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THE SITUATION AND NATURE CONSERVATION ASPECTS OF HORSE LOGGING IN HUNGARY'S STATE-OWNED FORESTS

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1. Background and objectives of the work

Before the mechanization of the forestry (before 1955), horse logging was a common process in forest management, but nowadays it is almost forgotten. The displacement of the use of animal power occurred due to the growth and change of social needs. Performance, speed and cost-effectiveness became the decisive factor. Only mechanization could satisfy these at the same time.

At the same time, the use of horses in forestry has countless advantages, the importance of which is incalculable in the long term. It can be considered environmentally and nature-friendly method, it causes less damage to the soil: there is no extensive compaction and trampling, as with the use of machines. It is much gentle with regard to standing stock, new growth and herbaceous vegetation. With horses there are no harmful emissions, no fuel consumption and no increase in noise level. The energy to be used for horses can be produced in our country, even close to the farmer (even by him), so there is no need for import or transport. In the case if indigenous Hungarian horse breeds are used, an additional benefit of the horse logging is gene preservation.

Globally, there is little research on yoked timber logging at a scientific level. At the international level, only one scientific article is available that deals with the frequency of equestrian entrepreneurs in forestry. Based on the results of BRAY et al. (2016), in the largest community forest (CFE) in Mexico (and perhaps in the world), El Largo, there is 100% timber extraction by horse, 800 horse brigades and 2,600 people work with it every year, in 10 years 3 million m^3 of timber are produced. In Mexico, the frequency of horse logging has increased in the last decade. 10 years ago, they started replacing winches with horses (RIL: Reduced Impact of Logging). Thousands of experienced equestrian professionals are available to train new ones (BRAY et al. 2016).

No research was previously conducted in Hungary that deals with the frequency and characteristics of horse entrepreneurs. With my thesis, I want to memorialize this traditional method. My work was guided by similar aspirations as Imre Ócsag, who in 1995 wrote the following in his work Farm Horse:

"For our grandchildren to see what their Great-Grandfather worked with."

2. Material and method

2.1. Interviews

In Hungary, slightly more than half (56%) of the forest area is managed by state forest managers (NFK 2021). The majority of the state-owned forest areas (about 84%) are managed by 22 state forestry joint-stock companies, including 116 state forestry companies, which hire contractors to carry out practical work.

According to the Forest Act (Act XXXVII of 2009), the state of naturalness is a feature estimated based on the tree species composition of forests. Most of the natural forest areas (257 ha) are state-owned, and only a small area (10 ha) of natural forest is privately owned (NFK 2020). The area occupied by natural forests is also the highest in the case of state forest farms, and very low in the private sectors (below 10%). Private individuals mainly cultivate cultural forests (NFK 2020). Since the nature protection role of horse logging is primarily justified in forest areas under nature conservation protection, I limited my surveys carried out during my doctoral research to state forest areas.

Due to the above mentioned reasons the main target groups were state-owned forestries and horse owned contractors. I conducted structured and semi-structured interviews with them in 2021 (NEWING et al. 2011). Compared to the thesis survey conducted in 2013, in the 2021 interviews, I went into more detail about the factors that make the handling of timber with a yoke more environmentally friendly, and I took several aspects into account.

The first step of my doctoral research was a phone call to all Hungarian forestry offices (116). The interviewee was a relevant employee of the given forestry: the director of forestry or the technical manager of wood use, because they have the widest perspective and knowledge on the subject. I conducted a total of 116 structured telephone interviews, the most important question of which was whether horse logging occurs in their area of operation. As a result, I determined the number of foresters in Hungary that employ and do not employ equestrian contractors.

I conducted a semi-structured interview with the contractors performing horse logging during a field participatory data collection. The main topics of the interview are personal circumstances; performance; the means and method of horse logging; advantages and disadvantages; the characteristics of the areas.

The second group of forests is made up of forests that are located in hilly and mountainous areas, but do not use a horse logging. In the case of such forestry, due to the territorial characteristics and difficulties, the continuation of the yoked timber movement would have been more necessary and justified. I conducted a short structured interview with this target group. My aim was to reveal what causes the lack of horse logging in such areas.

I recorded almost 2/3 of the interviews - depending on permission - with a dictaphone. On the one hand, summaries were prepared of the interviews, which I analyzed using qualitative content analysis based on predefined codes (PATTON 2002), which were related to my main topics. During the presentation of the results, I also used quotes as illustrations, where I also displayed the code of the interviewees after the quote (E = forestry, V = entrepreneur). I subjected the interview questions to which I received numerical answers to a simple statistical analysis and calculated frequency, percentage distribution, minimum and maximum values, average, and standard deviation (BABBIE 2013).

