Bulletin of the *Transilvania* University of Braşov
Series II: Forestry • Wood Industry • Agricultural Food Engineering • Vol. 10 (59) No.2 - 2017

A COMPARATIVE ANALYSIS OF PROTECTIVE SERVICES PROVIDED BY COPPICE AND HIGH FOREST

Victor-Dan PĂCURAR[1]

Abstract: *The paper presents an analysis of the protective functions of coppice and high forest. Forest protective functions are interrelated because these are all dependent on several structural characteristics, such as leaf area index, biomass and litter amount, root system etc. and values for these parameters were gathered by a review of several European studies reporting data on coppices and high forest stands in different site and management conditions. The continuous cover systems obviously provide superior protective services and traditional coppice is more efficient than the short rotation one. Coppice woods could provide land and water protection services, not as a substitute but in addition to the high forests, especially on the small farm estates in steep terrain regions and on riparian areas.*

Key words: *protective services, coppice, high forest.*

1. Introduction

The protective services provided by forest vegetation are presently gaining an increasing recognition, being worldwide considered at least as important as the wood production function. In Romanian mass media there is frequent news about catastrophic natural events, their severity being correctly related to the inadequate status of the forests in the affected area.

The properly structured forest cover represents an effective shield for vulnerable lands against aggressive torrential rains and violent runoff. In addition to their role in water regulation, forests are effective in soil erosion and landslide control, beneficially influence the local climate conditions and offer important social services.

It is important to point out the difference between the following terms: forest protective (or ecosystem) functions and services. Protective functions are integrated in the biological and physical processes specific to a certain ecosystem. As stated by Daily [4]: "They can be characterized apart from any human context, though they are generally affected by human activities". The difference is also well outlined by Constanza and co-workers [3], in a classic paper published in *Nature*: "Functions become services only to such an extent to what humans

[1] Silviculture Department, *Transilvania* University of Brasov, no.1 Beethoven st., Brasov 500123, Romania.
Correspondence: Victor-Dan Păcurar; email: vdpacurar@unitbv.ro.

acknowledge them within their social systems of the value generation. However, unlike forest products, most forest service values are not paid for".

Coppice is a management system widely used for a long time all over the world [8], especially for providing firewood [2]. In many parts of Europe, in the last century the main trend was the conversion of coppices to high forests [13], [15].

In Romania the coppiced woods extent is estimated at about 7% of the forest area. There are some countries with less coppiced woodlands, such as Austria (2%), but many others with larger proportions of coppice, such as France (47%), Italy (56%), Greece (65%) or the neighbouring countries Serbia (65%), Bulgaria (47%) and Hungary (29%) [19].

In this context and also considering the major changes in the Romanian forests ownership it is possible to anticipate a future debate about the opportunity of increasing the coppice area. Consequently an objective comparative analysis of protective services provided by coppice and high forest could be of real interest.

2. Material and Methods

Forest protective functions are interrelated because these are all dependent on several structural characteristics. Consequently the ecosystem functions efficiency for various stands could be inferred from data regarding leaf area index, biomass and litter amount, root system etc.

Among the factors affecting the protective efficiency one could mention: canopy closure and leaf area (affecting interception etc.), ground status and litter amount (influencing infiltration and runoff), root system structure (important for the water budget and landslide stability, by anchoring and physiological "drainage") etc. These stand characteristics depend on species, age, site conditions etc. and last but not least by the management system: high forest or coppice. In addition to the effects of the structure peculiarities the protective functions are considerably affected by the disturbances related to the specific management operations.

A special attention was given recently to carbon storage that could be regarded as a component of the climate services. The data referring to biomass and carbon amounts in leaves, litter or roots could be very useful in estimating the other protective effects.

In order to gather the necessary information for comparing the efficiency of the protective functions provided by forests managed in the high forest system and coppice it was undertaken a review of several European researches reporting data on coppices and high forest stands in different site and management conditions.

There were also made observations in Romanian black locust stands located in vulnerable land conditions after coppice cuttings.

3. Results and Discussions

The continuous cover systems obviously provide superior protective services. But traditional coppice is more efficient than short rotation coppice, which is generally better than most agricultural crops.

As regards coppices, the harvesting process could be less "invasive" (the transport of small wood pieces requiring light machinery or only horse power) but the more frequent interventions and the subsequent reductions of protective efficiency only allow a comparison with the clear-cuttings system. The negative effects of coppicing on soil properties (less degradation control and reduced fertility) are considered to affect not only the environmental services but even timber production [9], [16], [17].

