Revegetating Landfills and Waste Containment Areas Fact Sheet

This Fact Sheet Discusses the Following:

- It is possible to plant on landfill surfaces
- Native plants are recommended when revegetating sites
- Technical factors to consider when revegetating
- References and additional resources

Keys to Success when Revegetating Landfill Surfaces:

- Ensure proper planning, design, and funding
- Provide adequate soil quality and depth
- Determine appropriate target habitat and native plant selection
- Allow for appropriate planting and establishment
- Conduct routine monitoring and management

Introduction

The U.S. Environmental Protection Agency (EPA) Office of Superfund Remediation and Technology Innovation (OSRTI) is developing a series of fact sheets on ecological restoration and revegetation of contaminated sites. Former landfills, abandoned dumps, mines, and other contaminated sites throughout the U.S. - once thought to be of limited or no value - are being reclaimed for a variety of productive uses. These new uses include revegetation of land where plants and animals can once again flourish. For example, as of 2005, thousands of acres of land on Brownfields, Superfund, and Resource Conservation and Recovery Act (RCRA) sites have been assessed or cleaned up and revegetated. In particular, more than 50 Superfund sites have been cleaned up and returned to ecological use. Aesthetic and final land use considerations are becoming more common during cover design. Some increasingly common end uses include parks, hiking trails, wildlife habitat, sports fields, and golf courses. This fact sheet provides information on revegetation of landfill surfaces for EPA site managers, consultants, and others interested in the revegetation of landfill surfaces.

Contaminated material may be left on the property in containment systems designed to protect people and the environment from exposure and prevent contaminant migration. In deciding how to support the revegetation of these sites, however, there are questions about whether it is appropriate to plant on the landfill surface. Grasses are typically used to help stabilize the landfill surface and prevent runoff, but shrubs and trees are selected less frequently because of concerns that the root systems could damage the surface. Based on the location of the containment area, site-specific approaches should be used and a general approach has been discussed in this fact sheet. Former landfills, abandoned dumps, mines, and other waste containment areas will be referred to as landfill surfaces throughout the fact sheet.

Is it Possible to Plant on Landfill Surfaces?

Yes, it is possible to plant trees, shrubs, and other types of vegetation on the containment system at many sites without affecting its integrity and protectiveness. In fact, many sites have been revegetated with a variety of plants on a containment system. For example, grains, wildflowers, and other carefully selected flora were planted at the Army Creek Landfill in Delaware to create a meadow to attract migratory birds (http://www.epa.gov/superfund/programs/recycle/success/casestud/armycsi.htm).

The primary concern in planting on landfill surfaces is ensuring the integrity of the containment system, particularly the potential for roots to penetrate and physically damage the cap, thereby creating entry points for water, or to open fissures in the protective barrier by excessive moisture reduction. However, ongoing research and a growing body of experience indicate that, if it is properly designed and implemented, the integrity of the landfill surface can be maintained while it supports a variety of plants. Root growth depends on the characteristics of the soil, and the presence of a clay liner or geomembrane influences its growth. Research at the Brookfield Sanitary Landfill in New York showed that roots, including taproots, grow laterally once they reach the clay cap. No significant damage to the clay cap was observed as a result (Robinson and Handel 1995). The key factors that affect the feasibility of planting on a containment system include the characteristics of the landfill surface (such as soil depth and soil quality), the desired plant habitat, and the physical setting of the site (for example, topography and climate).

Why Use Native Plants?

- Native plants provide a beautiful, hardy, low maintenance, and drought resistant landscape
- Native plants can develop into a self-sustaining ecosystem, eliminating the need for fertilizers, pesticides, and water

Can Native Plants be Used on a Landfill Surface?

