2001

Ground Work

Basic Concepts of Ecological Restoration in British Columbia

SIFERP SERIES 3

Southern Interior
Forest Extension and
Research Partnership

SER-BC

Ground Work:

Basic Concepts of Ecological Restoration in British Columbia

Donald V. Gayton

Southern Interior
Forest Extension and
Research Partnership

SER-BC

National Library of Canada Cataloguing in Publication Data

Gayton, Don, 1946–
Ground work [computer file]: basic concepts of ecological restoration in British Columbia

(SIFERP series, ISSN 1495-9658 ; 3)
Co-published by SER-BC.
Includes bibliographical references.
Mode of access: World Wide Web.
ISBN 1-894822-02-1

1. Restoration ecology—British Columbia. I. Southern Interior Forest Extension and Research Partnership. II. SER-BC. III. Title. IV. Series: SIFERP series (On-line) ; 3.

QH106.2.B7G39 2001a 333.95'153'09711 C2001-903262-5

For more information about the Southern Interior Forest Extension and Research Partnership, visit: www.siferp.org

This report is published by:

Southern Interior Forest Extension and Research Partnership
478 St. Paul Street
Kamloops, BC V2C 2J6

and

Society for Ecological Restoration, BC Chapter
#3-130 Niagara Street
Victoria, BC V8V 1E9

The Southern Interior Forest Extension and Research Partnership would like to acknowledge the generous financial contributions of Forest Renewal BC.

FOREST RENEWAL BC
Investing in knowledge

ABSTRACT

Ecological restoration attempts to restore parcels of land or water that have been damaged by a range of past human activities. The scope of ecological restoration ranges from alpine meadows to saltwater estuaries, and the techniques are as diverse as the many ecosystems to which they are applied. This guide provides an introduction to ecological restoration for individuals, companies, students, non-profit groups, and government agencies involved in or contemplating restoration projects. It emphasizes the underlying concepts common to all restorations—the ecological concepts of succession, disturbance, and historical range of variability.

Citation—
Gayton, D.V. 2001. *Ground Work: Basic Concepts of Ecological Restoration in British Columbia*. Southern Interior Forest Extension and Research Partnership, Kamloops, B.C. SIFERP Series 3.

ACKNOWLEDGEMENTS

A number of people assisted in the development of this publication. Thanks to Phil Burton, Don Eastman, Mike Fenger, Eric Higgs, and my wife, Judy Harris, for reviewing the manuscript, and to Tanis Douglas and Mike Fenger, representing the Terrestrial Ecosystem Restoration Program, for their patience and determination to see this project through. Thanks to Susan Bannerman, SIFERP Editor, for excellent editorial skills. Finally, thanks to the Terrestrial Ecosystem Restoration Program of Forest Rewewal BC, for their willingness to fund this project.

This publication is dedicated to the memory of Dave White (1966–2001), who always found joy in restoration.

CONTENTS

INTRODUCTION

Ecological restoration is a fascinating and dynamic activity, engaging both young and old, urbanites and rural residents. Restorationists come from a host of different backgrounds and professions. In Vancouver, a group celebrates the liberation of a previously culverted urban salmon stream. In the East Kootenays, a small corps of trained volunteers assist with the light-up of a prescribed burn to restore a Ponderosa pine savanna grassland. Near Powell River, representatives from a local pulp mill collaborate with government officials on the phased dismantling of an outdated dam on the Theodosia River. South of Revelstoke, contractors plant willow stems on a recent landslide to prevent further erosion into the Akolkolex River. In the hills north of Kamloops, students plant bluebunch wheatgrass on dry hillsides scarred by motorbikes.

These, and dozens of other restoration projects, are found over the length and breadth of the province. Some are undertaken by contractors and government agencies, but most are done by dedicated groups of volunteers.

As little as 50 years ago, the prevailing view was that natural resources were inexhaustible, and that the Earth could easily absorb all human impacts. Our current view of nature is shifting dramatically, and ecological restoration is on the leading edge of this wave of change.

Pierre Raymond

Planting live willow stems ("wattle fences") on the Akolkolex River.

Darrell Smith

Getting ready for a prescribed burn in the East Kootenays.

This guide provides an introduction to ecological restoration (also known as ecosystem restoration) for individuals, companies, students, non-profit groups, and government agencies involved in or contemplating restoration projects. The scope of ecological restoration ranges from alpine meadows to saltwater estuaries, and the techniques are as diverse as the many ecosystems to which they are applied. This publication emphasizes the underlying concepts common to all restorations. Practical resources and further reading are provided in the Bibliography.

A BRIEF HISTORY

Some would argue that the concepts of nature conservation and restoration can be traced all the way back to classical Greece. The modern foundations of ecological restoration are contained in the writings of Henry David Thoreau, George Perkins Marsh, and Aldo Leopold. The first restoration projects began in Wisconsin, in the 1930s, under Leopold's direction. The North American Society for Ecological Restoration was founded in 1988. In Canada, the first silvicultural plantings in British Columbia occurred in the mid-1930s, and provincial mine reclamation legislation was enacted in 1969. John Morgan and others began restoring tall-grass prairie around Winnipeg in the 1980s, and the first project to restore Garry oak meadows on Vancouver Island began in 1991. Forest Renewal BC inaugurated a Watershed Restoration Program in 1995 and subsequently created a Terrestrial Ecosystem Restoration Program in 2000. The British Columbia Chapter of the Society for Ecological Restoration was formed in 1999.

> ***A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it does otherwise.***
>
> **— Aldo Leopold**

A Forest Of Words: What is the Difference between "Restoration" and Conservation, Reclamation, Mitigation, Stewardship, and Enhancement?

Several overlapping approaches have evolved to improve the condition of degraded ecosystems. The following capsule definitions should help clarify the terminology surrounding these approaches.

