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# Compensating the opportunity cost of forest functional zoning - two alternative options for the Romanian forest policy

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Abstract. An important challenge of the environmental policy is conceiving appropriate economic instruments able to account for the positive externalities provided by forest ecosystems. This issue is extremely important for implementing the provisions of the Romanian Forest Act, which states that forest owners shall be compensated for the opportunity costs of giving up harvesting operations due to various conservation purposes. The paper presents a statistical method based on analytical assessment of the effective forgone revenues brought about by banning the harvesting operations in 96 cases, each case being a distinctive forest management plan conceived for a large forest area, i.e. a production unit. Doing so, the scale effect has been taken into account because all legal provisions referring to forest management planning systems are focused on production units, considered the basic reference elements for sustainable forest management. The multiple regression function produced by the statistical analysis was turned into a simple formula allowing for a straightforward set up of the average compensation worth being paid per year and hectare. In order to better fetch the real opportunity cost paid for each hectare of protected forest, the algorithm was further improved in order to account for the differences in stumpage residual value. Actually, the average compensation is differentiated onto five categories of hauling distances, using the same algorithm used by the National Forest Administration for differentiating the average reservation price established at national level on the ground of full-cost method stumpage pricing system.
Keywords: opportunity cost, environmental services, economic instruments, forest management planning, indicative growth.

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## Introduction

### General considerations

The process of designing adequate instruments for implementing multifunctional forest management involves various stakeholders (state or local administrations, environmentalists, private forest owners etc) and recently it has being enveloped into a broader policy-making process defined by the new concepts of safe minimum standards, ecosystem services provision and trade-offs between conservation and whatever economic benefits people might take out from terrestrial ecosystems (Fisher et al. 2008). On the one hand, lots of reasons are brought on the table for banning harvesting operations wherever ecosystem services are obvious; on the other hand harvesting the trees is the most reliable way to secure the financial sustainability of the forest enterprise. This issue is quite important as the great expectations put into non-timber forest products seem to be not so promising in terms of investments (Kusters et al. 2006) and a tradeoff between preserving natural forest as such and managing them according to sustained yield principle shall be sought in the European forest economies, where both public and private forests coexist.

Although the sustained-yield principle has been sometimes criticized in literature (Smith 1969, Struhsaker 1998) its realm has been gradually broaden (Wiersum 1995) and nowadays not the principle is debated, but its main dimensions to follow: sustained yield of timber, or sustained provision of ecological services (Bass 1993, Kennedy 1985). Romanian forest policy is still hinged on this timber-yield oriented principle, meaning the harvesting decision still depends on age reached by each even stand of trees, which actually reflects little interest in grounding the managerial decision on the economic theory or social rules (Kant 2000, Normandin 1995).

According to the new Romanian Forest Act (Anonymous 2008a), the forest owners shall be compensated for the forgone revenues they have to give up for sake of different environmental considerations. The issue falls into the broad category of compensations for ecosystem services (Hackl et al. 2007), conceived as means to render non-market values, the human welfare relies on, into real financial incentives for the ones who provide environmental services (Engel et al. 2008, Fisher et al. 2008, Fisher et al. 2009). Broadly speaking in this category falls whatever action undertaken by governments in order to increase the amount in which ecosystem services are provided by ecosystems managed by individual people or local communities (Jack et al. 2008), although the concept has been used to address the biodiversity conservation at international level (Jones et Gardner 2008).

Quite similar economic instruments have been already implemented in some South and Central American countries (Ballestero & Rodriguez 2008, Boerner et al. 2007, Corbera et al. 2009, de Koning et al. 2007) and Europe (Anonymous 2008b) as additional means needed to implement Natura 2000 Network. Direct payments were embodied into an auction mechanism conceived to award the farmers who provide ecological services (Klimek et al. 2008). Other successful examples have been analyzed in the context of a voluntary program aiming at preserving the endangered habitats through fixed-term agreement between the governmental authority and the forest owners who shall put off the decision of harvesting the trees for a couple of years after the age of 80, when regular stands are harvested (Mäntymaa et al. 2009).

