

Costs of basic methods of forest land maintenance in protective zones of high-voltage power lines in the Czech Republic

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ABSTRACT: The paper describes the basic potential methods and their costs of maintenance of forest lands in protective zones under high-voltage power lines (HVPL) 400 kV and 220 kV. In the present situation and with available information and data, it was possible to accomplish the average cost calculations for the whole area of the Czech Republic. The paper analyses the following mechanical and chemical methods of maintenance of forest lands: full-area scrub clearing with power saw (PS), selective individual scattered clearing of trees with PS, full-area scrub clearing by milling, full-area scrub clearing by the application of herbicides and arboricides, selective individual scrub clearing of individual trees by cutting followed by spray treatment with arboricides. The maintenance of forest lands in zones of HVPL (scrub clearing) by milling belongs to the economically most convenient mechanical methods, for example when removing 3,000 trees.ha⁻¹, the cost of this option is 20,000–23,000 CZK.ha⁻¹ ha in a period of 3-year periodic frequency, while the most expensive method is selective individual scrub clearing of scattered individual plants with PS at costs of around 84,000 CZK.ha⁻¹.

Keywords: Czech Republic; forest lands; high-voltage power lines; maintenance costs

The forest land use in protective zones of high-voltage power lines (HVPL) 400 kV in the protective zone 70–80 m in width, and 220 kV in the protective zone 50–60 m in width is very limited or even impossible from the aspect of production. According to Energy Act No. 458/2000 in zones of HVPL any kind of vegetation that exceeds the height of 3 m must be cleared. These forest lands in zones of HVPL also require quite intensive and demanding maintenance. There are many methods and procedures of maintenance that can be used depending on particular stand, natural, possessory and legislative conditions (ŠIŠÁK et al. 2008).

In the present situation and with available information and data it was possible to accomplish only the average cost calculations for the whole area of

the Czech Republic for 2,797 ha of forest lands in zones under HVPL – data delivered by the Czech Electricity Transmission Company (ŠIŠÁK et al. 2007). It was not possible to provide any detailed local differentiation according to the site, field and stand conditions (tree species) because of the lack of information. That is the reason why local calculations can be very much different in the individual habitats. Though this fact might seem dissatisfying, it did not disturb the purpose of general decision to choose the particular option of maintenance where the average valuation is quite competent.

Nowadays, there is neither investigative work nor study on the number of trees and tree species that would naturally regenerate in zones of HVPL or in open areas outside the forest the results of which

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could be generalized. This also concerns height increments. According to qualified professional estimations, complemented by field investigations limited in time and area, especially light-demanding softwood broadleaved and coniferous tree species are regenerated in the zones of HVPL.

When we look at the number of trees and shrubs per unit area, we will see that their number in open areas increases compared to their numbers in forest stands because of the great influence of light. On the other hand, their amount is reduced by weeds, by drying up in many localities and by being damaged by animals that also limit height increments of individual trees and shrubs. There is also a competition among the tree species themselves which must not be omitted either.

Considering the above-mentioned facts, we can expertly estimate around 3,000 trees.ha⁻¹ as the average number of trees and shrubs but there might be a large difference, from several hundreds to twice as much as the average amount, depending on local conditions. Nevertheless, the number of individual stems per unit area does not really influence the cost relations calculated for various methods of forest land maintenance.

The aim of research and methodology

The aim of presented research was to find out the costs of basic methods of forest land maintenance in protective zones of high-voltage power lines (HVPL) 400 kV in the protective zone of 70–80 m in width, and 220 kV in the protective zone of 50–60 m in width as the average for the whole Czech Republic, i.e. for the area of 2,797 ha of forest lands. The goal of this survey is to use the results for making a decision which method of forest land maintenance in the zones under high-voltage power lines is economically effective and acceptable.

Calculations of costs to maintain the areas under HVPL are performed within prime costs, and are compared with available data on corresponding negotiated (market) prices. Calculations of prime costs are based on the average quality of advance growth in zones of HVPL and from current standards and norms of labour-consumption in the respective forest operations (NOUZOVÁ, NOUZA 2001). Standards and norms dealing with juvenile thinning of young forest stands were used that differentiate labour-consumption in accordance with the number of cleared individual trees (stems) per unit area, their height class and tree species divided into coniferous, broadleaved and mixed forest (ŠIŘÁK et al. 2007). Prime costs are calculated on the basis of labour-consump-

tion and direct costs resulting from it, overhead costs and profit rate valid in forest management in 2007. Unit costs (labour, material, machinery, etc.) and percentage of overhead costs (35%) and profit rate (10%) were based on the respective average costs and profit of a set of medium-sized forest companies in the Czech Republic in 2007.

