

## Reference Sites in Ecological Restoration

### *What is a reference site?*

A reference site in the broadest sense is an ecosystem that serves as a model for restoring another ecosystem. This implies that:

- (1) The reference site has more intact, autogenic ecological processes, higher functionality, more complex structure, and greater diversity than the system to be restored.
- (2) The biophysical site conditions of the reference site closely match those of the restoration site.

Reference sites may be less disturbed portions of the matrix in close proximity to the restoration site or more distant relatively intact sites occupying similar topographic positions in the landscape when the restoration site is an isolated fragment. Usually more than one reference site is considered when seeking guidance in the design of a restoration. These can be multiple sites that are similar in successional stage, structure, and function which provide more defined design parameters. They can also be multiple sites that represent a chronosequence of succession typical for a specific ecosystem. This is especially important when the site to be restored is highly disturbed and lacks any biological legacy.

### *How to identify a reference site*

In order to secure a good reference site the restoration site itself must be thoroughly assessed. The key restoration site attributes that help narrow the search for reference sites are:

- (1) Position in the watershed
- (2) Topography
- (3) Remnant/existing native vegetation
- (4) Soils esp. relatively undisturbed soils associate with native vegetation
- (5) Biological legacies such as snags, stumps, peat deposits, any indicator of the pre-disturbance ecosystem
- (6) Invasive/nonnative species which are indicative of particular site conditions

Once the restoration site has been assessed the search for reference sites should begin within the watershed containing the site. If no good quality reference sites are found there then neighboring watersheds with similar characteristics should be assessed. The search can be narrowed by looking only at areas with similar elevation, aspect and topographic position. Topographic maps and aerial photographs are especially useful in the search process. When

potential reference sites are found they should be surveyed on foot and put through a preliminary assessment to find the most relevant reference sites. Once one or a series of reference sites have been identified as strong models for the restoration site they need to be assessed to gather the information necessary to guide the restoration design.

#### *How to use a reference site*

The reference sites need to be inventoried and assessed to provide specific information regarding their species composition, structure, and function. When there is a luxury of time reference sites can be monitored over a span of several growing seasons so that ecological processes can be parameterized. Most restoration projects however are accomplished on an abbreviated timescale of 2-3 years based on economic, political, and logistical constraints. In this situation the reference sites must be quickly assessed for the most critical elements needed to inform the restoration design:

- (1) Plant community species composition, distribution, and structure with emphasis on the dominant species and successional stage.
- (2) Soils with emphasis on soil texture, the quantity/quality of the organic component, and evidence of hydric soils
- (3) Hydrology, how water moves through the site and where it is wettest and driest
- (4) Evidence of natural disturbance such as flooding, fire, wind throw, etc.
- (5) Key structural and topographic features such as pit/mounds, wet depressions, snags, beaver dams, swales, etc.

The first three elements, plants, soils, and hydrology form the foundation of the restoration design. In the simplest terms there must be sufficient moisture and nutrients in the soils to support the intended plant community. The reference site indicates plant species composition and the site conditions that select for and support those species. This of course leans towards oversimplification. The site conditions that support the seedling establishment of dominant species differ significantly from that of the mature plant community. Site conditions at seedling establishment typically are more stressful with less moisture and nutrients. As the plant community matures nutrient capture and moisture retention increase. This is where identifying a chronosequence of reference sites is helpful. Early successional sites would offer the best guidance for design when the restoration site is highly disturbed and the major limitations are abiotic. Mid to later seral sites provide models for degraded sites with some remnant native plant community, esp. when invasive species have inhibited, reversed, or altered the natural successional trajectory.

### *The limits of reference sites*

Reference sites are not simply templates from which species are 'cut & pasted' onto the restoration site. Reference sites are informative and suggestive rather than prescriptive. When focusing on the re-establishment of ecosystem processes techniques, materials, and species may be used that do not conform to observed 'natural' ecosystem structure and processes at reference sites.

When faced with highly degraded and/or novel restoration sites reference sites may have limited utility. A common strategy in restoration is to 'jumpstart' or 'bootstrap' ecosystem processes when a site is too degraded and/or isolated to undergo autogenic recovery when the inhibitory disturbance is removed or mediated. This 'bootstrapping' usually involves a subsidy of organic matter to the site in sufficient quantities to provide nutrients and promote moisture retention for successful plant establishment. The goal is to achieve rapid vegetative cover to stop soil degradation and initiate ecosystem processes. Early successional reference sites may not have direct applicability in this situation since early seral ecosystems develop organic soils gradually, have short-lived colonizing species, and are vulnerable to disturbance. Often a mid-seral reference site is used as a model for species composition when 'bootstrapping' in attempt to 'jump' ahead to a more stable, resilient, and productive plant community

Novel restoration sites are ones where the site conditions are so drastically altered from the original conditions that restoring the original system is unrealistic. Filled ravines, open pit mines, capped landfills, mountain top removals, dredge spoils islands, flooded excavations, and abandoned urban lots are examples of novel restoration sites. Reference sites still have relevance and utility in informing the design of novel sites. However the emphasis shifts toward matching the existing physical restoration site conditions to a reference ecosystem that has similar soils and hydrology and then using the plant species adapted to those conditions at the restoration site. For example introducing lowland Puget Sound prairie species to a capped landfill because the soils and hydrology are similar even though prairie vegetation is untypical of the immediate watershed.