During the research, I followed the ethical principles expected in social science research. The interviewees agreed to the interview voluntarily, knowing the aims of the research. During the processing and publication of the interviews, I also paid attention to ensuring anonymity in order to protect the interviewees.

2.2. Characterization of forest areas

The most detailed description of a forest section is contained in the forest section description sheet. In order to get a more accurate picture of the characteristics of the areas affected by the horse logging, I used the description sheets of the forest section. I collected the following data from the data sheets: mode of operation, method of wood use, destination, degree of protection, altitude, topography, forest cover, area extent, slope angle, protected species. In addition, based on the operation sheets, I also determined the amount of timber harvested in the given area.

2.3. Measurement of horses

A significant part of the horses working in the forest are not purebred, but bear the characteristics of one of the horse breeds. That is why I considered it necessary to take measurements in order to get a more accurate picture of their characteristics and to see whether the use of horses in forest work is a possibility for gene preservation and utilization of native breeds (e.g. Hungarian cold-blooded, Muraközi, Nonius). During the field data collection for "contractors who regularly perform horse logging", I recorded the following data of working horses based on the method of BENE et al. (2013): withers height (Figure 1.1, with tape and stick), girth size (Figure 1.2, with tape), stem circumference (Fig. 1.3.: with tape), estimated weight (with tape). I took a photograph of each individual from the side, as recommended by the literature dealing with the subject (BODÓ – HECKER 1998).

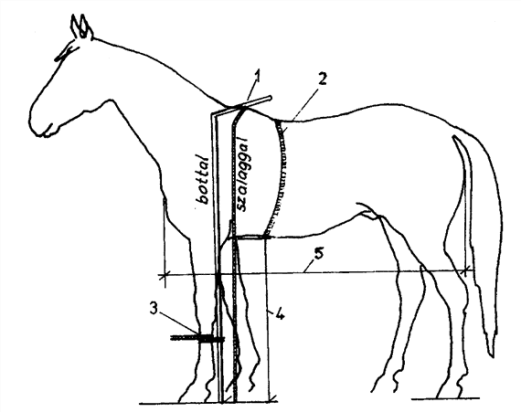

Figure 1: Measurements on horses used during the research: 1. wither height (with stick and tape), 2. girth size, 3. shank circumference (http7)

2.4. Examination of soil compaction

Part of my research was the investigation of the impact of the wood delivery machine on soil compaction. With this study, I wanted to emphasize the extent to which an logging machine has an impact on its environment - in this case, the soil structure - and at the same time draw attention to the fact that horse logging is soil-friendly.

The investigation was carried out in May 2017 on the Gudra side of the Gödöllő Forestry, in the gently sloping area of the Babat Valley affected by logging. The texture of the soil of the forest stands affected by logging and research is sand, the knowledge of which is essential for setting up the soil moisture meter. The actuality of the measurements was given by the fact that the trees designated for thinning in the forest were cut down and transported in the winter of 2016/2017.

The average width of the machine logging track in the area was 2.6 meters. For representable measurements, a 0.3 m wide buffer zone was created at the two edges of the logging track (Figure 2). The buffer zone is the two extreme lanes of the wheel track, which were visibly rarely affected by the machine, as it covers the junction of the logging track and standing stock, therefore the compacting effect of the machine was concentrated in the right and left wheel tracks that we selected and recorded. Due to the remaining trees, it was no longer possible to drive vehicles beyond the buffer zone.

The final size of our examined square thus became 2×2 m. We measured soil compaction and soil moisture in a total of 7 quadrats between 0 and 40 cm. The quadrats were marked next to each other continuously, examining a 14-meter-long logging track. The first square was placed where there was a sufficient distance from the nearby concrete road in order to avoid a more

concentrated and disturbed area. This 14 meter long logging track covered a flat area, however, during forestry operations, wheel tracks resulted in significant differences in microtopography. We considered it expedient to designate the squares - for the reasons mentioned above - until we got close to a previous round or loader.

