


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

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 Reintroduction of patterns related to natural disturbance: ➢ 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.

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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.

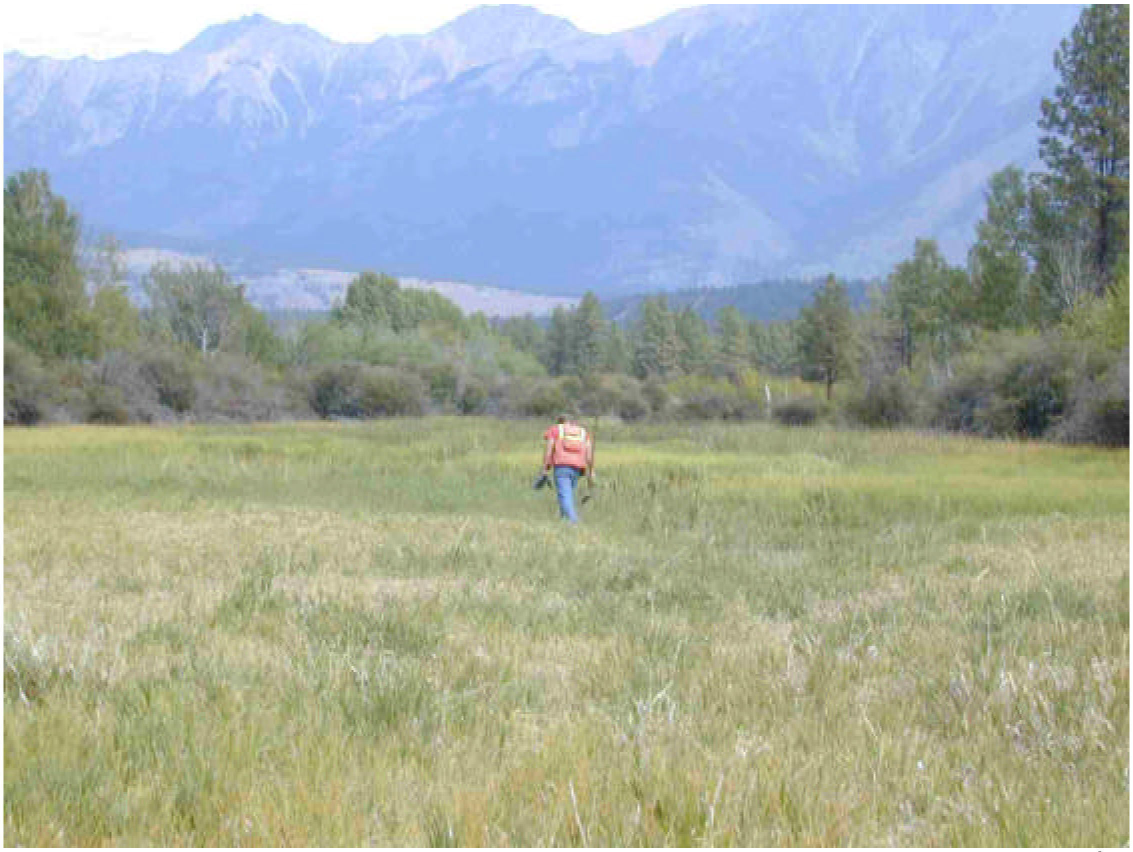
Terrestrial and aquatic restoration have been handled as separate programs by government, and the prioritization schemes are quite different.

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.