INSIGHTS ON FORESTS USE IN COMMUNES AFTER THE COLLAPSE OF SOCIALISM IN ALBANIA

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Abstract

This study examines forest use in post-socialist Albania. The aim was to investigate the use of high-stem forests, coppice forests, broadleaved forests and coniferous forests for resource and biodiversity in commune forests. Data of presences and absences of high-stem forests, coppice forests, broadleaved forests and coniferous forests were measured from forest surveys of management plans. These data were integrated with environmental, socioeconomic and policy data using generalized linear models and spatial scale. Policy models had ten neighborhood variables of the density of roads and the density of human settlements from one km to five km with *a priory* assumption that the extent of these variables influenced the use of forests in post-socialist Albania. The final policy model of commune forests included accessibility variables and had a prediction accuracy of 99 percent at radii of 2 km for high-stem forests and 1 km for coppice forests and broadleaved forests. It is recommended the implementation of a policy to use sustainably all forests in Albania.

Keywords: Albania, commune forests, coppice forests, high-stem forests, neighborhood variables, post-socialism

Introduction

Governmental forest policies can change the patterns of forest cover and use. Post-socialist countries are interesting to study because governments have implemented new land use and forest policies after the collapse of socialism, affecting potentially forest cover and use. There are empirical evidences indicating that forests in the countries of the Former Soviet Union (FSU) have a high potential for carbon sequestration because of forest increase there (Kuemmerle et al., 2011). Excessive timber extraction including illegal logging decreased forest cover after the collapse of socialism in many countries of Eastern Europe and the former Soviet Union;

forest increase, mainly in later periods of the transition, was mostly due to the natural forest succession of forests on abandoned agricultural lands (Taff et al., 2010).

Empirical studies of post-socialism countries may reveal worthy findings of forest use in socialism and compare with the forest use in the post-socialist period. This is especially true for Eastern Europe and the former Soviet Union, two regions that harbor significant forest resources, but experienced considerable illegal logging, clear cutting, but also significant natural expansion of forests on formerly used agricultural lands (Kuemmerle et al., 2009; Müller and Munroe, 2008). The contraction of cropland and pastures was brought about by the declining economic competitiveness of agriculture that frequently shifted rural livelihoods toward emigration and off-farm employment (Müller and Sikor, 2006; Stahl, 2007), the decline in agricultural subsidies leading to massive and extensive land-use change (Kuemmerle et al., 2008; Prishchepov et al., 2012). Yet, empirical studies on the use of high-stem forests and coppice forests, and type of broadleaved forests and coniferous forests in socialism and post-socialism are quite rare in southeastern Europe.

In this study, I addressed two research questions that concerned the use of high-stem forests and coppice forests after the collapse of socialism in Albania. I compared the share of for industrial wood and firewood versus protected forests to examine the patterns of forest use for the forest service of resource (firewood and industrial wood) and protection of soil and water, and biodiversity. Three models of environmental, socioeconomic and policy variables were fitted using generalized linear models to identify variables that explained the use of commune forests. Here, I tested *a priori* assumption of accessibility variables was having on forests using a separate modelling procedure to examine the extent to which these policy factors explained the use of commune forests in Albania.

Methods:

Study area

The study area is 38 communes in Albania. Albania has an area of 28,748 km^2 (Fig. 1). Albania was under socialist regime from the end of the Second World War until the early 1990s.

The area consisted of high-stem forests and coppice forests was 27 percent, high-stem forests and coppice forests and brushes 36 percent, and high-stem forests, coppice forests, brushes and other forest land 37 percent, in 2005 (EFI, 2009; FAO, 2010). Estimations from satellite images showed that forests and woodland covered 27 percent in 1988, 26 percent in 2000, and 28 percent in 2007 of the total land (Suess, 2010). These forests harbor high biodiversity (Breitenmoser et al., 2008; FAO, 2005), determining the presences of protected species of brown bear and wolf and endangered subspecies of lynx in Albania (Laze, 2013a). Protected areas covered approximately 10 percent of land and water area in 2006. Population in the study area was approximately 3.2 million inhabitants (Census 2001). Villages rich of forests and near inhabited areas have illegally sold their woods to market centers and to villages with limited forest resources (Agrotec.SpA.Consortium, 2004).

Forests and pasture land were 100 percent state-owned forests in socialism. In 2005, the forests consisted of public-owned forests (98 percent) and private-owned forests (2 percent) (FAO, 2010).

A new forest reform began in 1994. The central government allowed local people and local government to use and manage forests, respectively. This sounds promising for villagers living particularly in mountain areas of northern Albania, because they rely heavily on forests (deWaal, 2004). By 2003, almost one million people used 60 percent of total forested land in Albania (WB, 2011).

