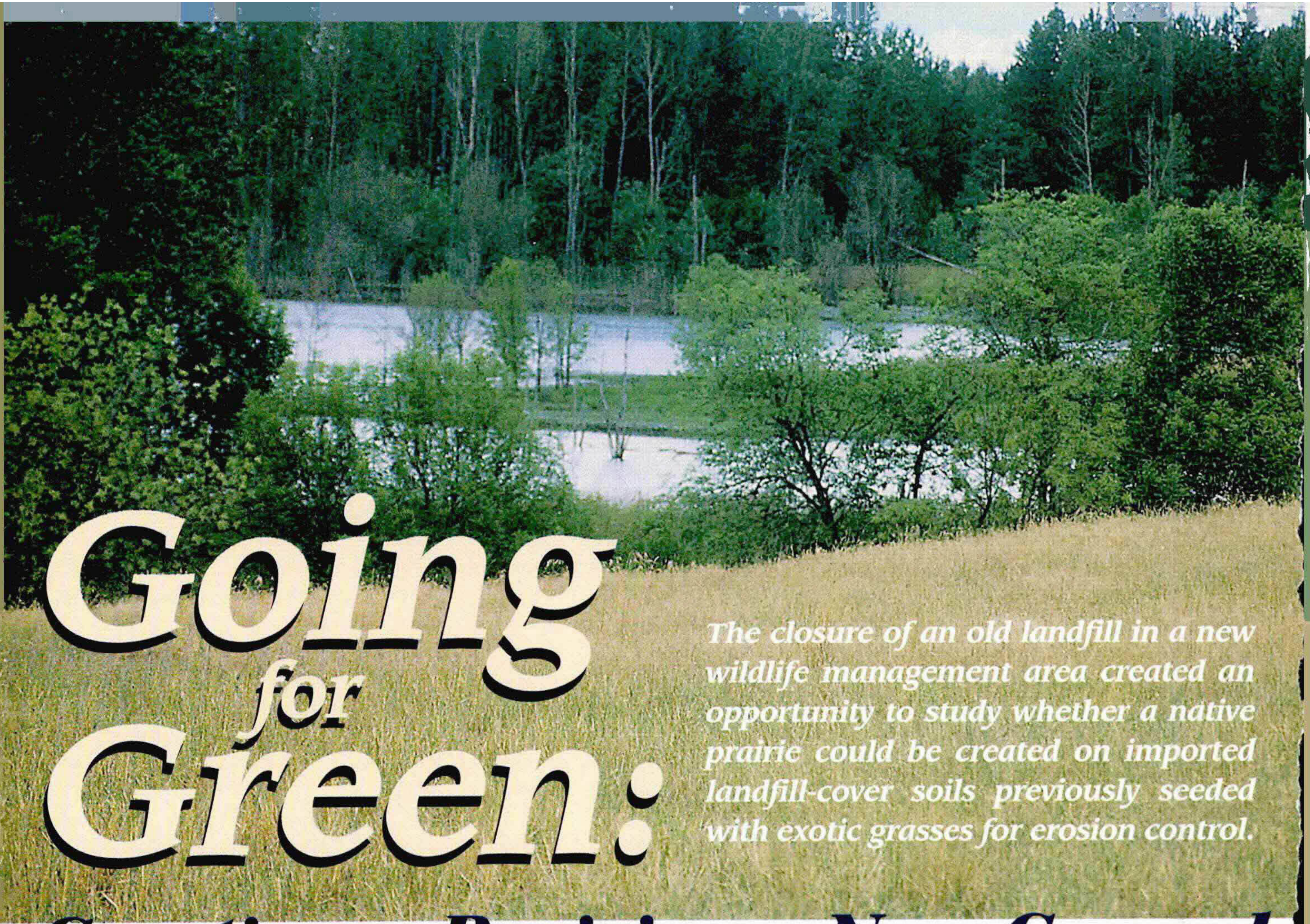


Going for Green: Creating a Prairie on New Ground

The closure of an old landfill in a new wildlife management area created an opportunity to study whether a native prairie could be created on imported landfill-cover soils previously seeded with exotic grasses for erosion control.

