FREP

REPORT #31

FOREST AND RANGE EVALUATION PROGRAM

December 2011

EVALUATING SOIL CONSERVATION USING HIGH RESOLUTION AIR PHOTOS AND EXPERT ELICITATION

Prepared by the Soils Value Team:
Chuck Bulmer, Shannon Berch, Bill Chapman, Stephane Dubé, Graeme Hope,
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Sustainability of Forest and Range Resources Through Science and Stewardship

MINISTRY OF FORESTS, MINES AND LANDS
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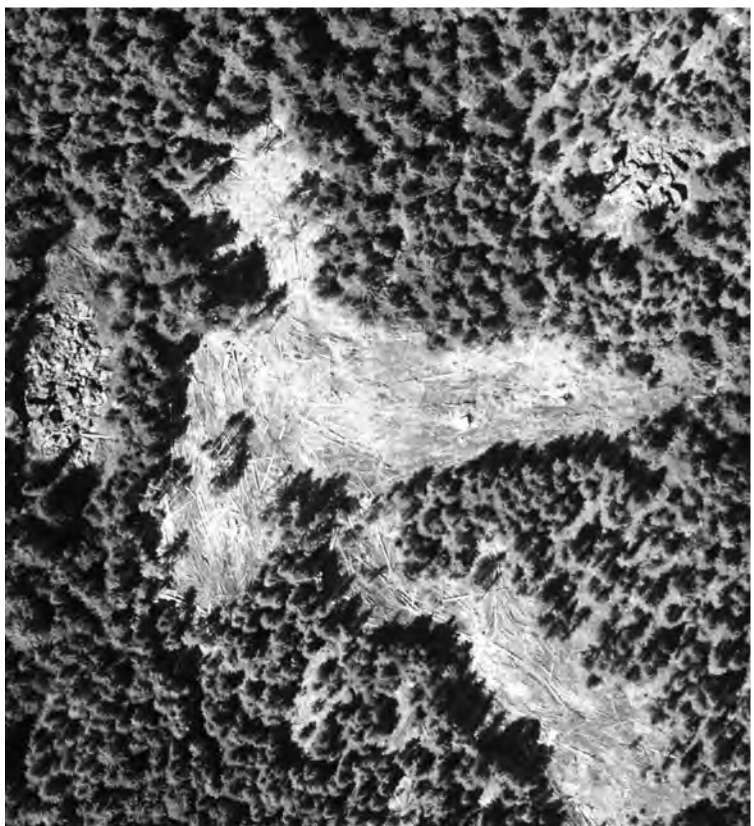

FREP Forest and Range Evaluation Program

BRITISH COLUMBIA

Management of forest and range resources is a complex process that often involves the balancing of ecological, social, and economic considerations. This evaluation report represents one facet of this process. Based on monitoring data and analysis, the Timber resource value team offers the following recommendations to those who develop and implement forest and range management policy, plans, and practices.

Citation:
Ministry of Forests, Lands and Natural Resource Operations. 2011. Evaluating Soil Conservation Using High Resolution Air Photos and Expert Elicitation. Min. For. Lands Nat. Resour. Oper., Resource Practices. Br., Victoria, B.C. FREP.
http://www.for.gov.bc.ca/hfp/frep/publications/index.htm

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ABSTRACT

Cost-effective monitoring is essential to ensure that soil conservation policies encourage forest practices that protect soil productivity and hydrologic function in British Columbia's forests. An effectiveness monitoring protocol was developed as part of the province's Forest and Range Evaluation Program (FREP) describing a set of indicators of soil conservation, and procedures for evaluating them in the field. The procedure was applied to more than 70 cutblocks over the 5-year period from 2005 to 2009. At the same time, high resolution images were obtained after harvest for the cutblocks, along with more than 60 others, totalling 125 cutblock images from 26 forest districts. The images were initially to be used to aid in the field evaluations, but subsequently became an integral part of an internet-based, collaborative approach to elicit the opinion of experts regarding soil conservation effectiveness. This report summarizes the results obtained from the image-based evaluations for more than 125 cutblocks, and compares the image-based and field-based results for 73 cutblocks. We discuss the implications for soil conservation monitoring in British Columbia, and the potential use of high resolution imagery to improve monitoring efforts and other essential natural resource management functions.

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 applied to more than 70 cutblocks over a 5-year period, but some field staff believed that the procedure was too complex for operational us—it required up to 2 days of field time to evaluate a single cutblock. To address this concern, a new approach was tested to see if a small group of experts could view high resolution images in a collaborative environment and provide an initial estimate of soil conservation effectiveness based on their responses to 9 soil conservation questions. If successful, this approach could identify cutblocks where soil conservation objectives may not have been achieved and allow field staff to focus their efforts where such problems were most likely to occur.

Sutherland (2006) described approaches for predicting the outcome of environmental change and making conservation decisions. Among various approaches that included extrapolation, experiments, and modeling, he described expert elicitation[1] as a commonly used approach for complex problems with considerable uncertainty. Despite an ongoing debate as to whether expert elicitation should be considered a scientific activity (Meyer and Booker 2001) when information is limited, as it often is when making conservation decisions, expert elicitation may be the only option available to incorporate scientific knowledge into decision making (Sutherland 2006). The U.S. Environmental Protection Agency has relied on expert judgement in environmental decision making since the late 1970s (USEPA 2009), and the questions regarding its use may best be focused on *how* to use expert elicitation, rather than whether to use it (NRC 2002).

For decisions based on expert judgement to be most effective, a structured elicitation methodology is required that addresses cognitive biases affecting experts during the elicitation process (Tversky and Kahneman 1974). The analysis and interpretation of resulting data also require special consideration (Sutherland 2006; Kynn 2008; O'Neill et al. 2008). The expert elicitation process inherently presents challenges with respect to aggregating/combining results across experts (USEPA 2009). In group elicitation, strong influences such as group pressures can shape the expert's opinion or group's outcome regardless of whether consensus is required (Forsyth 2010).

The cognitive biases described by Tversky and Kahneman (1974), including representativeness, availability, and adjustment/anchoring, have been thought by some to prevent or seriously obstruct efforts to arrive at reliable conclusions using expert elicitation. The representative heuristic refers to the tendency of people to rely too heavily on the extent to which two events or conditions resemble each other when evaluating probabilities; people tend to ignore other important information like the prior probability of an event. Availability refers to the tendency of people to assess likelihood based largely on the ease with which examples can be brought to mind, and to discount potential outcomes solely because they are more difficult to imagine. Adjustment and anchoring refer to the tendency for an initial estimate to have greater weight than subsequent adjustments. These cognitive biases can lead to flawed reasoning and poor decisions, even among experts. However, recent work suggests these biases can be overcome by adopting a structured approach to the elicitation process and the analysis of the resulting data (Kynn 2008; Cooke and Kelly 2010). These authors conclude that there is overall reason to be positive about the usefulness of elicited expert opinion, and results can be improved by considering their 10 recommendations for eliciting and analyzing expert opinion (Kynn 2008). According to the U.S. National Research Council, a rigorous use of expert elicitation for the analysis of risks is scientifically defensible and therefore can inform decision making in the presence of uncertainty or lack of data (NRC 2002).

Expert elicitation requires that experts be given consistent and reliable information about the problem and this information can take various forms. For resource monitoring, aerial photographs have long been used for resource evaluation and measuring the effects of forest management. Detailed studies of the factors affecting the measurement accuracy when aerial photographs are used came later (e.g., Naesset 1998). The use of digital

1 Expert elicitation, as used in this report, refers to the process of "drawing out" the judgement of experts. According to Meyer and Booker (2001), expert judgement "consists of information and data given by qualified individuals that in turn can be used to solve problems or make decisions."

imagery for quantitative resource monitoring is even more recent (Booth and Cox 2006; Matthews 2008). Recent advances in digital camera technology and image processing, along with high speed internet conferencing, have made it feasible to collect very high resolution images with excellent spatial precision at relatively low cost, and to display them to experts in different locations. Whereas technology costs have been declining in recent years, the cost of sending field personnel to remote sites has been increasing. These two factors have encouraged the search for alternative monitoring methods based on remote sensing and expert elicitation.

To summarize:

- The availability of high quality images at relatively low cost, along with increasing costs associated with deploying field staff for monitoring, suggests that a monitoring approach using high resolution imagery might be more efficient for soil conservation evaluations.
- The presence of uncertainty regarding the complex effects of soil processes on forest ecosystem productivity and stability provides an opportunity for improved decision making by aggregating the opinions of experts.

Both the use of imagery and expert elicitation have advantages and disadvantages (Table 1).

1.1 *Objectives*

We developed and tested a method for eliciting expert opinion using high resolution imagery (EEHRI) to evaluate soil conservation on recently harvested cutblocks in British Columbia. Our method builds on the *FREP Protocol for Soil Conservation* (Curran et al. 2009) and incorporates lessons from expert elicitation. The overall goal of this project was to evaluate soil conservation effectiveness with high resolution images, expert elicitation, and field surveys. Specific objectives were to:

1. Use a structured approach to elicit expert judgements related to soil conservation achievements by viewing high resolution images of more than 125 recently harvested cutblocks in British Columbia, and
   a. summarize the results of expert elicitation, and
   b. discuss the potential for bias and other factors that affect the reliability of conclusions drawn from expert elicitation.
2. Compare and contrast the results of expert elicitation using high resolution imagery with those from field surveys carried out independently by field staff on 73 of the cutblocks.
3. Provide a preliminary evaluation of whether the results indicate that soil productivity and hydrologic function are being conserved on recently harvested areas in British Columbia.

Table 1. The use of remote sensing imagery and expert elicitation for resource monitoring: strengths and weaknesses.

Imagery for resource monitoring		Expert elicitation for resource monitoring	
Strengths	**Weaknesses**	**Strengths**	**Weaknesses**
Provides a "bird's-eye view" of a large area.	No hand testing of soil conditions possible.	Results are correlated across regions.	Expert bias during elicitation.
Gives a wider perspective view of landscape (e.g., 3D view with elevation data).	Field surveys may still be needed to see some features.	A wide range of knowledge can be applied to the problem.	How to estimate variation and interpret results?
Facilitates observation through time.	Some indicators cannot be assessed using remote sensing (e.g., compaction).	If scientific info is scarce, it may be the only approach.	How to predict majority or minority influence in group elicitation?
Finer spatial resolution helps discriminate between ground features.		Experts may be best suited to incorporate uncertainty associated with data.	Risk of "conversion" when group experts are subject to strong influence.
Measuring distances and areas is easy by means of GIS mapping software.		Control for heuristics and biases when using process to formalize judgement.	
Lower cost for acquiring high resolution imagery compared to field surveys.			