Forest data:

Forest data of communes were collected by foresters in 38 communes from 1996 to 2009. The methods used for data collection consisted of surveys for tree species (broadleaved forests, coniferous forests), volume of firewood, stand types (high-stem forests, coppice forests, shrubs), land use management, forest management interventions (clear-cut, protection, thinning, fencing, conservation) at parcel level. A parcel was the unit of forest management for commune forest management plans (zoomed area of Fig. 1 shows (a) the number of parcels covered by high-stem forests and (b) coppice forests). Parcels consisted of parcels of high-stem forests, of coppice forests, of broadleaved forests, of coniferous forests, of shrubs and of non-forest use (e.g., agricultural land, see section of environmental, land use and accessibility data). Parcels of high-stem forests were merged for each commune. This “merge” algorithm of ArcGIS was also used for the parcels of coppice forests, of broadleaved forests, of coniferous forests and of shrubs resulting to a total number of parcels of 685. Parcels covered by high-stem forests were designated “presences” and parcels covered by any other forest and non-forestland type or uses were “absences” for the dependent variable of high-stem forests. The dependent variable of high-stem forests consisted of 151 presences and 534 absences. Dependent variable of coppice forests consisted of 127 presences (parcels covered by coppice forests) and 558 absences (parcels not covered by coppice forests), broadleaved forests of 322 presences (parcels covered by broadleaved forest) and 363 absences (parcels not covered by broadleaved forests), coniferous forests of 98 presences (parcels of coniferous forests) and 587 absences (parcels not covered by coniferous forests), shrubs of 129 presences (parcels covered by shrubs) and 556 absences (parcels not covered by shrubs).

Forest cover data of resolution 28.5 m derived from Landsat TM and ETM+ satellite images for ~1988, 2000 and 2007 were processed in the Geomatics Lab at the Humboldt University of Berlin with an overall accuracy of 93% and a kappa indices agreement of 0.85, and were provided by Stefan Suess (2010). The forest class consisted of forest patches greater than 7 pixels of Landsat including semi-natural terrestrial vegetation (broadleaved evergreen forest, broadleaved deciduous forest, coniferous forest and mixed forest), cultivated terrestrial (broadleaved arboriculture, fruit trees, orchards, groves, nurseries, vineyards) and shrub forest of a height of greater than 3 m and covering above the 50 percent of a Landsat pixel. The non-forest class consisted of all non-forest land cover (built up areas, urban and industrial areas, artificial and natural perennial water bodies, aquatic vegetation, beaches, bare rocks/soils, sparse trees and shrubs; rock outcrops, herbaceous crops, vegetated urban areas, grassland) (Suess, 2010). Further information are in Laze (2013a). These forest data were used for the calculation of the changes in forest cover in commune forests.

Environmental, land use and accessibility data:

Elevation and slope data were derived from the Digital Elevation Model (DEM) (25m resolution). Elevation, the boundaries of Albania, road networks, human settlements were provided by the Environmental Legislation Planning Albania (ELPA). Road data included four types consisted of main roads, well-kept roads, seasonal roads and village roads. Human settlements included the center of villages, communes and towns. Land use data were derived from the commune forest management plans. These data included six land classes consisting of other-land, agriculture land, no-destination land, brushes, non-productive land and pastureland. Forest parcels designated by communes and villagers exclusively for firewood were labelled “firewood”, forest parcels designated by communes and villagers exclusively for industrial wood was labelled “industrial wood”. Forests were commune forests and state forests. A forest that was governed by central government was state forests. A forest that was governed by commune was commune forests.

Roads and human settlements were transformed into a set of neighborhood variables by applying a “moving window smoothing” algorithm in ArcGIS. This algorithm calculated the value of a given focal cell based on the mean value of all the cells within the surrounding window defined by the radius *r*. Five values of *r* were used: 1 km, 2 km, 3 km, 4 km, and 5 km. This radii value of *r* corresponded roughly to the distance of a man to access forests from his home using any road, path to fetch wood. Stahl

(2012) showed that old-growth oaks (high-stem and broadleaved forests in state forests) were cut for firewood and or export. A man would take approximately three hours from his home to reach these old-growth forests (Stahl, 2012). Here, I test *a priori* assumption on the accessibility of forests as follows: "If a forest is abundant and accessible (by roads and or human settlements) within a distance between 1 km and 5 km, this forest is likely utilized by people for fuel-wood and industrial wood". Applying the moving window smoothing with five values to each of three spatial layers resulted in a total of 15 neighborhood variables for use in the commune forest modelling.