Although a variety of plant species can be used on a landfill surface, native plants are recommended when possible. While each project is site-specific, plants are typically selected based on the design of the landfill surface, the role of the vegetative cover, the depth of plant roots, irrigation and drainage requirements, geographic and atmospheric conditions, long-term maintenance requirements, and costs to acquire and install materials and plants. A single species of grass has commonly been planted as a monoculture to control erosion of landfill surfaces, but the species

For more information on the design of landfill caps, please visit the following Web sites:

- http://www.epa.gov/ORD/NRMRL/pubs/600r02099/600R02099.pdf
- http://www.epa.gov/epaoswer/non-hw/muncpl/landfill/techman/subpartf.txt

may or may not be indigenous to the surrounding habitat and are more vulnerable to disturbance (Harper 1987). However, planting native species that have been selected over thousands of years in that area are best adapted to disturbances and climate change (Waugh 1994). Species diversity helps reduce disease dispersal or blights and encourages wider biological diversity in the restored habitat, making it more like a natural ecosystem, in turn reducing long-term operation and maintenance (O&M) and promoting a self-sustaining ecosystem (Handel et al 1994).

Even sites that currently support monocultures can be converted to diverse native plant communities through careful planning and monitoring. The site can be prepared for native seeding or planting by prescribed burning, using herbicide, or removing a thin layer of soil along with the monoculture vegetation. Native plants can even be seeded through existing cover with a no-till drill; periodic burning would also be beneficial in controlling the monoculture vegetation. For example, the Christian County Landfill was converted from a sparse monoculture with eroding areas to a thriving native prairie (http://www.epa.state.il.us/environmental-progress/v25/n1/abandoned-landfill.html).

A major consideration when selecting plants for a site is Executive Order (EO) 13148, which promotes use of native species on revegetated sites. EPA defines native plants as plants that have evolved over thousands of years in a specific region and that have adapted to the geography, hydrology, and climate (see http://www.epa.gov/greenacres/). Native plants found in the surrounding natural areas will have the most chance of success, require the least maintenance, and are the most cost-effective in the long term. Ideally, revegetation of a site will create natural conditions that encourage re-population by native animal

Native Plants – Ecological Values

- Native plants do not require fertilizers
- Native plants do not require pesticides
- Native plants require less water (no watering once established) than turf grass (lawns)
- Native plants provide shelter and food for wildlife
- Native plants are critical to a diverse number of pollinators
- Native plants reduce air pollution
- Native plants provide biodiversity and stewardship of our natural heritage
- Native plants save money
- Native plants can offer economic values (medicinal, herbals, landscaping and food)

For more information on plant types, please visit the following Web site: http://www.ciwmb.ca.gov/LEACentral/Closure/Revegetate/.

To identify the type of general land use in your area, please visit the following Web site: http://www.nrcs.usda.gov/technical/land/cover_use.html.

For examples of natural habitat restoration on landfills, please see page 63 of the following Web site: http://www.epa.gov/tio/tsp/download/dctechnical.pdf.

Native Plants - Ecosystem Integrity

- Native plants support a complex web of life, and provide a critical component to ensure balance in our ecosystems
- Only native plants can provide long-term sustainability of the landscape

Yet:

- more than 200 plants have become extinct since the early 1800's
- nearly 5,000 native plants are "at risk"
- one in ten plants face extinction

species and that are consistent with the surrounding land. Furthermore, using non-native plants located close to native plant environments could displace the native plants; therefore, it is important to check the invasive nature of the proposed plants (EO 13112). Plant succession may occur; for example, the original species planted may not survive due to predation or drought. However, local wildlife, such as birds, may aid in the dispersion of appropriate plant species and in the overall revegetation of the site (Robinson and Handel 1993).

Landfills in arid environments pose additional challenges because soil must be stabilized with sparse vegetation. A variety of options are available, however, to increase the likelihood of successful restoration in these areas, including adding compost blankets or other organic amendments to the soil to increase water-holding capacity and fertility, shaping the ground to collect and retain water, and using locally collected seeds of native species.

The species that are appropriate for local habitat conditions can be selected with support from EPA's regional Biological Technical Assistance Groups, EPA's Environmental Response Team (http://www.ert.org), the Natural Resources Conservation Service (NRCS) (http://www.nrcs.usda.gov), and local native plant societies, such as the following: http://michbotclub.org/links/native_plant_society.htm.

What Types of Plants Can be Used on a Landfill Surface?

