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RESEARCH PAPER

Willingness of Private Forest Owners to Supply Woody Biomass in Croatia

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Abstract Renewable energy sources have received significant attention in European countries as a result of increasing dependence on energy imports and concerns over high prices of fuels and climate change. Although private forests in Croatia account for less than one quarter of all forests, they may play an important role in woody biomass energy production, due to their underutilized exploitation. The objective of this paper is to identify the willingness of private forest owners to supply woody biomass and to understand how this willingness is affected by certain owner, management and forest property characteristics. A survey conducted in Croatia in 2012 of a random sample of 350 private forest owners shows that almost half of them were willing to supply woody biomass. A random utility model was used to determine the factors influencing private forest owners' willingness to supply woody biomass. The results showed that willingness to supply woody biomass was influenced by property size, management objectives (production of fuel wood for personal needs and using the forest for outdoor recreation), cooperation with other forest owners and owner age. In order to enhance woody biomass mobilization from private forests it is important to identify the owners who are willing to supply it and to provide them with financial and administrative support using a mix of developed forest policy instruments.

Keywords Renewable energy · Small-scale forests · Forest policy · Logistic regression

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Introduction

The growing dependence of Europe on energy imports and further increases in energy prices reinforce the concerns about meeting the energy demand in the future (World Energy Council 2008). Along with this, energy supply has received significant attention in European countries, due to enhanced awareness regarding climate changes issues and the potential for economic growth and development (Benjamin et al. 2009; Shivan and Mehmood 2010; Halder et al. 2014; Lindstad et al. 2015; Peters et al. 2015).

Initial steps regarding renewable energy policies in the European Union (EU) started in the 1990s, resulting in the EU Renewable Energy Directive 2009/28/EC (hereinafter EU-RED), which set mandatory targets for all member states, such that by 2020 in the EU 20 % of energy should be derived from renewable sources (Directive 2009/28/EC 2009). In parallel, European countries have developed and implemented policies dedicated to promoting the production and use of energy wood from forests (Stupak et al. 2007; Sipila et al. 2008) and caused several shifts in related industries (Mihelič et al. 2015). Furthermore, in 2013 a new EU Forest Strategy (EU 2013) was adopted which responds to the new challenges that forests and the forest sector are faced with. According to this strategy the most important source of renewable energy is presently forest biomass and it currently accounts for around half of the EU's total renewable energy consumption.

During the pre-accession period, the process of harmonization of national legislation with EU policy concerning renewable energy, commenced in Croatia. The Energy Strategy of the Republic of Croatia (Croatian Parliament 2009) was adopted in 2009, where detailed roadmaps of how Croatia expects to reach its target for the share of renewable energy in their final energy consumption was presented. Moreover, in 2014, the Croatian government adopted the Third National Action Plan for Energy Efficiency by 2016 (Ministry of Economy 2014), designed in accordance with the EU-RED and with policy measures to meet the energy EU 20-20-20 target. Also, an energy report (Ministry of Economy 2013) showed that the total national energy demand in Croatia increased from 2012 to 2013 by 4.1 %, while the trends in the 6 year period, from 2008 to 2013, showed that energy imports decreased at an average annual rate of 4.3 %. During the same 6 year period, trends in the production of primary energy forms showed a slight increase of 0.8 %, while between 2012 and 2013 the production of primary energy forms increased by 17 %, mainly due to the favorable hydrological conditions. Between 2008 and 2013 the trends showed that the share of renewable energy doubled, of which fuel wood and solid biomass grew from 8.5 % to reach 14.3 % and other renewables increased their share from 0.5 % to reach 3.7 % (Ministry of Economy 2013).

The Energy Strategy and Third National Action Plan for Energy Efficiency showed that there was ample potential for the successful production of woody

biomass,[1] mainly based on huge areas of state-owned forest. The potential of private forests for woody biomass production was less clear (Posavec et al. 2015). Primary data on woody biomass, particularly woody biomass in private forests, are scarce. Estimated potentials for state and private forest have been derived from growing stock per hectare and refer to the above ground biomass.

