Ecological Restoration Guidelines

For British Columbia

British Columbia

Forest Renewal BC

Acknowledgements

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Large parts of these guidelines were informed by Don Gayton's "Groundwork: Basic Concepts of Ecological Restoration in British Columbia" (Gayton 2001), and numerous practical tips were taken from the BCEN's "Healing the Land...Healing Ourselves: A Guide to Ecological Restoration Resources for British Columbia" (Ritchlin 2001).

Cover photo courtesy Glen Davidson, BC Parks.

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INTRODUCTION

One of the most significant changes in recent history is the transformed relationship between humans and their environment. Widespread realization that natural systems are precious and limited has begun to change our values towards the world around us. In particular, there is higher awareness about how our behaviour and actions can degrade the health and integrity of sensitive and valuable ecosystems. One response to concern for the environment is to prevent ecological damage in the first place. The other answer is ecological restoration, to repair what damage has occurred.

> *We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect. – Aldo Leopold, in "A Sand County Almanac" (1949)*

This document gives guidance on developing and implementing restoration projects. These guidelines are designed to inform and guide groups undertaking restoration programs, regardless of funding source or type of project. Because every restoration site is different, the emphasis is on identifying important components common to all restoration projects, and on providing suggestions for finding resources and developing project-specific plans. By using these guidelines, your group will be able to set appropriate and measurable restoration goals, and develop a restoration plan that will define short- and long-term activities. Developing these restoration goals and plans will not only make for a sound project, but will also assist in obtaining restoration funding.

Philosophy of Ecological Restoration

While concepts of nature conservation and restoration can be traced back to classical Greece, modern ideas of ecological restoration are built on the writings of Henry David Thoreau, George Perkins Marsh, and Aldo Leopold. The first restoration projects began in Wisconsin in the 1930's, under Leopold's direction (Gayton 2001).

> *The aim of ecological restoration is to fully restore the components and processes of a damaged site or ecosystem to a previous historical state, to a contemporary standard, or towards a desired future condition (Gayton 2001).*

In more recent times, definitions have evolved to describe an ecological approach to restoration. The Society for Ecological Restoration describes ecological restoration as: *"the process of assisting the recovery and management of ecological integrity"* (SER, 2002), while others describe it as *"the art and science of repairing damaged ecosystems to the greatest possible degree of historical authenticity"* (Mills, 1995). Key to ecosystem recovery is the restoration of internal processes, as well as ecosystem components (such as rare species, or important habitat features). Implicit in any restoration project is that the cause(s) of ecosystem degradation are identified and controlled (Gayton 2001). Hence, restoration is sometimes as simple as removing degrading agents (e.g., roads, dams, cows, or resource extraction). It may also require long-term efforts, such as reintroducing native species, removing exotic species, or reinstating natural processes including fire and floods. A common concept in restoration is to provide assistance in the context of our incomplete knowledge of how ecosystems function. Given time and removal of degrading agents, natural processes will accomplish most of the work.

Tanis Douglas

Tanis Douglas

Addressing degrading agents is critical to ecosystem recovery

Content and Use of These Guidelines

These guidelines are divided into sections, starting with the development of restoration goals and moving through project planning, implementation, maintenance, and monitoring. Pointers on developing a good restoration plan are included throughout, and an example of a potential restoration plan is found in Appendix 1. The following descriptions will allow you to skip ahead to the section most relevant to your project.

Restoration Goals

Setting appropriate goals is a critical step in the development of an effective project. This section of the guidelines gives an overview of current concepts in ecological restoration and discusses how these concepts can inform your restoration goals.

Restoration Priorities

High priority restoration needs in British Columbia have been at least partially identified, and this section discusses available information on restoration priorities.

Planning

This section is the most extensive part of the guidelines, as it goes into a step-by-step description of how to gather information in order to make restoration prescriptions. This section will be especially useful to restorationists looking for practical suggestions on finding resources and making plans.

Implementation

Logistical tips on items like permits, safety and project timing are included here. Reporting on your project is an important part of project implementation.

Maintenance

Successful projects consider future maintenance requirements, as discussed in this section.

Monitoring

Monitoring is an essential part of restoration that allows you to evaluate the success of your project and adjust plans when necessary. Monitoring design must be included in the planning and implementation stages.

Resources

Resources that compliment this guide, such as web-pages, government agencies and non-governmental organizations are listed here. A glossary of restoration terms is provided, and helpful references are also included

Restoration Plan

A sample restoration plan is included as Appendix 1.

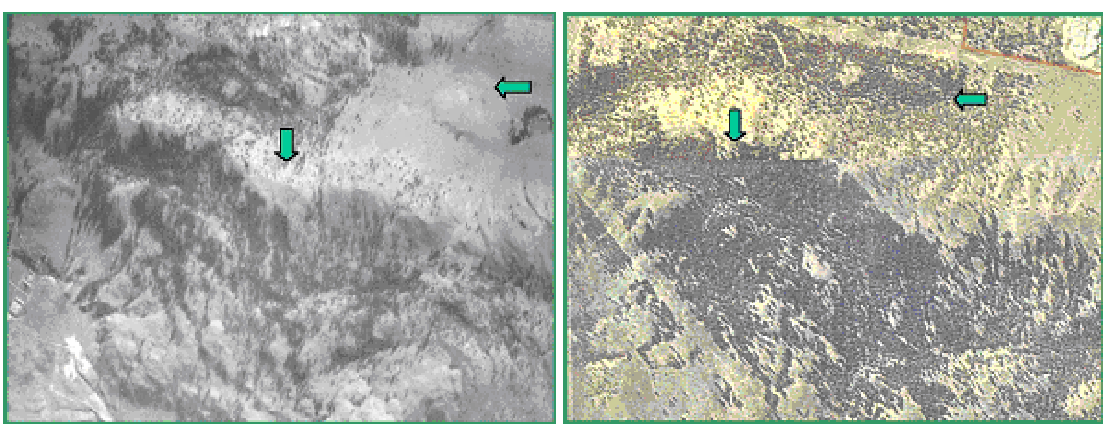
DEFINING RESTORATION GOALS AND OBJECTIVES

"Restore to what?" is a crucial question that every individual interested in restoration must ask. Ecosystems are dynamic, and continually changing over time and space. A common long-term goal (or *desired future condition*) for restoration is that the ecosystem looks and functions as it did before it was damaged or degraded, although exact replication of past conditions is rarely possible. Additionally, a similar ecosystem in good or excellent condition (a *reference ecosystem*) can be used in defining a goal (Gayton 2001). If you are planning a restoration project you no doubt have a goal in mind; this section should help you define your goals based on concepts common to all restoration projects.

What Are Restoration Goals & Objectives?

Restoration goals describe the *desired future condition* of a site, often decades into the future. These long term goals are supported with more short-term objectives, or targets. When establishing these goals and objectives, it is important to have an understanding of the *scale of restoration* (ecosystem processes, habitat, and/or individual species), processes of *ecological succession*, and the concepts of *natural disturbance regimes* and the *natural range of variability*. Taking into account natural healing processes, natural disturbance, and expected variability over time and space will help ensure your restoration prescriptions are appropriate for your site and the landscape you are working in.

Restoration objectives will be as explicit as possible about the *scale* and time-frame for restoration, and will be *measurable* so that progress towards the goals can be assessed. Given the dynamic nature of ecosystems, it is acceptable to state goals and objectives in terms of thresholds and ranges of values, as well as in definite number values.



BC Conservation Foundation

The same area in 1948 (left) and 1995 (right) – note changes in the amount of forest cover, partly as a result of fire suppression. A goal for this park near Kamloops might be to restore the amount of grasslands and open forests to within the natural range of variability, as described by old photographs and surveys

Table 1: Example Goals and Objectives

Example Goals and Objectives	
GOAL Restore valley bottom riparian vegetation composition and structure to former conditions (i.e. restore to a *desired future condition*, based on old surveys and photographs, stump counts, scientific literature describing typical ecosystem conditions, and the former disturbance regime).	**OBJECTIVES** ✓ Remove dykes and deactivate roads to allow flooding and channel movement to occur. ✓ Thin deciduous trees and plant coniferous trees native to the site to help attain target densities within a specified time frame. ✓ Create habitat features (e.g., snags, coarse woody debris, tree cavities, and shrubby gaps) by specified type and number/density.
GOAL Restore a Garry oak ecosystem to a condition of ecological integrity (as described by historic accounts, existing *reference ecosystems*, and professional opinion).	**OBJECTIVES** ✓ Remove specified exotic species to below a certain percentage of ground cover (specify time-frame) ✓ Plant native plants (specify type and number, time-frame) ✓ Re-introduce native butterflies (specify type and number) ✓ Introduce periodic fire to control Douglas-fir ingrowth (specify average fire return intervals)

Establishing Desired Future Condition

Desired future condition (DFC) is a commonly used term for describing a restoration goal, or end-point. The desired future condition may be an ecosystem that functions and looks like it did historically, before it was disturbed. In contrast, the DFC may describe a new reality that takes into account human presence and impacts that cannot be redressed. For example, exotic species and roads may never be removed from some ecosystems, but it is possible to reduce or limit their numbers or extent. Conversely, certain large predators or rare plants and animals may never be restored to some ecosystems, so the DFC would describe a relatively healthy ecosystem that is missing some of its former diversity.

Constructing a desired future condition is a fundamental step in a restoration project. *Reference ecosystems*, whether contemporary or historical, can often be of assistance in developing goals. The DFC is usually constructed using a variety of sources, such as reference ecosystems, knowledge of the former *natural disturbance regime* and the *natural range of variability*, local knowledge, historical references and maps, scientific literature, on-site clues, and professional opinion.

Using Reference Ecosystems

Undisturbed or less disturbed contemporary “reference” areas and historical landscape descriptions can be used in the development of restoration goals. Plant, animal, soil, and water data from these reference ecosystems provide useful “templates” for restoration work in similar sites (Gayton 2001). The potential and problems of using both contemporary and historical reference area information are discussed here in turn. The serious restoration practitioner should always consult a number of historical and contemporary sources before constructing a template for restoration (Gayton 2001).

Using Contemporary Reference Conditions as Templates

Ecological Reserves, Wildlife Management Areas, Parks, Protected Areas, Rangeland Reference Areas, and other relatively undisturbed sites, on both public and private land, can act as sources of restoration information (Gayton 2001). However, European influence on our ecosystems has been so pervasive that undisturbed areas are rarely found, particularly in zones of level, fertile land, in riparian communities, and near populated areas where restoration projects most often occur. Because reference areas are frequently small parcels, surrounded on all sides by early *successional* and disturbed lands, they are usually not fully representative of “pristine” ecosystems because of edge effects, invasion by introduced or undesirable native species, or “overrest” (too little natural disturbance), yet they still offer many useful clues. For example, at a Rangeland Reference Area near the East Kootenay community of Skookumchuck, even though the biodiversity and vigour of many species of grasses and herbs has increased inside the protected area, the accumulation of grass litter over the past fifty years has allowed for the establishment of a Ponderosa pine forest inside the exclosure. Normally the combined action of ungulate grazing and frequent fire on this dry site would not permit the establishment of a forest (Gayton 2001).

BC Ministry of Forests Don Gayton

The Milroy Grazing Exclosure in the East Kootenays. The photograph on the left was taken in 1951, the year the exclosure was built. The right-hand photograph was taken in 1995. Note the changes due to the exclusion of grazing cows and elk. This exclosure can be used as a reference area for grassland restoration.

Using Historical Reference Conditions as Templates

Another common reference point for ecological restoration is the way an ecosystem appeared to function historically (Gayton 2001). Such historical *benchmarks* are generally selected from within our modern climatic period, but before significant European influence. In British Columbia, this period is from about 1600 to 1880, and in some very remote areas this period may even extend to the present. Early published accounts, old-timers' recollections, early research projects, First Nations' accounts, archival photographs, tree rings, pollen cores, and fire scars are typical sources of data for this era, but many others are available to the creative investigator (Gayton 2001). Older air photos also add to an understanding of the site, though these generally date back only to the 1950s.

Don Gayton

Cross section of an old fire-scarred larch from the Canal Flats area of the East Kootenays. The tree germinated in 1600 and contains 10 separate fire scars.

National Archives of Canada

Don Gayton

Photographs of the Wildhorse River taken in 1883 (left) and 1998. Notice the changes to the hillside in the middle of the photographs. (The black marks on the 1883 photo are from damage to the negative.)

No single historical data source will be definitive. Historical journals and archival photographs can depict landscapes during atypical weather conditions or unusual disturbance events. Narrow, site-specific information and incomplete memory can skew historical observations. The restorationist must also guard against his or her own subjectivity when reviewing historical sources (Gayton 2001).

Concepts of Scale in Ecological Restoration

Ecosystems function at multiple spatial and temporal scales (Holt 2000), and so does ecosystem restoration. Table 2 provides examples of scales of restoration. Generally, examining ecosystem restoration needs at the scale of *ecological processes* is the most effective and appropriate way of addressing ecosystem damage, as it is ecological processes that regulate the condition of ecosystems. Natural disturbances and natural disturbance patterns are prime ecological processes that pertain to ecological restoration. It is implicit in process-based restoration that if the processes that were affected are restored, then other ecosystem components should also recover. This is sometimes referred to as the *coarse filter approach*. However, specific *habitat* needs or components within these ecosystems are often a crucial component of a restoration program. For example, *wildlife trees* are a critical habitat component for cavity nesters. The smallest scale of restoration is at the level of the individual *species*. While it isn't generally efficient to focus on one species, as opposed to a whole ecosystem, there are sometimes compelling reasons to do so. Restoration at the scale of habitat and species is sometimes referred to as the *fine filter approach*.

Dave Polster

Scales of Restoration. This photograph illustrates natural river morphology and the after-effects of fire, both prime examples of ecological processes. The process of succession will eventually regenerate a forest on the burn site. The small wetland at the top of the photo shows a habitat scale element. The standing snags are habitat features, and can provide critical habitat for specific species

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Jim Gilliam

Burning (coarse filter) restoration projects like this one near Squamish take into account fine-filter concerns, like preservation of important veteran trees and snags, and control of invasive weeds.

Table 2: Potential Scales of Restoration (adapted from Holt 2000)

Restoration Scale	Examples
Restoration of processes	✓ Re-introduction of natural disturbances: ✓ Setting ground fires in the Ponderosa Pine, Bunch Grass and Interior Douglas Fir zones ➢ Restoring unregulated flooding in formerly dammed or dyked river channels ➢ Restoring the former hydrologic regime post-logging or post-mining <u>Reintroduction of patterns related to natural disturbance:</u> ➢ Increasing the area of grasslands in the landscape ➢ Initiating or speeding up *succession*, to restore seral stage distributions across the landscape (e.g. restoring for old forests) ➢ Restoring former abundance of hardwood and mixed forest stands
Restoration of Habitat (ecosystem components)	➢ Restoration of specific structures/features within ecosystems: o Restoring *large woody debris* in streams o Restoring large-sized trees to managed forests o Restoring large-sized standing dead trees (*wildlife trees*), and fallen trees (*coarse woody debris*) to managed forests ➢ Restoration of soil in industrial areas, and in ecologically sensitive areas ➢ Restoration of wildlife habitat features, i.e. known critical or rare habitat such as: o *coarse woody debris* in appropriate salamander sites o tree cavities for cavity nesters o lichen populations for caribou browse
Restoration of Species	➢ Re-introduction of *extirpated* species (e.g., burrowing owl) ➢ Stabilization of decreasing populations (e.g., mountain caribou) ➢ Removal/management of invasive exotic species (e.g. Scotch broom/knapweed) ➢ Restoring *keystone species* (e.g. salmon, major tree species), and rare and endangered species, ➢ Restoring habitat for *umbrella species* (e.g. grizzly bear, caribou)

Coarse and Fine-Filter Restoration

The *coarse filter* concept is an ecosystem-based approach that assumes most species will have their needs met by restoring or protecting the fundamental structure of an ecosystem. For example, restoring natural flows to a degraded wetland can provide conditions suitable for the re-establishment of most wetland species. Fire-based restoration is another coarse-filter process, where it is assumed that the opening of forests or grasslands by fire will meet the needs of species dependant on these habitats. However, the *fine filter* approach should always be used in tandem with the more generic coarse filter approach. While it is impossible to manage for all the different species or attributes in an ecosystem, there are always some that will require individual attention. In the example of fire restoration, specific habitat features, including wildlife trees or coarse woody debris, may need to be preserved or created, weedy invasive species may need monitoring and control, and the timing or location of burning may need to take into account the nesting season of certain birds.

