Surface Use of Harvester Technology in the Forest Management in the Czech Republic

Jiří Dvořák*, Pavel Natov
Department of Forest Harvesting, Faculty of Forestry and Wood Sciences, Czech University of Live Sciences Prague
Kamýcká 129, 165 21 Prague, Czech Republic
DvorakJ@fld.czu.cz

Abstract:
Since the beginning of the 90s, there has been an expansive development in the cut-to-length method. There was also a rise in the number of harvesters in the forest management of the CR. At present, approximately 25 – 30 % of harvester technologies are deployed in forest harvesting (c. 330 harvesters and 557 forwarders). When using harvester technologies within the forest management of the CR, it is necessary to respect certain restrictions and proceed form the following preconditions. Technology will be applied in economical forests and in special purpose forests. It is not expected to use the technology in the first zones of Protected Landscape Areas and in National Parks. The areas with obstacles above 50 cm high are not suited for the technology and therefore the deployment of harvesters in those localities is not expected. Areas affected by water (waterlogged and so on), with generally lower bearing capacity of the terrain, are very sensitive to even single cross of heavy machinery and therefore the use of harvesters is not expected there either. To provide minimal affectivity of the technology, felling operations will be focused on stands with the diameter of medium stem from 0.05 m^3. The technology is optimised for coniferous stands with spruce and pine predominating. Out of deciduous tree species, only stands with beech and birch to the age of 50 are considered. Other tree species are from a technological point of view problematic for processing or they are not dominant in the forest management. From the point of view of terrain possibility and bearing capacity, harvesters can be used for 78 % of forest acreage in the CR, i.e. roughly on 2.02 million ha with 572 million m^3 of wood supply available. A considerable part of the area and supply is available for the use of the most efficient harvester + forwarder combination. It concerns approximately 72 % of total forest acreage, i.e. 1.88 million ha with 530 million m^3 of wood available.

Keywords: harvester technology, terrain classification, technological typification, surface use, Czech Republic

1 Introduction

In deploying harvester technologies, as with other logging and transport technologies, it is necessary to proceed from the requirements of the Act No. 289/1995 Coll. on forests, whose purpose is underlying the preconditions for forest preservation, forest cultivation and regeneration as national wealth forming an irreplaceable part of environment, fulfilling all its functions and supporting its sustainable management. When applying production procedures, basic duties according to the § 11must be respected, i.e. everyone should act as to avoid endangering or damaging the forests, their objects and equipment serving the forest management. § 34 says that pre-skidding, storing and forwarding timber must be carried out as not to cause inappropriate damage to the forest and other estates.

In order to sustain the sustainable management in the forests, it is necessary to create the concepts of long-term planning infrastructure narrowly linked to planned logging and transport technologies, which will lead to minimal damage to forest ground and trees remaining in the stands after thinning. In connection, there will also be developed off-road classification and typifications recommending suitable logging and transport technologies for specific production conditions. These can be in particular used for a short-term planning.

2 Material and methods

2.1 Possibilities of deploying harvester technologies in the CR

When using harvester technologies within the forest management of the CR, it is necessary to respect certain restrictions and proceed form the following preconditions.

⇒ Technology will be applied in economical forests and in special purpose forests. It is not expected to use the technology in the first zones of Protected Landscape Areas and in National Parks.

⇒ The areas with obstacles above 50 cm high are not suited for the technology and therefore the deployment of harvesters in those localities is not expected.

⇒ Areas affected by water (waterlogged and so on), with generally lower bearing capacity of the terrain, are very sensitive to even single cross of heavy machinery and therefore the use of harvesters is not expected there either.

⇒ To provide minimal affectivity of the technology, felling operations will be focused on stands with the diameter of medium stem from 0.05 m^3.

⇒ The technology is optimised for coniferous stands with spruce and pine predominating. Out of deciduous tree species, only stands with beech and birch to the age of 50 are considered. Other tree species are from a technological point of view problematic for processing or they are not dominant in the forest management.

