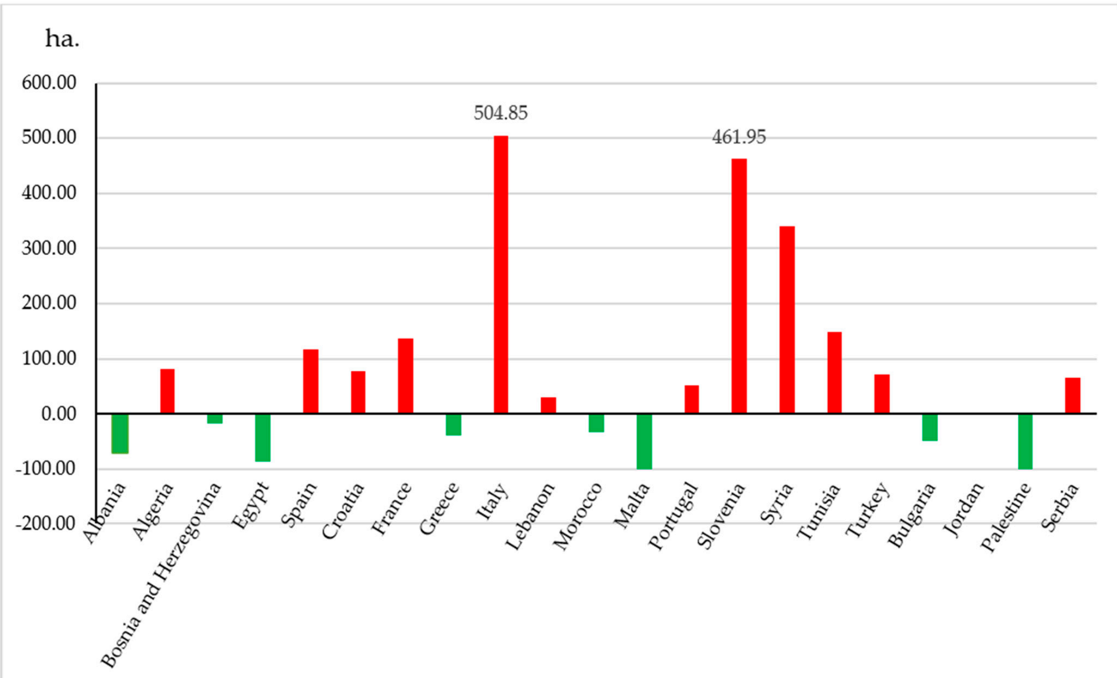

Figure 5. Evolution of the Tree Cover Loss Rate (2019 vs. 2001).

Table 3. Shapiro–Wilk normality test for data validation.

No.	Country	W	*p*-Value	Standard Deviation
1	Albania	0.81	0.001462	1724.88
2	Algeria	0.48	3.579×10^{-7}	9438.98
3	Bosnia and Herzegovina	0.92	0.1103	993.18
4	Bulgaria	0.95	0.4318	2105.93
5	Croatia	0.91	0.08276	1753.81
6	Egypt	0.56	2.787×10^{-6}	90.24
7	France	0.87	0.01634	26,971.25
8	Greece	0.59	3.138×10^{-6}	9791.96
9	Italy	0.79	0.0007701	13,047.56
10	Jordan	0.65	1.374×10^{-5}	0.60
11	Lebanon	0.93	0.1503	100.44
12	Malta	0.76	0.0003579	0.89
13	Morocco	0.92	0.1335	866.03
14	Palestine	0.85	0.006288	0.91
15	Portugal	0.71	7.214×10^{-5}	35,256.54
16	Serbia	0.98	0.9262	1053.05
17	Slovenia	0.79	0.0007622	2124.55
18	Spain	0.96	0.6258	25,074.63
19	Syria	0.74	0.0001789	1264.86
20	Tunisia	0.57	2.128×10^{-6}	1841.72
21	Turkey	0.96	0.602	5675.02

Analyzing the situation by country, Albania—although it presented a generally decreasing tree cover loss percentage—in many years showed increasing values over 400% (2004 vs. 2003 and 2007 vs. 2006). High values were also found in 2012 vs. 2011 (over 300%) and 2016 vs. 2015 (over 200%). Algeria also exhibited two periods with high values (2011 vs. 2010, over 200%, and 2017 vs. 2016, up to 500%). For Bosnia and Herzegovina, in 2004 vs. 2003, the tree cover loss rate was up to 1300%. For Bulgaria, the values were low (only 200% in 2012 vs. 2011). In Croatia and Egypt, the highest values oscillated around 300% (2004 vs. 2003 for Croatia and 2012 vs. 2011 for Egypt). For Greece and Italy, the values were up to 600%, and the latter country also showed a considerable increase for the entire period. Jordan and Palestine registered negative evolution for the entire period, but for Palestine, in 2008 vs. 2007, the tree cover loss rate was 200%. Slovenia and Syria had the highest values, with 800% for Slovenia in 2014 vs. 2013 and 3400% for Syria in 2012 vs. 2011. Very different was the situation of Turkey: for this country, the value was up to 75% each year—a moderate rate (Figure A2).

The tree cover loss in the different countries during the period of analysis (2001–2019) is depicted in Figure 6. It can be observed that in the upper part of the Mediterranean region (characterized by large areas of tree cover and situated closer to the temperate climate area—temperate forests), in countries such as Portugal, France, and Spain, forest loss is predominant. On the other side, in countries close to the desert areas and where the tree cover is not so dense, their loss is moderate to low. This image exhibits a significant amount of correlation with the two previous figures, which present the forest loss in comparison to the tree cover extent in 2000 and 2010.