Using Ecological Succession in Restoration

Ecological succession is the sequence of changes that a *biotic* community passes through before reaching its maximum possible development within the climatic context of the regional landscape. This is usually a self-sustaining condition often referred to as a *climax community*. Ecological restoration assists an ecosystem along this successional sequence towards a *desired future condition*, which is usually at, or near, the climax community (Gayton 2001). Damage generally reverts an ecosystem to an earlier successional stage, or shifts it towards another type of climax community.

By understanding the biotic community that your particular site would naturally support, achievable and appropriate restoration goals can be set. The Ministry of Forests' Biogeoclimatic Ecosystem Classification system (see sidebar) is a useful tool in setting restoration targets and understanding succession on many sites. This system's site series descriptions provide lists of appropriate plant species with which a planting program can be developed, in order to kick-start the process of succession on damaged sites.

Climax is a complex process that is not entirely understood. Originally, climax communities were regarded as the end result of a methodical, linear process. Today we understand that natural succession is sometimes unpredictable, and can follow several paths depending on site conditions. A different climax community may result. It is also important to note that not all ecosystems were at their climax state before European settlement. Natural and anthropogenic disturbances would have produced a mix of successional stages across the pre-contact landscape (Gayton 2001). In general, natural disturbance regimes play an important role in ecosystem development, and makes 'room' for some species not considered part of a 'climax' community. Disturbance regimes may prevent an ecosystem from reaching its climax community (Gayton 2001), and should be taken into consideration when making restoration plans. For example, excessive disturbance caused by over-grazing of grassland sites will prevent the climax grass community from establishing, and any restoration project should ensure that these types of *degrading agents* are addressed as a first priority.

Biogeoclimatic Ecosystem Classification system

The BEC system is an extremely useful tool for describing and managing BC's ecosystems. Every BC restorationist should be familiar with how his or her site fits into this classification scheme. For a more complete description please see the Resources Section.

The complexity of ecological succession should not be a barrier to action, but it should encourage restorationists to do their ecological homework before launching into a project (Gayton 2001).

Dave Polster

Succession from bare ground (left) to mature forest (right) is an important natural process that is fundamental to ecological restoration. Re-establishment of natural successional trends is often a goal of restoration projects.

The Importance of Natural Disturbance Processes

Natural ecosystems go through processes of establishment, aging, disturbance, and renewal. Renewal can be initiated by large wildfires, or by the toppling of a single old tree. While these *natural disturbances* and their subsequent effects are sometimes actively suppressed by humans due to the perception that they are harmful and destructive, many organisms and ecosystems depend on disturbance for survival. For instance, the black cottonwood, a *riparian* tree, times the release of seed to coincide with peak spring flows of the adjacent river. In years when the river floods and spills over its banks, cottonwood seed gets widely distributed downstream (Gayton 2001). In other examples, the unique high-elevation shrub communities created by repeated snow avalanches are crucial for foraging bears. Many species of forest birds rely on dead standing trees for nesting habitat, and seeds of the shrub ceanothus and lodgepole pine both germinate in response to fire.

Natural Disturbances

Insect outbreaks, fire, snow press, diseases, ice storms, windstorms, avalanches, volcanic eruptions, floods

Tanis Douglas

Thick stands of lodgepole pine on the site of a 1985 wildfire. Lodgepole pine germinates and thrives in response to fire.

Natural Disturbance as an Agent of Ecosystem Health – Forest Disease

The role of disease-causing tree fungi (e.g. *Armillaria* spp. and *Fomes* spp.) in creating un-even aged forest stands and valuable wildlife trees is only now beginning to be appreciated. Where forest pathogens and pests are traditionally viewed as negative and costly, disease agents are now sometimes acknowledged to be an integral part of a healthy ecosystem. The role of some of these agents can have a profound effect on large areas of anthropogenically-impacted forests. For example, mountain pine beetle (*Dendroctonus ponderosae* Hopkins) attacks older, even-aged lodgepole pine that have been allowed to establish over extensive areas due to wildfire suppression. The damage caused by the beetle kills most of the pine *overstory*, and allows different *successional understory* species to establish. While these beetle-killed forests usually represent serious economic losses, this disease-causing beetle can actually restore more natural and stable conditions to the dense forests created by decades of fire control.

Using Natural Disturbance Regimes to set Restoration Goals

An understanding of the local natural disturbance regime will help a restoration practitioner understand the types, patterns, and ages of ecosystems that would have been present prior to European influence. Natural Disturbance Types (NDT) are a useful tool, developed for British Columbia as part of the Forest Practices Code Biodiversity Guidebook (Province of BC 1995). These Types categorize the Province into zones based on the frequency and severity of pre-European disturbance events. It is important to note that this definition of "natural" disturbance includes aboriginal land management activities such as burning as they were conducted before European contact (Gayton 2001).

Natural Disturbance Types, as defined in the Forest Practices Code *Biodiversity Guidebook*:

NDT1: ecosystems with rare stand-initiating events
NDT2: ecosystems with infrequent stand-initiating events
NDT3: ecosystems with frequent stand-initiating events
NDT4: ecosystems with frequent stand-maintaining fires
NDT5: alpine tundra and subalpine parkland

The Biodiversity Guidebook assigns groups of *biogeoclimatic* subzones and variants to each NDT, and also provides general guidelines for forest stand age-class distribution in each of the five categories (i.e., it provides guidance on *landscape-level* ecosystem patterns). The NDT concepts are not specific to the local, *stand* level at which most restorations take place; however, the guidebook, together with biogeoclimatic maps, form valuable starting points for terrestrial restoration planning (Gayton 2001).

Identifying local-level natural disturbance regimes can be tricky; for example, the average fire-return interval in a fire-maintained (NDT4) landscape depends on slope, aspect, elevation, and topography. However, a variety of techniques can be used to understand your local disturbance regime (see 'Historic Reference Ecosystems'), and more information is available all the time. In general, methods of investigating the former disturbance regime and disturbance pattern on a site might include coring older trees, examining fire-scarred trees, assessing soil pits, looking at historic photos and records, and investigating local knowledge.

Mimicking Natural Disturbance – Ecosystem Management in the East Kootenays

In recent decades, the effects of fire suppression have become a cause for concern for many residents of the East Kootenays, BC. Historically, before widespread settlement and fire suppression efforts, ground fires would have burned relatively frequently due to lightning strikes and due to intentional ignitions by First Nations to increase hunting opportunities. Now, the amount of grassland and open forest is in serious decline, causing concern to various sectors of society. Hunters, government managers and ranchers are concerned about the loss of grassland and open forest habitat, formerly available to big game species, currently rare and endangered species, and livestock. Forest managers are also critically concerned about the risk of cataclysmic fire due to the increase in dense forests and fuel build-up. Hence, under the Kootenay-Boundary Land Use Plan (1990), there is wide agreement to manage the area to mimic the former disturbance regime.

Under the Land Use Plan, the Rocky Mountain Trench is zoned into the three main types of ecosystems desired: open forest, grasslands, and closed forest, based on interpretations of old air photos and site capabilities. It will take decades of selective logging, in-growth 'slashing', and ground fires to restore the area closer to how it was when fire was the main disturbance agent. However, all segments of society are in agreement that the alternative is not acceptable. The alternative to current management plans is an ecosystem far removed from its *natural range of variability*, with serious impacts to the plants, animals and humans that depend on it.

Natural Range of Variability

The *natural range of variability* refers to the spectrum of ecosystem states and processes encountered over a long time period (Gayton 2001). Because so many ecosystems have been altered by European settlement, the "natural" range of variability usually refers to the full range of ecosystem structures and processes encountered before major changes brought by non-aboriginal humans. The natural range of variability is typically defined by the period 100–200 years before European settlement, and is also surmised from knowledge of natural disturbance regimes. Natural range of variability is often used to describe disturbance processes, and the ecosystem variability that these disturbances create. Ecosystems are thought to be more sustainable if we manage them so that their current disturbance regime falls within the natural range of variability (Gayton 2001).

An example from studies of fire ecology shows how the natural range of variability concept works (Gayton 2001). Lewis Ridge, a dry, south-facing Douglas-fir forest near Cranbrook, had a historic fire return interval (the length of time between fires) that varied between 3 and 52 years, for the period 1600-1880. The average return interval was 19 years. If our restoration prescriptions call for fire every 2 years, or 80 years, or if over time the average interval between fires is shifted to 10 years or to 50 years, we can be said to be managing Lewis Ridge outside of its natural range of variability. However, if we were to use Lewis Ridge as a template for large-scale, fire-maintained ecosystem restoration in this forest type, we would *not* attempt to impose a 19-year fire return interval over the entire landscape. Instead we would create a mosaic of short, medium and long-return patches that collectively bring the average interval to near 19 years (Gayton, 2001). This *landscape scale* perspective is important, and will help restorationists restore the variability that was once present over space and time, rather than setting the same restoration target across the whole landscape. Of course, difficulties will arise when attempting to fit natural ranges of variability into modern concerns of a changing climate. If indeed the climate is warming, climate change concepts must then be applied as best as possible into restoration processes.

A natural range of variability should be developed not only for the disturbance *return interval* but also for the *size* and *severity* of the disturbance (Gayton 2001).

Enhancement versus Restoration

The words *enhancement* and restoration are often used interchangeably, but the difference is important, and relates to the natural range of variability. Enhancement often refers to the manipulation of habitat to allow a selected species to exceed its historical population levels in a particular area (Gayton 2001). Enhancement activities attempt to change a habitat type or species to outside its natural range of variability, usually for the benefit of humans. A potentially negative example of enhancement is stocking alpine lakes or stream reaches above waterfalls with economically important fish species. As a result of these ecosystem changes negative consequences are often suffered by the non-target species.

Measurable Parameters

Making restoration goals explicit and measurable is a critical step in restoration planning. Without a way to measure progress, we cannot assess the success towards our original goals, or discern whether such work is worth doing in future. *Adaptive management* (Walters 1986) is the term used for the “feedback loop” of continuous learning and improvement that is created by formulating clear restoration goals and then monitoring achievement of these goals (Gayton 2001), especially as the work progresses. Often we need both short-term and long-term goals in order to do this.

Appendix 2 describes an overview of Adaptive Management in the context of ecological restoration.

Tanis Douglas

Dave Polster

Left: Where the restoration goal is re-establishing a native plant community damaged by knapweed invasion, a measurable restoration objective could be a certain percent decrease in knapweed cover, with a concomitant increase in cover of the desired species. Right: Measuring changes in plant species composition by assessing ground cover in square ‘plots’ along a transect.

The parameters used to measure the success of restoration projects are sometimes self-evident. For example, if the goal is to restore fish habitat, fish densities or numbers will be measured; if the objective is to re-forest an area, tree survival will be measured. In other cases an indicator that provides information about ecosystem changes will be selected.

Measuring Ecosystem Change Using Indicators

The following are examples of indicators to measure ecosystem change.

Measuring species composition change in treated ecosystems:

- ✓ Wildlife assessments
- ✓ Breeding bird surveys
- ✓ Amphibian counts
- ✓ Vegetation cover – assessing vascular and/or non-vascular plants

Measuring *abiotic* indicators of ecosystem recovery:

- ✓ Soil nutrients
- ✓ Soil organic matter
- ✓ Hydrologic recovery (water flow and timing)

ECOSYSTEM RESTORATION PRIORITIES IN BC

Restoration practitioners can use this section to help choose a restoration project, or to understand how their restoration project fits into provincial-level restoration needs.

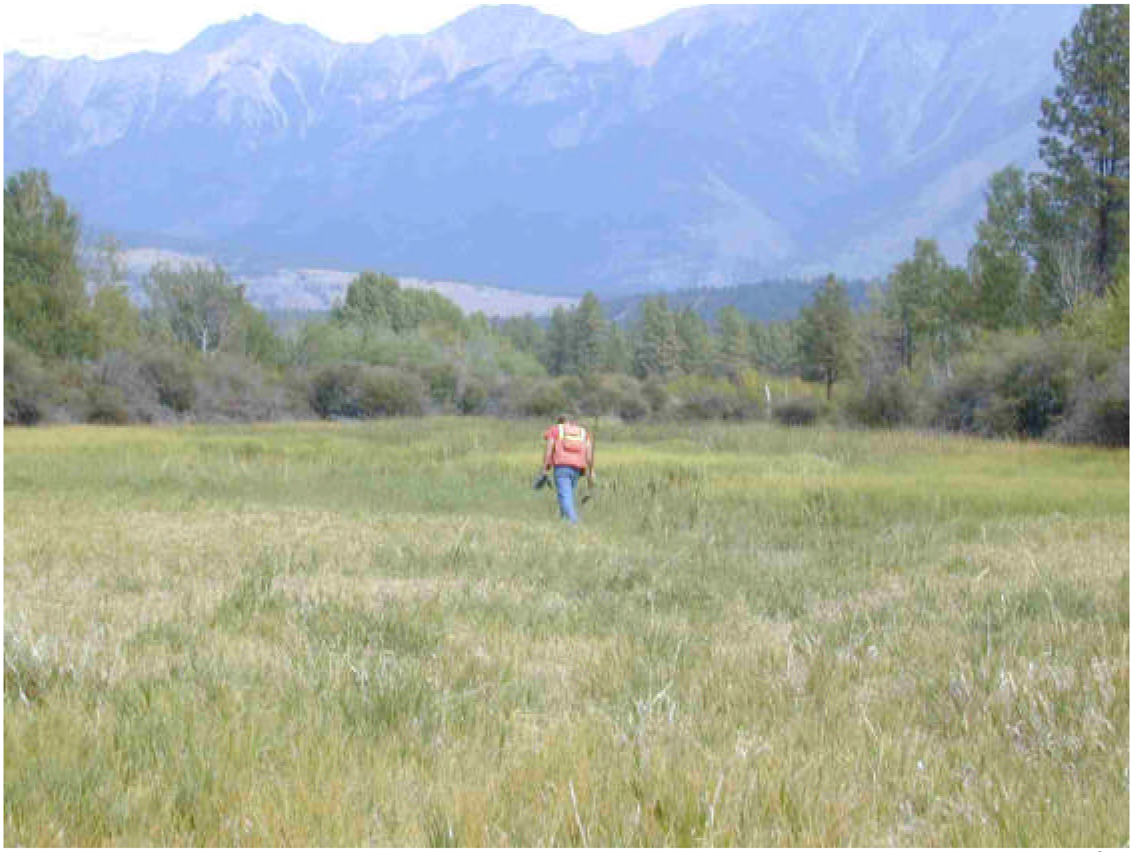
Terrestrial and aquatic restoration have been handled as separate programs by government, and the prioritization schemes are quite different.

Aquatic Restoration Priorities in British Columbia

A planning process was undertaken for the former Watershed Restoration Program that designated high priority watersheds and sub-watersheds, based on the importance and risk to the fish stocks that used those rivers. All watersheds in the Province are ranked using this system, and these lists are available on a region-by-region basis through your regional Ministry of Sustainable Resource Management office.

Watershed-based Fish Sustainability Planning is underway as of 2002. You can find more information about this comprehensive, high-level aquatic sustainability program by visiting the following webpage: http://www-heb.pac.dfo-mpo.gc.ca/publications/pdf/wfsp/wfsp_e.htm or by contacting the Department of Fisheries and Oceans, or the Ministry of Water, Land and Air Protection. The information generated through this initiative will be of interest to restorationists working in specific watersheds under discussion, and will help coordinate land management and restoration activities for aquatic values, whether on private or public land.

No priorities have been set for restoration work on wetlands and lakes around the province. In general, almost all wetland habitats are at risk in inhabited areas, and are often high priorities for restoration. Aquatic features such as kettle lakes in the dry interior are useful sites to consider for restoration; these areas are usually biodiversity 'hot-spots' and often suffer impacts from agricultural or human use.



Tanis Douglas

Wetlands, kettle lakes, and sloughs like the one pictured above are often high priority for restoration treatments.

Terrestrial Restoration Priorities in British Columbia

The Terrestrial Ecosystem Restoration Program (1999-2002) has designated restoration priorities based on the Biogeoclimatic Ecosystem Classification subzones of the Province (see BEC information in Resources section). Under the BEC system the province is divided into 14 BEC zones, and 94 subzones, and it is these subzones that are rated for their restoration need based on their extent of departure from the ***natural range of variability***. This analysis was done for each of the six provincial forest regions, and the resultant Strategic Ecological Restoration Assessment reports are available online from the Biodiversity Branch of the Ministry of Water, Land and Air Protection (http://wlapwww.gov.bc.ca/wld/fia/habitat_restoration.html). These SERA reports provide a basis for understanding the most pressing restoration needs in BC.

PLANNING YOUR PROJECT

This section provides information on steps and resources that are important to consider when planning your restoration project. By going through the steps outlined in this section you can help ensure your project is as informed and effective as possible. If you are forming a group for the purposes of restoration, you may benefit from The Stewardship Series publication: *Community Stewardship: A Guide to Establishing Your Own Group* (see Resources section).

