13

Gaming with Deadwood: How to Better Teach Forest Protection When Bugs Are Lurking Everywhere

Marian Drăgoi

1 Introduction

Over the past several decades, a series of droughts in Central and South-East Europe have triggered die-off symptoms amongst some timber broadleaved species (Brasier and Scott 1994; Thomas et al. 2002; Borlea 2004; Pautasso et al. 2013; Nagel et al. 2014). Resinous species, like silver fir (*Abies alba,* Mill.) and Norway spruce (*Picea abies,* L.) have also been affected by bark beetles, especially in those stands outside of their natural range (Jonášová and Prach 2004; Stanovský 2002; Olenici et al. 2011). Even though regular silvicultural measures are unable to prevent affected trees from dying, maintaining a certain level of forest biodiversity and a closed forest canopy are important goals that forest management must fulfil. As such, standing and fallen deadwood are important contributors to forest biodiversity (Humphrey et al. 2005; Verkerk et al. 2011), particularly those that have a slow

M. Drăgoi (✉)
University of Suceava, Suceava, Romania

J. Urquhart et al. (eds.), *The Human Dimensions of Forest and Tree Health*,
https://doi.org/10.1007/978-3-319-76956-1_13

decay rate (Lassauce et al. 2012). Such trees are crucial for maintaining populations of bats (Lučan et al. 2009), birds (Drapeau et al. 2009; Joseph et al. 2011; Miles and Ricklefs 1984) and mammals (Radu 2006). In Central Europe, the legacy of the former Austro-Hungarian Empire means that upland areas consist of large forests with Norway spruce and Scots pine (*Pinus sylvestris,* L.) planted instead of the indigenous broadleaved species like beech, oak, ash, maple and hornbeam. Nowadays most of these resinous stands are severely affected by insect pests (Jonášová and Prach 2004; Olenici et al. 2011; Panayotov et al. 2015; Sproull et al. 2015), droughts (Anderegg et al. 2013), windfall and/or wildfires (Flannigan et al. 2000).

In Romania, after 1970, the communist regime resumed planting Norway spruce and pines beyond their natural habitats to increase the production of high-quality wood and resin. A tipping point of the forest policy was 1986 when a new set of technical standards came into force focused on preserving the forests' naturalness. Furthermore, while in 2000, only 5.3% of the forests had been restituted by the Government back to former landowners (Abrudan et al. 2009), by 2017, the same area is equally shared by the state (public forests) and private ownership. However, little has changed regarding the managerial options, and all forests are managed to produce logs for lumber or veneer, but not pulpwood or fuelwood. There is effectively no guidance for the private owner on what management objectives they are meant to achieve, nor the timber grade she or he might aim at. To confuse matters further, the restitution process was driven by three different laws while the forest inspectorates in charge of checking the lawfulness and quality of any harvest operations were barely organised in 2000 but subsequently reorganised in 2003, 2004, 2005 and 2016.

Without having a reliable and extended forest road network (Drăgoi et al. 2015), the National Forest Administration (NFA) could not harvest the allowable quota using environmentally friendly logging operations and shelterwood forest systems. With fierce competition for wood, caused by thousands of small logging companies (authorised to operate for the sake of free competition), the public authority's inspectors are not able to trace all timber theft, their job being especially difficult

when the thief is the landowner. All these setbacks have been wrapped up in excessive bureaucracy, brought in by new institutions like environmental agencies, the Council of Competition, the Court of Accounts and many others.

However, the new institutions were not able to harmonise all the details of the forest policy, and a series of problems have occurred: sheer illegal logging, overharvesting through timber underestimation and different bureaucratic scams meant to get around legal obligations. Since 2010, the NFA has been continuously consolidating its position on the market by certifying its forest management according to Forest Stewardship Council (FSC®) standards. Hence, two divergent tendencies have occurred: on the one hand, the NFA staff pursued new environmentally friendly logging technologies and pest control in certified forests and, on the other hand, the forest rangers did their best to obtain more profit for their own account taking advantage of the weak control exerted by the forest inspectors. Cost-effective solutions are sought not only for economic reasons but also for simplifying the fieldworks; currently tagging trees for biodiversity (further referred to as TFB) and marking sanitation/salvage cuttings are two different tasks, carried out by the same people who have to wade through the forest twice: one time for sanitation fellings and the second time for tagging TFB. The order doesn't matter: usually, TFB are tagged prior to FSC audit, while sanitation/salvage fellings are stamped whenever is needed.

Where possible, forest rangers applied salvage cuttings in stands older than 60 years instead of regular harvesting operations in mature stands (for the sake of sustained yield principle the Forest Act allows this silvicultural swap). In addition to that, a systematic underestimation of the harvested volume was also an important scam as long as the amount of timber a logging company was charged for was not checked against the amount of timber transported by that company from the forest.[1]

Some illegal logging discovered in Retezat National Park in 2009 (Knorn et al. 2012) sparked media attention on harvesting operations generally whether they were legal or not legal. Later, in 2013, the Court of Accounts of Romania[2] published a retrospective report on the

consequences of forestland restitution, focused mainly on illegal logging. Two years later, the Forest Code was amended and one important side effect of the public debates of that time was a sound involvement of NGOs in preventing all types of illegal fellings, even though many activists were unable to tell the difference between regular fellings, as prescribed by the forest plan, and the illegal ones. Since then there has been extensive public attention on forests and the wood industry, particularly on illegal logging (mitigated by the wood tracking system) and biodiversity conservation (management plans for Natura 2000 network and old-growth forests). These two areas of interest are intertwined in the forest certification process that has been triggered mainly by the NFA in 2010 and 2011. So far about 2.3 million hectares (two-thirds of the public forests according to the NFA site: www.rosilva.ro) of forests have been certified by the FSC® scheme. However, the demand for timber labelled with the FSC® logo fell behind the supply because many logging companies are not able to comply with the high-quality standards required for harvesting operations and the European requirements on timber traceability (Gavrilut et al. 2015; Hălălişan et al. 2012).