A quite similar approach, based on net revenue from final logging was envisaged in order to derive a statistical relationship between the measure undertaken for environmental considerations and the revenue the forest owner shall give up in order to pursue ecological goals: having a set of observable data consisting of the two revenues (effective and forgone) and the reasons for making these differences, a statistical relationship was conceived in order to assess the compensation a forest owner shall receive for taken measures for the sake of forest ecosystem (Carlén et al. 1999). In China, a more integrated approach, assesses the opportunity cost of putting off harvesting operations by incorporating the foregone revenue and the Engel coefficient, used as a proxy of people willingness to pay (Xiao-bo et al. 2005). In Montana a price premium is being paid for wool and meat produced by farmers who are using non-lethal methods to protect the livestock (Badgley 2003); the author also quoted the case of shade-grown coffee system, where a price premium is also paid for the coffee produced in cultivated ecosystems resembling the natural forests (coffee shrubs grow under a forest canopy, thus contributing to biodiversity protection).

The new Romanian Forest Act (Anonymous 2008a) highlights the importance of multifunctional forest management both for public and private forests. In order to secure sustainability, forest health, biodiversity preservation and flood control, the Forest Act suggests, in general terms, some economic instruments able, on the one hand, to collect money from the ones who are the beneficiary of ecosystem services and, on the other hand, to compensate the private forest owners for the loss they incurred due to these ecosystem services. These challenges put the public authority responsible for forests in a complex situation, and the solution shall be sought in a thorough analysis of both social and private opportunity costs. Actually the public authority has to contemplate a tradeoff between the social cost of not having enough protective forests, not having enough money for the compensation system and not having enough resources to monitor and control whether or not the harvesting restrictions are abided by the forest owners who might have used both resources, wood and compensations.

## A snapshot on Romanian forest management planning system

Two ruling principles are pursued by Romanian forest management: the sustained yield principle, which states the allowable cut shall be even for the next 60 years (Sandulescu et al. 2007) and the territorial principle, according to which a forest management plan shall be produced for each production unit. According to this principle, all forest patches located in the same forestshed form a production unit, irrespective to the ownership pattern. The size of a production unit may vary between some hundreds hectare (in plain region) to 4-5 thousands hectare (in mountainous region); each production unit can be split into two or more subunits, each of them being more or less specialized on providing a given timber grade or a bunch of environmental services like flood prevention, soil protection, amenities and biodiversity preservation. Where the stands are managed mainly for timber production an allowable cut is set up using two different methods: the indicative growth method and the age-class method, each method being a sort of back-up for the other one; in most situations, the allowable cut assessed by the indicative growth method is accepted because this method, which will be further presented, is more consistent and relies on some input parameters easy to figure out. The allowable cut depends on the average annual yield harvestable in the next 10, 20, 40 and 60 years, each yield depending on the age class structure and the total forest area. All these harvestable volumes covering a period of 60 years are merged into a synthetic parameter, *Q*, which actually indicates the extent to which the growing stock is normal ($Q = 1$) is dominated by old stands ($Q > 1$), or, on the contrary, by younger stands, when $Q < 1$ (see, for more details, the Annex).

As the strictly protected forests are excepted from regular harvesting operations, it's obvious that withdrawing any patch of forest from timber production will diminish the potential allowable cut of the whole production unit, and this is the main input for assessing the opportunity cost of having protective forests instead on regular timber production forests.

In the last two decades the Romanian forestry has been implementing a gradually process of forest restitution which has resulted in a mixed ownership structure (figure 1), close to the one existing before the forest nationalization took place in 1948.