Carbon storage is an extremely important service provided by vegetation and the data gathered in this type of studies could be useful in estimating other protective functions. A stand with more biomass, or stored carbon, in the leaves could intercept and retain more rainfall, one with larger amounts of litter and roots will be able to better protect the soil etc.

As regards the average carbon storage in forests, short rotation coppice and agricultural crops [1], the total amount was estimated to be much higher in high forests (144.5 t/ha), than in coppices (69.5 t/ha) respectively agricultural crops (32 t/ha). The amounts of roots and litter are about two respectively three times greater in the forests as compared to coppices, but the leaves mass is similar.

Studies undertaken in Germany [10], in three 20-year-old coppice woods (mainly *Betula pendula*, *Quercus petraea* and *Corylus avellana*) compared to two nearby 140-year-old high forests of beech (*Fagus sylvatica*) indicate the clear superiority of old forests. The mean aboveground biomass of the two high forests (31.2 kg dry mass per square meter) was four times larger than that of the coppice woods (7.3 kg/m^{-2}) and stored 2 to 3 times larger amounts of Ca, K, Mg and N. The soil organic layers of the high forests were thicker and contained 6 times more organic matter than those of the coppice woods and stored 3 to 7 times more nutrients.

In older coppice woods, the biomass increases, as shown by Russian studies [20] carried in a 40-year-old coppice (composed of *Quercus conferta* and *Q. cerris*) where phytomass was reported to be 166 t/ha and 113.3 t/ha above respectively below ground level. The litter amount was about 19 t/ha and its decomposition period was estimated at 2 to 3 years.

The age influence on the aboveground biomass is also outlined by Italian studies in coppice woods (*Castanea sativa*) in the Mount Etna region [11], reporting values of 22 and 24 t/ha in seven years old stands, respectively 83 and 100 t/ha in coppices aging 12 and 22 years. Similar results occurred from other researches on sweet chestnut coppices in Southern Europe [18], two young stands (in Catania, Italy) had much lower leaf biomass values: (1600 and 1500 kg/ha) than the two older stands (3900 and 4100 kg/ha), located in Salamanca, Spain, and Montpellier, France.

A comparative study [12] between Bialowieza Forest, Poland, and three English woods (two coppiced and a high forest, largely neglected for 100 years and promoted from coppice) indicate that in the English high forest dead wood was only about a third of that in the undisturbed Polish forest.

The above information indicates that the older crops, typical of traditional coppice are more efficient than the short rotation young crops. But even the intensive hybrid poplar or willow crops, with dense foliage and roots, are protecting the soil [5] and could provide special services like phytoremediation [6], [7].

The species composition of the coppice highly influences the biomass amount. For short rotation coppices installed on reclaimed sites in Lusatia, Germany [14] the net production, in carbon tons per hectare, was much greater for black locust (64.5) than for poplar (8.9).

The protective services provided by high forests are obviously superior and consequently this management system is recommendable. But in Romania there are presently small farms, with patches of degraded pasture or neglected arable land, which are exposed to water and wind erosion, to landslides or other degradation processes. Here coppices of black locust could be effective in protecting the soil and the small dimensions wood products obtained after relatively short periods of time could be attractive for the farmers.

Black locust (*Robinia pseudoacacia*) is a species widely used in Romania for the afforestation of degraded lands. Certainly, it is not a native species and it should not be used to replace local species in existing woods, but on degraded bare land it is sometimes the best solution. The black locust recovers quickly the land after the coppice cutting, when no additional disturbances occur (such as sheep passage or vehicles circulation). A good example could be observed in the photographs (Fig. 1) showing a steep hillslope, where no signs of water erosion occurred after the coppice cutting.

a

b

Fig.1. *A black locust coppice on a steep hillslope, near Dumbraveni, Sibiu County, after the cutting (a) and two years latter (b). Foto: Pacurar V.D.*

Black locust has an outstanding capacity of issuing vigorous shoots from stumps and roots, and consequently the soil cover will be rapidly recovered. It is very important to pay maximum attention to the cutting and logging operations in order to avoid as much as possible soil disturbances. A better soil protection against intense runoff in the period after the cutting could be obtained by positioning the wood debris stripes not along the slope line (see Figure 1 a) but parallel to the contour lines. Black locust coppices could be a solution for restoring and protecting degraded pastures on small privately owned areas.

4. Conclusions

High forests are much more efficient than coppices in providing environmental services. The total biomass, indicating the carbon storage capacity, the leaves and above ground phytomass linked to the water retention potential, the litter and roots amounts (direct soil protection) are considerably higher in high forests. Also, the values of the above listed parameters are greater in old coppice stands as compared with the younger ones. The short rotation coppice has lower protective potential than other wood crops, but it is better than many agricultural crops.