Elements of Successful Projects

Common elements of restoration include assessing the feasibility of the plan, developing the plan, implementation, and monitoring. Successful restoration projects share several elements (adapted from Brown, 2000 and Ritchlin, 2001):

Elements of Successful Projects

- ✓ Understanding physical and biological processes, both those that are common to all ecosystems of the type under consideration, and those that pertain specifically to the site. Every site has special concerns that make it unique.
- ✓ Taking a landscape or watershed perspective. Local restoration efforts often relate to the larger ecosystem, and must acknowledge land uses from outside the restoration site that may influence project success.
- ✓ Setting clear goals and objectives. Goals and objectives need to be:
    - ✓ Specific
    - ✓ Achievable
    - ✓ Measurable
    - ✓ Understandable
    - ✓ Flexible
- ✓ Early stakeholder and public involvement.
- ✓ Political support.
- ✓ Effective communication and education
- ✓ Monitoring and evaluation

Hobbs and Norton (1996) describe a sequence of events common to any successful restoration project, and these factors are described in various ways throughout these guidelines:

1. Identify the processes underlying the degradation or decline;

2. Define suitable restoration goals and objectives based on a reference ecosystem, historic range of variability, and/or desired future condition;

3. Develop treatment prescriptions to reverse or ameliorate the degradation or decline at a spatial and temporal scale appropriate to the problem;

4. Implement treatment prescriptions and monitor to ensure that they are followed;

5. Identify and monitor key system variables and other easily observable measures of treatment success;

6. Review and summarize monitoring output, assess progress of restoration relative to initial goals, and make adjustments, if necessary; and

7. Communicate findings and incorporate them into future planning and management strategies.

Assessing your site

This section gives a step-wise list of actions needed to understand the restoration needs at your site. These steps are similar to those developed by the Society for Ecological Restoration, and more information can be found on their web site (www.ser.org).

Identifying Boundaries and Land Ownership

Once you've chosen your restoration site, the next step is to identify its boundaries and determine private land ownership and/or Crown land tenures. For BC, land title and resource tenure information can be obtained through the Land and Resource Registries Portal (http://srmwww.gov.bc.ca/sstu/portal), a project of the Ministry of Sustainable Resource Management. Alternatively, your local Ministry of Forests office may be able to provide information on Crown forest or rangeland tenures, special management zones, and resource management plans. If you are close to a town, your area will probably encompass a mix of land titles, and you may need to do a land title search with the help of the Land Title Office.

If your site is on private land, your restoration goals may still be possible if they meet the needs of the landowner. Options for conservation covenants (i.e., modifications to the land title for conservation goals) exist and should be explored with groups like Nature Conservancy of Canada or The Land Conservancy (see Resources section). Land trusts like these often work with private landowners to manage for ecological goals, and restoration can be part of their land management plans.

Identifying Causes of Damage

Identifying and understanding what caused the ecosystem damage will assist in developing restoration goals and prescriptions. The most effective restoration projects are those that simply remove the *degrading agents* to allow for ecosystem recovery. For example, fencing off a wetland or grassland from cows will allow for at least partial ecosystem recovery. Restoring natural flows to a wetland or stream by removing a dam or diversion is another example of addressing the cause of ecosystem damage. It is important to identify the reasons why the site is degraded, and ensure that these causes are addressed before much time and money is spent.

Tanis Douglas

The area to the right of the fence line has been protected from grazing for one year. Note the difference in the grass community between the protected area, and outside.

Causes of damage are not always obvious, and it may be unclear what the site was like before it was degraded. In these cases, expert opinions from government agency staff or experienced consultants may be needed. Information from local individuals or government on previous land uses may also help explain the current disturbed condition. Alternatively, historical research may provide some clues (see 'Using Historical Reference Conditions as Templates').

Setting Goals and Objectives

Successful restoration projects require that the effects are measurable, hence goals and objectives must be explicitly defined, something that will be possible only following a site assessment. At this stage, preliminary, qualitative goals should be set to provide a basis for further investigation. During the assessment phase, preliminary goals and objectives are refined as more information is gathered and options are assessed. (See the previous discussion on Defining Restoration Goals and Objectives.)

Identifying Key Players

A key player is any party who will work on the project, be directly or indirectly affected by it, or have legal jurisdiction or influence over some or any part of it (Ritchlin 2001). Identifying and contacting key players early on will help determine if your plans are feasible, and will also provide avenues for obtaining the resources and information that you will need.

<u>Key Players in Restoration:</u>
(adapted from Ritchlin 2001)

- ✓ **Landowners.** Whether the landowner is government or a private individual, you will need their support. In the case of private landowners, the booklet *Community Stewardship*, from the Stewardship Series, has a section on working with private landowners. The Stewardship Series also has specific guides for landowners, planners, and developers. If your site is on private land, you will want to involve the landowner as much as possible in order to allow them to develop a sense of stewardship of your project.

- ✓ **Various levels of government** (municipal, regional, provincial, and federal). Government staffers often are able to offer valuable technical advice, as well as provide information like maps, plans, reports, and aerial photographs. Depending on your site and what you plan to do, the government may have jurisdiction to regulate your activities (see 'Permits and Approvals'). See Table 3 below for an idea of which government agencies you might involve.

- ✓ **First Nations** with an interest or claim in the area. First Nations should be consulted in the earliest stages of restoration planning, as they often have land claims on the property and may have their own plans for the area, and will take an interest in restoration activities taking place in their traditional territories. They often provide unique perspectives on the history and ecology of the potential restoration site, and can provide resources such as maps, plans, reports, air photos, expertise, and equipment. Many restoration projects incorporate First Nations workers in the implementation phase.

- ✓ **Local industry** that depends on the site. This includes forestry companies that have rights to Crown timber, ranchers on Crown land, and any other commercial interest whose plans or livelihood might be affected. These companies may influence what is possible on your site, and may also be in a position to provide valuable information (e.g., maps, plans, reports, air photos), expertise, equipment, and other resources.

- ✓ **Environmental, civic or social groups** in your community. These groups are usually able to provide information and resources such as volunteers, as well as publicity, and access to decision-makers.

- ✓ **Academic experts.** Many academics are active in the field of restoration, and experts in such fields as botany or hydrology may give valuable input to your plans.
- ✓ **Funding agencies** (see Finding Funding).

The following table, adapted from the Streamkeepers Handbook (Department of Fisheries and Oceans 1995), gives an idea of which government agencies are responsible for which types of activities.

Table 3: Restoration Activities and Responsible Government Agencies

Activity	Local Government	Provincial Government Ministry	Federal Government Department
Fisheries management and restoration		Water, Land and Air Protection (MWLAP) – freshwater	Fisheries and Oceans Canada (DFO) – marine and anadromous fish)
Wildlife management and restoration		MWLAP	Environment Canada (Conservation)
Forestry and forest restoration	Planning (urban)	Forests (MOF) (Crown land only)	Canadian Forest Service
Grasslands		MOF, Ministry of Agriculture (Crown land only)	Canadian Forest Service
Gravel pits, mines	Engineering and Ops	Sustainable Resource Management (MSRM)	Natural Resources Canada
Land Development	Planning	MSRM (Env. Assess) and BC Land & Water	
Prescribed Fire	Fire department, Engineering and Ops	MWLAP (air quality), MOF (on crown land)	
Road stewardship and restoration	Engineering and Ops	Transportation and Highways, MOF	
Enforcement	Bylaw enforcement	MWLAP (conservation officers) and MOF (compliance and enforcement)	Environment Canada (Protection), Fisheries and Oceans Canada (fisheries officers)
Flood control	Engineering and Ops	MWLAP and MSRM (Water Management)	Environment Canada (Conservation)
Water use (incl. restoration), supply, drinking water	Public health, Regional water district	MSRM (Water Management)	
Streamside zoning and land use	Planning	MWLAP (all streams) and MOF (Crown Land)	Fisheries and Oceans Canada
Water Quality	Engineering and Ops	MWLAP	Fisheries and Oceans & Environment Canada
Air Quality	Engineering and Ops	MWLAP	Environment Canada

Gathering Information and Data

Information gathering is a critical phase of any project. Table 4 below shows the types of information that can be useful to your project, and the sections below discuss steps to gather the information that you will need. The more information gathered the better your chances for a successful project. It's important to consult as many sources, experts, and groups as possible.

Table 4. Planning Your Restoration Project – Types of Information
(adapted from Stewardship Series: Community Stewardship: A Guide to Establishing Your Own Group)

Types of Information		
Biophysical	**Social/Cultural/Economic**	**Organization/Strategic**
Ecosystem Classification (e.g. biogeoclimatic zone) Geology, topography Soils Climate Groundwater Surface water Watershed boundaries Vegetation, forest resources Wildlife, Fish Current Condition of above features (e.g. level of degradation, number of endangered species, levels and types of pollution)	History: cultural heritage, past settlement, resource land use First Nations traditional territories Current cultural groups in the community Land tenures Current land uses and values: recreation, spiritual, resource production (forestry, mining, agriculture, fisheries) urban (residential, industrial, institutional) Economic values of the above uses Existing and proposed land use plans	Other groups in the area and relevant provincial-level or umbrella groups Government agencies with planning, resource management, and conservation responsibilities and the policies and statutes they apply Governments having jurisdiction over the area, political boundaries, and the timing of up-coming elections Community organizations and volunteer pools Possible research support: educational institutions, libraries, consultants Recent and current resource and conservation issues and solutions

These information-gathering steps are presented chronologically but may take place in a different order, or simultaneously:

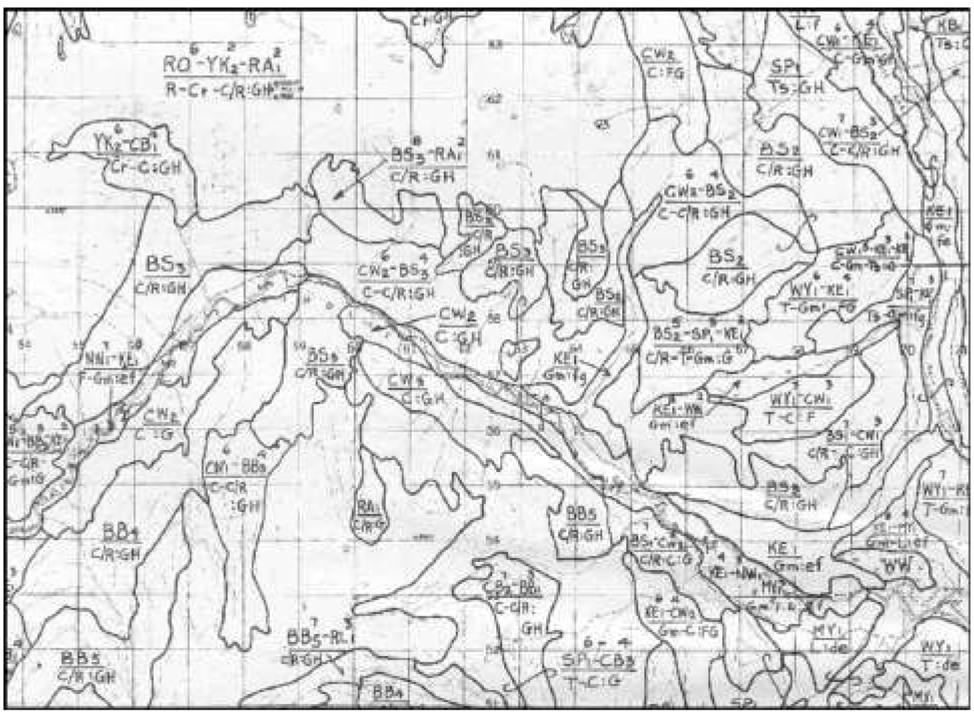
1. Identify Ecosystem Classification

The provincial Biogeoclimatic Ecosystem Classification (BEC) system provides a basis for understanding the type of ecosystem you are working with. The BEC system integrates climate, geology, and vegetation to provide an understanding of the native plant communities appropriate for a site. Therefore, it is important to identify which BEC subzone and site series your target area falls into (see the Resources Section for BEC resources; you may also be able to obtain or view a large-scale BEC map of your area at your local Ministry of Forests office). You should also know which *Natural*

Disturbance Type describes your site (see 'The Importance of Natural Disturbance Processes'), as the natural disturbance regime will also affect the types of ecosystems naturally present. The Biodiversity Guidebook provides a list of which BEC subzones belong to which Natural Disturbance Type.

2. Accumulate and Review Current Maps, Reports, Plans, and Aerial Photographs

Restoration planning always involves collecting relevant, project-specific information. Resources like maps, reports, plans, and aerial photographs are generally available through key players, such as government agencies. Your local Ministry of Forests office will have access to some of these resources if your site is on Crown forest or range land, and if your site is an aquatic feature your regional Ministry of Water, Land and Air Protection office or Fisheries and Oceans Canada office may have relevant reports or data. The Ministry of Sustainable Resource Management is the repository of inventories and maps. A great deal of information can be found on the web (see below). If your site is on Crown forest land, the local forest industry contact may have the best and most up-to-date aerial photographs and maps, and will be able to provide information on logging, road plans, and other pertinent details.



Dave Polster

Soils maps can be used to determine soil conditions in the project area, though more investigation is needed to determine exact conditions of the restoration site.

The following is a list of common types of information to gather for your project, and where this information is found:

- ✓ **Vegetation information**. This is available in the Biogeoclimatic (BEC) handbooks and online BEC information (please see Resources section). Vegetation information is also available through Forest Cover Maps, BEC maps, and Terrestrial Ecosystem

Maps (see next). Some areas of the province have more detailed vegetation studies and you should check with your local Ministry of Water, Land and Air Protection, or Ministry of Sustainable Resource Management office.

- ✓ **Maps**. The types of maps you may need (as available) are:

  - ✓ **Terrain Resources Information Maps (TRIM).** These maps are available at a 1:20,000 scale in paper copies or digital for the whole province, and can form a good base map for your project. Paper copies are available from your local Government Agent , or from Land Data BC (see Resources section).

  - ✓ **Biogeoclimatic Ecosystem Classification (BEC) Regional Maps.** These are available through your local or regional Ministry of Forests office, or Ministry of Sustainable Resource Management office. These maps are at a 1:250,000 scale, and show the BEC subzones for your region.

  - ✓ **Forest Cover Maps** are available for all Crown forests at a 1:20,000 (***stand level***) scale, and describe and map the distribution of the dominant tree species and age classes. These maps are very useful for restoration planning; paper copies may be obtained from Clover Point Cartographics in Victoria, BC, phone number: (250) 384-3537. Digital copies are available from the Ministry of Sustainable Resource Management.

  - ✓ **Terrestrial Ecosystem Maps (TEM)** are very useful if available, as they contain information on vegetation and soils at a 1:20,000 scale. **Predictive Ecosystem Mapping (PEM)** is also done for parts of the Province and similarly provides predictions of vegetation and soils types at 1:20,000 scale. The Ministry of Sustainable Resource Management is a contact for this mapping.

  - ✓ **NTS Topographic Maps**. These are produced by the federal government at a 1:50,000 scale for all of Canada. The 1:50,000 scale is a useful scale for project planning in larger areas. Ordering information is available from Natural Resources Canada. These maps can also be purchased at various commercial outlets, and through Crown Publications.

  - ✓ **Soils and Geology Maps**, where available, can provide good information about site characteristics and capabilities. **Landform** and **geologic** information can be useful in project planning. The Geological Survey of Canada is one source for this type of information.

  - ✓ **Grassland Maps** are recently available from The Grassland Conservation Council of British Columbia (see Resources section) for the Southern Interior, and grassland maps and information will be available for the entire province.

  - ✓ **Links to other maps,** and advice on finding maps and air photos, is available through Base Mapping and Geomatic Services Branch. Many map products and air photos from this branch are distributed through Landdata BC.

- ✓ **Aerial Photographs.** Aerial photographs are an important resource for project planning and can also be important for project mapping. Examining older air photos and comparing with more recent ones can show changes over time, and may show the site in less degraded condition. More recent photos give the best overview of a site. Black & white or color air photos are available for most of the province through **Private Air Photo Agents**, **Government Agents**, and **Landdata BC**, or can be borrowed in person at the Air Photo Library (810 Blanshard Street, Victoria). The oldest air photos are usually from the 1950's and are black & white, with color photo coverage beginning in the 1970's. Natural Resources Canada has its own **Air Photo Library**, for all of Canada (see their **Air Photo 101**). Not all air photos are catalogued this with the Provincial and Federal governments, and it is worth asking other agencies or corporations (e.g. BC Hydro, forestry companies) and local government staff if they have air photo coverage of your site. For large projects it is sometimes worthwhile to take aerial photos for planning purposes.

