Evaluating Soil Conservation Using High Resolution Air Photos and Expert Elicitation

FREP

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1.0 Introduction

Cost-effective monitoring is needed to ensure that British Columbia's forest soil conservation policies encourage practices that protect soil productivity and hydrologic function following forest harvesting. A monitoring protocol to evaluate soil conservation at the cutblock level was developed as part of the provincial Forest and Range Evaluation Program (FREP); this protocol outlined a set of indicators of sustainability and the procedure for evaluating them in the field (Bulmer et al. 2008; Curran et al. 2009). The procedure was used to obtain evaluations for more than 70 cutblocks from 2005 to 2009, but some field staff believed that the procedure was too complex for operational use.

To address this concern, a new, more efficient approach was tested. This approach, called expert elicitation, is commonly used for complex problems with considerable uncertainty (Sutherland 2006). If successful, this approach could identify cutblocks where soil conservation objectives may not have been achieved and allow field staff to focus resources on sites where such problems are most likely to occur.

1.1 *Objectives*

The overall goal of this project was to evaluate soil conservation effectiveness with high resolution images, expert elicitation, and field surveys. In addition, specific objectives included (1) providing recommendations regarding further use of these methods in monitoring the effects of forest practices on resource values in British Columbia, and (2) providing recommendations for continued improvement of management practices as they affect soil conservation.

2.0 Method for Expert Elicitation Using High Resolution Images

2.1 *High Resolution Images and Sample Population*

High resolution, geo-referenced images were obtained for more than 120 cutblocks throughout British Columbia (Figure 1). Images were obtained from each of 26 forest districts using a random sampling approach (Curran et al. 2009). Sites were selected from among those cutblocks that were harvested with ground-based operations in the absence of snow or frozen soils. The photographs were taken within 2–3 years of harvest and with minimal shadow effect.

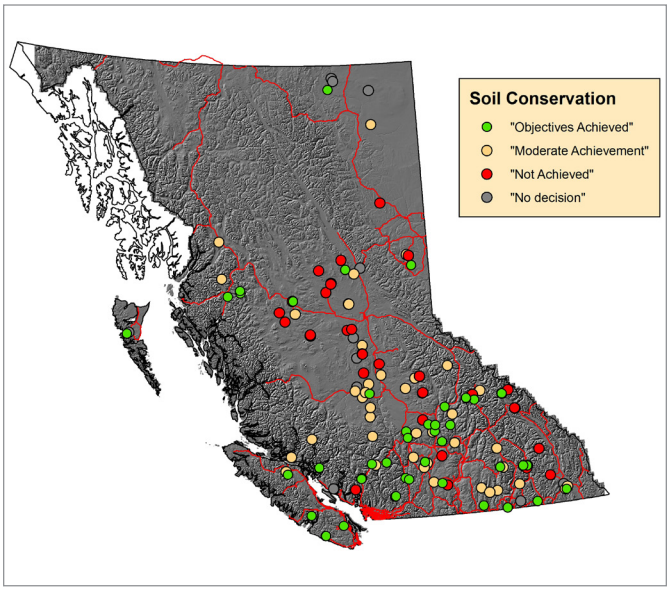

Figure 1. *Location of cutblocks where soil conservation effectiveness was evaluated using expert elicitation with high resolution images.*

The purpose of FREP Extension Notes is to provide the results and recommendations of the monitoring and evaluation of British Columbia's natural resource values for those who impact and influence the management of these resources.

FREP Mission: *To be a world leader in resource stewardship monitoring and effectiveness evaluations; providing the science-based information needed for decision making and continuous improvement of British Columbia's forest and range practices, policies and legislation.*

All FREP monitoring indicators, protocols and publications can be found on the FREP website at: http://www.for.gov.bc.ca/hfp/frep/index.htm

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Field Evaluations of Soil Conservation

Field staff carried out site visits and assessed soil conservation based on the FREP protocol for 73 cutblocks with imagery.

Expert Elicitation Using High Resolution Imagery (EEHRI)

Eliciting expert judgement involved an eight-step process where cutblock images were displayed through an internet conference (Live Meeting) with a minimum of three experts in attendance. The structured viewing was designed to ensure that a consistent approach was applied to each image, and to address some of the potential drawbacks of expert elicitation. Optimizing EEHRI requires consideration of the need for, among other factors, (1) a common and clear understanding of the objectives, (2) collaboration, (3) evaluator anonymity/autonomy, (4) replication and control, and (5) an "iterative" process.

3.0 RESULTS AND DISCUSSION

3.1 *Soil Conservation Achievements as Assessed by EEHRI*

Results of EEHRI indicated that soil conservation objectives may not have been achieved on about 25% of the 128 cutblocks for which decisions were reached, and that about 75% of cutblocks had at least moderate achievement of soil conservation objectives. The study found examples of successful management in all areas of the province, but at the same time, no region appeared to be completely free of concerns regarding soil conservation.

