Environmental Factors and Their Influence on Species Selection and Site Design

Garry Oak and Associated Ecosystems of Southwestern B.C.

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Principles of Ecosystem Recovery

- Set realistic goals given the degree of degradation ("ecosystem templates").
- Stop or remove "agents" of degradation (unsustainable uses, invasive spp).
- Restore the physical environment (decontamination, site stabilization, soil amelioration).
- Restore natural influences (natural hydrology, disturbance regimes).
- Restore the biota (natural regeneration [where possible], artificial re-vegetation [where necessary], micro-organisms, ecosystem structure).
- Keep records, monitor progress, and learn from the inevitable mistakes.

When is Artificial Re-vegetation Appropriate?

- In most cases of highly degraded, de-vegetated sites (reclamation).
- In cases where significant components of the “natural community” still exist, and after a comprehensive ecosystem assessment/inventory:

  - where an important species (keystone, SAR) has been extirpated from an area.

  -where a species’ reproductive success has been compromised by excessive exploitation.

  -where a species’ reproductive success has been compromised by the removal an important ecological influence (e.g. fire) or by an introduced invasive exotic species (e.g. competitor, herbivour, parasite)

GOERT COMPENDIUM OF PLANT PROPAGATION INFORMATION

- To access go to www.goert.ca. Click on “For gardeners and restoration practitioners” in the top menu, and then click on “propagation guidelines” on the side bar.
- The site provides species propagation and use guidelines for 3 trees, 15 shrubs, 35 forbs, 19 grasses and 4 ferns
- Each of the species guidelines gives the following information on “Geographic Range and Habitat Requirements”: - ecological setting; soil texture; nutrients; soil reaction; moisture regime, light requirements, successional status; and BEC zone, subzone and GOE community status.
- This information can be used in re-vegetation activities in two ways: 1) to select appropriate species for a given site; or 2) in a more limited way, to determine how to modify a site to support a desired species mix. The first is most relevant to large-scale restoration projects (landscape level,) while both may be relevant to urban/institutional gardens (site level).

Major Environmental Factors

- Regional climate and associated BEC zones
- Geology (bedrock and surficial)
- Topography and micro-climate (slope, aspect, elevation)
- Sunlight (intensity, duration)
- Soil (depth, texture, pH/nutrients, organic matter)
- Disturbance regimes
- Climate change and species provenance

Regional climate and associated BEC zones

- Garry oak ecosystems (GOEs) are exclusive to the Pacific Coast of North America in areas with a Mediterranean climate (dry summers/wet winters).
- In B.C. GOEs are limited to a narrow coastal strip (<30 km wide) in the Nanaimo Lowlands of southeastern Vancouver Island from Victoria to Comox, the southern Gulf Islands and two disjunct patches in the Fraser Valley.
- Major climatic control is the rain-shadow that occurs in the lee of the Olympic Mountains and Vancouver Island Ranges.
- Annual precipitation increases from east to west (e.g. Victoria 608 mm, Metchosin 1014 mm, Colwood 1029 mm, Sooke 1492 mm) and from south to north (e.g. Victoria 608 mm, Sidney 883 mm, Duncan 1039 mm, Nanaimo 1162 mm, Comox 1179 mm).

Regional climate and associated BEC zones (cont.)

- GOEs occur primarily in the Drier Maritime Subzone of the Coastal Douglas-fir BEC Zone, which grades into the Moister Subzone of CDF, which in turn grades into the Coastal Western Hemlock BEC Zone – one of the shortest ecological transitions anywhere in B.C.
- The increasing precipitation trends from south to north and east to west, coupled with fire exclusion, means that over the past century and a half there has been significant encroachment of species from the moister CDF sub-zone into GOE ecosystems.

Bedrock and Surficial Geology

- Bedrock geology on Southern Vancouver Island is far more complex than that on the adjacent mainland (outside of the Fraser floodplain).
- Major formations include: igneous intrusives - basalts, gabbros, granites and granodiorites; metamorphic complexes – gneisses, schists and siltstones; and sedimentary strata – limestones and sandstones.
- Generally, base-rich rocks (limestones and basalts) yield more productive soils than acidic rocks (granites, granodiorites and sandstones), and metamorphic rocks range somewhere in between depending on their specific mineral content. Metamorphic rocks generally weather much faster than igneous and sedimentary rocks and produce finer-textured soils.
- HOWEVER, It is very difficult to correlate soil quality to bedrock characteristics here because of past glacial, alluvial and marine activity, which have resulted in transport over considerable distances and extensive sediment deposition.
- Even given this limitation, knowledge of regional bedrock characteristics can give a general indication of the materials that may have contributed to soil generation at the landscape level.