For the calculations of costs of the particular methods chosen to maintain forest lands in HVPL zones, we can consider the tree species composition as important because height increments vary in accordance with the species and site conditions. The height increment of broadleaves can be up to 2 m a year but it is very exceptional. It holds for some types of tree species and for some types of sites, especially in the case of sprouts. Height increments are usually much lower. Height increments of coniferous trees can be up to 0.7 m a year and this is especially in the case of Scots pine (*Pinus sylvestris* L.). Height increments of other conifers typical of the area of the Czech Republic are lower. A conclusion can be drawn from these facts about particular increments that it is necessary to return to these areas every 3–4 years in the case of surface scrub clearing if we need to keep the areas under HVPL cleared from vegetation higher than 3 m. The following calculations consider 3 years of so called periodic frequency of scrub clearing. The paper analyzes the following basic mechanical and chemical methods of maintenance of the areas:

- (1) full-area scrub clearing with power saw (PS) – classic technology,
- (2) selective individual and scattered scrub clearing of trees and shrubs with PS – classic technology,
- (3) full-area scrub clearing by milling,
- (4) full-area scrub clearing by the application of herbicides and arboricides,
- (5) selective individual scrub clearing by cutting, followed by spray treatment with arboricides.

RESULTS

Full-area scrub clearing with power saw (PS)

Full-area scrub clearing with PS consists in cutting of trees, cross-cutting in one or two pieces to open up the area and in the handling of other wood – piling and burning. Hand cutting (using mechanical devices) is not used because of high manpower requirements and also because of its low productivity and high cost. This option could be considered only if the stand height was lower than 2 m with stem diameter of 4 cm maximally.

Calculations are made for broadleaved stands which dominate or represent a major part when growing in mixture according to experience with the zones under HVPL. Thus the basic and derived consumption of work-time is slightly higher. Cost tariffs per unit of work-time were derived from the data filed for logging operations with excess charge of 20% which corresponds to the character of this work.

The basic norm was used as combined for cutting trees with stem diameter of 7 cm at breast height (1.30 m above the ground) including their removal from the stand. The dragging operation makes up 45–50% of the aggregate amount of cost tariff per unit. When the stands are not the same in their growth form and height and if we cannot reliably find out the average height, we count the time consumption according to two trees of 2-cm stem diameter taken as one while their height interval is 2.6–5.0 m. If the height interval is more than 5.1 m, we take three trees.

Total time consumption includes work-time of batched and shift work and time for generally required breaks while working effectively, observing security and hygienic regulations. No adjustment of work-time was done that would concern special working conditions different from the standard ones like weather, nature influence or geomorphology of the terrain.

Considering the fact that there is neither such study nor field survey that would deal with the character, type, quantitative and qualitative description of the scrub in the zones of HVPL, we are able to work only with qualified estimation, supported by some field surveys. Examples of the results of cost calculations for full-area scrub clearing of about 100–4,000 cleared trees are shown in the basic table (Table 1), though the average number of usually cleared trees is estimated around 3,000 trees.ha⁻¹. We suppose that the area is cleared all at once. When calculating the prime costs, we come out from direct costs, modified by the average of 35% of overhead costs and 10% of profit rate.

The costs can be reduced substantially if scrub clearing is not done at a height of 3 m and higher but in a lower height class, even the periodic frequency of scrub clearing would have to be shorter. For example if the periodic frequency of scrub clearing with scrub of max. 2.5 m height were not 3 years but 2 years, the average cost per year would be 12,962 CZK.ha⁻¹. However, if this periodic frequency is 3 years and scrub belongs to a higher height class, the average annual cost is 13,716 CZK.ha⁻¹ (41,148 CZK.ha⁻¹ in a 3-year period – Table 1) although many areas with

scrub 2.5 m high might also need the 3-year periodic frequency. When we look at these calculations, we come out with results that when we work with scrub of a lower height class which is less than 3 m, this method in the zones of HVPL is much more cost-effective though the most cost-effective method is first of all to clear scrub which is about 1–2 m high but this must be done with different technology than PS completed with dragging out and burning the cut material.

