City of Austin

Invasive Species Management Plan

Field Resources

Section 1
Top 24 Invasive Species in Austin

Species	Common Name	Overall	Alert	Impact	Invasiveness	Distribution	Documentation
Arundo donax	Giant reed	High	no	A	B	A	3.84
Eichhornia crassipes	Common water hyacinth	High	no	A	A	A	3.3
Hydrilla verticillata	Hydrilla	High	no	A	A	A	3.38
Ligustrum lucidum	Glossy privet	High	no	A	A	A	3.41
Melia azedarach	Chinaberry tree	High	no	A	B	A	2.69
Phyllostachys aurea	Golden bamboo	High	no	A	B	A	2.61
Pueraria montana var. lobata	Kudzu	High	no*	A	B	A	2.8
Rapistrum rugosum	Bastard cabbage	High	no	A	B	A	2.92
Sorghum halepense	Johnson grass	High	no	A	A	A	3
Tamarix ramosissima	Salt cedar	High	no	A	B	A	3.15
Ailanthus altissima	Tree of heaven	Moderate	no	B	B	A	3.08
Broussonetia papyrifera	Paper mulberry	Moderate	no	B	B	A	2.16
Centaurea melitensis	Malta star-thistle	Moderate	no	B	A	A	3.15
Colocasia esculenta	Elephant ears	Moderate	no	B	A	A	2.5
Cynodon dactylon	Bermudagrass	Moderate[1]	no	B	B	A	2.7
Firmiana simplex	Chinese parasoltree	Moderate	no	B	B	A	2
Lonicera japonica	Japanese honeysuckle	Moderate	no	B	B	A	3
Macfadyena unguis-cati	Catclawvine	Moderate	no	B	A	A	2.15
Nandina domestica	Sacred bamboo	Moderate	no	C	A	A	2.8
Pistacia chinensis	Chinese pistache	Moderate	no	B	B	A	1.6
Pyracantha coccinea	Scarlet firethorn	Moderate	no	C	B	A	2.15
Triadica sebifera	Chinese tallow	Moderate	no	B	B	A	3.15
Cyrtomium falcatum	Japanese netvein hollyfern	Low*	no	B	C	A	1.14
Bothriochloa ischaemum	Bluestem, King Ranch	Unknown	no	B	B	U	2

[1, *] see notes section for description

Rating

1. High – These species have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. Most are widely distributed ecologically.

2. Moderate – These species have substantial and apparent—but generally not severe—ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal, though establishment is generally dependent upon ecological disturbance. Ecological amplitude and distribution may range from limited to widespread.

3. Low – These species are invasive but their ecological impacts are minor on a statewide level or there was not enough information to justify a higher score. Their reproductive biology and other attributes result in low to moderate rates of invasiveness. Ecological amplitude and distribution are generally limited, but these species may be locally persistent and problematic.

4. Unknown - Evaluated but lack sufficient information to assign a rating or the available information indicates that the species does not have significant impacts at the present time.

Alert

Specific combinations of section scores that indicate significant potential for invading new ecosystems triggers an Alert designation so that land managers may watch for range expansions. Y = Yes, N = No

Impact

The Impact section assess the cumulative impact (e.g., over a period of several decades) of the species on the wildlands where it typically occurs in Texas or other places with similar environmental conditions. The assessment applies to impacts within the area currently occupied by the species within Texas (to the extent that this area is known). This section is arranged hierarchically: species that significantly alter ecosystem processes and system-wide parameters (Q1.1) almost always have significant impacts on plant community composition, structure, and interactions (Q1.2), and higher trophic levels and interactions (Q1.3).

Invasiveness

The Invasiveness assessment rates a species' potential to establish, spread, and increase in abundance in wildlands.

Distribution

The Ecological Amplitude section rates the number and proportion of different ecological types invaded. The "ecological amplitude" of the species indicates the diversity of ecological types invaded. The "distribution" addresses the extent of infestation in any given ecological type. This is a percentage of the ecological type's total number of occurrences (frequency) that has been invaded, not as an estimate of the average percent cover occupied by the species within each ecological type.

Documentation

Assessed as highest level of documentation for each criterion.