The resistance of the soil layer was always examined in a specific 10 cm layer, i.e. between 0–10 cm, 10–20 cm, 20–30 cm and 30–40 cm. With the soil moisture measuring instrument, however, we always measured the moisture content of a point at a given depth every 10 cm, such as at 10 cm, 20 cm, 30 cm and 40 cm. During the field measurements, we distinguished the wheel track that forms the approximate track from the wheelbase. Data were collected at 10 points within a quadrat (5 points each in the wheel track and between the axles), if the soil condition permitted, at all four different depths. The points in the wheel track were selected so that they were located on the longitudinal axis of the wheel track, ensuring the assessment of the influence of all turns. The division of the 5 points placed in the wheel track was alternately placed in the right and left wheel track. The 5 points measured between the axes were chosen arbitrarily, as far as possible from the existing trees and stumps - as their root systems have an influence on the soil resistance (MAJOR et al. 2012) - but still within the square. In optimal cases, we were able to measure soil resistance and soil moisture in a total of 80 points within a square. This means a maximum of 280-280 data in total, which were evaluated by calculating the averages and standard deviations.

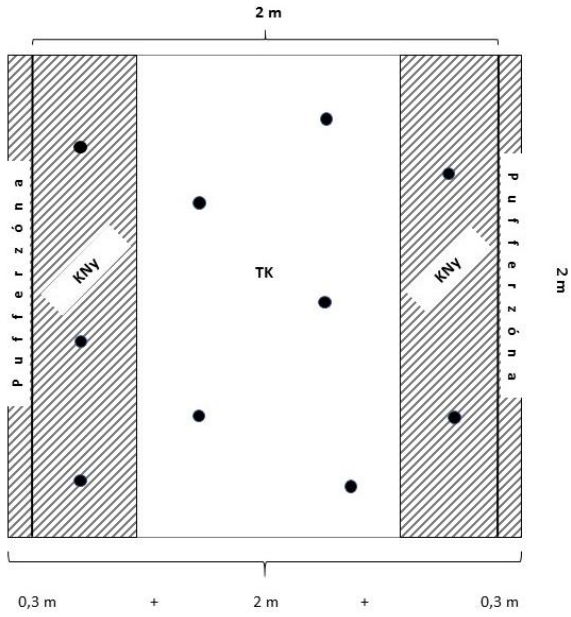

Figure 2: Location of a 2×2 m quadrat with the 5-5 sample point on the 2.6 m wide logging track (KNy: wheel track, TK: wheelbase)

The Kapacitív KKT. we used a PT-1 type instrument manufactured by Soil resistance was measured with a static penetrometer with a cone angle of 60 ° (USOWICZ – LIPIEC 2009), which is common in practice and shows the maximum value of a given soil layer. (BIRKÁS 2010).

The data were evaluated with the SPSS 20.0 statistical software. The existence of a normal distribution of the data was checked with the Kolmogorov-Smirnov test. Where the data series followed a non-normal distribution, a non-parametric Kruskal-Wallis test was performed instead of analysis of variance. A non-parametric test, the Mann-Whitney U-test, was used to compare the values of the wheel track and the wheelbase in the case of a non-normal distribution. A two-sample independent t-test was used to compare normally distributed data series. If the variance of the two groups differed significantly based on Levene's test, then the modified version of the t-test, the Welsh test, was used, otherwise, the basic version of the two-sample independent t-test was used.

4.5. Examination of the performance of horse logging

The purpose of the study was to compare the performance of a horse brigade and a zoom machine under the same conditions: within a forest section (Telkibánya 68D, 2.59 ha, mixed beech, mixed-age stand) and with parallel work. Since the performance of the logging is influenced by many factors (weather conditions, topography, soil type, wood type, mode of operation, etc.), we tried to exclude as much as possible when comparing the work of the two brigades.

The test was carried out over 2 working days (March 28 and 29, 2018), until the timber movement in the given area was finished. The horse brigade consisted of 3 men and a draft horse. The machine brigade, which also consisted of 3 people, worked with a Unimog 406 type machine. The gross volume of the trees marked for felling was estimated based on the measurement of the diameter at breast height (DBH) and the diameter of the trunk with a forestry cross (VEPERDI 2005), as well as the estimation of the height of the trees. To estimate the height, the tree weight estimation protocol served as a guideline. The trees marked for felling were marked with forestry marking chalk, so the output per round and the day (m^3; number of felled and moved trees) could also be determined. The director of Telkibánya Forestry, Péter Hulják, provided assistance for the professional evaluation and implementation of the methodology (providing tools and documentation).