In Croatia, 23 % of forests are privately owned (Čavlović 2010). Management of these forests is far from optimal due to diverse ownership and property structure (Krajter Ostoić et al. 2015). This diversity is displayed through a large number of owners (around 600,000), small forest property (on average 2.6 ha) and fragmentation (3 plots on average) (Glück et al. 2011). Private forest management is further hindered by constant processes in society which are related to an increasing number of owners due to partible inheritance and the diminishing sizes of forest properties, as well as a decrease in the percentage of rural population, which indirectly influences the socio-economic structure of the population (Pezdevšek Malovrh et al. 2010, 2015; Glück et al. 2011). Consequently, the economic dependence of people on forests is decreasing, which is reflected in insufficient utilization of natural resources that could play an important role in future wood supply. Nevertheless, private forests could play an important role in future timber supply in Croatia as wood is predicted to be an important source of renewable energy if the EU 2020 targets are to be met.

A number of studies (Kuuluvainen et al. 1996; Kennedy 2001; Conway et al. 2003; Vokoun et al. 2006; Joshi and Arano 2009; Posavec et al. 2015, Sjølie et al. 2016), especially in Scandinavian countries and in North America, have been conducted in order to understand the factors motivating timber harvesting behavior and intensity of harvesting by private forest owners (Shivan and Mehmood 2012). During the last few years, owing to the increased interest in renewable energy resources, research related to private forest owners and producers' willingness and ability to supply biomass has been conducted. These previous studies generally found that private forest owners had a positive motivation for supplying woody biomass (Conrad et al. 2011) and that the factors affecting private forests owners' willingness to supply woody biomass are as follows: property size, forest type, forest ownership, forest market, owners' management objectives and socio-demographic characteristics (Kennedy 2001; Joshi and Arano 2009; Joshi and Mehmood 2011; Gruchy et al. 2012; Joshi et al. 2013; Posavec et al. 2015). Previous studies on woody biomass in Croatia were mainly focused on biomass production as a part of state forest management taking into account different tree species (Orlić 1999; Topić et al. 2006, 2009; Zečić and Vusić 2013; Zečić et al. 2013; Kajba and Andrić 2014), or pellets and biofuels production potential as raw material for heating in the wood industry (Benković and Sušnik 2008; Risović et al. 2008) and cogeneration systems (Prelec et al. 2004; Risović et al. 2004). In recent years, two studies have explored energy wood production and supply from private forest in Croatia. Halder et al. (2014) examined perceptions and attitudes of nonindustrial

[1] In our study the FAO definition of woody biomass was used: "the mass of woody part (stem, bark, branches, twigs) of trees, alive or dead, shrubs and bushes, excluding stumps and roots, foliage, flowers and seeds".

private forest owners to energy wood production in Croatia and Serbia, while Posavec et al. (2015) studied private forest owners' willingness to supply woody biomass in selected South-Eastern European countries, including Croatia. Posavec et al.'s (2015) study identified factors that influence willingness of private forest owners to supply woody biomass, with focus on different management objectives (i.e. timber production, investment, game management and heritage) and forest and forest ownership characteristics. Halder et al. (2014) examined key dimensions of the nonindustrial private forest owners' perception and attitudes related to energy wood production using principal component analysis and based on that provided policy recommendations to the public authorities and professionals for improving the preconditions for energy wood mobilization from private forests.

The purpose of this study is to identify private forest owners' willingness to supply woody biomass in Croatia and to understand how certain characteristics such as forest management objectives (timber production, investment, recreation and non-wood forest products), forest property and forest ownership characteristic, owners' knowledge about biomass, willingness of owners to cooperate with other forest owners and socio-demographic characteristics of private forest owners had affected this willingness. The results of this research will be useful for forest and energy policy actors to improve the preconditions for woody biomass mobilization and to develop supportive policy instruments.