4 = Reviewed scientific publications

3 = Other published material (reports or other non-peer-reviewed documents)

2 = Observational (unpublished information confirmed by a professional in the field)

1 = Anecdotal (unconfirmed information)

0 = No information

Notes

[1] While Bermudagrass has an overall rating of being moderately invasive, it is recognized that Bermudagrass is useful in certain applications as a turf grass for ball fields and high traffic areas. It is recommended that improved hybrids of Bermuda grass such as Tifgreen, Tifdwarf, Tifway and Santa Ana be used in those applications as these hybrid varieties do not produce seed, whereas common bermudagrass produces seeds that remain viable in soil for at least 2 years.

[*] See weed risk assessment notes

Source: Warner et al. 2003

Section 2
Management Techniques

Best Management Practices

Best Management Practices for control of problematic vegetation are based on Integrated Pest Management (IPM) principles that will maintain the desired site conditions using a combination of available methods, while minimizing risk to people, property and the environment. Managers use current information on pest life cycles and control methods to select the least toxic control method that is effective and economical. IPM plans identify current infestations, set action thresholds for treatment, and prescribe control and prevention methods.

These principles include:

- Maintenance activities will use Integrated Pest Management methods that are supported by scientific research as increasing effectiveness and minimizing risk. All departments will combine physical, biological and chemical controls, whenever practical.
- Correctly identify the plant target pest species and understand the biology to determine what control practices may be most appropriate.
- Determine the threshold levels at which a pest becomes a problem, a safety hazard or obstacle to determine if and when control is needed and which control method is best suited to the situation.
- Determine the most vulnerable stages of the life cycle of the pest to determine when the target pest is most susceptible to treatment for effective control.
- Use the most effective and economical combination of methods to achieve the desired level of management while minimizing threats to water quality.
- Most vegetation management will be accomplished using individual plant treatments.
- The primary exception to this will be prescribed burning, which may be applied as a long-term, large-scale vegetation management tool, rather than an individual plant treatment.

The determination of a treatment prescription and application method will take into consideration the situation, location and surrounding vegetation. Adjustments will be made, as needed, to accommodate special circumstances related to the facility location and adjacent environmental conditions.

When a Best Management Practices option indicates that pesticide applications are appropriate, control treatments will favor effective low volume applications of the least toxic and effective pesticides.

Elements and Tasks of an Invasive Plant Management Program

1. Make a plan.

- Base your planned treatments on stated objectives and the best information, then schedule and acquire resources that support your plan.
- Devise both a short- and long-term plan including both specific infestation treatment regimes and ideas for how these fit into a general land management plan.
- Maps of infestation locations and priority ratings of invasive species will assist the planning process.

• An eradication and rehabilitation program for specific invasive plant infestations usually requires several years of treatments and many more years of surveillance.
• Newer infestations and smaller plants require much less time than extensive and dense infestations.

2. Prevent entry and spread.

• Educate users of your land about the invasive plants that pose major threats and how to prevent their entry and spread.
• Establish sanitation procedures to prevent the spread of invasives. Require all individuals to minimize invasive plant spread by following these procedures when working in or near infested lands:
  o Inspect the site and infestation before operations.
  o Avoid driving vehicles, mowers, all-terrain vehicles or spray equipment through infestations in seed or fruit.
  o Brush and wipe all seeds and debris from clothes, boots, socks, and personal protective equipment.
  o Clean motorized equipment, especially the undercarriage and tire surfaces.
  o Cover loads or bag cut invasive plants before transport.
• Monitor burn pile areas for new seedlings.
• Be careful not to disturb areas where there is a high probability of invasion.
• Map invasive plant locations and sites at risk, and denote treatments and their desired outcomes. You must positively identify those invasive plants that are present and those poised to enter from adjacent lands, determine their locations and abundance, and record this information.
• Monitor the locations through repeated visits and record progress or the lack of it.
• Employ the search, survey, inventory, monitor and surveillance method.

3. Eradicate, control or contain, and monitor results.

• Rehabilitate, restore or reclaim treated lands.
• Establish native or noninvasive plants.
• Promote invasion resistance by encouraging native diversity and ecosystem function.
• Effective treatment schemes for rehabilitation use an integrated approach that combines treatments in an appropriate sequence and at crucial times.