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. This may be done passively, by simply reinstating natural disturbances or removing unnatural disturbances, or actively, by reintroducing native species. Other intrusive measures, such as soil or water amendments or planting cultivated species (nurse crops), are sometimes used. However, these temporary interventions are only undertaken where they assist the site's return to an appropriate, self-regulating suite of native species. *Conservation* is a general term for the protection of existing species, landscapes, or ecosystems. Conservation is also frequently interpreted to mean the wise use of natural resources; "sustainable management" is another synonym. The goal of *reclamation*, as the term is used in British Columbia, is usually to stabilize soil and water on lands that have been damaged by industrial activity, and to return the land to some useful purpose. Reclamation is usually associated with mining and involves regrading and amending pits, slopes, and spoil piles and then planting them with cultivated species. *Mitigation* reduces environmental damage by manipulating a specific source of pollution, such as reducing industrial phosphate emissions into a river system. Mitigation includes the concept of environmental credits, in which a producer of pollution will undertake reclamation, a land purchase, or other work to offset their negative ecological effects. *Stewardship* is a general term for maintaining or protecting a natural area or natural resource. *Enhancement* refers to manipulating habitat to allow a selected species to exceed its historical population levels in a particular area, generally for socio-economic reasons. Ecological restoration, in its broadest sense, embraces all of these activities.

WHAT KINDS OF ECOSYSTEMS CAN BE RESTORED?

There are at least as many kinds of restorations as there are ecosystems. The table below shows a range of ecosystems and typical sources of damage to each. Forest Renewal BC's Terrestrial Ecosystem Restoration Program has done an initial survey of ecosystems in need of restoration (see Holt, 2001).

Ecosystem Type	Sources of Damage
Meadows, bogs	Drainage, alien species invasion, overgrazing, pollution
Sand dunes	Alien species invasion, off-road vehicle damage, structural damage
Grasslands	Overgrazing, forest encroachment, weed invasion, off-road vehicle damage, roads, utility corridors, cultivation
Dry forests	Forest ingrowth, alien species invasion, high-grade logging, soil erosion or compaction, wildfire, fire suppression, loss of old-growth or wildlife trees, loss of understorey communities
Wet forests	High-grade logging, soil erosion or compaction, wildfire, loss of old-growth or wildlife trees
Riparian communities	Overgrazing; alien species invasion; pollution; bank degradation; loss of habitat from damming, channelization, bank armouring, or water diversion
Lakes and streams	Alien species invasion; pollution; overfishing; loss of habitat from damming, channelization, bank armouring, or water diversion
Marine	Pollution, alien species invasion, logging/sawmilling debris accumulation, siltation, estuary destruction, overfishing

The types of restorations performed on these ecosystems are wide-ranging, and often limited only by the energy and imagination of those doing the work.

Don Gayton

Motorbike scars on the grasslands near Kamloops.

Canadian Wildlife Service

Artificial islands created to offset the loss of saltwater marsh habitat, Campbell River.

CAN WE ACTUALLY "RESTORE" NATURE?

Part of the fascination of ecological restoration is that it engages us on a philosophical level as well as on a practical one. Is it arrogance to think we humans can "restore" an ecosystem back to its natural state? Do we know enough to put all the "pieces" back into the right places? Does restoration imply that humans have no permanent role in nature? Does nature need us? Where do we set the limits between acceptable and unacceptable ecological damage? And what is "natural," anyway? These questions are being actively debated, but there are no right or wrong answers. Fundamental questions like these must be answered by all members of society, not just by scientists.

ISN'T IT SIMPLER TO SAVE A THREATENED OR VALUABLE SPECIES, RATHER THAN TRY TO RESTORE A WHOLE ECOSYSTEM?

Many of our past restoration efforts have been directed at single species—the marbled murrelet, the Garry oak, or the yellowfin rainbow trout, for example. However, no matter how rare and charismatic an individual species might be, it is always part of a larger web. Although species rescue efforts continue to be important, we are beginning to take a more holistic approach to restoration. Every species relies on a habitat, or a series of habitats, and habitats are ecosystems.

If we ensure that an ecosystem and its processes are intact, then the species which depend on that ecosystem have a far better chance of survival than if our efforts are concentrated on maintaining population levels of a particular species, while ignoring its habitat. In the case of wide-ranging or migratory animals, *all* habitats used during the species' life cycle must be in place, or the restoration will fail. The burrowing owl is a classic example. Great efforts (both in British Columbia and on the Prairies) have been made to preserve, maintain, and even enhance the *breeding habitat* of this delightful little bird, but the species remains in steep decline because of loss of its *foraging habitat* to agriculture and urbanization. In the long run, the way to ensure the survival of an individual species is to restore the complex biophysical web—in other words, the ecosystem—in which it lives.

Tim Ennis

Open Garry oak meadow, Cowichan Preserve, Vancouver Island.

Dick Cannings

Burrowing owls are very sensitive to habitat loss.

WHAT IS SUCCESSION, AND HOW DOES IT RELATE TO RESTORATION?

Ecological succession is the sequence of changes a biotic community passes through before reaching its maximum possible development, or potential natural community. Restoration seeks to move a community, site, or ecosystem along a successional sequence towards a desired future condition. This condition is usually at or near the potential natural community, or what has also been called the "climax" community.

Ecological restoration is the process of assisting the recovery and management of ecological integrity.
— Society for Ecological Restoration

The entire discipline of ecological restoration is strongly influenced by our concepts of ecological succession. Traditionally, we saw succession as a single, linear process—a ladder of equal steps, with bare ground being the bottom rung and the potential natural community at the top. Current ecological thinking has moved away from this model in several ways:

- There may be several different successional pathways and end points for a particular community, not just one.
- Certain introduced species may never be extirpated, and will be found in small amounts in late successional and undisturbed communities.
- Succession is not completely reversible and elastic. For example, the effects of pollution or overgrazing may so fundamentally change an ecosystem that natural succession may not be re-established, even after 20 years of no pollution or no grazing.
- Natural communities, for reasons both known and unknown, may get "stuck" at an early successional stage and not advance, though conditions seem to be right and the source of original degradation has been removed.
- Degradation may cause fundamental "changes of state," where one ecosystem is permanently transformed into another. This new ecosystem may advance successionally, but along a totally different pathway than before.
- Because they can effectively make room for some species, natural disturbance regimes are an important agent of ecosystem health. Altered disturbance regimes may prevent an ecosystem from reaching potential natural community.
- North American ecosystems were not all at potential natural community before European settlement. Natural and anthropogenic (human-caused) disturbances would have produced a mix of successional stages across the pre-contact landscape.

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.

WHAT TO RESTORE TO?