4. Provide recommendations regarding further use of these methods in monitoring the effects of forest practices on resource values in British Columbia.
5. Provide recommendations for continued improvement of management practices as they affect soil.

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 125 cutblocks throughout British Columbia. Images were obtained from each of 26 forest districts (Figure 1) 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 so that vegetation regrowth did not obscure the effects of machine traffic on soils; where possible, images were obtained near mid-day or under conditions where the effect of shadows would be minimized. After stitching together numerous individual images into a panorama, the images were saved to disc as TIFF files.

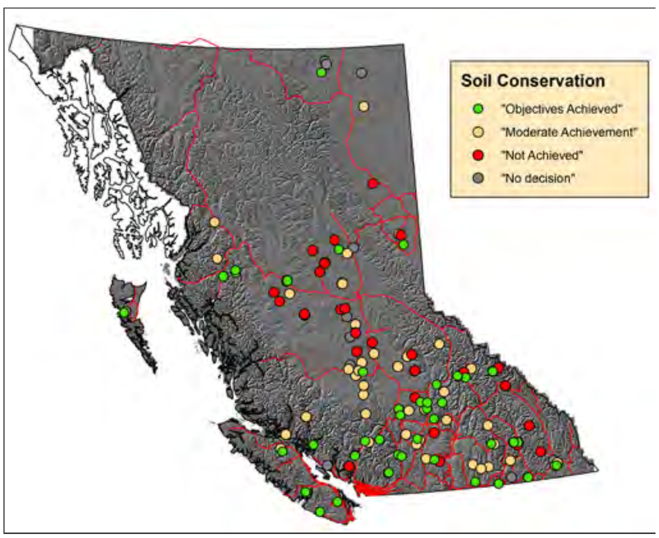


Figure 1. ***Location of cutblocks where soil conservation effectiveness was evaluated using expert elicitation with high resolution images.***

Field Evaluations of Soil Conservation

For more than 70 of the cutblocks with imagery, field staff completed assessments of soil conservation based on the FREP protocol (Curran et al. 2009 and previous versions of the FREP Protocol for Soil Conservation Monitoring).

Expert Elicitation

Our approach for eliciting expert judgement involved a structured process where cutblock images were displayed through an internet conference (Live Meeting) with a minimum of 3 experts in attendance. Each image was displayed in real time using ER Viewer 7.3 (Eridas Inc., Atlanta, Ga.). This software allows a navigator to zoom and pan the image following a standard approach, but also allows the experts to identify and view specific features of interest on a particular photo. Each expert provided interpretations of soil conservation questions (Table 2) for each image, including a decision regarding the overall extent to which the observed results were consistent with soil conservation objectives having been achieved. In addition, participants had the option to provide written comments on all questions and were alert for features that indicated other FRPA resource values could be at risk. To facilitate data analysis, all questions were structured so that an affirmative answer ("Yes") identified a concern for soil conservation. 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 described by Meyer and Booker (2001). Several key concepts guided the initial development of the method (Table 3), and the methodology is summarized in Table 4.

The cutblock images were displayed in random order over approximately 20 sessions spread over 28 weeks. For some cutblocks, a variety of problems (e.g., poor quality photos, brushed in blocks, lack of information on cutblock boundaries) prevented the group of evaluators from reaching a decision. After reviewing all of the available images, the evaluators were able to provide assessments of soil conservation effectiveness for 128 of the cutblocks.

3.0 RESULTS AND DISCUSSION

3.1 *Soil Conservation Achievements as Assessed by EEHRI*

Results of eliciting expert opinion using high resolution imagery (EEHRI) indicated that soil conservation objectives may not have been achieved on about 25% of the 128 cutblocks for which decisions were reached (Figure 2), and that about 75% of cutblocks had at least moderate achievement of soil conservation objectives. These values were consistent whether the expert opinions were aggregated based on the individual scores of each expert or the leading (i.e., most common) score for each cutblock.

Table 2. Response questionnaire for expert elicitation.

1. Does the total amount of permanent access seem excessive given the site conditions?
1.1 Are there portions of the un-rehabilitated access that should have been rehabilitated?”
1.2 Do any individual access structures seem larger than necessary?
1.3 Were pre-existing access structures, such as old roads and trails, present in the NAR?
1.4 Were pre-existing structures not used for access, where it appears that they should have been?
2. Is there evidence that harvesting, access construction, or maintenance have led to (or increased the potential for) mass movement or erosion?
2.1 Are there any potential or existing off-site effects related to mass movement, erosion or sedimentation evident?
3. Are there areas where measures should have been taken to restore natural drainage patterns, but they were not carried out?
3.1 Are there rehabilitated areas where drainage control was not included in the rehabilitation treatments, but should have been?
4.1 Does there appear to be excessive soil disturbance associated with roadside work areas?
4.11 Were any of the roadside work areas larger (i.e. Wider, or more extensive) than necessary for the harvesting system used?
4.12 Does there appear to be more soil disturbance within the roadside work areas than necessary?
4.2 Does there appear to be excessive dispersed soil disturbance in the NAR outside the roadside work area?
4.21 Does the area occupied by skid trails and temporary access and/or the associated disturbance appear excessive?
4.22 Were there features smaller than 0.2 ha, or other areas where soil disturbance appeared to be a concern?
4.23 Are there disturbance types present that should have been rehabilitated but the rehab treatments were not carried out?
5.1 Does it appear that there are insufficient mature forests to provide inoculum for organisms recolonizing the cutblock?
5.2 Does it appear that measures to conserve coarse dead wood should have been carried out but were neglected or ineffective?
6.1a In your professional opinion, to what extent did the practices on this block maintain soil productivity and hydrologic function?
6.1b Are there issues of concern for other FRPA Resource values?

Table 3. Key concepts and potential benefits of the eliciting expert opinion using high resolution imagery (EEHRI) method. (For more information, see Appendix 1.)

1. Aerial images provide an unbiased snapshot of the cutblock condition at a certain time (i.e., they are objective data that can be re-used and re-analyzed for different purposes, and allow initial interpretations to be checked and rechecked).
2. Expert interpretation using tacit knowledge, experience, and judgement provides rapid results, and thus can focus or inform subsequent monitoring efforts, or (if the results of EEHRI are found to correlate well with results obtained after detailed field sampling of the same cutblocks), EEHRI could replace field visits in certain cases.
a. Rapid screening of cutblocks (actual time was 10–15 minutes per cutblock) provides an initial assessment of expected results and allows field staff to focus on specific areas of interest.
b. Subsequent evaluations could be carried out if new information becomes available.
3. Optimizing expert elicitation requires the following:
a. *A common and clear understanding of the objectives* The experts all need to evaluate the same thing: We used a questionnaire “Would you answer ‘no’ to any of the questions in the FREP protocol?” or “Does it appear likely that the FREP threshold has been exceeded for the indicator?”
b. *Collaboration* Multiple viewers, all with experience, should provide all the available information (i.e., anything observed by any viewer is noted) leading to the best possible result.
c. *Anonymity* The process may require a “secret ballot” to address the “follow the crowd” effect (where social pressure encourages agreement). After some discussion we settled on a collaborative (but not consensus) approach where each expert completed the form and presented an initial assessment at the end of each image viewing session. After all experts had presented, participants could adjust their responses using the available information to arrive at their “best possible” interpretation. Experts defended their positions, but no attempt was made to force them to agree.
d. *Replication and control* To document how consistent the experts were in making their interpretations.
e. *An “iterative” process* Early decisions are considered a preliminary screen, which could then be refined using the same or a different process, possibly with different protocols for cutblocks that “passed” compared to those that “failed.” The results to date represent only the first iteration of evaluation (Phase 1).

Table 4. ***The consistent approach used to elicit expert opinion using high resolution imagery EEHRI***

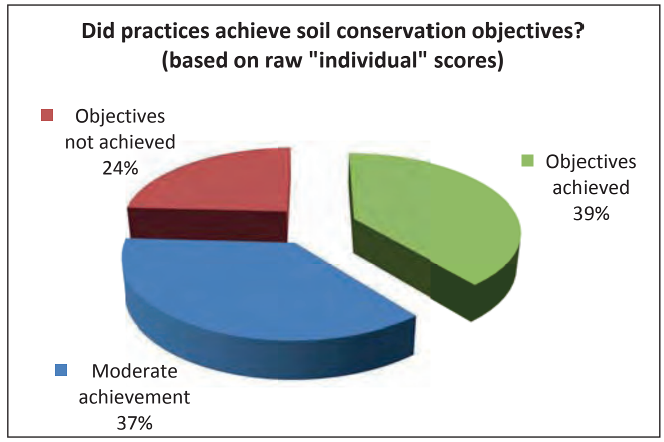
• For each image:
Step 1: Display an overview of the image, and measure the cutblock dimensions
Step 2: Carry out a close-up scan of all roads and landings, looking for drainage/erosion issues
Step 3: View close-up roadside work areas (RWA) and soil disturbance in the net area to be reforested (NAR)
Step 4: View several areas within the NAR for coarse woody debris coverage and the presence of mature trees
Step 5: View close-up of any feature requested by any of the participants
Step 6: Return to overview of the image
Step 7: Fill out the form
Step 8: Discuss our evaluations individually, in rotating order
• Throughout the viewing, the participants were encouraged to discuss their observations, but to avoid value judgements so as not to influence others.
• After each participant had filled out the questionnaire, the results were presented to the group in a rotating order, after which participants could choose to adjust their decisions based on what they heard from the other participants. The purpose of the *discussion was to ensure that all participants had the information they needed to make their* best assessment, but there was no pressure to agree with any decision. It was not a consensus process; diversity of opinions was considered a measure of the uncertainty for the overall decision.
• After all cutblocks had been evaluated, the experts completed an "exit interview" describing their approach to providing interpretations. For results from the exit interview, see Appendix 2.