Each project has site-specific considerations, and the plant types listed below are not applicable to every site.

- **Grasses and Wildflowers** are generally herbaceous and are limited to prairie-like habitats or appearances, with wildflowers providing a broad selection of plant heights, root depths, and aesthetic choices. Considerations when selecting these plants include the seeding cycle and whether they require re-seeding, as well as life span, resistance to invasive species, and root depth.

- **Shrubs** are woody perennials that range from several inches to several feet high. Considerations in selecting shrubs include their size when fully grown (and the resulting potential to obstruct gas vents, wells, or cap maintenance), root depths, irrigation requirements, and competition with other desired plants (such as saplings).

- **Trees** are the longest-lived plant group and can have the greatest influence on overall design of the vegetation. Considerations for selecting trees include root depths, size, irrigation requirements, competition with other vegetation, and debris.

What are the Key Considerations When Planting on Landfill Surfaces?

Each project is site-specific and depends on a variety of factors based on its individual requirements,including its location. There are eight distinct Level I eco-regions in the U.S., including Eastern Temperate Forests, Great Plains, and North American Deserts (http://www.epa.gov/wed/pages/ecoregions/na_eco.htm#Level%20I). Specific approaches for planting on landfill surfaces should be based on the particular eco-region. Information on planting in arid areas such as California can be found at http://www.ciwmb.ca.gov/LEACentral/closure/revegetate/. However, in general, the final cover (erosion or vegetative layer) should provide adequate soil depth to support the desired plant habitat to properly implement the revegetation of a site and help ensure survival. In addition, soil conditions and topographic features may be created that closely duplicate the surrounding soil types and geography. A revegetated site should duplicate the local native plant profile in terms of species selected and distribution of these species across the site. General factors to consider include:

- **Soil and Root Depth**. Soil and root depth are key determinants for whether and how a landfill surface can be revegetated. In general, the high density, low permeability, and poor aeration of the landfill surface provide an effective barrier to penetration by tree roots. Roots might penetrate a small distance into the landfill surface, but penetration through the entire landfill surface is prevented by the slow upward diffusion of landfill gases, which lowers the oxygen potential of the soil and can be toxic to plants (Flower et al 1981; Robinson and Handel 1995). Nonetheless, sufficient soil depth (18 to 24 inches optimum) is recommended to support the habitat selected. Several approaches can be taken in considering trees and shrubs with substantial root systems, such as building up berms or hillocks as areas for large vegetation. Simply providing a thicker erosion layer, even in small areas on the landfill, will improve the options for "naturalizing" the vegetation selected and the location of plants on the final landfill surface. Engineered soil and/or organic soil amendments, such as biosolids, can be used if sufficient amount of suitable soil is not available. Some examples of Superfund sites that used biosolids during restoration include Bunker Hill in Idaho; California Gulch in Leadville, Colorado; the Jasper County site in Joplin, Missouri; Palmerton Zinc in Palmerton, Pennsylvania; and the Lead Remediation Project in East St. Louis, Illinois. Another approach to support planting saplings in relatively shallow soil layers involves trimming the taproot, which encourages lateral root development. The lateral roots, up to three times the tree's canopy width, will provide ample anchorage and nutrient absorption for the tree. Indigenous tree species that lack a taproot also can be selected.

The following link provides additional information on tree planting and soil depth at the Fresh Kills Landfill in New York: http://www.sierraclub.org/sierra/200511/tr2.asp

For additional information on land application of biosolids, please visit the following Web sites:

- http://www.epa.gov/owm/mtb/land_application.pdf
- http://faculty.washington.edu/clh/newwet/summary.pdf

- **Soil Quality and Treatment**. The greatest cause of failure in revegetation, particularly with trees, is poor soil quality through factors such as soil compaction, water logging, drought, and insufficient rooting depth (Dobson and Moffat 1993; Watson and Hack 2000). Soil is an essential medium for plant growth, providing physical support for plants as well as access to water; soil also is the main source for nutrients that are necessary for plant growth. Soil needs to: (1) have a healthy layer near the surface, roughly equivalent to topsoil; (2) be tested as necessary for pH, nitrogen, phosphorus, conductivity, bulk density, organic matter, and other nutrients; and (3) be treated as necessary. (Soils with an acidic pH could be treated with lime before they are spread over the landfill surface.) Soils could be amended by incorporating lime or organic material into the top 6 inches of soil from one to several weeks before planting. The final soil surface should be loosely distributed during landscaping and should not be compacted with heavy equipment (Wong and Bradshaw 2002).