All data used in the descriptive statistics and commune forest modelling were aggregated to communes and parcels, respectively, using Zonal statistics (with aggregated pixel taking the mean value) in ArcGIS. For the descriptive statistics of commune forests, any data of 38 communes used in this study were aggregated to the year of establishment of commune administration from 1996 to 2009. All data were projected to UTM Zone 34N, datum WGS84 and prepared in ArcGIS using Arcmap 9.3 (ESRI, 2011).

Models:

The commune forest modelling were based on information-theoretic methods, which focus on the search for a parsimonious model, a "small model", as the primary philosophy of statistical inference (Burnham and Anderson, 2002; Johnson and Omland, 2004). First, a set of *a priori* hypotheses was identified on forests based on the literature of forest use in Albania. For example, villagers use forests for their resources (for firewood) in southeastern Albania (Stahl, 2007), northern Albania (deWaal, 2004), and government manage forests mostly for their resources (firewood and industrial wood) and less for biodiversity (EFI, 2009).

The variables were split into three categories: "environmental", "socioeconomic" and "policy" categories (see e.g. Laze, 2013b). Environmental variables were thought to be variables for natural forest growth. Socioeconomic and policy variables were anthropological factors. Anthropological factors were thought to cause changes in forest cover due to wood collection by villagers for firewood (socioeconomic), and forest governance by government for the production of industrial wood (policy). Environmental variables consisted of elevation, slope, coniferous forests, and broadleaved forests. Socioeconomic variables consisted of firewood, other-land, agriculture land, no-destination land, brushes, non-productive land and pastureland (surrogate variable for grazing), and policy variables consisted of human settlement density, road density, human settlement neighborhoods, road density neighborhoods, commune forests, state forests and the year of establishment of administration of commune forests (Appendix S1).

Tests for variables were conducted to remove those that were highly correlated (Pearson correlation test >0.70) and those that did not show statistically significant differences between presences and absences of forests (Kruskal-Wallis test; $p<0.05$) (Appendix S2). Models were fitted using the Generalized Linear Models (GLMs), which are an extension of classic linear models (McCullagh and Nelder, 1989), with logit-link and binomial error structure. The dependent variables were five (consisted of presences and absences of high-stem forests, of coppice forests, of broadleaved forests, of coniferous forests, of shrubs). The independent variables were made up of three groups of environmental, socioeconomic, policy variables, respectively. Spatial autocorrelation of presence and absences dependent variable was calculated (see Appendix S3). All GLMs were fitted using R (version 2.9.0) (RDCT, 2009).

In total, 150 GLMs models were fitted for forests comprising five presences and absences dependent variables (high-stem forests, coppice forests, broadleaved forests, coniferous forests, shrubs forests), three categories of variables (environmental, socioeconomic and policy), and ten neighborhood variables (two independent neighborhood variables of roads density and human settlements density of five radii of *r* 1 km, 2 km, 3 km, 4 km, and 5 km). Model selection was undertaken using the Akaike Information Criterion (AIC) and AIC weights (e.g. Fernández et al., 2006; Laze, 2013a). To evaluate models, the area under the Receiver Operating Characteristic Curve (AUC) and deviance explained in percentage (D^2) was calculated. Cross-validation was used to check if there was over-fitting in the fitted models (Fernández et al., 2003; Kanagaraj et al., 2011). A high value of AUC $\geq$ 0.9 indicates an outstanding prediction between presences and absences of forests in this study (Hosmer and Lemeshow, 2000).

Results and Discussion:

The high-stem forests and coppice forests were managed and used as industrial wood and firewood. All communes had more broadleaved forests than coniferous forests. These broadleaved forests were disproportionally allocated to communes. Areas of protected tree species of *Pinus heldreichii* were planned to be used for their resources (*Pinus heldreichii* has been a protected and native tree species). Communes of year 2002 planned to protect the forests of *Pinus heldreichii*. In total, about 18 percent of communes have designated forests for the protection of soil, water and biodiversity against grazing and illegal cutting. Forests on steep faces tended to be harvested by communes for timber. The average of protected forests was 4.7 percent for all communes, varying from the minimum of 0.4 percent to the maximum of 23.1 percent of protected areas. In total, 51 percent of communes increased forest cover from 1988-2000 to 2000-2007, while 49 percent of communes decreased their forest cover over the same period (using forest data from remote sensing provided by Suess (2010)). Forest cover has increased from 1988-2000 to 2000-2007 (Table 1). Communes used high-stem forests for industrial wood and coppice forests for firewood (Fig. 2a and Fig. 2b). Communes tended to use massively broadleaved forests for firewood and industrial wood, while coniferous forests for industrial wood (Table 2). The share of fuel-wood per village differed from one commune to another. Communes of year 1997, 2001, 2003, 2004, 2005, 2007 and 2008 had less firewood (m^3 per village) compared to communes of 1996, 1999, 2002, and 2006. The communes of year 2000, 2004, 2008 and 2009 harvested mostly forest resources for firewood (Fig. 2c).