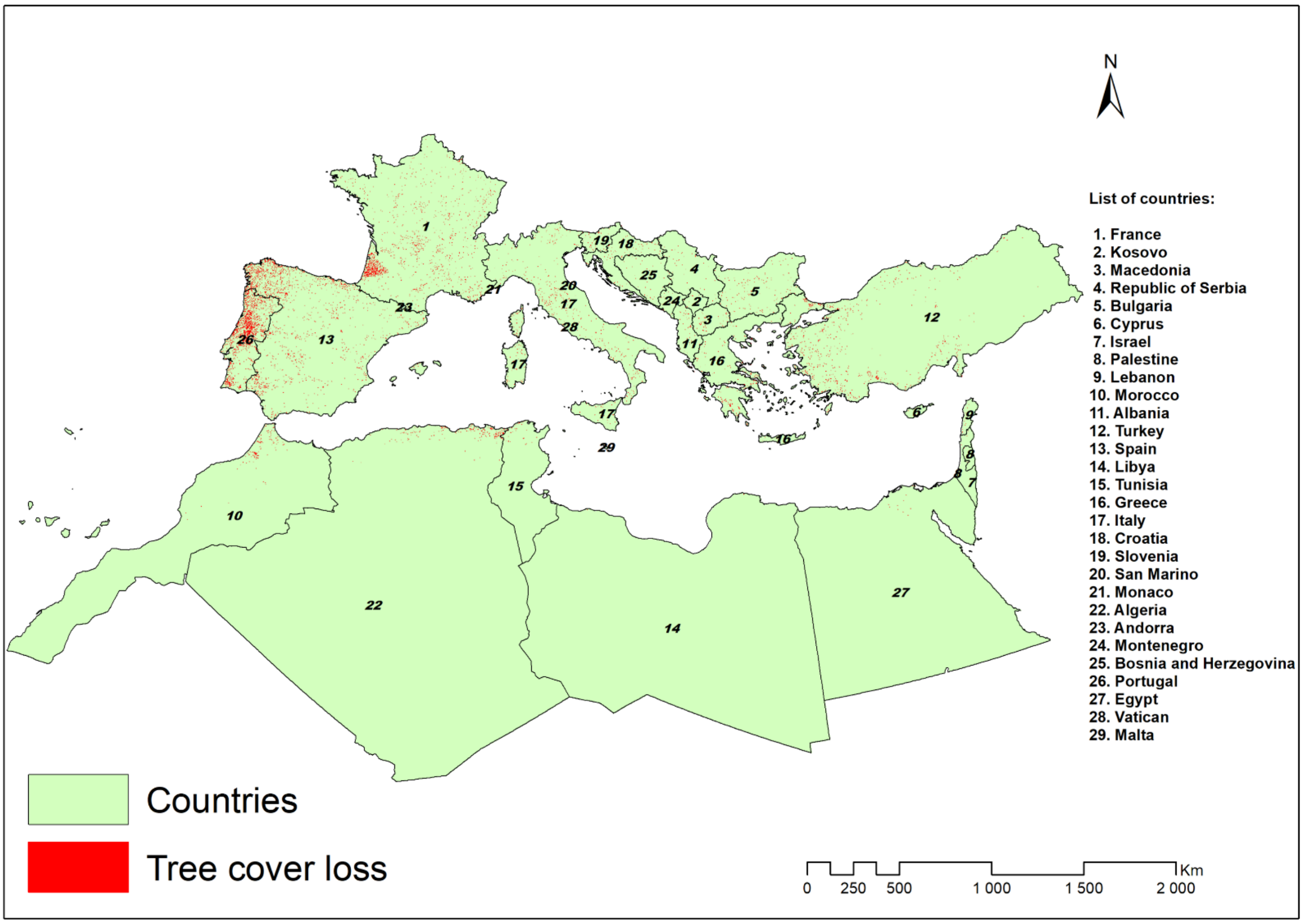

Figure 6. Spatial distribution of the tree cover loss areas in the Mediterranean Region (2001–2019).

4. Discussion

This article describes a methodology for studying the tree cover in the Mediterranean Region, providing a consistent spatial distribution of tree cover loss changes at the national scale for 2001–2019. The methodology used in this study based on the analysis of tree cover loss data is shown to accurately monitor the tree cover loss.

The vegetation is in strong correlation with the climate, characterized by a deficit of precipitation in the warm season and moist and cool winters [17].

In the last century, in the Mediterranean Region, the temperature has increased 1.3 °C [9]. The stability of forests is affected by both climatic factors and socioeconomic pressure. Therefore, the forest ecosystems are influenced by intense wildfires [20,24], loss of biodiversity [2,12,41], land degradation and fragmentation [9,15,46], and traditional agricultural techniques [16,23,46]. However, the drivers that modify the distribution of forest areas vary from one country to another.

Analysis of the forest loss data shows that the forests in the Mediterranean Region represent an ecosystem that is vulnerable to external threats and has experienced intense tree cover loss (a total of 581 Mha of tree cover loss area) [9,45].

In European countries, the major activity that affects forests is harvesting done to provide wood for industry [19,23,46]. On the other hand, in Africa, the dominant driver of tree cover loss is shifting agriculture, which determines temporary loss of forests, especially in Morocco, Algeria, and Tunisia [46,47]. Of the dominant threats to tree cover loss, including agricultural expansion, the underlying causes of tree cover loss are the global markets for cork oak, timber, and pulp [11,27,39,48]. In addition to this, another direct threat to tree cover loss includes intense forest fires [9,13,24,49], illegal logging [13,17], and some traditional tools for creating grasslands for extensive livestock farming and overgrazing in states such as Algeria, Lebanon, Morocco, Tunisia, and Turkey [9,16].

The utility of this study for the Mediterranean Region is to encourage continuous monitoring of tree cover loss evolution, as has already been conducted in countries in South America [50,51], Europe [52], and Africa [53,54].

We evaluated the tree cover loss in the Mediterranean Region and the significant drivers that affect the forest area. Second, analysis of tree cover loss by canopy cover signifies that the highest loss areas are specific to the Mediterranean countries.

Third, the highest tree cover loss areas have specific environmental conditions (high temperatures, dry periods), severe climatic events, frequent forest fires, and changes in land use among the principal causes of tree cover loss. Portugal and Spain recorded the highest rates of tree cover loss (1,231,065 ha in Spain and 1,027,175 in Portugal) [16,46].

Some sustainable measures of specific vegetation for the Mediterranean cork oak savanna are suitable to reduce the effects of tree cover loss and degradation [43–45].

Fourth, tree cover loss is strongly correlated with environmental conditions, the intensity of human activities such as intense urbanization, and the need for agricultural land.

The histograms show a normal distribution of data for most of the countries. This allowed us to conduct the analysis. Shapiro–Wilk normality tests and *t*-tests showed the suitability of the data for the analysis, with their significance considered to subscribe to the normal interval.

The scatterplot in Figure 7 shows the relation between country areas and tree cover loss; the dispersion of the points allows us to conclude that the disturbances in the tree cover loss are from natural causes. The small value of R^2, at about only 0.0399, illustrates that there is no correlation to the analyzed data.

We infer that the tree cover loss is influenced by a complex category of drivers (intense fires, increased temperatures, agricultural activities, and illegal logging) that determine the fragmentation of forests and the fragility of the Mediterranean environment.