Depending on the aggregation method, the proportion of cutblocks where soil conservation objectives were achieved (i.e., where the "harvesting practices conserved soil productivity and hydrologic function") ranged from 36 to 39%. Images of some cutblocks in each achievement category are presented in Appendix 3.

Figure 3 shows the overall cutblock scores presented by location. Although no rigorous analysis of the geographic distribution of responses was carried out in this preliminary work, examples of successful management are found in all areas of the province. Conversely, no region appears to be completely free of concerns regarding soil conservation.

Figure 4 provides the overall proportion of cutblocks where 2 or more evaluators identified a concern for each specific stewardship question, highlighting that the major issues affecting soil conservation included soil disturbance in the NAR and RWA, drainage, and mature forest inoculum.

a



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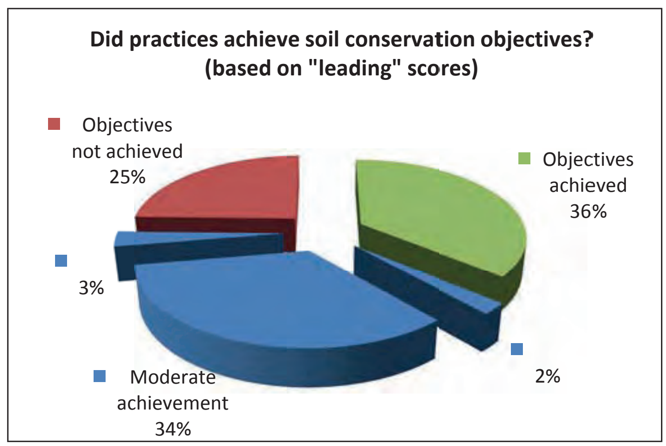


Figure 2. ***Results of expert elicitation regarding soil conservation effectiveness based on 2 approaches for aggregating the expert opinion: (a) a simple average of the raw scores from the individual evaluators, (b) the most common (i.e., "leading") score for each cutblock. The small slices in (b) represent cutblocks where opinions were evenly weighted between two categories, and no "leading" score was determined.***

In Figure 5, the geographic location of cutblocks where the experts identified specific soil conservation concerns is presented, along with the number of occurrences. Problems related to drainage and to soil disturbance in the NAR and RWA were more widespread than issues related to access or erosion. The specific concern most commonly identified was lack of mature forest close enough to provide inoculum for recolonizing soil organisms.
Each region appears to have similar types and numbers of the specifically identified issues.

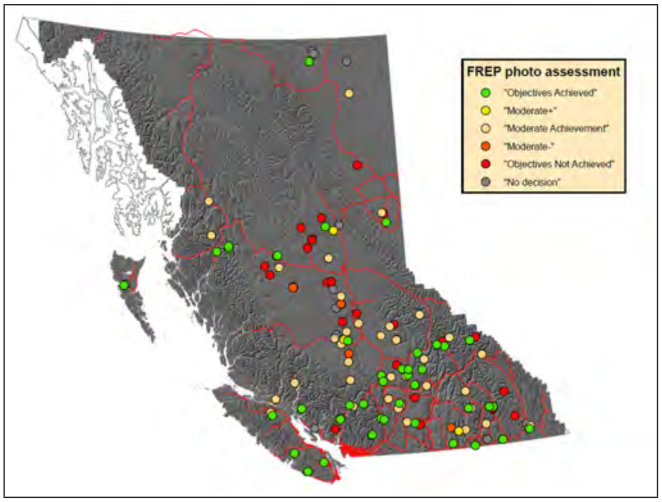


Figure 3. Results for expert elicitation: overall cutblock results.

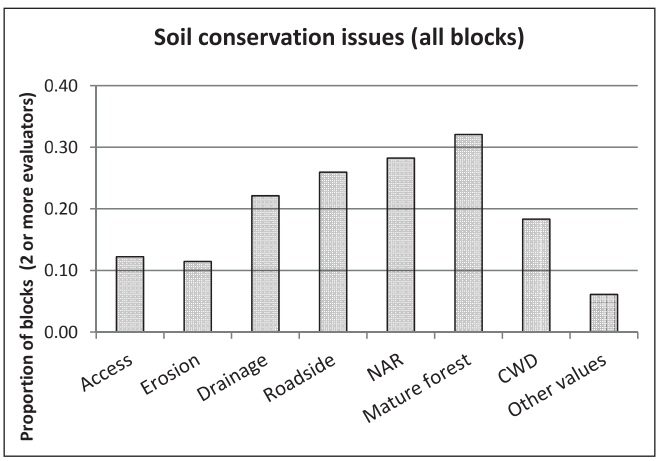


Figure 4. Responses to individual stewardship questions for soil conservation issues on all cutblocks, showing the proportion of cutblocks where 2 or more evaluators identified a concern.

Figure 6 provides insight into how the individual stewardship questions were aggregated into overall cutblock assessments. The proportion of cutblocks with 2 or more evaluators expressing concern was low for all indicators on cutblocks that received an "objectives achieved" rating (Figure 6a). By comparison, a much higher proportion of cutblocks where the overall rating indicated that soil conservation objectives were "not achieved" had 2 or 3 evaluators expressing concern over a specific question (Figure 6c), and soil disturbance in the NAR and in the RWA was most often identified as a concern.

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) and coarse woody debris were commonly identified as concerns, these indicators were unlikely on their own or in combination to trigger an overall assessment of "objectives not achieved" for the cutblocks evaluated.

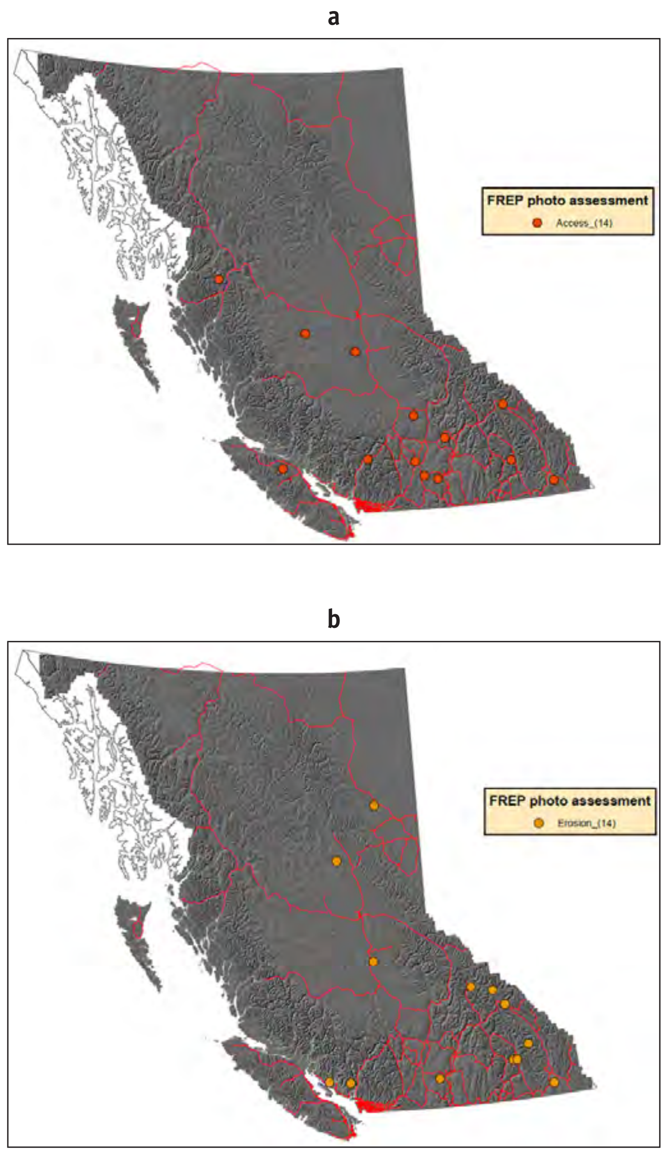
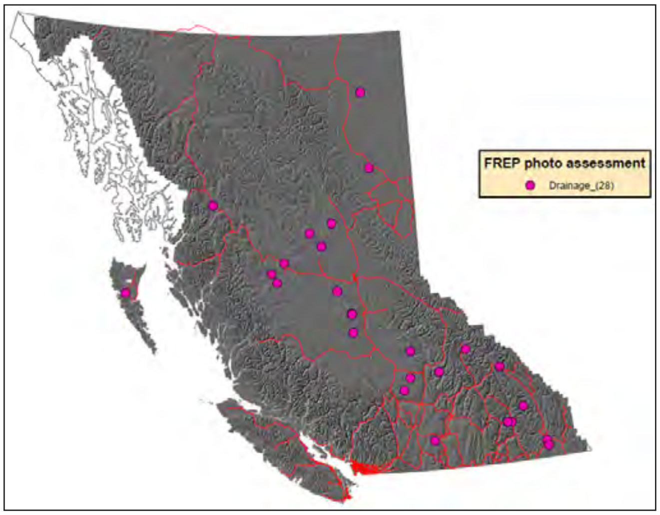


Figure 5. Results for expert elicitation: Responses to individual stewardship questions for problems related to (a) access, (b) erosion, (c) drainage, (d) soil disturbance in roadside work areas, (e) soil disturbance in the NAR, (f) mature forest inoculum, and (g) coarse, woody debris.