The established conditions take into account requirements and possibilities of wheeled harvesters which are still predominant in the forest management of the CR.

2.2 Selected production conditions for the deployment of harvester technology in the CR

Among primary terrain factors influencing and restricting harvester technologies belong slope inclination, its bearing capacity and presence of obstacles in the terrain.

Terrain inclination restricts technical utilisation of the harvester technology and it limits its possibility in the work area. It affects the stability of the machine, work safety and its practical utilisation. An ideal means for evaluating this factor is a digital model of the terrain. The model of the Czech Office for Surveying, Mapping and Cadastre in Prague (COSMC) was used. The basic sources for its creation were contours with 2 m resolution which were processed into a digital model of the terrain. The model defined several classes of inclination given in per cent. With prevailing wheeled harvesters in the CR, the technology will not be applied in inclinations over 50 %.

In addition to technical passability of harvesters and forwarders defined by the terrain inclination, another important role is played by the bearing capacity of the soil. For deploying harvester technologies a decisive factor is the pressure caused by the harvester crossing the trails several times. The surface bearing capacity is characterised by the terrain type. It can be roughly included among edaphic categories that can be classified into several groups based on the bearing capacity given by soil texture composition and its being affected by water. Generally, very good bearing capacity can be observed with edaphic categories characterised by a higher content of shell, which effectively decomposes the pressure caused to the ground by the device (J, X, Y, Z, C, N, A, F) (Ulrich et al. 2006).

On the other hand, the presence of obstacles - boulders and hollows higher or deeper than 50 m with spacing smaller than 5 m - limits or altogether forbids the movement of machinery on the area. Whether the use of machinery and technology is suitable or not is discussed by terrain and technological typification (see chapter 2.3).

The most sensitive to damage are edaphic categories permanently under the influence of underground water – permanently waterlogged, i.e. T – poor waterlogged sites, G – waterlogged nutrient sites or R – peat. They create almost 4 % of all stands. Permanently high level of underground water results in these categories being unbearable. Even though a present state of the technology allows the work in these areas using technical aids, the risk of damage to these areas is very high. They are not suited for harvester technologies.

The same is true also for particular groups of forest types, wet or waterlogged V9, and spring 3L2 and 5L2. The reason is the non-bearing capacity of the soil and a high risk of its damage.

As regards the soil bearing capacity, for edaphic categories J, Y, A, N, Z the situation is different. The bearing capacity of the soil is very good; however, these are categories with a high amount of shell, silt and boulders, which can become obstacles of the movement of harvesters and forwarders. For Y category- skeleton and J – silt maple the occurrence of obstacles is expected – boulders and hollows bigger than 50 m in spacing smaller than 5 m. These two categories present about 1% area of all forests in the CR.

In A categories – stony colluvial and N – acid stony, the obstacles may or may not occur. Therefore it is necessary to check the categories physically in the terrain. The two categories account for almost 4% of forest area. Since both terrain and technological typification which take all these factors into account are not available for the CR yet, we must proceed from the fact that edaphic A and N categories, where it is necessary to check the shell and the possibility for the machinery, are not suited for harvesters and forwarders.

When considering harvester technologies, it is also necessary to take into account and exclude the areas of priority interest of nature protection – in particular protected small-scale territories – nature reserves and nature monuments and their protection zones and, last but not least, the first zones of protected landscape areas and national parks. In these localities no active operations by man are planned and neither harvester technologies can be applied there. In European significant localities and bird areas there is a special regime. The localities overlap to some extent and they exceed the above mentioned categories of nature protection. The application of the harvester technology in these "overlaps" or on the edge of these localities is possible only after the agreement of nature protection authorities.

