Working time requirement for the management of semi-natural habitats

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Summary
Switzerland, with its topographically diverse structure, incorporates many different types of landscape elements and specific ecological habitats. There is broad consensus among politicians and society as a whole on the conservation of these varied and very different habitats.
Expenditure and income bear no economic relationship to each other in some sensitive areas. In many cases such land drops out of farm management, which is why various protective and promotional instruments have been created. One of these instruments is the compensation payment (ecological compensation (EC)), which compensates farmers for extra expenditure and lower revenue.
Work study data are required, firstly as a basis for adjusting the amount of EC, and secondly because work study data make it possible for both advisory services and farmers to identify and implement optimisation potential. It often proves difficult, however, to collect such data under practical conditions. The parameters and the problems of data collection are illustrated here.
The differences between different types of mechanisation are shown on the basis of four selected working procedures (mowing, handling, windrowing and bringing in). Suggestions are also made on optimising the collection of data.

Key word: time measurement, work load, model calculation, work time requirements, Ecological Compensation

Introduction and problem definition

In Switzerland's varied topographical structure there are many different types of landscape element, each with its specific ecological peculiarities. Behind this multitude of ecological landscape elements there are different types of habitats. As agricultural production intensifies and agriculture retreats from areas on which production is unprofitable, these are becoming endangered habitats, creating a threat to the existence of typical plant and animal species. This can also lead to a long-term change in scenery and hence significantly affect the attractiveness of areas frequented by tourists.
The consensus of society as a whole is to conserve such habitats and landscape types. This finds expression in different schemes. In Switzerland these include compensation payments (ecological compensation (EC)) for compensation areas (ECAs) under the Federal Ordinance on Ecological Quality (Öko-Qualitätsverordnung, ÖQV). The money from EC is intended to compensate for additional expenditure and lower income.
Work study data are needed, firstly to help adjust the amount of EC, and secondly because work study data make it possible for agricultural advisers and farmers to identify and implement optimisation potential.
The exact in situ recording of times and different influencing variables is a basic prerequisite for the correct evaluation and calculation of key work study figures and for ascertaining estimated labour requirement. In the case of qualitative influencing variables this poses special difficulties. The significance of the influencing variables recorded is determined by a multiple decomposition regression calculation.

Influencing variables

Gradient

The gradient is one of the most important influencing variables. Among other things, the choice of machinery used to manage an area depends on the gradient. The differences can be seen very clearly in Switzerland. In large parts of the lowlands tractors with tractor-mounted implements are mainly used for grassland management. In the hill zone and mountain area twin axle mowers (TA), transporters and motor mowers are chiefly used. The maximum gradient at which a machine is used varies from farm to farm. The measurements taken indicate that in most cases tractors are used up to a gradient of approximately 35 %. Work on slopes of between 35 % and 60 % is carried out mainly with a TA. On land with a gradient of over 60 % work is predominantly carried out using a motor mower or scythe. It is difficult to make an accurate breakdown, as differing gradients mean that two different systems are used on some areas.
The gradient also has a considerable effect on (effective) working width. On the one hand this is caused by design-related lower theoretical working widths, on the other by reduced working speed on slopes. Working safety must be borne in mind when a motor mower or scythe is used.

Obstructions

Obstructions also have a major impact on the working time required. Two influencing variables play a significant role here. The working time requirement of an area is increased by a detour or any additional manoeuvres, as well as by the extra use of manual labour.

Plot size and shape

The area and shape of the plot play a crucial role. Total plot area is relatively simple to record, but recording the shape of a plot correctly poses a considerably greater problem. Here this problem was taken into account in the underlying recording by including the necessary turning manoeuvres. The time for the turning manoeuvre and the type of turning manoeuvre were recorded. Turning manoeuvres were classified as 90° turns, 180° turns and shunting. A drawing of the area was also made.

Type and frequency of use

The type and frequency of management measures are crucial. Thus each type of meadow and each type of landscape traditionally has an appropriate use. Over- and under-usage lead to a change in the species spectrum (species impoverishment) and hence also to a change in biodiversity.
This adapted utilisation affects the performance of work. When examining one year it is not significant whether an area is used once or twice, for example. The type of usage also plays a role. Species-poor fertile grassland with a high yield are often managed with high-impact rotary equipment (rotary mowers). Rough pasture of high ecological potential is generally managed with precision cutting equipment (cutter bars and double cutter bars).