"What to restore to?" is a crucial question for every restorationist. Restoring an ecosystem is not at all like picking up the pieces of a broken vase and gluing them back together. A vase is a fixed, unvarying entity; ecosystems are dynamic, continually changing over time and space. A vase is a product; an ecosystem is both a process (many processes, in fact) and a product. A common goal (or desired future condition) for restoration is that the ecosystem looks and functions as it did before it was damaged or degraded. Alternatively, a similar ecosystem in good or excellent condition can be used in defining a goal.

Restorations must also account for human presence and legitimate human demands on nature, but defining "legitimate" is highly contentious. We are a part of nature, but our current ecological "footprint" is far deeper and wider than that of any other organism (as a part of nature, some would group us with the weeds!). It is important to recognize that ecosystems deliver both "products," such as timber and fish, as well as less tangible natural "services," such as absorbing carbon dioxide, or providing opportunities for outdoor recreation. Ideally, human demands should not exceed an ecosystem's current capacity to deliver these products and services, nor should they erode that ecosystem's future delivery capacity. Each restoration project must seek a progressive and dynamic balance between the needs of humans and the needs of nature.

Restorationists must also acknowledge that, in spite of best intentions, some types of restoration may be prohibitively expensive or physically impossible, and alternatives must be sought. Downtown Vancouver, for example, will never be returned to its natural state, but there are creative ways for Vancouver citizens and businesses to offset their impact. The genius of good restoration work lies in the fusion of the ideal with the practical.

Inventory and monitoring are fundamental to restoration. By starting a restoration project, we have made a judgement that a particular ecosystem has been degraded, reduced in extent, or both. Yet ecologists would be the first to admit that our ability to inventory ecosystems and to rate their condition is still quite primitive. Good inventory and assessment work is a mandatory precursor for any restoration, but uncertainty is a given. It is both perfectly acceptable and ecologically correct to set restoration goals as ranges or thresholds rather than as specific numerical targets.

ARE TEMPLATES AVAILABLE TO GUIDE RESTORATION EFFORTS?

Undisturbed contemporary "reference" areas and historical landscape descriptions can be used in the development of restoration targets. Plant, animal, soil, and water data from these reference ecosystems provide useful "templates" for restoration work in similar sites. The potential and problems of both contemporary and historical reference information are discussed here in turn.

> ***Ecological restoration is the art and science of repairing damaged ecosystems to the greatest possible degree of historic authenticity.***
>
> **— Stephanie Mills**

Using Contemporary Reference Conditions as Templates

Ecological Reserves, Wildlife Management Areas, Parks, Protected Areas, Rangeland Reference Areas, and other relatively undisturbed sites—on both Crown and private land—can act as sources of restoration information. However, European influence on our ecosystems has been so pervasive that undisturbed areas are difficult to find, particularly in zones of level, fertile land, and in riparian communities. Because reference areas are frequently small parcels, surrounded on all sides by early successional and disturbed lands, they may not be fully representative of "pristine" ecosystems because of edge effects, species invasion, lack of migration corridors, incomplete habitats, or "overrest" (too little natural disturbance). At the Milroy Rangeland Reference Area near the East Kootenay community of Skookumchuk, for example, 50 years' accumulation of grass litter has allowed the establishment of a Ponderosa pine forest inside the grazing exclosure. Normally the combined action of ungulate grazing and frequent fire on this dry site would not permit the establishment of a forest canopy.

B.C. Ministry of Forests

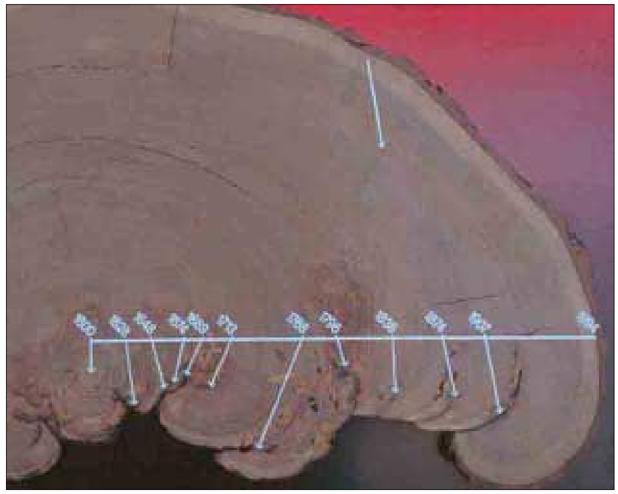
The Milroy Grazing Exclosure, near Skookumchuk. Photograph taken in 1951, the year the exclosure was built.

Don Gayton

Same exclosure in 1995, 44 years later.

Using Historical Reference Conditions as Templates

Another common reference point for ecological restoration is the way an ecosystem looked and functioned historically. 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 certain very remote areas, this may extend to the present). Early published accounts, old-timers' recollections, early research projects, First Nations' accounts, archival photographs, tree rings, and fire scars are typical sources of data for this era, but many others are available to the creative investigator. In one well-known example, officials at Batoche National Historic Site in Saskatchewan wanted to restore vegetation to what it was during the Riel Rebellion of 1885. Sharp-eyed investigators found



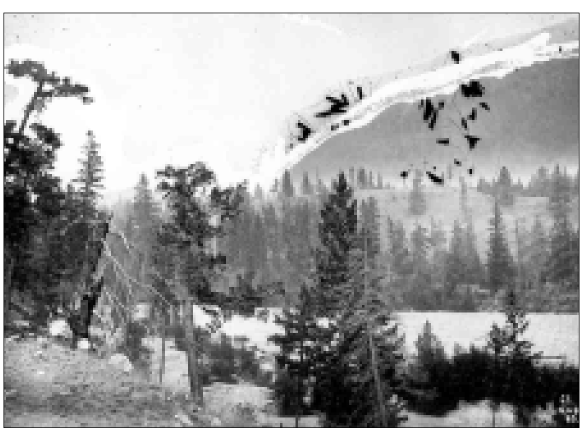
Don Gayton

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

well-preserved chunks of prairie sod underneath buildings built during the Rebellion era. By identifying species preserved in these sods, they gained valuable clues about the historic vegetation around the Batoche town site.