4.6. Investigation of the effect of the logging on the vegetation

The investigation was also carried out in the Telkibánya 68D forest section after the above-mentioned timber extraction, after the vegetation had developed, in May 2018. The recording was carried out following the method of BRAUN-BLANQUET (1928) (but recording the cover values as a percentage) after logging with both logging devices (Unimog 406 and horse) on May 10-11, 2018. The line was placed perpendicular to the logging track in the area, and its location was based on the location of the logging track. We examined 5 quadrats within a line, and the 3rd quadrat always fell on the logging track (Figure 3). The size of a square was 2×2 m, so 4 m^2. The distance between the lines was 5 m, which was marked with sharpened wooden stakes fixed in the center line of the 3rd square. Per quadrat, we recorded the vascular plant taxa that occurred, as well as their percentage coverage (and the bare soil surface and litter). A total of 31 lineaments were examined in the area affected by horse logging, and 34 in the machine area. We measured a total of 155 quadrats in the horse logging area, while 170 in the mechanical area.

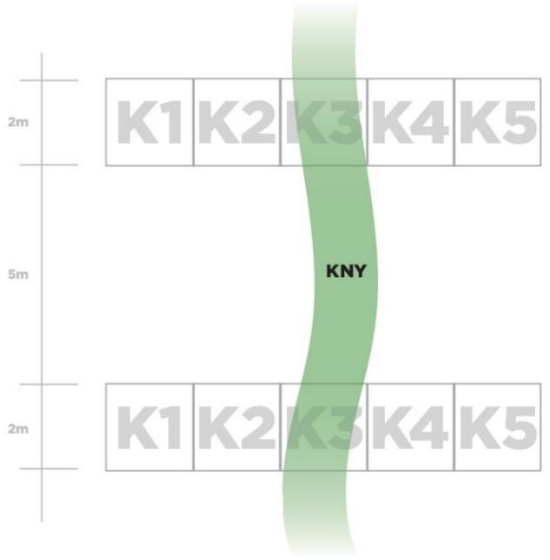

Figure 3: Vegetation recording scheme
(KNY: logging track, K: quadrat)

3. Results and their discussion

3.1. The trend of equestrian entrepreneurs between 2013 and 2021 in Hungary

In 2013, 39 forestry companies employed equestrian contractors for some purpose, by 2021 this number had decreased to 24. The number of permanently employed equestrian entrepreneurs decreased by 53.3%. The number of equestrian contractors and brigades shows a decreasing trend at the national level, but there is still a great demand for their unique work. This is confirmed by the fact that several forestry workers mentioned that they tried to hire a contractor with horses several times, but usually the contractor did not succeed due to a lack of expertise and experience, or "he was not up to the *task (E3)"* . More than half (34) of the 44 hill and mountain forests that do not use horses indicated that they have a need for the gentle movement of horse logging: *"we would do sample work with it (E8)* ".

3.2. Characteristics of the areas affected by horse logging

Based on the experience of the contractors who regularly perform horse-based logging, they most often logging with horses in the case of thinnings (seedling enhancer and stem selection). This is justified by the fact that at the time of thinning, the wood is still relatively young, with a dense structure and a smaller volume. Horses can maneuver through dense stands much more easily and with less damage than machines. Logs with a manageable volume are brought out with horses, and in many cases it would not be worth harvesting this small amount of wood with machines (it would not be economical to pay the transportation cost for a short period of time and for a small amount of wood). Horses are also used for felling, felling, pruning, sanitary cutting, pulling out wind-blown trees and public collection/sale. Based on the experience of entrepreneurs, foresters often designate an area for horses that is difficult to access with machines. Examples include steep, stony and rocky hillsides and mountains.

Based on the description sheets of the forest section, the most common mode of operation in forest areas affected by horse logging is felling, and the most common method of wood use is thinning (growth enhancer and trunk selection), followed by demolition cutting for renewal cutting, and there have also been cases of felling. The average extent of the forest sections affected by horse logging based on the 14 areas: 10.28 ha. The extent of the areas directly affected by timber handling may be smaller than this. The smallest area where horse logging was carried out was 4.32 ha, the largest was 16.91 ha in 2021.

With the exception of one area, the primary purpose of all forest sections examined in 2021 is nature conservation. The primary purpose of that one area is timber production, where the largest amount of timber was produced. Some

areas are also designated as Natura 2000 (2 units) and soil protection (1 unit). The degree of protection is most often a natural area with countrywide importance, protected by law, and there were also highly protected natural areas (1) and non-protected areas (1). Two of the forests visited are those with a large part of their management area under nature conservation protection. They have two permanent cavalry brigades each. Both forestry operations are characterized by steep, rocky hillsides.

The forest population of the affected areas is very mixed, so the tree species generally does not affect the use of horses, apart from one or two special cases. An example of this is the black pine forest, where special attention is paid to the growth of new flowering ash trees, so only horses are specifically allowed there. In the case of some affected forest stands, the protected plant species of the lawn level justify the preservation.