Method, procedure and data collection

The starting point of this study was a fundamental review of the existing literature. It was striking that a number of things were found on mountain mechanisation and farm organisation in the mountain area, but hardly any key work study figures. The underlying results here were obtained according to the formula of Schick M. modified in accordance with Auernhammer H. (see Figure 1).

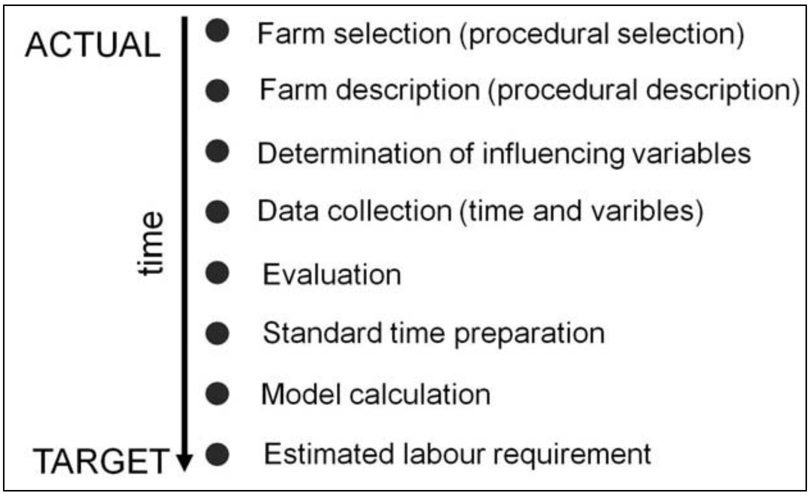

Figure 1: Procedure when compiling working time studies (Source: Schick, M. (2006))

The farms studied (n = 14) were randomly selected. The working procedures in question were derived from the manageable landscape elements. These were defined as follows: mowing, handling, windrowing and bringing in. The data underlying this work were recorded by a causal method and therefore correspond to a "causal working time classification". In other words, the procedures were logically subdivided into task elements and the times recorded. The classification is shown in Table 1.

Table 1: Classification of workflow segments by Schick M. modified in accordance with REFA

Symbol	Type of time
t_H	effective time (e.g. time spent mowing)
t_N	ancillary time (e.g. filling)
t_S	disturbances/down time (e.g. rectifying faults)
t_{RF}	Field set-up time (e.g. work preparation/follow-up, adjustment)
t_{RH}	Farm set-up time (e.g. attaching, detaching)
t_W	travelling time (e.g. transport)

Thus, for example, the mowing process was subdivided into different workflow segments such as "mowing grass with motor mower", "turning with motor mower", "preparing motor mower", "starting motor mower", "thorough routine cleaning of motor mower" etc. Disturbances were recorded in the same way, e.g. "telephone call" or "private conversation", "machine malfunction" or "breaks". Interruptions to work not associated with the job in hand, for example private conversations, were not included in the subsequent calculations. According to the REFA method, humans and their work are the limiting factor. This is therefore central to the classification of workflow segments in types of time (see Table 1). The working time for a procedure is the sum of all the workflow segment times and is therefore calculated using the equation below:

$$\text{working time (t)} = t_H + t_N + t_S + t_{RF} + t_{RH} + t_W$$

Data collection took the form of job observation. The actual times of each task element were recorded by means of Pocket PC (Dell Axim X50). This contains a microphone which allows the device to be used as a dictating machine, thus saving brief situation descriptions in spoken form as an audio file. The operating system used was Microsoft Windows MobilTM Version 5. "ORTIM b3" Version 1.05 software was used to record the data. This software allowed to register times and assign them directly to the appropriate workflow segment. It was also possible to define workflow segments as cyclic or non-cyclic.

Depending on type, distances were recorded in different ways during or after work observation. A mechanical road wheel of 10 cm measurement accuracy was used for distances and routes. Plot length and width were measured in approximate rectangular or square form or correspondingly subdivided partial areas.

The Garmin Gpsmap 60 CS GPS device was used as well. Without a correction signal it has an accuracy of 5 - 7 m and includes an area calculation function. Because of its relatively great inaccuracy this device was used only occasionally for recording sizeable areas or relatively long distances on foot.

The Gradient was recorded with a “Suunto PM-5/360 PC pocket inclinometer”. This is a manual gauge which can be operated with only one hand. It has a scaled measurement range of 0 to +/- 90° gradient angle and a 0 to +/- 150 % gradient.