No single historical data source is likely to be definitive, however. 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. For example, in reading geologist George Mercer Dawson's diaries of his 1883 exploration of the Rockies of southeastern British Columbia, one might take note of the number of days when Dawson records observations of smoke, fires, or evidence of past fires. On the other hand, the reader could easily reverse the procedure, focusing instead on the number of days that Dawson *does not* record observations of fire. The serious restorationist should always consult a number of historical and contemporary sources before constructing a template for restoration.

Some experts question the validity of historically authentic restorations, citing the dynamism of ecosystems and the irreversible changes that have taken place since European settlement. They propose instead that "natural authenticity" should be the goal, not historical authenticity. A naturally authentic



National Archives of Canada

Photograph of the Wildhorse River taken by George Mercer Dawson in 1883. (Black marks are from deterioration of the negative.)

Don Gayton

The same location on Wildhorse River, 1998. Notice the changes to the hillside in the middle of the photograph.

restoration would be one that has developed in response to natural processes, but was not guided towards a specific goal or set of species.

Potential natural community may not necessarily be the goal of every restoration project. Late successional (or "late seral") stages may actually be more desirable and easier to maintain than the potential natural community.

WHY ARE DISTURBANCE PROCESSES IMPORTANT?

Natural disturbances have a bewildering range—insect outbreaks, fire, snow press, diseases, ice storms, windstorms, avalanches, volcanic eruptions, floods—and all influence the diversity and complexity of ecosystems. Modern society actively suppresses the impacts of many of these natural disturbance events and, because they are harmful to us, we generalize and assume they are bad for all living things as well. In reality, many organisms and communities are not only adapted to, but even depend on natural disturbance regimes. For instance, the riparian species black cottonwood times its seed release 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. 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. The grasslands of the Milroy Reference Area depend on a certain level of grazing. Seeds of the shrub ceanothus (*Ceanothus velutinus*) germinate in response to fire. The list of biotic adaptations to natural disturbances is virtually endless.

Life was much simpler when we assumed a clear separation between humans and ecosystems. Now, not only do we find that humans negatively impact ecosystems in new and unexpected ways, we are also discovering that certain ecosystems have evolved to rely on human disturbance. For example, many of the grasslands and dry forests of western North America historically experienced a mixture of lightning-caused fires, and fires set by First Nations people for land management purposes. We now realize that these same ecosystems have evolved to *depend* on that mixed fire regime. When the historical fire regime was disrupted around the turn of the last century, the health of grassland and dry forest ecosystems began to deteriorate.

Restoration practitioners often face a double challenge—the natural disturbance cycle has been disrupted at the same time as a whole range of "unnatural," human-caused disturbance has been

Don Gayton

Ceanothus, an evergreen shrub, is well adapted to fire.

imposed, ranging from pulp mill effluent to global warming. Many experts feel that ecological restorations should focus on disturbance processes—restoring natural disturbances, reducing inappropriate human-caused disturbances, and eliminating the release of toxic chemicals into the environment. However, our task is made more difficult by an imperfect understanding of the earth. In many instances, we cannot even draw a clear line between natural and human-caused disturbance.

> ***The mission of every ecological restoration project is to re-establish a functional ecosystem of a designated type that contains sufficient biodiversity to continue its maturation by natural processes and to evolve over longer time spans in response to changing environmental conditions.***
>
> **—Society for Ecological Restoration**

WHAT ARE NATURAL DISTURBANCE TYPES?

The Natural Disturbance Type (NDT) framework is an attempt to categorize the frequency and severity of disturbance events prior to European settlement. It is important to note that this definition of "natural" includes Aboriginal land management activities (such as burning) as they were conducted before European contact. In British Columbia, five different NDTs are 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 guidebook assigns groups of biogeoclimatic subzones and variants to each natural disturbance type, and also provides general guidelines for forest stand age-class distribution in each of the five categories. The NDT concepts in the guidebook are aimed at the broader "landscape level," rather than the local "stand level" at which most restorations take place. However, the guidebook, together with biogeoclimatic maps, forms a valuable starting point for terrestrial restoration planning.

HOW IS HISTORICAL RANGE OF VARIABILITY USED?

Historical range of variability (HRV) is another useful concept in ecological restoration. It refers to the full spectrum of ecosystem states and processes encountered over a long time period, usually the 1600–1880 era. Historical range of variability is frequently used to describe disturbance processes. Ecosystems are thought to be healthier and more sustainable if we manage them so that their current natural disturbance regime falls within the historical range of variability.

An example from fire ecology shows how HRV works. 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 by our contemporary activities we create individual fire return intervals of 2 years, or of 80 years, or if over time we shift the average interval to 10 years or to 50 years, we can be said to be managing Lewis Ridge outside of its HRV. 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 across 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.

A historical range of variability (means and extremes) should be developed not only for the disturbance *return interval*, but also for the *size* and *severity* of the disturbance.

Restoration plans are developed through science and research, but "on the ground" knowledge and experience is also crucial. Local landscapes—and the local folks who know and love them—must be allowed to tell their story, and to help shape the restoration objectives.

WHAT ABOUT ALIEN SPECIES?

Weeds and alien species complicate nearly every terrestrial restoration project, as well as many aquatic ones. Weeds are such a profound and widespread problem that some practitioners limit their objectives to simply controlling weeds, thereby giving the ecosystem the opportunity to restore itself. Alien species removal is a central part of some restorations, as in the removal of Scotch broom (*Cytisus scoparius*) from Garry oak meadows, or the removal of introduced American bullfrogs (*Rana catesbiana*) from ponds and lakes on southern Vancouver Island. The introduced freshwater shrimp, Mysis (*Mysis relicta*), has complicated fisheries restoration efforts in large lakes of the Southern Interior.

In terrestrial restorations, soil disturbance should be kept to an absolute minimum since most weeds are adapted to exploit disturbed soil. Roads, utility corridors, and off-road vehicles all facilitate the spread of weeds, but weeds can also invade plant communities that have been weakened by overgrazing. Good weed control is niche control: prevent the creation of new, vacant niches by avoiding soil disturbance and any weakening of the existing native plant community. If soil disturbance is necessary in weed-prone situations, then seeding a "companion crop" (a short-lived cultivated species) along with the appropriate native seed may be an effective way of suppressing weeds.