The FSC® standard brought to light the problem of sanitation and salvage fellings because it requires the presence of deadwood in the forest (TFB), without providing any rigourous threshold in terms of number of trees or volume of deadwood per hectare (Humphrey et al. 2005; Schroth and McNeely 2011; Johansson and Lidestav 2011). The differences between the two types of fellings are important for understanding which is the problem with selecting and maintaining a certain number of TFB. Sanitation felling involves harvesting dead trees up to one cubic metre per hectare per year without indicating the cause of death, while salvage fellings allow harvesting more than one cubic metre per hectare for specific biotic or abiotic reasons such as insect pests, wind, snow or whatever natural causes, including the wounds produced to remnant trees by prior harvesting operations. Bluntly speaking, sanitation fellings do what nature does, i.e. natural selection, while salvage fellings are intended to keep the pests out. But reckless sanitation fellings eventually bring about more salvage fellings, and this was a *modus operandi* for a long period of time.

Hence, in 2016, the public authority invested funding for crowdsourcing on issues with high social exposure, like nature conservation, preservation of old-growth forests, illegal fellings and timber traceability (Stanciu 2017). Nowadays NGOs and laymen can check whether or not a load of wood is legal or not by searching on the website www.inspectorulpadurii.ro.

As Romanian forests have been traditionally managed to provide timber and ecosystem services, the growing stock has been maintained at high levels, together with shelterwood systems. Leaving aside sheer illegal cuttings[3] and felonies like marking green trees for sanitation felling, two types of poor practice are still common, and both are loopholes in the technical standards and the Forest Code. The first one briefly explained here is the provision that says that any tract of sanitation or salvage fellings shall follow the same commercial procedures as any regular tract of wood sold on the stump. The procedures of marking and auctioning any tract of wood takes over 30 days due to the following operational requirements: (1) marking up and measuring the trees to be harvested in each area (also referred to as *timber cruising*); (2) assessing the volume and the value of each tract of wood; (3) organising the auction; and (4) issuing all required approvals to commence the harvesting operations (a special authorisation from the national protection agency is needed for Natura 2000 sites). In Norway spruce stands, seriously affected by bark beetles, Duduman et al. (2014) showed that harvesting the already dead trees did not stop the insects' propagation; on the contrary, the authors concluded that the delay in harvesting operations caused by the bureaucratic procedure helps insects' propagation. Subsequently, the gaps in the forest canopy allowed more sunlight to reach the trees' bark, thus speeding up the occurrence of a new generation of beetles. Two or three weeks after the initial attack, when the affected trees will have been harvested, the beetles will have already been boring adjacent trees.

The second issue stemming from the sustained yield principle is the provision that all salvage cuttings ranging from 1 to 5 $m^3\ yr^{-1}\ ha^{-1}$, located in stands older than 60 years, shall be deducted from the main yield allowable cut, without any formal approval issued by the public authority (the public authority shall endorse tracts larger than

5 m^3 yr^{-1} ha^{-1}). This provision is very misleading because the Forest Code says that the amount of wood harvested from a certain forest unit cannot exceed the annual allowable cut prescribed by the forest management plan. Hence, the more scattered salvage fellings (up to 5 m^3 yr^{-1} ha^{-1}), the less "regular" harvesting operations will be carried out in mature (and often remote) stands. Because the many "tiny" tracts cannot be checked in the field by the forest authority, many weakened, but still alive trees, can be harvested. Replacing the main yield with salvage fellings provides another advantage to the forest manager, who pays less for the so-called regeneration fund that, according to the same Forest Code, is collected from the revenues brought by the main yield only. Thus, by adopting a strategy of "more salvage cuttings instead of main yield cuttings", the money that would otherwise go into the regeneration fund can be used to finance other activities, not precisely the ones envisaged by the regeneration fund (afforestation and thinnings).

The consequence of these poor practices, encouraged by the legal framework, is shown in Fig. 1: the gap between regular silvicultural

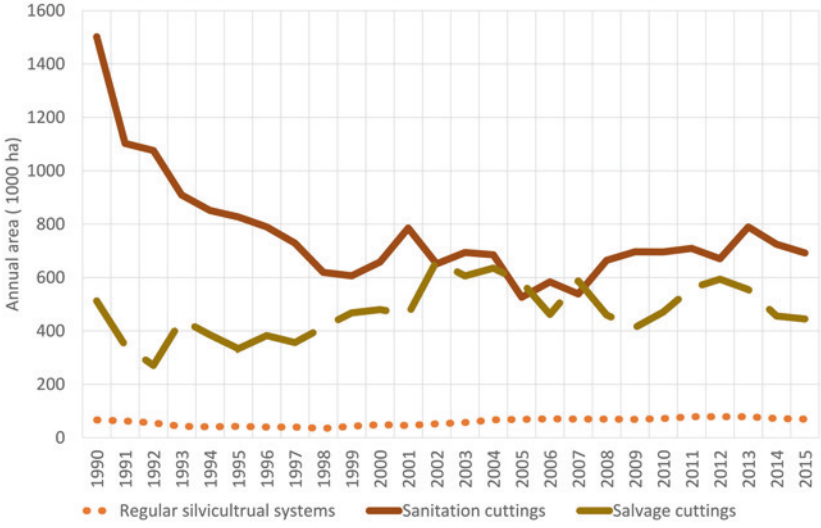

Fig. 1 Dynamics of the main types of fellings carried out in Romania since 1990 (*Source* Romanian national yearbooks)

systems and salvage fellings was still large in 2014, meaning that salvage cuttings replaced regular systems on large areas. The large share of sanitation cuttings is not a problem because the amount of wood per hectare and year is less than one cubic metre.

For two-thirds of the public forests managed by NFA, a feedback loop has been produced by the FSC® certification procedures in the sense that some TFB are left uncut in the forests. For the forests out of the scope of FSC® certification, maintaining a certain number of TFB is optional, but these trees must be properly labelled in the forest.