- **Terrain and Slope**. Although the landfill ideally could be contoured to match the topography of the surrounding area, it often is mound-shaped with steep slopes that can impair plant establishment. Biosolids with site-specific amendments can be used on steeper slopes to help prevent the surface soil from drying out and hold the seed until it germinates and establishes a vegetated surface. In addition, compost berms, blankets, and socks can be used to slow the rate of storm water as well as reduce erosion along steep slopes. The compost retains water, aiding in revegetation and filters the water, improving water quality as it flows off-site.

- **Moisture and Irrigation**. Water logging and drought stress are major factors that limit plant growth and revegetation on landfill sites and can occur on the same site at different times of the year in areas with low and erratic rainfall (Wong and Bradshaw 2002). Trees and shrubs can remove large quantities of water from soil quickly and efficiently, which can mitigate water logging (Robinson and Handel 1995). In addition, landfill surface material typically includes a geomembrane or clay layer that requires moisture in the soil to safeguard against desiccation. The need for moisture is seasonal and depends on annual precipitation and climate; moisture, however, also is beneficial to support vegetative surface. The moisture level must be monitored to avoid compromising the surface layer with saturated soils and must account for the season and volume of annual rainfall, the type of clay material used in the barrier, and the plant community to be grown.

- **Landfill Gas**. Landfill gases can create a hostile environment where vegetation cannot survive because of the lack of oxygen in the root zone. Gas collection systems can both alleviate or aggravate this problem. Exposure of vegetation to high gas concentrations can lead to stunted

For additional information about planting on steep slopes, please visit the following Web sites:

- http://www.nrcs.usda.gov/feature/backyard/grndcovsl.html
- http://cfpub.epa.gov/npdes/stormwater/menuofbmps/idex.cfm

Search by keywords: Compost blanket, compost filter sock, and compost filter berm.

growth, defoliation, or death, so that the existing plant community requires removal and replanting (Flower et al 1981). Methanotrophic bacteria in soil may consume landfill gas; these bacteria thrive symbiotically with plant roots, existing in concentrations 10 to 100 times higher than in unplanted soils. A well-established root zone can consume vast quantities of landfill gas, even when the plants are dormant.

- **Pests and Invasive Species**. The federal government promotes management of invasive plant species during revegetation, as detailed in EO 13112. This order states that, to the extent possible, federal agencies must prevent the introduction of invasive species, monitor and control existing populations, and restore native species and habitat of ecosystems in invaded areas. Invasive plant species can quickly disperse and invade disturbed land. Close monitoring of the habitat during establishment and control of invasive species will be required. A variety of methods can be used to control invasive species, including prescribed burning, chemical (herbicides) or biological (such as the purple loosestrife beetle) methods, and hand pulling. Careful plant selection can reduce the potential for disease from insects, molds, and fungi, as well as from burrowing animals such as gophers, moles, and other rodents. Judgment may be exercised in cleanup on a containment system because removal of too much material can jeopardize the nutritive regeneration qualities of ground litter and can remove an added means of soil protection and moisture retention in the natural soil surface.

- **Windthrow and surface integrity**. Windthrow (blowdown) of trees is a potential problem on landfill sites because it may jeopardize the integrity of the landfill surface should the roots peel away the soil layer with the toppled tree. Still, the risk of windthrow should be no greater than for conventional forested sites if there is an adequate depth (14 to 18 inches) of rootable soil. Monitoring for windthrow damage is necessary. However, the risk of windthrow can be reduced if trees are harvested before they reach a height where they might be more susceptible to windthrow or species are planted that remain relatively small (Dobson and Moffat 1995). In addition, planting shorter trees at the perimeter of a grove around taller varieties or adult trees can provide a windbreak by slowing the wind and directing airflow over or around the taller canopy layer. Single-line, hedgerow-like plantings or isolated individuals, especially at the edges of top decks and maintenance roads, leave adult trees vulnerable to strong winds, encouraging windthrow.