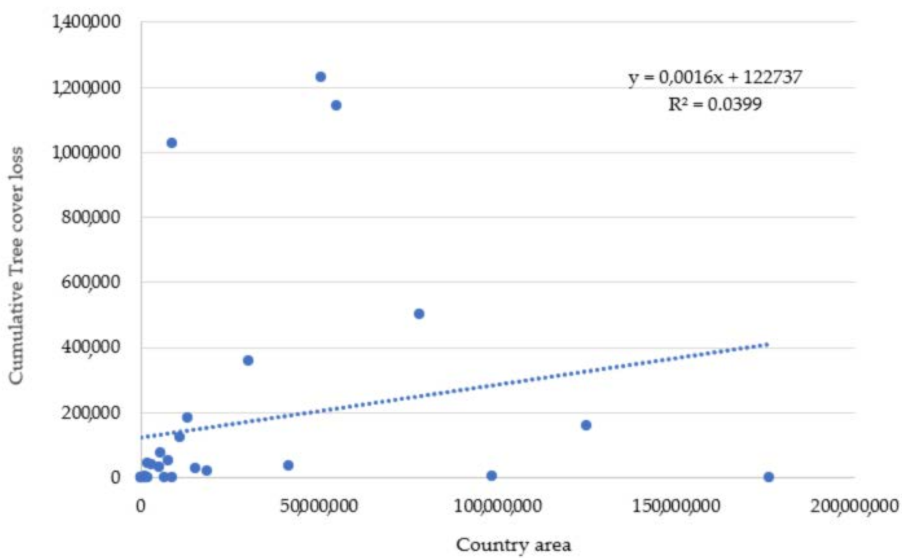

Figure 7. Relation between country area and tree cover loss area.

5. Conclusions

Tree cover loss in the Mediterranean Region is induced by both direct and indirect causes: local policies that need improvements for sustainable forest management; demographic changes and urbanization, which can cause degradation; and desertification, especially in the northern part of Africa.

Analysis of tree cover loss changes using Landsat imagery in the Mediterranean Region represents the focus of much research over the years. The current study presents a tree cover loss mapping and evaluation of the *TCLR* for the period 2001–2019 in the context of significant threats in southern Europe, North Africa, and southwest Asia, such as intense forest fires, overgrazing, development of urban areas, illegal logging, intense agriculture, and changes in land use and land cover. Improved policies regarding management and maintenance of land use are important for the constant monitoring of forest ecosystems in the Mediterranean Region.

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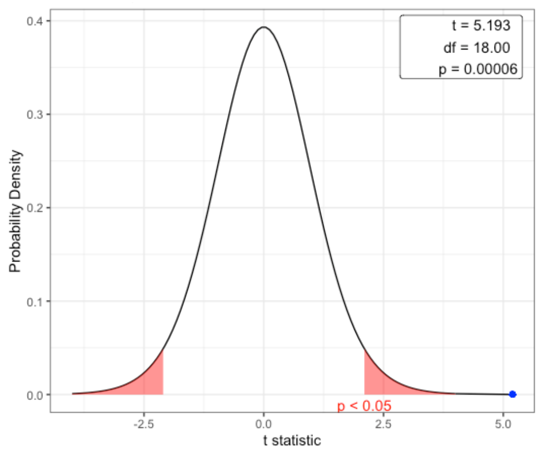
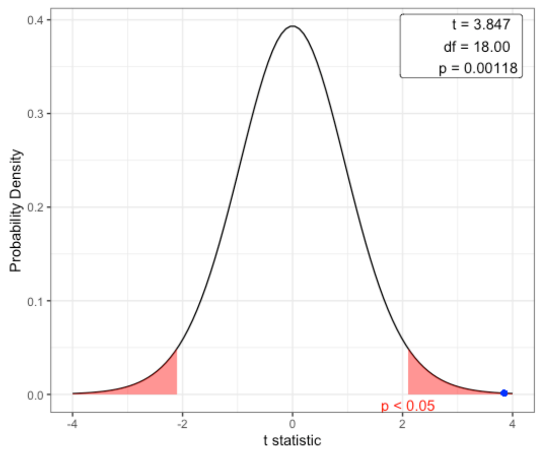
Conflicts of Interest: The authors declare no conflict of interest.

