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The Benefits and Challenges of Large-scale Silvicultural Experiments: Perspectives from Forest Managers on the Demonstration of Ecosystem Management Options (DEMO) Study

Abstract

The purpose of this paper is to share with other land managers and scientists some of the lessons learned in implementing the Demonstration of Ecosystem Management Options (DEMO) study, and to give our perspectives on the application of large-scale harvest experiments on public lands. We briefly discuss aspects of site selection; timber sale planning, administration, and post-harvest activities; assistance in study installation; funding and timelines; and public involvement. We offer perspective on large-scale studies, including the importance of adaptive management, the value of a study plan, the necessity for collaboration in the process, and the benefits of public involvement.

We have already learned a great deal about implementing large-scale experiments, gathered a wealth of information about the DEMO research sites, and experienced first-hand the challenges and rewards of collaboration among scientists and managers. Perhaps the most important lesson to emerge is that the rigidity required of scientific study may conflict with operational forest management. However, collaboration among participants can allow implementation of large-scale experiments that are both rigorous in design, and relevant in practice. Managers and scientists involved with the DEMO study would like data collection and analysis to continue in future decades. Knowledge of long-term responses, such as tree growth and forest structural development, will not be developed in the short run. We would also like to encourage new studies within the existing research sites, timely sharing of research results, and continued collaboration among scientists and managers.

Introduction

Forest managers on public lands are faced with the challenge of implementing ecosystem management. A key feature of ecosystem management is the concept of adaptive management, a process by which we test ongoing standards and practices, and accordingly revise management practices. The Demonstration of Ecosystem Management Options (DEMO) study will test an important component of the Northwest Forest Plan (USDA and USDI 1994)—the requirement of green-tree retention during regeneration timber harvests.

The DEMO study is being implemented on eight sites in western Oregon and Washington, on public lands managed for commodity production and other resources. Installing a large, multidisciplinary experiment on managed lands has proven challenging for both managers and scientists. It has, however, been a rewarding endeavor; the study has resulted in increased collaboration, has already provided new information, and has been a valuable learning tool for both managers and scientists. The goals of this paper are two-fold: (1) to share with other managers and scientists who may embark on similar large-scale experiments, some of the lessons that we have learned, and (2) to give our perspective on the values of DEMO and other large-scale research on public lands.

Lessons from Project Implementation

The DEMO study is a large-scale experiment that focuses on the effects of different levels and patterns of green-tree retention on various elements of Pacific Northwest forest ecosystems. These include responses of wildlife, vegetation, fungi, and canopy invertebrates; effects on snow hydrology; social perceptions of these harvests; and harvesting costs (Aubry et al. 1999). Each of the eight replications, or blocks, in the study include six 13-hectare (32 acre) treatments:

1. 100% retention (uncut control)
2. 75% retention (harvest in small, 1-ha circular patches)
3. 40% dispersed retention (retained trees uniformly dispersed)
4. 40% aggregated retention (retained trees in five, 1-ha circular patches)
5. 15% dispersed retention (retained trees uniformly dispersed)
6. 15% aggregated retention (retained trees in two, 1-ha circular patches)

Four DEMO replications are located in western Oregon on the Umpqua National Forest. Four replications are in western Washington—three on the Gifford Pinchot National Forest and one on Washington State Department of Natural Resources (DNR) land (see Figure 3 in Aubry et al. 1999).

The DEMO study has presented numerous challenges, due in large part to different objectives and working approaches between research and management (see also Franklin et al. 1999). Researchers must be concerned with evaluating treatment effects in an objective, unbiased fashion. These concerns have required harvests that may be more uniform in treatment and arrangement than managers would otherwise implement. In addition, treatments must be randomly assigned to experimental units rather than in some manner that optimally meets management objectives. These requirements have led to rather unconventional approaches to timber sale planning, preparation, administration, and post-sale operations in implementing the DEMO study treatments.

Constraints of the Study Design on Site Selection

One of the biggest challenges with implementing the DEMO study was finding suitable sites for the treatments. The experimental design required relatively large, uniform, regularly shaped units that were difficult to find on the managed landscape. Site selection required efforts from both scientists and managers to ensure that experimental needs were met, while minimizing adverse environmental effects from implementation of the timber harvests. Several criteria, in combination, made site selection difficult:

- The DEMO study design required relatively large units. Each unit had to be 13 ha (32 acres) in size, large enough to encompass the home ranges of small mammals (see Aubry et al. 1999).
- Units had to be square or slightly rectangular in shape, to conform to the shape of the sample grid, and to maximize interior habitat. Many potential sites were large enough, but lacked enough length or width to include the entire 13 ha grid.
- Sites had to be composed of upland, mature forests, the more homogeneous the better. Streams, riparian areas, roads, and existing harvest units were to be avoided if possible, to reduce additional sources of variability.
- The experiment had to be implemented on lands available for timber harvest in current Forest Plans.