Research Methods

Survey Method

A quantitative door-to-door survey of private forest owners was conducted in Croatia to estimate private forest owners' willingness to supply woody biomass and to understand the factors influencing their decision. The sample design for the survey was based on experiences gained through PRIFORT[2] project (Glück et al. 2011) and started from the fact that a nationwide list of all private forest owners does not exist and that owners are scattered throughout the country. Given the quite limited budget available to the study, it was decided that the most appropriate sample design was multi-stage cluster sampling consisting of three steps: (a) determination of overlapping areas with the highest percentage of forest area and the highest share of private forest area; (b) determination of settlements in overlapping areas and (c) selection of individual respondents. The data source for the first step was the Forest Advisory Service map (Posavec and Trninić 2008). Based on this map a list of selected municipalities was made. For the second and third steps a list of all settlements within the chosen municipalities was made. A random sample of 35 settlements were selected from the list. Within each settlement, the first person for survey was selected randomly and asked if he/she

[2] The project "Research into Organization of Private Forest Owners' Interest Associations in the Western Balkan Region—PRIFORT" was financed by the Ministry of Agriculture, Forestry, Environment and Water Management of Republic of Austria.

owns a forest. If the person owns the forest, then he/she was interviewed otherwise the person was asked to recommend another person (private forest owner) for survey (such as his or her neighbour), until the quota of 10 per settlement was completed, yielding a total sample size of 350 respondents (Glück et al. 2010, 2011). In some cases respondents refused to answer the survey, mostly due to the lack of time or interest or they were not a forest owner, so the interviewers went to another one who was recommended. Selected private forest owners were informed about the meaning of the term woody biomass according to the FAO definition prior the survey. The structured questionnaire used was developed within the WESSPROFOR[3] project, and consisted of five sections seeking information on private forest characteristics (property size, fragmentation, distance from household, type of forest, etc.), forest management and management objectives, willingness of private forest owners to cooperate, owners' opinion about woody biomass production, and socio-demographic characteristics. Section four consisted of several questions aimed at gathering information on owners' opinion and awareness of woody biomass, their willingness to supply woody biomass, their main motivational factors for woody biomass production and supply (i.e. subsidies, financial benefits, energy supply), and main obstacles to woody biomass production. The questions in the survey were developed based on the factors identified as impacting on the willingness of private forest owners to supply woody biomass in previous research (Kennedy 2001; Joshi and Arano 2009; Joshi and Mehmood 2011; Gruchy et al. 2012). The questionnaire was pre-tested in May 2012 and the survey was carried out between August and December 2012. The survey was conducted by a young researcher. The data were analyzed using the statistical package SPSS 18 (Inc. 2009).

Theory Behind the Econometric Modeling Method Used

Assuming rational behavior, private forest owners will maximize the utility from their forest by choosing their subjective preference from a set of available alternatives, for either supplying woody biomass or doing something else (Shivan and Mehmood 2010, 2012; Joshi and Mehmood 2011). To take into account the uncertainties that surround the private forest owner decision making processes owing to unobserved alternatives, unobserved individual attributes and measurement errors (Manski 1977; Lynch et al. 2002), a random utility model was used to determine the factors influencing private forest owners' willingness to supply woody biomass.

Given the information from previous studies on the factors that influence private forest owners' willingness to supply woody biomass, the utility function can be expressed as:

[3] The project "Opportunities for Wood Energy Production from Small-scale Forests in the South-Eastern Europe Region—WESSPROFOR" financed by Ministry of Foreign Affairs of Finland and coordinated by the European Forest Institute.

$$U_i = f(x_i) + \varepsilon$$

where U_i is the utility received by private forest owners by engaging in supplying woody biomass; x_i is a vector of forest property and ownership characteristics (FOROWN), forest management objectives (MANOBJ), willing of owners to cooperate with other forest owners (COOP), owners' knowledge about biomass (KNOWBIO) and socio-demographic characteristics (SOCIODEM) and ε is the random error term.

Since the dependent variable in this study was converted to a binary scale, logistic regression was applicable for estimating the model parameters using the Enter algorithm (Field 2009). Logistic regression is based on the cumulative logistic probability function and estimates the probability of an action given a set of categorical characteristics (Pindyck and Rubinfeld 1981). In binary logistic regression, the probabilities of each outcome are specified as:

$$\ln \frac{P\left(Y = \frac{1}{x_1, x_2, \ldots, x_p}\right)}{1 - P\left(Y = \frac{1}{x_1, x_2, \ldots, x_p}\right)} = logit\, P(Y = 1) = \beta_0 + \beta_1 x_1 + \cdots + \beta_p x_p$$

where P is the probability that an owner is willing to supply woody biomass, x denotes the value of the independent variables and β denotes model coefficients. Maximum likelihood estimation was employed to estimate the values for model parameters from 1 to p. The testing for statistical significance of the regression coefficients in the model was carried out using the Wald's test at a significance level of 0.05 (Hosmer and Lemeshow 2000).