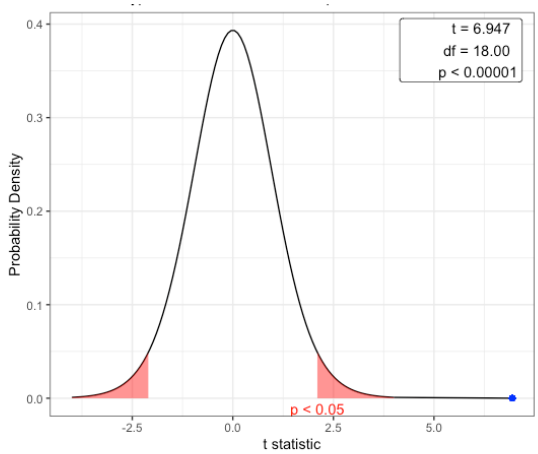
Appendix A



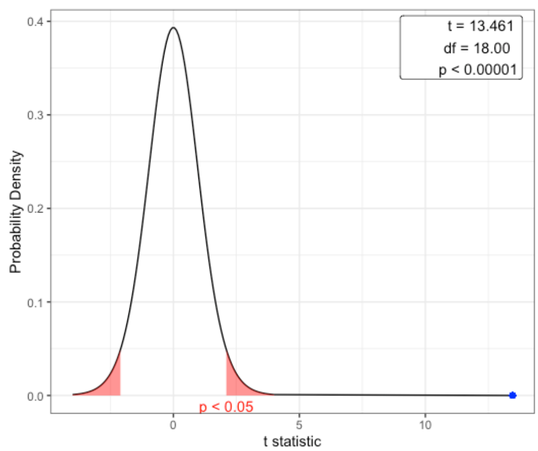
Albania



Algeria

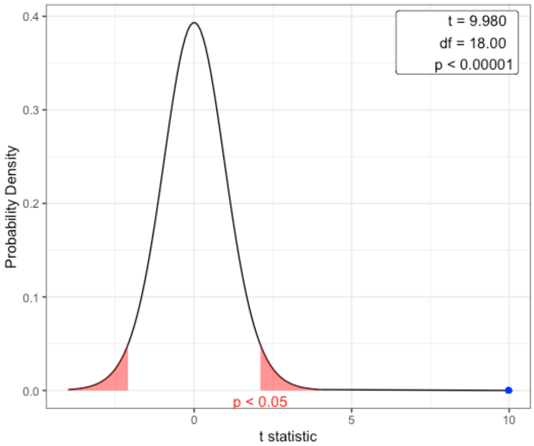


Bosnia and Herzegovina

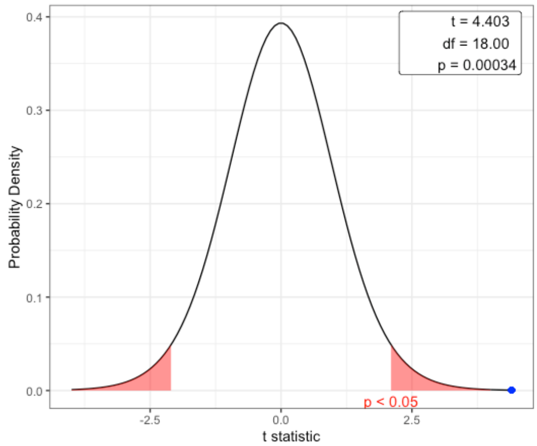


Bulgaria

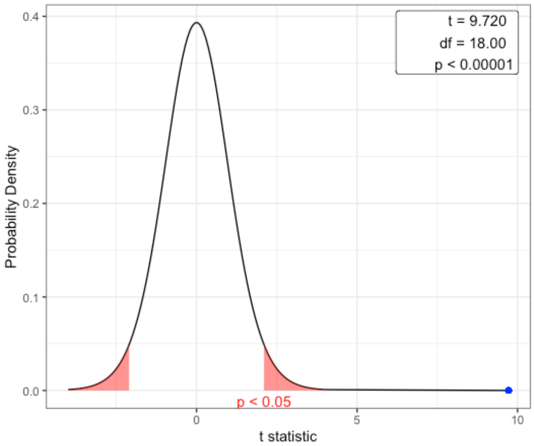
Figure A1. *Cont.*



Croatia



Egypt



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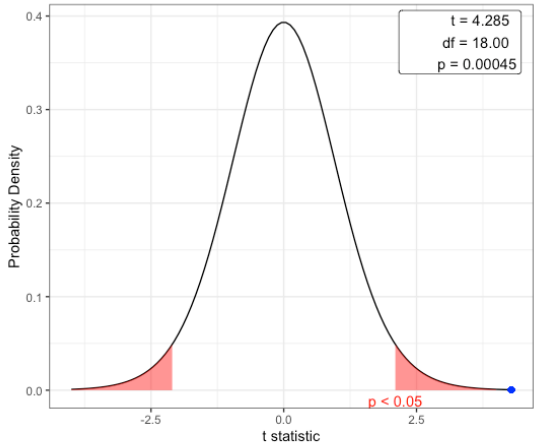
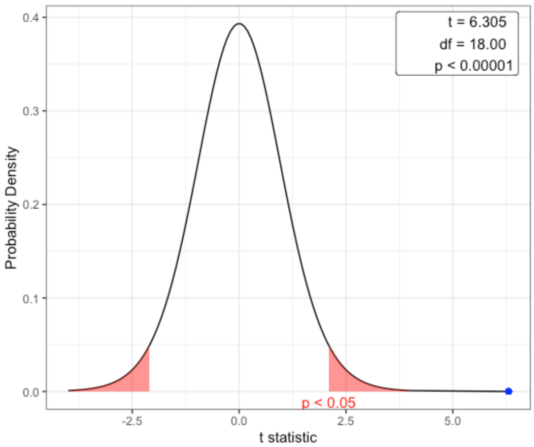
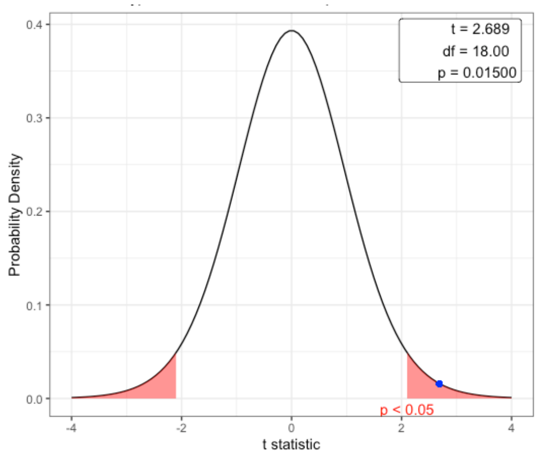