Black locust coppices could be used on small areas on lands vulnerable to water and wind erosion. Coppice woods could provide land and water protection services, not as a substitute but in addition to the high forests (managed for their protective services as a priority, being included in the first functional group, according to the Romanian zoning system), especially on the small farm estates in steep terrain regions and on riparian areas.

References

1. Bowman, U., Turnbull J., 1997. Integrated biomass energy systems and emission of carbon dioxide. In: Biomass and Bioenergy, vol. 13(3), pp. 333-343.
2. Buckley, G.P., 1992. Ecology and management of coppice woodlands. London, Chapman and Hall, 339 p.
3. Constanza, R., Darge, R., Groot, R. et al., 1997. The value of the world's ecosystem services and natural capital. In: Nature – International Journal of Science, vol. 387, pp. 253-260.
4. Daily, G.C., 1997. Nature's Service: Societal Dependence on Natural Ecosystems. Island Press, Washington, 392 p.
5. Dickmann, D.I., Nguyen, P.V., Pregitzer, K.S., 1996. Effects of irrigation and coppicing on above-ground growth, physiology and fine-root dynamics of two fieldgrown hybrid poplar clones. In: Forest Ecology and Management, vol. 80(1-3), pp. 163-174.
6. Dickinson, N., Baker, A., Doronila, A. et al., 2009. Phytoremediation of inorganics: realism and synergies. In: International Journal of Phytoremediation, vol. 11(2), pp. 97-114.
7. Dickinson, N.M., Pulford, I.D., 2005. Cadmium phytoextraction using short-rotation coppice Salix: the evidence trail. In: Environment International, vol. 31(4), pp.609-613.
8. Fujimori, T., 2001. Ecological and Silvicultural Strategies for Sustainable Forest Management. Elsevier, Amsterdam, 398 p.
9. Hansen, E.A., Baker, J.B., 1979. Biomass and nutrient removal in short rotation intensively cultured plantations. In: Leaf A.L. (ed.): Impact of

Intensive Harvesting on Forest Nutrient Cycling. Symposium State University of New York at Syracuse. Syracuse, Aug 13–16, pp. 130-151.
10. Hölscher, D., Schade, E., Leuschner, C., 2001. Effects of coppicing in temperate deciduous forests on ecosystem nutrient pools and soil fertility. In: Basic and Applied Ecology, vol. 2(2), pp. 155-164.
11. Leonardi, S., Rapp, M., Failla, M. et al., 1996. Biomasse, productivité et transferts de matière organique dans une séquence altitudinale de peuplements de Castanea sativa Mill. de l'Etna. In: Annales des Sciences Forestières, vol. 53(5), pp. 1031-1048.
12. Kirby, K.J., Webster, S.D., Antczak, A., 1991. Effects of forest management on stand structure and the quantity of fallen dead wood: some British and Polish examples. In: Forest Ecology and Management, vol. 43(1-2), pp. 167-174.
13. Matthews, J.D., 1991. Silvicultural Systems. Oxford University Press, Oxford, 284 p.
14. Quinkenstein, A., Jochheim, H., 2016. Assessing the carbon sequestration potential of poplar and black locust short rotation coppices on mine reclamation sites in Eastern Germany - model development and application. In: Journal of Environmental Management, vol. 168, pp. 53-66.
15. Peterken, G.F., 1993. Woodland Conservation and Management. London, Chapman and Hall, 314 p.
16. Ranger, J., Bonneau, M.,1986. Effets previsibles de l´intensification de la production et des recoltes sur la fertilite des sols de forêt. Effets de la sylviculture. In: Revue Forestière Française, vol. 38, pp. 105-123.
17. Ranger, J., Nys, C., 1996. Biomass and nutrient content of extensively and intensively managed coppice stands. Forestry, vol. 69(2), pp. 91-110.
18. Santa Regina, I., Leonardi, S., Rapp, M., 2001. Foliar nutrient dynamics and nutrient-use efficiency in Castanea sativa coppice stands of southern Europe. In: Forestry, vol. 74(1), pp. 1-10.
19. Stajic, B., Zlatanov, T., Velichkov, I. et al, 2009. Past and recent coppice forest management in some regions of South Eastern Europe. In: Silva Balcanica, vol. 10(1), pp. 9-19.
20. Trashliev, Kh., Ninov, N., 1975. Amount and composition of biomass in an oak forest on cinnamon-podzolic soil. In: Pochvoznanie i Agrokhimiya, vol. 10(6), pp. 7-11.