How Do I Establish Plants on a Landfill Surface?

While it may be difficult to establish native plants in almost all areas in the U.S., site-specific considerations will increase the chances of success. A proper site-specific planting plan is necessary in the revegetation of a landfill or waste containment area. It is most cost efficient to combine the application of the nursery crop and the native seed planting. In addition, the success of the native seeding is much higher and the reseeding potential of the nursery crop lower. Once the site is stable, appropriate species can be introduced by hand. Planting clusters habitat can promote seed dispersal, such as by birds and insects, and they will assist in introducing local native species. In general, options exist for restoring a site, including:

- **Planned planting of all plant types, such as grasses, shrubs, and trees, at the very outset of restoration**. This approach may require the most advanced planning but should provide the greatest element of control in the design and outcome of the overall plant community. The final plant community would be established and maturing early in the revegetation and post-closure maintenance program. Some invasive volunteerism by outside plants could occur if the operator does not exercise aggressive control efforts.

- **Providing the proper environment and soil conditions to encourage plant growth volunteering by local native plants.** This approach provides the lowest element of control on the types of plants that may be introduced to the site because it depends on the unpredictable phenomenon of natural plant establishment and succession. Some sort of initial soil stabilization by planting with a rapid-growing annual and perennial grass or ground cover will still be required to prevent erosion of the landfill surface. The plant succession process occurs as the selected area matures. Pioneer plants (typically low-growing or prostrate weeds and grasses with deep taproots, most adapted to the harsh conditions of bare, usually poor-quality soils) establish first in the ruderal environment and begin the process of soil nutrient construction and softening. Taller grasses then gain a foothold and establish themselves. In time, legumes, herbaceous perennials, and woody perennials begin the larger plant occupation as soil quality and nutrient content continues to improve. Eventually, shrubs and the larger trees assume the mature level on the location.

- **Combining planned planting with volunteering by adjacent native species to create the final vegetation cover.** This approach has a high potential for erosion and the cost of controlling invasive species is also high. Invasive species typically thrive in early successional habitat and once established will be difficult and expensive to combat. Efforts may still be required to control undesired invasive species. An effective and cost-efficient method to revegetation in the woodland and shrubland habitat includes planting islands of habitat to attract wildlife, such as birds, that can disperse seeds to expand the habitat.

What Maintenance and Repair Should be Expected?

Planting on landfill surfaces will require some maintenance, but the use of native plants should create a self-sustaining habitat that minimizes the requirements. The following maintenance and repair should be expected to support revegetation of the landfill surface:

The following Web site provides information on management of invasive species:
http://www.invasivespeciesinfo.gov/council/actiond.shtml

The following Web site describes many monitoring and management techniques:
http://www.ciwmb.ca.gov/LEACentral/Closure/Revegetate/Part6.htm

The following Web site provides additional information on performance criteria:
http://www.ser.org/content/ecological_restoration_primer.asp#8

- **Monitoring and Management of Habitat at Initial Planting**. When plants are first established on the site, monitoring and management could consist primarily of re-seeding and irrigating, if necessary, to ensure the health of the plants and control of invasive species. A program may be needed to safeguard against disease, insect pests, drought, windthrow, and wildlife damage. Various control methods can be used to control invasive species on landfill surfaces, including hand pulling, prescribed burning, or use of herbicides; the most appropriate method depends on the final use of the site. This type of program may be required only during the first 5 years, may diminish over time, and will cease as the plants mature. In addition, guidelines on mowing may need to be developed and followed, particularly as forbs and young trees will be effectively removed if they are inadvertently mowed.

- **Maintaining Site Access**. Maintaining access to the site and other components of the remedy is necessary and includes pruning or removing plants that could interfere with access roads and trails that lead to vents and other features of the landfill surface. Signage may be used to designate newly planted areas and to restrict mowing.