Effective Treatments for Integrated Management of Nonnative Invasive Plants

A successful invasive plant management program usually involves a combination of treatment methods based on these and other available tools and resources:

1. Cultural Methods
2. Manual Methods
3. Mechanical Methods
4. Biological Methods
5. Chemical Methods
6. Strategic Control Method: Combination of Control Methods
7. Rehabilitation, Restoration, and Reclamation

Many methods are available to manage invasive plants and rehabilitate sites and more are being developed. A successful plan of attack depends on integrated management that considers all methods relative to the site and its invaders. These methods will be presented in greater detail.

1. Cultural Methods

Proper cultural practices are essential in establishing healthy landscapes and can often help to maintain their resistance to pest problems. Several cultural practices, including prescribed burning and water-level manipulation, can reduce or control invasive plant populations. However, such practices may also have undesirable impacts to soils, animal habitat and native species, so care in planning and enactment must be exercised.

Prescribed Burning

Prescribed Burning is a tool used for many facets of vegetation management. With regards to pest management, it may be used to manage both herbaceous and woody species. It provides the opportunity to accomplish vegetation management over a relatively large area at relatively low cost and target multiple species and individuals with minimal threats to non-target plant and animal species. When applied appropriately, prescribed burning can help significantly improve the effectiveness of other more intensive and costly treatments. Prescribed fire also avoids threats to water quality associated with use of chemical herbicides.

Prescribed burning is generally planned to target species that are susceptible to fire and do not exhibit re-sprouting behavior. Some re-sprouting species can be kept in check by prescribed fire when conducted on a recurring basis. Low intensity burns can be used to treat susceptible young or small-statured woody plants. High intensity burns may also be conducted to increase burn effectiveness on larger woody plants and King Ranch bluestem. For most herbaceous species, the timing of application of this practice must coincide with a particular phenological stage of the target species life cycle. For instance, when thistle plants are in the rosette stage or before annual species flower and produce seed. Winter or early spring burns are most effective for invasive forb species and King Ranch bluestem is best managed by summer fire.

Water-Level Manipulation

Flooding or drawdowns can reduce invasive plant species in aquatic and wetland habitats but is usually not effective as a stand-alone treatment. This method is species and site specific. For effective outcomes, managers must first understand the biology of both invasive and native plants in the treatment area. Both processes can spread floating seeds of invasives and make habitats more vulnerable to nonnative plant establishment. Lowered water levels in spring and summer can also facilitate herbicide applications in wetlands.

Prescribed Grazing

Prescribed grazing is an approach that relies on cattle, sheep, goats or horses to reduce infestations. Grazing is a potential control treatment when the invasive is palatable and the invasive plant is not poisonous to the animal. Cattle and horses are used for many herbaceous invasive plants, while sheep

and goats will feed on invasive woody plants as well. The animal species is important, as is the breed, the best being those breeds that are larger and can handle difficult grazing and browsing conditions. Grazers must be managed so that they do not selectively target palatable native species. Additionally, it is important to note that the animals would be used as a tool for vegetation management. A strict accounting of animal numbers, incoming and outgoing, must be provided so that animals are not allowed to remain on the property following the completion of work, becoming a management issue themselves.

Mulching

Mulches and other ground coverings are often employed during the installation and restoration of landscapes as well as their ongoing maintenance. They are utilized for a variety of reasons. Mulches suppress weeds, help to retain moisture around plants, reduce possible erosion, and provide visual enhancement. Use of landscape mulches in vegetative buffers should take into account any possible impacts to the buffer as well as nearby waterways. These impacts may include:

- Inadvertent introduction of non-native weeds to the site.
- Leaching of substances such as tannins or nutrients from the mulch into nearby waterways.
- Migration of mulch material into waterways.

Choices of mulches should take these concerns into account. Mulching in areas that are below typical high water lines is discouraged in any vegetative buffers. Seeding of cover crops for erosion control is allowed in buffer zones.

Solarization

Soil solarization uses polyethylene sheeting to cover low growing, cultivated, mowed or chopped invasive infestations and trap solar energy to heat the soil and space under the sheeting to kill and suppress invasive plants. At least 2 years of summer cover are needed to suppress most invasives plants by 90 percent. Other plants are killed by this method—it is not selective. Black sheeting is more effective than clear sheeting because it blocks needed sunlight, and, at an extra cost, is available with UV blockers to greatly extend the useful life of sheets to more than one growing season. The method is useful as a first treatment for relatively small areas and where herbicides cannot be used. Summer is the most effective season, and use on wet soils increases control. After removal, the bare soil is open for reinvasion and should be quickly revegetated or otherwise protected.