Among other conditions that need to be considered belong the following:

Logged tree species and their dimension. Harvester heads are constructed particularly for coniferous trees. With the head of the Finnish type it is possible to process birches and younger beeches as well (ULRICH *et al.*, 2006). The technology is applicable from the medium stem volume 0.05 m^3. As this fact is not always available, it can be replaced with medium height and thickness. Based on the volume tables for individual tree species, it is possible to define basic differential parameters for medium thickness ($d_{1,3}$) at the height of 11 cm and for medium height 9 m. Individual trees that meet or exceed these taxation parameters can be effectively processed by harvesters.

Woody composition and the age of stands. Harvester nodes are most often deployed in coniferous stands – spruce or pine, with possible individual dissemination of larch or deciduous tree species (usually birch). Deploying harvester nodes in deciduous stands is recommended only in beech stands of a lower age class. Thus a smaller curvature and branching of the trees is guaranteed and the stands can be processed by the harvester (Malík and Dvořák 2007).

For further use of harvesters in the Czech Republic there are interesting stands with the representation of spruce and pine above 60 %, from deciduous stands interesting are those with 60% representation by beech or birch to 50 years of age. The stands with other woody composition are not suited for the use of harvesters due to the risk of stem curvature or branching.

2.3 Off-road classification and technological typifications in the CR

"Forest Project 1980", off-road classification, stems from the basic classification of the terrain to bearable, unbearable and with obstacles. In combination with terrain inclination, a numerical indication of a terrain type is created (Tab. 1). Based on their terrain adaptability, the terrain types can be combined into five terrain groups. Each group has been attached applicable equipment for timber pre-skidding (Tab. 2) (The Forest Management Institute, herein FMI, 2007). For harvester technologies the most optimal seems to be A terrain group, i.e. terrain types 11, 12 and 13 based on the terrain classification of the Forest Project from 1980. This terrain group is characterised by the inclination 0 – 25 %, bearable (bearable capacity above 50 kPa), without obstacles (i.e. boulders or hollows to 0.5 m deep or at the distance of 5.0 m). In other terrain types, the deployment of machinery is more difficult, it requires good technological preparation including both specific work procedure at the workplace and time deployment in the season and good pre-preproduction preparation (Gross 1984). The disadvantage of the terrain classification is the range of inclination categories which do not correspond to the parameters of present forest technology.

Table 1: Terrain classification based on the Forest Project from 1980

<table>
<tr><th colspan="2" rowspan="2">Terrain inclination (%)</th><th colspan="2">Bearable terrains</th><th colspan="2">Unbearable terrains</th><th colspan="2">Terrains with obstacles**</th></tr>
<tr><th>type</th><th>group</th><th>type</th><th>group</th><th>type</th><th>group</th></tr>
<tr><td>1</td><td>to 8</td><td>11</td><td rowspan="3">A</td><td>21</td><td rowspan="5">D</td><td>31</td><td rowspan="5">E</td></tr>
<tr><td>2</td><td>9 – 15</td><td>12</td><td>22</td><td>32</td></tr>
<tr><td>3</td><td>16 – 25</td><td>13</td><td>23</td><td>33</td></tr>
<tr><td>4</td><td>26 – 40</td><td>14</td><td>B</td><td>24</td><td>34</td></tr>
<tr><td>5</td><td>above 40</td><td>15</td><td>C</td><td>25</td><td>35</td></tr>
</table>

*50 kPa is regarded as a boundary between bearing and non-bearing capacity. **As terrain obstacles are considered terrain unevenness, hollows etc., whose height or depth is 0.4 m and which are in mutual proximity of 5 m.