After the year of 2000 many forests have been restituted to the local communities irre-

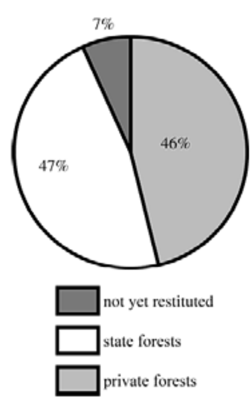


**Figure 1** The pattern of Romanian forest fund on ownerships

spective to their internal functional zoning and a compensation system had to be conceived in order to avoid any conflict between forest owners and the public authority responsible for forestry (Strimbu et al. 2005). In 2006 the Ministry of Agriculture, Forests and Rural Development issued the Ministerial Order no. 625 to compensate the individual forest owners for the revenues they have to give up whenever a strictly protected area has been delineated on within the forest they own. The methodology implemented through this order was pretty simple, and the compensation was equal to the value of the average growth at maturity age for the main species found on each individual property. Such an approach shan't be able to make an adequate difference between two neighbors owning similar forests, one being managed for timber production and the latter for protection only and therefore an additional study was needed in order to better differentiate the likely situations.

The baseline of designing the compensation scheme for the forest owners is the opportunity cost of obeying the functional zoning. In economic terms, such an opportunity cost is the amount of money a forest owner gives up for producing more positive externalities than the average amount of positive externalities provided by a forest designated for timber production. This provision is necessary because, according to the Romanian forest management system, what makes the difference between a protective forest and a commercial one is not the maturity age, but the officially accepted reason for cutting the trees: while commercial forests once they have reached the maturity age are harvested for being regenerated, and an allowable cut is set up for each forest, when it comes to strictly protected forests there is no allowable cut, meaning that only dead trees can be harvested.

Nevertheless such a scheme shall be able to cope with most of the situation when a compensation is needed but, at the same time, it shall be enough simple to make the difference both for the authority and the forest owner who are contemplating three sets of decisions: to pay or not to pay, to accept or not the compensation scheme and the forest functional zoning.

### Aim of study

The goal of this study is to conceive a formula-based compensation scheme tailored to the existing forest management planning system able to account for the most important signal given by the local market, which is wood-by-stem market price. Having a formula-based compensation scheme, it will be possible to better tune up the appropriate compensation that shall be paid for each hectare of forest withdrawn from the timber production, and, as shown further, this average compensation will be differentiated according to the hauling distance, which actually increases or decreases the timber market price. Having done this differentiation, the public authority will pay more for the patches of protective forests located nearby the forest roads and less for the remotest, which really makes sense for the decision made by the forest owners, to accept or not the functional zoning constraints, having to contemplate different opportunity costs for the two extreme situations, i.e. timber production or strictly protected forest area.

## Materials and method

Initiating the process of functional zoning from scratch, the "default" destination of forest is timber production, the age structure would be $S$ and the allowable cut would be $A(Q_{(S)})$. Withdrawing from timber production a forest patch, assumed to produce only environmental services, the age structure of the remaining forest meant to produce timber would change and, consequently, the $Q$ parameter and the allowable cut. This economic effect of changing the ratio between the productive and protective forests was further used to hypothesize what can be considered a sort of "crisp" average opportunity cost of forest zoning, which actually is the long-term effect of shrinking the production forests due to whatever reason (biodiversity conservation, soil and water protection and so forth).

Having the age structure and the volume distribution against these age structure for the strictly protective stands, is further possible to assess to which extent these stands would have change the allowable cut unless they hadn't been withdrawn from the timber production. The same approach can be refined with the same software used for producing the forest management plans, but it would be more difficult to run twice this computer program: once with the “true” information referring the strictly protected stands, and secondly with “altered” information as if these stands weren’t protected. This effort doesn’t pay off because the difference between the two allowable cuts is just a piece of the puzzle called opportunity cost of forest functional zoning. The other pieces are equally important and it would be more helpful to allocate some effort to address other issues, like the extent to which people would be willing to accept to be compensated, which implies a sound local experience in participatory management (Mäntymaa et al. 2009).

Roughly speaking, the per year-and-hectare compensation ($C$) worth being paid to the forest owner is given by equation

$$C = \frac{\left(V^* - V\right)P}{S_p} \quad (1)$$

where $V^*$ is the allowable ent the production unit would have had without having harvesting constraints, $V$ is the actual allowable cut, $P$ is the average price fetched on the local market by wood-by-stem and $S_p$ is the forest area withdrawn from the timber production for conservation purpose (strictly protected area).