2. Manual Methods

Manual methods include hand pulling as well as use of a wide array of tools for cutting, chopping, wrenching and girdling invasive plants. Manual methods are generally used on woody invasive plants when they are small. Eradication is only possible when the root crown or roots that can resprout are completely extracted and seedlings are pulled or eliminated following seed germination. Because it is difficult and even impossible to extract all of the shallow roots, stolons, and rhizomes of many mature invasives, resprouting will usually occur. When this occurs, chemical treatment is usually required.

3. Mechanical Methods

Mechanical methods usually involve top removal or uprooting of individual plants. This method may be accomplished using hand tools, chain saws or heavy equipment. These methods can complement and increase the efficiency of herbicide treatments, followed by revegetation with desirable plants. Some equipment, with appropriate attachments, can prepare the site for seeding and tree planting. Most important is using the appropriate size equipment to meet job requirements and minimize damage to soils and streams. Timely follow-up with other control methods is essential, because disturbance of the soil creates favorable conditions for regrowth from seeds and root fragments. Mechanical removal with heavy equipment may be appropriate in natural areas. However, care should be taken and the use of heavy equipment should be limited or eliminated, in particularly sensitive areas (e.g. near streams or karst features).

Mechanical treatments will be applied in a manner that minimizes ground disturbance. Methods will be limited to those that allow selection of individual plants. These include use of hand tools, chain saws, and tractor or skid steer mounted devices such as tree shears and others. Less discriminating treatments such as chaining and root plowing will be avoided. Exceptions may be considered on a case-by-case basis.

Skid-Steer Loaders

Tracks attached to the tires of the loader help traction and access to difficult terrain. Skid loaders are easily transported, highly maneuverable, and capable of lift and tilt, which gives this machine, if equipped with appropriate attachments, potential for other invasive plant removal tasks in dense infestations. However, track driven equipment can cause a high level of soil disturbance and should be used with care, and where possible, managers should opt for wheeled equipment.

Mulchers

Mulchers are increasingly preferred for reducing both standing invasive and native woody plants in dense infestations. Mulching machines are best for nonselective situations where the cost of selective control is prohibitive. Mulching machines are land-clearing tools that can cut through dense stands of nonnative plants, reducing them to small pieces of woody debris. After a mulched area has dried and regrowth occurs, prescribed burning can be used to reduce the surface mass, while herbicides can be more efficiently applied to the resprouts.

Bulldozers

Bulldozers (or tracked tractors) are made in a range of sizes and have found use in large-scale invasive plant reclamation projects tackling extensive woody infestation, although smaller tractors and implements are used. The amount of soil disturbance and compaction is considerable with bulldozers, varying by equipment size, soil moisture, number of passes, stand density, and tree/shrub size. The substantial soil damage caused by bulldozers should be an important consideration when weighing the benefits of using such equipment against the drawbacks.

4. Biological Control Methods

Biological control of plants uses living organisms to weaken, kill, or stop seed production of the targeted plant. The most common agents in bio-control programs are insects and pathogens. Uses of nematodes and mites are under study.

5. Chemical Methods

When other techniques are not sufficient, herbicide can offer an alternative. Effective herbicide applications can kill roots without exposing soil, though herbicide toxicity to non-target species and persistence, activity and mobility in soil or water must be considered. Exposed soil is susceptible to reinvasion and erosion. For successful herbicide treatments:

- Select the least toxic herbicide that is effective for the target species and appropriate for the landscape. Also consider soil mobility, activity in soil and half-life. See White 2007.
- Follow application and mixing requirements prescribed on the label and use the most directed application method that will be effective.
- Choose the optimum time for applications. Factors to consider include the condition and stage of growth of target species, and weather considerations (probability of rain following application, wind speed during application). Many herbicides are effective only when plants are actively growing, so periods of drought, cold or heat may render pesticides ineffective. Uptake of foliar application may be hindered when leaf stomata are closed due to high temperatures.
- Be patient. Allow herbicides to work for several months to a year before resorting to other treatment options or re-treating.