The specific binary logit model used in the study is represented as:

$$\begin{aligned} \text{WILLING} = {} & \beta_0 + \beta_1 \text{FOROWN} + \beta_2 \text{MANOBJ} + \beta_3 \text{COOP} + \beta_4 \text{KNOWBIO} \\ & + \beta_5 \text{SOCIODEM} + \varepsilon \end{aligned}$$

Before running the analysis, the data was assessed for multi co-linearity, using variance inflation factors (VIFs). All variables with VIF higher than 5 were excluded from the model (Field 2009). Moreover, the data were checked to reduce the problem of coefficients with unreasonably large standard errors, using multiway cross tabulation of all categorical independent variables with the dependent variable. The VIFs for independent variables were smaller than 5, with the average VIF 1.202.

Variable Definition and Predicted Influence

The dependent variable (WILLING), for the selection equation was binary in nature, taking the value of "1" if private forest owners were willing to supply woody biomass and "0" if not. As highlighted above, the independent variables used in the model were grouped into five categories: forest property and ownership characteristics, forest management objectives, cooperation with other forest owners, knowledge and socio-demographic characteristics.

The first group of variables "forest property and ownership characteristics (FOROWN)" included variables such as forest property size (PROSIZE), fragmentation (FRAGM), distance of owner's residence from the forest (DIST) and ownership structure (OWSTR). The variable PROSIZE was a continuous variable indicating how many hectares of forest land that the respondent owns. This variable was expected to be a positive predictor of owners' willingness to supply biomass, because owners with a larger forest property were often identified as active forest managers who were engaged in timber production activities as they could provide a larger amount of woody biomass than the owners with smaller properties and thus generate a bigger profit (Zhang and Mehmood 2001; Beach et al. 2005; Joshi and Mehmood 2011). The FRAGM variable was expected to be a positive predictor of the owners' willingness to supply biomass, because the owners with consolidated property have better preconditions for active forest management (Posavec et al. 2015). The variable was coded as 1 if the forest property is consolidated and 0 if it is fragmented. The FRAGM variable was based on the question that asked whether the owner had only one consolidated parcel or has more dislocated parcels (i.e. if their property was fragmented no matter when the parcels have been acquired).

Earlier research e.g. Shivan and Mehmood (2010) and Conway et al. (2003) indicated that owners who lived near their forest, were more likely to be involved in forest management activities than those residing further away (Joshi et al. 2013). Therefore the variable DIST, which is a continuous variable, was expected to be a negative predictor of the dependent variable. Furthermore the variable OWNSTR was expected to be a positive predictor of willingness as owners who were sole holders and thus independent in their business decisions, were more likely to be involved in forest management activities than those who shared their forest with other owners (Posavec et al. 2015). The variable was coded as 1 if the private forest owners were sole holders and 0 if they shared their property with others.

The second group of variables "forest management objectives (MANOBJ)" included the variables that captured the use of forest (production of fuel wood for personal needs—FUELPER, production of fuel wood for sale—FUELSAL) and owners' timber and non-timber management objectives (timber production—TIMBERPRO, investment for future—FUTINV, non-wood forest products production—NWFP and outdoor recreation—OUTREC). The variable FUELPER was expected to be a positive predictor of the willingness to supply woody biomass as it was assumed that private forest owners who were producing fuel wood for personal needs already had the equipment and experience needed for the production of woody biomass. Similarly, it was expected that the variable FUELSAL would be positive predictor, since it was assumed that those forest owners who were already selling fuel wood would be willing to expand their sales of woody biomass. Both variables were coded as 1 if private forest owners produced fuel wood for personal needs and for sale and 0 if they did not. According to previous studies (Dennis 1989; Conway et al. 2003; Majumdar et al. 2008; Joshi and Mehmood 2011) it was difficult to predict the sign of the TIMBERPRO variable, as some studies have shown that the timber management behavior of private forest owners is far less predictable than that of industrial owners due to the multi-objective nature of their

