Designing an adaptive management field project: A case study

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INTRODUCTION

As more forest managers adopt the notion of adaptive management as a way of responding to changing expectations and uncertain knowledge, they face the challenge of turning what to many is a fuzzy concept into real-life practice. One of the tasks many managers find difficult is designing field experiments, often called operational trials. These experiments are one of the essential components of the systematic adaptive management process of learning from the outcomes of operational policies and practices, but they are not the typical focus of an operational manager's work. Here we point out some of the issues managers should consider in designing field experiments, and provide some advice on how to deal with the stickier problems.

CASE STUDY

Throughout British Columbia, foresters and biologists are trying to determine the best harvesting and silvicultural practices to apply to riparian areas along small streams. Streams designated as "S4" under the Forest Practices Code—the smallest (< 1.5-m wide) fish-bearing streams—are particularly challenging. In the central Interior, for example, the Code states that the best management practice for these streams is to retain all trees within 10 m of the stream bank, except where windthrow hazard is moderate to high (see Table 11 in the *Riparian Management Area Guidebook*). However, because many areas on the interior plateau experience frequent strong winds, logging companies remove all merchantable trees along many S4 streams in their cutblocks. This has raised concerns that some of the ecological functions of streamside trees and other vegetation are being lost, to the detriment of the stream, its fish, and other aquatic organisms.

In the Prince George Forest District, the district manager recently issued a policy to guide foresters in writing prescriptions for harvesting and silvicultural practices along S4 streams. The policy is intended to protect S4 stream and riparian conditions, while recognizing the risk of windthrow. This policy introduces the notion of managing for retention of a high percentage of natural shade along the stream, and for continuing the periodic recruitment of large organic debris in the riparian area in both the short and long term.

The Prince George Forest District is committed to the monitoring and evaluating of this new policy to ensure that it achieves both ecological and timber management goals. District staff and a group of local and Victoria co-operators, including staff from Research Branch and Forest Practices Branch, are developing an adaptive management approach to evaluate the S4 stream guidelines. The important

Citation —

Sit, V. and B. Nyberg. 2000. Designing an adaptive management field project: a case study. *In* Proceedings, From science to management and back: a science forum for southern interior ecosystems of British Columbia. C. Hollstedt, K. Sutherland, and T. Innes (editors). Southern Interior Forest Extension and Research Partnership, Kamloops, B.C., pp. 59–62.

question in the evaluation is: how successful is the district manager's policy in protecting the stream and riparian values, compared to:

- leaving a 10-m reserve zone;
- harvesting all merchantable trees, while still providing a 5-m "machine-free" zone adjacent to the stream and retaining non-merchantable vegetation; or
- not logging at all.

These alternatives can be considered to be four treatments (called District Manager's Policy, 10-m Reserve, Clearcutting, and Control). The concept for the adaptive management project is to test these alternative treatments in the Prince George District by using operational logging activities planned through the co-operation of local forest companies and the Small Business program. Stream temperature, post-logging shade, large organic debris level, and windthrow are the indicator variables that would be monitored to assess the suitability of the various treatments.

We used the design of an operational test of these riparian management alternatives to illustrate some of the many questions that should be considered by managers who want to conduct operational trials or management experiments. For this discussion, we will simplify the Prince George situation by ignoring the details of study site selection and monitoring designs.

DESIGNING THE ADAPTIVE MANAGEMENT STUDY

Ideally, we would want to design our study to produce the most reliable and informative results. To a statistician this means: minimum variation between experimental units, lots of replications, and fully randomized treatments with a proper control. These requirements can often be met in small-scale experiments performed in a controlled environment, but are not always possible in an operational setting where factors such as expense, feasibility, and efficiency need to be considered. In the Prince George adaptive management study, we tried to plan a rigorous study in a very variable environment with limited resources.

To minimize variability in the experimental units, it is necessary to stratify the streams by forest type and stream gradient. With four forest types (various mixes and structures of lodgepole pine and spruce), three stream gradients (< 2% slope, 2–10%, and > 10%), and four treatments, we would need 144 streams for three replications, or 240 streams for five replications. From the lead author's experience in reviewing many research proposals, three replications seems to be the Forest Service norm for minimum number of replications, but three is really not enough, particularly for systems with large unknown variations. To reduce the number of streams sampled, we recommended narrowing the scope of the study to two forest types (the extremes: single-storey pine and multistorey spruce mix), and two stream gradients (moderate: 2–10% slope; low: < 2% slope). We, therefore, chose between getting a little data on many strata, and much more data on fewer strata.

We then considered treatment layout. We could arrange all four treatments sequentially along a stream, or apply one treatment to each stream. We abandoned the single-stream design because it would require deliberately setting all four treatments along the same stream. This could prove difficult because it might not be possible to accommodate all four treatments along a stream, or each stream section might have different forest type or gradient. In addition, we recognized that the operational setting of the work is more suited to using only one stream treatment in each cutblock, rather than multiple treatments as might be the case in a more traditional scientific research design. We decided to apply each treatment to an entire stream segment within a cutblock with an upstream control. This, in effect, reduced the number of treatments to three. This layout would allow us to assess the effects of each treatment and compare the effects between the three treatments. We still need 60 streams for five replications.

Bearing in mind the logistic difficulties of finding suitable streams and prescribing the required treatments, it is quite impossible to get enough streams in one field season, and the cost would be enormous. One solution is to run the study over at least 3 years. We could find some streams for each forest type or stream gradient each year, but we should include all treatments in each year to allow proper analysis by year.

We have recommended a "Before/After Control Impact" design for this study to properly evaluate the effects of the three treatments. Because clearcutting is not recommended as a riparian prescription for S4 streams under the district manager's policy, we considered using already-logged streams for the clearcut treatment. We decided not to compromise the design this way, however, because the after-treatment data would be of doubtful value without the before-treatment data. Another solution to the problem is available: the clearcut treatment is already routinely applied to S6 (small non-fish bearing) streams. We can thus find appropriate S6 streams similar to S4 streams in all respects, except for fish presence.

To reduce cost, we restricted the number of measured variables. We also tried to find monitoring methods that would minimize field time. For instance—

- Stream temperature can be assessed using temperature sensors that store a year's data.
- Shade over the stream need only be assessed once a year.
- Channel structure and large organic debris can be assessed using overhead photographs taken with a camera on a long pole.

To ensure that the collected data would meet the study's objectives, we examined our analysis options. The study design considerations that we weighed are summarized in Table 1.

TABLE 1 *Design considerations*

Features we stand firm on:	Compromises we made:
• Have sufficient number of replications	• Span study over several years
• Maintain the range of treatments to be tested	• Narrow the scope of the study
• Require before and after sampling	• Use S6 streams instead of S4 streams
• Measure the important variables affecting future decisions	• Reduce the number of indicator variables

CONCLUSIONS

1. It is feasible to establish an adaptive management study to test management policy in an operational setting.
2. Do not do it alone. Get a helpful statistician involved at the beginning of a study.
3. "Policies are experiments; *learn from them*" (Kai Lee 1993).

REFERENCES

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