By Martha S. Mitchell

A green canoe cuts quietly through the slack water at the edge of a 2,000-ac. wetland wildlife park where volunteers are surveying the Western painted turtle. As the canoe moves through the dappled shade of Pacific willow at the water's edge, its approach is heralded by the clumsy departure of a great blue heron and the plop of turtles diving for cover. Around a bend, an adult bald eagle and a splotchy juvenile take flight from a cottonwood where they have been keeping an eye on a group of coots. The canoe beaches below a rolling grassland where the shoreline of the fringing riparian woodland is embroidered with the tracks of mink, otter, beaver, Canada goose, muskrat, and raccoon. The soft whistle of a Northern harrier comes from overhead, and cottonwood fuzz drifts on small breaths of warming air.

Flash back half a century. The squalls of gulls and other scavenging birds carry over the open water at the edge of an expanding dump. The site that today is a rolling grassland was a remote swamp at the edge of town where ash from the Portland, OR, area's garbage incinerator was disposed along with every other kind of waste that would not burn. This was not an unusual garbage-disposal practice for the time. But the setting was unusual, for the dump is situated in the floodplain of the lower Columbia River, a stream that drains some 259,000 $mi.^2$ of the Pacific Northwest. This big-league river tumbles out of the Rockies, slices west through the Cascade Range, and sprawls mile-wide into a watery bottomland shared by the Willamette River, creating a riverscape studded with islands, sloughs, and backwater channels. The dump is located in this setting.

Fast forward to the early 1990s. In the years since 1934, St. Johns Landfill has grown to about 250 ac. and is surrounded on all sides by remnant lakes and wetlands of the once-extensive floodplain. These floodplain remnants have been set aside as a regional wildlife park, and the landfill comprises its upland habitat. The regional government, Metro, has acquired the landfill, closed it, started to cap it, and initiated studies to learn whether it will be possible to establish native prairie grasses and shrubs on the manmade slopes.

The Landfill Cap: Functional Requirements

The cap is a layer cake of materials stacked to provide performance not usually required of either natural or human-influenced landscapes. According to Metro's landfill closure plan, the cap must prevent rainwater from seeping into the waste and leaching pollutants into ground and surface water. There can be no ponding of water on the surface, and slopes after settlement must be steep enough to facilitate rapid stormwater drainage. Runoff should not erode the cap. Trees should not be allowed to become established because of the potential for their root systems to damage a subsurface geomembrane that seals the waste beneath. Plants that might support burrowing animals should be avoided for the same reason.

To accomplish these objectives, explains Dennis O'Neil, Metro's

Solution for the Emergency Bypass Road

DOT officials, Kiewit Pacific, the Army Corp of Engineers, and Structural Systems Inc. met immediately to determine construction of a bypass road. After surveying the proposed area and its proximity to Waimea Bay Beach Park, the design team recommended that the road meet four important requirements: (1) withstand the North Shore's high surf conditions and the rainy season, when 30 in. of rain per week is not uncommon, (2) have minimum impact on the environment, allowing the site to be easily returned to its original natural state once the highway reopens, (3) support heavy vehicles over the soft sand subgrade, and (4) be cost-effective.

Following the team's fact-finding mission, a design by the US Army Corps of Engineers and DOT was accepted that created a temporary two-lane roadway approximately 24 ft. wide x 1,000 ft. long. The construction materials included geotextile fabric and Presto Products' (Appleton, WI) Geoweb cellular confinement system filled with native beach sand and surfaced with a native crushed coral.

"Based on past challenges, we've experienced tremendous success with the Geoweb cellular confinement system, which has a proven track record for its reliability over a wide range of applications," remarks Joe Enright, president of Structural Systems Inc., a Honolulu-based general engineering contractor. "Turnaround time was key to this project; therefore accessibility to a rapid load support system and onsite engineering personnel were reasons why the Geoweb system was selected."

Cellular confinement was developed as a means of constructing rubber-tired military-vehicle access roads over beaches. The three-dimensional polyethylene, honeycomb-like structure confines and strengthens cohesionless materials in its cells, preventing shear failure and lateral movement of the infill material. The system produces a stiff base with high flexural strength, acting like a semirigid slab by distributing loads laterally and reducing subgrade contact pressures. The flexible engineered system can be designed to handle loads as great as 40 tons.

Installation Process

Within 30 hours of the design team's March 12 job-site meeting, the Geoweb material was air-shipped from Wisconsin to Waimea Beach in order to expedite installation. Forty-three pallets were delivered in collapsed form, which were easily expanded to their full width and length (8 x 20 ft.) and secured with Presto's ATRA anchors prior to infilling.

"This is a classic example of job-site partnering whereby various government agencies work with local businesses to design and build this type of engineering solution," notes Enright.