Table 2: Technological typification based on the Forest Project from 1980

<table>
<tr><th colspan="2" rowspan="2">Terrain inclination (%)</th><th colspan="4">Bearable terrains</th><th colspan="2">Unbearable terrains</th><th colspan="2">Terrains with obstacles</th></tr>
<tr><th>type</th><th colspan="3">group</th><th>type</th><th>group</th><th>type</th><th>group</th></tr>
<tr><td>1</td><td>to 8</td><td>11</td><td rowspan="3">FT*</td><td rowspan="4">Skidder</td><td rowspan="5">horse</td><td>21</td><td rowspan="5">CS</td><td>31</td><td rowspan="5">CS</td></tr>
<tr><td>2</td><td>9 – 15</td><td>12</td><td>22</td><td>32</td></tr>
<tr><td>3</td><td>16 – 25</td><td>13</td><td>23</td><td>33</td></tr>
<tr><td>4</td><td>26 – 40</td><td>14</td><td></td><td>24</td><td>34</td></tr>
<tr><td>5</td><td>above 40</td><td>15</td><td colspan="2">CS**</td><td>25</td><td>35</td></tr>
</table>

* farm tractor. **cableway system.

Table 3: Terrain classification by Macků-Popelka-Simanov

<table>
<tr><th rowspan="5">Slope inclination (%)</th><th colspan="4">Soil surface</th><th rowspan="5">Obstacles</th></tr>
<tr><th colspan="3">Bearable</th><th rowspan="4">Unbearable</th></tr>
<tr><th colspan="2">Permanent</th><th>Conditioned</th></tr>
<tr><th colspan="3">Unevenness of the terrain</th></tr>
<tr><th>*</th><th>**</th><th>*</th></tr>
<tr><td>to 10</td><td>11</td><td>12</td><td>13</td><td>15</td><td>16</td></tr>
<tr><td rowspan="2">11 – 20</td><td rowspan="2">21</td><td rowspan="2">22</td><td>23</td><td>25</td><td rowspan="2">26</td></tr>
<tr><td colspan="2">29</td></tr>
<tr><td rowspan="2">21 – 33</td><td>31</td><td>32</td><td>33</td><td>35</td><td>36</td></tr>
<tr><td colspan="5">39</td></tr>
<tr><td rowspan="2">34 – 50</td><td>41</td><td>42</td><td>43</td><td>45</td><td>46</td></tr>
<tr><td colspan="5">49</td></tr>
<tr><td>51 – 70</td><td colspan="5">59</td></tr>
<tr><td>above 71</td><td colspan="5">69</td></tr>
</table>

*≤ 0.3 m, or with spacing ≥ 0.5 m. **≤ 0.5 m, or with spacing ≥ 0.5 m. Bearable soil surface is characterised by the resistance to static rated pressure ≥ 200 kPa in the trail (the depth of the trail to 5 cm of single travel of LKT 80). Conditioned bearable capacity is characterised by the conditioned bearable capacity 50 – 200 kPa depending on the change of conditions (moisture). Obstacles are the types of unevenness, i.e. ≥ 0,5 m and narrower than a triple of the depth while their mutual spacing is ≤ 5 m.

Newer terrain classification (Tab. 3) and a corresponding technological typification– Macků-Popelka-Simanov – should be more compatible with new knowledge and applied technologies (Simanov et al. 1993, Tuháček 1997). The classification determines the technologies acceptable from the point of view of minimization requirements for damage to forest ecosystems. As opposed to Forest Project terrain classification, *inclination degrees* were changed to 10 %, 11 – 33 %, 34 – 50 %, 51 – 70 %, above 70 %. Further there is specified the *bearing capacity of the soil surface, unevenness of the terrain and terrain obstacles.* Each inclination, bearing capacity and terrain obstacles have their technological types recommending suitable logging and transport means or their combinations. Under these conditions a year-round deployment of harvester technology is applicable in terrain types 11, 12, 21, 22, 31, 32 and under limited conditions in the stands classified by terrain types 13, 23, 33, 41, 42, 43. Terrain types are characterised by erratic categories (Tab. 4) and as with the Forest Project terrain classification, for different terrain types there are recommended applicable means for timber pre-skidding (Tab. 5).