Selective individual and scattered scrub clearing with PS

Individual selection and scrub clearing using PS consists in the selective disposal of individual plants (overtopping trees) from scrub which reach the height of 3 m, followed by cross-cutting into 2 to 3 sections, dragging them out to about a distance of 35 m, piling and burning. Considering the above-mentioned average height increments, it is assumed that while clearing the overtopping trees, the rest of the individuals will grow up in three years, that means 1/3 of the individuals will be cleared every year.

When calculating the direct and prime costs of individual selective choice and disposal of overtopping trees, it is possible to count on the basis of standards and norms for full-area scrub clearing including skidding of a mass though considering only one third of the amount for the particular unit of area. On the other hand, the periodic frequency for the particular area will not be once in three years but once a year. In that case the amount of 1/3 of scrub will be removed by individual scrub clearing every year in the presumed three-year time in the same area as if cleared by full-area scrub clearing within the periodic frequency of 3 years.

It means that in the case of the amount of 3,000 trees per ha the cost of the full-area scrub clearing of 2.6–5.0 m (Table 1 height, 3-year periodic frequency) would be 41,148 CZK.ha⁻¹ in prime costs. However clearing only 1/3 of the amount, which is 1,000 trees per ha, the cost would be 24,474 CZK.ha⁻¹ in prime costs. We need to point out that this particular operation must be repeated every year, it means 3 times, so the total cost when clearing 1/3 every year would be 73,422 CZK.ha⁻¹ in the periodic frequency of 3 years, which is the cost higher by 78% than when full-area scrub clearing is used! This example shows that selective individual and scattered scrub clearing is economically very inconvenient. The reason is that with the linear growth of removed individual plants per unit area there is a nonlinear growth of norms

Table 1. Prime costs of full-area scrub clearing with power saw (cutting, dragging out, piling and burning) – height of 2.6–5.0 m

Trees.ha ⁻¹	Direct costs (CZK.ha ⁻¹)	Overhead costs 35%	Profit rate 10%	Prime costs (CZK.ha ⁻¹)
< 100	2,070	564	218	3,072
110–150	3,284	925	357	4,877
160–200	4,258	1,233	476	6,322
210–250	4,899	1,394	538	7,275
260–300	5,963	1,702	656	8,855
310–350	6,655	1,912	737	9,883
360–400	7,578	2,171	837	11,253
410–450	8,502	2,430	937	12,624
460–500	9,566	2,738	1,056	14,205
510–600	10,949	3,157	1,218	16,259
610–700	12,473	3,626	1,398	18,522
710–800	13,714	3,995	1,541	20,367
810–900	14,957	4,365	1,684	22,211
910–1,000	16,481	4,834	1,864	24,474
1,010–1,200	18,168	5,326	2,054	26,980
1,210–1,400	20,046	5,918	2,283	29,770
1,410–1,600	21,593	6,361	2,453	32,066
1,610–1,800	22,958	6,804	2,624	34,092
1,810–2,000	24,131	7,148	2,757	35,834
2,010–2,250	25,109	7,455	2,876	37,287
2,260–2,500	26,086	7,762	2,994	38,739
2,510–2,750	27,014	8,020	3,093	40,116
2,760–3,000	27,709	8,228	3,174	41,148
3,010–3,250	28,829	8,585	3,311	42,809
3,260–3,500	29,756	8,842	3,411	44,186
3,510–3,750	30,733	9,149	3,529	45,639
3,760–4,000	31,520	9,357	3,609	46,807

and tariffs, and that is degressive which proves the economic pattern, one unit of product is cheaper in higher amount than one unit taken in low number when considering variable and fixed costs.