This average compensation per hectare and year shall be further differentiated on hauling distances to account for the differences brought by the cost of harvesting operations. The Romanian stumpage pricing system refers to five classes of hauling distances[1]; hence the average compensation can be broken down into five distance-dependent compensations, according to relation (2), where $c_i$ stands for the per-year compensation paid for one hectare of forest that falls into the $I$ category of hauling distance.

$$c_i = k_i \cdot C \quad i = 1,..,5 \quad (2)$$

where

$$k_i = \frac{q_i}{\sum_i q_i \frac{s_i}{\sum_i s_i}} \quad i = 1,...,5$$

The only new variables are $s_i$ - the protected forest area that falls into the $i$-th category of hauling distance and $q_i$, which is timber price differential corresponding to the $i$-th category of hauling distances. These coefficients are accounting for the differences between the average hauling distances and they have been used for setting up the seller’s reservation price; their values are presented in table 1 and they have been undertaken from the National Forest Administration timber pricing system.

The difference between the two allowable cuts is difficult to calculate because it implies two different and independent runs of the specialized software used to produce the whole forest management plan. Although it seams a quite easy task, in fact it is not easy at all, because for each stand included in the strictly protected sub-unit the planner shall recommend hypothetical silvicultural systems as if that stand would not have been withdrawn from timber production; in other words, alternative technical solutions shall be conceived although they are just hypothetical. Hence a statistical approach was conceived and the first step in this direction was to divide both terms of equation (1) to $P$, thus resulting on the left side the ratio between the compensation and timber price, while on the right side we have only volumes divided by the strictly protected area. Since both $V^*$ and $V$ eventually depend

**Table 1** Price differentials used to break down the average compensation on hauling distances

| Hauling distance (m) | Timber price differential ($q_i$) |
|---|---|
| < 250 | 6.0 |
| 251-500 | 5.5 |
| 500-1000 | 5.0 |
| 1001-1500 | 4.5 |
| >1500 | 3.5 |

[1] Less than 250 m, 251-500 m, 501-1000 m, 1001-1500 m and more than 1500 m hauling distances, measured on the map according to the natural course of hauling operations.

on the age structure of the two sub-units (wood production and conservation), a reliable statistical dependency between the compensation/price ratio and the forest fund main indicators was sought, as follows.

In equation (1) the only unknown variable is the allowable cut without functional zoning, $V^*$. Mathematically, this hypothetical allowable cut depends on the variables presented in the bottom row of Table 2 and the fist column of Table 3.

These data were produced by the forest management planning software for each production unit. Without having the harvesting ban brought about by protection goals - whatever these goals are - all input data needed for computing the allowable cut would have changed, as shown in the 4th column of table 3. In the case study presented in these two tables, the new indicative growth accounts for a larger forest area, i.e. 1890.5 ha (845 ha timber production sub-unit, plus the protective forests accounting for 1045.5 ha) while the volumes that wound have been harvestable in the next 10, 20, 40 and 60 years would be larger, the difference being given by volumes recorded, on the bottom line of Table 2.

Since these volumes are known for both sub-units - the one managed for timber production and the one managed for conservation - it is possible to assess this parameter for any operational forest management plan included in the studied sample; accordingly, as many as 96 production units were randomly selected more than 40 forest districts providing the presence of one subunit where no allowable cut is allowed (Figure 2). The number of analyzed production units in each forest district varies from one to five.

The calculation went on according to the formulae and conditions presented in the Annex; the output is a hypothetical allowable cut allowing for assessing the compensation worth being paid. For all production units included in the sample the same algorithm was used and the next step was to figure out the most accurate regression function relating the compensation/price ratio to all significant variables that refers to the structure of the production unit as a whole. The volumes (*Vd, V1, V2* and *V3*) recorded in the 3rd column of table 3 were summed up as follows: (i) At the initial *Vd*, half of the 5th age class volume is being added being added, along with the cumulative volume of the last two age classes (6th and 7th ); (ii) *V1*, which refers to the stands harvestable in the next 20 years, summed up the volumes of all last three age classes, in addition to the initial value, recorded in 3rd column; (iii) *V2*, which refers to the stands harvestable in the next 40 years, summed up the last four age classes to the initial value and the same rule applies for the *V3*.