Romanian forestry has been confronted not only with *illegal logging* (Bouriaud and Marzano 2016) but also with the erosion of foresters' professional prestige (Lawrence 2009), undermined by an unsteady institutional and legal framework (Abrudan 2007; Knorn et al. 2012). Pursuing the same technical standards conceived as a command and control economy, forestry professionals face challenges in reconciling traditional forest management practices with the new socio-political context. The shift from the old paradigm which states that "all dead trees must be harvested", to a new one claiming that a certain number of dead trees must be spared for biodiversity purposes needs new procedures to train the forest rangers and the forest inspectors. Indeed, keeping TFB in order to maintain habitat for insectivorous birds doesn't help forest protection when the affected species are elm and ash as all affected trees must be harvested shortly after attack, without paying any attention to TFB. However, such situations are beyond the scope of this training scheme simply because such a process is even harder than one would expect because the professional responsibility of foresters has been eroded by the long and confusing process of land restitution.

2 Goal of the Study

The current policy is that NFA professionals (forest rangers and engineers) must maintain a certain amount of TFB to comply with the FSC® requirements. This goal has far-reaching implications at the level of forestry culture. Thus, this chapter describes a training drill that was developed and tested to provide the necessary tools for forest rangers

and inspectors as they fulfil their obligations for forest management under the FSC requirements. The process for finding dead and weakened trees, marking, measuring them and storing the data into a tablet requires good coordination across a team of 2–3 people.

When it comes to salvage cuttings, it is not only about poor practices; it is about adopting a different mindset about what a healthy forest should mean: a series of stands of perfect and healthy trees or a series of stands enriched in biodiversity? Although some insects or fungi diseases (like the ones affecting elm and ash trees) cannot be eliminated by other means than sanitation/salvage fellings (sometimes resembling clearcuttings on small areas), in much numerous cases the foresters have been applying small-scale salvage fellings just to avoid harvesting operations in remote compartments (i.e. not related to biotic or abiotic threats). At the same time, the challenge of sparing some standing dead or near dead trees for complying with FSC® certified forests compounds the fieldworks carried out by the professional foresters (rangers, technicians and engineers).

The traditional way of marking the tree for fellings has never required "undo" or "unmark" procedures, excepting forest offences, when trees are demarked, and a special procedure applies. Because demarking a single tree takes time, the foresters must keep track of all trees already marked in the same compartment and the "undo" decision should be made prior to stamping. Indeed, avoiding (i.e. undoing) wrong stampings can be better learned if both operations are carried out simultaneously. In so doing the felony of marking a supposedly dead tree for salvage fellings can be avoided by marking that tree as TFB.

Learning to balance the tendencies to mark too many TFB (just for getting rid of duty) or too many salvage trees (as most of the foresters are currently doing) requires a thorough understanding of the role played by TBF. When it comes to reaching a certain amount of deadwood per hectare things are more complicated for two reasons: (1) the alternative to TFB is salvage, which may produce some profit and (2) TFB shall be evenly spread throughout the forest area. Therefore, the fieldwork requires competence in assessing the health status, identifying the most contagious pest and insects and assessing the volume of any affected tree. All these activities have been carried out on regular

basis except for the decision to stamp TFB. This new series of decisions makes the difference between the mechanistic approach and the new one for two reasons at least: (1) a negative feedback loop is being triggered by the simple fact that two options are at hand, not only one; (2) a glimpse of reflection prior to stamping a tree is in place, in order to recall similar situations encountered in the past. Adding to these two mental processes, a more profound understanding of the forest ecosystem functions and boundaries, a keen sense of negotiation between environmental and economic goals and the ability to integrate newly acquired knowledge in everyday life, we have four out of the five strands of social learning, identified by Keen et al. (2005).

Assuming that none of the forest professionals wants to break the law by cutting healthy trees, we tried to conceive a sort of game with rules inspired not only by the legal framework but also nurtured by the belief that a certain amount of deadwood is welcome in any mature forest. It also provides a compromise between harvesting all dead trees and letting some TFB remain. Our game was inspired by the Operant Learning Theory (OLT), also known as Operant Conditioning Theory (OCT).

Burrhus Frederic Skinner, the American psychologist who developed OL/CT in the late 1930s, defined the goal of any learning process as changing the probability of having a certain response, under specific conditions (Skinner 1938; Thyer et al. 2012). In this regard, he suggested that learning "*is a series of discriminative stimuli and hence a series of reinforcers. It reinforces the act of blazing or otherwise marking the trail. Marking a path is, technically speaking, constructing a discriminative stimulus. The act of blazing or otherwise marking a trail thus has reinforcing consequences*" (Skinner 1988, 221). He also hypothesised that quite a large proportion of human behaviour is controlled by rules rather than by direct reinforcers. From his point of view, the outcome of applying a rule is a consequence of a particular response to a particular stimulus (Skinner 1969). In the context of salvage cuttings, we had to consider the real reinforcements and penalties brought about by the legal framework that refers to timber cruising and the FSC® standards and that influence the decision to "mark it as salvage timber" or "tag it as TFB".

Despite the fact that OL/CT oversimplifies the learning process and does not seem suitable for more complex learning situations, in this very particular case, where real penalties may apply as fines or may bring about major conditions,[4] according to FSC® procedures, we developed a training scheme inspired by OL/CT. Forest rangers, forest engineers and forest inspectors who are responsible for monitoring timber cruising for salvage and sanitation fellings could be better trained for tagging the TFB required by FSC® standards. It does not mean that all trees affected by pests should be kept uncut for the sake of biodiversity; it only implies that in the healthy forest a certain number of TFB shall be maintained. That being said, in "hotbed" areas, where infestation rates are very high, it is likely that the best approach to control the outbreak is for sanitation felling, maintaining no TFB in this instance.

3 Methodology

3.1 Operant Learning/Conditioning Theory

Basically, OL/CT assumes that behaviours are driven by reinforcements and punishments. Reinforcement occurs whenever an intensifying stimulus increases the likelihood to reproduce that behaviour—this is positive reinforcement; negative reinforcement is associated with a higher probability to maintain a given behaviour under decreasing stimuli. A punishment is a stimulus that reduces behaviour likelihood, and the same dichotomy applies; positive punishment—more stimulus, greater likelihood to resume the behaviour, and negative punishment—less stimulus, the lesser likelihood of maintaining that specific behaviour.