Table 4: Terrain types expressed by edaphic category and terrain inclination (FMI, 2007)*

Slope inclination (%)		Soil surface				Obstacles
		Bearable			Unbearable	
		Permanent		Conditioned		
		Unevenness of the terrain				
to 10		M K S B C I H	X Z N W A	O D L P Q U V	T G R	Obstacles including Y J
11 – 20				Landslide		
21 – 33				O D L P Q V	T G R	
		Landslide				
34 – 50	34 – 50	C	X Z N W A	O D V	V U	Obstacles Including Y J
	40 - 50	M K S B	Landslide			
51 – 70		Extreme				
above 71						

*for Characteristics of edaphic (soil) categories see Průša (2001). X: xerothermic, Z: dwarf, Y: skeletal, M: poor, K: acid, I: acid laid-down, N: acid stony, S: medium rich (fresh), C: drying, F: stony, fresh, H: loamy, B: rich, D: loamy (colluvial), A: stony (colluvial), J: silt (maple), L: floodplain, U: valley, V: wet (rich waterlogged), O: gleyed medium rich, P: gleyed acid, Q: gleyed poor, T: poor waterlogged, G: waterlogged, medium rich (gleyed), R: peat.

Table 5: Terrain classification by Macků-Popelka-Simanov

Slope inclination (%)	Soil surface				Obstacles
	Bearable			Unbearable	
	Permanent		Conditioned		
	Unevenness of the terrain				
to 10	FT	skidder forwarder	forwarder, FT*, skidder**		
11 – 20			FT*, skidder**, horse, CS, helicopter		CS
21 – 33	FT*, skidder**		FT*, skidder**		
	FT*, skidder**, horse, CS, helicopter				
34 – 50	horse			CS	
51 – 70	FT*, skidder**, horse, CS, helicopter				
above 71					

FT: farm tractor. CS: cableway system. FW: forwarder. * Horal FT. ** with low-pressure tires.

3 Results and discussion

Results (Tab. 6 and 7) are influenced by woody composition and structure of present-day stands. If the trend of softening the management continues, or the trend in increasing the stand detail, change in woody composition, economic means and the shape of the forest, the results of the analysis will lose their validity.

Basic parameters to which all below mentioned facts are related, are total stand soil 2,593, 923 ha and total wood supply 678 mil. m^3 without bark (timber to the top material) and they are stated in the Report on the State of the Forest and Forest Management in the CR in 2009.

Table 6: Potential acreage of forests suited for harvesters deployment

inclination (%)	Representation of suitable coniferous and deciduous tree species (%)					
	to 60		60 - 80		above 80	
	Forest estate area					
	(ha)	(%)	(ha)	(%)	(ha)	(%)
to 10	54, 518	2.10	99, 700	3.84	777, 447	29.98
10 - 20	44, 783	1.73	76, 475	2.95	467, 180	18.02
20 - 35 (33)	34, 255	1.32	54, 755	2.11	272, 134	10.49
35 - 50	16, 507	0.64	23, 754	0.92	94, 763	3.65
Total	**150, 063**	**5.79**	**254, 684**	**9.82**	**1, 611, 524**	**62.14**
Total for the CR					**2, 016, 271**	**77.75**

Table 7: Potential supply of forests suitable for the use of harvesters

inclination (%)	Representation of suitable coniferous and deciduous tree species (%)					
	to 60		60 - 80		above 80	
	Forest stands supply					
	(thous. m^3)	(%)	(thous. m^3)	(%)	(thous. m^3)	(%)
to 10	10, 792	1.59	19, 743	2.91	219, 245	32.34
10 - 20	10, 570	1.56	17, 694	2.61	141, 919	20.93
20 - 35 (33)	9, 326	1.38	13, 904	2.05	86, 422	12.75
35 - 50	5, 091	0.75	6, 484	0.96	30, 958	4.57
Total	**35, 779**	**5.28**	**57, 825**	**8.53**	**478, 544**	**70.59**
Total for the CR					**572, 148**	**84.40**

Natural conditions are a criterion which is not affected by the forest management. It is not expected to change radically even in the future. The data mentioned in Tables 6 and 7 present theoretical potential of deploying harvester technologies in the Czech Republic with respect to natural conditions. The limitations are the terrain inclination, its bearing capacity and respecting the interests of nature protection.