ownership. According to the results of Joshi and Mehmood (2011), TIMBERPRO was a negative predictor as the private forest owners who valued timber production (growing and selling timber) as an important management objective were less likely to supply woody biomass for bioenergy. In this study the variable TIMBERPRO was expected to be a positive predictor, due to the assumption that forest owners who produced timber were also willing to produce woody biomass from wood residues such as those derived from thinning and pruning. Moreover, the variables NWFP and OUTREC were expected to be negative predictors of the willingness to supply woody biomass. This is due to the fact that harvesting operations are an inevitable part of the woody biomass production process, which could be in conflict with the production of some non-wood forest products or outdoor recreation (Shivan and Mehmood 2012; Posavec et al. 2015). Furthermore, the variable FUTINV was also expected to be a negative predictor given that those private forest owners, who maintained their forests as an investment, have previously been shown less willing to produce woody biomass (Gruchy et al. 2012; Posavec et al. 2015). These Likert scale variables were coded as 1 if the management objective was rated by the owner as very important or important, or 0 if the private forest owner indicated that the management objective was neutral, not very important or not important at all.

The third category of independent variable included "cooperation of private forest owners with other forest owners (COOP)". The variable COOP was coded as 1 for the private forest owners who were already cooperating with other forest owners and 0 otherwise. It was expected to be positive, because of the assumption that those owners who were cooperating with owners enjoyed some privileges, such as sharing information, common equipment usage, joint selling of timber, etc. (Pezdevšek Malovrh 2010; Pezdevšek Malovrh et al. 2010).

The fourth category included the variable private forest owners' knowledge about biomass (KNOWBIO). The owners' knowledge was assessed by asking them whether they knew the benefits of woody biomass. The KNOWBIO was coded as 1 if owners said they were aware of the benefits of using wood for energy and 0 if they said they did not know the benefits. The variable KNOWBIO was expected to be a positive predictor of willingness, because of the assumption that those owners who were more informed about the use of biomass and aware of environmental benefits of biomass would be more likely to supply it. According to Joshi et al. (2013) non-industrial private forest owners who were aware of wood-based bioenergy were more willing to harvest woody biomass for bioenergy production.

The fifth category of variables included "socio-demographic characteristics (SOCIODEM)" such as age (AGE) and education (EDU). The continuous variable AGE was expected to be a negative predictor of willingness as, in general, elderly owners are less receptive towards active forest management (Joshi and Arano 2009; Joshi and Mehmood 2011; Joshi et al. 2013; Posavec et al. 2015). They were more likely to own forest for amenity purposes rather than maximizing financial returns from it (Zhang et al. 2005). On the other hand, the variable EDU was expected to be a positive predictor of owners' willingness, given a likely concern of more formally educated people for climate change issues and energy efficiency (Joshi et al. 2013). The variable EDU was coded 1 for those private forest owners who had at least a high school diploma, 0 otherwise.

Table 1 Definition, coding system and summary statistics of the variables used for model creation

Variable	Definition	Coding system	Mean	SD
WILLING	Decision to supply woody biomass or not	1 willing, 0 not willing	0.43	0.49
PROSIZE	Property size (ha)	Continuous variable	3.24	6.22
FRAGM	Fragmentation of forest property	1 consolidated, 0 fragmented	0.23	0.42
DIST	Distance of owner's residence from the forest (km)	Continuous variable	6.76	21.85
TIMBERPRO	Management objective—timber production	1 important, 0 unimportant	0.76	0.42
FUTINV	Management objective—investment for future	1 important, 0 unimportant	0.40	0.49
NWFP	Management objective—non-wood forest products	1 important, 0 unimportant	0.29	0.45
OUTREC	Management objective—outdoor recreation	1 important, 0 unimportant	0.36	0.48
FUELPER	Forests used for production of fuel wood for personal needs	1 yes, 0 no	0.91	0.28
FUELSAL	Forests used for production of fuel wood for sale	1 yes, 0 no	0.21	0.40
COOP	Cooperation of private forest owners with other owners	1 cooperate, 0 do not cooperate	0.10	0.30
KNOWBIO	Private forest owners' knowledge about the benefits of biomass	1 knowledge exists, 0 otherwise	0.92	0.26
AGE	Age of forest owners in years	Continuous variable	59.39	14.01
OWNSTR	Ownership structure	1 sole holder, 0 sharing ownership	0.57	0.49
EDU	Level of education	1 high school or higher level of education, 0 primary school or less	0.59	0.49

The definitions and coding system of all variables have been presented in Table 1.

