PCA
Property Care
ASSOCIATION

Guidance Note

Revegetation following Invasive Non-Native Weed Management

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1. BACKGROUND

The management of non-native invasive plants such as Japanese Knotweed, Himalayan balsam, Giant hogweed etc., which usually involves either herbicide treatment or excavation or a combination of both, typically results in exposed ground/bare soil. ***Incorporating revegetation into an Invasive Species Management plan is therefore considered essential*** to avoid the risk of:

- erosion, especially along streams and rivers
- unsightly areas, particularly in public areas e.g. parks/playing fields
- undesirable plants moving in, especially other invasive species, and
- a failure to restore biodiversity

Also, a carefully thought out revegetation strategy, e.g. creation of a good sward, could help to inhibit or supress any regrowth of invasive species from remaining root/rhizome fragments and/or seed.

Weed-infested sites alter the structure, organisation and function of ecosystems. **The development of a healthy plant community is an important part of sustainable invasive weed management** and can meet other objectives e.g.; appearance of the site, wildlife habitat development, maintenance of ecological function. In practical terms re-vegetation to develop a healthy plant community can occur either *naturally*, when desired vegetation cover and propagules are adequate, or through *management* of the site.

The re-vegetation process involves several steps including: salvaging resources, protecting key plant community components, appropriate site preparation, reducing weed interference, designing a proper seed mix, and seeding with the most effective method based on your situation. Establishment should be monitored and proper vegetation management that favours the seeded species will be necessary. This includes short and long-term maintenance of the desired plant community and deterring future establishment and growth of invasive weeds.

The scale of the revegetation can vary from small patches, <100m^2 in area, to substantial areas measurable in hectares. In the case of the former, this can be easily built into the Invasive Species Management Plan. For example, after treating Japanese Knotweed or Giant Hogweed with glyphosate which will also kill the majority of vegetation in that patch, a basic seed mix, pre-prepared and kept in the van, can be put into a broadcaster and spread over the patches to encourage controlled regrowth. ***This type of revegetation can be undertaken by the weed control specialist simply and effectively with minimum additional cost.***

However, the planning and execution of larger re-vegetation programmes should involve expertise from many sources (Ecologists etc.) and the following guidance is given solely *to help invasive weed specialists recognise the many factors which need to be considered to achieve a successful outcome on each site*. Specialist suppliers in the plant management and horticultural sectors should be consulted for specific guidance and advice on seed mixes, nutrients etc. Consultant ecologists may be found via ***Ref. 1***. The charity Plantlife offers free guidance on all aspects of wild flower ecology ***(www.plantlife.org.uk).***

2. PLANNING & PREPARATION FOR REVEGETATION

Re-vegetation strategies should be thought of in four key stages: Design, Site preparation, Implementation and Site maintenance.

Design: Clear objectives need to be established for 'ecological' weed management that will result in a healthy plant community that is relatively invasion-resistant while meeting other land use objectives, such as wildlife habitat development or recreation land maintenance etc.

A healthy, weed-resistant plant community consists of a diverse group of species that maximize niche occupation. Diverse communities capture a large proportion of the resources in the system, which pre-empts utilization by weeds. They also optimize ecosystem functions and processes which in turn regulates plant community stability. 'Ecological' weed management programs must therefore focus on establishing and maintaining desired functional groups/plant species to establish the highest likelihood of sustainable weed management.

One approach to consider enhancing the functional diversity of plant communities is to use native herbs and shrubs rather than grasses. These are better able to compete with invasive non-native weeds (many of which grow rapidly to capture light early in the season) since they are within the same functional plant group. Maintaining native functional plant communities, such as shallow-and deep-rooted species, should be *a primary objective* of land managers for ecosystem maintenance and invasion resistance. Such ecological knowledge will be important in formulating objectives that direct the establishment of desired plant communities for sustainable land management.

Revegetation goal statements may include:

- Establish plant cover to facilitate recreational use (e.g. community parkland)
- Quickly re-establish vegetation to minimize erosion* (e.g. riverbank)
- Establish species that can minimize invasion or reestablishment by the same or other invasive non-native weeds; and/or
- Restore plant biodiversity (e.g. pocket park, nature reserve)

*on bare slopes revegetation often requires a combination approach with mulch, netting, or erosion control blankets for wind and water protection and to assist germination and establishment (see below)

Revegetation is not necessary at every degraded or disturbed site. Often, adequate desired vegetation is present or immediately adjacent that can assist a *natural recovery process*. As a result, natural regeneration may sometimes be the best option.