Given these criteria, National Forests found it difficult to locate suitable sites. The mosaic of existing harvests, roads, and streams made it difficult to place 13 ha square units within landscapes that lacked these features. The most limiting factor proved to be streams; we found very few areas where replications could be placed without impacting even intermittent streams. Lands allocated to timber harvest amount to approximately 18% of the Gifford Pinchot National Forest, and 25% of the Umpqua National Forest, which also limited areas available for site selection.

Two changes to the experimental design and its siting made implementation possible. First, an early design called for eight treatment units (see Franklin et al. 1999), each 20 ha or larger; decreasing the number of treatments to six and reducing the size to 13 ha, helped considerably. The reduction in size was a compromise from the more ideal size originally proposed for arboreal rodent sampling (Lehmkuhl et al. 1999). Second, the Washington DNR was contacted and agreed to install one of four replications in Washington (Capitol Forest). Although it was not difficult for the DNR to find suitable harvest locations, there was concern in the organization that they not commit adjacent lands to serve as buffers (a similar concern exists with National Forests). Thus, we found that we could locate suitable sites, but only with difficulty, after revisions to the study design and by finding another cooperator in Washington (DNR). Studies of similar size and scope will be increasingly difficult to establish on National Forest lands. Smaller, more

focused studies will be easier to install and implement, although it may not be possible to ask questions that require sampling at larger spatial scales.

Timber Sale Planning, Administration, and Post-harvest Work

Environmental Consequences of the Treatments

Requirements of the DEMO study presented unique challenges for timber sale planning. Planners typically design harvest units to minimize adverse environmental and social impacts, to meet the standards and guidelines of National Forest Plans, or to fit in with harvest schedules on DNR lands. The DEMO experimental design imposed several constraints. Two examples illustrate this problem. First, in replicated experiments, treatments must be randomly assigned to avoid investigator bias. This requirement precluded the possibility of applying treatments with higher levels of green-tree retention to the more environmentally or socially sensitive sites. Second, the design required uniform application of treatments to minimize variation: patches retained in aggregated retention treatments had to be of equal size and distance from each other (see Aubry et al. 1999). If streams were present within units, the design required that riparian areas along those streams be harvested, except where they occurred within uncut patches. In essence, the study design did not accommodate the use of streamside buffers, or "riparian reserves" which are prescribed in the Northwest Forest Plan. These buffers would have had a confounding influence on the primary treatment effects. Managers were faced with a design that increased the probability of adverse environmental consequences, and that allowed only limited ability to work within the design to minimize environmental consequences.

Other specific environmental concerns included the locations of some treatment units within home ranges of northern spotted owls, or in habitat for threatened anadromous fish. These situations required consultation with US Fish and Wildlife or National Marine Fisheries Service biologists, to determine the potential effects of the proposed timber sales on these species. One Oregon replication is located within a municipal watershed which has earthflow terrain and soils with colloidal clays. The Environmental Protection Agency (EPA) reviewed the proposed timber sale and the research design and was concerned that in two treatment units, the removal of trees within riparian zones could increase stream turbidity over both the short and long term. EPA, managers, and scientists agreed to mitigate these concerns by providing additional large woody material to the streams. Some trees will be felled into streams, while others will be killed and left standing, to fall into streams over the next several decades. The additional woody material in the streams should help to trap sediment, but will have minimal effect on the upland processes that are being studied.

Logging Systems

The logging systems used in the DEMO study are often non-standard and more costly, due to requirements of the study design. To minimize additional sources of variation it was required that the same logging system was used in all treatments within a block. This led, in some cases, to cable or helicopter logging of gentle topography, where ground-based systems might otherwise have been used. An exception was permitted at the Capitol Forest block, where due to a combination of steep and gentle topography, the use of a single system would have led to greater variation in disturbance. Here, a combination of logging systems was used.