The “MDL LaserAce 300”, a trigonometric laser, was also used. Using the MDL LaserAce 300 makes it possible, among other things, to determine distances, areas and angles of inclination. It has a working range of 300 m (5 km with reflector), an accuracy of 10 cm and a resolution of 1 cm. This device was employed to determine areas and direct distances.

The recording of data is affected by inaccuracies. There are two different reasons for this, firstly the person measuring the data, and secondly technical sources of error. A lot of data does not lend itself to automatic recording, or only with great difficulty. A device must ultimately be operated, adjusted, read etc. by only one individual. Here, as in other fields, errors can occur due to tiredness, lapse of concentration, distraction or similar. Reaction times are reduced, particularly in monotonous repetitive procedures. In the case of time measurements this can sometimes affect the result.

The use of electronic aids can reduce errors. The shadowing of satellites by trees, shrubs, mountains etc. poses a problem here. Even differing climate-related signal transit times can adversely affect position sensing.

When the area is recorded mechanically using a mechanical road wheel, the exact area can only be measured up to a point. Here uneven ground leaves its mark on distance, and land geometry is seldom consistent with common polygons. Slip also affects the distance measured. Compared with the change due to slip and uneven ground, the effect of slip is so small as to be negligible.

The use of a trigonometric laser likewise has potential for inaccuracy. The optimum measurement result is obtained with a 90° angle of incidence at the measuring point. This is seldom achieved without a reflector on the ground.

The data was evaluated with “ORTIMzeit” Version 4 software. The program facilitates a detailed summary of individual workflow segments. Among other things, the average working time of all the recorded measurement points of the workflow segment per reference quantity or cycle is displayed. Standard times were compiled with the results of the different measurements and served to calculate the working time requirement within a calculation model. In order to preclude the risk of falsification due to outliers in the calculation of standard times, the recorded actual times were subjected to statistical analysis using the Excel table calculation program. The arithmetic mean, median, minimum/maximum value, standard deviation, variance and coefficient of variation were investigated. The mean of the recorded actual times of a workflow segment gave the standard time.

A model which establishes a logical link between individual workflow segments is needed in order to use the data and standard times obtained to calculate the working time requirement. The PROOF model calculation system is used for this job. This was developed at Agroscope Reckenholz-Tänikon Research Station and allows the anticipated time requirement of the working procedure employed to be determined independently of a farm or a production method.

Results

Mowing

The individual mowing methods exhibit great differences in relation to working time requirement (MPh).

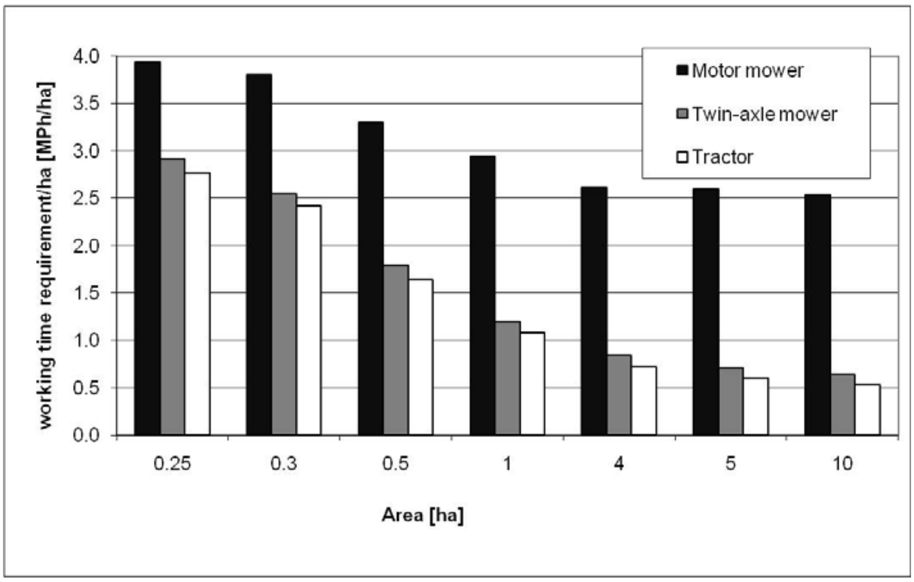

Figure 2: Comparison of the working time requirement of motor mower, twin axle mower and tractor methods

Figure 2 shows the evolution of working time requirement per hectare (MPh) as management area increases, subject to the mowing system used. Mowing with a motor mower (working width: 1.8 m) requires 3.94 MPh for an area of 0.25 ha compared with 2.91 MPh for mowing with a TA (working width: 2.2 m) and 2.77 MPh for mowing with a tractor (working width: 2.7 m). The motor mower was driven at 3.2 km/h, the TA and tractor each at 9.5 km/h. As the management area increases the working time requirement per hectare reduces for all mechanised methods.