- ✓ **Aquatic Information**. Information and various map products related to fish are available through FishInfo BC (http://www.bcfisheries.gov.bc.ca/fishinv/fishinfobc.html), from the Ministry of Sustainable Resource Management:

  - ✓ FishWizard can be used to create a map and find fisheries information about your site

  - ✓ The Fisheries Project Registry is a database of current and past fisheries inventories, assessments, restoration and enhancement projects, and research.

  - ✓ The Fisheries Information Summary System (FISS) provides fish and fish habitat information and lists of reports for BC and the Yukon, displayed on 1:50,000 scale maps using the Watershed Atlas

  - ✓ Aquatic Biophysical Maps (1:50,000 scale) can be bought from Crown Publications, and show information on physical channel and valley characteristics, substrate (bed) materials, aquatic and bank vegetation, hydraulics and fish species presence and life history. Watershed boundaries are also delineated on the maps.

  - ✓ Watershed-Based Fish Sustainability Planning is a coordinated agency and stakeholder effort that will make aquatic restoration needs available. Information from this planning process should be consulted as it becomes available.

- ✓ **Rare and Endangered Species and Ecosystems**. A website from The Ministry of Water, Land and Air Protection gives information on species and ecosystems at risk in British Columbia, and provides a link to 37 brochures on species and ecosystems at risk. You should check with the Conservation Data Centre (CDC) (see Resources section) for an 'Element Occurrence Report' of rare and endangered species or plant associations potentially present in your area. Requests for these reports can be made over the web. It is important to know that many organisms have regional or local significance and are not listed by the CDC or others as rare or endangered; these species may become important within the framework of your project. These organisms can be identified and assessed with the help of local natural history groups and biologists.

- ✓ **Existing Inventories, Assessments or Reports**. There are usually data on a site that are essential to consider in making informed decisions. Key players can make this information known, and, for aquatic systems, some information is available on the web (see above). Examples of other sources are:

  - ✓ Sensitive Ecosystems Inventory (http://srmwww.gov.bc.ca/cdc/sei/seiprojects.htm) (SEI) for Eastern Vancouver Island and the Gulf Islands, Sunshine Coast, and the south Okanagan Valley. This inventory provides a general baseline of information for conservation or restoration planning through identification of rare and fragile ecosystems.

  - ✓ The Natural Resources Information Network (NRIN – see Resources Section) is a virtual library that provides access to many reports and data sources. A search of the NRIN should be done for background information and data pertinent to your project.

- ✓ **Historical Information.** Local archives or museums may have useful information. Additionally, old air photos (see above) will provide excellent information on former site conditions. Resource agencies and other key players will sometimes have files with old information and reports.

- ✓ **Existing Assessment Procedures and Best Management Practices.** In some cases, guidance may be found in government-generated, standardized methods of collecting information. The major sources of these standards are the Resources Inventory Standards Committee (RISC), and the various Watershed Restoration Program (WRP) technical circulars available from the Ministry of Sustainable Resource Management. A Riparian Best Management Practices manual is available from the Ministry of Forests, and the Stewardship Centre offers technical suggestions and case studies, particularly for aquatic ecosystems (see Resources Section for contact information for these standards and information sources).

3. Do a Search for Archival Materials or Research on the Site

Gathering historical information, such as air photos and photos from local archives, and research will be important for understanding the history of the site.

4. Review Historic and Current Land Use

An understanding of the past and current land uses will help make clear the sources of impact to the site, and assist in delimiting restoration possibilities and constraints. Resource agencies, resource users, First Nations, and local residents can provide information on land uses (see 'Key Players', and 'Determining Land Ownership and

Tenures'). For historic land uses, sources of information are various (see 'Using Historical Reference Conditions as Templates').

5. Become Familiar with Similar Restoration Projects

Though no two projects are alike, significant savings in time, money, and effort can still be realized by learning from those with experience in similar situations. Interviews with project proponents, reviewing their reports, and/or arranging site visits will help to capitalize on the efforts of others. Through this type of networking, practical concerns can be identified and addressed in the planning stages.

6. Survey Your Site & Create a Map

By this stage you will already know a great deal about your site, but more detailed data is usually necessary in order to develop good restoration prescriptions. You should start by using collected maps, air photos, site reconnaissance, and other information to understand the site characteristics. An on-the-ground survey should be undertaken to refine this information, and provide enough information for quantifying restoration needs and mapping restoration zones. It may be necessary to bring in specialists for this phase (see Resources section). Suggestions for data collection or observation include:

Collecting Site Information

✓ **Hydrology** (current and previous). Aquatic and hydrological features should be noted and located on a map, and the previous hydrology noted if apparent. Hiring a professional hydrologist may be useful where sites are complicated; the distribution of water on a site will have great bearing on diversity and types of vegetation present and possible. The condition of aquatic features can be described using various assessment procedures (see above).

✓ **Vegetation Polygons**. Areas of similar vegetation types should be located and their extent mapped. Often the site survey will be done to confirm and refine vegetation information described in maps, air photos and previous reports. In general, descriptions based on the dominant species for each main type of vegetation (trees, shrubs, forbs, grasses, or bryophytes) are sufficient for restoration purposes. Rare species or communities, and concentrations of invasive species should be noted. The key is to define similar enough units that consistent restoration treatments can be prescribed for similar vegetation polygons. For these vegetation assessments it is often prudent to seek the advice of an experienced biologist or forester.

✓ **Wildlife use.** Important animal trails or nesting or denning sites might become obvious during your site assessment. These should be noted to ensure that restoration activities preserve important habitats.

Dave Polster

Mapping the vegetation of the project site is critical for planning what restoration needs to take place where. This photo shows the delineation of vegetation polygons into two distinct types.

Dave Polster

Wildlife use: this well-used elk trail should be preserved as part of restoration efforts in this fire-suppressed sub-alpine forest.

- ✓ **Previous land use and condition**. Observing clues of previous land uses and previous site conditions can be helpful in understanding the impacts on your site. Clues of previous land use might include old railway grades, old roads, and farmsteads, as well as overgrown dykes. Previous land condition may also be apparent from observations such as stump counts (i.e., former size, distribution and species of trees, or types of trees selectively logged) and remnant fragments of the former ecosystem

- ✓ **Soils**. If site has been changed radically, as is common in agricultural or urban areas, an examination of the soils may give clues about the previous ecosystem. For example, digging a soil pit might reveal the peat of a former bog, or the rich black soils of a former Garry oak meadow.

- ✓ **Access and other infrastructure**. Good road or trail access can make a difference to a restoration project. Points of access and other infrastructure should be noted for inclusion in the site map.

A detailed map should be created based on the information collected. TRIM maps or air photos often provide a base for a site map (see above). Vegetation polygons, aquatic features, and infrastructure should be noted.

Dave Polster

A careful inspection of the soils of the site can reveal information about the nature and history of the site

Developing Prescriptions

Final restoration objectives can now be set, based on the site survey and maps. Your prescriptions should take the form of maps showing the treatment locations, accompanied by the rationale for treatment, descriptions of treatments, and treatment schedules and costs (see Restoration Plan example, Appendix 1). Restoration prescriptions will also include future maintenance and monitoring requirements, and will take into account safety and other logistical concerns.

Some considerations common to many projects are listed below. In a world of limited funding, it is important to prioritize treatments; for example, present each site or prescription type in terms of high, medium, and low priority. At the stage of prescription development, it is also wise to involve key players (see below). It's important to note that prescribing no treatment is often a valid option - either because the ecosystem is healing itself satisfactorily, or because the problem is too difficult or expensive to fix.

Checklist for Prescription Development

Good Restoration Prescriptions Are:

- ✓ **Cost effective**
- ✓ **Likely to succeed**
- ✓ **High priority**
- ✓ **Reasonable in maintenance requirements**
- ✓ **Approved by key players**

Involving Key Players in Prescription Development

Using Experts

Most restoration projects require professional advice in the planning and prescription development stages. An appropriate specialist can usually be found by asking key players, or by making inquiries to the BC Chapter of The Society for Ecological Restoration.

Involving Stakeholders

Government, First Nations, commercial interests, or other key players will often have some say in what happens, and for prescription development you will need their buy-in. The best way to solicit input is to have these parties visit the site before the plans are finalized. It is at this stage that you can get technical input and future commitments to your plans, often for free.

The local community may also need to play a role or be educated about the restoration project. An example of the need to involve the community is where community viewscapes or recreation opportunities will be affected, or where there is a perception of risk to private property. The importance of community buy-in cannot be overemphasized on these types of sites, as an uninformed and unhappy public can successfully oppose your restoration plans. Another important reason for community education is to create potential volunteers that may lend a hand to your efforts, and assist in stewardship and monitoring in years to come.

Common Restoration Considerations

Some special considerations must be taken into account, depending on your site and project. Table 5 lists some common considerations, which are also explained individually below.

Table 5. Common Restoration Considerations

Common Restoration Considerations	
✓ Planting prescriptions	Consider the timing of planting, type of planting stock, and hazards once planted
✓ Invasive species	Control invasives, and ensure that you do not worsen the problem
✓ Species at risk/ species needing special management	Address the special needs of and mitigate risk to certain species, especially rare and endangered species
✓ Values at risk	Manage and mitigate risk to ecological and economic values
✓ Soil rehabilitation	Address altered soil conditions
✓ Slope instability/ Bioengineering	Stabilize and vegetate unstable slopes
✓ Cost effectiveness	Prioritize treatments based on cost-benefit

Planting Prescriptions

Planting trees, shrubs, or grasses is part of many restoration projects. It is important to consider the timing of planting, type of planting stock, and hazards to the planted stock, such as drought or disturbance by animals. The specific timing of planting will depend on your region, but it is generally in spring or fall, when there is enough moisture to allow the plants to establish. In particularly vulnerable areas, irrigation, though expensive, may be the only way of ensuring survival through the summer months.

Choosing the right type and size of plant stock is important to help ensure the plant's survival. Local plant stock should be used whenever possible, because it may have attributes that will help it survive better. Using local stock is easiest when the project involves using deciduous cuttings or "whips" (e.g., dogwood, willow, or cottonwood) that can be collected from nearby sites, as long as care is taken not to overharvest the source populations. Local native vegetation is rarely available in quantity from nurseries without special ordering, thus it may take advance planning to collect and grow local trees, shrubs and herbs, something your local nursery can do if given enough notice. Generally, a lead time of two or three years will be required to collect seed and grow the plants to sufficient size. If you are time-limited and wish to purchase standard trees from a nursery, you will usually obtain different stock than would exist in your area, though controls exist in BC to ensure that tree seedlings are ecologically appropriate for the general region. In general, the largest possible tree stock should be used, in order to maximize survival and minimize maintenance.

Dave Polster

Contracting with a nursery to grow the plants you need is an effective way of ensuring the right materials are available.

On barren, disturbed sites where erosion control is the objective, you may decide to seed grasses and legumes for quick ground cover. However, native grass seed mixes are not commercially available at present, though several projects are underway to improve this situation. Restorationists should be on the lookout for native seed options as they develop. Another consideration for grass seeding is the avoidance of dense, sod-forming species in the wetter zones of the province. Dense grass sod can out-compete planted trees, exclude later seral species from establishing, and harbour rodent populations that will girdle trees. Your seed supplier will be able to exclude or balance the sod-forming species in your seed mix, upon request.

Once the trees or shrubs are planted, you often need to protect them from animals. You'll need to make inquiries about the risk of animal damage in your area, and monitor your planted stock closely to make sure you are not simply providing animal food. Deer browsing is a big problem in most areas, and protective tree covers are commercially available to allow trees to attain heights where deer are less interested in browsing. Trees planted in grassy areas are prone to girdling from rodents, and rabbits will also girdle trees. If you are planting cuttings near a beaver dam you can expect the beaver to take some, and should think about a fence to exclude the beaver.

Trees and shrubs should be planted at densities higher than the final target, to account for mortality due to animals, disease, and drought. Once trees are well-established, thinning may be necessary in order to establish a tree density appropriate for the site.

Dave Polster

Grazing animals can severely damage planted stock.

Dave Polster

Planting programs must be conducted when the conditions are optimum for plant growth. Avoid times when the newly planted materials will be stressed due to lack of moisture.

Invasive Species

There are many invasive non-native species, both plant and animal, that are a major restoration concern in British Columbia. Many restoration projects simply attempt to control the invasive species to allow native ecosystems to re-establish. For example, much effort goes into Scotch broom eradication on eastern Vancouver Island, and knapweed control in the dry interior. Restoration efforts may also open up an area to problem invasive plants by disturbing soil or increasing light availability. Restorationists must take care to not make the problem worse.

Dave Polster Dave Polster

The effects of Scotch broom removal on Garry oak communities can be dramatic, as seen in these before (left) and after (right) photos taken 5 years apart in the same general area.

Invasive exotic species are highly competitive and are difficult to eradicate, as they lack the predator, competitor and disease controls from their native environments. Many weedy plant species produce large numbers of seeds that can persist in the soil for decades. The long-term presence of these invasive weeds and animals degrades ecosystems through competition, exclusion, and predation on native plants and animals. While eradication of all but the most recent arrivals isn't likely, with vigilance and effort their numbers can be controlled.

In previously forested environments, establishing fast-growing native trees and shrubs will usually shade out the light-requiring exotics. For example, red alder, willow, dogwood, and cottonwood can be used on the coast to shade out problem species like reed canarygrass and blackberry, and re-establishing Douglas-fir forests will eliminate Scotch broom.

In many places in the dry interior the weed problem is severe. Biological controls are used for some of these species, and should form part of a restoration program in areas where they can be applied. Other methods of control are hand-pulling, mowing, or in special cases, using herbicides.

Herbicides

Herbicides are used to control unwanted vegetation, like exotic weeds. However, in ecological restoration projects they are not usually the method of choice, as they may kill native species or lead to other problems in the ecosystem. The ability of herbicides to be selective is related to a higher tolerance of the poison by some species compared to others. Some authors believe that using herbicides creates a disturbance into which weeds invade, thereby worsening the problem (Polster and Landry 1993). Where herbicides are chosen to control problem weeds, follow-up monitoring will be necessary to discern whether they are having their intended effect.

Dave Polster

Mowing can be an effective strategy for control of some unwanted invasive plants as it can remove the seed portion of the plant, impeding the plant's ability to propagate.

Information on managing invasive plant species may be obtained from a variety of resource agencies as well as private groups such as the Cattleman's Association. Information on control of some specific invasive species can be obtained from researchers at universities as well as Ministry of Forests research stations throughout the province. However, as much information as there is on the control of weeds, there is relatively little information on the management of invasive species in the context of ecosystem restoration. Adopting treatment methods that are used in agriculture or forestry may be inappropriate within the context of ecological restoration. Developing a strategy for environmentally sensitive management of invasive species requires careful consideration of the ecological consequences of the various potential management techniques.

Species At Risk/ Species Needing Special Management

Even when your restoration project is addressing ecosystem or habitat-related restoration needs, single species are usually a consideration. You should have identified any species of concern early in your information-gathering phase (see 'Gathering Information and Data'). At the very least, your plans should ensure that you will not harm species at risk, and ideally your restoration program should attempt to restore both the species and its native ecosystem.

Working with rare and endangered 'species at risk' will require agency buy-in. If your plans include restoration of rare plants, the Native Plant Society of BC can also provide advice on your strategy, and guidelines to avoid damaging limited populations through collection of seeds or plant parts. (Contact information for the Society can be found at: http://www.vcn.bc.ca/npsbc/).

Dave Polster

The yellow montane violet (Viola praemorsa) is a species at risk in the Garry oak ecosystems of SE Vancouver Island. Restoration efforts in these ecosystems must ensure that these important ecosystem elements are not lost.

Many species that are not officially 'at risk' may also require special consideration in your plans, due to specific habitat needs that wouldn't otherwise be met, possible impacts to their habitat caused by your restoration project, or because of their importance to the ecosystem. For example, certain species use tree cavities to nest, roost, and feed, and populations of these species are generally depressed or absent due to a lack of adequate habitat. Second growth forests, even when thinned in order to develop old-growth characteristics, will lack these cavity features for decades. Techniques are under development to create cavities and rot in trees, and using these techniques is an example of the *fine-filter* approach to restoration, within the context of stand-level (*coarse-filter*) treatments like thinning and fire. If you require information about individual species in your ecosystem, your regional office of the Ministry of Water, Land and Air Protection may be able to help.

Values at Risk

Restoration work may involve risk to ecological values or species at your site, as well creating risk to property values. As part of your planning process you should ensure that any risk is warranted and mitigated. Getting the proper permits, making detailed plans, and consulting with the community will lower your liability and your risk.