What we need to take into account is the fact that the clearing of 1/3 of plants is not done in the whole area, that not all scrub is removed in the area of 1/3 of unit area, i.e. in 1/3 ha, but the whole unit area is cleared individually, by individual scattered selection in the area of 1 ha. However, this type of operation when only individual scrub of 1 tree, 10 trees etc. is cleared is more labour-intensive than the full-area scrub clearing which destroys all scrub. When using the selective individual scrub

clearing, longer distances between removed trees are covered, individuals left to keep growing must be avoided, cut scrub among growing individuals is more difficult to bring down, it is worse to manipulate with, work is more risky. All this is reflected in an increase in the existing normative tariff by 10–20% per unit amount of cleared scrub against the full-area scrub clearing. So the total cost of the selective individual scrub clearing of 1/3 of scrub every year when increasing the tariff by about 15%, reaches 84,435 CZK.ha⁻¹ in a period of 3 years in prime costs, and that is twice as high as the full-area scrub clearing of 41,148 CZK per ha, done once in a three-year period.

Full-area scrub clearing by milling

This method is based on full-area scrub clearing by milling and wood chipping at the same time. Concerning the wood chipping it is possible to:

- disperse wood chips in the whole area, which is ecologically beneficial for the habitat and quality of the surface layers of soil,
- gather wood chips in order to sell them and utilize them in the production of bio-energy, which is productive and ecologically beneficial (connected with profitable methods of maintenance),
- incorporate biomass into soil to a depth of 5 to 15 cm, which brings ecological benefits again and improves the soil quality.

When wood chips are either dispersed across the whole area or gathered, negotiated (market) prices reach generally 20,000–23,000 CZK.ha⁻¹ according to available information. The area is free from natural seeding of seral tree species which are 2–3 cm high above the ground. The economic effectiveness of this type of scrub clearing is high in most cases. For example at the amount of 3,000 trees.ha⁻¹ the total cost is half compared to full-area scrub clearing with PS including the burning of the material.

When scrub clearing is done by milling, including the incorporation of biomass into soil, market prices are by 3,000–5,000 CZK.ha⁻¹ higher. However, the decomposition of wood chips including the enrichment of soil with humus is faster and more effective but questionable from some nature conservation points of view.

The method is very effective in untouched stands like in stands with slash up to 1.5 m height. There is no need to cut and remove trees selectively neither within the whole area. Neither stools nor stony debris are an obstacle. It is somewhat difficult to use mechanization because of the terrain and soil properties (steep slopes, wet lands). However, the area of possible full-area scrub clearing by this method can be found out only on the basis of a deeper survey within the Czech Republic.

Full-area scrub clearing by the application of herbicides and arboricides

There is a possibility to use a spray treatment with herbicides and arboricides in the whole area once or twice in the vegetation period. Chemical formulations are applied within a surface with special devices (sprinklers). Sprinkling must be applied to stands of max. 1 m to 1.5 m height (optimal up to 50 cm) in the vegetation period but the best time is late spring. Security and hygienic regulations must be strictly

observed so that the rest of the stands and young plantation around would not be affected.

There was a possibility of the application of Velpar SG 50 in the past, which had not only retarding but also redeveloping effects for the period of 2–3 years. However, this type of chemical product is not allowed to be used any more, ordinary formulations are used which are always available such as Roundup classic, bio, etc. The full-area clearing of forest weeds and self-sown tree species is calculated in global negotiated prices of 9,000–16,000 CZK.ha⁻¹, depending on the chemical formulation used. It is expected to use sprinklers carried by a steering frame skidder.

The prices of this particular operation are much lower than those of mechanical scrub clearing. Costs of chemical scrub clearing are 50% lower compared to mechanical scrub clearing. All the results depend on the particular stand and soil conditions, option to leave the cleared individual scrub in the area or to gather it, neither of these facts influences the above-mentioned price differences. The only strong competition is basically in mechanical scrub clearing by milling although the chemical scrub clearing lasts longer than for a 3–4 year period.

On the other hand, the option to use a chemical method is also influenced by the site and other factors including the ecological ones and also the categorization of forests (protection forests and special-purpose forests are usually excluded). Particular costs and prices concerning the number of individual trees and scrub height need a more detailed study to analyze them.

Selective individual scrub clearing by cutting, followed by spray treatment with arboricides

It is possible to clear individual trees and shrubs that reached the height of 3 m by cutting, followed by the spray treatment with arboricides. The destroyed scrub is left in the area to undergo natural disintegration. When talking about the methods to be used and about costs, the same principles as mentioned above with full-area scrub clearing are applicable. The particular prices concerning the number of individual trees and shrubs are higher than in full-area scrub clearing because it is based on the individual selection and the difference is 10–20%. Particular costs and prices concerning the amount of scrub and its height need a more detail study to analyze them.

