Vegetative solutions to landfill closures

By Cheryl Hendrickson

Controlling undesirable outcomes of water movement in and on landfills is a common element of landfill closure efforts. Trees, shrubs, and other plants can be added to the engineer's tool kit as part of the remediation strategy for closed landfill sites. Vegetation can assist with typical issues such as slope stability, erosion control and leachate management, but choosing to recreate natural plant communities also provides habitat for animals and future recreational opportunities for the public.

Designing vegetation covers for specific functions

The biological functions of plants include stabilization, interception, transpiration and volatilization.

1. *Stabilization:* Plant roots stabilize soil from wind erosion and slopes from rill- and gully-forming water erosion. The roots of prairie grasses such as switchgrass, big and little bluestem, and prairie cordgrass provide dense mats that stabilize shallow and deep substrates. Prairie grass root systems may be 3-4 metres deep. Trees and shrubs such as hybrid poplar and willow develop woody structural roots that provide stability on a coarser scale.

2. *Interception:* Leaf surfaces, and in the case of trees and shrubs, branches and stems, intercept and slow down rain before it hits the ground. High velocity sheet runoff is prevented. The greater the plant surface area above ground, the higher the interception rate. Some water stays on leaf surfaces and is evaporated without reaching the ground surface. A "closed canopy" forms as vegetation matures, providing erosion control both by protecting the soil surface, as well as by actual root stabilization.

3. *Transpiration/volatilization:* These functions are sometimes referred to as a "biological pump and treat system". Soil moisture, including some contaminants, is drawn up through the root system and evaporated (transpired) through the leaves. Transpiration rate is a function of the plant species, leaf surface area, extent of the root system, temperature, wind, and relative humidity. A dry windy site will generate a higher transpiration rate if adequate soil moisture is present.

Small molecular weight contaminants that may be in groundwater are taken up and moved through the plant. There may be some metabolism and degradation within the plant, and these compounds can also be volatilized. For example, in the case of trichloroethylene (TCE) several processes are at work at the same time: degradation in the soil or groundwater; metabolic uptake by the plant; and volatilization.

Poplar, willow, and a number of other trees can tolerate some level of contamination, and can take up and transpire landfill leachate and contaminated groundwater. They have some of the highest known transpiration rates in northern climates, which is why they are the first choice for many remediation and reclamation projects. Transpiration rates can be monitored by using a sap flow meter which provides accurate, on-site determinations, regardless of the species. A managed willow plantation can remove up to 10 litres/sq.m/day during the growing season. Transpiration volume of individual trees will increase as they get larger.

Poplar and willow can also be used to intercept groundwater plumes to prevent off-site migration as the plantation transpiration rate can be integrated into the design to match groundwater flux. Costs per hectare are also lower than off-site transport and treatment, as there is a one time installation cost for a system that will function for decades.

All of these processes occur at the same time, so that vegetation provides an integrated approach to water management. Some plants perform some functions better than others, and not all plants will find ideal growing conditions in the landfill environment. The factors of function and site suitability must, therefore, be taken into account when selecting species to revegetate landfills.

Creating habitat and passive recreation areas

Residents of many communities have generated a widespread public interest in habitat restoration with species of local origin – native species. They value this approach because it allows society to replace what was removed historically through agriculture, urbanization and resource development. The revegetation of landfill caps provides the perfect opportunity for naturalization; species representative of marshes, prairies and forested communities may be used.

Native plant species, in turn, provide food and shelter to animals, and eventually, a pleasant and interesting place for the public to stroll, appreciate nature and the viewshed provided by the elevated landscape. Plantings can be designed with a park-like setting in mind, with a vision for the future, incorporating the wealth of experience in natural area design and management.

Phase 1 and 2 panorama of maturing habitat. All photos by Mark Peterson.

Habitat restoration demands vegetation professionals that have knowledge of native species that are compatible with existing landscape conditions. They must also be able to assess the developing vegetation community so that they can manage succession – the ecological maturation of a plant community - to desirable end points.

Mark Peterson and Associates, and LandSaga Biogeographical have worked together at the Regional Municipality of Waterloo (RMOW) landfill towards that end. In 1997 the Region added the naturalization of closed landfill cells to their roster of green management initiatives. The approach has been to install a selection of nursery-grown native trees and shrubs incrementally over the last 10 years.

The total planted area to date is 2.7 hectares with an average installed cost for the 10,000 plus shrubs and trees of about $4.85 per square metre or $48,500 per ha. The 1m clay cap is covered with a planting layer comprised of a 75 cm mixture of daily cover (on-site silty and sandy soil), peat and compost, although other cells received woodland soil salvaged from a local development site. Costs to create a favourable planting substrate vary, as may actual installation costs depending on the size and form of nursery stock and its planting density.

At the Waterloo landfill, before plant material is installed, the planting cell is topped with 15-25 cm of chopped woody mulch processed from wood waste received at the landfill. Mulch helps to control weeds and conserve moisture while the plants become established. Either bare root or containerized stock can be used, although container stock has some advantages in terms of drought tolerance and survival in unmanaged conditions. Weed control, especially after the third year, greatly improves long-term success.

In a similar naturalization project at New York's Fresh Kills landfill, field monitoring indicates that woody roots do not penetrate the landfill cap. These findings reinforce other investigations in northeastern US landfills that show that roots generally stayed in the upper 50 cm of substrate in the presence of water and air. In the unlikely event of root penetration, the anticipated effect would be more than offset by the known interception and evapotranspiration of water that mature plants provide with their leaf canopy.

Once shrubs and trees have been planted, other desirable and unwanted plants begin to arrive. Annual weed management is necessary to control aggressive weedy competition so that the desired native species can become established.

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Weed control in naturalization projects demands vegetation professionals who can distinguish native, planted species from unwanted weeds. At the Waterloo landfill LandSaga provided this service, while also identifying and saving "volunteers"– desirable native plants that came in on their own. This has proven to be a cost-effective management technique that has contributed to the success of the planting.

In the case of older landfills, a botanical assessment of existing vegetation should be done. Through forensic botany, a rapid assessment of site conditions affecting current and future plant communities can be made, including soil conditions, groundwater location, leachate breakouts, and site history. Vegetation characteristics can then guide which plant species are likely to be most successful for their determined function, whether it be leachate control, stabilization, interception, and/or habitat restoration. Species identified may or may not be recommended in the literature, since not all plants have been evaluated.

Colonization by other native plants from adjacent natural areas via rabbits, birds, deer and wind, is an indicator of a thriving installation. This is the "successional" restoration that was the goal of the Region of Waterloo at the outset, which describes an evolving, self perpetuating ecological system, and one that also works passively to manage the unproductive effects of water. The presence of predators like coyotes and hawks reflects the successful development of the ecological community.

Typical planting with trees and shrubs planted into wood mulch.

Future residents of Waterloo enjoying the view of the city from a forested hilltop will reflect on the successful closure of this landfill.

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