Figure 5. *Continued from page 6.*

c



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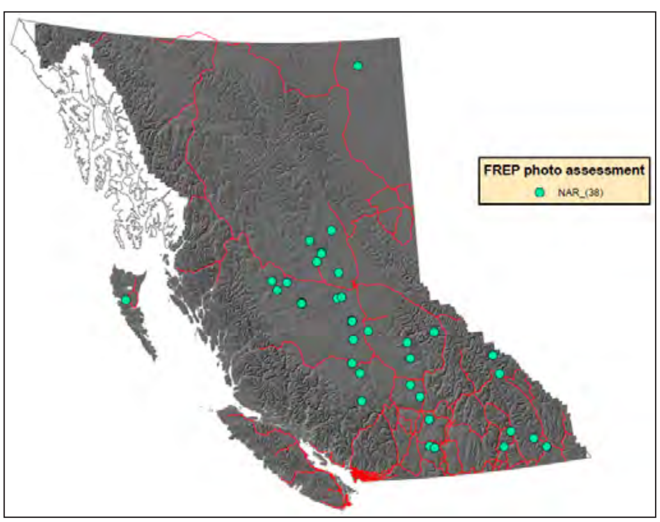

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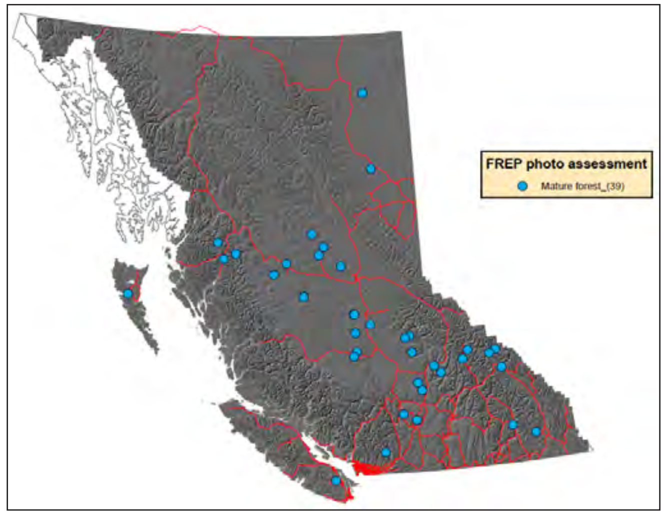

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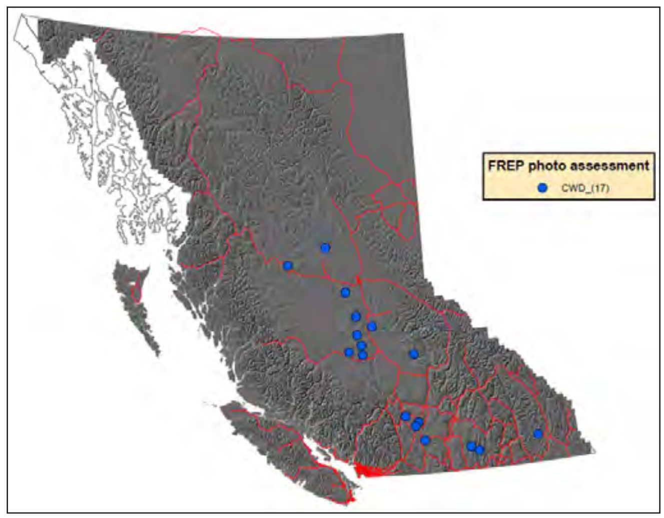


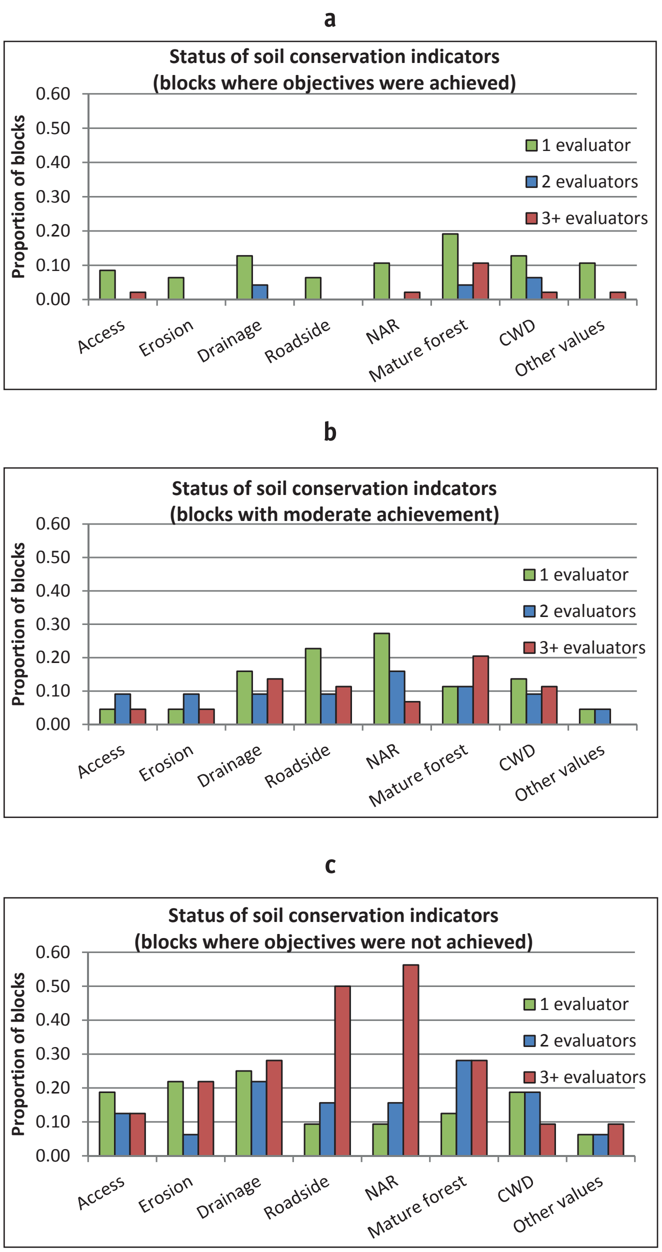


Figure 6.** **The proportion of cutblocks where evaluators identified problems when soil conservation objectives were (a) achieved, (b) moderately achieved, or (c) not achieved.

3.2 *Understanding the EEHRI Method*

To better understand the eliciting expert opinion using high resolution imagery (EEHRI) method, we evaluated the level of agreement among the expert responses for individual cutblocks, and how the results changed over time. Figure 7 shows that the experts had a high level of agreement for most cutblocks, as indicated by the proportion of experts agreeing with the leading (i.e., most common) score. Figure 8 provides a timeline of how the experts evaluated the cutblocks, presented in sequential groups of 5 images. Early sessions had a higher number of “don’t know” responses than later sessions, and more variability, but the overall pattern of response was similar at the end of the process to what it was at the start.

Assessments were replicated on 14 randomly selected cutblocks (Figures 9 and 10). In Figure 9, the shaded oval indicates the area of repeatability where no more than one expert had a different assessment for the two evaluations (i.e., good replication). Outlier points indicative of poor replication were circled if the difference in the proportion of experts providing a particular overall assessment (i.e., “achieved,” “moderate,” or “not achieved”) was greater than 0.5. Figures 9 and 10 indicate that there was broad (but not complete) agreement between our initial and replicated assessments of the individual indicators, providing some confidence that the experts were evaluating soil conservation consistently over the 6 months for which the assessments were carried out on the 140 cutblocks. In Figure 10, the replicated results are compared cutblock by cutblock; these results show that the evaluators had divergent opinions on Pics 2, 13, 41, and 44. This could be of interest in subsequent analyses attempting to determine if unique characteristics of these cutblocks made it more difficult for the experts to provide consistent opinions, or if, for example, different experts were in attendance during the two sessions for those particular cutblocks. Such analyses have not yet been 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. For example, it is possible that a different group of experts could arrive at different conclusions, highlighting the fundamental importance of participant selection on the results of such evaluations. 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 the field protocols, the forest harvesting methods, the soils, and the major concepts that have guided the development of soil conservation policy in British Columbia’s forests. Our structured EEHRI method could be used to test whether the underlying concepts are valid, and whether potential concerns are equally shared by other resource professionals such as industry foresters, managers, and soil scientists from other jurisdictions.

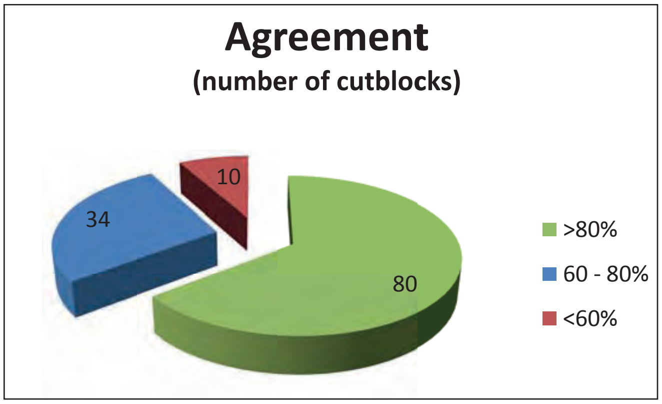


Figure 7. The extent to which experts reached agreement regarding soil conservation effectiveness on individual cutblocks. Agreement is recorded as the proportion of experts who agreed with the leading score.