The commune forest modelling:

The policy model of forest use was the one with the lowest AIC value. The area under the receiver operating characteristic curve (AUC) was 99 percent for the models of high-stem forests, coppice forests, 89 percent for broadleaved forests and 78 percent for coniferous forests. The explained deviance (D^2) was above 40 percent for high-stem forests, coppice forests and broadleaved forests (Table 3).

The spatial extent of 1 km of density of human settlements was negatively correlated with coppice forests, and broadleaved forests. The density of human settlements was negatively correlated with high-stem forests at the distance of 2 km. Communes, which had higher populated areas, denser roads and more agriculture land, no-destination land, pasture land, non-productive land, tended to have less or no high-stem forests, coppice forests and shrubs altogether. This analysis showed the negative relationships of the coniferous forests with coppice forests and shrubs forests (Table 4).

The variables of firewood and pasture were statistically significant (in best socioeconomic models) for high-stem forests, coppice forests, broadleaved forests, coniferous forests, shrubs indicating that the collection of wood for firewood and the grazing of livestock could change the forest cover. The collection of firewood was more intense in forests compared to the grazing of livestock. The best environmental model of variables showed that high-stem forests were distributed in higher elevation, steeper slope faces consisting of either broadleaved or coniferous forests (Table 3 and Table 4).

Discussion:

This study uncovered interesting findings on the explanation of the forest use after the collapse of socialism in Albania, combining a description statistics and a modeling of forests for communes. The description statistics enabled us to distinguish the use of broadleaved forests for firewood and industrial wood and coniferous forests for industrial wood. By modeling separately high-stem forests, coppice forests, broadleaved forests and coniferous forests, this work informed the most important factors influencing the changes of forest cover. Forest use and type were influenced negatively by the spatial extent of the density of human settlements and roads, indicating that these two factors can reduce the area covered by the high-stem forests and coppice forests in communes. Hypotheses of models correctly predicted 99 percent of presences and absences of high-stem forests and coppice forests indicating accurate measurements of locations of these forests from the surveys and management plans of commune forests. This study provided new insights on the forest use in post-socialist Albania, demonstrating that high-stem forests and coppice forests, broadleaved forests and coniferous forests were massively used for their resources for firewood and industrial wood, and a few communes have designated forest areas for environmental protection and biodiversity conservation. This work allowed an estimation of the forest increase and forest decrease of the high-stem forests and coppice forests for the communes accounting for sustainably relevant use of these forests and the relevance of this forest reform. Although, this new forest policy aimed the regeneration of degraded forests, and the decrease of pressure on forests for their resources, these findings indicate that half of communes decreased their forest cover from 2000 to 2007. These findings highlight the extent to which the government, the managers and the users of forests in Albania may consider to increase the area of protected forests in steep slope faces, old grown trees and in the areas of native and protected tree species. The results presented in this study showed the importance for the development of forest management plans grounded on the principles of sustainable use of forest ecosystems, and enabling forest reforms to ensure an environmentally friendly use of forests in Albania.

Accessibility of forests:

Scale had an effect in the performance of models. The policy variables explained the use of the commune forests for firewood and industrial wood. The policy model with the best performance resulted from smoothing the accessibility data (by applying moving window smoothing) for the density of human settlement and roads with a window of radii 2 km for high-stem forests and 1 km for coppice forests and 1 km for broadleaved forests. This implied forest users would likely utilize forests for firewood and industrial wood, if high-stem forests were available at the distance of 2 km, coppice forests at the distance of 1 km and broadleaved forests at the distance of 1 km. This implied also the pressure of forests for firewood and industrial wood in communes could be extended to surrounding forests, which might be commune forests, state forests or protected forests. For example, Laze (2013a) found that forests surrounding protected areas were cut. This study showed local government and the users of forests affect the forest cover, implying that both government and users have responsibilities for the sustainable use of forest resources.

Land use:

The socioeconomic models demonstrated that agriculture land, pastureland, roads, populated areas and non-forested land-uses (non-other land, no productive land and no-destination land) had a negative impact on the abundance of the high-stem and coppice forests. The expansion of these land-uses decreased the areas of forest cover in communes. The data of commune management plans described the forests existed in the land-uses of other-land, no-destination, no-productive land in state-owned forests; these forests were damaged (cleared-cut, burnt) after the collapse of socialism contributing to the remarkable changes of land cover noted by other studies (Müller and Sikor, 2006; Stahl, 2012).