Greece

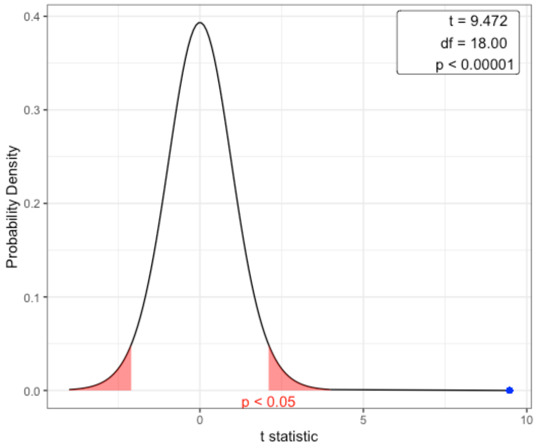


Italy

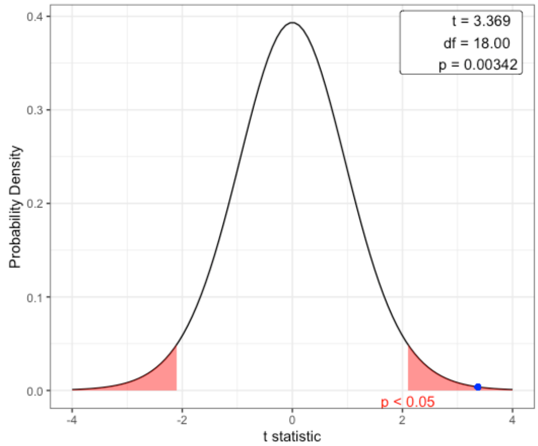


Jordan

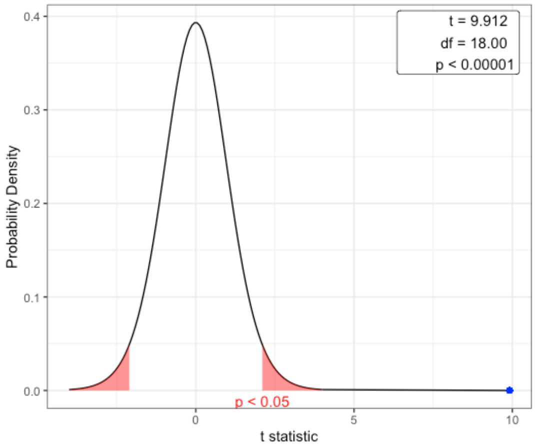
Figure A1. *Cont.*



Lebanon



Malta



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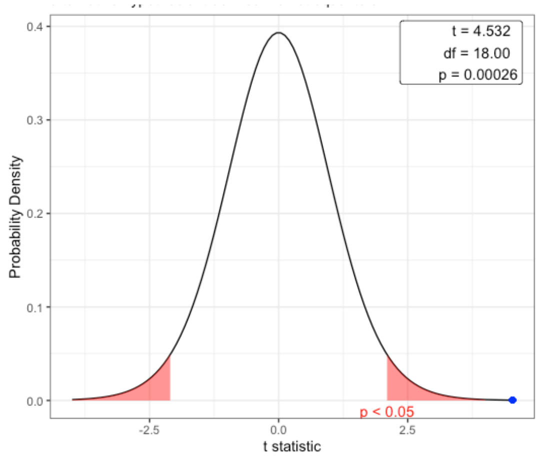
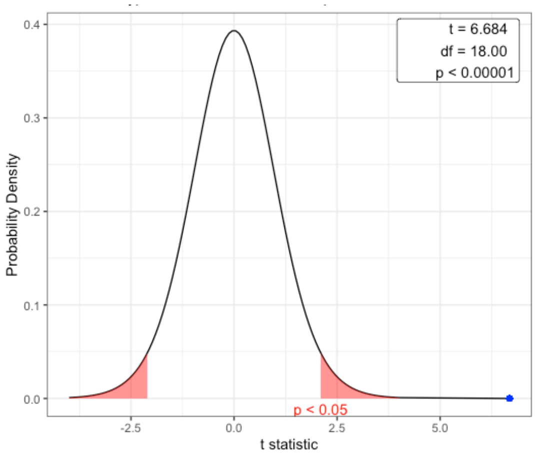
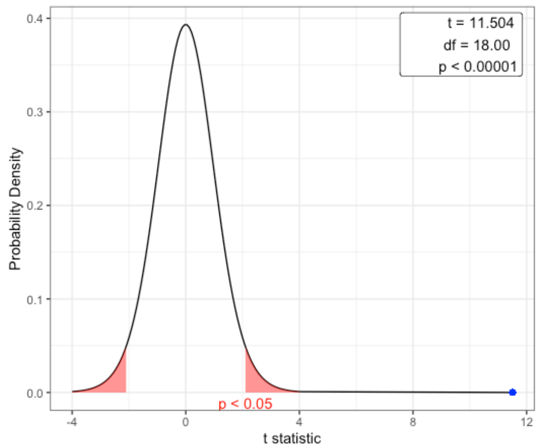


Palestine

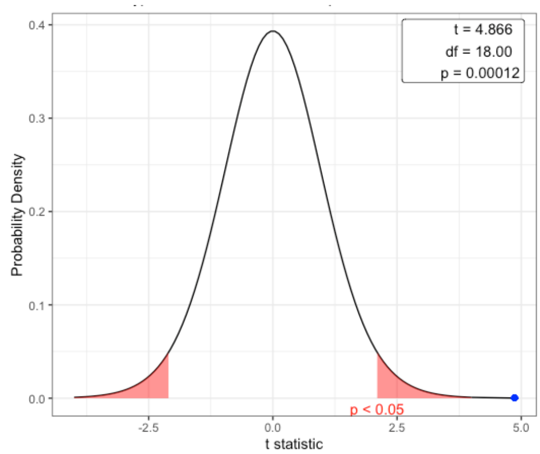


Portugal

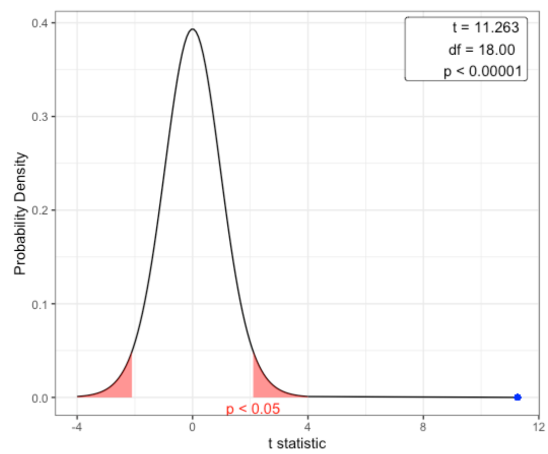


Serbia

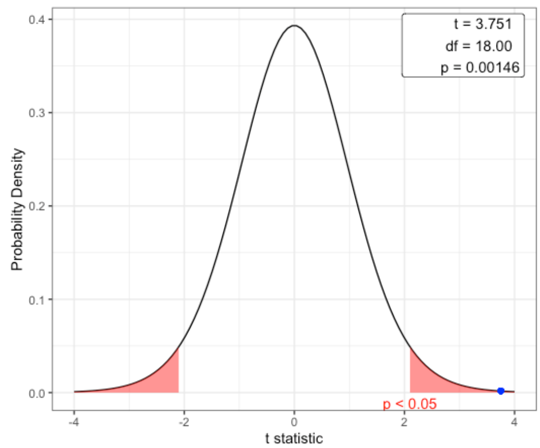
Figure A1. *Cont*.