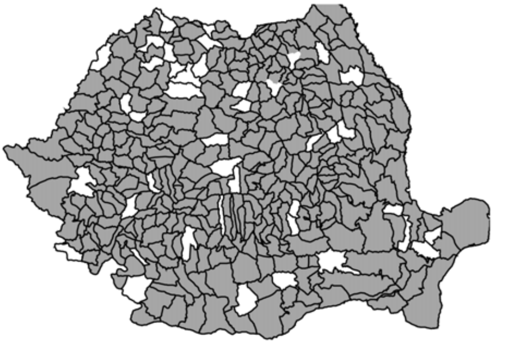

**Figure 2** Location of forest districts where input data where collected from

The average compensation shall be further broken down according to the five categories of hauling distances taking into account the hauling distance distribution as shown in Table 4.

This differentiation was done according to relation (2), considering the coefficients presented in Table 1 and the distribution of the forest area on hauling distances as presented in

**Table 2** Age structure of the protective sub-unit and potential harvestable volumes that would have altered the allowable cut of the whole production unit (Vatra Dornei Forest District, 1st Production Unit)

| Variables | Total | Ages class | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | VI | VII |
| Area (ha) | 1045.5 | 26.7 | 34.7 | 20.9 | 428.6 | 513.3 | 12.2 | 9.1 |
| Volum ($m^3$) | | 1346.0 | 5330.0 | 7651.0 | 191469.0 | 223494.0 | 5604.0 | 3762.0 |

**Table 3** Input data for re-computing the allowable cut as if no protective sub-unit would have been created (Vatra Dornei forest District, 1st Production Unit)

| Variables | Units | Actual values | Values without harvesting constraints |
|---|---|---|---|
| Indicative Growth | $m^3$ | 4,382 | 7,803 |
| Vd | $m^3$ | 16,738 | 137,851 |
| V1 | $m^3$ | 246,025 | 367,138 |
| V2 | $m^3$ | 376,012 | 608,872 |
| V3 | $m^3$ | 399,444 | 823,773 |
| D1 | $m^3$ | -54,164 | 119,642 |
| D2 | $m^3$ | 158,385 | 211,078 |
| D3 | $m^3$ | 200,732 | 296,752 |
| D4 | $m^3$ | 136,524 | 355,593 |
| Dm | $m^3$ | -54,164 | 119,642 |
| Q | | 0.3 | 1.767 |
| m | | | 1.134 |
| Rotation | Years | 110 | 110 |
| Vd/10 | $m^3$/year | 1,673 | 13,785 |
| V1/20 | $m^3$/year | 12,301 | 18,357 |
| V2/40 | $m^3$/year | 9,400 | 15,222 |
| V3/60 | $m^3$/year | 6,657 | 13,730 |
| A | $m^3$/year | 1,673 | 8,850 |
| Area managed for timber production (ha) St | | | 845 |
| Protected area (ha) Sp | | | 1045.5 |
| Wood-by-stem price | lei/ $m^3$ | 90 | |
| Compensation | lei/year/ha | 618 | |

**Table 4** Compensation per year and hectare for Vatra Dornei For est District (1st production unit), differentiated on hauling distances

| Hauling distance category | Area under harvesting ban (ha) | Compensation (lei/year/ha) |
|---|---|---|
| <250 | 42.0 | 772.754 |
| 251-500 | 284.0 | 708.358 |
| 501-1000 | 243.0 | 643.962 |
| 1001-500 | 320.0 | 579.566 |
| >1501 | 476.5 | 450.773 |
| Total | 1365.5 | |

column 2.

Having a quite representative data sample, extracted from 96 forest management plans, as many as 96 new hypothetical allowable cuts were calculated as shown in Table 2 and Table 3. Further, using relations (1) and (2), the compensations were calculated and then differentiated using the coefficients presented in Table 1 and the distribution of strictly protected forests against haling distance.