Forest protection:

Interestingly, the calculation of forest use indicated all communes designated an average of protected forests for the protection of soil, water and biodiversity and afforested areas of 5 hectares considering these forests were generally overused. Only 18 percent of these communes planned to protect forests for environmental protection and biodiversity conservation. The increase of protected forests for environmental protection and biodiversity conservation and the increase of afforested lands to other-land, no-destination, no-productive lands would increase the forest cover. As the demand for firewood was still considerable utilizing broadleaved forests (Fig. 2), an efficient heating alternative (not relying on forests) to meet partly or entirely the demand for firewood in rural areas might affect positively the forest cover. The increase of protected forests, reforested and afforested lands with native tree species on landscape-level may increase the forest cover of broadleaved and coniferous and high-stem forests and coppice forests in post-socialist Albania.

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Appendix

Appendix S1 Model explanatory variables, units and model of forests

Model explanatory variables	Units	Models
Elevation	Meters	Environmental
Slope	Degree	Environmental
Coniferous forests	Hectares	Environmental
Broadleaved forests	Hectares	Environmental
Firewood	Binary	Socioeconomic
Pasture	Binary	Socioeconomic
Other-land	Hectares	Socioeconomic, policy
Agriculture land	Hectares	Socioeconomic, policy
No-destination land	Hectares	Socioeconomic, policy
Brushes	Hectares	Socioeconomic, policy
Non-productive land	Hectares	Socioeconomic, policy
Pastureland	Hectares	Socioeconomic, policy
High-stem	Hectares	Policy
Coppice	Hectares	Policy
Shrubs	Hectares	Policy
Human settlement density	Number of villages per parcel	Policy
Human settlement density neighborhood*	Percentage in km^2, unitless	Policy
Road density	km per km^2	Policy
Road density neighborhood*	Percentage in km^2, unitless	Policy
Euclidean distance to road	Meters	Policy
Euclidean distance to well-kept road	Meters	Policy
Euclidean distance to seasonal road	Meters	Policy
Euclidean distance to main road	Meters	Policy
Euclidean distance to village road	Meters	Policy
Year of establishment of commune forest	Unitless	Policy
State forests	Binary	Policy
Commune forests	Binary	Policy
Parcel area	Km2	Policy

Note: *Denotes the ten spatial layers that had moving window smoothing applied.

Appendix S2 Results of the tests of spatial autocorrelation, Kruskal-Wallis test, Pearson test

The dependent variables' spatial autocorrelation of the Moran's I values was of 0.09 for high-stem forests, 0.15 for coppice forests, -0.02 for broadleaved forests, 0.07 for coniferous forests, 0.07 for shrubs. The explanatory variables that passed Kruskal-Wallis test for high-stem forest dependent variable were as follows: the amount of high-stem forests, the amount of coppice forests, the amount of brushes, the amount of shrubs, the amount of other-land, the amount of agriculture land, the amount of no-destination land, the amount of non-productive land, the amount of pastureland, human settlement density, human settlement density neighborhood of distance of 1 km, 2 km and 5 km, road density, road density neighborhood of distance of 1 km, 3 km, 4 km and 5 km, elevation, slope, the year of establishment of commune forests, firewood and the Euclidean distance to roads. The explanatory variables that passed Kruskal-Wallis test for coppice forests dependent variable were as follows: the amount of high-stem forests, the amount of coppice forests, the amount of brushes, the amount of shrubs, the amount of other-land, the amount of agriculture land, the amount of no-destination land, the amount of non-productive land, the amount of pastureland, human settlement density, human settlement density neighborhood of the distance of 1 km, elevation and slope. The explanatory variables that passed Kruskal-Wallis test for broadleaved forests dependent variables were as follows: the amount of high-stem forests, the amount of coppice forests, the amount of brushes, the amount of shrubs, the amount of other-land, the amount of agriculture land, the amount of no-destination land, the amount of pastureland, human settlement density and neighborhoods variables of the density of human settlements of the distance of 1 km, 2 km, 3 km, 4 km and 5 km, road density, neighborhood road density of the distance of 1 km, 2 km, 4 km and 5 km, slope, and the Euclidean distance to human settlement. The explanatory variables that passed Kruskal-Wallis test for coniferous forests dependent variables were as follows: the amount of high-stem forests, the amount of coppice forests, the amount of brushes, the amount of shrubs, the amount of other-land, the amount of agriculture land, the amount of no-destination land, the amount of non-productive land, the amount of pastureland, road density, road density neighborhood of the distance of 1 km, the Euclidean distance to well-kept roads and the year of establishment of commune forests. The explanatory variables that passed Kruskal-Wallis test for the dependent variable of shrubs were as follows: the Euclidean distance to well-kept roads, elevation, human settlement density, human settlement density neighborhood of the distance of 1km, the amount of non-productive land, the amount of no-destination land, the amount of agriculture land, the amount of pastureland, the amount of other-land, the amount of shrubs, the amount of brushes, the amount of high-stem forests, the amount of coppice forests.