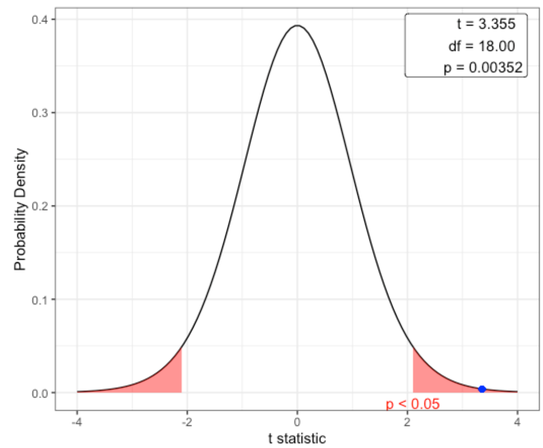
Slovenia



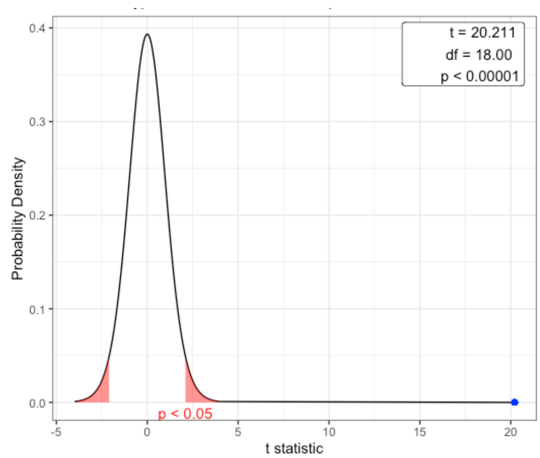
Spain



Syria

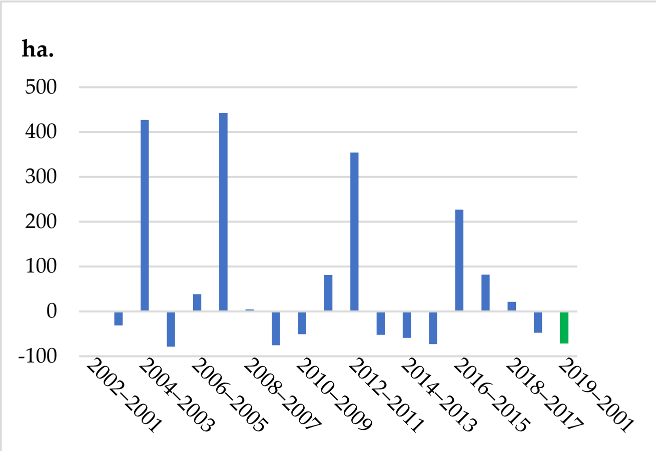


Tunisia

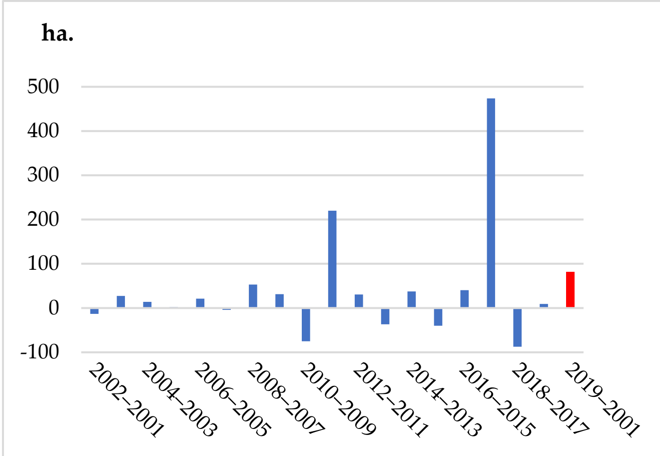


Turkey

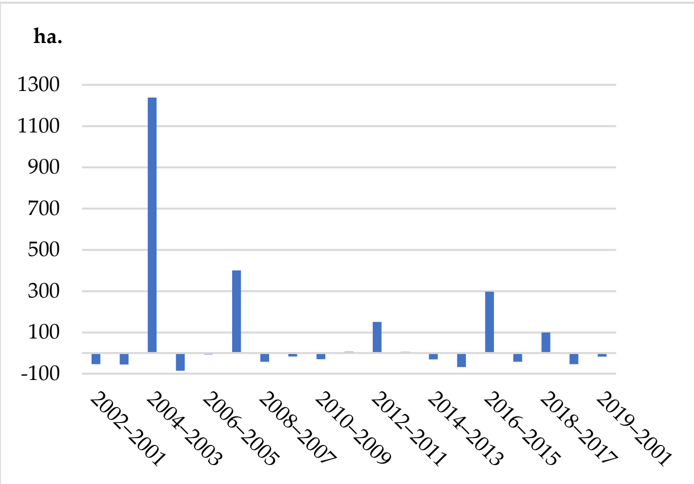
Figure A1. One-sample *t*-test results on tree cover loss data by country.



