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A METHOD FOR THE USE OF EXPERTS EXPERIENCE IN QUALITY MANAGEMENT

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Abstract: *Nature oriented forestry is characterised by a high variation of forest structures, silvicultural measures, products, working conditions. This particularly affects feasibility and acceptance of forest operations. A method is suggested to utilise local experiences of experts for quality management in order to reduce risks caused by harvesting operations. Very often general rules about the implementation of forest machinery and harvesting methods are set up in advance before applying refined planning methods. In difference to that the core idea here was to start with putting the individual harvesting case into the centre of consideration.*

1. Focus on harvesting situations

The concept is based on standardised descriptions of the individual "harvesting situation". A harvesting situation is defined by parameters of the pre harvest frame conditions like terrain, forest structure and by the definition of the harvesting operation itself like cutting intensity, organisational aspects and applied harvesting methods. The list of included variables was developed by interviews and discussions with practitioners in management of harvesting operations. Soil conditions were indirectly represented by referring to regional growth zones and forest districts.

2. Pilot study: random sample and generator of harvesting situations in regeneration stands

In a first phase a random sample of 160 foresters all over Bavaria evaluated 520 artificially generated harvesting situations. The interviews were done before a organisational reform of the forest districts took place. Thus the results represent the frame conditions in the last years of the former Bavarian State Forest Administration.

Each forester was personally instructed and interviewed. For that purpose a generator of artificial harvesting situations had to be created. The following principles were considered:

- use metric variables as far as possible
- start with basic variables from which others can be derived easily
- obey limitations in stem numbers, heights and diameters
- the variables of stand and site description and their combinations have to stay within ranges possible in nature.

For the construction of a situation-generator two competing aspects have to be considered: On the one hand it is necessary that the harvesting situations exceed borders of implementation of harvesting technology and borders of acceptance as regards planned measures. This is necessary in order to detect the position of these border zones. On the other hand these assumed border zones should not be exceeded too far so as to keep the portion of acceptable cases and cases within border zones high enough.

After production of situations a further precondition was the foresters to confirm that they could imagine the presented site conditions and stand structure. Refused stand structures and site conditions were not discussed whereas all operations suggested by the generator had to be evaluated: The generator suggested random-measures e.g. between clearcuts and extremely selective cuts of a very few single trees.

3. Dimensions of evaluation

The success or failure of each harvesting situation had to be evaluated individually by experts. This assessment was separated into angles of view which may be called "dimensions of evaluation". These selected "dimensions" were technical feasibility ("technology and methods"), organisational feasibility ("manager"), work safety and health ("humans"), silviculture ("forest stand"), nature protection ("species, habitats"), soil conservation ("soil physics and chemistry"), timber procurement ("market, industry") and economy ("money").

The resulting variable was the probability of success respectively acceptability estimated by the expert for each dimension of evaluation and for 6 different technical harvesting methods. The technology of these variants could be understood as available technical options. These technical variants were defined in a experts workshop at the beginning of the project:

1. chainsaw - cable skidder
2. chainsaw - forwarder
3. chainsaw - full trees - cable skidder - harvester - forwarder
4. chainsaw - multiple length of butt logs cut off from full trees - harvester - forwarder ("Königsbronn")
5. chainsaw - full trees - harvester - forwarder
6. harvester - forwarder

Randomly wrong measures where absolutely intended to find the borders of acceptance. The foresters in many cases got outraged about these "wrong suggestions" although there was absolutely no intention to convince them of the suggested random operations. In that case it was possible to motivate them by hinting at the importance of their negative answer because otherwise the acceptance in comparable situations would have been statistically overestimated.

4. Some Examples of data analysis

4.1 Mean values in a range of comparable situations

A first approach may be to select cases within a certain range of frame conditions in order to calculate mean values of acceptance. Interactions between variables can cause in detail realistic but at the first moment surprising interconnections which are difficult to be interpreted within bigger samples of situations. Therefore it is important to mention that selected ranges have to be defined rather precisely. The randomly generated situations do not represent real life samples and intentionally include rather extreme conditions! That method comes close to a Bayesian approach and could be further developed in that direction. Extending the idea of this pilot study and sufficient data of practical cases assumed, it is suggested to ease data bank enquiries of experts in order to estimate planning risks.

4.2 Trendlines depending on selected variables

Furthermore within these selected ranges the statistical influence of a variable (e.g. mean timber volumes per tree or skid track distances) on estimated probabilities can be demonstrated. One option would be to use preliminary trend lines as shown below. Of course instead of such trend lines logistic regression models were used as well.