The range of the area where harvester technologies can work with respect to age, medium stem volume or woody composition of the stand presents almost 78 % of the total forest acreage of the CR, i.e. more than 2 million ha. More than 62 % forest acreage, i.e. more than 1.61 million ha, amounts to stands, where the share of required spruce, pine and birch tree species exceeds 80 %. In those forests there is 572 million m^3 wood available, i.e. as much as 84 % of total forest supply. A considerable part of wood supply is also concentrated in the stands with more than 80 % presentation of required tree species. The stands with spruce, pine or beech and birch representation lower than 80 % are as supplies less significant.

The mentioned results correspond with the results of the study of the Ministry of Agriculture from 2010 "*Detecting area and stand supplies in the forests of the CR where harvester technologies can be used in the forest management*" The study numbered the potential of harvester technology based on natural conditions per 85 % of total forest acreage in the CR.

A more complex classification from the point of view of woody composition, acreage and supplies is presented in Tables 8 - 11.

Table 8: Potential acreage of coniferous trees suitable for the use of harvesters

Inclination (%)	Coniferous trees representation (%)					
	to 60		60 - 80		above 80	
	Forest estate area					
	(ha)	(%)	(ha)	(%)	(ha)	(%)
to 10	36, 341	1.40	92, 053	3.55	753, 068	29.04
10 - 20	32, 297	1.25	70, 683	2.73	456, 132	17.59
20 - 35 (33)	26, 383	1.02	50, 750	1.96	265, 543	10.24
35 - 50	13, 728	0.53	22, 132	0.85	92, 246	3.56
Total	**108, 749**	**4.20**	**235, 618**	**9.09**	**1, 566, 989**	**60.43**
Total for the CR					**1, 911, 356**	**73.71**

Table 9: Potential acreage of deciduous trees suitable for the use of harvesters

Inclination (%)	Beech and birch representation (%)					
	to 60		60 - 80		above 80	
	Forest estate area					
	(ha)	(%)	(ha)	(%)	(ha)	(%)
to 10	18, 177	0.70	7, 647	0.29	24, 379	0.94
10 - 20	12, 486	0.48	5, 792	0.22	11, 048	0.43
20 - 35 (33)	7, 872	0.30	4, 005	0.15	6, 591	0.25
35 - 50	2, 779	0.11	1, 622	0.06	2, 517	0.10
Total	**41, 313**	**1.59**	**19, 066**	**0.74**	**44, 535**	**1.72**
Total for the CR					**104, 914**	**4.05**

Table 10: Potential supply of coniferous forests suitable for the use of harvesters

Inclination (%)	Coniferous trees representation (%)					
	to 60		60 - 80		above 80	
	Forest stands supply					
	(thous. m^3)	(%)	(thous. m^3)	(%)	(thous. m^3)	(%)
to 10	8, 329	1.23	18, 664	2.75	215, 349	31.76
10 - 20	8, 835	1.30	16, 863	2.49	140, 355	20.70
20 - 35 (33)	8, 234	1.21	13, 325	1.97	85, 478	12.61
35 - 50	4, 715	0.70	6, 248	0.92	30, 584	4.51
Total	**30, 113**	**4.44**	**55, 100**	**8.13**	**471, 766**	**69.58**
Total for the CR					**556, 979**	**82.15**

Table 11: Potential supply of deciduous forests suitable for the use of harvesters

Inclination (%)	Beech and birch representation (%)					
	to 60		60 - 80		above 80	
	Forest stands supply					
	(thous. m^3)	(%)	(thous. m^3)	(%)	(thous. m^3)	(%)
to 10	2, 463	0.36	1, 079	0.16	3, 895	0.57
10 - 20	1, 735	0.26	831	0.12	1, 564	0.23
20 - 35 (33)	1, 093	0.16	580	0.09	944	0.14
35 - 50	376	0.06	236	0.03	374	0.06
Total	**5, 667**	**0.84**	**2, 726**	**0.40**	**6, 777**	**1.00**
Total for the CR					**15, 170**	**2.24**