Soil (depth, texture, pH/nutrients, organic matter)

- Soil depth to parent material (bedrock or compacted surficial materials) will control both soil moisture (saturation vs drought) and the rooting zone of plants.
- Soil texture (determined by the proportions of sand, clay, silt and organic matter) will influence water-holding capacity, soil aeration and nutrient retention (cation-exchange capacity).
- Soil reaction (pH) affects both nutrient availability (particularly N and P) and biological activity: soil pH ranges from 6.0 to 7.0 are favourable for most plants; below 6.0 conditions become increasingly unfavourable for micro-organism activity; below 5.0 many nutrients become unavailable; and below 4.0 chemical and biological activities suppress plant growth for most species.
- Coniferous and heather species are tolerant of acidic soils and low nitrogen levels. Broadleaf trees, many grasses and most legumes prefer slightly acid to neutral soils and higher nitrogen levels.

Soil (depth, texture, pH/nutrients, organic matter) cont.

- Organic matter (OM) has a fundamental influence on the chemical and physical properties of soil: on nutrient storage and availability; moisture-holding capacity; and soil texture (particularly on clay/silt soils).
- Many ecological studies refer to a European definition of three types of humus formations:

  - Mor humus, developed under strongly acid conditions (<pH 5), in which minimally-decomposed raw OM occurs as a blanket layer on the surface and is not mixed with underlying mineral soil;

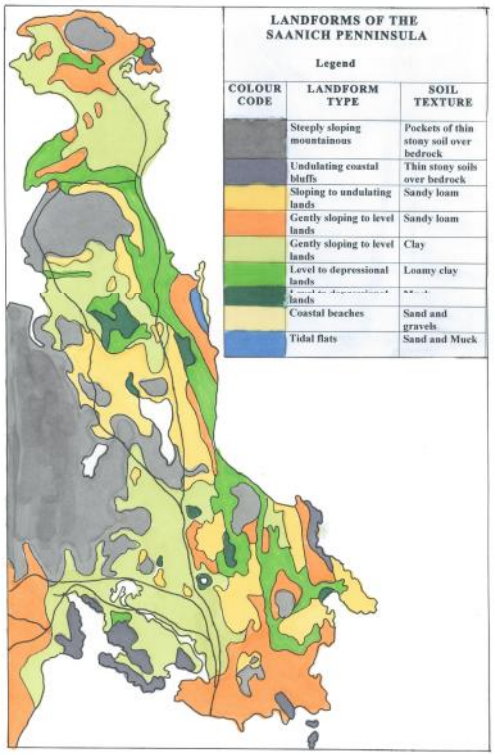
  - Moder humus, developed under moderately acid conditions (pH 5 to 6), in which OM is partly-decomposed (fungal and insect activity) and incompletely mixed with underlying mineral soil; and

  - Mull humus , developed under slightly acid to neutral conditions (>pH 6), in which OM is well-decomposed (bacterial and earthworm activity) and well mixed with underlying mineral soil.
- Humus types will have a significant influence on species composition. (See Table 1. "**The Effect of Humus Type, Soil Nutrition and Soil Moisture on the Occurrence of Selected Species**").

Topography and microclimate (slope, aspect, elevation)

- GOEs in B.C. lie mainly in the Nanamo Lowlands but also partly in the foothills along the eastern flanks of the Vancouver Island Mountains.
- In areas of such variable topography, site conditions can change over very short distances and ecological communities will occur in complex mosaics across the landscape.
- The repeating sequence of landscapes comprised of excessively-drained upland “mountains”, well-drained intermediate slopes, well-watered lower slopes and terraces, undulating to level coastal bluffs, and poorly drained, seasonally-inundated level and depressional lands. Underlying impervious layers (bedrock and clay hardpans) will accentuate these moisture relationships.
- Temperature and moisture conditions are influenced by aspect – south facing slopes will be warmer and drier, while north-facing slopes will be cooler and moister – which will affect rates of organic matter decomposition and accumulation, and the composition of vegetation communities.
- The best way of integrating these complex relationships to support a restoration plan is through a landscape analysis (see Map 1 and Table 2 for a simple analysis of the Saanich Peninsula).