In the initial stages of construction, DOT personnel readied the beach for road construction by clearing trees and building a ramp at one end of Waimea Bay. In efforts to remain sensitive to local cultural and political concerns, Kahu Samuel Safrey, a Hawaiian priest, performed a ground blessing at the site.

The bypass road was constructed by placing a layer of geotextile directly onto the sand. The first course of 8-in.-deep Geoweb sections was placed and infilled with the surrounding beach sand and compacted. A second course was placed, repeating the same procedure. The top 3 in. consisted of imported crushed coral placed on top of the two Geoweb courses, saturated and compacted. The 8- x 20-ft. sections of Geoweb were placed three across to create a 24-ft.-wide roadway some 1,000 ft. in length. Water-filled barriers were placed on both sides of the roadway to help delineate the two traffic lanes, protect the cells nearest the edges, and prevent cars from going off the secure road into the sand.

Late winter storms creating flooding and surfs as high as 20 ft. posed a threat to the integrity and foundation of the bypass road. The anchors—plastic clips attached to 24-in.-long rebar—provided additional anchorage to the Geoweb sections. The effectiveness of the anchors was tested a few days later. High surfs ripped out the center portion of an adjacent walkway, washing it out to sea. Although the waves also emptied sand from some of the roadway cells, the anchors prevented the road sections from completely pulling out.

The bypass road was completed March 18 at 6:30 a.m. and has been open to traffic since.

Currently traffic is limited to a 5-mph speed limit and a 4-ton weight limit. Met with initial skepticism and opposition, the Waimea Bay Emergency Bypass Road is being accepted by residents and businesses and functioning as planned. **EC**

Sources: *The Honolulu Advertiser, Honolulu Star-Bulletin Hawaii News*, and *enews Hawaii*

landfill manager, the waste was surcharged where necessary to promote settlement and covered with a minimum 6-in. lift of soil that was compacted to achieve low permeability. A 40- to 60-mil welded geomembrane was placed over the compacted soil to serve as a barrier to rainwater from above and gas from below. A 12- to 18-in. layer of sand on top of the geomembrane served as a medium to allow for rooting depth and for the drainage of any rainwater percolating through the topsoil. On steep slopes, a composite of geotextile and drainage mat was placed between the sand and the membrane to facilitate drainage.

Mark Wilson, a Portland restoration ecologist, led a team to design and oversee the implementation of a landfill-cover vegetation plan. For the top soil layer, Wilson mixed several lifts of soil and compost into the top few inches of the sand layer. The cover-soil depths were designed to vary with landscape position. The nearly flat ridgetops were to be seeded with mesic prairie, the slopes with xeric prairie, and the valley bottoms with a combination of shrubs and mesic prairie. This was the planting medium to be tested in experimental plots on the final landfill cover.

Photo: Port of Portland, OR, courtesy of Metro

After a half century as a garbage dump in the floodplain of the Columbia River, the closed 250-ac. St. Johns Landfill became critical habitat in a wildlife management area.

Project economics, soil recycling objectives, and construction deadlines made the acquisition of seed-free topsoil impossible, reports O'Neil. After placement, seedbank tests of the imported soils used for the uppermost soil layer identified huge quantities of non-native grass and pest seeds, he noted in a 1997 report. According to Wilson and Laura Brophy (*www.peak.org/~brophyl*), another ecologist who worked on the project, an additional problem was a large soil seedbank of perennial rye grass, bent grass, and clover in the recycled soils used for the cover. These aggressive non-natives were legacies of temporary erosion control seeding carried out in the late 1980s during the course of landfill closure.

The Experiment Begins

Test plots were set up between 1992 and 1997 to test the following: (1) four soil-preparation variations; (2) three seeding techniques: dual-stage hydroseeding, broadcast track hydroseeding, and no-till drill seeding; and (3) dry and moist prairie assemblages. The first year, the construction schedule for the final landfill closure was hurried, and only minimal site and soil preparation was possible before seeding in mid-fall, says Wilson. A sterile, hybrid wheatgrass was used in the test plots as a nurse crop in the native seed mix to provide quick cover for erosion control, to suppress weeds in the seedbank, and to serve as a temporary placekeeper for the slower-growing natives. In addition, the hybrid, seeded at 25 lb./ac., was used as a cover crop on all other areas of freshly placed landfill-cover soils that were planned for permanent seeding in the future. An inorganic fertilizer was applied in all areas.