Handling

The three methods of handling the mown material show differing working time requirement figures (see Figure 3).

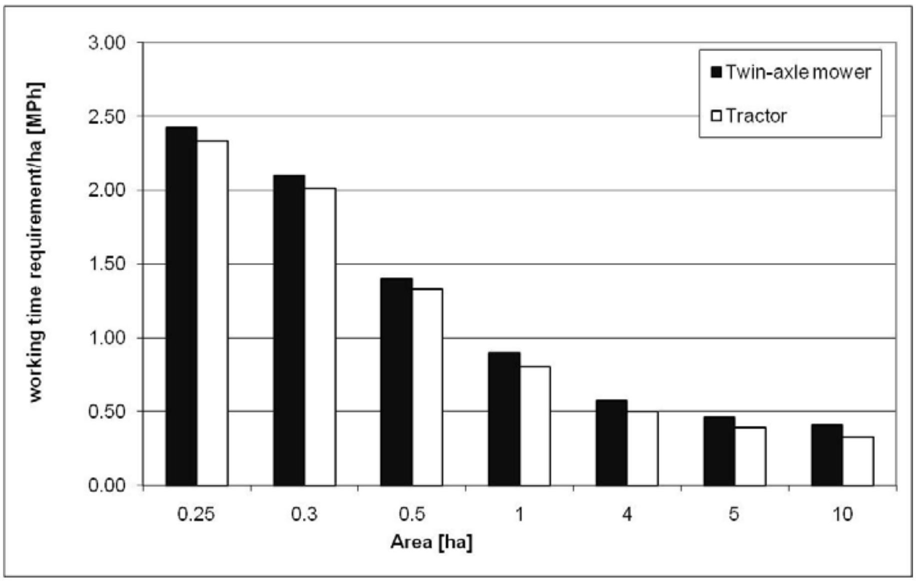

Figure 3: Working time requirement per hectare of individual handling methods (working width: TA = 5 m, tractor 6.5 m)

Figure 3 shows the evolution of working time requirement in MPh/ha by management type as management area increases. With manual handling the working time requirement per ha is constant at 12.83 MPh/ha, therefore runs parallel to the abscissa and was not included in Figure 3. With TA handling (working width: 5 m) the working time requirement per ha is 2.42 MPh/ha on an area of 0.25 ha. The working time requirement for tractor mechanisation (working width: 6.5 m) is 2.33 MPh/ha on 0.25 ha. TA and tractor were both driven at 6.5 km/h.

Windrowing

Figure 4 shows the evolution of working time requirement in MPh/ha for TA and tractor windrowing as management area increases. When TA windrowing the working time requirement was 2.49 MPh/ha on an area of 0.25 ha.