Screening the input data, a significant correlations between the *Q* coefficient for the timber production subunit and the hypothetical new *Q* for the whole production unit was found; so, the actual *Q* is a good proxy for the extent to which the protection unit is or it is not rich in old stands that would have been harvestable. Having these 96 theoretical compensations worth being paid, the average price fetched by the timber in each production unit, and all others input data a multiple linear regression was conceived, considering the ratio between compensation and the price as regressand.

## Results

The data presented in Table 5 suggest that most significant variables would be *Q*, *St* and *Sp*, because they are not inter-correlated but strongly correlated with other variable not taken into account (*CI, VD, V1...V3*); keeping only these variables of the empirical model, the multicolinearity is avoided and the final statistical inference is being simplified.

The outcome of the statistic data processing is presented in Table 6. Some possible changes for area variables were tried in order to figure out the most accurate statistical model; this explains why the two areas were merged into the natural logarithm of the ration between the total forest area and the square root of the strictly protected forest area.

Then the regression function presented in Table 6 was rendered into (3), which has been further used to assess the average compensation per year and hectare.

$$C = P\left(1.428Q + 0.663\ln\frac{S_t + S_p}{\sqrt{S_p}}\right) \qquad (3)$$

Having this average compensation per year and hectare it is further possible to break it down according to the five hauling distance categories, into the five different values, accounting for the residual value differences brought about by hauling operations.

**Table 5** Matrix of correlation coefficients and their statistical significance for the regressors used to assess the ratio compensation/price (96 cases) Signification level (s): *, s >95%; **, s > 99%; n.s., non significant

| Variables | CI | VD | V1 | V2 | V3 | Q | St | Sp |
|---|---|---|---|---|---|---|---|---|
| CI | 1 | 0.690** | 0.755** | 0.505** | 0.876** | 0.004 | 0.938** | 0.196 |
| VD | | 1 | 0.929** | 0.473** | 0.690** | 0.393** | 0.697** | 0.086 |
| V1 | | | 1 | 0.563** | 0.822** | 0.405** | 0.759** | 0.088 |
| V2 | | | | 1 | 0.627** | 0.217* | 0.456** | 0.038 |
| V3 | | | | | 1 | 0.207* | 0.828** | 0.076 |
| Q | | | | | | 1 | 0.041 | -0.048 |
| St | | | | | | | 1 | 0.170 |

**Table 6** Multiple regression function having the ration compensation/price as regressand

| Regressor | Regression coefficients | | Standardized coefficients (Beta) | *T* test | *p* (%) |
|---|---|---|---|---|---|
| | *B* | Standard error | | | |
| *Q* | 1.428 | 0.377 | 0.315 | 3.785 | 0.000 |
| $\ln \frac{S_t + S_p}{\sqrt{S_p}}$ | 0.663 | 0.093 | 0.595 | 7.150 | 0.000 |

## Model validation

The two methods were tested on the same data sample, which covers 7560 hectares, randomly selected from another set of production units, that have not been used for statistical analysis, and two type of compensations were computed: one set using the methodology embodied in the Ministerial Order no. 625 and another one using the methodology based on equations and the results are summarized in Table 7.

As presented in Table 7, on the average, the compensation worth being paid per year and hectare seems to be a little smaller than the compensation calculated through the average growth method. Nevertheless the proposed method allows for a more logical differentiation on haling distances, which really makes sense in a real economy where people are contemplating not the “official” prices, but the prices fetched by the timber sold on a free market. This issue will be discussed in the next session.