However, on larger sites where invasive weed management has removed the seed bank of the problem species and will have done the same for most if not all other species, natural revegetation could take a long time during which there is the potential for undesirable opportunist species to become established.

Site preparation: There are measures that can be taken ahead of invasive species management, e.g. herbicide treatment or digging out the target species. These include making the most of the existing resource of soil and plants. Some, or all, of the following can be considered:

- put top soil to one side and store appropriately
- collect seed from the area to be managed, e.g. desirable species for re-establishment post management

- remove blocks of the existing native sod, set aside, and replace after the work is complete
- salvage individual or specimen plants for cultivation and re-planting
- remove or substantially reduce the seed bank of the invasive weed

Where possible, it is always desirable to protect the remnant native plants within the weed-infested site during weed management. This may be difficult to attain as the preferred choice of weed management may often involve broadcast herbicide treatments that injure or permanently damage native plants. However, site-specific methods may be used to protect remnant plants such as careful herbicide spot treatments, leaf wiping or stem injection (where possible). Protection of some species within weed-infested sites can be vital to ecosystem stability and to long-term weed management success given that these species have already demonstrated competitive resilience in the presence of invasive weeds. Also, the protection of remaining plants is beneficial as this component is very difficult and expensive to re-establish relative to a grass component.

The following sections covering the areas of **Implementation** and **Site Maintenance** provide help and advice on the successful establishment of self-sustaining plant communities. In all cases, long term maintenance that favours the seeded species will be necessary. See below.

3. IMPLEMENTATION AND SITE MAINTENANCE

Natural area rehabilitation

When designing a seed mix for natural areas, including wetlands, the local landscape or nearby wetlands are good references for species selection based on each species' frequency and distribution.

The local landscape also provides an ecologically important and economical source of seed and plants to enhance revegetation. Germination success and plant hardiness may be increased because the seeds are local and well adapted to local environmental conditions. Further, the local landscape can provide species that may not be commercially readily available.

However, depending on current year growing conditions, sometimes collections of such local seed can have low viability. To offset this disadvantage the collection of large quantities of seed is required. This may increase collection time and costs although sometimes these costs can be controlled through volunteer labour. For further details see ***Ref. 2 & 3a***.

Revegetation of roadsides

Roadsides often have low fertility and depleted biological activity. This reduces the establishment and persistence of vegetation and can limit long-term revegetation success. To increase long-term success, healthy topsoil additions will serve as a source of nutrients, plant propagules and mycorrhizal inoculum and should be implemented when topsoil is unfit or missing from roadsides. Prior to treatment, plan a topsoil salvage and replacement operation using a donor source of roadside topsoil which is healthy and relatively invasive weed-free.

Following completion of roadside treatment, application of seed may or may not be necessary depending on the amount of desired plant propagules in the replaced topsoil. Delayed application of seed is not advised given the likelihood of rapid invasive non-native weed establishment along roadsides. When selecting plant materials consider species' relevance (i.e. native plants), their ability to adapt to the site, rapidly establish and self-perpetuate. Whenever practical, select and distribute native species for ecological reasons including an ability to cope with occasional increases in salinity due to use of salt in winter. Use short-growing grasses where possible as these can significantly reduce roadside mowing maintenance.

Dominant, prevalent (i.e. species typically occurring most abundantly) and species having special visual importance within the community should be included. Implementing integrated roadside vegetation management practices that favour the seeded species will be essential to long-term roadside revegetation success (see ***Ref. 3b***).

Revegetation to reduce risk of soil erosion

Rapid establishment is critical when selecting species to minimize soil erosion. Sloped landscapes and drainages should be seeded with soil stabilizing species to minimize erosion. Quick establishing annuals can provide immediate protection, but only for a year. Grasses and grass-like plants that reproduce through rhizomes are ideal for erosion control because of the extensive network of underground stems that stabilize soil.

Species that can minimize invasive non-native weed invasion or re-establishment

An effective seed mix should avoid niche overlap and contain a functional diversity of aggressive, quick-establishing plants, often with grasses that can occupy available niches. A diverse, well-established plant community will better resist weed invasion than a less diverse community. A high functional diversity of native plants is most likely to resist invasion and establishment. It is highly recommended that the native plant component of a plant community be protected and enhanced to resist weeds and maintain ecosystem stability. Once removed, this critical feature of plant communities is very difficult and expensive to re-establish. Careful weed management activities should aim to preserve valued native plant species.