<u>Selecting an Effective Herbicide</u>

If a herbicide is not prohibited for use on a specific site then the broad category of non-crop areas even allows use in “non-used” lands and parks in urban and suburban environments. Some prescriptions for these other land types will also be given along with aquatic sites. Carefully read and study the herbicide label for information on specified areas of use, crops and prohibitions. It is not necessary for the target invasive plant to be listed on the label for permitted use if the label allows use for general weed control or control of broad categories, such as “annual weeds”,” perennial weeds” or ”woody species”. These more general uses are often discussed on the label under the heading of “non-crop areas”, “natural areas”, or “habitat management”. Additional sources of information on both effectiveness and toxicity include Material Safety Data Sheets (MSDS) that can be obtained from manufacturers and herbicide fact sheets. Fact sheets are prepared by third parties and may contain additional information not found on the label or MSDS sheet. Fact sheets, if used, should come from reputable sources.

<u>Adjuvants and Additives to Herbicide Spray Solutions</u>

Adjuvants are any product added to a spray solution to improve herbicide performance and effectiveness, including delivery, retention on foliage, and foliar or bark penetration. Adjuvants may be included as part of the commercial herbicide product or sold separately as an additive you must mix with the herbicide before application.

Choose an adjuvant, according to label recommendations, that is appropriate for your particular

application method and field conditions. Obtaining information about adjuvants and their effects can be difficult. MSDS sheets often the best source of information. Be aware that adjuvants may have more serious or long lasting environmental effects than the active ingredient of the herbicide, especially on aquatic organisms.

Another common additive used by professionals is a marking dye, which makes it easier to determine which areas have been sprayed and which still need treatment. Dyes marketed for this purpose will fade after a period of sunlight exposure.

Water Quality Protection

Water quality is an important environmental issue in relation to pesticide use. The strategies for reducing or preventing water contamination by these products are largely based on common sense. When applying pesticides, the applicator should read the product labels and use the lowest effective rate listed on the label for any one application. Calibrate equipment to deliver herbicides according to label recommendations and keep records of the amount of product applied. An applicator should NEVER "double the rate for better results" and NEVER deviate from strict label application rates.

The key to minimizing impact is reducing the levels of possible pollutants that enter the system. Factors determining the potential for ground water and surface water contamination include tendency for the pesticide to attach to soil particles or organic matter, solubility in water, rate of degradation and volatility. Soil is a common pathway to groundwater and soil characteristics, along with the chemical's inherent mobility, determine the rate at which chemicals move through the soil. Soils with high clay or organic-matter content are more likely to bind herbicide molecules, tying up the material while it is decomposed by microorganisms or other degradation processes. To minimize contamination due to runoff, do not apply products within 48 hours of expected heavy rainfall.

Pesticide drift can be controlled by spraying only on calm days, using lower pressure, larger droplet size and drift control additives in the spray solution to reduce spray drift. These precautions should be taken to reduce spray drift on all occasions. More detail on managing spray drift is given in the following section of this plan. The use of broadcast spray methods should be minimized in favor of more directed application methods.

One potential source of water contamination is the disposal of unused herbicide, product containers and rinse water. Prepare only the amount recommended for the area to be treated to prevent having unused herbicide at the end of an application. Rinse all empty containers, regardless of their type, three times before disposal. Do not dispose of container rinse water where it may flow into a waterway.

Instead, dispose of rinse water by application on the treated area. Dispose of the product containers according to label directions.

Selective Herbicide Applications

The best approach is usually selective applications to target plants while avoiding or minimizing

application to desirable plants. The selective methods described below are directed foliar sprays and wipes, basal sprays and wipes, stem injection, cut-treat, and soil spots.

Directed Foliar Sprays and Wipes

Directed foliar sprays are herbicide-water-adjuvant solutions aimed at target plant foliage to wet all leaves, applied by either low- or high-volume sprayers. Herbicide application by directed foliar spray is one of the most cost-effective methods for treating many types of herbaceous and woody invasive plant species. With this method, herbicide mixtures are applied to the foliage and especially the growing tips of woody plants, or to completely cover all leaves. Foliar sprays can be applied whenever leaves are present but, for woody plant control, are usually most effective from midsummer to late fall.

Winter and spring applications are also effective in controlling some species and are often required to prevent seed formation.

Selective treatment is possible because the applicator can direct the spray towards target plants and away from desirable plants. The addition of a spray shield to the end of the wand confines spray to the target. Another safeguard is to only use foliar-active herbicides, because directed sprays of soil-active herbicides can damage or kill surrounding plants when their roots are within the treatment zone. Never use herbicides with soil activity to treat invasive plants under desirable trees or shrubs that are susceptible to the herbicide. If non-target foliage is accidently sprayed, clip off the foliage to prevent uptake.