Table 12: Potential acreage of forests suitable for the use of a harvester and forwarder combination

Inclination (%)	Suitable coniferous and deciduous tree species representation (%)					
	to 60		60 - 80		above 80	
	Forest estates area					
	(ha)	(%)	(ha)	(%)	(ha)	(%)
to 10	54, 518	2.10	99, 700	3.84	777, 447	29.98
10 - 20	44, 783	1.73	76, 475	2.95	467, 180	18.02
20 - 35 (33)	34, 255	1.32	54, 755	2.11	272, 134	10.49
Harvester and forwarder	**133, 566**	**5.15**	**230, 930**	**8.90**	**1, 516, 761**	**58.49**
Total for the use of harvester node					**1, 881, 247**	**72.54**

Table 13: Potential supply of forests suitable for the use of a harvester and forwarder combination

Inclination (%)	Suitable coniferous and deciduous tree species representation (%)					
	to 60		60 - 80		above 80	
	Forest stands supply					
	(thous. m^3)	(%)	(thous. m^3)	(%)	(thous. m^3)	(%)
to 10	10, 792	1.59	19, 743	2.91	219, 245	32.34
10 - 20	10, 570	1.56	17, 694	2.61	141, 919	20.93
20 - 35 (33)	9, 326	1.38	13, 904	2.05	86, 422	12.75
Harvester and forwarder	**30, 688**	**4.53**	**51, 341**	**7.57**	**447, 586**	**66.02**
Total for the use of harvester node					**529, 615**	**78.12**

4 Conclusion

The submitted data present top limit of theoretical potential of harvester technology in the CR. It is caused by the fact that neither slope inclinations taken from the terrain digital model nor typological units copy the limits of the units of forest spatial distribution (UFSD) but respect natural environment characteristics. Thus there is a slight influence of the results towards an upward direction, because some UFSD correspond with the given requirements only to a low extent, some even up to 50 %. Real possibilities can be lower about stands managed as undergrowth and stands with several floors where there prevails thread of causing damage to present stand by heavy machinery movement.

From the point of view of terrain possibility and bearing capacity, harvesters can be used for 78 % of forest acreage in the CR, i.e. roughly on 2.02 million ha with 572 million m^3 of wood supply available. A considerable part of the area and supply is available for the use of the most efficient harvester + forwarder combination. It concerns approximately 72 % of total forest acreage, i.e. 1.88 million ha with 530 million m^3 of wood available.

The focus of the harvester technology potential is on coniferous stands with spruce and pine representation above 80 %. Taking into account the total results, beech and birch deciduous stands are only of marginal importance. However, their local significance can be much higher.

5 References

Malík, V., Dvořák, J., 2007: Harvestorové technologie a vliv na lesní porosty (Harvester Technologies and Impact on Forest Stands), Kostelec nad Č.l.: Nakladatelství a vydavatelství Lesnická práce, s.r.o., 84 p.

Simanov, V., Macků, J., Popelka, J., 1993: Nový návrh terénní klasifikace a technologické typizace (New proposal of terrain classification and technological typification), Lesnictví – Forestry, 39 (10), p. 422-428.

Tuháček, F., 1997: Rozbor modelů technologické typizace a dopady transformace lesního hospodářství na těžebně-dopravní proces (Analysis of models of technological typification and impact of forest management transformation on the logging and hauling process), Bulletin Národního lesnického komitétu, Praha, p. 8-13.

Ulrich, R., Neruda, J., Zeman, Vl. sen., Zeman, Vl. jun., Zemánek, T. 2006: Harvestorové technologie a jejich optimální využití v praxi (Harvester technology and their optimum practical application), Brno: Mendlova zemědělská a lesnická univerzita v Brně, 87 p.