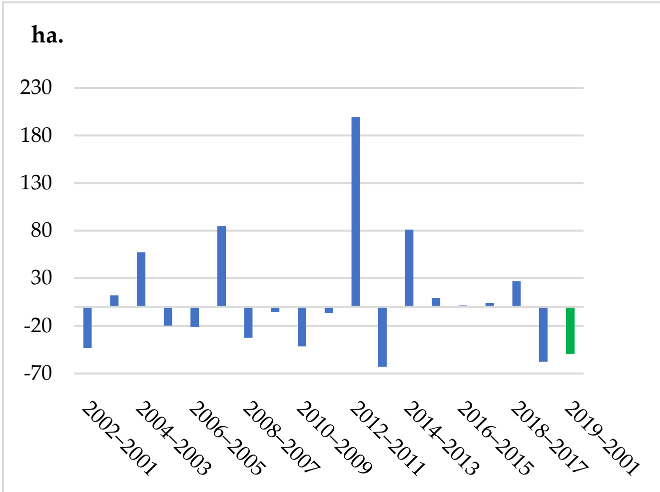
Albania



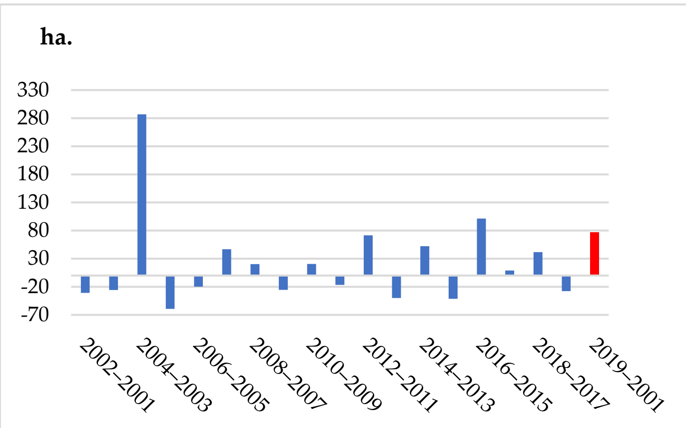
Algeria



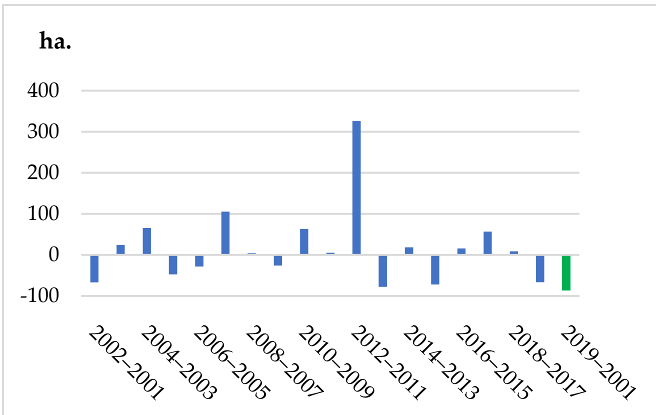
Bosnia and Herzegovina



Bulgaria

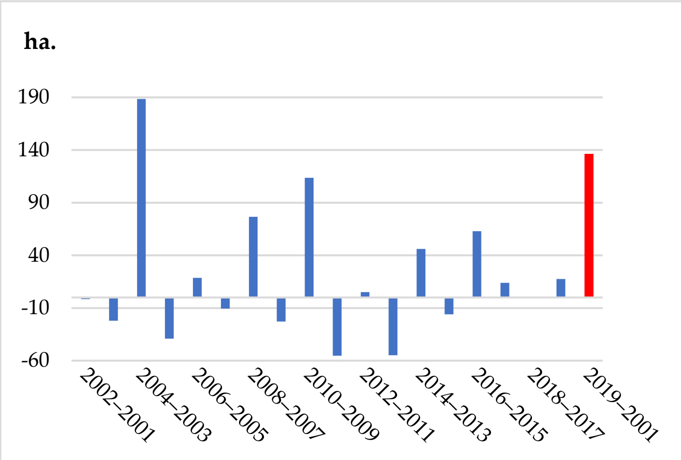


Croatia

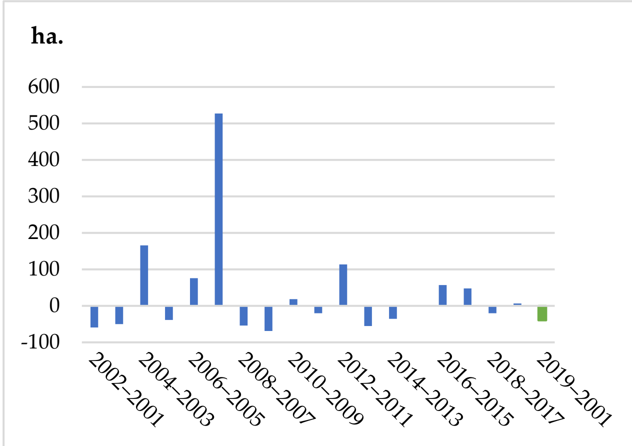


Egypt

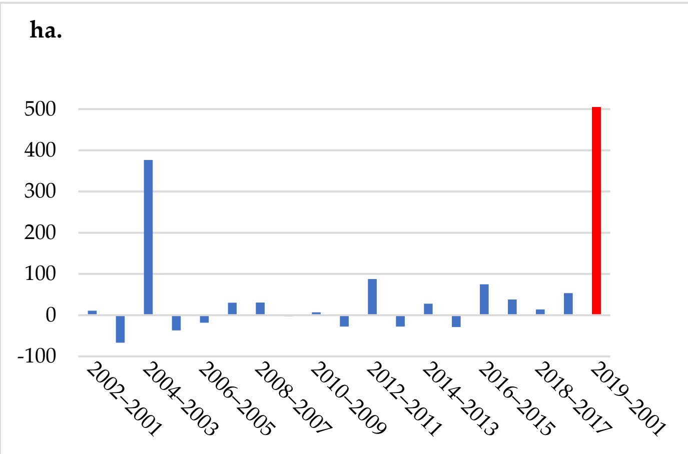
Figure A2. *Cont.*



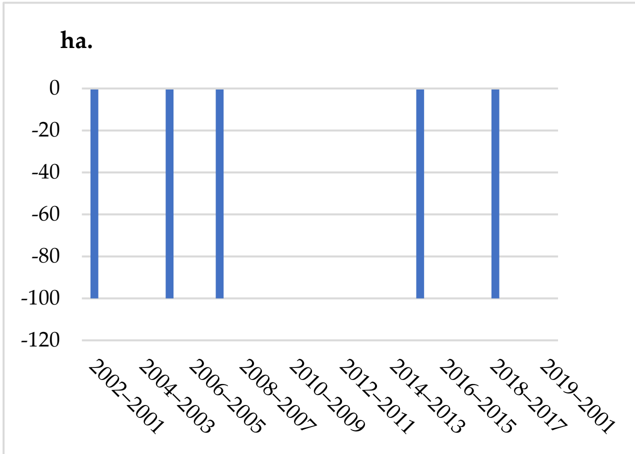
France



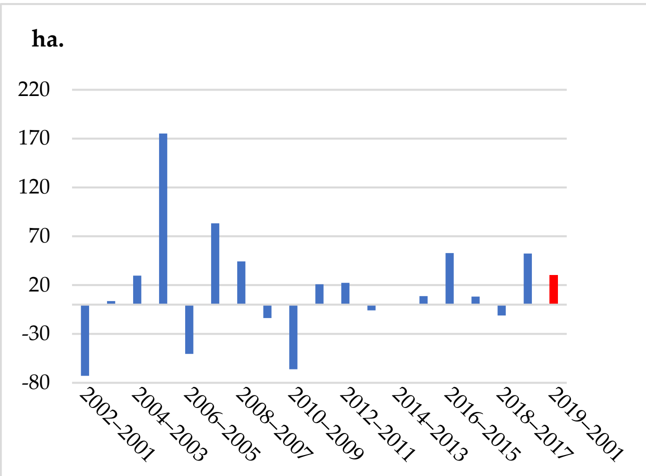
Greece



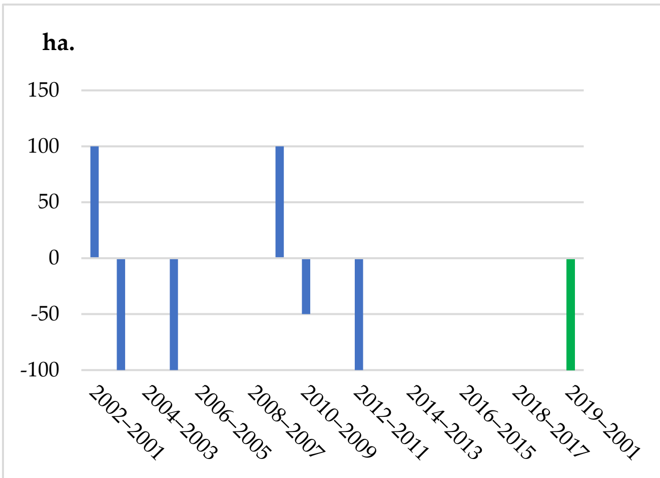
Italy



Jordan

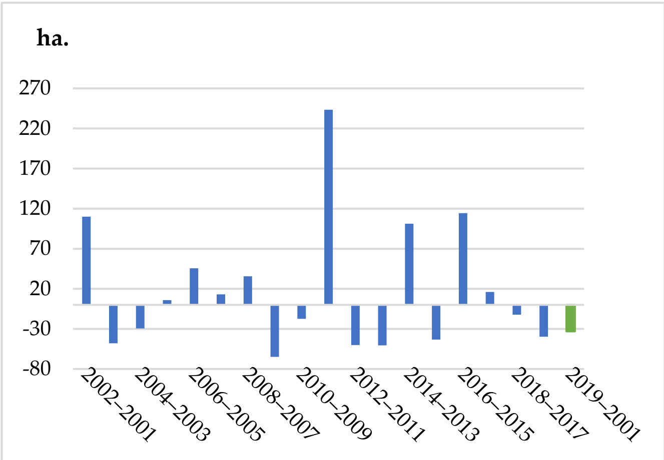


Lebanon

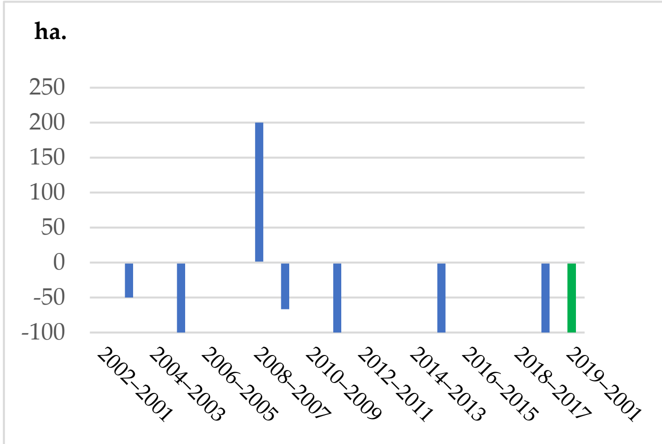


Malta

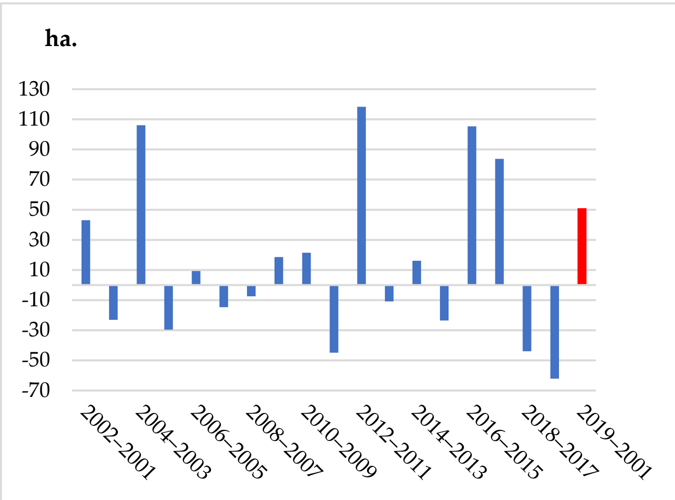
Figure A2. *Cont*.