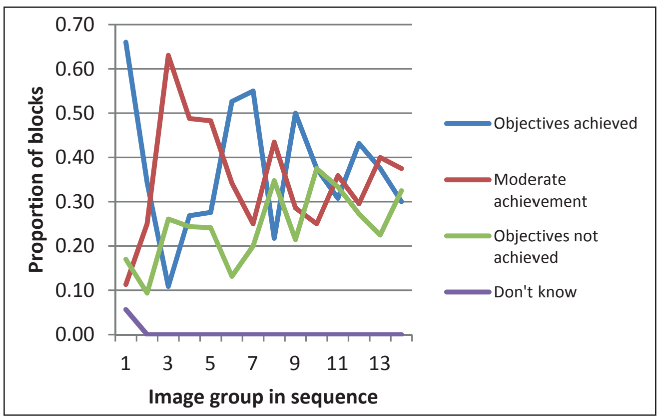
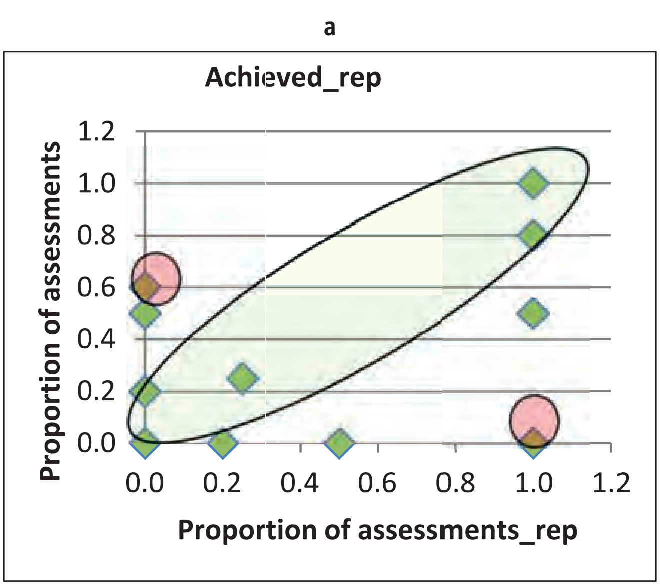
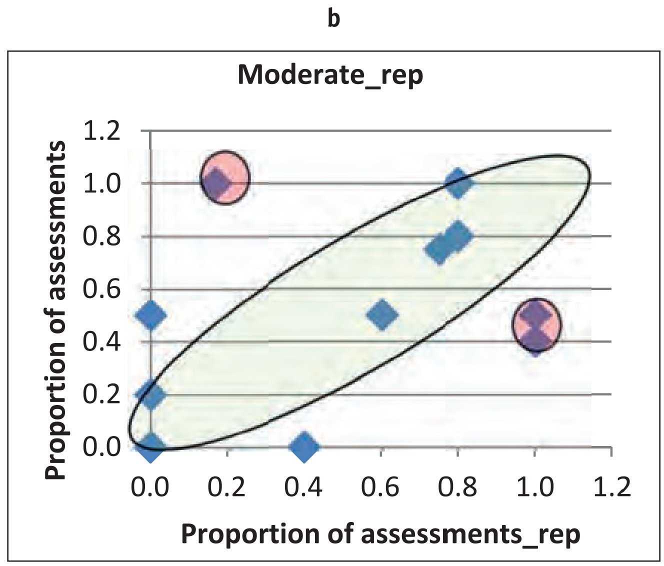


Figure 8. Changes in expert elicitation overall scores over the lifetime of the project.





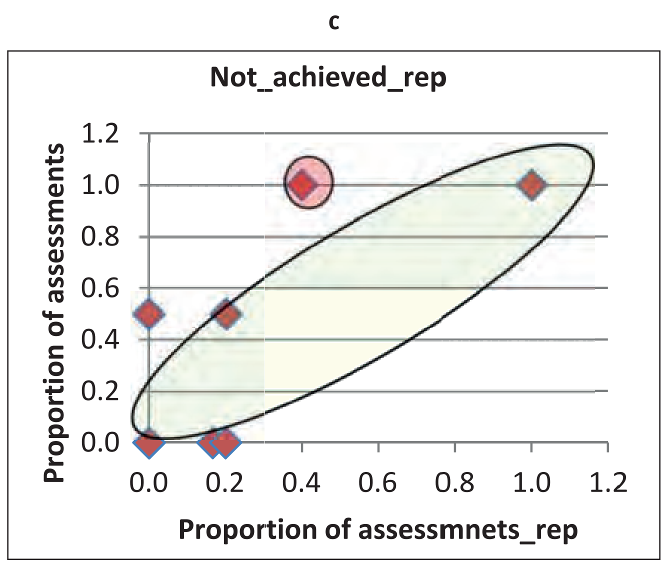


Figure 9. Responses for overall cutblock assessment on replicated cutblocks. Proportion of experts providing an assessment that soil conservation objectives were (a) achieved, (b) moderately achieved, or (c) not achieved for replicated cutblocks.

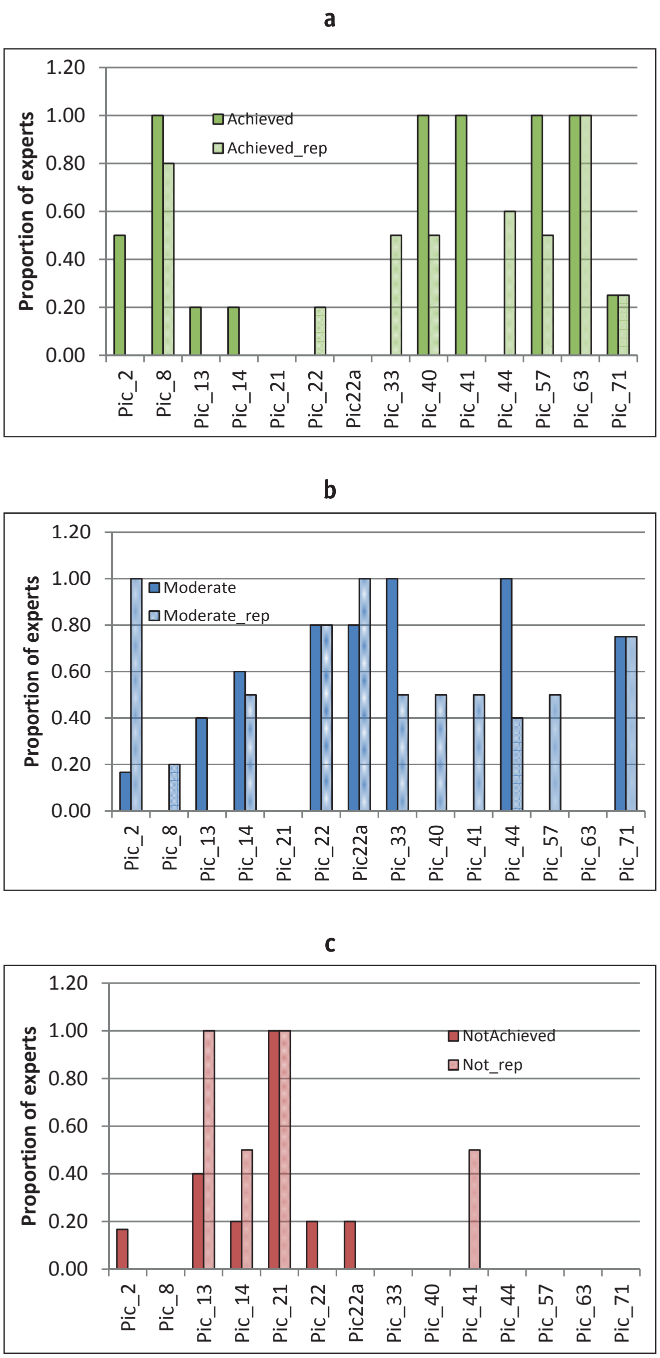


Figure 10. ***Responses for overall cutblock assessment on replicated cutblocks. Proportion of experts providing an assessment that soil conservation objectives were achieved for replicated cutblocks with an overall assessment that soil conservation objectives were (a) achieved, (b) moderately achieved, or (c) not achieved.***

3.3 *Soil Conservation Achievements as Assessed by Field Surveys*

Field surveys were completed on 73 cutblocks from 16 forest districts. 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 5 cutblocks as not having met soil conservation objectives, and they were unable to decide on an overall score for 6 cutblocks (Table 5).

Table 5. ***Results of field surveys for achievement of soil conservation objectives, and comparison with 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*

The EEHRI results for this subset of 73 cutblocks with field evaluations are roughly similar to the EEHRI results for the entire EEHRI set of 128 cutblocks: they are therefore representative of the entire collection of cutblocks.
A comparison of the results between field surveys and expert elicitation suggests that the expert elicitation process identified more problems than the field surveys (Table 5). Of the 73 cutblocks with field data collection and EEHRI, field staff indicated that soil conservation objectives were achieved on 59%, while 26% were ranked as moderate, 6.8% did not achieve the objectives, and 8.2%, had no decision. In contrast, for the same 73 cutblocks soil experts considered that soil conservation objectives were achieved on 32%, with moderate achievement on 44%, and soil conservation were not achieved on 23%. In general, the expert elicitation method and field surveys arrived at the same conclusion

for 44% of the cutblocks, while 44% of the cutblocks were ranked higher (i.e., "greater achievement") in the field than by expert elicitation. Only 3 of the cutblocks were ranked lower in the field than by the EEHRI method.

Despite the discrepancy in overall cutblock evaluations between field surveys and EEHRI, the two methods were often in close agreement concerning responses to individual questions (yes/yes or no/no; Table 6). Another way of looking at the same information is provided in Table 7. These results suggest that, despite the significant discrepancies in overall cutblock rankings, the experts and field staff were close in their assessment of soil conditions as they were observed in the field and expressed in the individual stewardship questions.

Table 6. Agreement percentages for expert elicitation (EEHRI) results and field surveys to individual questions (1, 2, 3, 4.1, 4.22). A summation of the individual (bold and italicized) values provides the overall agreement percentage as 88, 89, 82, 79, and 77 for questions 1, 2, 3, 4.1, and 4.22, respectively.

Field response	EEHRI response: Yes	EEHRI response: No
Yes	***3, 1, 4, 7, 5***	5, 1, 3, 7, 12
No	5, 4, 13, 9, 9	***85, 88, 78, 72, 72***
Don't know	1, 1, 0, 3, 0	0, 4, 3, 3, 1

Table 7. Agreement percentages for eliciting expert opinion using high resolution imagery (EEHRI) results and field surveyor responses to individual questions.

	Agreement (%)
Q1: Does the total amount of permanent access seem excessive given the site conditions?	88
Q2: Is there evidence that harvesting has led to (or increased the likelihood of) erosion?	89
Q3: Are there areas where measures should have been taken to restore natural drainage patterns?	82
Q4.1: Does there appear to be excess disturbance in the roadside work area?	79
Q4.22: Does there appear to be excess disturbance in the NAR outside the roadside work area?	77

A detailed analysis was carried out for 12 photos where the soil experts believed that soil conservation objectives had not been met, but the field surveyors had assessed at least moderate achievement of the objectives. This summary was based on (a) soil disturbance data collected and recorded by the field surveyors, (b) answers provided by field surveyors to the individual stewardship questions, and (c) the overall cutblock rating provided by the field surveyors. In several cases, this analysis revealed that the field data provided evidence of high levels of permanent access, impeded drainage, or increased erosion potential; or higher than acceptable soil disturbance in RWA and in NAR.

Based on this detailed analysis, a revised (lower) field rating was prepared for 5 cutblocks (Table 8). Of these, 4 had on-block counted disturbance of 20% or higher, and RWA soil disturbance greater than 25%. The fifth had several areas of inordinate disturbance and at least 50% disturbance in the RWA (Table 8).