Plant communities that are weed resistant require the ability to effectively and completely utilise resources temporally and spatially. Designing a seed mix that includes the combination of shallow- and deep-rooted species that grow early and late in the year will maximize niche occupation in time and soil profile space. Cool-season species initiate growth in late winter. In early spring these species use soil resources available in the upper soil profile and begin seed production in early summer.

Incorporating deep, tap-rooted shrubs in the seed mix or as young plants can further use resources from the lower soil profile throughout the growing season. Further, the addition of shrubs can enhance establishment of understory species by increasing water availability, infiltration rates and water holding capacities, and soil fertility and seedbanks. Shrubs also increase establishment of understory species by concentrating nutrients and decreasing understory temperatures that reduce evapotranspiration and increase nutrient cycling.

Site characteristics

Soil texture - You can roughly estimate the approximate amount of sand, silt and clay in soil by a simple method called manual texturing. The feel of the moist sample when rubbed between the thumb and forefinger determines the texture. If the soil sample is predominantly sand, it will feel very coarse and gritty. If it is predominantly silt, it will feel smooth or slippery to the touch. And if it is predominantly clay, it will feel sticky and fine in texture.

pH – The optimal pH range for most plants is between 5.5 and 7.0. However, many plants have adapted to thrive at pH values outside this range so it will always be important to establish the actual pH value for each site before selecting suitable species.

Salinity - High salt levels in the soil, especially chlorides, typically in coastal areas or roadsides (de-icing salt) can lead to particular challenges for plant re-colonisation.

Organic content – Typically, fertile soils contain from 1-5 % organic matter but it is also important to understand what proportion of soil carbon is made up from e.g. plant debris, humic/fumic acids, carbohydrates etc. The soil analysis report should provide as much detail as possible to help optimise revegetation strategies.

Precipitation, soil moisture, temperature, and elevation - Seeded species should be adapted to the precipitation and moisture level of the soil, temperature zone and elevation of the site.

Seed Collection and Introduction

Wildland seed, or seeds collected from the local landscape, are locally adapted and can have excellent establishment and long-term resiliency. But large quantities must be collected to offset the disadvantage of low seed viability. Custom collections are commercially available for large projects when site-specific seed is desired or when preferred species are not available in the marketplace. Seeds can be collected for immediate use or increased through cultivation, or "grown-out", to meet future needs.

Species that perform well within high soil moisture or riparian/wetland sites, such as stream bottoms or wet meadows that are sub-irrigated for at least a portion of each growing season, include numerous native species.

Native sedges & rushes/bulrushes are grass-like species used extensively in riparian and wetland revegetation projects because of aggressive root systems and wildlife habitat value.

Numerous native grasses, herbs, and shrubs are available for wetland / riparian revegetation projects. Planting greenhouse-grown plugs has shown higher establishment over seeding or collections of wildlings (plugs collected from wild populations). Plugs should be planted during summer when heat, light, and water are greatest. Broadcast seeding of wetland / riparian areas are used primarily as a method to increase overall species diversity. Following seed broadcast, for these wetland species, avoid covering seeds with soil as light and heat is needed for proper germination.

Seedling establishment

Seedling establishment is the most critical phase of revegetation. However, variation in soil, site exposure and climate can hinder this vulnerable phase. Further, failures in establishment are usually caused by a combination of factors. The most important are insufficient soil moisture or intense weed competition. Early revegetation success is more a function of moisture than of soil nutrient availability and weed interference is a primary constraint to successful establishment of native plants. Enhancing establishment can increase revegetation success.

Avenues for enhanced establishment include:

a) Using species adapted to local site conditions and using high-quality, certified seed;

b) Reducing or eliminating weed interference through herbicide treatments or early season cover crops that work to reduce the availability of soil nitrogen;

c) Inoculate seed, nursery stock, locally collected or salvaged legumes with *Rhizobium* bacteria to ensure maximum nitrogen fixation that can contribute to a healthy nitrogen cycle. This will improve phosphorus uptake, water transport, drought tolerance, resistance to pathogens and increase offspring quality contributing to long-term reproductive success and fitness of seeded species;

