The strategic use of plant forms and spacing for ecological restoration

Ecological background

Often the installation of plants in restoration is perceived narrowly in terms of choosing the native species most likely to survive the given site conditions. While this is a primary concern the choices made in the forms, size, and spacing of those plants not only effect their establishment but also alter the abiotic and biotic site conditions. Abiotic deficiencies limiting plant establishment and biotic limitations from invasive competitors are addressed initially during site preparation. Post-installation however the developing plant community becomes the primary force in preserving and reinforcing resource capture and retention. These emerging ecological processes resulting from revegetation can not only be anticipated but also intentionally manipulated by varying the form, size, and spacing of plants to counter specific functional losses as well as promote self-reinforcing resource capture and retention.

Plant forms & size

In restoration, the **form** of a plant refers to the growth state of an individual (seedling, sapling, juvenile, mature) and the way it is delivered (bare root, containerized, balled in burlap, grow bags, etc.) or the type of propagule (seed, division, plug, cutting, stake, rhizome, runner, bulb, corm, etc.) available to introduce that species to the site. **Size** refers typically to the height of individual plants though the volume of the growing container is commonly used as a correlate to plant height. Heights of bare root nursery stock come typically in a range on 6" increments; plug (<6"), 6-12", 12-18", 18-24", and 24-36". Woody plants taller than 36" typically are either in containers or offered balled in burlap (B/B). Container plants come in increments of gallons; ½, 1, 2, 3, 5, 10, 15, and sometimes 20. The height of containerized plants tends to increase with the container volume and varies according to species, nursery care, time since potting up, etc. **Stock type** describes how long a bare root plant stock has been growing in a seed bed and how long it has been since transplanted out of the seed bed. Typically this is represented by a two number system; 1-0, 2-0, 1-1, 2-1, etc. The first number is the number of growing seasons in the seed bed; the second number is how many growing seasons since transplanted into a transplant bed. Each stock type has certain advantages and disadvantages which break down to a matter of cost vs. maturity.

Size	**Cost**	**Installation difficulty**	**Aftercare**	**Ecological impact**	**Invasive resistance**
Small	cheap	easy/fast	lower	gradual	lower
Large	higher	more work/slower	higher	more immediate	greater
Form					
Seed/bulb/corm	cheap/free	easy/fast	low	gradual	low
Live stakes	cheap/free	easy/fast	low	fast	good
Bare root	cheap	depends on size	moderate/high	depends on size	depends on size
Container	moderate/high	more work/slower	moderate/high	depends on size	depends on size
B/B	high/expensive	more work/slower	moderate/high	immediate	good

Table 1: Advantages and challenges of plant forms and sizes

Choosing plant species, forms, and sizes for a restoration site requires balancing cost, installation effort, and ecological results. As summarized in Table 1, in general the less mature and smaller the plant, the easier it is to purchase, install, and maintain. However less mature and smaller plants generally are slow to establish, contribute gradually over time to resource capture and retention, and are less competitive with invasive species at the outset. Larger, more mature plants are relatively expensive, more difficult to install and maintain yet contribute more immediately to resource capture and retention and compete with invasives more readily. Each species however poses exceptions to this generalization. Some small, less mature forms of a rapidly growing species would establish faster than a more mature, slower growing species. A red alder (*Alnus rubra*) recruited from seed will within 3 years or less grow to exceed a 1 m tall Douglas-fir (*Pseudotsuga menziesii*) planted from a container. Knowing the relative growth rates and means of reproduction/spread of your chosen species is crucial to making strategic choices in plant material. Table 2 summarizes growth rate for broadly defined functional groups of plants and the resulting ecological effects in terms of shading, soil retention, and organic matter outputs, all relevant to addressing degraded site conditions.

Functional group	Growth rate	Shade provided	Erosion resistance	Litter output
Deciduous trees	faster	seasonal	strong	Heavy
Coniferous trees	slower	year round	strong	Light
Deciduous shrubs	faster	seasonal	moderate/strong	Can be substantial
Evergreen groundcovers	slower	year round	moderate/strong	Light
Herbaceous groundcovers	faster	mostly seasonal	strong to weak	Can be substantial
Wetland emergents	faster	mostly seasonal	strong to weak	Can be substantial

Table 2: Functional group growth rate and form vs. cover and primary production

Plant spacing

The basic approach to plant spacing is to space according to size at maturity. Each species fills physical space over time at a particular growth rate towards its mature size and **habit** (structural form). Variability from species to species in mature size and habit is obvious and species can be grouped according to growth rate, size at maturity, and habit. There also can be great variability within a species due to site conditions; generally the more stressful the conditions the smaller and slower growing the plant. **In restoration practice the standard has been to plant groundcovers on 0.25-1 m centers, shrubs at 1-2 m centers, and trees at 2-4 m centers.** This is not written in stone! Other factors essential to consider in plant spacing are:

- Growth form of each species (rhizomatous? Clump forming? Single stem?)
- Anticipated reoccurrence of invasives
- Recommended methods of follow-up invasive control
- Desired aesthetic effects
- Resistance to recurrent disturbances
- Anticipated mortality
- Resource retention goals
- Cost!
- Plant availability

- Relative growth rates of species mix
- Plant distribution (clumped? Even spacing? Drifts?)

Strategizing

Utilizing plants in a strategic manner means that species, forms, and sizes are being chosen to address a specific design problem. Let's take the example, slope erosion. The first step in determining which species and their forms to chose is answering the question: **Which plant attributes best resolve the design problem?** In the case of slope erosion, deeply rooting, fast growing perennials and mat forming, clonally spreading perennials. Next question is: **Which species that have the desired attributes will successfully establish with the given site conditions after site preparation?** The eroded slope has sandy loam soils and a southerly aspect. Which native species with the desired attributes will thrive in these conditions? Those that tolerate full sun and well drained soils, Nootka rose (*Rosa nutkana*) and American dunegrass (*Leymus mollis*) for example. The next question is: **Are these species appropriate to the intended target community?** If the eroded slope in part of dune/bluff community then yes, if it is in a former gravel mine in a riparian forest community then *L. mollis* is not an appropriate choice and other species should be considered.

Once the species have been selected that best address the specific problem given the site constraints, then forms, size, and planting density can be selected as outlined above. There is a 'sweet spot' that balances rapid revegetation, cost, and maintenance for each project site. The challenge is to manipulate densities, form/size, and plant growth rate to achieve stated benchmarks within the given constraints. Table 3 below demonstrates the trade-offs between density, form/size, and the growth rate of the species selected that can be made in order to achieve the stated benchmark.

BENCHMARK	DENSITY	FORM/SIZE	SPECIES GROWTH RATE
80% shrub cover in 3 years	2 m	5 gal containers	Fast/moderate
	1 m	5 gal containers	Moderate/slow
	2 m	12-18" bare root/1-1	fast
	1 m	12-18" bare root/1-1	Moderate/slow
	1 m	6-12" bare root/1-0	Moderate/fast
	0.5 m	6-12" bare root/1-0	Slow/moderate

Table 3: Alternative strategies for achieving benchmark