Significant amounts of soil disturbance were also observed on the (7) cutblocks where field data and field responses did not trigger a revised rating. Although further evaluation may be warranted, 2 of these cutblocks were left as "Objectives achieved" and 5 were left as "Moderate achievement."

Appendix 4 provides images of some of the cutblocks subjected to this re-evaluation.

An analysis was also carried out comparing field and expert evaluations for 29 cutblocks with moderate ratings by the EEHRI method. Although the two methods identified a similar number of potential concerns overall (Table 9), the correlation between field and expert concern for a particular cutblock was not high (Table 9), and the best agreement was for soil disturbance in the RWA.

A significant portion of the discrepancy between field results and EEHRI involved soil conservation problems that were recognized in the field (as indicated by measurements or stewardship question responses), but these observations were not translated into an overall conclusion of "objectives not achieved" for the cutblock. This suggests that although field surveyors were acquainted with the techniques for collecting data on soil conditions in the field through their experience with forestry field surveys, they were less familiar than the experts with the FREP process of aggregating those observations into overall cutblock scores.

One of the benefits of a properly structured expert elicitation process is that all of the experts are attempting to answer the same question (i.e., they are using a common set of criteria to make their evaluations). Our group of experts were very familiar with the specific questions being addressed. The process we used to arrive at an overall cutblock score was partly described in the *FREP Soils Protocol* (Curran et al. 2009; Section 6.1, p. 22), and further discussion is provided in Appendix 2 (exit interviews for the EEHRI process evaluators). The field surveys were conducted by staff from each forest district, so the field results represent the efforts of several teams of evaluators, with less opportunity than the experts to correlate their results and become familiar with the procedure for aggregating the field data and stewardship responses into an overall score for each cutblock.

Based on the analysis of cutblocks where both (revised) field data and EEHRI interpretations were available, we conclude that the percentage of cutblocks in our dataset where soil conservation objectives were not met are between 13.6% (field surveys including revised values) and 23% (expert opinion using EEHRI). The discrepancy in these values is caused by diverging field and EEHRI assessments on the cutblocks that were reviewed but not revised. A visual analysis of some of these cutblocks suggested that on some cutblocks the experts appeared to have identified disturbance that was not identified in the field (2 cutblocks). In other cases, features that looked like disturbance were apparent on the images, but field staff may not have considered it detrimental to productivity (4 cutblocks). For 2 other cutblocks, results of the photo evaluation were inconclusive.

Therefore, further investigation may result in a revised rating for some but not all of the cutblocks with field versus EEHRI discrepancy. If such an analysis revealed that half of those cutblocks should be revised to “objectives not met” then, for the entire dataset, we could expect that soil conservation objectives have not been achieved on approximately 18% (± 5%) of all the cutblocks assessed, while objectives were at least moderately achieved on about 82% of cutblocks harvested during the 5-year period.

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 is between 13.6% (field surveys including revised values) and 23% (expert opinion

Table 8. Re-evaluation of 12 cutblocks ranked “objectives not achieved” by EEHRI method, but “moderate” or “objectives achieved” in the field. Highlighted values indicate 5 cutblocks where the initial “overall” assessment appeared to be inconsistent with the field data and responses to individual stewardship questions, so these cutblocks were given a revised rating.

Photo	Expert reasons for rating of “objectives not achieved”	Initial field rating* (and revised rating)	% NAR	% RWA	Inordinate	Other
4	Excess soil disturb	M (NA)	25	30	N	
21	Soil disturb, drainage	M (NA)	30	40	N	
26	Drainage, erosion, disturb	M (M)	12	12	N	6% PAS
34	Disturb, access, drainage	OA (OA)	6		N	
49	Drainage, disturb	M (NA)	4	50	Y	
66	Drainage, RWA disturb	OA (OA)			N	
102	Disturbance	OA (NA)	20	70	N	
109	Disturbance	M (M)	3	20	N	drainage
114	Disturb, CWD	M (M)			N	culverts
118	Disturb, no rehab	M (NA)	20	30	N	
121	Disturb, access/rehab	M (M)	6	22	N	
137	Disturb, erosion, drainage	M (M)	v low	50	N	

* OA = soil conservation objectives achieved; M = moderate achievement; NA = objectives not achieved

Table 9. Comparison of 29 cutblocks ranked moderate by EEHRI method. Number of cutblocks with soil conservation concerns.

	PAS	MW / erosion	Drainage	SD in NAR	SD in RWA	Inordinate disturbance	Rehab needed	Mature forests	CWD
Expert concern	7	5	4	12	9	2	3	7	8
Field concern on same cutblock	0	1	1	2	5	1	1		
Field concern on different cutblock	4	0	2	0	3	4	3		

PAS permananet access structures; MW mass wasting/landslide; SD soil disturbance;
EEHRI concern indicated by "yes"; field concern indicated by comment or interpretation of transect %.

using EEHRI). More detailed analysis in the future could reveal that over the whole dataset, we could expect that soil conservation objectives have not been achieved on approximately 18% (± 5%) of the cutblocks harvested during our study period. Results from field surveys and EEHRI appear to agree on most of the major questions related to soil conservation.

These results are also consistent with the conclusion that soil conservation objectives were at least moderately achieved on approximately 82% of cutblocks harvested during the 5-year period.

The most common soil conservation problems identified were related to:

1. disturbance in the roadside work areas (RWA) and the net area to be reforested (NAR);
2. drainage, access construction, and erosion; and
3. the presence of mature trees for soil organism inoculum and coarse woody debris levels, but these concerns alone seldom triggered an overall assessment of "objectives not achieved."

Our results demonstrate the power of high resolution air photos for assessing soil conservation. They are likely useful for evaluating other resource values as well. These images could be useful as a tool for compliance and enforcement staff.

Considering the relatively high level of agreement of the EEHRI method 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 work has demonstrated that the EEHRI method is flexible in that it can bring a wide range of expertise to address questions on natural systems that may be difficult to answer using other methods. Therefore, EEHRI likely could have general application to resource management issues in British Columbia.

5.0 RECOMMENDATIONS

1. High resolution imagery has tremendous potential to improve monitoring of forest practices in British Columbia. Work should continue to evaluate this potential and to carry out a detailed analysis of how to realize it.
2. Expert elicitation was effective for evaluating soil conservation. Its usefulness for other environmental and forest monitoring questions should be further evaluated.
3. Soil productivity and hydrologic function are being protected on most cutblocks we observed from throughout British Columbia, but opportunities exist for improving the current record. Specifically:
   a. Soil disturbance associated with access construction, and in the NAR and RWA, is often higher than it needs to be. There is a need to identify and implement steps necessary to achieve reductions in these types of soil disturbance through improved planning (e.g. designating skid trail locations and/or patterns) and by promoting greater soil conservation awareness (e.g. communicating soil conservation principles to operators regarding the importnce of minimizing compaction in roadside work areas, maintaining natural drainage patterns and avoiding over concentration of skid trails during harvest).
   b. Harvesting has significant effects on the amount of coarse woody debris and mature forest inoculum available to sustain the new forest. Efforts should continue to quantify these changes and their effects on long-term forest productivity, hydrologic function, and ecosystem resilience, and to consider the importance of soil organism inoculum in planning for single tree and patch retention.

c. The Ministry of Forests, Lands and Natural Resource Operations and Ministry of Environment should continue monitoring soil conservation using the FREP protocol and long-term studies to evaluate the effects of changing management practices, economic conditions, and policy on soil disturbance and forest productivity over the next 20 years.

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APPENDICES

APPENDIX 1. CONCEPT FOR AN ITERATIVE EEHRI PROCESS

Initial (Phase 1) Viewing Session

To rapidly screen cutblock photos and see if we can consistently identify blocks that (in our opinion as a group of experts) have/have not met soil conservation objectives.

1. To tally the results of the viewing session to compare responses of individual specialists and to compare with field data where available.

Method: Participants will be asked to view a series of photos, and answer questions regarding the extent to which the results appear to meet soil conservation objectives. They will then submit results by email immediately after the session.

Suggested viewing protocol: (Note: these "rules" are flexible based on the expert panel, and questions being addressed.)

1. Random photo order selection using the following procedure
   a. Identify all blocks on all "air photo lists" in the FREP shared folder; sort by opening ID and remove duplicates.
   b. Assign a random number to each block and sort by the random number; start from the top of the list and search for photos by opening ID in all folders of the FREP shared folder.
   c. Continue until all photos have been found.
   d. Replace block ID with a generic identifier (e.g., Pic_1) so that the block ID is hidden at this initial viewing; evaluate the photo only ("no prior knowledge").
2. Evaluation of stewardship
   a. Address stewardship questions for each of five FREP indicators (access, landslides/erosion, drainage, dispersed disturbance, and green tree retention/dead wood) using the structured viewing process.
   b. Participants can discuss what they see, but should not indicate which way they will be voting for the particular questions associated with the indicator.
   c. Initially we can take our time, but for the "operational" process to be practical over many blocks in the province, we will eventually need to move relatively quickly (about 5–10 minutes per photo).
   d. We will all complete the evaluation form (Table 1) before we move on to the next photo.
3. Submit all results by email before we sign off. Once they are all in, they can be distributed to everyone immediately for those who are interested.

Comments:

4. Photos may provide a better overview than a mini-survey "walk through."
5. "Coarse filter" (i.e., "dark ruts") may provide enough detail versus precise measures of depth.
6. A rapid process could be very efficient for screening.
7. List of things you can see, such as:
   a. ruts, machine traffic, access
   b. water diversion (past)
   c. ponding if the soil is wet at the time of photo.
8. List of things you may not be able to see
   a. the potential for landslides.
9. At the beginning of each session, should we see some "calibration" pictures?

Subsequent (Phase 2,3) Viewing Sessions

1. To serve as a check on initial assessments.
2. To introduce more information not available in Phase 1
   a. site location, BEC zone, soil conditions from maps or data
   b. harvest history, season, soil disturbance hazards.
3. To refine results and allow for site-level interpretations and recommendations.
4. To allow for a higher level of confidence and referral of significant problems to compliance and enforcement personnel.