Two principles apply to OL/CT: (1) *Immediate consequences* (reinforcements or punishments) exert a stronger influence on behaviour than delayed consequences, and (2) behaviours already established can be maintained but with less effort (either slim rewards or penalties).

Apart from a long series of clinical studies focused on child behaviour therapy, summarised by Carr and Durand (1985), only one paper is relevant to our approach and refers to financial incentives for weight control (Jeffery 2012).

In our study, we have identified the optimum management option as maintaining a given number of standing dead trees per hectare with less sanitation fellings applied than is currently practised. A stimulus is the occurrence of a new "candidate" tree, physiologically weak and/or unsuitable for being felled for lumber or firewood: this is the "perfect" TFB. Further, on observing the methodical pattern of OL/CT, the reinforcements and punishments have been defined as follows:

(1) Positive reinforcements: tag a dead tree with "B" (for TFB);
(2) Negative reinforcement: tag a dead tree with "S" (sanitation cutting);

(a) Positive punishment: change the tag from "S" to "B";
(b) Negative punishment: change the tag from "B" to "S".

Tagging a TFB is the positive reinforcement because each new dead tree the operator comes across is a stimulus to look for another one, which can also be a TFB or a salvage tree. Conversely, marking a tree for salvage felling is negative reinforcement because it may be a strategy to harvest more wood in the most convenient way, as is happening now.

Demarking a tree from salvage to TFB is a positive punishment because that tree must be erased from the records and the effort and time taken to gauge its diameter, height and quality class is a waste of time.[5] The opposite action is a negative punishment because the field team must go back to a tree that has just been analysed, maybe a few minutes before. Erasing the letter "B" painted on its bark and resuming the timber cruising operations is obviously less costly than the previous operation.

Assessing the most appropriate number of TFB and salvage trees in any given stand is difficult. For this study, the "optimal" B/S ratio was estimated as 0.3–0.75. This was calculated by drawing on crowdsourcing data produced by a group of volunteers for the Romanian Ministry of Water and Forests in 2016 along with data taken from the evaluation forms issued in the last two years by Suceava branch of NFA relating to the average number of trees harvested per hectare as salvage cuttings. By combining the two datasets, a series of ratios were produced between the number of trees marked for the two types of sanitation fellings (S) and standing deadwood trees (B), per hectare.

3.2 Rules of the Game

Drawing on OL/CT, a field game for two teams of forestry students was designed to simulate the timber surveys in a mixed forest with Norway spruce and beech. The game involved the following rules:

(1) The final B/S ratio reached by each team after six hours of fieldwork should fall between 0.3 and 0.75;
(2) The positive punishment (F_{p+}) should be higher than the negative punishment (F_{p-}) for the reasons already explained. Both teams were encouraged to avoid as much as possible demarking salvage trees, once they have been impressed with the hammer, measured and recorded into the field evaluation form.
(3) An additional penalty per cubic metre was applied whenever a healthy tree was marked as salvage (according to Romanian legislation this is illegal);
(4) Each TFB is marked with a yellow fabric strip and each salvage tree with a red fabric strip.
(5) The total worth of the salvage trees is estimated according to the official rules, and the lump sum of all punishments are deducted from this value.

The same portion of natural forest was surveyed by two teams, each team consisting of three students; the scores of each team were updated each hour. In addition, there was a qualitative indicator of the work done by each team, which recorded how many times each team went "outside the box" of the B/S optimal range, and the amount of money "earned" by each team after six hours of fieldwork.

3.3 Timber Survey Location

The methodological framework was tested in September 2016 over two days, with two crews of three students each in Rarau-Giumalau natural reserve; this reserve harbours two Natura 2000 sites (see Fig. 2). The protected area is covered with old-growth forests of beech and Norway

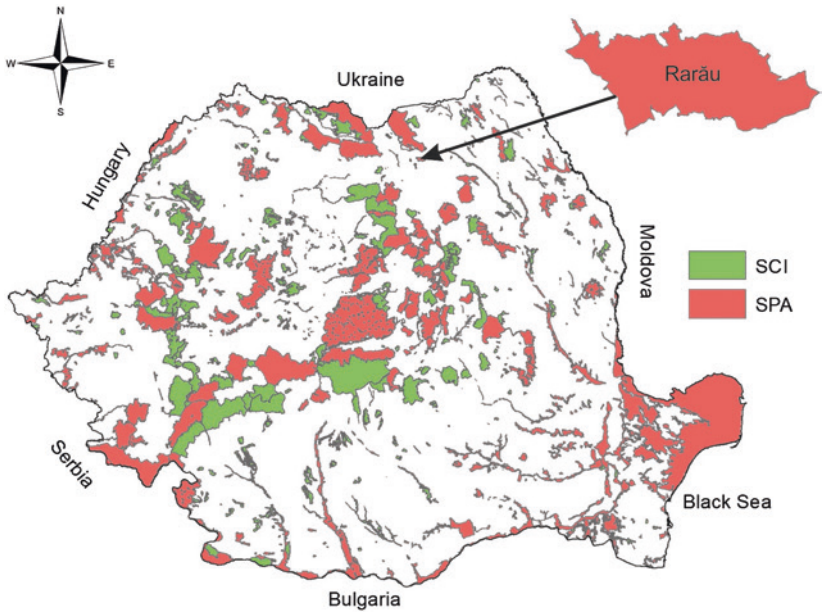

Fig. 2 Location of Rarau-Giumalau natural reserve (*Source* http://natura2000.eea.europa.eu)

spruce, and the natural selection is very intense. Hence, dead trees smaller than 20 cm in diameter were not taken into consideration either for salvage cuttings or deadwood because they do not occur very often in managed forests.

We chose a natural reserve because the density of dead and dying trees is much higher than in a managed forest; thus, it was less time consuming for the fieldwork carried out by the students.

The students were instructed to select trees larger than 30 cm in diameter as standing deadwood, observing the recommendation found in the literature (Dudley and Vallauri 2004). The positive punishment was set to 10 €/m^3, and the negative punishment to 3 €/m^3. The effective location of the six compartments where the timber cruising drill took place is presented in Fig. 3, indicated by the red line.