An obvious example of managing risk is with fire-supported restoration. If you plan to do a prescribed burn, you will need to manage risk to organisms and habitat features on the site, as well as ensure that your fire doesn't escape and damage property. Other options besides fire will need to be explored when the risk or consequence of failure is too high.

Soil Rehabilitation

If you have reason to believe the soils on your site have been altered and will not support your desired vegetation, you may have to address soil compaction or lack of nutrients and organic materials as one of your first restoration activities. Without the proper soil conditions, your desired plant community may not become established.

Chuck Bulmer

Soil ripping is an important part of soil rehabilitation where soil compaction is a problem, such as on roads and landings where heavy equipment has operated.

If your site was used for industrial or urban activities, soil compaction caused by heavy machinery may inhibit plant growth. "Ripping" old roads and landing sites might be required to loosen up the ground for growing plants. Industrial areas also tend to suffer from the removal of topsoil. Chemical fertilizers or organic mulch can be used, and sometimes, the planting of nitrogen fixing plant species such as legumes and alder is useful. Adding old logs and stumps (*coarse woody debris*) to the soil surface will help the area recover moist microsites and organic material, and may speed up recovery of the ecosystem. These activities might be enough to start the process of succession. Comparison with a reference ecosystem will help illustrate the appropriate chemical and physical goals for your degraded soils.

Methods used to reclaim mine sites must be used with caution in ecological restoration. Soil amendments like manure and biosolids can alter natural soils and may introduce foreign materials to your site.

The Forest Practices Code Soil Rehabilitation Guidebook (Province of BC 1997) provides a good discussion of all types of soil rehabilitation in BC. This and other guidebooks are available for purchase through the Crown Publications Index: www.publications.gov.bc.ca.

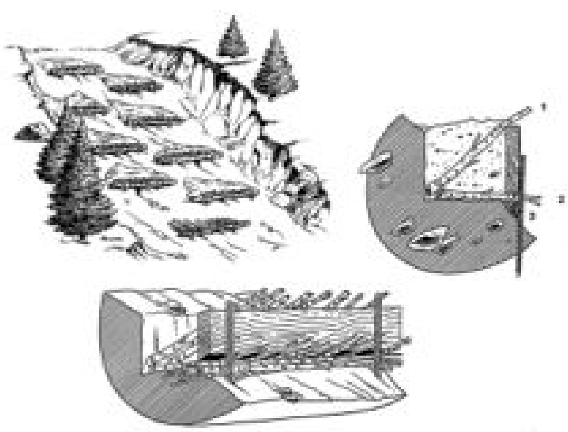
Slope Instability/ Bioengineering

Unstable areas can remain unvegetated for years. When the source of the instability is below the surface, devastating landslides can result. Most slope instability is caused by forestry or mining access roads, where older techniques of road building have created unstable 'fill' slopes, steep 'cut' slopes, and harmful drainage pathways. It is important to consult an experienced geoscientist in cases of slope instability. In addition, when addressing instability as part of an ecological restoration project, you will need to give special consideration to the types of plant material used to revegetate the area.

Road and hillslope related rehabilitation is discussed in detail in the publication "Best Management Practices Handbook: Hillslope Restoration in British Columbia. Watershed Restoration Technical Circular No. 3 (revised), (Atkins et al. 2000). This publication is available from the Ministry of Forests, through the website: http://www.for.gov.bc.ca/RTE/engineering/wrp-pub.htm.

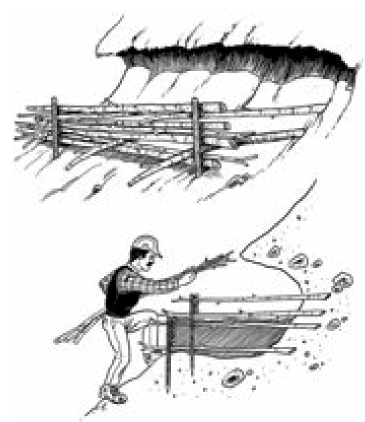
Surface instability can be treated very effectively with soil bioengineering techniques, where live materials are used to create physical stability. Growth of these materials allows the process of succession to begin. See Polster (2001) for more information on using bioengineering techniques in restoration. Bioengineering courses are offered through the Forestry Continuing Studies Network (see Resources section.)

Common Bioengineering Techniques



Dave Polster

Modified brush layers are used on steep ravelling slopes to stop the rolling stones and allow vegetation to establish. The cuttings are placed above the board on moderate sites (1), on dry sites they are placed below the board (2), while on wet sites a small wattle fence is built below the board (3).



Dave Polster

Live reinforced earth walls are used where slumping has resulted in a cavity in the slope. Backfill comes from shaving the slope above the cavity.

Cost Effectiveness

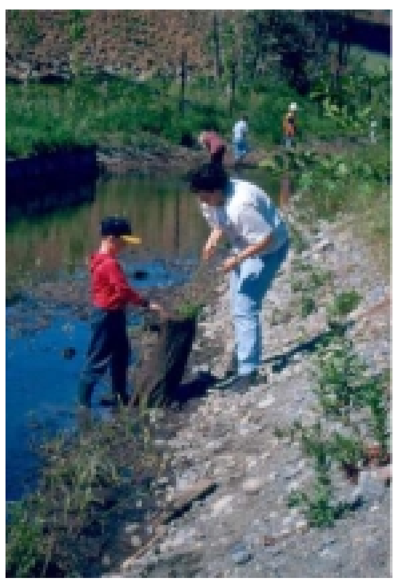
Restoration dollars are always at a premium. Hence, cost-effectiveness should always be explored, and treatments must be prioritized based on need and on the benefit relative to the cost. Often, operational trials can be done to explore whether cheaper methods yield acceptable results. More expensive techniques don't necessarily translate into improved performance. An example is establishing trees like red alder: nursery-grown trees are expensive to buy and plant, and direct seeding may provide a reasonable alternative at a fraction of the cost (Warttig and Wise 1999). Restoration techniques that work with natural processes like succession will be the most cost effective, and the most likely to succeed.

Including Maintenance in your Restoration Prescriptions

Maintenance is so important to restoration that a section is devoted to it later in these guidelines (see 'Maintenance'). However, mention is also warranted here. Maintenance needs will determine the cost effectiveness and feasibility of a prescription, and these needs must be considered when choosing the appropriate prescriptions to implement. Good restoration prescriptions will include maintenance in the budget and schedule of activities.

Stakeholder and Community Support

Aside from the permissions and involvement you will need from key players, the community will need to support your efforts. Community support helps decrease vandalism, and community support will help you find funding, recruit volunteers, and navigate bureaucratic hurdles (Ritchlin 2001). Start educating and involving the community as early as possible. Talk about the project to local clubs and schools. Do field trips to the site, and if possible, to a site that resembles your predicted ecosystem. Let community members be involved in building your baseline data through interviews, art projects, and storytelling sessions. These activities will enhance the success of your restoration efforts (Ritchlin 2001).



Dave Polster

Involving the community in your restoration project will enable you to recruit volunteers, garner support, and provide education about the importance of caring for local ecosystems.

The boxes below (adapted from Brown 2000) give more examples of ways to build community around your project:

Tools for Increasing Public Involvement

- ✓ Stream cleanups
- ✓ Tree planting
- ✓ Invasive species removal
- ✓ Storm drain marking
- ✓ Public art projects
- ✓ Urban ecology adventures
- ✓ Community festivals

Tools for Educating

- ✓ Case studies – illustrate similar projects in other areas
- ✓ Field trips – demonstrate important ecosystem features and problems
- ✓ School projects – allow students to experience ecosystems
- ✓ Training projects – increase community capacity

Tools for Receiving Input

- ✓ Workshops
- ✓ Open houses
- ✓ Task forces
- ✓ Public hearings
- ✓ Training seminars
- ✓ Surveys
- ✓ Interviews
- ✓ Focus groups
- ✓ Websites
- ✓ Community mapping

Tools for Informing

- ✓ Public meetings
- ✓ Newsletters
- ✓ Press releases
- ✓ Websites
- ✓ Brochures or fact sheets
- ✓ Radio and TV "ads"
- ✓ Telephone hotlines
- ✓ Report summaries
- ✓ Training seminars
- ✓ Community art
- ✓ Community mapping

Establishing a Monitoring Plan

Before you begin implementing your restoration plans, you will need to consider how you will monitor your project's success. How will you measure progress towards your goal? What, where, when, how long, and how will you measure? A more detailed discussion of monitoring is given later in these guidelines; monitoring is mentioned here to emphasize the need to consider data collection previous to any restoration treatments. Pre-treatment data, and/or data from a 'control' (similar, untreated area) are essential for assessing change as a result of your restoration. A monitoring plan should be in place previous to starting work. A sample monitoring plan outline is given in Appendix 3.

Finding Funding

While there are many funding sources that support restoration projects, finding stable funding can be considerable work. Most restoration projects are funded by multiple sources. Aside from applying to funding agencies and foundations, it is a good idea to approach local and regional governments, resource users, businesses and other key players for support.

The following are internet-based funding directories:

- ✓ The Canadian Stewardship Funding Sources Directory, from the Stewardship Centre (BC): http://www.stewardshipcentre.bc.ca/sc_bc/sc_funders/funderSearch.asp
- ✓ The Green Source, prepared by Environment Canada, is a guide to funding for environmental projects: http://www.pyr.ec.gc.ca/ecoaction/otherfunding/fund_e.htm

Your library will also have reference books that list foundations that you can apply to for funds.

Writing a Restoration Plan

The outcome of your planning efforts should be a restoration document that describes how and what you want to accomplish. This plan will always be in progress, but needs to contain as much detailed information as possible, including maps, budgets, and schedules for work, for both current and future years. Creating this type of document is essential to ensure your work is organized and thoughtful, and it also demonstrates to funding agencies that you know what you're doing. A sample plan is included in Appendix 1, and the table below highlights the most important items necessary for a good restoration plan.

Restoration Plans Include:

- ✓ A baseline description of the ecosystem to be treated, and a rationale for doing restoration work
- ✓ Clear goals and objectives based on a desired future condition
- ✓ Explicit plans, maps, schedules and budgets for restoration activities, including plans for contingencies
- ✓ Plans and procedures for future maintenance activities
- ✓ Performance standards for monitoring project effectiveness, and a monitoring protocol and schedule for measuring the performance standards

IMPLEMENTING YOUR PLAN

At last, your plans are almost complete and your funding is secured. All your hard work and planning can now pay off. However, there are still practical and logistical considerations that need addressing, and this section attempts to describe the most common of these. You will need to incorporate some of these practical concerns into your restoration plan document, as they will affect your budget and may dictate what is possible on your site.

Implementation Considerations	
✓ Permits and approvals	Ensuring that regulatory agencies and key players approve of your plans.
✓ Project workforce and supervision	Finding a good project supervisor, and effectively using staff, contractors, and volunteers.
✓ Safety	Planning for safety.
✓ Project timing	Choosing the right time of year.
✓ Tools, and materials	Getting the best tools and materials at the right price.
✓ Implementation monitoring	Ensuring your project goes according to plan
✓ Celebrating and publicizing your efforts	Making contact with the community and recognizing project workers.
✓ Project reporting and extension	Writing up your project results and sharing them.

Permits and Approvals

If your group has done its planning homework, this stage should go smoothly. Your key players should be able to direct you to the appropriate agency if your activity needs government approval. It is important to realize that even if your project is on private land, you will need government authorization if you are working around water or are planning a prescribed burn. First Nations should always be contacted, as the land in question may be part of a larger land claim. First Nations contacts are also important for gaining a fuller perspective on the long-term ecological and social interactions of the site (Ritchlin 2001).

Commonly required approvals are those under the Provincial Water Act, where a water license is required to divert water, and a regulatory approval is necessary for making changes to a watercourse. Water Act approvals should be sought from your regional Ministry of Sustainable Resource Management. Similarly, approvals for work in or near streams may be necessary to obtain from Fisheries and Oceans Canada, or the Ministry of Water, Land and Air Protection, under the Fisheries Act. If you plan to alter a forest or grassland on Crown land, you will need approval from the Ministry of Forests under the Forest Practices Code. Prescribed burning on Crown and private land is regulated for air quality by the Ministry of Water, Land and Air Protection, and by Ministry of Forests for burn planning (see Resources Section on Prescribed Burning).

Please refer back to Table 3 in "Identifying Key Players" for information on which government agencies have jurisdiction over which types of activities. You can also check the blue pages in the telephone book. You may get redirected several times in the permitting process, and permits can sometimes take weeks or months to obtain. Review your plans or conduct site visits with the appropriate agency whenever you can, as this will reduce the number of surprises and will also improve your project. You will want to develop a positive relationship with the regulating body to make the process easier.

Project Workforce and Supervision

Your project workforce and supervisor will make the difference between a good and bad project, and you'll want to plan carefully.

Supervision

Your project supervisor may be a professional, or a project employee with expertise or ready access to technical advice. In any case, this person will need to be familiar with the ecological objectives for your site so that changes can be made to the plans as issues arise. Your supervisor should be comfortable with making on-the-spot decisions: project planning can rarely foresee all the needs at the site, and effective decision-making and delegation of responsibility are essential (Ritchlin 2001). The supervisor will need to know about obtained permits, and will be responsible for managing safety, tools, materials and supplies. Your group may decide to hire an outside specialist for this responsibility. You can get advice on the appropriate specialist from your key players, or from the BC Chapter of the Society for Ecological Restoration.

Work Force

Your project work force may be contractors, volunteers, staff, or a combination of the three. Contractors can offer special skills not otherwise available to your group – whether this is professional advice and supervision, special tools, or skilled crews. In your dealings with contractors you must be careful to explicitly define the scope of work in a signed contract, including project milestones or quality or quantity targets that will define payment. Don't pay out the last of your contractor's invoices until the work is finished and you are satisfied with the result. If your contract does not contain a sufficient description of your expectations, you may have to pay your contractor even if you are unhappy with the work – a good reason to spend some time drafting a sound contract.

Dave Polster

Given training, volunteers can perform many tasks with enthusiasm and commitment. Volunteers may become stewards of your project and provide continuity for years to come.

Volunteers are an important part of many projects. Besides offering their services for free, they provide links to the community, and can be stewards of your project in years to come. Your volunteers may be locals with excellent knowledge of your site. You can also use volunteering as a means to educate the public or school groups about the importance of caring for the land (see 'Stakeholder and Community Support'). When using volunteer labour you will have to provide training, be clear about exactly what is expected, and have good on-site supervision. Volunteer labour requires flexibility, and the efforts of your volunteers need to be recognized, and celebrated.

Volunteers and contractors have their limits, and you may prefer to assign some staff members to carry out the work. Staff offer the advantages of flexibility, accountability, and sometimes, long-term involvement. However, permanent employees may be more expensive than contract workers, and care needs to be taken that employees understand the ecological objectives for the site. You must consider having Workers' Compensation Board coverage in the event of on-the-job injuries.

Temporary Staff, Payroll and Workers Compensation Board

Looking after temporary staff payrolls and other employment expenses can be a major part of a restoration project. It may sometimes be best to contract work out to reputable companies, groups or individuals to avoid the administrative headaches of staffing up. Using contractors also avoids the need to get and pay for Workers Compensation Board coverage. You should ensure any contractors you hire have a WCB insurance number, to avoid any liabilities to your group.

Safety

Safety is a primary concern during on-site work, and will be an important part of your restoration planning. You should identify and mitigate any potential hazards in advance, and plan for the proper safety gear, equipment, and procedures. You'll also need to consider whether your plans will pose a hazard to the public, either during the work or after the work is complete. An example of a public hazard is girdled trees near a walking trail. These trees will eventually snap and pose a hazard as they fall.

Potential Safety Hazards

- ✓ Heavy machinery
- ✓ Power tools and hand tools
- ✓ Remoteness
- ✓ Lack of safety plans & equipment
- ✓ Un-heeded safety procedures
- ✓ Communications and vehicle breakdowns
- ✓ Poison ivy, nettles
- ✓ Wild animals and snakes
- ✓ Ticks, wasps and bees
- ✓ Steep slopes
- ✓ "Snags"
- ✓ Swift water
- ✓ Foul weather

Dave Polster

Note the hard hats and high visibility clothing, necessary for safety reasons.

You will need to be familiar with Workers' Compensation Board procedures to avoid accidents and to ensure coverage if someone gets injured. If one of your WCB hazards are 'snags', (*wildlife trees*) you should minimize their removal; Wildlife Tree Assessors are available to assess their risk, and no-work zones can be created to ensure that these important habitat elements are not lost due to safety concerns.

