Habitat features: Creating structural complexity in restoration

Ecological basis

The primary emphasis on establishing native plant communities in ecological restoration tends to overshadow other critical ecosystem processes that support and even drive ecosystem development, stability, and resilience. There is often an unstated “Field of Dreams” assumption regarding introducing non-plant species to restoration sites; if you build it, they will come. However, non-plant species are also dispersal limited, especially in fragmented landscapes. They can also be limited, as plants are, by lack of suitable habitat to carry out critical life processes even if they are able to disperse to the site. When it comes to habitat ‘charismatic megafauna’ tend to be the first to come to mind; how do we attract the cute vertebrates? Equally important though is the need to create habitat for the less cuddly species, most importantly invertebrates and microbes that serve as critical links in the decomposition of organic matter and cycling of nutrients. The glamorous and not-so-glamorous non-plant species also serve to disperse seed and spores, pollinate flowers, control pathogens, balance population dynamics through predation & parasitism, and serve as fuel in the food chain among other valuable services.

Non-plant community composition also changes over time as ecosystems undergo succession. This change in non-plant species composition can be driven by change in plant species composition and plant species composition can change due to the effects of non-plant species, especially population density dependent pathogenic/parasitic species. As with utilizing plants in a successional strategy to initiate ecosystem processes, a successional strategy should also be considered when designing the habitat features for a restoration site. Early successional non-plant species tend to be invertebrates, fungi, and microbes dispersed by wind, water, and migratory vertebrates, especially birds. These early colonizers typically initiate organic matter decomposition which is crucial to forming biologically active soils that retain and cycle nutrients through the ecosystem. In order for these colonizers to survive and reproduce there needs to be:

(1) Species-appropriate organic substrate
(2) Species-appropriate microclimatic conditions that moderate temperature and conserve moisture

Fortunately invertebrates, fungi, bacteria, and assorted microbes mostly have simple requirements; organic matter in a state of decomposition amenable to their specific feeding strategy, and a temperature and moisture regime to support their life processes. In ‘natural’ succession post-disturbance biological legacies, remnant organic matter (living or dead), serve both as refugia for pre-disturbance species and new habitat for non-plant (and plant) colonizers. For example, after flooding partially buried woody debris and deposits of highly organic muck serve as 'hot spots' of biological activity supporting decomposers and their predators (and their predator's predators, ad infinitum) as well as microsites for plant re-establishment. These biological legacies also serve as feeding, breeding, and resting habitat for vertebrates such as birds, small mammals, and herps which disperse spores, seeds, cysts, and larval invertebrates to the recovering site. Abiotic features such as coarse mineral deposits from gravel to boulders and protected openings in mineral substrates like cracks, holes, depressions, caves, and fissures retain moisture, moderate temperature and tend to trap fine particulates and organic matter. This structural 'roughness' offers microsites for initiating soil development even when lacking organic substrate with chemoautotrophic microbes, algae, and lichens colonizing and breaking down mineral surfaces. As with biological legacies such as debris piles and snags, rock piles, fissures, caves, etc. become nesting/resting/hibernation sites for non-plant species that leave behind seed, spores, cysts, and other propagules along with nutrient rich fecal matter to serve as substrate for decomposers.

Design & creation

Intentionally creating biotic and abiotic features to attract and support dispersers of propagules and organic matter is a commonly employed strategy in restoration. The key concepts in designing and creating viable habitat structures are:

- **Moisture retention**
- **Temperature moderation** - All species have an optimal moisture and temperature range to support life functions. Knowledge of those requirements informs the design parameters for a box built for bat roosting as well as to how deep to bury a log in the soil for isopods.
- **Surface area** - Increased surface area supports more life per unit volume and higher levels of nutrient and energy exchange. Surface area can be created through scarification, pitting, gouging, layering, orientation, size and quantity of materials.
- **Interface** - Interface, the contact between surfaces particularly when the interfacing surfaces are dissimilar, provides the actual living space for organisms. Macroinvertebrates, fungi, bacterial, herps and other organisms rely on woody debris and rocks partially buried in the soil or in contact with the soil surface for living space.