- **Long-Term Monitoring and Management of Habitat**. Mechanical methods such as prescribed burning, light disking, mowing, grazing, chemical application, or a combination of methods may be required during the first five years to maintain early successional habitat. Once native plants are established, the habitat will require minimal maintenance. Periodic removal of plant affected by windthrow, disease, drought, and frost also may be required. After plant roots are established, the frequency of maintenance can be reduced, and natural processes will take over. Highly invasive species may continue to pose a problem after five years and should be periodically monitored. In addition, data on the quantity and composition of leachate generated within a landfill can be an indicator of the integrity of the cover system. While leachate generation should be minimal with a properly designed cover, leachate control should be considered during the design phase and monitored as necessary.

What are the Important Things to be Aware of?

- The grass is **not** always greener - especially during the first couple of years. For the first couple of years, native, warm-weather bunch grasses spend their energy growing roots and establishing themselves below ground.

Site-Specific Examples/Case Studies

Bower's Landfill, Ohio:
http://www.epa.gov/superfund/programs/recycle/success/casestud/bowercsi.htm

Walsh Landfill, Pennsylvania
http://www.epa.gov/reg3hwmd/super/sites/PAD980829527/index.htm

Woodlawn County Landfill, Maryland
http://www.epa.gov/reg3hwmd/npl/MDD980504344.htm

Therefore, it may initially appear as if the seeding wasn't successful - as only a little plant material will be visible above ground. But most of the growth is occurring below the surface. A trained restoration ecologist familiar with native plants can tell you if the planting was successful and will become more manifest with time. Technical performance measures used for turf grasses (for example, 50 percent growth within a measurement hoop) are not appropriate. Unfortunately, sometimes a planting will fail and will need to be repeated.

- To maximize success - or minimize failure - note that **native plant seeds may be difficult to sow.** They require specialized equipment, such as drill seeders, available from groups familiar with native plant restoration (such as the Fish and Wildlife Service; state agencies; Park Service; local native plant societies; and native plants restoration ecologists). The keys are timing (the time of year, which varies by species and geographic location) and maintaining soil contact (use of a drill seeder is essential in this regard). Do not expect to be able to measure significant success in the first growing season.

- If the soil used as a borrow source for the cover originally supported vegetation, it can be expected to do so after being moved to the site. If the borrow source supported weeds, weed seed will be present on the cover system and weed growth will likely require control methods.

- Native plant materials - either seed or growing stock - are best obtained with as much **lead time** as possible. Do not wait till the last minute to try to purchase the plant materials. This long lead time is dictated by both the limited availability of the plant material from reliable sources and the need to plant at the most opportune time. The U.S. Department of Agriculture (USDA)/NRCS maintains Plant Material Centers that can augment commercial nurseries, but these centers need advanced notice. Many native plants suppliers can provide healthy material at a reasonable cost if awarded a contract in advance for a specified delivery time. The more time they have, the better, especially for harvesting local genotypes for planting in nearby restoration projects. The seed must be collected and then grown for planting, which is time intensive. In addition, you should assume you will have to save 10 percent of your budget to reseed or replant.

- Do not forget to post **DO NOT MOW** signs after the planting. Some sites have ongoing contracts with landscaping firms - some with other agencies. Many a first flush of growth was killed or severely damaged by well-intended maintenance workers. This caution also applies to spraying herbicides.

- Managing wildlife is often overlooked and can be a problem. The biggest culprits are deer. They can overbrowse a newly planted site and leave it vulnerable to invasive non-native species. In addition, small mammals can debark trees causing significant damage or killing the trees. Wildlife control is difficult, however. Options include repellents such as putrefied egg solids and home-made soap. Providing alternative food sources can work, although they should not be located near the new growth. Other options can include constructing physical barriers (such as tall fencing, cages, or nets), providing access to hunters, and planting at a higher density to compensate for expected loss. The over planting approach applies to seeding rates as well as stocking rates for plants. Options should be explored with the local community to ensure that they are acceptable.