In Manitoba, tall-grass prairie restorationists have been so plagued by broad-leaved annual weeds that they have resorted to one-time herbicide applications to give their native seedlings a competitive edge.

Tim Ennis

Carrying out the dead after a broom bash at the Cowichan Preserve, Vancouver Island.

Gravel pit near Grand Forks infested with Dalmatian toadflax, 1997.

Same area in 2000, after 3 years of biocontrol with the weevil, Mecinus janthinus.

Ecological restoration strives to move a community along a successional pathway towards the potential natural community, but alien species can hijack that process, trapping the community in an unnatural, intermediate stage. In some dry Southern Interior range lands, knapweed (*Centaurea* spp.) persists as a dominant species long after grazing pressure is drastically reduced or eliminated and other sources of soil disturbance are removed. In these instances, biological control may be the only long-term solution. The presence of introduced weeds, such as knapweed, Dalmatian toadflax (*Linaria genistifolia*), and sulphur cinquefoil (*Potentilla recta*), in undisturbed, ungrazed grassland areas is an indication that these weeds will probably never be completely eradicated, and will in time become a permanent, naturalized part of our flora.

CAN SUCCESSION BE "SPEEDED UP" TO ACHIEVE RESTORATION SOONER?

Yes, and no. Control of weeds and other competing vegetation is a common way of hastening succession; improving the physical condition and fertility of the soil can also speed up the process, as can seeding or transplanting the desired native plants. However, the final, complete development of the potential natural community, including all its members, their relationships, and their structure on the landscape, will follow its own clock.

NOXIOUS WEEDS

British Columbia's *Noxious Weed Control Act* identifies the following species as noxious in all parts of the province. The *Act* also identifies species that are declared noxious in certain parts of the province.

- Annual sowthistle (*Sonchus oleraceus*)
- Canada thistle (*Cirsium arvense*)
- Crupina (*Crupina vulgaris*)
- Dalmatian toadflax (*Linaria dalmatica*)
- Diffuse knapweed (*Centaurea diffusa*)
- Dodder (*Cuscuta* spp.)
- Gorse (*Ulex europaeus*)
- Hound's-tongue (*Cynoglossum officinale*)
- Jointed goatgrass (*Aegilops cylindrica*)
- Leafy spurge (*Euphorbia esula*)
- Perennial sowthistle (*Sonchus arvensis*)
- Purple nutsedge (*Cyperus rotundus*)
- Rush skeletonweed (*Chondrilla juncea*)
- Scentless chamomile (*Matricaria maritima*)
- Spotted knapweed (*Centaurea maculosa*)
- Tansy ragwort (*Senecio jacobaea*)
- Velvetleaf (*Abutilon theophrasti*)
- Wild oats (*Avena fatua*)
- Yellow nutsedge (*Cyperus esculentus*)
- Yellow starthistle (*Centaurea solstitialis*)
- Yellow toadflax (*Linaria vulgaris*)

Many native plant species can enhance soil stabilization and nutrient cycling. Plants like yellow mountain-avens (*Dryas drummondii*) secrete sticky carbohydrates into the root zone, providing structure and increasing microbial activity in gravelly soils of low fertility. Sand-loving grasses such as calamovilfa (*Calamovilfa longifolia*) can bind loose, sandy soil and tolerate burial by windblown sand. Native legumes, such as lupines (*Lupinus* spp.) and vetches (*Vicia* spp.), absorb nitrogen from the air. When they die, that nitrogen becomes available to other plants. Shrubs, such as soopolallie (*Shepherdia canadensis*), wolf willow (*Eleagnus commutata*), and ceanothus (*Ceanothus velutinus*), also have the ability to absorb atmospheric nitrogen. Other plants are adept at absorbing contaminants or excess water. Many of these functions have only been discovered recently, and it is safe to assume that restorationists will discover many more useful plant functions in the future.

WHAT ABOUT RARE AND ENDANGERED SPECIES?

Endangered species and ecological restoration are frequently found together. Currently, we try to maintain viable populations of rare and endangered species out of a sense of social responsibility, but these same species may have economic importance in the future. As we move into an era of global warming, the ability of ecosystems to respond to dramatic climate fluctuations becomes crucial. Species that are endemic, rare, or at the northern edge of their range could become quite important in altered climate scenarios. Maintaining and preserving rare species, through ecological restoration and other means, is a good insurance policy.

Dick Cannings

The burrowing owl sits uneasily on the province's Red List of endangered species.

Don Gayton

The rare grass little bluestem (Schizachyrium scoparium) has only been found in seven locations in British Columbia.

WHAT ROLE DOES THE LOCAL COMMUNITY HAVE IN RESTORATION?

Most successful restoration projects have a strong community component, and there are obvious reasons for this. Local experts will have detailed current and historical knowledge of the area in question. Other local people may have taken ecological damage for granted in the past—they need the opportunity to learn about the ecology of their area and to gain a sense of "ownership" of the restoration. Most restorations involve numerous manual and administrative tasks (see Appendix 1). Volunteers can be instrumental in getting this work done if they are brought in early, provided with some training and background, and given specific tasks to do. Inventories, grant proposal writing, communications, weed pulling, transplanting, shovel work, and monitoring are typical areas of volunteer involvement.

Preliminary inventory work usually has a training component, which may make it eligible for government training or retraining funding. A fine example of this occurred in the Georgia Basin and on the west coast of Vancouver Island, where a Department of Fisheries and Oceans employee helped to secure training and project funds for displaced fisheries workers and community groups. He showed them how to use hand-held GPS units to map small fish-bearing streams in urban areas. This initial "ground truthing" work became the basis for a multi-partner project that generates information on the precise locations of the streams, presence or absence of fish, barriers to fish migration, other wildlife observations, and potential restoration opportunities.

Local, community-based mapping processes can range from informal to scientific, but all are an excellent prelude to restoration. They focus attention on local issues, provide a means for "harvesting" and communicating local ecosystem knowledge, and encourage community ownership of the resulting restoration project.

Fisheries and Oceans Canada

Maps are a great asset to ecological restoration. This Sensitive Habitat and Inventory map (SHIM) shows riparian features in the Comox Valley.