The explanatory variables that passed the Kruskal-Wallis test of environmental, socioeconomic and policy models, respectively, showed insignificant correlation values of Pearson test of $r < 0.7$. The global Moran's I of residuals of the policy models was of 0.04 for high-stem models, -0.01 for coppice models, -0.06 for broadleaved forests, -0.04 for coniferous forests, and -0.05 for shrubs.

Appendix S3 Spatial autocorrelation of dependent variable

Spatial autocorrelation of dependent variables was checked in Geoda095i. A spatial weights matrix was created, using the first order queen's contiguity neighbor; the first order neighbors had weights. If spatial autocorrelation was high then we had to use sample of observations and to repeat the test of spatial autocorrelation until the spatial autocorrelation was insignificant of the sample of observations (see e.g. Laze, 2013a).

Tables

Table 1 Forest cover change between 1988 and 2000 and between 2000 and 2007 for communes established from 1996 to 2009

Forest cover change in hectares	Years of the establishment of commune forests													
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1988-2000	50	-50	-150	-60	10	90	-2640	-20	210	120	0	50	140	90
2000-2007	-70	-430	300	150	-10	-30	280	420	90	540	170	10	20	-10

Table 2 The use of broadleaved and coniferous forests for industrial wood and firewood for communes established between 1996 and 2009

Forest type use, percent	Years of the establishment of commune forests													
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Broadleav. firewood	99	100	75	92	100	97	97	95	100	95	100	70	97	88
Coniferous firewood	1	0	18	8	0	3	3	5	0	5	0	30	3	12
Broadleav. industrial wood	16	100	83	97	0	0	87	0	0	30	100	0	0	0
Coniferous industrial wood	84	0	13	3	0	0	13	100	0	70	0	0	0	0

Table 3 Summary of best logistic regression models for high-stem forests, coppice forests, broadleaved forests, coniferous forests, shrubs, and model selection estimators. Neighborhood area is the size of the moving window smoothing used (see Methods); AIC = Akaike's Information Criterion. Akaike Wi = Akaike weight, D^2 = Deviance Explained, CV = cross validation, AUC = area under curve.

Model	Distance, (km)	AIC	AIC weights, (%)	AUC, (%)	D^2, (%)	CV, (%)
Policy (HSF)	2	79.7	36	99.0	91.5	92.3
Socioeconomic (HSF)		592.8	<0.01	74.0	17.5	78.0
Environmental (HSF)	1	603.8	<0.01	0.81	15.1	76
Policy (COP)	1	115.9	38	99.0	84.3	98.7
Socioeconomic (COP)		556.9	<0.01	74.0	14.7	81.5
Environmental (COP)		497.3	<0.01	82.1	23.22	65.7
Policy (BROADF)	1	546.7	70	89.0	42.9	80.6
Socioeconomic (BROADF)		576.5	<0.01	83.0	39.2	81.0
Environmental (BROADF)		931.1	<0.01	62.1	0.6	59.0
Policy (CONF)		488.2	72	78.0	12.9	85.3
Socioeconomic (CONF)		505.6	<0.01	71.0	9.71	85.7
Environmental (CONF)		562.4	<0.01	55.4	1.25	66.7
Policy (SHR)		155.0	100	99.0	78.9	96.4
Socioeconomic (SHR)		560.4	<0.01	73.0	14.9	81
Environmental (SHR)		605.1	<0.01	70.8	7.2	82.8

Note: HSF is the amount of high-stem forests, COP is the amount of coppice forests, SHR is the amount of shrubs, BROADF is the amount of broadleaved forests, CONF is the amount of coniferous forests.

Table 4 Summary of best logistic regression models for forests. For each model the coefficients and their sign is shown along with their standard errors and statistically significance

Model	Distance, (km)	AIC	Variables	Coeff.	Standard errors of coeff.	P<0.05
Policy (HSF)	2	79.7	HSF	+1.668	0.275	0.000
			COP	+0.001	0.0009	0.077
			SHR	+0.001	0.001	0.083
			HSET	+0.100	0.065	0.124
			ROAD	-0.065	0.017	0.000
			EST	-0.034	0.129	0.787
			EDRO	+0.0007	0.0004	0.111
			HSETR	-8.600	6.257	0.169
			Intercept	-4.53	0.721	0.000
Socioeconomic (HSF)		592.8	Firewood	+4.139	1.725	0.016
			Pasture	-3.923	1.539	0.010
			OLAND	-1.120	0.673	0.096
			AGRI	+0.0008	0.001	0.471
			NODES	-0.346	0.266	0.194
			BRU	-0.195	0.123	0.115
			NONPR	-0.116	0.078	0.138
			PASTR	+0.0006	0.0005	0.239
			Intercept	-4.793	1.722	0.005