d) Heightening seedling survival by preparing a seedbed before and after broadcast seeding and lightly packing the soil (consider the application of hydromulch following broadcast seeding to enhance establishment) or placing seeds at the proper depth using a no-till drill if site is accessible to equipment. Avoid covering wetland / riparian species with soil as light is needed for proper germination;

e) Planting plugs to establish wetland / riparian grass-like species;

f) Use a land imprinter to form depressions in the soil to retain moisture at the surface longer than smooth soil surfaces. Soil depressions also create more favourable conditions for soil coverage of broadcast seeds (i.e. trapping wind-blown particles, sloughing of sides of depressions);

g) Increase seeding rates to:
    - Enhance desired species competitive interaction with invasive non-native weeds;
    - Increase the likelihood that an adequate amount of broadcast seeds find safe sites; and
    - Compensate for lack of understanding of plant-site relationships

h) Adding small amounts of water temporarily and 'as required' to encourage establishment but only in cases when natural precipitation has proven inadequate (an initial watering is recommended after transplanting during the growing season). Be aware that frequent watering can likely result in poor plant adaptation i.e. only short-term success followed by failure once supplemental water is withdrawn. Consider using commercial water holding polymers and other similar products during the establishment period to provide young plants with moisture;

i) Deferring grazing through fencing or herding until vegetation reaches establishment, usually after two growing seasons. If palatable, slow-maturing shrubs are recovering, do not graze until the shrubs are able to produce viable seeds.

Treating seeds may also enhance the establishment phase of revegetation. Consider the following seed treatments as appropriate:

j) Seed priming – initiates the germination process, allows it to continue to a certain point, then suspends it. The primed seed is then ready to continue germination in the field when conditions are favourable;

k) Seed fungicide – protects seeds from numerous soil-borne organisms. Consider this treatment in mesic (moderately moist) environments;

l) Stratification – cold stratification "fools" seeds into germination mode by mimicking the winter environmental conditions the seeds would be subject to in the natural environment. Many upland species require cold stratification. Most wetland /riparian seeds should be cold stratified in a proper medium, usually distilled water and sphagnum moss, for 30 days at 0 – 2 °C.

m) Seed scarification – some seeds with considerable dormancy benefit from acid or mechanized scarification of the seed coat. This greatly improves germination;

n) Seed coating – seeds coated with growth regulators, such as cytokinin, and diatomaceous earth can improve seedling establishment.

Providing an immediate mulch cover can protect soil and seeds from erosion by wind and water, conserve soil moisture from the effects of wind and sun, and moderate soil temperatures. The following selected mulches can enhance germination and establishment:

- Hay mulch - native certified weed-free hay is a beneficial mulch, containing a small amount of nitrogen from leaves, flowers, and seed heads. Native hay can also contain seeds of native plants if harvested with mature seeds present. To avoid losing mulch to the wind, it can be crimped into the soil if still pliable to avoid excessive breakage, trampled short-term by livestock, or an organic tackifier (a glue that breaks-down into natural by-products) can be applied;

- Cover or companion crops – fast growing, non-persisting annuals or short-lived native perennials, are seeded with perennial grasses to protect soil and the young, slower establishing perennial seeded grasses.
- Hydromulch / hydraulic mulch – virgin wood fibres or recycled paper are mixed into a water slurry and sprayed onto the ground surface. Particularly useful in conjunction with quick establishing vegetation or following broadcast seeding;
- Erosion control blankets – usually composed of woven organic material, such as straw or coconut fibre.

These blankets are designed so seeds germinate and stems grow through and above the mat. As the fabric ages, it becomes incorporated into the soil and decomposes. The ability of the mat to control erosion is replaced by established vegetation. Mats are expensive, but highly effective and sometimes the only choice for steep slopes (3:1 and greater) that need long-term protection.

Overall, successful establishment is dependent on the co-occurrence of many features/factors:

- Seed placement in favourable microsites;
- Precipitation adequate to stimulate germination;
- Recurrent precipitation for seedling establishment;
- Low levels of herbivory; and
- Absence of competition during establishment

Seeding methods

The most common seeding methods are drilling, broadcasting, imprinting, hay mulch seeding, hydroseeding, and plugging. Sprigging is another seeding method often used in saline-alkaline soils with rhizomes as plant propagules. The best seeding method will depend on site accessibility and terrain and seedbed characteristics.