Habitat features can be species specific and typically are designed to support a single life process for that species; breeding, rearing, nesting, roosting, feeding, sunning, bathing, hiding, hibernation, and so on. Species and life process specific designs abound in wildlife resource websites and texts. The critical factors to consider in any of these designs are:

(1) **Can they get there?** A wood duck nesting box does not serve its intended function if the wood ducks can not get there to discover and use it.
(2) **Is it in the right place?** A bat roosting box in the middle of the forest is likely to not be used by bats which prefer to roost in south facing areas along the edge of water bodies and open areas where they feed.

Less specialized habitat features tend to host multiple species and trophic levels which interact and exert a more direct impact on the reestablishment of ecosystem processes, particularly recruitment of new species, decomposition, moisture retention, and nutrient retention and cycling. A rock pile partially buried in the soil potentially provides habitat for a whole host of organisms; lichen, fungi, bacteria, algae, mosses, herps, mammals, plants, birds, and macroinvertebrates. Some simple structures that create complexity are:

- Rock piles
- Partially buried logs
- Brush piles
- Boulders
- Shallow basins
- Snags
- Partially buried pipes
- Knocked over trees/nurse logs

The critical elements for these habitat features are;

(1) **Soil contact** - wicking and trapping of moisture at points of contact between the materials and the soil is what creates viable habitat space for macroinvertebrates, fungi, microbes and herps.
(2) **Structural complexity** - variety in the size, materials, decompositional state, shape, and orientation creates more unique niches to be filled and utilized.
(3) **Interiority** - interiority comes about when the conditions inside a habitat structure differ significantly from ambient conditions outside the structure. This is a function of surface area to volume ratio. The smaller the rock pile the more likely it is to be just as cold or hot inside as it is outside. A larger rock pile attenuates temperature extremes.

Installation

Species-specific habitat features usually have well defined design parameters and methods of installation which can be found in numerous texts and websites. General principals to keep in mind when installing species specific habitat features are:

- **Time installation to occur immediately prior to or at the beginning of the season of the intended use.** Putting up a nesting box for a specific species after its nesting season leaves the box open to being taken over by non-target species.
- **Don't destroy habitat to create habitat.** Minimize impacts. Removing a vigorous patch of native shrubs to install a raptor perch is contrary to your goals; the shrubs are habitat for raptor prey.
- **Avoid overhandling of materials.** Many animal species are averse to human scent.
- **Don't crowd.** Know the territorial space required for your target species. Nesting boxes may go unused if too close together.
- **Install adjacent to known presence of target species.** The habitat feature will be easier to find if located closer to areas where your target species has been sighted and/or is known to travel.
- **Install before planting.** It is easier to plant around a raptor perch or a bat box on a pole than to try to avoid damaging new plantings during an installation.

Less specialized habitat features intended for multiple species require less strategizing however there are a few basic guidelines:

- **Install during the dry season.** Disturbing soil when it's saturated causes compaction and erosion
- **Install before planting.** Some habitat features such as rock piles or nurse logs require heavy equipment to move through the site.
- **Don't create refuges for invasives.** Design and install the habitat feature so that it precludes invasive establishment or easily allows invasive control. Brush piles are great habitat for birds however birds will transport invasive seeds and deposit them below the brush pile. This then necessitates removing the brush pile to control the invasives.
- **Remove invasives thoroughly before installation.** Don't leave roots & rhizomes behind! Create an invasive-free buffer around the habitat feature. If herbicides are to be used, allow for the herbicide to dissipate before installing the structure.
- **Site habitat feature close to potential source of colonizers.** The closer it is to remnant habitat the more likely it will attract or trap dispersing organisms and their propagules.
- **Plant around the habitat feature.** Installing plants around your structure enhances its habitat quality through shading, organic matter deposition,

and protection from predation. The plants benefit from the structure promoting soil moisture retention and biologically active soils that release nutrients.