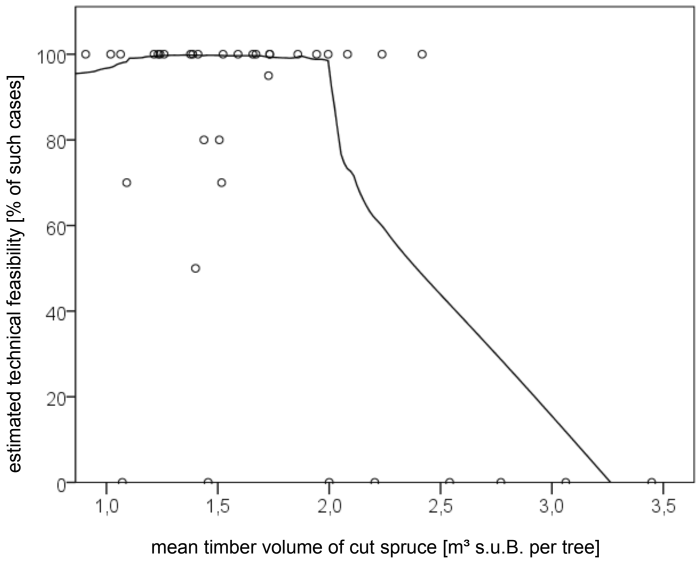

Figure 1. Decrease of technical feasibility of the pure harvester forwarder method with rising mean tree volume of cut spruce (selected range: more than 50 m³ of cut spruce / ha, skid trail distance <= 21 m, less than 300 m³ per week).

In comparison to that the silvicultural acceptability is significantly lower. But the form of the trend line is significantly different (Fig 2). The acceptance rises up to 2 m3 per stem, and again decreases with higher volumes. This is interpreted as example of two interconnected effects: on the one hand, technical feasibility and silvicultural acceptance are interlinked. Thus as well as technical feasibility, the silvicultural acceptability decreases with rising tree volumes because of emerging technical problems to handle the cut trees (damages to remaining stand). But on the other hand the silvicultural acceptance increases from very low tree volumes up to mature trees. This is a rather simple example for interconnections of different characteristics.

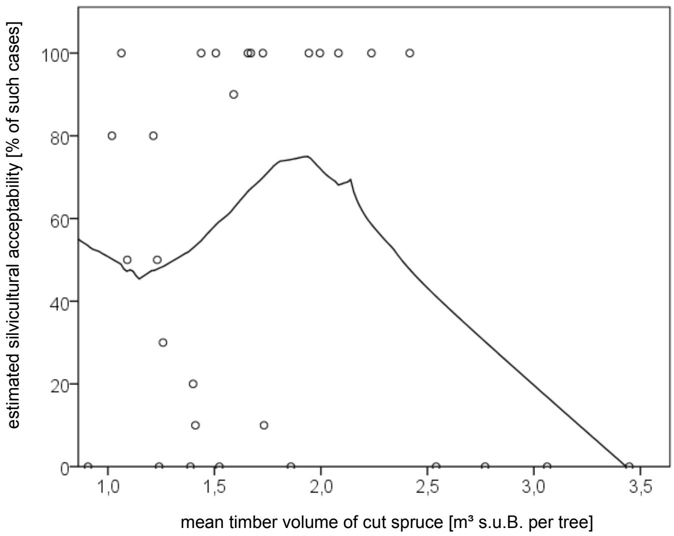

Figure 2. Silvicultural acceptance technical feasibility of the pure harvester forwarder method with rising mean tree volume of cut spruce (selected range: more than 50 m³ of cut spruce / ha, skid trail distance <= 21 m, less than 300 m³ per week)

4.3 Multivariate logistic regression models

To a certain extend it is possible to model the experts estimation by more complex combinations of multivariate regression. In order to derive upper thresholds of feasibility some basic deliberations were applied as roughly described below:

- Regarding every influencing variable, the existence of a global optimum is assumed within the range of possible situations. Especially there exists a range of situations with 100% feasibility for every harvesting method.

- Partial multivariate models were standardized by using the optimum value as a 100 % reference

- Upper borders of estimated feasibility were derived by the multiplication of these standardized multivariate models of feasibility.

The idea was to estimate values of feasibility respectively acceptance for each dimension of evaluation and each harvesting method. This way of modelling acceptance is rather demanding in detail. Professional knowledge about details of harvesting practice and interconnections of variables is required. Still a lot of refinement work has to be applied. The results estimate feasibilities and acceptance optimistically (upper limits). So far the results are interpreted as first indicators of feasibility respectively acceptance. By that means it might already be possible to apply optimisation methods in bigger lists of planned harvesting operations.