Safety Equipment and Procedures

- ✓ Hold tailgate safety meetings regularly stressing proper lifting, tool use safety, and reporting accidents and injuries.
- ✓ Follow Workers Compensation Board regulations but avoid loss of important ecological elements such as wildlife trees ("snags").
- ✓ Maintain appropriate first aid kits and supplies.
- ✓ Plan for communications (the ability to call an ambulance or helicopter if needed).
- ✓ Plan for emergency medical evacuation.
- ✓ All workers should have personal safety gear; the type will depend on the project. Safety gear includes:
    - ✓ hard hat
    - ✓ gloves
    - ✓ appropriate boots (may be hard toed)
    - ✓ safety glasses
    - ✓ high visibility vest
    - ✓ proper foul weather gear

Project Timing

Timing is often critical when it comes to a project's success. For example, planting projects must be done in the appropriate season for plant growth, in-stream projects require summer low flows, and moving soil requires dry weather. In the interior parts of the province, projects involving heavy machinery may be scheduled for the winter when the ground is frozen, which will minimize ground disturbance. If your funding doesn't come through when expected it may be better to wait rather than to do your work out of season, when your chances of success decrease. In some cases, poor project timing can cause more harm than good.

Dave Polster

Planting in the right season will maximize your chances of success

Tools and Materials

Getting the right kinds of tools and materials at the right price will be an important part of your efforts. Most restoration projects require tools of some sort, from simple shovels to heavy machinery. Your funding agency will probably be comfortable with a combination of purchasing cheaper tools and renting the rest. Spend some time at your tool rental shop to learn what kinds of tools are available, and which approach is cheaper or more efficient. Restoration supplies may also include items like fertilizer, brush mats, or rebar. You should consider the long-term safety, maintenance requirements, and biodegradability of your materials. When it comes to using heavy machinery, the equipment operator may give you a discounted rate as a contribution to your project, so be sure to ask around. You may consider asking your local retailer for a discount in return for recognition of their support.

The key players in your project may be able to help you out with cost, quality, and availability of materials. Many innovative arrangements can be made; for example the local forest company or land developer can provide you with stumps and rotten logs, or the local nursery can give you their excess seedlings (see 'Common Restoration Considerations – Planting Prescriptions' for a discussion of sourcing plant materials). When it comes to using materials like large woody debris, gravel, rocks, and soil, local availability is usually the most important factor, and your key players may be able to help. Before your project starts you will need to identify the right kinds of materials, how these materials can be brought to your site, and how they will be moved around once at your site, so that you can avoid costly delays or oversights, and minimize disturbance.

Dave Polster

Natural soil is the best growth medium for natural ecosystems. Salvage and subsequent use of this resource can be very important for effective restoration.

Implementation Monitoring

There are two kinds of monitoring: effectiveness monitoring and implementation monitoring. The type of monitoring discussed here is implementation monitoring. Effectiveness monitoring is discussed in a later section, and requires taking baseline data to record the conditions at your site before you make any changes.

Implementation monitoring involves making sure the project is completed according to plan. Sometimes your monitoring may indicate that the plan needs changing as the project progresses, but your ecological objectives should not change. If your project needs a fundamental goal shift midstream, you should probably do a complete re-evaluation.

All stages of your work should be documented, and the documentation updated daily as part of your implementation monitoring. You'll need to keep good field notes and take lots of photos. Implementation monitoring includes documenting the final result of your efforts as part of a project report (see 'Project Reporting'). This is essential, because few projects are done exactly as planned – differences from the original prescription should be noted and explained. Your photos and descriptions of your methods, costs and results will be an important part of this document, and will be essential to future effectiveness monitoring

Objectives specified by regulatory agencies must sometimes be monitored in order to satisfy regulatory requirements. This may occur when there are concerns about water quality, air quality or fire risk as a result of your project, and all parties should be very clear on how this type of monitoring and data are to be handled.

Laurie Smith

Monitoring water quality during the course of restoration work is a common form of implementation monitoring. The detailed protocol for such monitoring needs to be worked out with regulatory agencies prior to the start of the project

Celebrating and Publicizing your Efforts

As important as planning and doing the work is celebrating your project with staff, volunteers, supporters, landowners, and the community. Consider making videos, picture collages, written accounts, and art about your project, and displaying these to the community at public markets and events. Reward people for their efforts so they'll know they're appreciated. You'll keep people involved and this will probably lead to positive results in the future (Ritchlin 2001).

Let the world know what you have done and are planning to do. The British Columbia government maintains a media guide that you can search and download to find all the print, and online media outlets, at http://www.gov.bc.ca/mediaguide.html. Using newspapers, radio, and television to inform the community about your efforts is good for your project and helps more people appreciate the values inherent in restoration. You should also plan and publicize a field day to bring stakeholders and the public to your site. Consider making interpretive signs describing your rationale and efforts. Raising the profile of your project will strengthen support from government, the public, and funders, and will help everyone understand the value of intact natural systems (Ritchlin 2001).

Project Reporting and Extension

The results of your project need to be documented and shared. You will need to produce a report describing your goals, methods, costs, and interim results. A photographic record will be an important part of your report. Future prescriptions, including monitoring and maintenance needs, will also need to be described.

Your reporting is essential as a record of what happened at the site, for reference for those that come after you, and for future monitoring efforts. It will also help other practitioners learn from your experience. The information you generate can be shared with other restoration practitioners and the scientific community, through journal and newsletter articles, as well as at conferences. For distribution of information within BC, you may wish to contact FORREX (www.forrex.org), and determine which of their information venues is appropriate for your project.

MAINTENANCE

Maintenance is an important component of restoration projects. Sometimes your maintenance needs are obvious. For example, you may need to irrigate or fertilize your plantings, or continue to remove exotic species from your site for as long as it takes to establish a healthy native plant community. Some maintenance needs aren't known in advance and scheduled visits are necessary to determine if your project is functioning as planned. Few restoration projects will succeed as planned if they are treated once and never re-visited.

Dave Polster

Repair work should be undertaken in a timely manner. Prompt repair helps to ensure that the project goals will be met.

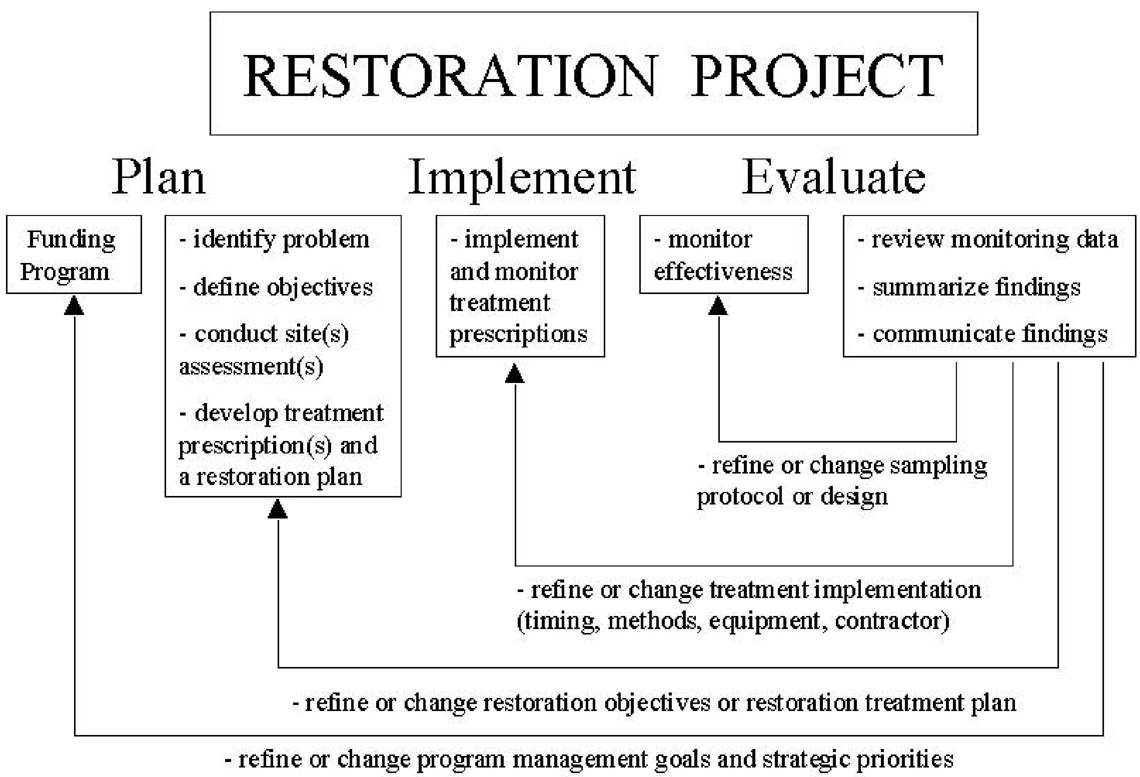
You can assume that you will need to return to the site on a yearly basis to check on its progress, at least in the initial years. These visits can be a simple walk-through to make sure everything is still intact and looks as it should. You'll find there is usually something that needs 'tweaking' before a project is quite right, and this may not be evident at the outset. In fact, it may not be evident for years. Hence you should try to budget for maintenance needs whether they are obvious or not. One suggestion is to set aside a percentage of the budget (e.g., 10%) for unexpected future maintenance needs.

EFFECTIVENESS MONITORING

Effectiveness monitoring is the process of identifying and measuring key indicators of ecosystem response to a restoration treatment (Machmer and Steeger 2002). Monitoring is essential to an adaptive management approach to restoration, as it assesses progress towards your goals and objectives. It also enables you to improve your restoration techniques and their cost effectiveness. Without monitoring, there is a tendency to repeat treatments without questioning their efficacy, or their applicability to different biogeoclimatic zones (Clewell and Rieger 1997). In other words, without monitoring you can't tell what works.

The Biodiversity Branch of the Ministry of Water, Land and Air Protection has copies of a more comprehensive report on effectiveness monitoring for ecosystem restoration (Machmer and Steeger 2002), and you should obtain a copy to assist you in making your plans. The basic points are repeated here.

Figure 1. The following is taken from Machmer and Steeger (2002), and illustrates the role of effectiveness monitoring within an adaptive management framework for ecosystem restoration



Effectiveness monitoring differs from *implementation monitoring,* which answers the question of how well the treatments were carried out relative to a restoration prescription (Machmer and Steeger 2002). Implementation monitoring is discussed in a previous section. Effectiveness monitoring can be carried out at different levels of intensity, depending on the complexity and scale of your restoration project. *Routine evaluations* are the kind that most readers of this guide will undertake. Routine evaluation will apply to restoration projects with relatively straightforward objectives and established methods, which are applied to a relatively small area over a relatively short time period. This type of evaluation involves quick data collection at low cost, using mainly qualitative methods, including photo points, visual estimates, or rating systems, to compare one or a few key response variables before and after restoration. This method will also serve to identify areas where more detailed evaluation is required. An example of a routine level of effectiveness monitoring would be in a project involving noxious weed removal. Monitoring the effectiveness of the weed removal might entail qualitatively assessing weed and native species vegetation cover through pre- and post-treatment photographs taken at permanent photo-points. In some cases, a low level quantitative assessment might be warranted: for example, measurement of percent cover and weed species density in sampling plots along a random transect (Machmer and Steeger 2002).

Dave Polster

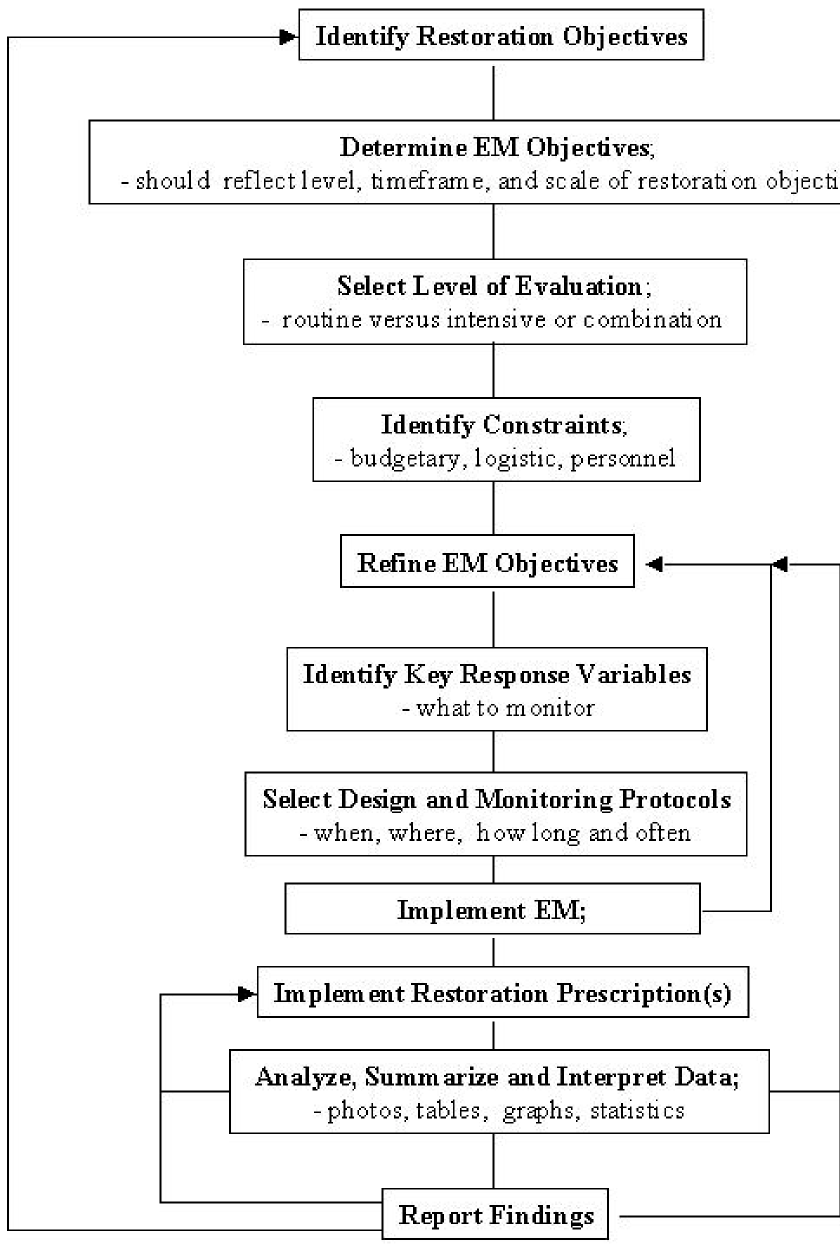
Dave Polster

Low intensity monitoring using site visits and photographs is all that is necessary to evaluate the success of this bioengineering project. Often some small, subsequent treatment is necessary for project success.

Intensive evaluation involves taking quantitative data over a longer time period, and is generally more expensive (Machmer and Steeger 2002). An intensive evaluation would be used only for selected projects, for individual sites that are part of a larger ‘program’, or in critical parts of projects, for example, where the success of the establishment of rare species is an essential restoration goal. Intensive evaluation would be necessary when applying a restoration treatment over a large area, when using new or weakly documented techniques, or when several treatments are involved and you wish to discern their individual and collective effects. Such an evaluation provides a quantitative measurement of pre- and post-treatment site condition, and ecosystem recovery is based on the measurement of several key response indicators (Machmer and Steeger 2002).

Whether you decide you need a routine or intensive level of evaluation, carrying out effectiveness monitoring will involve the steps outlined in the figure below. It is important to note that without clear and measurable goals and objectives, you will not be able to monitor your project’s effectiveness (see ‘Defining Restoration Goals and Objectives’). A measurement of the pre-treatment conditions is a prerequisite for later monitoring and comparison of data. Your pre-treatment data must be collected with monitoring in mind, and your procedures must be documented so that the same procedures can be followed post-treatment.

Figure 2. Steps in Effectiveness Monitoring, from Machmer and Steeger (2002), adapted from Gaboury and Wong (1999).



It will be important to share your monitoring findings in progress reports, anecdotally, and at conferences and in publications. All data should be stored in both hard copy and electronic form in a manner that makes it easy to share with others. You will want to make this data available to people that may learn from or eventually take over the restoration program. You can check with FORREX (www.forrex.org), for ways of disseminating your findings to other practitioners in BC.

Dave Polster

Dave Polster

Detailed vegetation assessments provide information on the species compositional changes that occur following restoration treatments. Thoughtful collection of pre-treatment information is essential to allow comparisons with post-treatment samples

Appendix 3 contains an example outline for drawing up a monitoring plan. Monitoring must be built into your restoration plan schedules and budgets. Some forms of monitoring will not be complete until years or decades into the future, and you must document your monitoring needs and procedures, and share your monitoring plans and data.

RESOURCES

The following resources can help you plan or carry out your restoration project:

B.C. Conservation Data Centre (CDC) (http://srmwww.gov.bc.ca/cdc/index.htm). This site provides a gateway to the resources of the Conservation Data Centre. The CDC collects and disseminates information on rare and / or endangered plants, animals and plant communities of B.C.