Broadcast seeding
Broadcast seeding is a commonly used method, frequently utilized on steep, rocky, or remote sites that are not accessible to equipment. Small areas can be broadcast seeded with a hand spreader while commercial spreaders could seed larger areas. Seedbed preparation is recommended prior to broadcast seeding. On accessible sites, dragging small chains or harrowing / raking will roughen and loosen the soil surface. This roughening will create seed safe sites, ensuring proper seed placement for enhanced germination and establishment. Roughen the soil surface again following seeding and lightly roll or pack the soil, if possible.

If seedbed preparation is not feasible, doubling or tripling the broadcast seeding rate based upon drill seeding or ploughed ground, will be necessary so an adequate amount of seed find safe sites for proper germination. Consider introducing short-term livestock trampling where “hoof-action” can work to push the seeds into the soil.

Broadcast seeding of wetland / riparian species is not a primary means of revegetation, but as a method to increase overall species diversity. When broadcast seeding, do not cover or pack the seeds with soil as wetland plant seeds need plenty of heat and light for proper germination. Consider planting plugs of wetland / riparian species as the primary revegetation method to ensure long-term success.

Hydroseeding

Hydroseeding is a form of broadcast seeding where the seeds are dispersed in a liquid under pressure. The hydroseeder consists of a water tanker with a special pump and agitation device to apply the seed under pressure in the water that may include fertilizer, mulch, or other additives. Hydroseeding is usually the only practical method for seeding slopes 3:1 or steeper and the addition of mulch can enhance soil protection.

Hay mulch seeding

Hay mulch seeding involves spreading seed-containing hay over a prepared seedbed. Hay mulch seeding is a useful method as the hay works both as a seeding technique and as mulch that prevents soil erosion, conserves moisture, and moderates soil temperatures. Hay should be cut when the important species are at an optimum stage of maturity and spread during the optimum seeding time for the dominant or preferred species within the hay. Spreading hay by hand is practical on small sites, but chopper-shredders can shred and apply the hay on larger sites. To avoid loss to wind, hay could be crimped into the soil using machinery, pushed into the soil using the "hoof-action" of short-term livestock trampling, or held with an organic tackifier.

"Island" Planting

Planting nursery stock with selection based on the environmental, physical, and chemical characteristics of the site can also be considered to complement reseeding and increase overall revegetation success through rapid plant establishment. Planting mature stock circumvents the susceptible and critical seed germination and establishment stages. Purchasing stock can be costly, so incorporation in a revegetation project can sometimes have a higher initial cost. However, planting fewer individuals in "islands" where a central, established stand of plants can reproduce and eventually spread throughout the area can reduce costs. Keep in mind that "islands" will usually take a long time to impact the site overall. Planting should occur during periods of early spring or late autumn dormancy. For larger areas, "islands" can be seeded by using a seed drill. Over time, the seeded strips spread into the unseeded areas. Careful monitoring for weeds in the unseeded areas will be important until vegetation is established.

Plugging

Establishing wetland / riparian plants from seed is usually difficult because site hydrology must be carefully controlled and precise amounts of heat, light, and water is needed. Planting plugs circumvents the susceptible and critical seed germination and establishment stages. Greenhouse-grown plugs of wetland /riparian grasses, grass-like species, herbs, and shrubs should be planted at 450 – 600 mm centres or about 5000 plugs per hectare. Over time, the plants will spread out into the unplanted areas.

Spring planting is generally preferred over autumn planting since spring planted plugs will have a longer establishment period. Autumn planting may result in lower establishment success because of the shorter growing season and frost damage.

Calculate seeding rate

Depending on the species, seeding rates are typically 200 – 500 viable seeds/m^2. The actual rates vary depending on many factors such as weed interference, known differences in seedling vigour, site conditions, and components of a mix.

When a species is used as a component of a mix, adjust to percent of mix desired. Increasing seeding rates will add expense to a project but may work to ensure establishment and long-term revegetation success.

Follow-up management

In all cases, re-vegetation of sites following invasive weed control or removal is only likely to meet the initial objectives if the works are followed by several years of monitoring and management (as required). This may include: establishing or varying grazing pressures to encourage optimum diversity, follow-up spot treatments with herbicides, or targeted 'pulling' or digging-out of undesirable plants before they set seed, re-seeding or repeat broadcasting of the original or a modified seed mix, etc. Whilst the actual interventions that may be required are unknowable at the outset it is prudent to ensure the client is aware of the long-term commitment required, especially on large sites.

4. REFERENCES

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3. Plantlife:

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