4.4 Simple comparisons of accepted and not accepted situations

It was possible to derive tables with thresholds of acceptance for many variables just by comparing percentiles of these variables resulting from e.g. cases at 100 % acceptance and cases at 0%.

Table 1. Example skid trail distance: thresholds of technical feasibility derived by comparison

Skid trail distance m]	„regular case“	related percentile	threshold	related percentile
1 chainsaw - cable skidder	<= 35	66	<= 50 (60)	90
2 chainsaw - forwarder	<= 30	66	<= 45	90
3 chainsaw - full trees - cable skidder - harvester - forwarder	<= 35	66	<= 50 (60)	90
4 chainsaw - multiple length of butt logs cut off from full trees - harvester - forwarder (“Königsbronn”)	<= 30	66	<= 45	90
5 chainsaw - full trees - harvester - forwarder	<= 30	66	<= 45	90
6 harvester - forwarder	<= 25	66	<= 35	90

Table 2: Example production per week: thresholds of organisational feasibility derived by comparison

Production per week [m3 s.u.B.] (until date of delivery)	„regular case“	related percentile	threshold	related percentile
1 chainsaw - cable skidder	<=70	66	<=230	90
2 chainsaw - forwarder	<=70	66	<=240	90
3 chainsaw - full trees - cable skidder - harvester - forwarder	<=90	66	<=280	90
4 chainsaw - multiple length of butt logs cut off from full trees - harvester - forwarder (“Königsbronn”)	<=110	66	<=380	90
5 chainsaw - full trees - harvester - forwarder	<=110	66	<=400	90
6 harvester - forwarder	-	66	<=450	90

Table 3. Example cut volume per ha: thresholds of acceptance as regards soil protection

Cutting intensity [m³ s.u.B. / ha]	„regular case“	related percentile	threshold	related percentile
1 chainsaw - cable skidder	<=110	66	<=220	90
2 chainsaw - forwarder	<=110	66	<=220	90
3 chainsaw - full trees - cable skidder - harvester - forwarder	<=110	66	<=250	90
4 chainsaw - multiple length of butt logs cut off from full trees - harvester - forwarder (“Königsbronn”)	<=120	66	<=250	90
5 chainsaw - full trees - harvester - forwarder	<=120	66	<=250	90
6 harvester - forwarder	<=120	66	<=260	90

4.5 Comparisons between harvesting methods

The direct comparison of different harvesting methods shows the grade of acceptance in practice. Surprisingly the acceptance of highly mechanised methods was rather high among foresters.

5. Relations between estimations in different dimensions of evaluation

Final remarks

indicators for scopes of harvesting methods under certain frame conditions. On the other way round, there is the potential to indicate and minimise risks in harvesting planning.

In future practice it should be possible to create a real life data base. The concept can be designed dynamically and provides a means to describe the actual state of harvesting practice. It potentially enhances communication and focus discussions in order to improve the quality of harvesting operations. In turn it is possible to further develop the technical expertise of foresters. Other than by just filling checklists the necessary feedback loop of real quality management could be closed. Such data bases would finally allow for learning a lot about on site estimations and decisions made in practice.

So far it is denoted to be careful with generalised applications of feasibility onto the single case. Interferences between variables cause broad ranges of individual situations. Thus methodological

approaches oriented at individual situations should provide advantages which up to now had rarely been used in forest science.
The basic steps to be done are rather simple:

1. Establish standardised descriptions of harvesting situations (random sample before operations start)
2. Apply evaluation scheme at single situation in practice by qualified experts (after operation)
3. Create data bank of evaluated harvesting situations: failure, success
4. Use data bank inquiry (or more refined analysis) for future plannings
5. Feed information back to practitioners, experts

A close look at harvesting processes in practice is opened. It is clear that the results of evaluation depend on the selected groups of experts. Therefore the results are dynamical and show the actual state of expertise. By the way, communication, experience and the basis of discussions can be improved. There is the potential of continuous improvement and dynamical adaptation. The feedback loop of quality management would be closed.

The reference to practice in real life affects natural resources, humans and economy. This is seen as an indicator of relevance. And it is furthermore expected that research on relevant topics will face impediments. First of all it is necessary to convince politics to fund projects, second to get data from running enterprises, third to gain high quality results and objective interpretation of nonlinear interconnections, third to secure fair discussions.

Running processes of resource utilisation in practice are phenomena of real world in a visible range of scale. There are large potentials for scientific research in that field.