A secondary consequence of study constraints on logging systems was that it affected our ability to analyze the harvest costs of the different treatments. Because different logging systems are being used in different blocks, there was little opportunity for comparison between blocks. In addition, some non-standard operating procedures were employed, such as yarding tops to reduce slash. This measure served to remove slash in a very uniform manner, which was beneficial to many aspects of the study; however, it added a non-standard cost, adding to the difficulty in analyzing costs of operations. As a consequence, a harvest cost study was discontinued after the first two blocks were harvested.

Sale Preparation and Administration

Sale preparation activities were largely straightforward, but some tasks were more labor intensive than for standard sales. For example, the experimental design required that the basal area

of trees left in the dispersed retention units was within five percent of that in the corresponding aggregated retention unit (Aubry et al. 1999). This required more intensive tracking of marked trees in the dispersed retention units than under normal marking operations. Layout of harvest or non-harvest areas within treatment units also required different techniques, often taking more time than standard layout procedures. Extra time was often required to best place DEMO units, with their exact size requirements, on the landscape between streams and other features. On the other hand, once the sampling grids were surveyed and in place, they helped to make some layout work easier. Interior grid points could be used to locate within-unit harvest or retention patches.

The study design also required non-standard contractual provisions. For example, contractual language was included that required sale purchasers to collect information for preliminary studies of harvesting costs. Provisions were also included to protect sampling-point designation tags from damage due to logging operations. Standard provisions allowing for possible sale extension due to market conditions were withdrawn from sale contracts, because harvest delays could introduce unwanted temporal variation in treatments and the sampling units thereof. These provisions added complexity to the timber sales, and probably affected their marketability.

Since DEMO timber sales were non-standard, extra efforts were made to inform prospective purchasers about the project. During sale advertisement, meetings and field trips were held with prospective purchasers to discuss study requirements and research objectives. Meetings were also held with sale purchasers prior to harvest, again to clarify the intent of the experiment. These meetings were very helpful; requirements that at first appeared unusual to purchasers made more sense once the underlying objectives were understood.

In general, the potential environmental consequences of DEMO timber sales proved more difficult to assess than do those of most sales. Despite reduced flexibility to mitigate for potential consequences, we did not encounter significant adverse effects. The logging methods used were sometimes not standard, affecting the harvest cost study. Sale preparation and administration were fairly straightforward; the outcome of harvests to date illustrate the importance of clear communication with timber operators.

Post-Harvest Activities

Post-harvest practices, such as slash disposal, snag creation, and reforestation will be treated somewhat differently in DEMO study areas than in normal timber sales, once again to minimize confounding effects. Regeneration harvests on National Forests usually contain provision to create snags, by topping and killing "wildlife trees", green trees retained for that purpose. This measure mitigates the loss of snags from timber harvest, due to statewide safety regulations that require snags to be felled during harvest operations if they present a safety hazard. Normally, some wildlife trees are killed immediately after timber harvest, while others are left alive, to be topped in future years or to eventually become snags through natural mortality.

Because the principal effects being tested in the DEMO study are the pattern and amount of green-tree retention, leaving additional green trees for eventual conversion to snags could have confounding effects. Scientists and managers agreed to leave 6.5 additional green trees per hectare, provided that they were uniformly distributed and converted to snags immediately after harvest. This allowed for some mitigation of the loss of snags, while not further confounding the main effects of retention.

Slash disposal operations will also be affected by the study design on some blocks. Researchers seek uniform methods of slash disposal among harvest units; the goal is to minimize slash treatment, but provide for fuel reduction and allow for adequate sampling of post-harvest communities. Possible approaches include no treatment, yarding tree tops to landings along with logs, and slash piling.

On some blocks, contingency plans were made for additional slash treatment (burning) if initial approaches were inadequate. Decisions to pursue these options will be made by managers and scientists following harvest. From an experimental perspective, additional work is not desirable; it may add variability among treatments and delay initiation of post-harvest sampling. On the first two blocks harvested, slash levels were acceptable following the initial treatment (yarding tops). For one of these, managers would have preferred

to have greater slash removal, but could accept the levels present.

In summary, we found that the DEMO study design resulted in timber sales that were more difficult to plan and implement than standard timber sales. However, we also discovered that we have the flexibility to work with scientists to design and implement large-scale experiments on our matrix lands.

