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A NEW TRAINING CONCEPT FOR THE PRACTICE

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Abstract*: Due to increasing mechanisation, there is an urgent need to train the practice, such as forest personell, machine operators, forest owners but also certification companies in order to avoid soil damage during forest machine operations. Therefore, a new training tool was developed at the Technical University of Munich in cooperation with the LWF Bayern, financed by the Bavarian Ministry of Food and Agriculture in 2005.*

The course consists of three main parts:
The first one gives general information about legal regulations, soil structural characteristics and functions, machines and operations as well as tyre and contact area pressure basics.
The second part enlightens the chain of mechanical impact – soil physical effects and ecological consequences. The different effects on soil include slight impacts such as "elastic deformation", as well as heavier impacts such as "compaction". The latter mainly results in a reduction of the ecologically crucial soil functions water and air conductivities. The worst case is called "visco-plastic deformation", which goes hand in hand with a complete loss of the conductivities and the constant decline of the soil organisms. Even a long term regeneration is questionable.
The third part provides different methods of prevention and gives recommendations. They consist, for example, of machine adjustments like inflation pressure or type of tyre. That means there are a lot of different ways to improve soil protection in dependence of machinery, soil mechanical properties, site and weather conditions, respectively.
In addition, the participants can exercise on practical examples by an interactive test.

The training, lasting one day only, is a helpful tool regarding the social demand of sustainability in soil protection. The presentation will outline the conceptual structure in detail by representative examples from the course itself.

1. Introduction

Due to increasing productivity heavy machinery with often severe consequences for the soil and tree stand is been used. Regarding soil impacts, the different soil structure deformations can be divided into three types:

a) „elastic deformation"
b) „plastic deformation"
c) "visko-plastic deformation"

The damage level increases from „elastic deformation" to "visko-plastic deformation". The optimum result can be achieved by "elastic deformation" with no heavy injuries for the soil and the surrounding tree stand. "Plastic deformation" causes compaction with middle-long term effects on the soil structure with his biological functions. The worst result is the "visko-plastic deformation" with heavy effects on the soil structure.

a. **b.** **c.**

Figure 1: The three different types of deformation. a. elastic deformation: only light marks of machine traffic; b. plastic deformation: compaction; c. visko-plastic deformation: heaviest impact with specific marks such as obligatory bulges besides the track

In order to avoid the last mentioned consequences the scientific knowledge about soil protection has to be transferred to the practice. Therefore a new training program was initiated by the Bavarian Ministry of Agriculture and Forestry in 2005/2006 and worked out by the Bavarian Forest Institute in cooperation with the Technical University Munich.

2. The training concept

The entire course has a duration of one day. It addresses not only to the qualified forest personnel, but also all people involved in forest harvesting operations such as contractors. That presumes a different state of knowledge in dependence of the required person. The consequence was to concept a training course which is easily understandable for everyone.

The training concept comprises four main chapters which partly contain subdivisions:

1. German law regulations
2. basics in:
    a. soil
    b. machines
    c. contact area pressure
3. impacts due to soil-machine interaction
4. Recommendations for environmentally sound forest operations regarding soil protection

The information is transported by power-point-sheets accompanied by demonstration objects. The last concerns especially the subject “soil”. The idea was to design a teaching program, which could be held by teachers with differing background in soil and machine knowledge. Therefore the training course consists of a comprehensive power-point-manual with detailed information in soil as well as machine basics. The following figure gives an example.

Figure 2: An example out of the teaching material. It shows the different soil alterations and gives additional detailed information

Demonstration objects support the information, such as e.g. a regular sponge could help to illustrate the pore size distribution in soils.

The **first chapter** starts with an overview of the German legislation regarding soil protection, nature conservation and general forest regulations. This shows that machine traffic in forests is subject to special restrictions.

The **second chapter** gives comprehensive information regarding the soil properties, such as e.g. grain size distribution, texture and conductivity for water and air. Not only the soil is focussed but also the machine characteristics are explained in detail, such as the load index, the inflation pressure and the tyre width. These are the main influencing factors to the contact area pressure.

Figure 3: Examples out of the second chapter. Each power-point-sheet is corresponding to the subdivisions soil, machines and contact area pressure.

The impact on soils and root system as a consequence of machine traffic is the subject of the **third chapter**. It gives an overview of the possible soil deformations, which are different in dependence of e.g. the soil moisture or the inflation pressure.

The range of **soil deformations** comprises light impacts such as the “elastic deformation”, medium-heavy such as the “plastic deformation” and the heaviest impact like the “visko-plastic deformation”. The consequences for the soil and also the root system range from short-term to irreversible. The “elastic deformation” is a only short-term deformation, after been trafficked the soil gains back its original structure. The “plastic deformation” is a typical compaction with effects on the biological soil functions, mainly reductions in water and air conductivities (fig. 4, a). It is a middle to long-term deformation. The worst case is the “visko-plastic deformation” with a total loss of the biological soil functions (fig. 4, b). The consequence is a horizontal orientation of the pore system which nearly causes the complete loss of gas exchange and leads to anaerobic soil properties. Soil fauna, especially earthworms, the most important organisms for building up the soil structure, migrate or die.

a. b.

Figure 4: Impacts on soil and consequences for the remaining tree stand. a. plastic deformation; b. visko-plastic deformation

The main steering parameter is the soil moisture during forest operations. The higher the soil moisture of a given soil type the higher the risk of impact. Assigned to the different types of soil deformation, low soil moisture causes mainly “elastic deformation”. With increasing soil moisture the soil alterations become more severe. Additional steering parameter are the Atterberg limits, which depend upon the plasticity of soils. Therefore a soil with a fine texture, such as clay, is highly sensitive to soil alterations compared to soils rich in skeleton.

Not only negative effects on the soil structure but also on the root system were expected. **Root damage** can be classified according to MENG (1978). The original classification was modified and one additional class was added: root breakage. The modified classification comprises five classes from simple bark peeling (classes 1, 2) beyond wood cracking (class 3) and splintering (class 4) to root breakage (class 5). Classes 1 and 2 are light impacts, affecting only the bark. Whereas classes 3 to 5 are greater impacts, that means infringements of the wooden body, which often implicates a high risk of fungal infection. Hence a loss in timber quality is expected. Wheeled machines and felastec tracks cause mostly classes 1 and 2, while steel tracks provoke predominantly classes 3-5. Figure 5 show typical injuries: the green coloured frames indicate injuries caused by wheeled machines, while the red coloured frames demonstrate characteristic caused by tracked machines.

Figure 5: Root damage. Wheeled machines and felastec tracks cause minor injuries, such as bark peeling and squeezing; steel tracks cause greater impacts, especially infringements of the wooden body

The topic of the **fourth chapter** consists of recommendations in terms of soil protection. It starts with an interactive test, which allows one, to prove one´s own knowledge. Subsequent optimized solutions will be developed: they comprise opportunities to avoid heavy impacts. There are a various range of different parameters with such a capability. For example, a possible reduction of the contact area pressure and with it the risks of heavy injuries are reasonable in the machine setting. That comprises the lowering of the load axle, reduction of the inflation pressure and also the enlargement of the tyre width. The greatest potential with about 50 % is based on the reduction of the inflation pressure. All these advantages have the capability to improve a given machine setting from a “worth” risk up to a “middle” risk.

Based on comprehensive knowledge in soil and machine basics and the awareness of possible “problems” during machine operations the participants of the course are well prepared even for difficult forest operations. Provided with effective recommendations they gain the ability to plan operations regarding soil protection and sustainable forestry.