## Discussion and conclusion

More or less this research falls into the broad category of studies focused on appraising the ecosystem services produced by forests (Alexander et al. 1998, Lewandrowski et al. 1999, Mäntymaa et al. 2009, Xiao-bo et al. 2005). In this respect a very comprehensive literature is at hand (Hoehn 2006, Villa et al. 2002) but this study was strictly focused on finding an appropriate and simple economic instrument able to stimulate the forest owners to obey the managerial provisions of banning the harvesting operations. The corresponding economic instrument needed to finance these compensations is, ultimately, a local or a national tax for environmental services. Dimensioning this tax needs a thorough analysis of people willingness-to-pay, and prior to that, a consistent awareness campaign. The existing situation, when these compensations are being paid from the budget of the public authority responsible for forestry is not a sustainable one and, probably, the best option would be the already existing environmental fund, which is fed on regular basis from all kind of economic activities, including harvest-

**Table 7** Comparative analysis of the two methods used to figure out the compensation

| Main statistics and methods | Average compensation (lei/year/ hectare) | Total compensation to be paid for the sample area (lei) | The highest/the lowest compensation lei/year/ hectare) | Standard deviation on the whole sample (lei/year/ hectare) |
|---|---|---|---|---|
| Average growth method Ministerial Order 625) | 578 | 4,369,680 | 1206/444 | 253 |
| Formulae-based method | 465 | 3,515,400 | 1579/20 | 1269 |

ing operations.

This goal of encouraging forest owner to accept and obey the harvesting bans cannot be reached without having a good sense of the real opportunity cost a forest owner contemplates whenever s/he has to decide to go for compensation or for regular harvesting operations. The method proposed in this article relies on two pillars of the existing Romanian forest management system: the former is the method used to calculate the allowable cut and the latter is the algorithm used to calculate the timber price. Both inputs, the amount of harvestable wood (allowable cut) and its corresponding price turn into a given overall value; dividing that total value to the total area wherein harvesting operations are prohibited, an average compensation per hectare, worth being paid, is finally estimated. Doing so, the whole compensation system depends on the amount of wood both protective and productive forests can give in a certain area, not on what the forest owners expect from a normal forest, as the method proposed by the public authority has done.

From the technical point of view, the amount of timber to be compensated for[2] depends on three inputs: the total area of the forest (*St*), the area of protected forest (*Sp*) and the indicator (*Q*) that shows to which extent the age class structure of the productive forest is balanced or not, and which type of stands (older or younger than 60 years) dominates the forest[3]. Entering this indicator into the statistical relationship makes the difference between young forests, where the allowable cut would have been the same, with or without protective stands, and mature forests, where a patch of protective stands seriously diminished the would-be allowable cut for the whole forest. The underline assumption is that protective forests are more protective the older they are, which really makes sense from all points of view.

Making this reference to overall indicators of the forest structure is consistent with the provisions of the Forest Code, which says that a distinct managerial plan shall be produced for each productive unit (UP), irrespective to the ownership structure of that forest area, meaning that the allowable cut shall not be set up for each ownership. What really matters for the individual forest owner is not the total allowable cut, but the volume s/he is allowed to harvest in the next ten years from her/his forest. If none of her/his neighbors is allowed to cut, due to the age structure of the whole forest, s/he has no reason to ask for being compensated; for all forest owners only the tax relief shall apply, according to Art. 137 of the Forest Code (Anonymous 2008a). Somehow the method proposed here is very penurious: it doesn't compensate any environmental service, unless a real loss is being produced instead of that service (see the comparison presented in Table 7).

From the economic point of view, this approach could be more effective than a flat-rate compensation used in developed countries for two reasons at least: (i) Those who have "protected forests" located nearby the forest

2 This amount is within the brackets of the 3rd formula.

3 $Q<1$ means that young stands prevail; $Q=1$ denotes a balanced structure for the productive forests; $Q>1$, denotes that older stands prevail in the forest structure.

road will receive a higher compensation, accounting for the rent differentials brought out by lower harvesting costs; being better paid, statistically it is more likely for them to observe the managerial plan provisions because they get a comparable income as if they were allowed to harvest. (ii) Those, whose forests are quite remote, will get a smaller compensation, because their opportunity cost is lesser too. It doesn't mean that "environmental services" are undervalued, but the same rationale apply: as long as the forest owner compares two equal revenues, s/he will prefer the most certain one, which is the compensation.