Wetlands Institute

Community volunteers learn mapping skills as they plan a restoration project.

WHERE SHOULD RESTORATION EFFORTS START?

Ecosystems exist in a matrix of soil, water, and air. If these physical components are degraded, then that is where restoration efforts must start. A commonly held principle of restoration is that the cause(s) of ecosystem degradation must first be identified and controlled. Damage to soils occurs through erosion, compaction, salinization, water table fluctuations, or contamination with toxic chemicals. Soil damage may also result from the loss of organic matter, structure, microbial activity, and fertility. If any of these conditions are present, they must be addressed before a return to the potential natural community can be expected. Open pit mine areas and mine tailings present major restoration challenges, since the substrate usually has low fertility, low moisture-holding capacity, and altered pH.

Terrestrial ecosystems possess a crucial cycle of live plant biomass production, dead biomass breakdown, and subsequent nutrient cycling, which leads to further biomass production. In healthy plant communities, this cycle is tightly closed; in low seral communities, the loop may be "leaky," and in severely degraded communities it is completely broken. In the latter case, the restorationist's first job is to re-establish a functioning biomass cycle, which may require the temporary use of low seral or agronomic plant species. Upward succession cannot occur in the absence of a functioning biomass cycle.

Before the biological issues can be addressed in aquatic and riparian restorations, the first step is often to adjust water conditions so that water flow, seasonality, chemistry, and temperature return to their historical range.

HOW SHOULD NATIVE PLANT MATERIALS BE USED IN RESTORATION?

Replanting of native plant propagules (i.e., seed, transplants, or cuttings) is a common restoration practice, which can greatly accelerate succession. However, using native plant materials raises the following important issues:

- Plant propagules (seeds or cuttings) should ideally be taken from similar areas adjacent to the restoration project.
- Wild stock should only be removed from areas about to be destroyed (e.g., suburban development).
- Deep-rooted perennials can rarely be moved successfully.

Pierre Raymond

A wattle fence on the Akolkolex River, one year after planting. Compare this to the establishment photograph on page one.

- To avoid depletion, seed or cuttings should not be harvested from the same natural area in successive years.
- If large volumes of seed are required, small amounts of appropriate seed should be multiplied in a nursery, rather than risk overharvest of native stands.
- Selected lines of some native species are now being grown commercially, and may be used if local propagules are not in sufficient supply. However, repeated use of the same seed source may reduce the all-important genetic diversity of a restored stand.
- Severely degraded soils may have lost the microbial populations on which some native species depend. Re-inoculation of these soils, by mixing in small amounts of soil taken from a healthy area, or by using commercial preparations, often improves growth and survival of native plants.

IS SILVICULTURE CONSIDERED ECOLOGICAL RESTORATION?

Silviculture is normally directed at restoring the productive capacity of a forest stand, rather than returning it to a pristine, historical, or late successional state. However, good silviculture contains many of the elements of ecological restoration. Old Growth Management Areas will provide opportunities for silviculturists to attempt full-scale forest ecosystem restoration, including the re-establishment of old-growth forest structure and composition. Many progressive foresters advocate the principles of "ecosystem management" or "ecoforestry" as the basis for preserving and restoring near-natural ecological structure and function in forests in which some timber harvest occurs.

> ***Ecology is the painful elaboration of the obvious.***
> **— Charles Elton**

WHY MONITOR RESTORATION ACTIVITIES?

If individual commitment is the heart of ecological restoration, then monitoring is its soul. As with any management project, the goals of a restoration plan should be defined, and progress toward the goal should be periodically assessed (see Appendix 2). Long-term monitoring of vegetation, of a particular species of interest, or of a key physical parameter (such as soil erosion or average water temperature) is the only way to determine the success of a restoration effort. Many species-specific monitoring techniques have been developed, and the development of the restoration-monitoring plan should include consultation with experts in the appropriate field.

The ultimate in monitoring is to be able to compare data from the restored area (the treatment) against data from a similar untreated area (the control), and draw statistically valid conclusions. This requires randomly located monitoring sites, many repeated treatments (replicates), as well as many observations. Because of financial constraints and site variability, statistical validity is a goal rarely achieved in operational restoration monitoring. However, well-planned and rigorous non-statistical monitoring can still provide a wealth of valuable information.

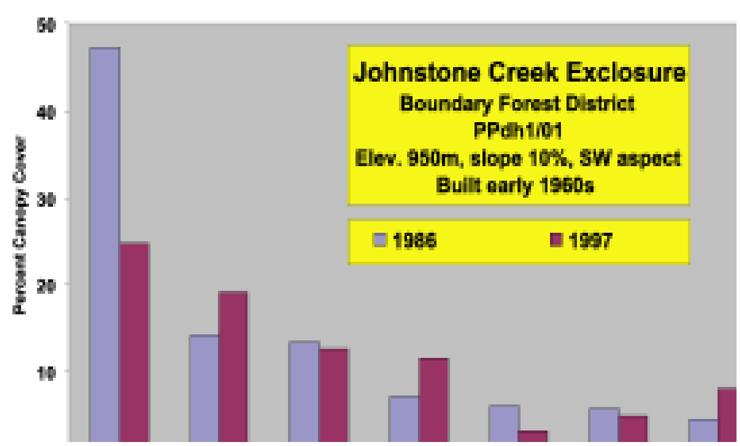
Ecological succession, particularly on highly disturbed, very dry, or very cold sites, operates on the scale of decades, not years. Restorationists should plan their monitoring over a 40-year time horizon. This long time period is appropriate for the slow processes of ecological succession. It also forces us to acknowledge that in four decades none of the original project workers will still be active, new measurement methodologies will be in place, computer software and storage systems will be totally new and incompatible, and paper files will be archived, misplaced, or even destroyed.

Often data can be found from old ecological monitoring projects, but inadequate or missing descriptions of sites and monitoring methodology can render the data useless. For all new ecological restoration projects, a detailed description of the location, monitoring objectives, monitoring methodology, and baseline conditions is essential. Detailed site maps and labelled photographs should be included. The completed document outlining objectives and methods should become part of the public record, stored at more than one location, explicitly referenced and cross-referenced in appropriate filing or bibliographic catalogues, and saved in more than one electronic format.