Assistance in Study Installation

The National Forests and Washington DNR not only prepared and sold the DEMO-related timber sales, but also installed the study sampling grids and provided logistical assistance to data collection efforts. Each DEMO treatment unit contains a grid of permanent sampling points, used to structure data collection (see Aubry et al. 1999). The National Forests and DNR were asked to establish the sampling grids. Engineering personnel were able to utilize survey techniques to meet the tight measurement tolerances required by the study design. The effort was costly (about $3,000-$5,000 per block) and there were a few communication problems regarding installation criteria on some blocks. Overall, however, the effort represented an excellent use of resources; during this period (1993-94) National Forest engineers had relatively low workloads due to a court injunction limiting timber harvests in spotted owl habitat, and they had the right skills to accomplish the job. It also had a secondary benefit, enabling engineers to contribute to a forest research project, something they may not normally have the opportunity to do.

National Forest and DNR managers were also confronted with additional logistical challenges: helping to secure housing or camping sites for university field crews, providing access and maps to study sites, occasionally arranging for volunteer assistance for researchers, and helping to coordinate the timing of field activities. As a consequence, National Forest and DNR personnel have become more familiar with the study and with the university researchers involved.

Funding and Timelines

Court injunctions, timing and processing of funds, and annual budgeting affected initial implementation of the study. A first appropriation of $1.5 million was allocated in fiscal year 1993, an amount that did not arrive on the National Forests until May (seven months later). At that time, National Forest lands within the range of the northern spotted owl were enjoined from harvests in spotted owl habitat, and a plan to address that injunction was being formulated. Thus, it was unclear when it would be possible to implement the DEMO study. Draft plans for the study were prepared and a "pilot" effort was begun on the Umpqua National Forest, with some data collection accomplished by Forest Service personnel during fall 1993. Additional replications were established, and pre-harvest data collection (by participating Universities under cooperative agreements) began in 1994. A study plan was developed and completed in 1996. The pilot data, collected before study plans were developed were never used. The completion of the Northwest Forest Plan (USDA and USDI 1994) allowed for completion of timber sale plans on National Forest blocks, and the study has progressed in a relatively smooth manner since then. However, based on our experience, a more efficient avenue for study development would have been to fund completion of a study plan first, then to implement the study.

Annual budgeting has also made planning difficult. Recently, the Pacific Northwest Research Station and the Pacific Northwest Region signed a memorandum of understanding helping to ensure 4 years of funding for the first phase of post-harvest analysis.

Public Involvement

The DEMO study has presented some interesting challenges in public involvement. Both managers and scientists participated in many meetings describing the rationale for the study, the study questions being asked, and the information being collected. Many people expressed interest in the study. Some were concerned about potential impacts of the timber sales, and others wondered whether the Forest Service would continue the research once the trees were harvested. Modifications to the study plan reduced probable environmental impacts (e.g., reducing the number and size of units, dropping an initially proposed clearcut treatment, and other smaller changes). These modifications to the design were at least partially in response to feedback gathered during public involvement.

Perspectives in Implementing Large Harvest Experiments

The DEMO study is still in its implementation stage, with initial post-harvest analysis several years in the future. However, we have learned a great deal about the benefits and potential problems involved with installing large-scale harvest experiments on managed National Forest and State lands. The study has been difficult to install on our landscapes, and it has taken a persistent and focused effort to make it possible. However, utilizing some Northwest timber sales to learn how to better achieve ecosystem management seems altogether appropriate. We share our perspectives on implementing large-scale experiments in the sections that follow.

*1. **DEMO and adaptive management.*** The information obtained from studies such as DEMO can provide the ecological or sociological basis for modifying our management practices over time. Under the Northwest Forest Plan, timber will continue to be harvested from several million acres of public land in the Pacific Northwest. However, the consequences of varying levels and patterns of green-tree retention in regeneration harvests have not been systematically examined. The DEMO study will test some of the assumptions used to formulate the Northwest Forest Plan and its associated standards and guidelines. Where appropriate, the information can also be used by local managers to meet resource objectives that are formulated by interdisciplinary teams at the project level.

So that future management can be more effective, we will need to provide specific examples of how the information obtained from DEMO can be used to design new silvicultural regimes, and guidance on how related harvest practices might influence forest function. The greatest challenge in DEMO is to tangibly link study results to decision support tools for forest management.

*2. **Large-scale interdisciplinary studies have benefits and limits.*** One of the potentially strong points of the DEMO study is that it encompasses both biological and social investigations and attempts to integrate among these. For example, wildlife investigators are providing fecal material from trapped small mammals to investigators of fungal communities. Jointly, researchers are examining which species of fungi are consumed by small mammals, and how these relationships vary with the relative abundance of fungi, thus providing insight into food web relationships (see Cazares et al. 1999). Similarly, vegetation studies (Halpern et al. 1999) will provide information on the changes in forest composition and structure that may drive many of the responses of the other organisms and ecosystem processes being investigated. However, multi-disciplinary studies may have limitations. Legal and managerial requirements for conducting timber harvests on National Forests make installation of large, complex experiments particularly difficult, and may constrain designs that would satisfy multiple research objectives.