The two situations described above can be re-word as follows: "the forest nearby the forest road deserve more money for being protected" while "distant forest are already somehow protected by higher harvesting costs, and the state shall pay only the difference to the opportunty cost of preserving them".

From the social and ecological point of view, the method might have positive side-effects because it doesn't produce any bias in the decision making process: all parties involved in drafting the management plan have to think not over the outcome of functional zoning, but over the rationale behind that functional zoning: what's worth being protected and what is not.

Like the alternative option, drafted by public authority, the average compensation shall be updated each year, taking into account the timber market price, which the best proxy of the forgone revenue. In contrast to that method, where the hauling distance doesn't matter, differentiating the compensation on hauling distances allows a better allocation of the money, since the compensation is higher for accessible stands and lower for the remote ones, which really makes sense for the forest owners who might be tempted to harvest the trees; getting a higher compensation, these forest owners, when they really need timber, they might buy some from the market. If they need just money, it's more convenient for them to get that money from the state instead of harvesting and selling the wood.

For the public authority, that is the Forest Inspectorates who are in charged with implementing the whole system, it would be more convenient to handle an economic instruments that provides effective incentives for the forest owners to obey the managerial plans, instead of giving flat-rate compensations for a large areas, where some forest owners might not be compensated enough, while others might be overcompensated.

Nevertheless, the method presented in this study shall be endorsed by a socio-economic survey on some very important protected areas in order to assess the gap between what can be effectively paid by the public authority and really can be accepted as compensation by the forest owners. Without this tuning-up the whole system might be unproductive: the state might have some money for these compensations but this money cannot be used because most of the forest owners were not content with the compensations they would have received. This is one possible blockage; the other blockage, brought about by the economic crisis, could be the financial resources these compensations shall be paid from. In both situation, a thorough analysis of private forest functional zoning is needed, in order to identify those issues which are really important and make the difference between a real sustainable forest management and a counterfeit sustainability.

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## Appendix

According to the indicative growth method, the allowable cut ($A$) is given by $A=m.C_i$ where $m$ is $a$ altering factor and $C_i$ is the indicative growth, meant as the current growth of growing stock resembling the real one in terms of composition and density but equally distributed against age classes. The altering factor m is given by another equation $m = a + bQ$ where the regression coefficients a and b depends on the rotation, according to the data presented in the table below, when $Q > 1$.
$Q$ is a key variable in all these computations and it is given by

$$Q = \frac{20C_i + Dm}{20C_i}$$

where $Dm$ is the minimum value of the following array:

$$D_d = 2Vd - 20C_i$$
$$D_1 = V1 - 20C_i$$
$$D_2 = V2 - 40C_i$$
$$D_3 = V3 - 60C_i$$

where $Vd$, $V1$, $V2$ and $V3$ stand for the amount of timber harvestable in the next 10, 20, 40 and 60 years, according to the present situation of age distribution, and health condition of stands that will be mature in the next decades.
If $Q < 1$, the calculation goes on another path, meaning that $A$, the allowable cut, will equal to the lowest value of the following ratios:

$$\frac{Vd}{10C_i};\frac{V1}{20C_i};\frac{V2}{40C_i};\frac{V3}{60C_i}$$

If one term of these ratios are smaller than one, then the following formula will apply

$$A = \zeta + \frac{\zeta}{V_d}\cdot\frac{\Delta_{iv}}{2}$$

where $\zeta$ is the smallest ratio of

$$\frac{Vd}{10};\frac{V1}{20};\frac{V2}{40};\frac{V3}{60}$$

and $\Delta iv$ is the difference between the total growth for the next 10 years and the growth of the main yield corresponding to the same period; actually this difference accounts for half of the growth expected in the next decade.

| Coefficient | Rotation (years) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 80 | 90 | 100 | 110 | 120 | 130 | 140 | 150 | 160 |
| a | 0.651 | 0.756 | 0.825 | 0.867 | 0.895 | 0.916 | 0.931 | 0.942 | 0.951 |
| b | 0.349 | 0.244 | 0.175 | 0.133 | 0.105 | 0.084 | 0.069 | 0.058 | 0.049 |