Although we have discussed the arguments against a single-species focus, limited budgets and ecosystem complexity may dictate use of the "indicator species" concept in restoration monitoring. Based on our best knowledge of a restoration project, sometimes a single key species is chosen as the representative for the entire ecosystem, and that species alone is monitored to determine the success of the restoration. Indicator species are generally either predators or those near the top of the food chain, so we can assume that if the indicator species is healthy and reproducing, then the species it preys on is healthy as well. Vertebrates such as salmon or grizzly bears often serve as indicators, but plants such as rough fescue (*Fesuca scabrella*) or whitebark pine (*Pinus albicaulis*) could also fulfill this role in their respective ecosystems. Caution must be exercised in using indicator species in restoration monitoring, since some species that are vital to ecosystem function may not be directly linked to the chosen indicator.

Wetlands Institute

Establishing a monitoring transect in a coastal marsh.



The value of long-term monitoring: grassland plant succession changes in a grazing exclosure.

IS THERE AN ECONOMIC ARGUMENT FOR RESTORATION?

Few, if any, ecological restoration projects will generate a short-term cash return greater than the value of the labour and materials required to complete the project. In traditional economic terms, ecological restoration does not make sense. However, there is a growing awareness that traditional economics cannot measure the true value of nature and ecosystems. Restoration proponents counter the negative cost–benefit analyses of traditional economics by calling for a more inclusive and long-term method (known as "environmental full-cost accounting") of computing the value of a project.

One of the services that healthy ecosystems deliver is the maintenance of water quality and quantity for human use. Clean, pure water is becoming an increasingly important priority to society. This reprioritization may bring a greater recognition of the economic value of watershed restoration.

Many observers argue that the current approach of overusing and degrading ecosystems, and then repairing the damage through ecological restoration, is bad economics. They support the more efficient approach of moving toward sustainable ecosystem management, so that ecological restoration will no longer be required. Indeed, tabulating the cost of labour, equipment, and materials used in restoration projects helps us appreciate at least some of the "replacement costs" associated with damaged ecosystems.

WHAT ABOUT OTHER VALUES?

Much has been written about the personal, social, and spiritual values of restoration work. As we shifted from a rural, agrarian society to a largely urban, industrialized, and technologically oriented lifestyle, opportunities to develop bonds with nature have decreased dramatically. Many see ecological restoration as a new means of providing opportunities to connect with the natural world. Others, however, shy away from the philosophical aspects and simply see restoration as a way of being out in nature and doing positive work with like-minded people.

Traditional ecological knowledge is an important asset to restoration. First Nations people developed their understanding of British Columbia's ecosystems in the context of long-term, low impact use of natural resources—a context that overlaps very well with the goals of ecological restoration and ecosystem management. Although they are different forms of knowledge, models exist for integrating Western science and traditional ecological knowledge that are respectful of both.

Don Gayton

The landscape contains many layers of information. Shuswap knowledge keeper Henry Michel explains the narrative significance of a rock formation.

William Jordan, one of the foremost theorists of the restoration movement, sees the practice of restoration as a modern replacement for the traditional rituals that have disappeared from our secular society. Jordan also argues that an ecological restoration project captures, in miniature, some of the great traditions of human history, starting with gathering seed, then cultivation agriculture, on through natural history, human history, and finally, to measurement and science. Restoration also provides the participant with the satisfaction of being involved in meaningful work, and of volunteering to benefit the larger community. Researchers also value restoration as a form of holistic science, in which we learn about the natural world by our attempts to put it back together. This approach is an important new alternative to the standard reductionist method of learning about the world by taking it apart.

To keep every cog and wheel is the first precaution of intelligent tinkering.

— Aldo Leopold

CONCLUSION

Our society is experiencing such rapid technological development that land and water, particularly small, damaged portions, often seem trivial and expendable. The simple act of repairing that damage, of caring for local parcels of land and water, can send a powerful social message, both to ourselves and to those around us.

Ecological restoration is simply one of many positive ways of working with nature and natural resources. Ideally, a full spectrum of restoration, conservation, reclamation, mitigation, stewardship, and enhancement activities can take place in British Columbia. This effort will require large numbers of people, working in concert with sustainable resource extraction, for the betterment of our terrestrial and aquatic ecosystems.

The positive human aspects are undeniable. It is as much for ourselves as for the ecosystems that we embrace ecological restoration.

Tim Ennis

Garry oak meadow, Cowichan Preserve, Vancouver Island.

APPENDIX 1 Steps in Setting Up a Restoration Project[1]

Research and Objective Setting

- Identify project site location and boundaries.
- Determine land ownership.
- Identify the causes of damage.
- Set preliminary restoration objectives.
- Identify biogeoclimatic subzone, site series, and natural disturbance type.
- Accumulate and review current maps and reports on area.
- Do a search for archival materials or research on the site.
- Do a biophysical survey of the site.
- Create a detailed map (or series of maps) of the site.
- Consult with local stakeholders and interest groups.
- Become familiar with similar restoration projects.
- Set final restoration objectives.
- Establish monitoring plan.
- Seek funding and manpower sources.

Operational Phase

- Make sure monitoring points are permanently marked and mapped.
- Leave an untreated portion so that visual and numerical comparisons can be made.
- Secure the site against vandalism and accidental damage.
- Invite stakeholders and the interested public to a field day.
- Periodically review monitoring data and compare against objectives.
- Ensure that monitoring data are properly stored and analyzed, and a detailed description of monitoring methods is on file.
- Compare results with similar restoration projects.

[1] Adapted from the Society for Ecological Restoration Web site (www.ser.org).

APPENDIX 2 Adaptive Management and Ecological Restoration

Adaptive management fits very well with ecological restoration. The principles of adaptive management combine research and monitoring with flexible management practices. By formulating clear restoration goals and then monitoring achievement of those 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.[2]

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 of 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 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 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.

In reality, some of the steps outlined 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.

[2] Adapted from "An Introductory Guide to Adaptive Management," by Brian Nyberg, B.C. Ministry of Forests, Forest Practices Branch, Victoria, B.C., 1999.

BIBLIOGRAPHY AND RESOURCES

Books, Pamphlets and Journals

Baker, W.L. 1994. Restoration of landscape structure altered by fire suppression. *Conservation Biology* 8:763–769.