DISCUSSION AND CONCLUSIONS

There is a lack of information about the character of the areas of forest lands under HVPL in the Czech

Republic, about the differentiation of natural, site and stand conditions as well as about other factors (ecological, nature conservation). Only a very extensive analysis of information database and physical state of these areas could fill in this gap, at least in the above-mentioned situations. That is why a part of initial information for the analysis of costs in accordance with basic potential methods of forest land maintenance was based on expert estimations utilizing the knowledge of the average conditions of HVPL forest land areas within the Czech Republic and also the knowledge of forest management within the Czech Republic. Concerning the available initial data it is necessary to understand the results as general, expressed expertly, valid for broader average conditions in the Czech Republic. Nevertheless, this initial information is reliable to be used to recognize economic advantages or disadvantages of the particular basic methods of maintenance of forest areas under HVPL.

Results of this analytical study document that full-area scrub clearing is economically much more effective compared to the method of individual scattered clearing of the scrub which exceeds the height of 3 m including the disposal of material. For example when taking into account the number of 3,000 trees.ha⁻¹ in a broadleaved scrub, the method of individual scattered clearing once a year, removing 1/3 of the individuals each year of a 3-year period, is twice more expensive (84,435 CZK.ha⁻¹ of prime costs) compared to the method of full-area scrub clearing with the 3-year periodic frequency (41,178 CZK.ha⁻¹ of prime costs).

The maintenance of the protective zones under HVPL (scrub clearing) by milling belongs to the economically most effective methods when considering mechanical ways of maintenance. It is the full-area scrub clearing with carried milling cutters while wood chipping and dispersing the wood chips across the area. At the number of 3,000 trees.ha⁻¹ the cost of this method is 20,000–23,000 CZK.ha⁻¹ with the 3-year periodic frequency of scrub clearing. It is basically the cost lower by more than 50% than that of full-area scrub clearing by classical technology of PS. This method is considered to be ecologically beneficial for the habitat and quality of surface layers of soil.

Theoretically, it is also possible to use the chemical method of scrub clearing which could be suitable for some sites and which would be of the highest economic effectiveness, even more effective than

milling. However, it requires quite good natural stand conditions and other factors including fulfilling different roles of the forest, ecological factors and interests in nature conservation.

There is a possibility to use other methods of the maintenance of forest lands under HVPL in such a way that forest owners would be included in the process and motivated (Šišák 2008). The spectrum of such possibilities is quite wide while some of them, especially profitable ones (like e.g. production and sale of Christmas trees, ornamental plants, forest fruits, fodder for cattle, etc.) which should be related to the respective land owners and other interested entities, would basically mean costless or even profitable methods of the maintenance of zones under HVPL in the majority of the particular areas within the Czech Republic. Nevertheless, it should require more detailed and extensive research in this matter in the Czech Republic.

References

- NOUZOVÁ J., NOUZA J. (2001): Labor consumption norms in forestry. *Silvaco*, a.s.: 136 (in Czech).
- ŠIŠÁK, L. (2008): Forest Functions Development and Forestry Innovations Problems in the Czech Republic. Proceedings International Symposium on Emerging Needs of Society from Forest Ecosystems: Towards the Opportunities and Dilemmas in Forest Managerial Economics and Accounting. Ljubljana, University of Ljubljana: 125-133.
- ŠIŠÁK L., SLOUP R., KALINA Š., KREČMER V., BUKÁČEK J. (2007): Technology-economic evaluation of protection zones under electricity lines maintenance on forest lands. [Research report.] Prague, Faculty of Forestry and Wood Sciences, Czech University of Life Sciences in Prague: 24 (in Czech).
- ŠIŠÁK L., ŠACH F., KUPČÁK V., ŠVIHLA V., PULKRAB K., ČERNOHOUS V., ZEMAN M. (2008): System of valuation of socio-economic importance of forest functions including criteria and indicators of multifunctional forest management. [Research Report.] Prague, Faculty of Forestry and Wood Sciences, Czech University of Life Sciences in Prague: 94.
- Code No. 458/2000 Coll. on conditions of entrepreneurship in energy sectors and on state administration executive in energy sectors and on changes of some codes (Energy Code).

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