Both teams were organised in the same way: one student searched for the dead trees, while others measured the selected trees: species,

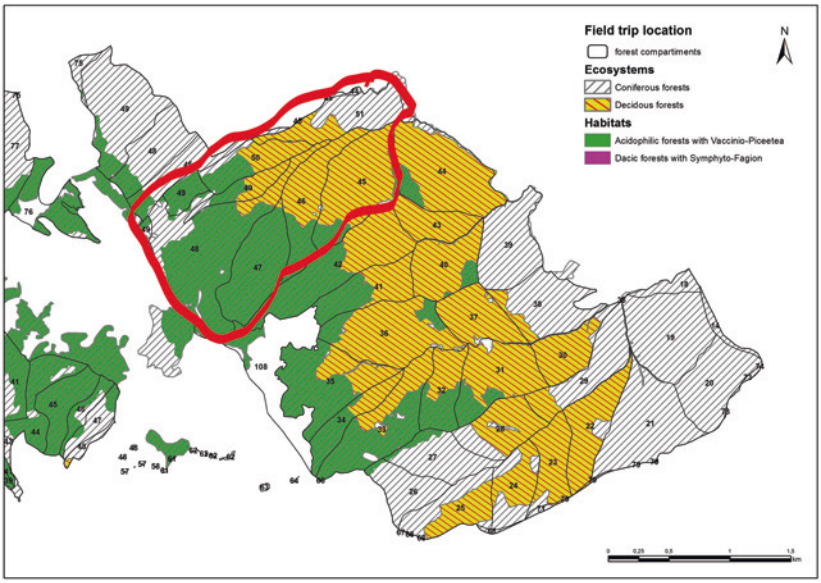

Fig. 3 Precise field-trip location in Rarau-Giumalau natural reserve (*Source* the management plan)

diameter, height and the wood quality (quality grade for salvage products, or decaying level for deadwood).

4 Results

The main outcome, in terms of B/S ratio per hour, is presented in Fig. 4. Because the sanitation tracts were not confined to a certain compartment or sub-compartment, the crews were advised to zigzag (uphill) within all compartments planned to be surveyed in a working day.

The penalties per hour (positive and negative punishments) are summarised in Fig. 5. All in all, the second team was penalised with 23.6€, while the first team, allegedly more efficient, was penalised with 14€. During the first hour, the first team got two negative punishments for swapping two TFB for sanitation cuttings, while the second team started a little bit awkwardly and got a positive punishment for demarking a salvage cutting (being afraid of not having enough TFB).