Banerjee, S.M., K. Creasey, and D.D. Gertzen. 2001. Native woody plant seed collection guide for British Columbia. Crown Publications, Victoria, B.C.

Berger, J.J. (editor). 1990. Environmental restoration: Science and strategies for restoring the Earth. Island Press, Washington, D.C.

British Columbia Ministry of Agriculture and Fisheries. *Noxious Weed Control Act*. [Contains current list of provincially and regionally designated noxious weeds.]

British Columbia Ministry of Forests and B.C. Ministry of Environment, Lands and Parks. 1995. *Biodiversity guidebook*. B.C. Forest Practices Code. Victoria, B.C. [Contains information about natural disturbance types, seral stages, and forest age-class structure.]

Clewell, A. 2000. Restoring for natural authenticity. *Ecological Restoration* 18(4):216–217.

Dawe, N.K., G.E. Bradfield, W.S. Boyd, D.E.C. Trethewey, and A.N. Zolbrod. 2000. Marsh creation in a northern Pacific estuary: Is thirteen years of monitoring vegetation dynamics enough? *Conservation Ecology* 4(2):12. [Long-term monitoring of vegetation changes following marsh creation in Campbell River estuary. Available on-line at: www.consecol.org/vol4/iss2/art12]

Dobson, A.P., A.D. Bradshaw, and J.M. Baker. 1997. Hopes for the future: Restoration ecology and conservation biology. *Science* 277:515–522.

Ecological Restoration [Quarterly technical journal of the Society of Ecological Restoration.] University of Wisconsin Press, 2537 Daniels Street, Madison, Wisconsin 53718-6772.

Egan, B. 1999. *Helping the land heal: Ecological restoration in British Columbia*. Proceedings from the 1998 conference in Victoria. B.C. Environmental Network Educational Foundation, Vancouver, B.C. [A good introduction to the range of restoration activities in British Columbia.]

Harrington, S. (editor). 1999. *Giving the land a voice: Mapping our home places.* Land Trust Alliance of BC, Saltspring Island, B.C. [Community-based mapping as a basis for ecological restoration.]

Hobbs, R.J. and D.A. Norton. 1996. Towards a conceptual framework for restoration ecology. *Restoration Ecology* 4:93–110.

Holt, R.F. 2000. An ecological foundation for a proposed ecosystem restoration program. Prepared for Forest Renewal BC and B.C. Environment, Nelson B.C. [Available on-line at: www.forestrenewal.bc.ca/terp.htm]

________. 2001. Strategic ecological restoration assessment: Provincial overview. Prepared for Forest Renewal BC and B.C. Environment, Nelson B.C. [Strategic assessments are also available for each forest region. Available on-line at: www.forestrenewal.bc.ca/terp.htm]

Jordan, W. III. 1991. A new paradigm. *Restoration and Management Notes* 9(2):64–65.

Jordan, W.R., R.L. Peters, and E.B. Allen. 1988. Ecological restoration as a strategy for conserving biodiversity. *Environmental Management* 12:55–72.

Kimmerer, R.W. 2000. Native knowledge for native ecosystems. *Journal of Forestry* 98(8):4–9.

Leopold, A. 1949. *A Sand County almanac and sketches here and there*. Oxford University Press, New York, N.Y.

Luken, J.O. 1990. *Directing ecological succession*. Chapman and Hall, New York, N.Y.

Mills, S. 1995. *In service of the wild: Restoring and reinhabiting damaged land*. Beacon Press, Boston, Mass.

Morgan, J.P. 1995. *Restoring Canada's native prairies*. Prairie Habitats, Argyle, Man. [Copies may be obtained from: Manitoba Naturalists' Society, 401-63 Albert Street, Winnipeg, Man., Canada R3B 1G4.]

Noss, R.F. and A.Y. Copperrider. 1994. *Saving nature's legacy: Protecting and restoring biodiversity*. Island Press, Washington, D.C.

Nuzzo, V. and E. Howell. 1990. Natural area restoration planning. *Natural Areas Journal* 10(4):201–209.

Ritchlin, J. 2001. Healing the land . . . *Healing ourselves: A guide to ecological restoration resources for British Columbia*. BC Environmental Network Foundation, Vancouver, B.C. [Copies may be obtained from the Network at 610 W. Hastings Street, Vancouver, B.C., Canada V6B 1H7.]

Web Sites

BC Conservation Data Centre: www.elp.gov.bc.ca/rib/wis/cdc
(includes information on rare/endangered animal and plant communities)

British Columbia Archives: www.bcarchives.gov.bc.ca
(includes an on-line, searchable photographic archive)

British Columbia Chapter of the Society for Ecological Restoration (SER-BC): www.ser.org

Fire Effects Information Service (FEIS): www.fs.fed.us/database/feis

Range Reference Areas: www.for.gov.bc.ca/hfp/range/rra/rra.htm
(long-term grassland monitoring data)

Sensitive Habitat Inventory and Mapping Project: www.shim.bc.ca

Terrestrial Ecosystem Restoration Program: www.hctf.ca/app/terp/index.html

The Land Conservancy of BC: www.conservancy.bc.ca

Other Resources

Society for Ecological Restoration, BC Chapter
#3–130 Niagara Street
Victoria, BC V8V 1E9
Phone: 250.356.6810 Fax: 250.387.0046
john.parminter@gems7.gov.bc.ca

Restoration of Natural Systems Program
School of Environmental Studies
University of Victoria
PO Box 1700, Stn. CSC.
Victoria, BC V8W 2Y2
Phone: 250.472.4568
rns@uvic.ca

Douglas College Habitat Restoration Program
David Lam Campus, 1250 Pinetree Way, Coquitlam, BC
Mailing Address: PO Box 2503
New Westminster, BC V3L 5B2
Phone: 604.527.5817 Fax: 604.527.5969
habitat@douglas.bc.ca

Native Plant Society of British Columbia
2012 William Street
Vancouver, BC V5L 2X6
Phone: 604.255.5719
npsbc@hotmail.com

British Columbia Grasslands Conservation Council
954A Laval Crescent
Kamloops, BC V2P 5P5
Phone: 250.374.5787
gcc@bcgrasslands.org

NOTES