Environmental (HSF)		603.8	Elevation	+0.0008	0.0002	0.005
			BROF	+1.722	0.235	0.000
			Slope	+0.006	0.017	0.703
			CONF	+2.107	0.269	0.000
			Intercept	-3.23	0.340	0.000
Policy (COP)	1	115.9	HSF	+0.0005	0.0005	0.311
			COP	+0.431	0.059	0.000
			SHR	+0.001	0.0009	0.247
			HSET	+0.075	0.063	0.232
			HSETR	-8.662	1.859	0.000
			Intercept	-3.995	0.345	0.000
Socioeconomic (COP)		556.9	Firewood	+3.881	1.725	0.024
			Pasture	-3.665	1.540	0.017
			OLAND	-0.930	0.590	0.115
			AGRI	+0.0008	0.001	0.471
			NODES	-0.2058	0.171	0.230
			BRU	-0.165	0.114	0.147
			NONPR	-0.089	0.063	0.160
			PASTR	+0.0006	0.0005	0.239
			Intercept	-4.793	1.722	0.005
Environmental (COP)		497.3	Elevation	0.0006	0.0003	0.031
			BROADF	3.314	0.387	0.000
			Slope	-0.008	0.019	0.671
			CONF	-0.438	0.366	0.231
			Intercept	-4.041	0.455	0.000
Policy (BROADF)	1	546.7	HSF	+0.0005	0.0005	0.279
			COP	+0.029	0.008	0.000
			SHR	-0.00002	0.0005	0.963
			OLAND	-1.202	0.44	0.006
			AGRI	-0.590	0.361	0.101
			NODES	-0.762	0.419	0.069
			BRU	-0.209	0.080	0.008
			Pasture	-0.0388	0.016	0.017
			NONPR	-0.139	0.061	0.021
			HSET	-0.008	0.063	0.896
			ROAD	+0.001	0.010	0.862
			EHSET	-0.0001	0.0001	0.441
			HSETRP	-2.431	1.147	0.034
			ROADR	+0.003	0.190	0.984
			Intercept	+0.745	0.235	0.001
Socioeconomic (BROADF)		576.1	Firewood	+5.735	1.726	0.0008
			Pasture	-3.671	0.703	0.000
			OLAND	-1.409	0.486	0.003
			AGRI	+0.0008	0.001	0.471
			NODES	-0.923	0.471	0.050
			BRU	-0.242	0.084	0.004
			NONPR	-0.172	0.069	0.012
			PASTR	+0.0002	0.0004	0.673
			Intercept	-4.793	1.722	0.005
Environmental		931.1	Slope	0.047	0.011	0.000

(BROADF)					
		CONF	-0.487	0.226	0.031
		Intercept	-0.840	0.209	0.000
Policy (CONF)	488.2	EST	+0.118	0.041	0.004
		HSF	+0.0001	0.0004	0.598
		COP	-0.004	0.002	0.049
		SHR	-0.009	0.0007	0.192
		OLAND	-0.883	0.594	0.137
		AGRI	-0.042	0.031	0.187
		NODES	-0.002	0.003	0.472
		BRU	-0.118	0.094	0.210
		PASTR	-0.008	0.072	0.216
		ROAD	-0.001	0.010	0.900
		EWK	+0.0001	0.00005	0.002
		Intercept	-2.124	0.284	0.000
Socioeconomic (CONF)	505.6	Firewood	+3.47	1.726	0.044
		Pasture	-3.25	1.540	0.034
		OLAND	-0.67	0.473	0.158
		AGRI	+0.0008	0.001	0.471
		NODES	-0.001	0.002	0.651
		BRU	-0.11	0.092	0.219
		NONPR	-0.055	0.044	0.213
		PASTR	+0.0006	0.0005	0.239
		Intercept	-4.793	1.722	0.005
Environmental (CONF)	562.4	BROADF	-0.436	0.223	0.050
		Intercept	-1.593	0.140	0.000
Policy (SHR)	155.0	HSF	-1.819	0.944	0.054
		COP	-0.471	0.223	0.034
		SHR	+0.023	0.007	0.002
		OLAND	-2.198	1.217	0.071
		AGRI	-0.637	0.410	0.119
		NODES	-0.690	0.405	0.088
		BRU	-0.310	0.159	0.051
		PASTR	-0.573	0.359	0.111
		NONPR	-0.245	0.146	0.092
		Intercept	+0.306	0.262	0.249
Socioeconomic (SHR)	560.4	Firewood	+3.903	1.725	0.023
		Pasture	-3.687	1.540	0.016
		OLAND	-0.946	0.597	0.113
		AGRI	+0.0008	0.001	0.471
		NODES	-0.218	0.180	0.227
		BRU	-0.168	0.115	0.144
		NONPR	-0.091	0.064	0.158
		PASTR	+0.0006	0.0005	0.239
		Intercept	-4.793	1.722	0.005
Environmental (SHR)	605.1	Elevation	-0.001	0.0002	0.0002
		BROADF	+1.197	0.216	0.000
		CONF	+1.348	0.255	0.000
		Intercept	-1.818	0.220	0.000