The average altitude of the forest areas affected by horse logging is 387.5 m. The lowest area lies between 250-350 m, the highest between 450-550 m, the most common altitude is 350-450 m. Their topography, without exception, is classified as "mountain, hill, hill side". The average slope angle of the areas affected by horse logging is 13.86°. The largest slope angle is 20-25°, the smallest is between 10-15°. Most often, they logginged with horses in an area with a slope angle of 15-20°.

In 2021, the horse brigade was mostly called to work in sloping, stony-rocky or hard-to-reach areas, where the machine would have difficulty entering or would cause great damage. On steep hillsides, the wood is pulled downhill with the horses and the loader is formed there. More experienced equestrian contractors hang the drag chain on the log differently in the case of very steep hillsides and "rolling gravel" soil, or they don't even undertake the area with a shallow crop layer, because it creates a dangerous environment for people and horses. Among hill and mountain foresters (n=44), most (20 people) associated the work of horses with gentleness. This is also supported by the fact that, based on the description sheets of the forest section, horses were mostly used in areas under nature protection protection.

3.3. Horse logging performance and factors affecting it

Based on my 2021 surveys, there are usually 3 people working in a brigade, although there would be a need for more people, but entrepreneurs cannot find reliable workers in the area (MALATINSZKY et al. 2022). The performance of the horses could also be increased with the number of workers. The classic setup: the entrepreneur decides, one person accompanies the horse, and one person chooses at the workbench. The most people in a brigade were 5 people, but this only happened in 2 cases. The average working time is 7 hours per day, excluding breaks and access to the area (which is sometimes significant).

Based on my 2021 surveys, the average distance between the barn and the forest on foot or by cart is 11 km. The largest mentioned distance traveled by cart in one direction is 15 km, which means a total of 4 extra hours per day, reducing productivity, because only 2 entrepreneurs out of 15 have horse transporters.

Our results regarding the performance of the yoke logging are in line with the international literature: it largely depends on the logging distance and the slope angle of the area (BORZ–CIOBANU 2013). Based on the description sheets of the forest section used during the research, the average slope angle in Hungary where horses are used is 13.86°, i.e. 24.67%, which is close to the average value found in the international literature (20% = 11.31°) . In Hungary, horses were most often logginged in areas with a slope angle of 15-20° (27-36%), a similar value can be found in 5 studies. The highest average slope angle where animal yoke force is used was found by GHAFFARIYAN (2008) TO BE 75% (36.87 º) in Iran. In AA literature, a slope angle of 20% (11.31°) is considered average.

Based on the results of the research carried out in the Telkibánya 68D sample area, it can be said that under the same conditions, the machine logging provided more than twice as much performance (59.6084 m^3) as the horse logging (24.749 m^3).

3.4. Characteristics of workhorses used for timber logging

Most of them use offspring resulting from the crossbreeding of cold-blooded and warm-blooded horse breeds. Entrepreneurs who use cold-blooded horses prefer the slow pace, calmness and docility of larger horses, and they can pull more weight with them. Those who keep horses of a twisted nature, of smaller stature, like the speed of the horses. There are also those who use both types at the same time: " *I like twisted horses because of their speed and endurance, and cold-blooded ones because of their strength and calmness. (V2)"* The entrepreneurs' decision is not influenced by the fact that they choose a native Hungarian breed of horse for the work. This is evident from the fact that among the horse breeds and types used for forest work, there are also cold-blooded horse breeds of Belgian or French origin, and the most frequently used type is the twisted one, which can include native and foreign horse breeds. In their opinion, it is difficult to buy experienced, healthy, heavy-duty workhorses in Hungary, so entrepreneurs have few opportunities to choose between different breeds. In addition, the price of a purebred cold-blooded horse can be several times, even three times that of a twisted horse. However, one of the advantages of the equestrian logging is that the business can be started with a smaller investment.

Based on the measurements of the 30 working horses measured in the field and the measurements of the cold-blooded breeds native to Hungary, it

is not possible to draw clear conclusions as to which breed would be better suited for forest work based on the body size data.

3.5. The effect of logging effect on vegetation

On the heat maps made based on the cover values for the vegetation of the quadrats marked in the lines, a clear difference can be seen in the effect of horse and machine logging on the vegetation. The vegetation cover is the smallest on the skidding road of the machine. The vegetation of the equestrian track is similar to its surroundings.