Low-volume foliar sprays using spray tips and spraying pressures of 20 to 30 pounds per square inch can ensure productivity and limit drift. Wind must be minimal (less than 10 miles per hour) and used by the applicator to facilitate upper crown coverage. Low wind can be dangerous because it is variable and unpredictable, wind speeds of 5-10 mph is optimal.

Directed foliar sprays can be applied in higher volumes by using spray wands attached by hoses to vehicle-mounted spraying systems that have much larger herbicide tank capacities. The high-volume directed foliar spray is the most efficient approach to large infestations of multiple invasive species where there are few non-target plants.

Handheld weed wicks and rollers apply ultra-low volumes by wiping the herbicide mix onto the target leaf surfaces or bark; the herbicide mixture is contained in the handle. Most wick systems have limited use and durability in forest and field situations, but are useful when the applicator needs to avoid applying herbicide to rare or protected plants. Vehicle mounted wipe bars can be used to selectively target large areas of taller target species (e.g.- Johnsongrass) with minimal impacts to shorter desirable species.

Basal Sprays and Wipes

Basal sprays are herbicide-oil-penetrant mixtures sprayed on the lower portion of woody stems. The sprays are usually applied with a backpack sprayer or wick applicator. Avoid spray contact with desirable

trees or heavy use within their root zone. The herbicide must be an oil-soluble formulation and mixed with a special basal oil product, penetrating oil, diesel fuel, fuel oil, mineral oil, vegetable oil with a penetrant, or blends of these ingredients.

The most effective time period in most of the South for a basal spray and streamline is June through September, while winter treatments are easier when leaves do not block access and spray. After treating with a basal spray, wait at least 2 years before disturbing aboveground plant material, because herbicide activity within plant roots can continue for an extended period.

Stem Injection

Stem injection (including hack-and-squirt) involves the use of mechanical herbicide injectors or the application of herbicide concentrate or herbicide-water mixtures into downward incision cuts spaced around woody stems and often made by a hatchet or machete. Tree injection is a selective method of controlling larger trees, shrubs and vines with minimum damage to surrounding plants. Injection treatments are sometimes not as effective in controlling multiple-stemmed species compared to the faster basal bark treatments, but may be easier in remote or rough terrain where a backpack sprayer might be impractical or cumbersome. Incisions should be spaced around the stem, deep enough to penetrate the bark and inner cambium, slightly into the wood. Do not make multiple cuts directly above or below each other because this will inhibit movement of the herbicide within the stem. A complete girdle or frill of the stem is not needed or desirable.

Cut-Treat or Cut-Stump

Cut-treat involves applying herbicide concentrates, herbicide-water or herbicide-penetrant mixtures to the outer circumference of freshly cut stumps or the entire top surface of cut stems. Applications are made with a spray bottle, squeeze bottle, backpack sprayer, wick or paint brush. Freshly cut stems and stumps can be treated with herbicide mixtures to prevent resprouting and to kill roots. It is critical that the cut is made as low as possible to the ground, and that the stem is treated immediately after the cut is made. To minimize deactivation of the herbicide in the cut-treat method, remove sawdust from stumps before treatment. For stumps over 3 inches in diameter, completely wet the outer edge with the herbicide or herbicide mixture. Make certain that the solution thoroughly covers the wood next to the bark of the stump. Completely wet the tops of smaller stumps and all cut stems in a clump. Note that some herbicide labels advise treating the outer portion of the stump down to the ground.

Broadcast Herbicide Applications

Broadcast application of pesticides will be avoided. However, in rare cases in which broadcast application is deemed appropriated, chemicals should be selected that have low-non target toxicity, low potential for movement and a short half life in the environment. The Texas Agricultural Extension has developed a list of recommended chemicals for broadcast application with these characteristics.

6. Strategic Control Method: Combination of Control Methods

The most appropriate, effective and safest control of a target pest is a strategic combination of several of the control methods outlined above, integrating herbicides into the available management methods.

The combination of various manual, mechanical, and chemical methods is often the Best Management Practice for cost-effective and environmentally safe management. All options involving chemical control methods will be in strict compliance with product label requirements.