APPENDIX 2. RESPONSES FROM "EXIT INTERVIEW"

Exit Interview Q1: Please provide your best answer to the following question regarding indicator 1.

1 Does the total amount of permanent access seem excessive given the site conditions?
- 1.1 Are there portions of the un-rehabilitated access that should have been rehabilitated?
- 1.2 Do any individual access structures seem larger than necessary?
- 1.3 Were pre-existing access structures, such as old roads and trails, present in the NAR?
- 1.4 Were pre-existing structures not used for access, where it appears that they should have been?

What features on the photo did you look for to help you evaluate these questions? (Please include your overall comfort level and previous experience in making these assessments.)

Responses:

"We did not measure the roads or landings while viewing photos. We assessed road layout and looked for excessive roads built. We looked for roads not rehabbed AND not leading toward unharvested areas. Personally, I had moderate confidence in my ability to evaluate the permanent access. Would have been improved by contour lines, etc., to more easily determine lay of the land."

"Turnouts – sometimes very large – trucks can turn in narrow area so why was turnout so big?"

"Landing – should it be rehabbed? Look for proximity to timber – 100 m away was suggested as a threshold."

"Rule of thumb for distance between parallel roads – closer than 100 m was a worry. We looked for road spacing that was obviously wrong."

"Rare that we discussed 1.3 or 1.4."

"Landings – Tendency on flat grounds for landings to get really big. One expert allowed them to be bigger on flat ground than steep ground before getting worried. But, above ½ ha was a concern – bigger than 1/3 ha began to be concerning."

"Ratio of landing versus roadside logging – Choose one or the other, but sometimes both are used, which leads to too much disturbance. Unless there is abnormal topography, then stick to one approach or the other, not both.

"Knowing size of cutblock gives us some idea of the scale, so looked at amount of roads and landings relative to cutblock size was possible even without doing the measurements."

"Would have preferred to take more measurements without adding too much time to the assessment."

"Question 1.4 – was it ever answered? How could it be answered?" . . . "We did use it once."

"Efficiency of road and trail design. There was little evidence of time taken to design roads and trails for maximum access with minimum construction."

"Rehabilitation attempt and quality were taken into account."

"Roads and landings, rehabilitated structures, and manmade features described in the questions."

"The size of the cutblock, any indicators (road cuts, stream channels, landscape features) visible in the image which gave clues regarding slope steepness and length."

"Was the amount of road and landing visually more than 5% of the cutblock area? Did roads end within the cutblock with no indication that they may be used in the future? Were roads rehabilitated? Were all portions of the road rehabilitated? Did the rehabilitation give the visual appearance of a 'loose' soil structure, with organic matter and mixed in and woody debris placed on top? Were there parallel roads which were close (less than 200 m apart)?"

"Was the amount of road and landing visually more than 5% of the cutblock area? Did measurements using the image to confirm size of landings in some cases."

Exit Interview Q2: Please provide your best answer to the following question regarding indicator 2.

2. Is there evidence that harvesting, access construction, or maintenance have led to (or increased the potential for) mass movement or erosion?

   2.1 Are there any potential or existing off-site effects related to mass movement, erosion or sedimentation evident?

What features on the photo did you look for to help you evaluate these questions? (Please include your overall comfort level and previous experience in making these assessments.)

Responses:

"Landslides, erosion – were these features seen in photo? If not, no problems at present. 2) Natural drainage pattern was first thing looked at to evaluate possible future problems – channelization, culverts, crossings at roads, water pooling – indicate future problems."

"I looked for signs of erosion on roads and landings. And landslides. And slumps along roads."

"Rilling on roads and in blocks. Ravelling."

"Identified rills and channels. Not really confident that we could assess potential because we cannot see all culverts."

"Not very confident that we can evaluate future problems (this is hard even in the field)."

"Felt confident with evaluating future problems when evidence was visible in photos."

"Culverts within roadbed, number of streams or channels crossing roads, dark (wet) areas on road cuts or road beds, rill erosion on roadbeds, stream channels, hill side slumps, road cut slumps,"

"Were these features (e.g., culverts) present? How long and deep were the erosion features? Did erosion features appear to connect to steams or water bodies?"

"If there was visual evidence of a slump – then a ground inspection is needed to properly evaluate the mass movement hazard, but giving an unacceptable score for the block would flag it as needing attention."

"If the amount of erosion or severity of the erosion feature appeared to create potential for deposition into a stream, or loss of productive forest land over time, then a negative rating was given."

Exit interview Q3: Please provide your best answer to the following question regarding indicator 3.

3. Are there areas where measures should have been taken to restore natural drainage patterns, but they were not carried out?

   3.1 Are there areas where drainage control was not included in the treatments, but should have been?

What features on the photo did you look for to help you evaluate these questions? (Please include your overall comfort level and previous experience in making these assessments.)

Responses:

"Water pooling in ruts, water pooling above roads."

"Water pooling or collection, channelling of water, accumulations of surface water."

"Could pick up culverts and cross-ditches really well."

"Water-barring, cross-ditching – if could see water running along surface of cutblock to road without cross-ditches, etc., then could predict future problems."

"Comfort level is high. But not in photos with poor resolution. This is a huge improvement over what we had in the past."

"Drainage patterns appeared darker in photos – raised confidence. And the use of a number of pairs of eyes raised likelihood of finding problems."

"Not so confident (e.g., sometimes about culverts) in some cases."

"If we think "there should be a culvert but I don't see one", this raises a red flag – perhaps poor culvert installation."

"Ponded water, "new" drainage channels created by disturbance during harvesting, "fresh" erosion or deposition connected to a stream or drainage pathway, water filled ruts, ponds on roadbeds connected to drainage pathways, erosion on roadbeds from redirected water, lack of culverts, water filled ruts."

"Were the features described above present, and were they present to the degree that there was clear loss of soil productivity and hydrologic function?"

Exit interview Q4: Please provide your best answer to the following question regarding indicator 4.

4.1 (new question) Does there appear to be excessive soil disturbance associated with roadside work areas?

- 4.11 Was the RWA larger (i.e., wider, or more extensive) than necessary for the harvesting system used?
- 4.12 Is there inordinate disturbance in the RWA?

4.2 (new question) Does there appear to be excessive dispersed soil disturbance in the NAR outside the roadside work area?

- 4.21 Does the area occupied by trails and temporary access and/or the associated disturbance appear excessive?
- 4.22 Were there areas where inordinate soil disturbance appeared to be a concern? Add comments on size and severity.
- 4.23 Are there disturbance types present that should have been rehabilitated but the rehab treatments were not carried out?

What features on the photo did you look for to help you evaluate these questions? (Please include your overall comfort level and previous experience in making these assessments.)

Responses:

“RWA – ruts, repeated machine traffic clearly visible – tone of photo is clearly different from rest of block, exposed mineral soil, assessment of relative size of area and degree of the modification – confidence about ruts (shadow, water-filled) good (visibly apparent) – but hard to evaluate soil texture. Used same indicators in NAR. Network of heavily used trails.”

“We measured the size of some RWAs – wider than 40 m caused concern (2 log lengths).”

“RWA – tone change; burn piles apparent; felt confident.”

“Very confident about tone change delineating RWA and confident about recognition of disturbance types (excess disturbance).”

“Stoniness helped in evaluating texture/sensitivity. Ruts, shadowed?”

“Ruts, disturbed surfaces showing evidence of repeated machine traffic.”

”Size of area affected.”

“How heavily disturbed were areas within the photo, how much of the block area was in that condition.”

Exit interview Q5: Please provide your best answer to the following question regarding indicator 5.

5.1 (JEMS article) Does it appear that there are insufficient mature forests to provide inoculum for organisms recolonizing the cutblock?

5.2 (JEMS article) Does it appear that measures to conserve coarse dead wood should have been carried out but were neglected or ineffective?

What features on the photo did you look for to help you evaluate these questions? (Please include your overall comfort level and previous experience in making these assessments.)

Responses:

“Measured block size; used distance to forest (100 m); convoluted block boundaries – big-squarish blocks or just big blocks, set off alarms – looked for distribution of standing trees; confidence – varied with forest type due to ill-defined concept of what is sufficient; dark wood = new wood which is better than white wood = old wood.”

“Forwarder harvesting (cut to length) – not too concerned about amount of slash left because buffer zones provide lots of this material; whole tree harvesting with burn piles at roadside was more mindful of assessing material on cutblock; harvesting method was first filter; beetle-killed – looked at block edge and surrounding areas and found that if it was salvage of older material the amount of DW was probably not an issue due to breakage during harvest.”

“Harvest method – roadside logging – with big and extensive burn piles – inclined to be more concerned about woody material on site.”

"Live trees within the harvested area. Wildlife tree patches within the harvested area, adjacent area not harvested.”

“Could more trees have been left as standing trees on site? E.g., if understory was present within one portion of the site, was it present on all portion s of the opening that seemed similar.”

”Woody debris, visual estimate from image, depended on quality of image for the ability to do this. "White" probably older woody debris compared to a fresh pulse of debris with the most recent harvest."

"Was the majority of the cutover area within 100 m of a live tree as a source of inoculum?:

"Size of cutblock, shape of cutblock, number and distribution of wildlife tree patches. Larger, more rectangular cutblocks without wildlife tree patches or standing residual stems, would be more likely to have a low or negative assessment."

Exit interview Q6: Please provide your best answer to the following question.

6.1a In your professional opinion, to what extent did the practices on this block maintain soil productivity and hydrologic function?

6.1b Are there issues of concern for other FRPA Resource values?

What criteria did you use to make these evaluations?

Responses 6.1a

"2 yes answers headed this expert away from well; poor = 2 answers with very obvious problems."

Responses 6.1b – erosion

"Presence or absence of features is first filter (e.g., landslide, erosion); second filter is severity (e.g., one poor water crossing, not terrible). See pages 21 and 22. Also simple or complex topography, steep cutblock, sensitive soil (hard to use with photos)."

"Features as in each question, did I have more than one negative indicator, how severe was the negative change."

"Negative conditions may have been observed, but extent or severity of negative condition may not have been sufficient to rate as a "poor" condition."