3.6. Examination of soil compaction

The obtained soil resistance data were analyzed based on their depth (0–10 cm, 10–20 cm, 20–30 cm, 30–40 cm) and their location on the approximate track (wheel track or wheelbase). In the wheel track, based on the Kruskal-Wallis test, the upper two layers have the highest ground resistance, they differ significantly from the lower two layers ($KW=31.532$; $df=3$; $p<0.05$). In the wheel track, the soil resistance of the upper two layers does not differ significantly from each other, just as the lower two layers do not differ from each other. If we examine the medians, the highest soil resistance (3.84 MPa) is shown by the uppermost soil layer, but this does not differ significantly from the value of the second soil layer (3.648 MPa; $p<0.05$). The lower the soil layer we examined, the smaller the median was obtained, so the depth and soil resistance are inversely proportional to each other. The lowest median of soil resistance (2.592 MPa) has the lowest one, but it is not significantly different from the third layer (3.264 MPa; $p<0.05$). The medians of the top three layers measured in wheel tracks (3.84 MPa, 3.648 MPa and 3.264 MPa) exceed the limit value of 3.00 MPa (B IRKÁS 2010), for this reason the soil is considered highly compacted at a depth of 0–30 cm, however, the 20- The 30 cm soil layer differs significantly from the upper two layers. The lowest layer - with a median value of 2.592 MPa - forms a transition between sufficiently loose and compacted soil conditions, but does not differ significantly from the soil layer above it, which is considered compacted.

According to the results of the Kruskal-Wallis test between the axes, the soil resistance in the lowest layer is significantly higher than in the upper two ($KW=15.427$; $df=3$; $p<0.05$). The lowest layer is not significantly different from the 20-30 cm layer, just as the upper two layers are not significantly different from this layer, so this represents an overlapping category between 0-20 cm and 30-40 cm. Among the medians measured between the axes, the lowest layer shows the highest soil resistance (1.728 MPa), although this layer does not differ significantly from the layer directly above it (1.536 MPa;

p<0.05). The medians fall within the range of 1–2.5 MPa (B IRKÁS 2010), so we can speak of sufficiently loose, favorable soil in the 0–40 cm layer between the axes. The median values of the soil resistance measured between the axles - in contrast to the median values of the soil resistance measured in the wheel track - are directly proportional to the depth of the soil layer, i.e. the deeper the layer we examined, the higher the median resistance was.

Overall, the highest ground resistance in the wheel track is shown by the upper two layers, which are considered highly compacted. On the other hand, the soil resistance between the axes was significantly higher for the lowest layer compared to the upper two, which can be said to be a sufficiently loose soil condition. Therefore, the compacting effect of the forestry machine was effective up to a depth of 40 cm, but it affected the layers closer to the soil surface to the greatest extent.

After that, we examined whether the soil resistance differs in the wheel track and between the axles according to the individual depths. In the 0-10 cm layer, a highly significant difference can be detected between the two areas. Ground resistance was significantly higher in the wheel track than between the axles (U=19.5; p<0.05; n1=33; n2=35). For the 10-20 cm layer, the difference between the two areas was highly significant (t=15.411; df=52.857; p<0.05), as was the case for the 20-30 cm layer (t=11.712; df= 55.863; p<0.05). At 30-40 cm, based on the basic version of the two-sample independent t-test, the difference between the two areas was also highly significant in this case (t=4.051; df=64; p<0.05).

Therefore, in the 0-40 cm layer of the soil, a highly significant difference can be shown between the ground resistance values of the wheelbase and the wheel track, which supports the harmful, compacting effect of the machine on the soil structure. effect.

4. Conclusions and recommendations

Compared to the data of the 20th century, I registered a drastic decrease even in 2013. This negative trend continued during my doctoral research: many of the entrepreneurs I met in 2013 stopped their equestrian activities, citing various reasons, or due to their aging or health conditions. This is also shown by the further decreasing trend of horse entrepreneurs. According to my experience, several brigades have ceased their activities in Hungary in recent years as well. That is why I considered it important to collect and describe the knowledge experienced and acquired by equestrian professionals.

Based on telephone data collection, field investigations and the literature, the primary role of the equestrian logging is to protect the soil

affected by logging, the remaining stock, and the new growth (Table 1). It exposes the soil to a lesser degree of impact, as it involves less trampling damage than mechanical logging. This can reduce invasive species that like disturbance, e.g. also the appearance of idol tree (*Ailanthus altissima*). Thanks to the minor disturbance, it does not prevent the growth of the seedlings, nor does it prevent regeneration. The protection of the remaining stock unfolds in the fact that there is less damage to the stumps of standing trees, since the horses have better maneuverability and can be used in dense forests without significant damage. That is why horses are the most suitable for thinnings.