The proposed use of chemical controls in the following instances must be reviewed and approved by the City of Austin IPM Coordinator prior to their use:

- The proposed use of pesticides within 50' of surface water resources (standing water)
- The proposed use of pesticides within 150' of a cave, sinkhole, and/or other recharge features (Edwards Aquifer recharge zone). When chemicals are to be used in close proximity to caves, within or near sinkholes or waterways the most precise methodologies will be used to minimize any and all overspray or drips (Gleason and Taffinder 2007).

7. Rehabilitation, Restoration, and Reclamation

Once invasive species are removed, plants and animals can recover. However, natural recovery processes can be overwhelmed by invasive species and restoration is required. Although restoration efforts have common elements, each area is unique. Work must be guided by site-specific considerations and analysis. However, some generalizations can be made. When soil is disturbed, and especially if it is left bare, it must be revegetated with appropriate species to prevent soil loss and reinvasion. Below is a discussion of some of the factors to consider in a restoration project, followed by a generalized protocol for rapid revegetation of an upland site.

The goal of restoration is to restore ecosystem process, not simply to replace components. Ecosystem processes allow natural systems to repair themselves and to remain relatively stable. The primary processes of concern to a manager are hydrology, nutrient cycling and energy capture. In practice, the assessment and repair of these processes begins with the soil. In the process of treating and removing invasive species, the soil may be disturbed and left bare. In some cases, compaction reduction activities (raking, tilling, disking, ripping) and organic soil amendments may be needed to restore soil to a useful state. In all cases, soil should be protected. Revegetation with appropriate native species provides permanent protection, but in some cases temporary soil protection measures such as mulch may be needed before the site can be revegetated.

Generalized revegetation protocol:

- Address soil disturbance. Compacted soils will need to be loosened as appropriate prior to seed addition.
- Bare soils should be seeded or otherwise stabilized within 15 calendar days of disturbance to prevent erosion and reinvasion. Denuded areas that are inactive and will be exposed to rain for 30 days or more should also be temporarily stabilized, usually by planting seeds and establishing vegetation during favorable seasons in areas where vegetation can be established. In very flat, non-sensitive areas with favorable soils, stabilization may involve simply seeding. Mulching and/or sodding may be necessary on moderate to steep slopes, more erosive soils, or more sensitive areas.
- Appropriate native plant material should be added as seed, live plantings or a combination. Plants vary as to climatic adaptability, soil chemistry and plant growth characteristics (Berglund, 1978). USDA

Soil Service technical guides at the statewide level are excellent sources of information for seeding mixtures and planting prescriptions (Hynson et al., 1982). The U.S. Forest Service, State foresters and County Extension agents can also provide helpful suggestions (Kochenderfer, 1970). Locally, the Grow Green guides provide a useful resource. In addition to selecting a seeding mixture, the seeding rate must be determined so that adequate soil protection can be achieved without excess cost of overseeding. Berglund (1978) describes how to determine seeding rates in Seeding to Control Erosion along Forest Roads.

• In riparian areas, special consideration should be given to species' contributions to bank stability and water quality. Many species found in central and southwest Texas have been given draft stability ratings based on their contribution to bank stability (Nelle 2009), ranging from 1 (bare ground) to 10 (anchored rock). Ideally, riparian areas will be dominated by plants with stability ratings between 6 and 9. Stability ratings of 7 or higher are considered to be the minimum for acceptable bank stability. However, combinations of species, particularly woody species in association with grasses or sedges, can provide higher stabilities than reflected in individual species ratings (Nelle 2009). In addition to stability ratings, US Fish and Wildlife Service wetland indicator status should be considered. Riparian areas should contain a mix of obligate wetland (always occurs in wet areas), facultative wetland (frequently occur in wet areas) and facultative species (equally likely to occur in wet and non-wet areas), dependent on water availability. Perennial waterways can support a larger complement of obligate and facultative wetland species and intermittent waterways will require a higher proportion of facultative species. Regardless of the mix, it is important that all riparian areas contain some species from the facultative groups to provide stability as water availability fluctuates (S. Nelle pers. comm).
• On steep slopes, incorporate native woody plants planted in rows, cordons or wattles.
• Seed during optimum periods for establishment, preferably just prior to spring or fall rains (Larse 1971). Most forbs must be sown in the fall; grasses can be sown in either the spring or fall. Supplemental irrigation, if feasible, during the establishment phase will increase germination and survival. During non-growing seasons, apply temporary surface stabilization methods to control surface erosion. Possible methods include mulching (without seeding) and installation of commercially produced matting, blankets and wattles.
• Mulch as needed to hold seed, retard rainfall impact and preserve soil moisture (Larse 1971).
• Amend soil according to site specific conditions
• Protect seeded areas from grazing and vehicle damage until plants are well established
• Inspect all seeded areas for failures, and make necessary adjustments