Additional Information Resources

References used to prepare this fact sheet include the following:

Dobson, M.C. and A. J. Moffat. 1993. "Woodland Establishment on Landfill Sites: Site Monitoring."; http://www.odpm.gov.uk/index.asp?id=1145641

Dobson, M.C. and A. J. Moffat. 1995. "A Re-Evaluation of Objections to Tree Planting on Containment Landfills." *Waste Management & Research.* Volume 13. Pages 579 through 600.

Flower, F.B. et al. 1981. "Landfill Gas, What It Does to Trees and How It's Injurious Effects May Be Prevented." *Journal of Agriculture.* Volume 7. Pages 43 through 52.

Handel, S.N. et al. 1994. "Biodiversity Resources for Restoration Ecology." *Restoration Ecology.* Volume 2, Number 4. Pages 230 through 241.

Harper, J.L. 1987. "The Heuristic Value of Ecological Restoration." *Restoration Ecology: A Synthetic Approach to Ecological Research.* Cambridge University Press. New York, NY. Pages 35 through 45.

Robinson, G.R., and S.N. Handel. 1993. "Forest Restoration on a Closed Landfill: Rapid Addition of New Species by Bird Dispersal." *Conservation Biology.* Volume 7, Number 2. Pages 271 through 278.

Robinson, G.R., and S.N. Handel. 1995. "Woody Plant Roots Fail to Penetrate a Clay-Lined Landfill: Management Implications." *Environmental Management.* Volume 19, Number 1. Pages 57 through 64.

Watson, D. and Valerie Hack. 2000. *Wildlife Management and Habitat Creation on Landfill Sites - A Manual of Best Practice. Ecoscope Applied Ecologists.* UK.

Waugh, W.J. 1994. "Paleoclimatic Data Application: Long-Term Performance of Uranium Mill Tailings Repositories." *Workshop Proceedings: Climate Change in the Four Corners and Adjacent Regions.* Grand Junction, CO. September 12-14.

Wong, M.H. and A.D. Bradshaw. 2002. *The Restoration and Management of Derelict Land - Modern Approaches.* World Scientific Publishing Co. NJ.

Web sites to obtain additional information include the following:

U.S. Environmental Protection Agency Land Revitalization Offices and Programs
http://www.epa.gov/swerrims/landrevitalization/index.htm

U.S. Environmental Protection Agency Green Landscaping
http://www.epa.gov/greenacres

U.S. Department of Agriculture Beltsville Agricultural Research Center (BARC)
http://www.barc.usda.gov

U.S. Department of Agriculture - PLANTS Database
http://plants.usda.gov/index.html

U.S. Department of Agriculture, Natural Resource Conservation Service
http://soils.usda.gov/survey/printed_surveys/

Center for Plant Conservation
http://www.centerforplantconservation.org

Plant Conservation Alliance (PCA)
http://www.nps.gov/plants

Society for Ecological Restoration International
http://www.ser.org

State of California Guide to Revegetation and Environmental Restoration on Closed Landfills
http://www.ciwmb.ca.gov/LEACentral/Closure/Revegetate/

Wild Ones: Native Plants, Natural Landscapes
http://www.for-wild.org

Wildlife Habitat Council
http://www.wildlifehc.org/

Internet Seminars on Ecological Restoration
http://www.clu-in.org/studio/seminar.cfm

Interstate Technology and Regulatory Council (ITRC): Ecological Enhancements.
http://www.itrcweb.org/gd_EE.asp

Other Guidance, Policies, and Executive Orders

EPA Municipal Solid Waste Landfill Regulations
http://www.epa.gov/epaoswer/non-hw/muncpl/landfill/msw_regs.htm

EO 13148 Greening the Government through Leadership in Environmental Management
http://www.epa.gov/greenacres/EO13148.pdf

EO13112 Invasive Species
http://www.invasivespeciesinfo.gov/laws/execorder.shtml

Title 40 Code of Federal Regulations Parts 60, 62, 258, and 445
http://www.epa.gov/docs/epacfr40/chapt-I.info/

Contact Us

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