B.C. Government Publications List (http://www.publications.gov.bc.ca/). All government publications can be purchased through this site. Look under various ministries to see what is available.

Biodiversity Branch. This Branch of the Ministry of Water, Land and Air Protection is the steward of ecosystem restoration information and strategies. The Branch has various publications and reports, including strategies for invasive species management, and a report on effectiveness monitoring for ecosystem restoration.

Biodiversity Guidebook.
http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/biodiv/biotoc.htm
This early Forest Practices Code guidebook gives a solid overview of current conservation biology concepts for managing biodiversity.

Biogeoclimatic Ecosystem Classification
(http://www.growingtogether.ca/maps/e_biogeo/biogeo.htm)
(http://www.for.gov.bc.ca/research/becweb/index.htm)
This important classification system describes ecosystems in BC, and provides a framework for ecosystem management and restoration decisions. The first website listed gives descriptions and a map of the BEC zones in BC, and the second site listed describes how the BEC system works. BC is comprised of 14 zones (and 94 sub-zones), based on similar climate and vegetation types. Regional subzone maps at a 1:250,000 scale are available through the Ministry of Forests. More detailed information about the zones, sub-zones and site-series are available in the Land Management Handbook Series of publications from Ministry of Forests. These handbooks give invaluable information about local plant communities and ecologically appropriate vegetation. You can purchase, download, or learn more about the appropriate handbook for your area at one of the following links, or do a search using the Publications Index (www.publications.gov.bc.ca):

BEC Site Series Guides for British Columbia (Land Management Handbooks):

Vancouver forest region	Cariboo forest region
Nelson forest region	Prince Rupert forest region
Kamloops forest region	Prince George forest region, Southwest portion

Prince George forest region, Northern Rockies portion

Canadian Land Reclamation Association (CLRA) (http://www.clra.ca). This site provides information about the CLRA, a national organization dedicated to the reclamation and rehabilitation of disturbed lands and waterways.

Clover Point Cartographics (http://www.cloverpoint.com/). Phone: (250) 384-3537. This company is the official supplier of Forest Cover maps for the province. These maps describe the distribution of dominant tree species and age classes at a 1:20,000 scale, and are useful for restoration planning.

Crown Publications Inc. (http://www.crownpub.bc.ca). This site provides information on obtaining most government publications including the Biogeoclimatic Ecosystem Classification field guides, the forest practices code guidebooks and some maps such as Forest Cover maps.

Ducks Unlimited (DU) (http://www.ducks.ca/). DU is involved in lots of wetlands restoration projects in the Interior, with spillover into dry land areas. Their Kamloops office staff ((250) 374-8307) are knowledgeable about Interior restoration issues.

Effectiveness Monitoring. An excellent resource on effectiveness monitoring (Machmer and Steeger, 2002) is available through the Biodiversity Branch, Ministry of Water, Land and Air Protection. The exact address was unavailable at the time of writing, but this document will be online through the Biodiversity Branch site on the Ministry web-page: http://www.gov.bc.ca/wlap/.

Forestry Continuing Studies Network (http://www.fcsn.bc.ca). The FCSN offers basic forestry courses and some courses related to restoration, including courses on bioengineering.

Geological Survey of Canada (http://www.nrcan.gc.ca/gsc/index_e.html). A branch of Natural Resources Canada, the Geological survey can provide geology, soils, and landforms maps.

Grasslands Conservation Council (http://www.bcgrasslands.org) This site provides information on grasslands and grassland restoration and protection as well as information on various grasslands programs and an annual symposium on various aspects of grassland management.

Government Agents (http://www.governmentagents.sb.gov.bc.ca/). Provincial resources and services are available through your government agent, including land title searches, government publications, and maps. Your government agent should be able to answer questions about accessing government resources.

Landdata BC (map and air photo sales) (http://ldbcweb.landdata.gov.bc.ca:8001) This site provides access to map and air photo sales, and is the commercial arm of the Base Mapping and Geomatic Services Branch of the Ministry of Sustainable Resource Management.

Media Guide (http://www.gov.bc.ca/mediaguide.html). An information site maintained by the Province, the Media Guide gives information on all the print and online media outlets in the province.

Ministry of Forests (http://www.gov.bc.ca/for/). The MoF web site has online resources and downloadable publications including the Forest Practices Code guidebooks and the Land Management Handbook series.

Ministry of Sustainable Resource Management (http://www.gov.bc.ca/srm/). This Ministry is responsible for land use and permitting, and for provincial inventories and mapping.

Ministry of Water, Land and Air Protection (http://www.gov.bc.ca/wlap/). This Ministry is responsible for environmental protection of air, water and land quality, and environmental stewardship of biodiversity. The Biodiversity Branch within the Ministry includes ecological restoration within its purview.

Natural Resources Information Network (http://www.nrin.siferp.org). This site provides access to an online library network of ecosystem management and restoration resources for BC. A key-word search will reveal publications of interest to your restoration project.

Natural Resources Canada (http://www.nrcan-rncan.gc.ca/inter/index_e.html). This federal department can provide resources such as soils, geologic and topographic maps, and air photos.

Nature Conservancy of Canada (NCC) (http://www.natureconservancy.ca/). The NCC is a conservation organization that works to preserve important ecosystems, and to restore these ecosystems where they have been degraded. The NCC may also be able to help you provide stewardship options to private landowners.

Pacific Streamkeepers Federation (http://www.pskf.ca/). The Pacific Streamkeepers are dedicated to helping streamkeepers take action through support, education, and building partnerships. The Federation works together with Fisheries and Oceans Canada to provide the Streamkeepers program (see below).

Prescribed Burning. Information on the Forest Fire Prevention Regulations that cover the execution of prescribed burns can be found at the following web site: http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcaregs/ffirepre/ffpasr.htm. Burn Plan details are on the MOF Protection Branch's website: http://www.for.gov.bc.ca/protect/burning/planning.htm. Information on complying with the Open Burning Smoke Control Regulation is at the following web site: http://wlapwww.gov.bc.ca/air/particulates/agttobsc.html. In order to carry out a prescribed burn, you will require approval of your burn plan (Ministry of Forests) and compliance with the Open Burning Smoke Control Regulation (Ministry of Water, Land and Air Protection). On Crown land you will likely also require additional approval under the Forest Practices Code (Ministry of Forests). Generally, restoration burning is carried out with the assistance of the Ministry of Forests, due to the technical requirements and the potential liability if things go wrong.

Professionals and Specialists. Outside expertise is often needed for assessing a site and developing restoration prescriptions. If you need to hire a biologist, forester, hydrologist or other expert, local government agency staff or other restoration groups may be able to offer recommendations. Alternatively, the Society for Ecological Restoration, BC Chapter, (http://www.serbc.org/) should be able to provide names of suitable professionals. If you are working in Crown forest, you may be required to have a professional forester's advice on your restoration prescriptions.

Resources Information Committee (http://www.for.gov.bc.ca/RIC/). This committee provides standards for data collection for various types of inventories.

Restoration of Natural Systems, University of Victoria (UVic RNS) (http://www.uvcs.uvic.ca/restore). The UVic RNS program offers on and off campus courses on all aspects of restoration. All of the courses are open to anyone, and include field tours, short courses, and distance education.

Rocky Mountain Research Station of the US Forest Service (www.fs.fed.us/rm/aspen and www.fs.fed.us/rm). The aspen site has a comprehensive list of publications on aspen restoration in grassland-forest transition areas of U.S. while the general site has a lot of interesting materials that have been generated at the Rocky Mountain Research Station.

Society for Ecological Restoration (SER) (http://www.ser.org**)** This is the site of the international SER and lists a wide variety of information useful for restoration projects, including "Guidelines for Developing and Managing Ecological Restoration Projects", and conference and workshop information.

Society for Ecological Restoration (SER-BC), B.C. Chapter (http://www.serbc.org/) This is the link to the B.C. Chapter of the SER. It provides contact names for board members and can serve as a useful way of contacting people involved in restoration in the province.

Soil Rehabilitation Guidebook
(http://www.for.gov.bc.ca/tasb/legsregs/fpc/FPCGUIDE/soilreha/rehabtoc.htm)
This Forest Practices Code Guidebook provides guidance on soil rehabilitation planning and techniques.

Southern Interior Forestry Extension and Research Partnership (http://www.siferp.org). This web-site provides access to current resource management and restoration information and events, and provides access to an online library network (Natural Resources Information Network - NRIN). NRIN (www.nrin.siferp.org) provides access to publications from a number of sources that relate to ecosystem management and restoration in BC. A key-word search will reveal documents of interest to your restoration project.

The Streamkeepers Handbook (http://www.stewardshipcentre.bc.ca). This guide to local stream stewardship and restoration is invaluable to community groups throughout BC and the Yukon. It has 14 step-by-step modules for stream restoration. You can download or order a printed copy through the Stewardship Centre (www.stewardshipcentre.bc.ca).

The Stewardship Centre (http://www.stewardshipcentre.bc.ca). The Centre provides encouragement, information, and guidance on managing for conservation values. The site contains excellent resources, including the Stewardship Series, and is a good place to search for information.

The Stewardship Centre Funders Guide (http://www.stewardshipcentre.bc.ca). You can search for funders using this resource found at the Stewardship Centre website.

The Stewardship Series (various eds.)
(available through http://www.stewardshipcentre.bc.ca):
Stream Stewardship: A guide for planners and developers
Community Greenways: Linking communities to country and people to nature
Watershed Stewardship: A guide for agriculture
Access Near Aquatic Areas: A guide to sensitive planning, design and management
Community Stewardship: A guide to establishing your own group
Fish Habitat Enhancement: A manual for freshwater estuary and marine habitats
Landowner Contact Guide for British Columbia
Stewardship Bylaws: A guide for local government
Stewardship Options: For private landowners in BC
Streamkeepers Handbook: A practical guide to stream and wetland care
Naturescape British Columbia: Caring for wildlife habitat at home
Naturescape: Resource booklet, Georgia Basin
Water Stewardship: A guide for teachers, students and community groups
Wetlandkeepers: A practical guide to wetland care
Land Development Guidelines: For the protection of aquatic habitat
1994 Proceedings Revisiting the Land Ethic – Caring for the Land
Living Legacies: A guide to conservation giving in BC

Strategic Ecological Restoration Assessments. Terrestrial ecological restoration priorities were developed for each of the six forest regions of the Province in 2001. These assessments of restoration needs are based on the current extent of deviation from the natural range of variability in each of the BEC subzones. These reports are available online from the Biodiversity Branch of the Ministry of Water, Land and Air Protection (http://wlapwww.gov.bc.ca/wld/fia/habitat_restoration.html).

The Land Conservancy (TLC) (http://www.conservancy.bc.ca/). The TLC works to protect areas needed for natural communities, through purchase, lease or conservation covenants.

Wetlandkeepers Handbook. (www.stewardshipcentre.bc.ca). This handbook from the Stewardship Series offers a wetland ecology overview, extensive information on laws and rights regarding wetland conservation, and 5 activity modules with step-by-step procedures for restoration and stewardship.

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Streamkeepers Handbook: A practical guide to stream and wetland care
Naturescape British Columbia: Caring for wildlife habitat at home
Naturescape: Resource booklet, Georgia Basin
Water Stewardship: A guide for teachers, students and community groups
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GLOSSARY

abiotic – non-biological elements of the ecosystem (from *a* – not, and *bios* life)

adaptive management - adaptive management rigorously combines management, research, monitoring, and means of changing practices so that credible information is gained and management activities are modified by experience

anthropogenic – produced or caused by humans (from *anthropo* – human and *genes* – produced)

autecology – the biological relationships between a single species and its environment, the biology of individual species (from *autos* – self, *oikos* – household and *logos* – discourse)

benchmark – a state (e.g. of an ecosystem) against which later change is measured.

biogeoclimatic – dealing with living organisms and their relationship to earth (soils, landforms, etc.) and climate (from *bios* – life, *ge* – earth and *klima* – climate). In British Columbia a Biogeoclimatic Ecosystem Classification system provides a basis for ecosystem restoration planning. Ministry of Forests BEC publications will give ecosystem information for your site. See resource section.

biotic – pertaining to life (from *bios* – life)

climax community - a plant community that represents the final stage of natural succession for its environment.

coarse filter restoration – an ecosystem-based approach to restoration that assumes that most species will have their needs met by restoring or protecting the fundamental structure of an ecosystem. The coarse-filter approach is almost always used in tandem with the fine filter approach to restoration.

coarse woody debris - sound and rotting logs and stumps that provide habitat for plants, animals, and insects and a source of nutrients for soil development.

decompaction – to release from a compacted condition by ripping or otherwise loosening the soil

degradation - the diminution of biological productivity or diversity.

degrading agent – a mechanism or instrument of degradation (see above).

desired future condition – a description of a restoration goal, or end-point. The desired future condition may be a facsimile of the ecosystem before degradation, or it may describe a new reality that takes into account impacts that cannot be redressed, including climate change.

ecological integrity - the quality of a natural unmanaged or managed ecosystem in which the natural ecological processes are sustained, with genetic, species and ecosystem diversity assured for the future.

ecological restoration – the process of assisting the recovery and management of ecological integrity. Ecological integrity includes a critical range of variability in biodiversity, ecological processes and structures, regional and historical context, and sustainable cultural practices. (*definition from the Society for Ecological Restoration)*

ecological processes – natural phenomena that determine the patterns of ecosystems. Specifically, ecological processes such as natural disturbance, hydrology, nutrient cycling, biotic interactions, population dynamics, and evolution determine the species composition, habitat structure, and ecological health of every site and landscape.

enhancement – in the context of restoration this usually means to change a habitat type or species to outside its natural range of variability.

exotic species – organisms from outside the bio-region or continent in question. The term exotic species are often used synonymously with the term 'invasive species'. Invasive species may or may not be exotic. Invasive species expand their range and their coverage at the expense of other species, often aiding by human activity. Many problem weedy plants are both invasive and exotic.

extension – in this context extension means to spread information about the subject to others either through presentations at conferences, preparation of papers or reports

extirpate – to lose from the area. This refers to plants or animals that were once found in the area but are no longer present. This is not to be confused with extinction, where the species is gone from the earth.

fine filter restoration – restoration treatments for ecosystem components, like individual species or specific habitat attributes. Fine filter restoration is usually paired with the concept of coarse filter restoration.

habitat (scale) restoration – restoring specific structures or features within ecosystems. This approach usually assumes that ecological processes do not need restoring, and individual species will recover once the appropriate habitat is restored.

keystone species – a species that affects the survival and abundance of many other species, and if removed will result in a relatively significant shift in the composition of the ecological community

landscape-level - a watershed, or other natural biophysical (ecological) unit, within a larger regional planning area. This term is most often used for conservation or restoration planning, where large areas are needed to plan for ecological integrity.

large woody debris - a large tree part, conventionally a piece greater than 10 cm in diameter and 1 m in length. This term most often refers the tree parts that provide channel stability or create fish habitat diversity in a stream channel. Similar tree parts on land are usually called coarse woody debris.

mitigation – the reduction of environmental harm or impacts. Sometimes mitigation includes the concept of working to offset overall negative impacts by creating habitat or undertaking reclamation in one area to make up for losses in another.

natural disturbance – periodic processes or events such as insect outbreaks, fire, disease, flooding, windstorms and avalanches that cause ecosystem change and renewal.

natural disturbance regime - the historic patterns (frequency and extent) of fire, insects, wind, landslides and other natural processes in an area.

natural disturbance pattern – the landscape level effects of natural disturbance. For example, fire may create a mosaic or pattern of forest stands of different ages. Infrequent disturbance (such as in coastal forests) creates a pattern of mostly older trees, with smaller areas of the landscape in younger age classes.

natural range of variability – the spectrum of ecosystem states and processes encountered over a long time period.

overstory – the layer of vegetation above the layer being considered such as the herb layer provides an overstory to the moss layer and the shrub layer is an overstory to the herb and moss layers

reclamation – to stabilize soil and water on lands that have been damaged by industrial activity, and return the land to some useful purpose.

reference ecosystem – a less disturbed ecosystem similar to the one requiring restoration.

riparian – an area of land adjacent to a stream, river, lake or wetland that contains vegetation that, due to the presence of water, is distinctly different from the vegetation of adjacent upland areas.

seral/ seral stage – a successional stage of a plant community before it reaches its ‘climax’ community

species (scale) restoration – restoration where the focus is on an individual species, rather than on ecosystem components or ecological processes. Species scale restoration may include restoring habitat or population size for important or rare species, and it also includes the removal of problem species, like invasive exotics.

stand-level – usually used in conjunction with *landscape level*, stand level refers to the scale of forest management at which a relatively homogeneous land unit can be managed under a single prescription, or set of treatments, to meet well-defined objectives.

succession – the sequence of changes a plant community passes through before reaching its maximum possible development, or ‘climax community’.

umbrella species – a species that requires large areas of habitat, and if managed for, will encompass the needs of some other species as well.

understory – the layer of plants below the overstory such as the mosses under an overstory of herbaceous vegetation or mosses, herbs and shrubs under an overstory of trees

wildlife trees - a wildlife tree is a standing live or dead tree with special characteristics that provide valuable habitat for the conservation of wildlife. Characteristics include large diameter and height for the site, current use by wildlife, declining or dead condition, value as a species, valuable location and relative scarcity.