The major issues affecting soil conservation included soil disturbance in the net area to be reforested (NAR) and roadside work areas (RWA), access, drainage, and the availability of mature forest inoculum. Soil disturbance in the NAR and RWA was the most important trigger of the "not achieved" result. In contrast, even though insufficient mature forest inoculum (i.e., mature trees left on the cutblock) was commonly identified as a concern, this indicator was unlikely on its own to trigger an overall assessment of "not achieved" for the cutblocks evaluated.

3.2 *Understanding the EEHRI Method*

To better understand the elicitation process, we evaluated the level of agreement among the expert responses for individual cutblocks, and how the results changed over time. The experts had a high level of agreement for most cutblocks and the overall pattern of response was similar at the end of the process to what it was at the start.

Assessments replicated on 14 randomly selected cutblocks indicate that there was broad (but not complete) agreement between initial and replicated assessments, providing some confidence that the experts were evaluating soil conservation consistently over the 6 months during which the assessments were carried out.

The implications of consistent scores and good replication are that the method was internally consistent. It is an important first step in demonstrating the usefulness of the EEHRI method, but does not necessarily imply that the results are accurate. Results obtained from expert elicitation are highly dependent on who is selected to provide assessments (i.e., the makeup of the panel). Our evaluators were all Ministry of Forests, Lands and Natural Resource Operations and Ministry of Environment soil scientists who were intimately familiar with the development of soil conservation policy in British Columbia's forests. The structured expert elicitation method is flexible: it could be adapted to test whether the underlying concepts related to soil conservation are valid, and if potential concerns are equally shared by other resource professionals in British Columbia, or soil scientists from other jurisdictions.

3.3 *Soil Conservation Achievements as Assessed by Field Surveys*

Field surveys completed on 73 cutblocks from 16 forest districts showed that field staff believed soil conservation objectives were achieved for 43 of the cutblocks, while results for a further 19 cutblocks were consistent with a moderate achievement of the soil conservation objectives. Field surveys ranked only five cutblocks as not having met soil conservation objectives, and they were unable to decide on an overall score for six cutblocks (Table 1).

Table 1. *Results of field surveys for achievement of soil conservation objectives, and comparison with the expert elicitation using high resolution imagery (EEHRI) results for 73 cutblocks.*

	EEHRI: ACHIEVED	EEHRI: MODERATE	EEHRI: NOT ACHIEVED	TOTAL FIELD
Field: Achieved	19	20	4	43 (59%)
Field: Moderate	2	9	8	19 (26%)
Field: Not achieved	0	1	4	5 (7%)
Field: Don't know	3	2	1	6 (8%)
Total EEHRI	24 (33%)	32 (44%)	17 (23%)	73

3.4 *Comparison of Expert Elicitation and Field Surveys*

A comparison of the results between field surveys and expert elicitation suggests that, despite the significant discrepancies in overall cutblock rankings, experts and field staff were close in their assessment of soil disturbance and of individual stewardship questions. The expert elicitation process identified more problems than the field surveys, which may partly reflect the broader perspective provided by the high resolution images and the resulting ability to better integrate findings for an entire cutblock.

4.0 CONCLUSION

Based on the analysis of cutblocks where both field data and EEHRI interpretations were available, we conclude that the percentage of cutblocks where soil conservation objectives are not being met ranges between 13.6% (from re-evaluated field surveys) and 23% (expert opinion using EEHRI). Results from field surveys and EEHRI appear to agree on most of the major questions related to soil conservation.

The combined results are consistent with the conclusion that soil conservation objectives were at least moderately achieved on some 82% of summer-harvested cutblocks harvested during the 5-year period.

The most common soil conservation problems identified were related to disturbance in the roadside work areas and the net area to be reforested, drainage, access construction, erosion, and the presence of mature trees for soil organism inoculum.

In addition, our results demonstrate the power of high resolution air photos for assessing soil conservation and for potentially evaluating other resource values. Considering the relatively high level of agreement of EEHRI with field surveys on individual questions related to soil conservation, we conclude that EEHRI has the potential to improve resource monitoring on recently harvested areas in British Columbia, at least as a screening tool before field surveys.

Our preliminary results also suggest that the EEHRI method likely has general application to other potential issues in resource management in British Columbia (e.g., images could be of interest as a tool for compliance and enforcement staff). The method allows for a wide range of expertise to be included on problems in resource management.

RECOMMENDATIONS

1. Soil productivity and hydrologic function are being protected on the majority of cutblocks we observed from throughout British Columbia, but opportunities exist for improving this record. Specifically, efforts should be undertaken to:
   - Reduce soil disturbance through improved planning by designating skid trail locations and/or patterns, and considering the importance of soil organism inoculum in the location of single tree and patch retention.
   - Promote greater soil conservation awareness by communicating soil conservation principles to operators regarding the importance of minimizing compaction in roadside work areas, maintaining natural drainage systems and patterns, and avoiding concentration of skid roads in harvest areas.
   - Further evaluate the effects of harvest-related changes in mature forest inoculum and coarse woody debris on soil productivity, hydrologic function, and ecosystem resilience.
   - Continue monitoring soil conservation with the FREP protocol and long-term research studies.
2. Expert elicitation using high resolution imagery was effective for evaluating soil conservation, and could likely be applied to other types of resource monitoring. Efforts should be undertaken to further evaluate and realize the potential of this method.

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