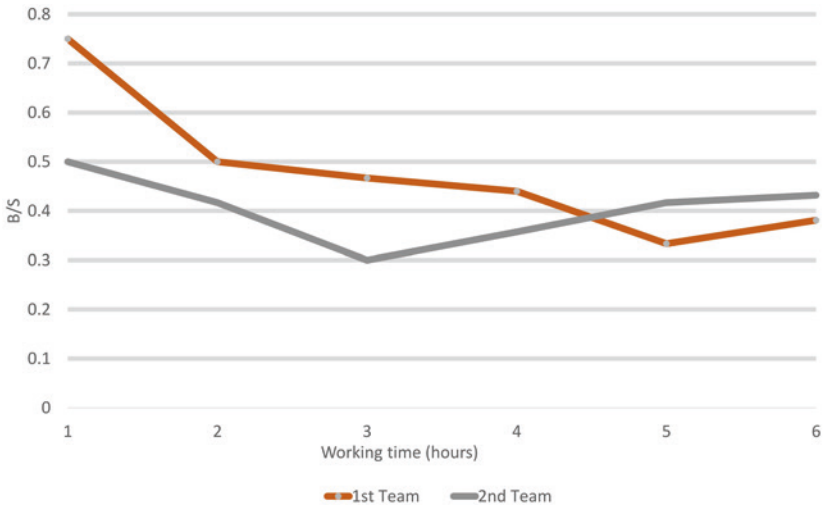

Fig. 4 Learning progress by working hours

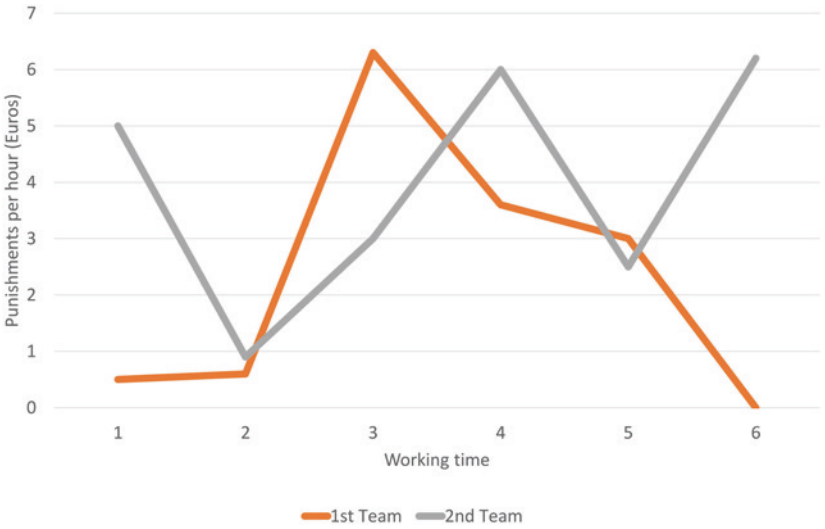

Fig. 5 Penalties recorded by the two teams

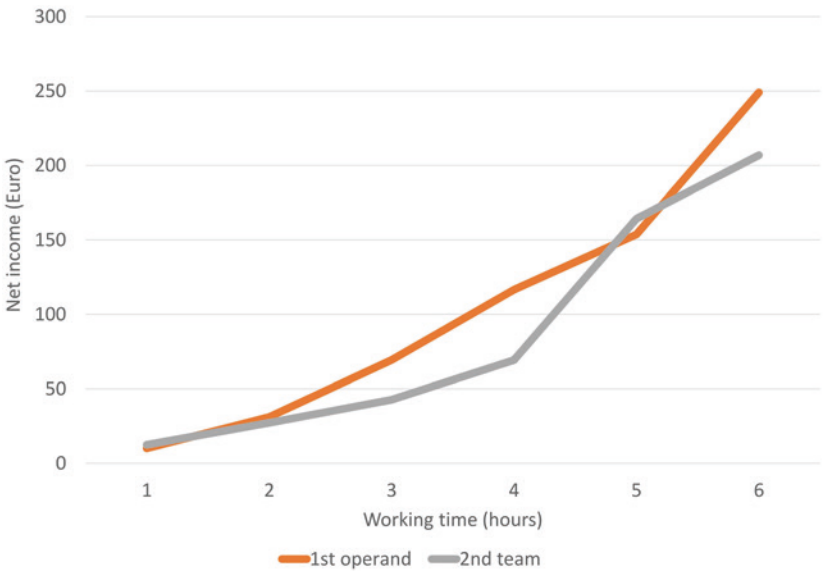

Fig. 6 Net cumulative incomes per hour

The dynamics of the net cumulative revenues gained by the two teams (income from salvage timber minus penalties) are presented in Fig. 6. The average number of trees marked for sanitation cuttings was seven trees per hour, for both teams. Two different strategies for tagging the trees were identified after the first two hours: the first team plunged from a high B/S ratio of 0.75 at the end of the first hour to nearly 0.33 at the end of the fifth hour; the second team worked steadily, keeping the B/S ratio near 0.4, which is close to the lower limit.

5 Summary

The first team tagged many TFB shortly after commencing the fieldwork (see Fig. 4), and more sanitation fellings afterwards; therefore, the "revenue" (the estimated worth of the trees to be harvested) went up faster in the last two hours of the working day, compared with the "revenue" gained by the second team, as shown in Fig. 6.

Did the first team do a better job, marking more trees for harvesting and lesser TFB at the end of the day? It is hard to tell because the quality of the work done depends to a large extent on the harvesting conditions for each tree or bunch of trees marked for salvage or sanitation cuttings. If the sanitation cuttings are dispersed in remote areas (and riparian, in most of the cases), it is better to tag those trees as TFB, because the cost of collateral damage brought about by harvesting operations is higher than the expected revenue of sanitation/salvage cuttings. These damages refer to wounds produced to other remnant trees and topsoil removal because each log needs to be towed for long distances.

So far these issues have never been contemplated by the professional foresters because they have had no other option than sanitation or salvage fellings (as already mentioned, the difference between sanitation and salvage is the amount of harvestable wood per year and hectare). Moreover, pursuing that threshold on one cubic metre per hectare per year is technically difficult when the whole forest is healthy, and trees are older than 60 years. Since the harvestable trees are rare, it is easier and cost-effective to mark salvage cuttings instead of sanitation, having the additional benefits already mentioned (the possibility to harvest less mature and over-mature stands, and less money paid to the regeneration fund).

Tagging TFB at a constant pace (as the second team did) is the best option in any situation, but the opposite strategy, chosen by the first team, could also be optimal if the fieldwork started from the top, not from the valley. Yet if happens that TFB are not evenly spared, it is better to have higher concentration of TFB uphill than downhill simply because the habitats are less disturbed uphill by anthropogenic factors, like illegal harvesting operations or poaching. Even though the second team earned less than the first team (see Fig. 6), its strategy of maintaining a constant trade-off between preserving biodiversity and salvage cuttings is recommended in any situation.

We confined our training scheme to maintaining a certain ratio between the two cumulated numbers of trees (S/B), and not to pursuing a certain amount of deadwood per hectare (as literature recommends) because, in the latter case, TFB refers to all types of deadwood

(including snags laid on the ground), not only to the standing dead trees. However, once the stratum of TFB has been settled, a thorough monitoring of the decaying process shall be pursued afterwards.

6 Discussion

Through this small-scale training project, we tried to develop a training framework for students and professional foresters to encourage them to behave as information processors rather than simply acting. Even though saving a certain number of TFB will not substantially improve the forest health, it is a good premise for managing deadwood. Managing the deadwood involves a fairly complex screening process but getting enough forests managed in this way is the first condition of having a biodiversity monitoring system implemented, as FSC® and Natura 2000 management plans compel. That being said, for the purpose of this training programme, we did not consider the amount of deadwood but rather focused on the spatial distribution and the balance between salvage cuttings and TFB.

We conclude that by applying the new training scheme, foresters will be deterred from marking all big dying trees for salvage or sanitation felling and small trees as TFB, as they will realise that keeping small-size trees as TFB is not a long-term solution. If small trees are tagged as TFB, they eventually will be blown down and must be replaced by identifying other TFB, which requires additional effort next year. On the other hand, an old tree, not yet dead but physiologically very weak, can be confidently tagged as TFB. This type of conduct is encouraged by the new training system, which is unparalleled by any drilling scheme based on the technical standards only.

A similar game can be designed for the first thinnings when a certain set of "trees for the future" must be tagged, while another set of trees are to be harvested; such a drill is extremely important in mixed forests, where different species have different commercial and ecological values. However, it would be quite a challenge to design a drill for selecting the trees to harvest from mixed high forests when the group system is applied, as this would involve considering the ratio between

shade-tolerant and light demanding species, the terrain aspect and the desired composition of the future generation of trees.

The training scheme presented in this chapter is the first attempt at solving the TFB issue. No other alternative exists, except for a simple checklist with criteria for salvage cuttings *and* TFB, used by different people, at different times. However, instead of training the foresters to go through the same area twice, firstly for salvage cuttings and secondly for a thorough selection of TFB, we came up with a training scheme that helps people address the two issues simultaneously.

Applied to forestry, the method presented in this chapter is not only about training, it is about changing the professional culture, in the sense that foresters should account for biodiversity issues on a regular basis. FSC® standards, embraced by the NFA require an integrated approach to pest control, subject to a regular audit, carried out by a different auditing company. Selecting TFB is just the first step towards having implemented the biodiversity management system.