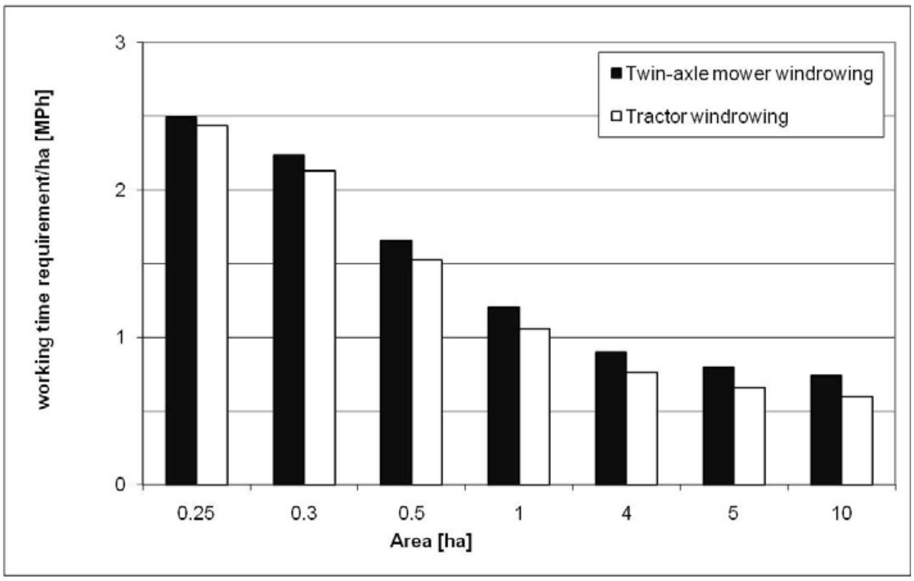

Figure 4: Working time requirement per hectare of individual windrowing variants

The tractor working time requirement is 2.43 MPh/ha for 0.25 ha. As in handling, the tractor was driven at 6.5 km/h. The working time requirement per ha for manual handling is constant at 32.5 MPh/ha, therefore runs parallel to the abscissa and was not included in Figure 4.

Bringing in

In addition to the common definition, bringing in included road transport from field to farm, but not putting into storage.

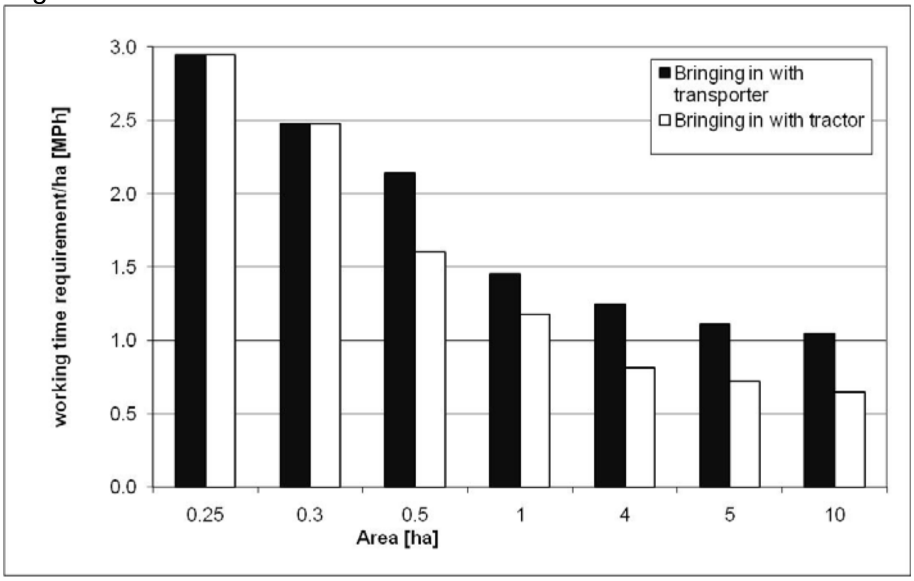

Figure 5: Working time requirement per hectare for bringing-in variants

Figure 5 shows how working time requirement evolves as cultivation area increases, depending on the type of system used for bringing in. The area in ha is shown on the abscissa and the requisite working time requirement values on the ordinate. It is striking that when small areas were worked both bringing-in systems had the same working time requirement per area. The difference was only significant on an area of 0.5 ha or over. Both bringing-in methods needed 2.94 MPh/ha for 0.25 ha and 2.48 MPh/ha for 0.3 ha. 2.14 MPh/ha was needed for 0.5 ha when using a transporter, 1.6 MPh/ha for 0.5 ha with a tractor. The loading volume of the transporter with a loading attachment was 13 m^3 and of the loader waggon 25 m^3.

Conclusions

In future the management of ECAs will also require varying mechanisation and additional working methods. Job observation is an appropriate method of collecting work study data. The use of additional technology seems a sensible way of ruling out potential errors or inaccuracies or reducing them further. The use of DGPS or dual-frequency DGPS would therefore represent sensible optimisation, with an improvement in accuracy to 1 2 m and 0.1 0.5 m respectively. Distances can be recorded accurately in real time if this technology is used directly on the implement.
Likewise, the use of a (high speed) camera with appropriate software for analysis and evaluation appears desirable. This can subsequently help to elucidate one or other measurement point and so aid considerably in reducing the number of unusable measurement points. In combination with DGPS technology on the implement, perfect clarification of position, work element and situation can also be obtained.
The use of modern technologies is no substitute for manual measuring instruments such as mechanical road wheels, inclinometers and stopwatches, as the latter are indispensable for cross-checking. They do, however, permit greater precision and further analysis.

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