APPENDIX 3: EXAMPLES AND EVALUATION OF HIGH RESOLUTION CUTBLOCK IMAGES

Example 3.1: ***Rated "Objectives achieved" by 3 out of 3 evaluators (Pic_43).***

Close up of Pic_43 showing absence of soil disturbance, lots of CWD

Example 3.2: ***Rated "Objectives achieved" by 4 out of 4 evaluators (Pic_70).***

Close-up of Pic_70 showing absence of soil disturbance.

Example 3.3: ***Rated "Moderate achievement" by each of the 4 experts (Pic_32).***

Close-up of Pic_32 showing site prep, rehabilitated road, and low amounts of coarse woody debris.

Example 3.4: ***Rated "Moderate achievement" by 2 and "Don't know" by 1 evaluator (Pic_45).***

Close-up of Pic_45 showing erosion on left side of the image; lots of brush complicates evaluation.

Example 3.5: ***Rated "Objectives not achieved" by 3 out of 3 evaluators (Pic_52).***

Close-up of Pic_52 showing significant amounts of soil disturbance in the NAR and RWA.

Example 3.6: ***Rated "Objectives not achieved" by 3 out of 3 evaluators (Pic_95).***

Close-up of Pic_95 showing extensive soil disturbance in the NAR.

Example 3.7: ***Rated "Objectives not achieved" by 3 out of 5 evaluators (Pic_52).***

Close-up of Pic_52 showing slope failure.

APPENDIX 4: COMPARISON OF FIELD SURVEYS AND EEHRI

This Appendix provides a closer look at blocks where field surveys and expert opinion using high resolution imagery (EEHRI) arrived at different conclusions regarding soil conservation. Features visible on the photos appear to support the re-evaluations provided for 5 blocks (Pic_4, 21, 49, 102, 118, illustrated with bold italics in Table 4.1). All 5 of these blocks showed features that the soil experts would have considered indicative of soil conservation objectives not being met. Seven blocks remained with discrepancy between field and expert assessments. A preliminary interpretation showed that some appeared likely to have an "expert – leaning" outcome (Pic_121, 137), while others had a likely "field – leaning" outcome (Pic_26, 109, 114) as being final evaluations. The bias in others was difficult to determine (Pic_34, 66).

All of these blocks should likely be revisited to understand better the reasons for discrepancy.

***Pic_4:* EEHRI "Not achieved" Field "Moderate" Re-evaluated "Not achieved."**

Close-up of Pic_4 showing soil disturbance in the NAR and RWA.

***Table A4.1* Summary of blocks with significant discrepancy between field and expert assessments.**

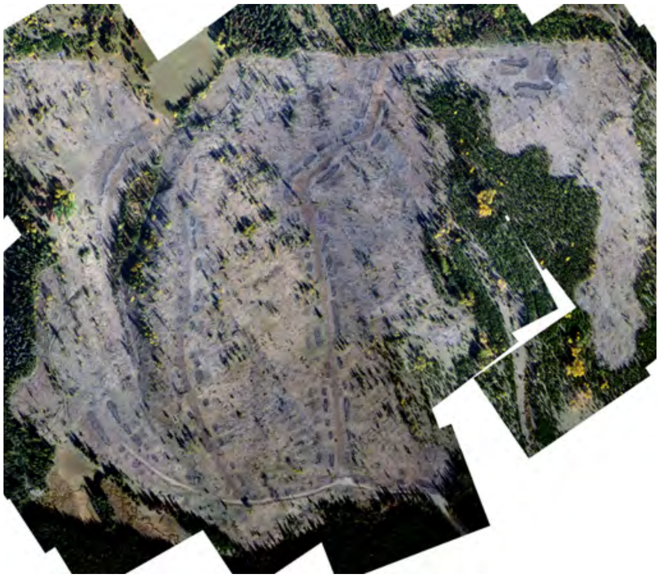
Photo	Expert reasons for poor	Initial Field Rating (and revised rating)	% NAR	% RWA	Inordinate	Other
4	***Excess soil dist***	***M (P)***	***25***	***30***	***N***	
21	***Soil dist, drainage***	***M (P)***	***30***	***40***	***N***	
26	Drainage, erosion, disturb	M (M)	12	12	N	6% PAS
34	Disturb, access, drainage	W (W)	6		N	
49	***Drainage, disturb***	***M (P)***	***4***	***50***	***Y***	
66	Drainage, RWA disturb	W (W)			N	
102	***Disturb***	***M (P)***	***20***	***70***	***N***	
109	Disturbance	M (M)	3	20	N	drainage
114	Disturb, CWD	M (M)			N	culverts
118	***Disturb, no rehab***	***M (P)***	***20***	***30***	***N***	
121	Disturb, access/rehab	M (M)	6	22	N	
137	Disturb, erosion, drainage	M (M)	v low	50	N	

Pic_21: EEHRI "Not achieved" Field "Moderate"
Re-evaluated "Not achieved."

Close-up of Pic_21 showing soil disturbance in the NAR.

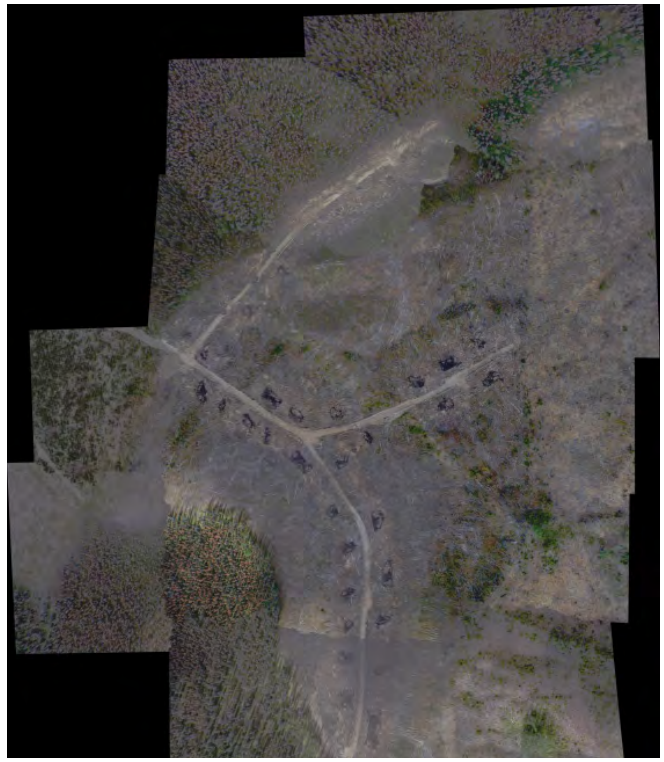
Pic_26: EEHRI "Not achieved" Field "Moderate"
Re-evaluated "Moderate."

Close-up of Pic_26 showing numerous gray areas that were interpreted as disturbance by experts.



Pic_34: EEHRI "Not achieved" Field "Achieved" Re-evaluated "Achieved."

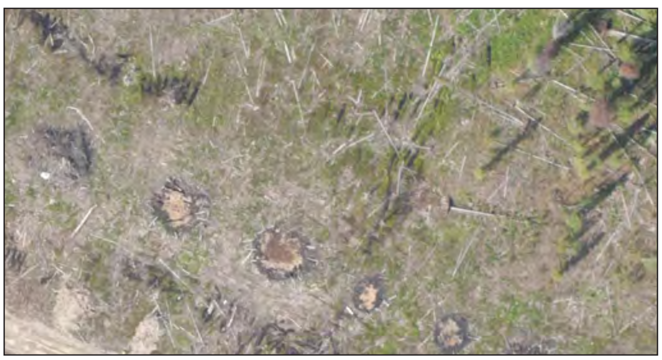
Close-up of Pic_34 showing an area where the experts saw significant soil disturbance in the NAR.



Pic_49: EEHRI "Not achieved" Field "Moderate" Re-evaluated "Not achieved."

Close-up of Pic_49 showing an area where experts saw significant soil disturbance in the RWA, NAR.

Pic_66: EEHRI "Not achieved" Field "Achieved" Re-evaluated "Achieved."



Close-up of Pic_66 showing rutting in wet areas.

Pic_102: EEHRI "Not achieved" Field "Achieved" Re-evaluated "Not achieved."

Close-up of Pic_102 showing soil disturbance on trails and dispersed disturbance in the NAR.

Pic_109: EEHRI "Not achieved" Field "Moderate" Re-evaluated "Moderate."

Close-up of Pic_109 showing areas where experts saw soil disturbance but field staff did not.

Pic_114: EEHRI "Not achieved" Field "Moderate" Re-evaluated "Moderate."

Close-up of Pic_114 with areas of soil disturbance identified by the experts but not by field staff.

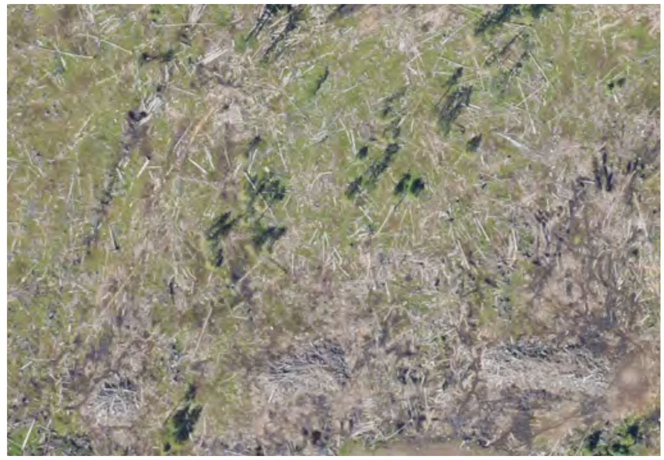
Pic_118: EEHRI "Not achieved" Field "Moderate" Re-evaluated "Not achieved."

Close-up of Pic_118 soil disturbance recognized by field staff, but not incorporated into assessment.

Pic_121: EEHRI "Not achieved" Field "Moderate" Re-evaluated "Moderate."

Close-up of Pic_121 showing typical NAR and RWA soil disturbance in this block.

Pic_137: EEHRI "Not achieved" Field "Moderate" Re-evaluated "Moderate."



Close-up of Pic_137 showing soil disturbance associated with wet soils in this block.