Results and Discussion

Basic Characteristics of the Sample

Out of a total of 350 respondents, 67 % were male and 33 % were female. The predominance of male forest owners is similar to that noted in a previous research study, where male respondents also dominated accounting for 75 %, a trend which can be explained as a result of certain socio-cultural characteristics typical to the Western Balkans (Glück et al. 2011), where forest properties, are usually inherited by male children. The average age of the respondents was 59, while one quarter of them was older than 71. Around a half of private forest owners (53 %) were retired or unemployed and 84 % of them lived in a rural area with up to 500 inhabitants.

The average size of the forest property of the respondents was 3.2 ha, which was in 76 % of cases fragmented on four dislocated plots and was on average 6.7 km away from the owner's place of residence. Fragmented small-scale estates make it difficult to apply economies of scale (Glück et al. 2011), due to the challenges of forest management on such small properties, unless owners work together.

Most respondents had finished high school (49 %) or primary school or less (40 %). Only 11 % of them had college or university education. The respondents mentioned timber production as an important management objective. Most of them used their forests for personal needs for the production of firewood (91 %), for the production of technical wood (48 %) and for the production of non-wood forest products (41 %).

Most of the private forest owners were not willing to cooperate with other private forest owners (60 %). A very small number of owners were already cooperating with other owners (10 %), although some indicated that they were willing to cooperate in the future (30 %). The main obstacles to cooperation and involvement in associations was lack of trust, owner age (mostly retired and old owners), small property size (3.2 ha per owner) or lack of time (focus on agriculture or something else). Although most of the respondents were aware of the woody biomass benefits (63 %) and were familiar with the term woody biomass (73 %), only 44 % of them were willing to supply it from their properties. Their interest in supplying woody biomass may be attributed to the recent promotion of woody biomass utilisation in Croatia from the state administration and the high market prices that are currently available. In Halder et al.'s (2014) study a greater proportion of owners were found to be willing to supply woody biomass. They found that almost three-quarters of private forest owners were interested in producing energy wood from their forests, and that 95 % of them were highly interested in producing wood for energy over timber production against the backdrop of a stable energy wood market in Croatia. The higher willingness noted in Halder et al.'s (2014) study could be explained by the sampling procedure adopted by them, i.e. they used convenient sampling with private forest owners who are members of private forest owners associations.

Results of Logistic Regression Model

The estimates of the binary logistic regression model for the willingness of private forest owners to supply woody biomass are shown in Table 2. The Chi-squared test on the log-likelihood ratio indicates that the model was significant at the 99 % confidence level, indicating that the model was able to distinguish between private forest owners willing to supply woody biomass and those who were not. The model correctly classified 71.3 % of cases.

The results revealed that five out of 14 independent variables significantly influenced the owners' willingness to supply woody biomass and these were as follows: property size (PROSIZE), outdoor recreation (OUTREC), production of fuel wood for personal needs (FUELPER), cooperation of private forest owners with other owners (COOP) and the age of private forest owners (AGE). The direction of the relationship between the variables and the dependent variable was consistent with that hypothesised except for FUELPER which turned out to be a negative

Table 2 Logit estimates for determining the factors influencing owners' willingness to supply woody biomass in Croatia