APPENDIX 1: Example Restoration Plan

Introduction

The restoration plan presented here is an example for the purposes of this report, and is designed as a generic template. It is theoretical in nature and does not refer to a specific Garry oak site. In real situations, more information would be added to this plan, and much of it modified, depending on the type of ecosystem and needs of a particular restoration project. Under some headings, we have provided text examples.

Bullets represent key considerations for various sections. This plan does not contain figures (photographs or maps), but suggests appropriate places where they could be included. These places are noted as Fig. or as Figs. where more than one figure would be appropriate.

Template for a Restoration Plan

Introduction

- provide an overview of your project and the key components of your Restoration Plan
- if this a proposal for funding, list other sources that you have applied to, or that are providing financial or volunteer assistance

Project Rationale

- provide as many details as possible on why this project deserves to be undertaken and funded; although we didn't use references from the literature here, important project-related references should be included as support for your project. We have noted where references would be appropriate by using (ref.).

Example:
Garry oak ecosystems are one of the most endangered ecosystems in British Columbia and Canada (ref.) and, as a result, have a high priority for ecological restoration work (ref.). Since European settlement, all provincial Garry oak ecosystems have been negatively impacted to some degree and many have been lost (ref.). Our proposed site for ecological restoration on Blanshard Island has had relatively less disturbance than many other sites, but will benefit greatly from the proposed restoration work.

Site Description

- the site description should provide available and up-to-date information on the target site. Some characteristics to consider include thorough descriptions of the vegetation (describing communities and key plant species), BEC subzone and site series, general to specific wildlife values, species of concern, aquatic values and hydrology, and general comments on geology and climate.

- include a series of overview photographs showing the major features along with an aerial photograph of the site; photographs used later in the plan can be referred to here as well.
- include a site map showing the location and relevant site features.

Example:

Our proposed restoration activities will be completed in a Garry oak (Quercus garryana) ecosystem on Blanshard Island north east of Victoria (in a complete plan, a map showing the location and relevant features of the site would be included here as Figure 1). The site is a complex of rock outcrops, cliffs, and gullies, with Garry oak and associated communities dominant on the more exposed and drier sites. The total area of the site is approximately 100 hectares. The underlying rock is principally sandstone. The site is generally south facing and surrounded on three sides by a forest mosaic comprised principally of Douglas-fir (Pseudotsuga menziesii) and arbutus (Arbutus menziesii). The south side of the stand lies along the shoreline of Puffin Bay.

Two broad-based Garry oak-associated plant communities have been identified for this site and are the focus of our restoration activities. These communities are:

1. **Open moss-dominated communities** (Figs.). These communities are found on rock outcrops characterized by extremely dry conditions and shallow, poorly developed soils. Characteristic plant species are mosses, including frayed-cap mosses (Racomitrium spp.), and hair-caps (Polytrichum piliferum and P. juniperinum), introduced grasses, including early hairgrass (Aira praecox), dogtail bristlegrass (Cynosurus echinatus), and sweet vernal grass (Anthoxanthum odoratum), and the forb, Wallace's selaginella (Selaginella wallacei).

2. **Garry oak woodland communities** (Figs.). These communities are found on more mesic sites of deeper, well developed soils, often adjacent to or admixed with the moss-dominated outcrop communities. Mature Garry oaks range on average from 8 to 13m in height, and their canopy ranges from 40% to 75% cover. The understory is dominated by grass species, including the native species (Elymus glaucus), brome (Bromus sp.), and Idaho fescue (Festuca idahoensis), and the introduced species dogtail bristlegrass (Cynosurus echinatus) and sweet vernal grass (Anthoxanthum odoratum). One small portion of the site has a relatively high cover of long-stoloned sedge (Carex inops). The introduced vascular plant species usually have a greater cover than the native species.

Site History and Related Disturbance

- relevant details of human disturbances on-site should be provided here.
- details of historical disturbances and impacts could be included here, or in a separate section

Example:

The proposed site has been cut through by two former logging roads running roughly east to west (Fig. 1). These roads were formerly used by the Amadeus Logging Company to access various portions of the Douglas-fir forest. They have not been used by vehicles since the 1940's and are mostly overgrown with broom and other invasive species (Fig.). The roads have often been used by hikers so that they can access view-points in open Garry oak habitats. Natural and First Nations fires that once were common on site have been actively suppressed since the mid-1800's.

We have identified three key phenomena that have most impacted the ecological health of the Garry oak and associated habitats on site. These are encroachment by Douglas-fir, invasive introduced plant species, and human activities, including hiking and camping. All of these factors have markedly altered the ecosystem to some degree. Our restoration plan will focus on reducing the impacts of two of these disturbance factors, Douglas-fir encroachment and invasive plants, in particular Scotch broom. The problems with hiking and camping have recently been addressed by local groups, and concerns regarding impacts related to these activities have been greatly reduced.

Encroachment by Douglas-fir

Certain areas, in particular in the upper portions of the property, exhibit signs that former Garry oak communities have been encroached by the much faster growing Douglas-fir. Evidence of ingrowth include oaks that have had their main stems die, with, subsequently, one or more lower branches growing out from under the faster growing Douglas-fir canopy (Fig.). Some oaks have died. Also, the forest floor in these areas shows a replacement of typical dry-site mosses, in particular *Racomitrium*, and some grasses with more shade and humidity tolerant species. The cover of native shrub species is generally higher in areas of Douglas-fir encroachment.

Much of this encroachment appears to be related to an alteration in the site's fire history. Fire scars are evident on veteran Douglas-fir and some of the larger Garry oaks, and supports the fact that fire was more common in the past. Whether fire was First Nations-induced or 'natural', it probably occurred relatively frequently in these ecosystems and kept the Douglas-fir in check. The fire factor, in conjunction with the relatively shallow soils on site and, possibly, insect pathogens, probably helped maintain stable Garry oak and open communities over the past centuries.

Invasive Plant Species

Some introduced and invasive herbaceous plant species, in particular sweet vernal grass (*Anthoxanthum odoratum*) and hedgehog dogtail grass (*Cynosurus echinatus*), are common to abundant in many of the Garry oak and rock outcrop communities on site. Scotch broom (*Cytisus scoparius*) is a serious problem in some gullies and along the old logging roads, but less so in the more open and drier rock outcrop communities, where the plants are usually stunted. These relatively small and patchy broom plants could be easily removed.

<u>Project Goals</u>

- details of your goals as they address the critical needs of the project are listed and described in detail here.

- Goals must be explicit and measurable, so that success can be monitored

<u>Example:</u>

The proposed Blanshard Island restoration site has many of the classic characteristics of a degraded Garry oak ecosystem. Except for the areas adjacent to rock outcrops, much of the oak stand has been invaded by Douglas-fir and various shade-tolerant shrubs that likely would not be prominent in the historical oak ecosystem. Invasive species are common in many portions of the site, and pose an increasing threat not only to the native species, but also increase the probability of a major fire.

The overall goals of our restoration project are to improve the general vigour of Garry oaks, and to restore herbaceous native herbaceous communities that we believe are characteristic of historical Garry oak habitats on this site. Our management emphasis is on removing encroachment Douglas-fir and broom from selected sites. Although there are many invasive species on site, we will focus on broom, as it is more readily controlled than other species and appears to have the greatest impact. For our selected sites we intend to keep the Douglas-fir below 5% percent canopy closure in except in designated areas, and to remove and monitor Scotch broom to keep it below 5% of ground cover on the site as a whole. We also intend to increase the ground cover of important species X, Y, and Z, by at least 5% over the project's term. A long- term objective is to eradicate Scotch broom from the entire site. More specific objectives may be generated from the biological inventory to be completed this year.

<u>Details of Restoration Activities</u>

- include all details of the work that you are proposing, including onsite supervision and workforce, logistics, permits, and safety concerns.

- locations of the work should be clearly identified on maps.

- include timing and projected completion costs of each activity. It might be helpful to include a table that details the schedule and cost of all restoration activities for the current year, and over the next five years. Monitoring and maintenance can also be included.

- include details of your methods that you plan to use to assess the results of your project (monitoring), as they often go hand in hand with the initial restoration activities.

<u>Example</u> (much more detail will be needed in this section of your plan than is provided here):

Because of financial constraints, we are not planning to initiate restoration activities in the whole of the Blanshard Island site, but in four areas most critically in need of restoration activities. The total area of these sites is approximately 50 hectares. Please refer to Figure x for the locations of these areas.

Our activities in each of the four areas in the next year will include:

Activities in 2002	**cost**
a detailed biological inventory (to be completed from May through September)	$2,500
setting up permanent vegetation monitoring transects and plots in order to assess the changes that will occur following treatment. Estimations of percent cover and canopy closure will be the principal data collected, although, as the project advances, other data may be collected, such as frequency and density data. We will photograph each trial plot in order to document its general appearance; photographs will be taken along both transects as well and in all or selected understory plots. (to be completed along with the following activity from May 12 to 18)	$3,000
completing baseline vegetation measurements and entering data into database	$3,000
in the treatment trial plots, marking all Douglas-fir trees for removal	$375
in all plots mark and describe the general condition of all Garry oak trees and seedlings/regenerating stems.	$500
cut down all of the Douglas-fir trees[1]; a professional feller must be in charge of this operation for safety reasons as well as care since one of our aims is to minimize damage and disturbance to the Garry oaks.	$1,000
Remove all broom plants (with volunteer assistance)	$5,000
Remove all Douglas-fir and broom debris, burn broom debris	$2,000
Create a project report and a poster for a Garry Oak conference	$3,000
Total cost for 2002:	**$20,375**

We anticipate removing the broom and Douglas-fir, and measuring the permanent transects and plots each year for the following five years. The detailed biological inventory will likely reveal rare species of concern and other areas of the site that will be included in more detailed project goals in Year 2. In future years, once the fire hazard posed by the broom and Douglas-fir is lessened, we will consider prescribing ground fires to maintain the oak groves in an open condition. To meet our current objectives we anticipate requiring a follow-up budget of at least $2,000 to $5,000 per year for the following 5 years (more if burning occurs), and after that time we hope that standard maintenance can be completely taken over by volunteers. Longer-term data collection will be done on a periodic basis and we will seek funds in several years time to re-assess our progress.

[1] girdling has been suggested as a method for killing the trees; this method may be effective but we cannot predict which way dead trees will fall and damage may occur to the Garry oaks.

Long-Term Maintenance and Project Monitoring

- include details of the planned maintenance activities, and discussion on monitoring for future maintenance needs.
- include the performance standards that you will be monitoring here (performance standards relate to the measurable project goal).
- include details of how you will assess your long-term data.
- include a monitoring schedule.

Example:

Maintenance

Long term maintenance will include the continuous removal of new Douglas-fir and Scotch broom. The removal of these species will be of much less cost than the initial work, and can be completed annually along with the vegetation survey. A local group, The Blanshard Island Naturalists, has volunteered their time to assist in ensuring that the site will not be disturbed by recreationalists. Selected volunteers from this group have been trained in broom and Douglas-fir removal and will also assist in this chore.

Monitoring of Vegetation Changes

Since one of our main goals is to restore native species over time, we plan to resample each set of permanent plots and transects in the fall of the treatment year, and in the spring and fall, in order to account for seasonal variation, of each successive year for at least five years. We do not have, at present, any local standard comparative data with which to compare the 'success' of the changes, but we consider that incremental increases of 5% per year of the major species X, Y, and Z, based on work in California and Oregon (ref.), will be of initial value as a performance measure. Our current performance standards also include the reduction of Douglas-fir canopy closure to below 5% except in designated areas, and to remove Scotch broom to below 5% of ground cover. If monitoring reveals that these standards are not being met the maintenance program will be re-evaluated. Monitoring will also reveal how often maintenance must be conducted, and if periodic interventions like ground fire are necessary.

Monitoring Changes in Garry Oaks

There is very little data on how to measure the success of Garry oaks in restoration projects (ref.). However, all of the young Garry oaks that were tagged will be measured for increase in stem length and change in height on an annual basis for 5 years after the initial treatment. The older Garry oaks will also be measured for changes in their upper stems and branches. We expect that new leaders and shoots will develop once the oaks are released from under the Douglas-fir. We expect that measurement methods and frequency may change as the project progresses and more data is gathered on these trees.

Monitoring Schedule

Data will be collected each year for the 5 years following treatment, for assessing vegetation change and Garry oak vigor. After that time a new monitoring schedule will be developed. We anticipate monitoring may be necessary only at 5-year intervals after that time, if the treatments are working as planned.

References

- include references

APPENDIX 2: Adaptive Management and Ecological Restoration

(Adopted from Gayton 2001)

Adaptive management fits very well within ecological restoration. The principles of adaptive management combine research and monitoring with flexible management practices. By formulating clear restoration goals and then monitoring achievement towards these goals as the project develops, we create a "feedback loop" of continuous learning. Our restoration activity can then be modified and enhanced by that learning.

In the context of restoration, adaptive management consists of the following steps.

Step 1 – Problem Assessment

Participants define the scope of the damaged site or ecosystem, synthesize existing knowledge about it, and explore the potential outcomes of alternative restoration actions. Explicit forecasts are made about outcomes to assess which actions are most likely to meet objectives. During this exploration and forecasting process, key gaps in understanding the system (i.e., those that limit the ability to predict outcomes) are identified

Step 2 – Design

A restoration plan and monitoring program are designed that will provide reliable feedback about the effectiveness of the chosen actions. Ideally, the plan is also designed to yield information that will fill out the key gaps in understanding identified in Step 1.

Step 3 – Implementation

The restoration work is started. Effective restoration is usually a multi-step process, requiring not only installation, but also many years of maintenance.

Step 4 – Monitoring

Indicators are monitored to determine how effective the chosen actions are in meeting objectives, and to test the hypothesized relationships that formed the basis for the forecasts.

Step 5 – Evaluation

The actual outcomes are compared to the forecasts; the reasons underlying any differences are interpreted.

Step 6 – Adjustment

Practices, objectives, and models used to make forecasts are adjusted to reflect new understanding. Understanding gained in each of these six steps may lead to reassessment of the problem, new questions, and new options to try in a continual cycle of improvement for a given project and for others like it.

Some of the steps will overlap, some will have to be revisited, and some may be carried out in more detail than others. All steps should be planned in advance, though it may be necessary to modify them later. All six steps are essential to adaptive management; omission of one or more will hamper the ability to learn from restoration activities. In addition, documenting the key elements of each step, and communicating results are crucial to building a legacy of knowledge, especially for restoration projects that extend over a long time.

APPENDIX 3: Generic Outline of an Effectiveness Monitoring Plan

1. Information Review:

This section would review existing information regarding restoration planning, approaches, objectives, practices and initiatives targeting the ecosystem/habitat or habitat component under consideration. It would also review ongoing, planned and completed monitoring initiatives and data available for the type of restoration that is being proposed. Monitoring needs, gaps and options would be discussed (particularly in the case of large-scale projects that have province-wide relevance, and for which considerable information is available).

2. Ecosystem Restoration Objectives:

This section would provide restoration objectives for the restoration site(s) being targeted and provide a detailed rationale based on sound ecological information (i.e., from a reference ecosystem, determined from the historic range of variability, and/or desired future conditions).

3. Effectiveness Monitoring Objectives:

This section would list and provide a brief explanation for effectiveness monitoring objectives. The latter would reflect the restoration objectives developed above, as well as consideration of the appropriate level of evaluation for the project and associated constraints (e.g., budgetary, logistic, personnel).

4. Monitoring Design, Response Variables and Protocols:

This section would describe an overall monitoring design, as well as specific response variables and monitoring protocols (how, where, when, how long and how often) to address each monitoring objective formulated above. It should also provide a clear rationale for selection of all response variables.

5. Analysis, Summary and Interpretation of Monitoring Data:

This section will provide details of how interim and final monitoring data and deliverables will be stored, analyzed, summarized and interpreted. It should also present a tentative schedule for completion of these phases.

6. Summary of Findings and Adaptive Management:

This section should describe how the findings of this project will be communicated and shared with identified target audience(s). It should also explore how interim and final project results/deliverables could potentially be applied within an adaptive management context.