From an environmental point of view, a significant argument in favor of using horses is that they do not emit harmful substances. Thus, they do not pollute the soil and air, and do not increase air and soil pollution, as well as the noise level. They have no fuel consumption, the energy source they need can be grown by the owner, so there is no need even for long-distance transportation. In this way, they comply with the principles of sustainable management. One of the important distinguishing features of teeth from machines is that they can access places that machines can't, without leaving a significant mark. Another possibility in the use of horses is the preservation of the genes of native horse breeds suitable for draft, such as the Hungarian cold-blooded and Muraköz. Due to the above-mentioned advantages, the use of horses is currently important in areas with nature conservation protection, since the preservation of natural values is the priority there. Another argument in favor of using horses is that you can get extra income from foaling.

The disadvantage of horse logging is mostly expressed in performance, as it can logging a smaller volume of wood in a given time than machines. From the point of view of contractors, it is disadvantageous that their salary is defined as a performance fee, as it takes more time to move the given wood with a horse. In contrast, the essence of the equestrian logging is not rooted in performance, but in gentleness. Therefore, it would greatly contribute to their livelihood and increase their number if, as in the past, the distance traveled and the difficult terrain were a wage-changing factor.

Another disadvantage is that the horses have to be maintained, fed and kept busy, even on public holidays. This is considered difficult to integrate into today's way of life. It often complicates the situation if the logging site cannot be logginged on foot or by cart. In this case, it is necessary to find accommodation that is also suitable for horses, but the number of such forest workers' accommodation, farms and village inns shows a decreasing trend. Some people solve this with a horse transporter or a horse transport cab on a flatbed truck, which leads to additional costs. They need to earn additional income during the growing season when logging, timber extraction cannot be done. Finally, the lack of people who know horses and has the experience on horse logging. Another important factor is that the experts who know horses

are old and extinct, so there are few opportunities to pass on knowledge. The Transdanubian Agricultural Vocational Training Center (DASZK) Móricz Zsigmond Agricultural Vocational School and the Kaposvár University were supposed to fill this gap by starting a special horse logging training in 2012.

The development and up-to-date use of horse logging devices is justified, as they make the work of horses easier and thereby increase their performance. There are logging devices that are also gentle on the stock, but have a larger loading surface and also make it easier to pull out the load. In an exemplary manner in Western and Northern Europe, they help horses work with modern, modern logging tools, thus increasing their performance (http9). The development and practical implementation of such tools is also recommended in Hungary.

The fact that parts of the forest that can no longer be harvested with machines become accessible with horses can be seen not only as an advantage, but also as a disadvantage, depending on the point of view, since it has been considered inaccessible until now, and because of this, human activity can appear through the mediation of the horse even in stands that have remained in their natural state.

My results they support the gentleness, nature and environmental protection role of the yoked timber movement during forest management, which could be the reason for the renaissance of the equestrian logging. This is reinforced by people's ever-increasing demand for nature conservation in forest habitats (e.g.: negative perception of clear-cutting). This gives more space to natural forest management, during which there is also logging, but taking nature conservation aspects into account. The movement of timber with horses provides a good solution and a compromise, since it can maintain the natural state of the forest without significant damage or anthropogenic impact, while you do not have to give up the financial benefits provided by the forest either. This is proven by the fact that 3.12. 124/2009 described in chapter (IX. 24.) FVM decree from the European Agricultural Fund classifies the animal-drawn logging among nature-friendly means of moving wood. The cost-increasing features and disadvantages of natural forest management include the following: a better road network is needed, less wood is used several times, each forestry activity must be carried out at the same time, and only gentle technologies can be used (ILLÉS–SOMOGYI 2010). Three of these can be avoided by using horses: the use of yoked timber does not require a higher quality and more well-explored road network, less timber and multiple harvests are an advantage and opportunity for horses, and moving timber with animals is considered a gentle technology. It follows from these that the horse logging is a solution and an alternative option during natural forest management.

I consider the spread of the equestrian logging to be conceivable if the economic situation and wages adapt to the extreme conditions of the

equestrian entrepreneurs, so that they can do their work not only out of love and tradition, but also provide them with a secure livelihood. As a result, perhaps more local young people would be more motivated to learn from their elders and would see a perspective in taking over and preserving this gentle, slow, but all the more burdensome past activity and tradition. Since the investigation covered equestrian contractors working in state forest areas, measures from above would help to change the economic situation of the contractors. It is already clear that the foresters farming in mountainous and hilly conditions require the gentle work of horses, so the employees of the foresters would support the presence of horses if they could. Therefore, cooperation between equestrian entrepreneurs and forestry could be facilitated through a state measure.