	B	SE	Wald	*df*	Sig.	Exp(B)
Constant	1.896	1.473	1.657	1	0.198	6.656
PROSIZE	0.160	0.067	5.711	1	0.017*	1.174
FRAGM						
Consolidated	0.403	0.461	0.767	1	0.381	1.497
Fragmented	0.000					
DIST	−0.011	0.009	1.523	1	0.217	0.989
FUTINV						
Yes	0.050	0.375	0.018	1	0.893	1.052
No	0.000					
TIMBERPRO						
Important	0.463	0.526	0.775	1	0.379	1.589
Unimportant	0.000					
FUTINV						
Important	0.050	0.375	0.18	1	0.893	1.052
Unimportant	0.000					
NWFP						
Important	0.136	0.428	0.101	1	0.751	1.145
Unimportant	0.000					
OUTREC						
Important	0.821	0.380	4.657	1	0.031*	2.273
Unimportant	0.000					
FUELPER						
Yes	−1.735	0.831	4.362	1	0.037*	0.176
No	0.000					
FUELSAL						
Yes	0.611	0.488	1.567	1	0.211	1.842
No	0.000					
COOP						
Yes	1.941	0.826	5.522	1	0.019*	6.968
No	0.000					
KNOWBIO						
Yes	0.761	0.667	1.300	1	0.254	2.140
No	0.000					
AGE	–0.042	0.016	7.114	1	0.008*	0.959
OWNSTR						
Sole holder	0.145	0.375	0.150	1	0.699	1.156
Joint ownership	0.000					
EDU						
Primary or less	0.000					
Other	0.023	0.417	0.003	1	0.956	1.023

Table 2 continued

	B	SE	Wald	*df*	Sig.	Exp(B)
STATISTICS						
χ^2		54.645				
p value		0.000				
Log-likelihood		191.913				
Observations correctly predicted (%)	71.3					
Hosmer and Lemeshow	$\chi^2 = 5.689$; $p = 0.682$					

* Significant at 5 % level

predictor and OUTREC which turned out to be positive predictor of the willingness to supply woody biomass.

The variable PROSIZE was positive and significant, which indicates that the private forest owners with bigger property size were more likely to supply woody biomass. This is consistent with the previous findings (Beach et al. 2005; Joshi and Mehmood 2011; Posavec et al. 2015) and indicates that owners with larger forest properties achieve economies of scale in woody biomass production or any other type of production. It was assumed that owners with larger forest properties were more engaged in timber production activities as they could provide a larger amount of woody biomass than the owners with smaller properties and thus gain a bigger profit. According to Glück et al. (2010) the average forest property size in Croatia is 2.9 ha, while 60 % of private forests are fragmented into 2–4 separate plots.

The direction of the relationship between the variable FUELPER and willingness to supply woody biomass was not consistent with the hypothesis, indicating that private forest owners who produced fuel wood for personal needs were less likely to supply woody biomass. This could be due to the fact that the property size of private forest owners who used their forests for personal needs is small and their resources were insufficient, hence they could not supply extra resources for sale. The variable OUTREC indicates that the owners who valued outdoor recreation as an important management objective were more willing to supply woody biomass. The explanation for that could be found in the fact that in Croatia harvesting for woody biomass energy production is mostly obtained from selective felling or thinning. According to Marzluff et al. (2002) such practices may even influence habitat conditions in a positive way, and as such reduce conflict between outdoor recreation and woody biomass production.

The strongest predictor of willingness to supply woody biomass was the variable COOP, with an odds ratio of 6.968. This indicates that the private forest owners who cooperated with other private forest owners were almost seven times more likely to supply woody biomass than those who did not cooperate with other private forest owners, controlling all the other factors in the model. This is consistent with the assumption that the owners who cooperated with other owners enjoyed some privileges, such as sharing information on the market, common equipment and joint

selling, especially if they are members of an interest association (Pezdevšek Malovrh 2010; Pezdevšek Malovrh et al. 2010).

The direction of the AGE variable was negative, which indicates that the willingness to supply woody biomass decreased with the owner's age. This result is in accordance with previous findings (Joshi and Mehmood 2011; Posavec et al. 2015). In Croatia it is evident that the transfer of forest ownership between the family members occurs in owner's old age or even after they have passed away (Glück et al. 2011). This fact, in combination with other negative demographic factors, such as migration from rural areas to cities, indicates that in the future there is a possibility of a significant occurrence of a new trend in forest ownership where new forest owners will appear with different socio-economic status (non-farmers with higher education) and will have a different lifestyle, motivations and attitudes toward their ownership. In addition, older private forest owners were not willing to manage their forests due to lack of manpower and poor health conditions (Posavec et al. 2015).