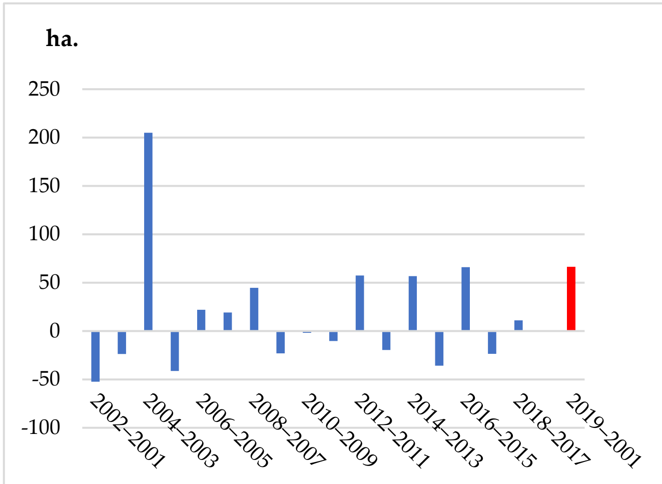
Morocco



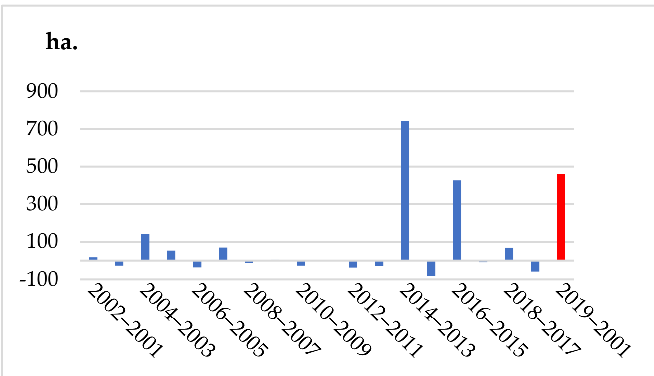
Palestine



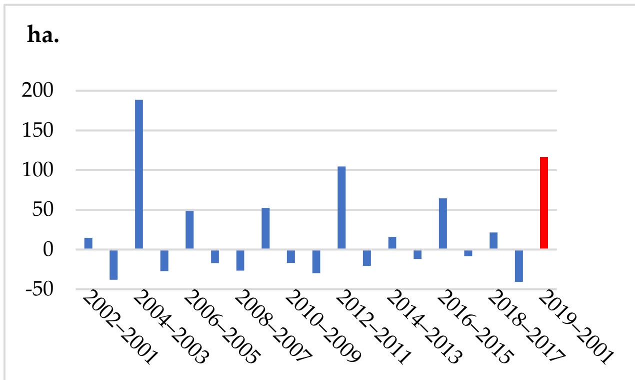
Portugal



Serbia

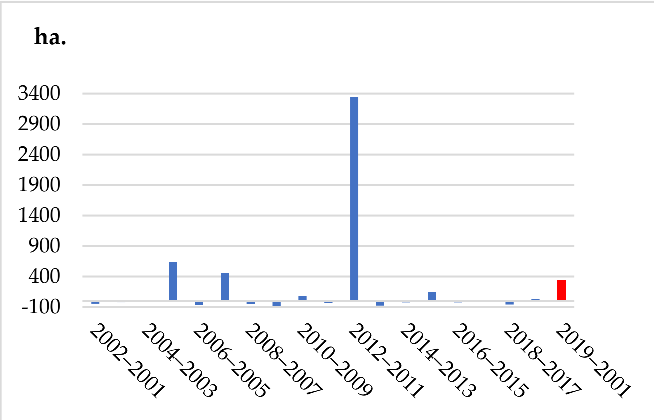


Slovenia

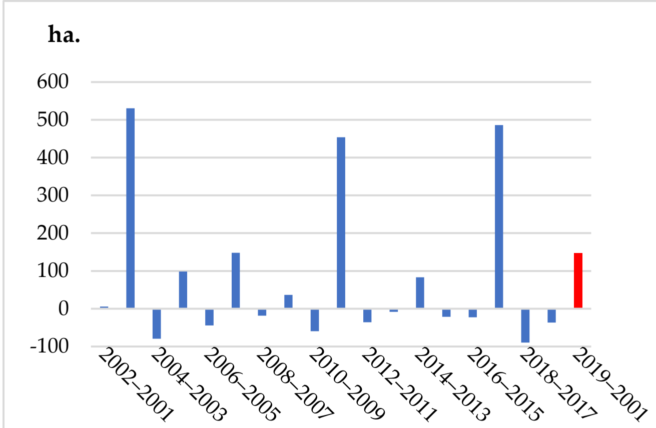


Spain

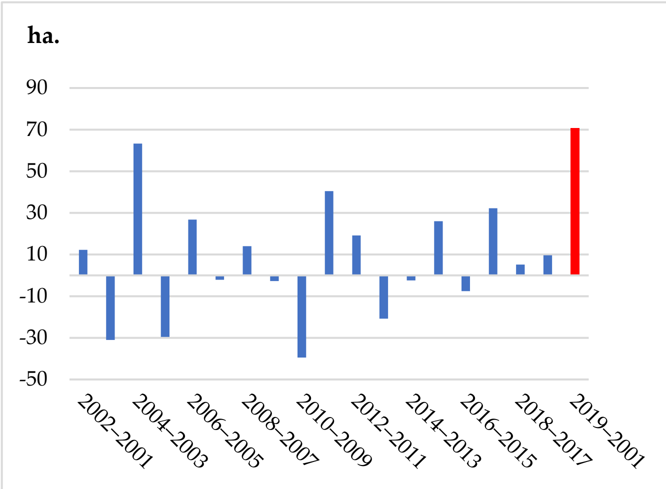
Figure A2. *Cont.*



Syria



Tunisia



Turkey

Figure A2. The annual evolution of the TCLR for Mediterranean countries (2001–2019): the blue bars present the annual evolution of TCLR; the green and red bars present the evolution trend of TCLR for the entire period.

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