Note: HSF is the amount of high-stem forests, COP is the amount of coppice forests, SHR is the amount of shrubs, BROADF is the amount of broadleaved forests, CONF is the amount of coniferous forests, HSET is the density of human settlement, ROAD is the density of roads, EST is the year of establishment of communal forest, EDRO is the Euclidean distance to road, HSETR is the human settlement density neighborhood, OLAND is other-land, AGRI is the agriculture land, NODES is the no-destination land, BRU is brushes, PASTR is the amount of pastureland, PASTURE is the binary variable of pastureland, NONPR is non-productive land, EWK is the Euclidean distance to well-kept roads, ROADR is the road density neighborhood, EHSET is the Euclidean distance to human settlements.

Figures:

Fig. 1 Locations of commune forests in Albania

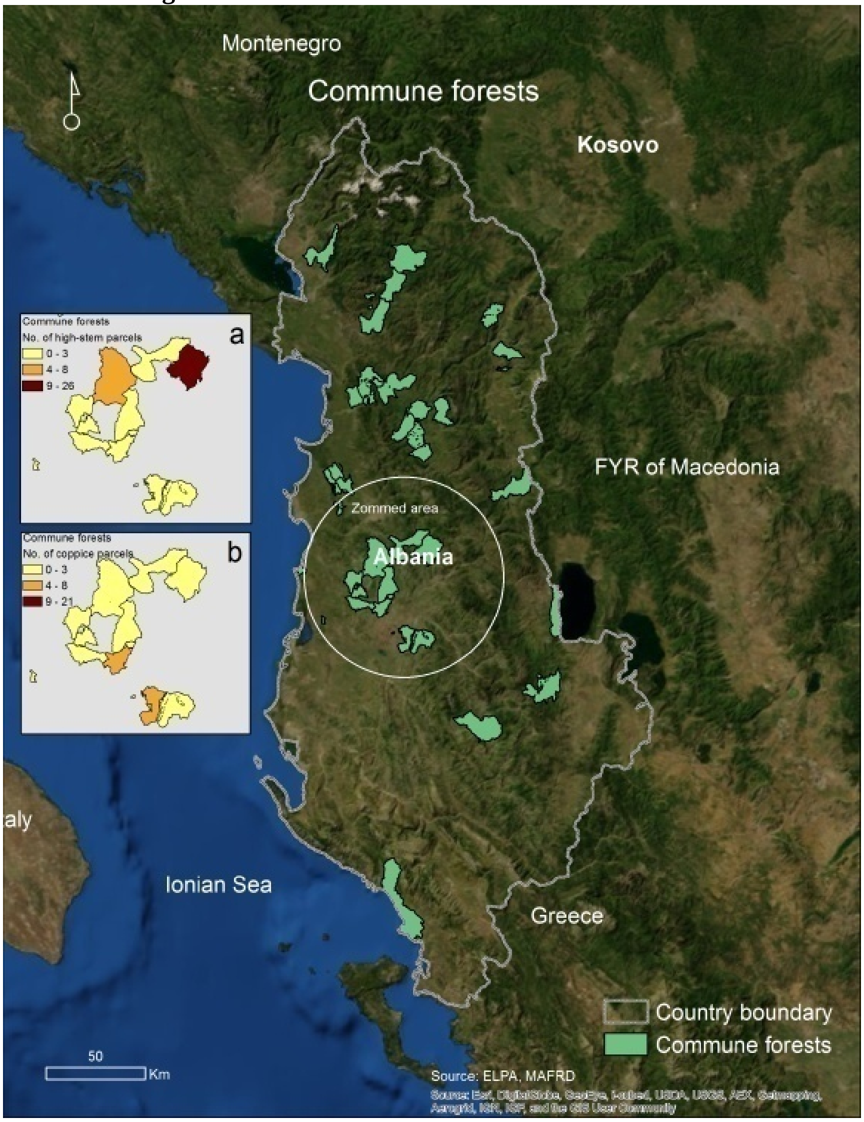

Fig. 2((a) percent of share of industrial wood as used by communes in Albania, (b) percent of share of firewood as used by communes in Albania, (c) percent of share of firewood and the volume of firewood (in m3 divided by 100) as used by communes in Albania.