Map 1. Landforms of the Saanich Peninsula



Landforms of the Saanich Penninsula

- Table 2 provides Soil Texture, Drainage, Soil Reaction (pH), Nutrient Status (N/P), Probable Native Vegetation and Percent of Total Area for the following nine landforms:

  Steeply sloping mountains; undulating coastal bluffs; sloping to undulating lands (sandy loams); gently sloping to level lands (sandy loams); gently sloping to level lands (clays); level to depressional lands (loamy clays); level to depressional lands (muck soils); coastal beaches; and tidal flats.

Sunlight (intensity and duration)

- Plants are usually described as being “light demanding” or “shade tolerant”.
- Light, as it affects species choices for re-vegetation has two components:
  - intensity (full sun, partial sun, partial shade and full shade); and
  - duration (number of hours of light per day of a given intensity.
- Most plants purchased commercially will come with instructions on light requirements, and the GOERT propagation guidelines provide advice on the 76 species described there.
- At the landscape level, light intensity and duration will be determined by general topography (north vs south aspects) and existing vegetation (if any).
- At the site level (residential and institutional properties) light will be affected by many more complex, small-scale influences – micro-topography, structures (buildings, houses, fences), trees and hedges (both on the subject and adjacent properties)
- A full seasonal assessment of sunlight patterns should be a pre-requisite to a re-vegetation plan.
- See **“Table 3. Selected Native Species for Different Light Conditions”.**

Natural Disturbance regimes

- The BEC system is based on the concept of “climatic climax” or the theoretical end point of ecological succession under the regional climate regime.
- However other factors beside regional climate will affect climax, the main influence being the natural disturbance regime (NDRs).
- There are three principle NDRs in forested landscapes: Gap-Driven, Disturbance-Driven and Fire-Maintained.
- Garry oak meadow ecosystems fall within the Fire Maintained category.
- Fire-maintained ecosystems are multi-aged, savannah-like forests and grasslands in mediterranian (temperate) and monsoonal (tropical) climates whose structure and composition have been determined by regular (<10 year return), low severity, generally anthropogenic, ground fire.
- Fire exclusion policies world-wide have led to serious degradation, loss of biodiversity, and catastrophic wildfires in these ecosystems.
- It will probably be impossible to successfully rehabilitate GOEs at the landscape level without the reintroduction of regular, low-intensity fire. At the site level, maintenance will require annual physical defoliation.

Species/provenance selection and climate change

- The decades from the mid-18C to the late 19C were period of unusual climate stability. During that period foresters, biologists and and other natural resource managers established comprehensive protocols governing the use of species and species provenances in re-vegetation activities.
- Since the early 1990s it has become apparent that we have not taken the reduction of greenhouse gases seriously enough, and we are now well into global climate change.
- Resource management strategies must now include both carbon reduction and climate change adaptation.

Species/Provenance Selection and Climate Change (cont.)

- A 2006 paper (Hammond and Wang[1]) attempted to estimate changes in BEC zone distribution as climate change progresses. They reached the following conclusions:

  - low elevation, southern systems will expand their ranges at the expense of alpine, sub-alpine and boreal systems;

  - warm, dry forests will have the greatest increase both in elevation and latitude; and

  - CDF is likely to expand (335%) at the expense (primarily) of CWH. The climate for Garry Oak Ecosystems could spread up the coastal lowlands as far as the Skeena and Nass valleys.

[1] Potential effects of climate change on ecosystem and tree species distribution in British Columbia. Ecology, Vol. 87, pp 2773-2786.

Species/Provenance Selection and Climate Change (cont.)

- A paper this year (Wang, Campbell, O'Neill & Aitken[2]) re-visits the 2006 analysis of climate data. It concludes that the climate envelopes that maintain BEC zones have migrated, on average across all zones, by 23% from their 1970 boundaries – a degree of change that was not anticipated to occur before the late 2020s.
- The Ministry of Forests is now considering a reforestation strategy of "assisted migration" in response to climate change and has struck a working group to consider changes to the current species and provenance protocols.
- A precautionary approach probably means that there will be no significant changes to provincial forest management protocols in the near future.
- A more liberal approach to provenance may be beneficial in highly-fragmented ecosystems like GOEs to prevent genetic isolation between fragments

[2]Projecting future distributions of ecosystem climate niches: uncertainties and management applications. Forest Ecology and management, Vol. 279, pp 128-140.