Conclusion

Although the use of woody biomass (fuel wood) as a source of energy has a long tradition in Croatia, natural gas and fuel oil currently have the biggest share in primary energy sources. However, as the national energy demand grows and the government has the obligation to reach the EU 20-20-20 target by increasing the share of renewable energy sources, the potential of woody biomass is becoming more important. Most of the woody biomass in Croatia is obtained from state owned forests and although the potential of private forests is less clear, it still exists. The most important factor influencing whether a reliable biomass supply can be obtained from private forests is private forest owners' willingness to supply woody biomass. This study showed that almost half of private forest owners were willing to supply woody biomass and a surprisingly high percentage of them were familiar with the term woody biomass. The results showed that the willingness of private forest owners to supply woody biomass is likely to be influenced by various factors; property size, production of fuel wood for personal needs, outdoor recreation as a management objective, cooperation of private forest owners with owners and private forest owners' age. Among the previously mentioned independent variables, the cooperation with other owners was identified as the strongest predictor. Private forest owners who were cooperating with other owners were almost seven times more likely to supply woody biomass than those who were not. This indicates how cooperation of private forest owners is a motivating factor and has a positive influence on enhancing owners' motivation for further activities, such as the production of woody biomass. The fact is that the willingness for supplying woody biomass decreases as the private forest owners' age increases, because most of them are elderly people and that trend is a continuous process, mostly due to inheritance, constant emigration from rural areas and youth emigration. These negative trends severely jeopardize the capacities of private forests for woody biomass mobilisation. Furthermore, another important factor is the size of the property; as the property size

increases, so too does the willingness to supply woody biomass. Since a majority of private forest owners used their forests for production of fuel wood for personal needs, often on their small-scale properties, it can be concluded that they do not possess enough financial, labour or organisational sources to meet both needs, their own and the requirements of the potential market. Consequently, this could explain why the private forest owners who produce fuel wood for personal needs are less motivated to supply woody biomass compared with the private forest owners who produce it for sale.

In order to motivate private forest owners for active management and mobilisation of woody biomass in Croatia it is necessary that policy makers prepare a mix of forest policy instruments that will encourage private forest owners to produce woody biomass from their forest and contribute to the biomass market. Since cooperation among owners is the strongest factor positively influencing the willingness of owners to supply woody biomass, it is important to continue the work on strengthening the cooperation among private forest owners and to develop the biomass market in order to enhance their possibility to participate in that market. The existing advisory service, within the ministry of agriculture, should assume the most important role in the future. Its task is to encourage and support the establishment of private forest owners associations and their activities, to educate owners on forest management and to obtain subsidies from Green taxes in order to improve production from forests. Through a well organised and active association, it is easier to reach private forest owners, and such organisations facilitate sustainable forest management, cost sharing and market access. Another possible way of achieving cooperation among private forest owners is through cooperatives, where private forest owners jointly manage their properties striving for mutual benefits. This type of cooperation would be the most suitable, but it is difficult to achieve, owing to private forest owners' lack of trust in any kind of cooperation. According to Glück et al. (2011), a majority of owners believe that their interests are not appropriately represented in the policy arena by interest associations, which indicates a high level of mistrust towards both public forest administration and state forest enterprises.

It is important to develop a full range of communication tools in order to inform owners about the importance of environmental and economic benefits of woody biomass production, best management practices, current market prices for woody biomass and other features related to bioenergy. Following the development of these communication tools it would be important to identify a target group of private forest owners who are willing to supply woody biomass and to inform them about existing funding possibilities through national ("Green taxes") or EU funding programmes (i.e. Croatian Rural Development Programme 2014–2020). Moreover, it is recommended to focus on the development of specific target-oriented instruments of forest policy in order to motivate the owners to release the wood potential from their forests. It is also important to highlight forest policy instruments such as tax breaks for younger forest owners of rural areas and thus contribute to general national objectives such as rural development and increasing self-employment of private forest owners and their families.

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