Such a new approach to supporting professional training could make all the difference between the current behaviour of foresters, which is a mixture of rent-seeking practices (Nichiforel and Schanz 2011) and the desired behaviour, based on rapid and cost-effective field assessments. Keeping some standing TFB is just a part of the solution to the very complex problem of forest health under climate change. However, without a clear methodology properly designed for selecting TFB, all discussions around the biodiversity topics were somehow futile as long as professional foresters could not learn new practicalities, starting with a ratio between TFB and trees for salvage fellings. For the time being, this figure shall not be debated too much; rather, it might be regarded as a simple hint towards getting a trade-off between social aspects of forestry (like firewood provision) and biodiversity goals. Linking the two issues in a single training scheme is also important for getting to terms with local communities, who perceive biodiversity as a threat and forest diseases as opportunities for having cheap fuelwood. Instead of making the worst of them, we tried to make the best of the two worlds by designing this training scheme.

Maintaining forest health has many dimensions because each pest or disease outbreak needs to be treated individually, taking into account

the weather conditions, the aspect, the stand density, the magnitude of potential damages and the biotic and abiotic propagation factors. There is no panacea in this respect, and the approach presented in this chapter offers an attempt to address just a small fraction of the whole problem.

Acknowledgements I am grateful to the two anonymous peer reviewers for their support in improving the first version of this chapter. I also acknowledge Mrs. Monica Vasile for her useful comments and feedback on the second draft of this paper, and to Mr. Dan Grigoroaea, ranger with the Muntii Calimani National Park for valuable hints about the ecologically optimal amount of deadwood per hectare in Norway spruce forests. Many thanks to my colleagues from Suceava office of the National Forest Administration for supporting our research with field data concerning sanitation cuttings.

Notes

1. This type of scam is no longer possible now due to the wood tracking system implemented after 2015.
2. Court of Accounts is the central authority in financial matters and public fund and public assets.
3. No evaluation form based on legal measurements, no marks applied to the tree prior to harvesting operations.
4. In FSC terminology, a major condition is a bunch of actions or misconducts that must be corrected within three months if the certificate was issued or within a year if the certification process is ongoing.
5. The two stamp impresses made with a special hummer (one on the stump and one on the trunk) must be taken away and destroyed according to a special procedure, which makes the process expensive.

References

Abrudan, I. V. (2007). Cross-sectoral linkages between forestry and other sectors in Romania. In Y. C. Dubé & F. Schmithüsen (Eds.), *Cross-sectoral policy developments in forestry* (pp. 183–189). Rome, Italy: CABI.

Abrudan, I. V., Marinescu, V., Ionescu, O., Ioras, F., Horodnic, S. A., & Sestras, R. (2009). Developments in the Romanian forestry and its linkages

with other sectors. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 37*, 14–21.

Anderegg, W. R. L., Plavcová, L., Anderegg, L. D. L., Hacke, U. G., Berry, J. A., & Field, C. B. (2013). Drought's legacy: Multiyear hydraulic deterioration underlies widespread aspen forest die-off and portends increased future risk. *Global Change Biology, 19*, 1188–1196.

Anonymous. (2016). Ministry orders published in official. *Journal of Romania*, vol. 539, 551.

Borlea, G. F. (2004). Ecology of elms in Romania. *Forest Systems, 13*, 29–35.

Bouriaud, L., & Marzano, M. (2016). Conservation, extraction and corruption: Is sustainable forest management possible in Romania? In E. Gilberthorpe & G. Hilson (Eds.), *Natural resource extraction and indigenous livelihoods: Development challenges in an era of globalization* (pp. 221–240). London and New York: Routledge, Taylor & Francis.

Brasier, C. M., & Scott, J. K. (1994). European oak declines and global warming: A theoretical assessment with special reference to the activity of *Phytophthora cinnamomi*. *EPPO Bulletin, 24*, 221–232.

Carr, E. G., & Durand, V. M. (1985). Reducing behaviour problems through functional communication training. *Journal of Applied Behaviour Analysis, 18*, 111–126.

Coleman, D., Georgiadou, Y., & Labonte, J. (2009). Volunteered geographic information: The nature and motivation of producers. *International Journal of Spatial Data Infrastructures Research, 4*, 332–358.

Drăgoi, M., Palagianu, C., & Miron-Onciul, M. (2015). Benefit, cost and risk analysis on extending the forest roads network: A case study in Crasna Valley (Romania). *Annals of Forest Research, 58*(2), 333–345. https://doi.org/10.15287/afr.2015.366.

Drapeau, P., Nappi, A., Imbeau, L., & Saint-Germain, M. (2009). Standing deadwood for keystone bird species in the eastern boreal forest: Managing for snag dynamics. *The Forestry Chronicle, 85*(2), 227–234. https://doi.org/10.5558/tfc85227-2.

Dudley, N., & Vallauri, D. (2004). *Deadwood–Living forests.* WWF report, October 2004. Gland, Switzerland: World Wildlife Fund for Nature. http://wwwpanda.org/downloads/forests/deadwoodwithnotes.pdf.

Duduman, M. L., Olenici, N., Olenici, V., & Bouriaud, L. (2014). The impact of natural disturbances on the *Norway spruce* special cultures situated in Nord Eastern Romania, in relation with management type. In E. Scrieberna & M. Stark (Eds.), *Adaptation in forest management under*

changing framework conditions. *Proceedings of IUFRO Symposium*, 19–23 May 2014 (Groups 3.08.00 and 4.05.00) (pp. 44–45). Sopron, Hungary.

Estellés-Arolas, E., & González-Ladrón-De-Guevara, F. (2012). Towards an integrated crowdsourcing definition. *Journal of Information Science, 38*, 189–200.

Flannigan, M. D., Stocks, B. J., & Wotton, B. M. (2000). Climate change and forest fires. *Science of Total Environment, 262*(3), 221–229.

Gavrilut, I., Halalisan, A.-F., Giurca, A., & Sotirov, M. (2015). The interaction between FSC certification and the implementation of the EU timber regulation in Romania. *Forests, 7*, 3.