There are very few studies in the Hungarian literature that specifically deal with the soil compaction effect of forestry machines and their investigation. Several relevant literature can be found in English, which most often examine bulk density and soil resistance on forest soils to determine the degree of compaction. The conclusions of many authors support the incompleteness of the literature in assessing compaction effects affecting forest soils (LIPIEC—HAKANSSON 2000, MCNABB et al 2001, GODEFROID—KOEDAM 2004). My research in this regard needs to be expanded with a larger number of samples and multiple repetitions, with additional tests in order to draw a reliable and general conclusion. It is recommended to carry out field measurements for different slope angles and soil types. In the logging process, it is essential to record the number of rounds and the amount of timber delivered on the given logging track, as well as the weather conditions.

1. **Table:** Advantages and disadvantages of the horse logging

The advantages of the horse logging compared to the machine	**Disadvantages of horse logging**
Environmental aspects: • less noise pollution • no oil stains • minor soil compaction • minor damage to the remaining stock, novelty and natural values • the effect is concentrated in a smaller area Economic aspects: • requires a smaller investment • less exposed to fuel price changes • it can also be used when it can no longer be solved with machines or it is no longer economical to use them (e.g. steep slopes, scattered timber, sensitive areas) Sociocultural aspects: • preservation of tradition • livelihood opportunity in the countryside, in poorer areas • conservation and utilization of indigenous gene stock	• labor intensive • hard work • lack of skilled labor • low wages • intermittent work that needs to be supplemented

5 . New scientific results

5.1. I showed that, while in 2013 horse logging were used in 39 of the 116 domestic state forestry areas, by 2021 this number had decreased to 24, and horses were increasingly forced out of meaningful forest work and timber logging.

5.2. In the area of operation of the domestic state forestry, horse logging occur mostly in mountainous environments (the average height above sea level is 350-450 m, the average slope angle is 15-20°) and in protected natural areas.

5.3. Among timber extraction in Hungary, horses are mainly used during thinning (growth enhancer and trunk selection).

5.4. The average performance of the horse logging is 0.78 m^3 per round , the average length of the logging track is 185 m, and its width is 96 cm in the operational area of the Hungarian forestry.

5.5 Nowadays, in our country, offspring resulting from the crossing of cold-blooded and warm-blooded horse breeds are mainly used during the horse logging.

5.6. I have found that in terms of all environmental factors, horse logging is a more environmentally and nature-friendly method of timber logging than the use of work machines: it involves less soil compaction, causes less stem damage and causes less damage to the vegetation of the logging track. At the same time in terms of the amount of extracted wood, the horse logging is significantly lower than the mechanical one. The revealed domestic trends are consistent with international experience.

6. Major publications related to the thesis

Á. Malatinszky, **Cs. Ficsor** , E. Tormáné Kovács (2022): Which Factors Determine the Distribution of Low-Impact Horse Logging in the Hungarian State-Owned Forests? Forests 13, 1959. https://doi.org/10.3390/f13111959 [Q1]

Ficsor Cs ., Centeri Cs., Kónya L., Gönye Zs., Malatinszky Á., Biró Zs. (2018): The effect of timber movement with forestry machinery on soil compaction in the Babat Valley. Landscape Ecology Papers 16(1): 53-64. [Q4]

Cs. Ficsor , Á. Malatinszky (2017): The situation of animal-powered logging in state-owned forests of Hungary. 1 st World Conference on Soil and Water Conservation under Global Change - CONSOWA. 12-16 June 2017, Lleida, Spain. ISBN: 978-84-697-2909-0

THE. Malatinszky, **Cs. Ficsor** (2016): Frequency and Advantages of Animal-powered Logging for Timber Harvesting in Hungarian Nature Conservation Areas. Croatian Journal of Forest Engineering 37(2): 279-286. [Q1]

Cs. Ficsor , Á. Malatinszky (2014): The role of horse logging in nature protected areas of Hungary. Annals of Faculty of Engineering Hunedoara - International Journal of Engineering 12(3): 307-312.

Cs. Ficsor , Á. Malatinszky. (2014): The situation of horse logging as a nature-friendly material handling method in domestic forest areas. Landscape Ecology Papers 12(1): 127-135. [Q4]