Section 3
References

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Section 4
Summary of Approved Herbicides

Active Ingredient	Trade Name Examples	Ester (E) or Salt (S)	EPA Reg. No.	Ready-to-Use	Carriers	Aquatic Approved	Application						
							Foliar	Basal Bark	Stem Injection	Cut-Stump	Soil Spots	Girdle	Hack & Squirt
AMINOPYRALID	Milestone®	S	62719-519	N	Water	N	√						
BENEFIN + ORYZALIN	XL 2G®	S	70506-45	Y	-	N					√		
CLOPYRALID	Reclaim®	E	62719-83	N	Water	N	√						
	Transline®	E	62719-259	N	Water	N	√	√	√	√		√	√
COPPER-ETHANOLAMINE	Cutrine-Plus®	E	8959-10	N	Water	Y	√		√				
ENDOTHALL	Aquathol-K®	S	70506-176	N	Water	Y	√						
FLUAZIFOP	Fusilade II®	E	100-1084	N	Water	N	√		√	√			√
FLURIDONE	Sonar AS®	E	67690-4	N	Water	Y	√						
FLUROXYPYR	Vista®	E	62719-308	N	Water	N	√						
GLYPHOSATE	Accord®	E	62719-324	N	Water	Y	√						
	Aquamaster®	S	524-343	N	Water	Y	√						
	Enforcer Brush Killer®	S	62719-226	N	Water	N		√		√			
	Razor Pro®	S	228-366	N	Water	N	√		√	√			√
	Rodeo®	S	62719-324	N	Water	Y	√						
	Round-up®	S	524-539	N	Water	N	√						
	Round-up Pro®	S	524-475	N	Water	N	√		√	√			√
	Round-up Pro Dry®	S	524-505	N	Water	N	√		√	√			√
HEXAZINONE	Velpar L®	E	352-392	N	Water	N	√		√		√		
IMAZAMOX	Clearcast®	S	241-437	N	Water	Y	√	√	√	√		√	√
IMAZAPIC	Plateau®	S	241-365	N	WATER	N	√	√					
IMAZAPYR	Aresenal AC®	S	241-299	N	Water	N	√		√	√		√	√
	Arsenal PowerLine®	S	241-431	N	Water	N	√		√	√		√	√
	Habitat®	S	241-426	N	Water	Y	√			√		√	√
	Stalker®	S	241-398	N	Water	N	√	√	√	√		√	√
ISOXABEN	Gallery 75 DF®	E	62719-145	N	Water	N	√						
METASULFURON	Escort XP®	S	352-439	N	Water	N	√						
ORYZALIN	Surflan WDG®	E	70506-50	N	Water	N	√				√		
PELARGONIC ACID	Scythe®	E	53219-7	N	Water	N	√						
PICLORAM	Tordon K®	S	62719-17	N	Water	N	√						√
	Tordon 101®	S	62719-5	N	Water	N	√			√			
PICLORAM + 2,4-D	Pathway®	S	62719-31	Y	-	N			√	√			√
POTASSIUM SALTS OF FATTY ACIDS	Garden Safe Moss & Algae Killer®	E	59913-4	Y	Water	N	√						
SULFOSILFURON	Outrider®	E	524-500	N	Water	N	√			√			
TRICLOPYR	Garlon 3A®	S	62719-37	N	Water	Y	√			√		√	√
	Garlon 4®	E	62719-40	N	Oil	N	√	√		√			
	Green Light - Tough Brush Killer®	S	62719-226	N	Water	N	√			√			
	ORTHO Brush-B-Gon®	S	239-2491	N	Water	N	√	√		√			
	Pathfinder II®	E	62719-176	Y	Oil	N		√		√			
	Remedy RTU®	E	62719-176	Y	Oil	N		√		√			