*3. **Long-term planning**.* Large-scale silvicultural or ecological experiments, placed on public lands that are managed at least partly for timber production, require comprehensive planning prior to initiation. National Forests and other cooperating agencies should be included in planning activities from the outset. Large-scale experiments involve numerous considerations to ensure that they can actually be implemented.

*4. **The greatest value may be long-term in nature**.* Large-scale harvest experiments such as DEMO may provide their greatest value in decades to come. Initial results will indicate the immediate changes due to treatments, but long-term results may be more relevant than short-term responses to disturbance. Managers and scientists encourage maintenance of study sites and sampling grids for this long-term work.

However, any long-term study on actively-managed lands, rather than in research natural areas or experimental forests, presents difficulties. For example, adjacent or nearby harvests may influence study sites. The participating National Forests have committed not to harvest the study sites in the future. Sites will be protected from wildfire as much as possible, but there is the possibility of future disturbances from fire, wind, or pathogens. The possibility of future stand treatments, e.g., precommercial thinning of young trees, will be addressed over time. Long-term maintenance of the DEMO study will require ongoing commitment and effort from both managers and scientists. From our perspective, the value of maintaining this large experiment, with its potential wealth of information, is worth the effort.

*5. **Collaboration with scientists on public lands**.* A major benefit that can result from

experiments such as DEMO is the resulting collaboration between participating managers and scientists. One benefit of collaboration is simply the increased interaction between managers and scientists, sharing past experiences, results of other research, and future desires. Collaboration has been essential to the planning of the DEMO study to ensure that we prepare a scientifically valid, yet feasible study. Collaboration with Oregon State University and the University of Washington has attracted additional research to DEMO sites, that has culminated in a number of graduate theses (e.g., Pipp 1998). In addition, ancillary research is being performed at other sites on the Diamond Lake Ranger District, Umpqua National Forest, as the result of DEMO-related connections with local managers. Findings from such research hold the promise of providing assistance to local managers in future projects.

6. Studies provide increased local information. A great value of experiments such as DEMO is the increased level of local knowledge they afford. Pre-harvest sampling on DEMO sites has provided the two National Forests and DNR with a wealth of information about these specific sites. Species lists for vascular and non-vascular plants, birds, small mammals, flying squirrels, bats, fungi, and amphibians provide much more detail than we normally gather in Forest monitoring and project planning activities. Longer-term results should be even more valuable.

7. Participation. Public participation is essential in designing large harvest studies. Virtually all timber harvesting on public lands is controversial to some degree; timber harvests designed as experiments bring additional complications. Some welcome the idea that we may gather information from harvests that will enable us to improve future work. Others are concerned by the limited flexibility to mitigate problems. Much time needs to be invested in describing standard experimental procedures such as the need for random assignment of treatments.

It is important that scientists are an integral part of public involvement. Project scientists can better describe the rationale for study designs than can managers, and the public usually expects to hear from scientists as well as project managers. Participation in this process also helps scientists better understand public concerns and expectations.

A common concern raised during implementation of the DEMO study has been its longevity. Many people question the resolve of scientists and managers to carry out long-term research. Given annualized budgeting and decreasing federal budgets, most federally-sponsored researchers are in no position to provide guarantees. Indications of support, such as the memorandum of understanding for DEMO between the Pacific Northwest Region and the Pacific Northwest Experiment Station, can help to show intent. It is equally important, however, to be honest about the uncertainty of continued funding.

Concluding Thoughts

The design, planning, and implementation of the DEMO study has involved ongoing discussion and compromise among managers and scientists. The experimental design is intended to reduce extraneous variation, and to increase our ability to detect how forest ecosystems respond to varying levels and patterns of green-tree retention. In the process, however, this experimental design has led to unconventional types of timber sales, and may therefore produce unanticipated results. The scientists and managers involved understand these limitations, as well as the rewards that large-scale interdisciplinary studies may provide.

Although post-harvest sampling is just beginning, we have learned a great deal about implementing large-scale experiments, gathered a wealth of information about DEMO sites, and learned about interaction and collaboration between science and management. Although the rigidity required of scientific study may conflict with desires of forest management, it takes collaboration and compromise between managers and scientists to design and implement studies of this magnitude and scope.

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