Hălălişan, A. F., Marinchescu, M., & Abrudan, I. V. (2012). The evolution of forest certification: A short review. *Bulletin of the Transylvania University of Brasov, Series II. Forestry, Wood Industry, Agricultural Food Engineering.*

Humphrey, J. W., Sippola, A. L., Lempérière, G., Dodelin, B., Alexander, K. N., & Butler, J. E. (2005). Deadwood as an indicator of biodiversity in European forests: From theory to operational guidance. *Monitoring and Indicators of Forest Biodiversity in Europe—From Ideas to Operationality, 51*, 193–206.

Jeffery, R. W. (2012). Financial incentives and weight control. *Preventive Medicine, 55*, S61–S67.

Johansson, J., & Lidestav, G. (2011). Can voluntary standards regulate forestry? Assessing the environmental impacts of forest certification in Sweden. *Forest Policy and Economics, 13*(3), 191–198.

Jonášová, M., & Prach, K. (2004). Central-European mountain spruce (*Picea abies* (L.) Karst.) forests: Regeneration of tree species after a bark beetle outbreak. *Ecological Engineering, 23*, 15–27.

Joseph, G. S., Cumming, G. S., Cumming, D. H., Mahlangu, Z., Altwegg, R., & Seymour, C. L. (2011). Large termitaria act as refugia for tall trees, deadwood and cavity-using birds in a miombo woodland. *Landscape Ecology, 26*, 439–448.

Keen, M., Brown, V. A., & Dyball, R. (Eds.). (2005). *Social learning in environmental management: Towards a sustainable future.* New York: Routledge.

Knorn, J., Kuemmerle, T., Radeloff, V. C., Szabo, A., Mindrescu, M., Keeton, W. S., et al. (2012). Forest restitution and protected area effectiveness in post-socialist Romania. *Biological Conservation, 146*, 204–212.

Lassauce, A., Lieutier, F., & Bouget, C. (2012). Woodfuel harvesting and biodiversity conservation in temperate forests: Effects of logging residue characteristics on saproxylic beetle assemblages. *Biological Conservation, 147*, 204–212.

Lawrence, A. (2009). Forestry in transition: Imperial legacy and negotiated expertise in Romania and Poland. *Forest Policy and Economics, 11*, 429–436.

Lučan, R. K., Hanák, V., & Horáček, I. (2009). Long-term re-use of tree roots by European forest bats. *Forest Ecology and Management, 258*(7), 1301–1306.

Miles, D. B., & Ricklefs, R. E. (1984). The correlation between ecology and morphology in deciduous forest passerine birds. *Ecology, 65*, 1629–1640.

Nagel, T. A., Diaci, J., Jerina, K., Kobal, M., & Rozenbergar, D. (2014). Simultaneous influence of canopy decline and deer herbivory on regeneration in a conifer–broadleaf forest. *Canadian Journal of Forest Research, 45*, 266–275.

Nichiforel, L., & Schanz, H. (2011). Property rights distribution and entrepreneurial rent-seeking in Romanian forestry: A perspective of private forest owners. *European Journal of Forest Research, 130*, 369–381.

Olenici, N., Duduman, M.-L., Olenici, V., Bouriaud, O., Tomescu, R., & Rotariu, C. (2011). The first outbreak of *Ips duplicatus* in Romania. In H. Delb & S. Pontuali (Eds.), *Proceedings of the Working Party 7.03.10 Methodology of Forest Insect and Disease Survey in Central Europe* (pp. 135–140), 10th Workshop, Vol. 89, 20–23 September 2010, Freiburg, Germany. Freiburg: FVA.

Panayotov, M., Bebi, P., Tsvetanov, N., Alexandrov, N., Laranjeiro, L., & Kulakowski, D. (2015). The disturbance regime of Norway spruce forests in Bulgaria. *Canadian Journal of Forest Research, 45*, 1143–1153.

Pautasso, M., Aas, G., Queloz, V., & Holdenrieder, O. (2013). European ash (*Fraxinus excelsior*) dieback–A conservation biology challenge. *Biological Conservation, 158*, 37–49.

Radu, S. (2006). The ecological role of deadwood in natural forests. In D. Gafta & J. Akeroyds (Eds.), *Nature conservation, environmental science and engineering (environmental science)* (pp. 137–141). Berlin, Heidelberg: Springer.

Schroth, G., & McNeely, J. A. (2011). Biodiversity conservation, ecosystem services and livelihoods in tropical landscapes: Towards a common agenda. *Environmental Management*, 48(2), 229–236.

Skinner, B. F. (1938). *The behavior of organisms*. New York: Appleton-Century-Croft.

Skinner, B. F. (1969). *Contingencies of reinforcement: A theoretical analysis*. Englewood Cliffs, NJ: Prentice Hall.

Skinner, B. F. (1988). An operant analysis of problem solving. In A. C. Catania & S. Harnad (Eds.), *The selection of behavior the operant behaviorism of B. F. Skinner: Comments and consequences* (pp. 221–222). Cambridge: Cambridge University Press.

Sproull, G. J., Adamus, M., Bukowski, M., Krzyżanowski, T., Szewczyk, J., Statwick, J., et al. (2015). Tree and stand-level patterns and predictors of Norway spruce mortality caused by bark beetle infestation in the tatra mountains. *Forest Ecology and Management, 354*, 261–271.

Stanciu, E. (2017). Secretary of state report at the end of the mandate. Manuscript (Unpublished).

Stanovský, J. (2002). The influence of climatic factors on the health condition of forests in the Silesian Lowland. *Journal of Forest Science, 48*, 451–458.

Thomas, F. M., Blank, R., & Hartmann, G. (2002). Abiotic and biotic factors and their interactions as causes of oak decline in Central Europe. *Forest Pathology, 32*, 277–307.

Thyer, B. A., Dulmus, C. N., & Sowers, K. M. (2012). *Human behaviour in the social environment: Theories for social work practice*. New Jersey: Wiley.

Verkerk, P. J., Lindner, M., Zanchi, G., & Zudin, S. (2011). Assessing impacts of intensified biomass removal on deadwood in European forests. *Ecological Indicators, 11*, 27–35.