By the following spring, it was apparent that the sterile hybrid had failed as a nurse crop in the native-seed test plots, Wilson says. The hybrid quickly grew to 4 ft. high, forming a closed canopy over the slower-growing natives. Wet spring conditions presented a hazard of compaction and thus delayed the ability of management to bring mow or spray equipment onto the landfill cover to control it. The aggressive hybrid and pest plants formed a monoculture by early summer.

Results: Conditions Favor Exotics

By 1999, all 12 test plots had become dominated by non-native grasses and forbs. According to Wilson, four of the plots had no site preparation other than placement of the cover soil. These had been seeded

A five-year study assessed whether native grasses could be grown on imported soils seeded with perennial rye grass.

by dual-stage hydroseeding or broadcast tracking. Five of the plots failed as a result of competition from non-native grasses (primarily rye grass) and weeds in contaminated seedbanks. Ironically, two plots failed as a result of grazing by waterfowl and overgrazing by sheep. Secondary factors that contributed to failure of test plots included soil compaction and use of native seed produced from out-of-area sources.

O'Neil says the test results put landfill cover management in a tug-of-war situation with respect to the amount of effort that should be expended to keep out competing vegetation. "Do we have to nuke the whole landfill with herbicides? What would be the environmental impacts of that?" For proper erosion control, he continues, there must be a strong vegetative cover. Pulling against this is the fact that native vegetation does not compete well on sites enriched to support good stands of exotic grasses. The non-native perennial rye grass used for temporary erosion control was tough and hardy but needed fertilization and liming to get a good stand going. The success of the non-natives contributed to the failure of the natives. "This is the crux of the problem," O'Neil states.

Soils Are Key

Both Wilson and Brophy take a long view about reestablishing the native prairie at the landfill. They note that a large body of knowledge about grassland restoration comes from the Midwest or California, where there are different species, climates, soils, and soil genesis. What is needed, they say, is more base knowledge about Pacific Northwest prairie systems west of the Cascades. Brophy believes there needs to be more study of the texture, chemistry, drainage, and structure of the soils of nearby native grasslands so that scientists can learn to duplicate them. Wilson adds that we know very little about the mixes of native prairie species that will enable long-term succession to occur. Fast-growing but short-lived pioneer grasses are necessary to control erosion, but very slow-growing (late-succession) grasses and forb species are needed to provide long-term wildlife habitat and ecosystem stability.

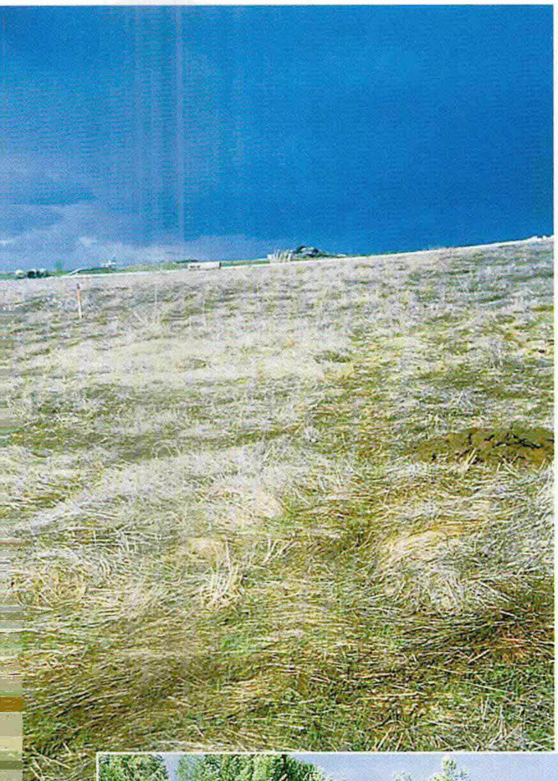
"We have very few prairie remnants to use as restoration reference sites," observes Wilson, "because nearly all of the historic mesic grasslands of the Willamette Valley have been colonized by woodlands or converted to croplands." Those that remain are disturbed by grazing and non-native species. He mentions that historical documents from the early 1800s indicate that wet and upland prairies were maintained by fire, a practice displaced by pioneer settlement in the 1850s. Finally, he says, the climate west of the Cascades is ideal for grass. The Willamette Valley is one of the world's largest producers of grass seed, such as rye grass. Adds Brophy, "Native grasses are in trouble everywhere in this landscape. We're losing them even in places that have never been disturbed."

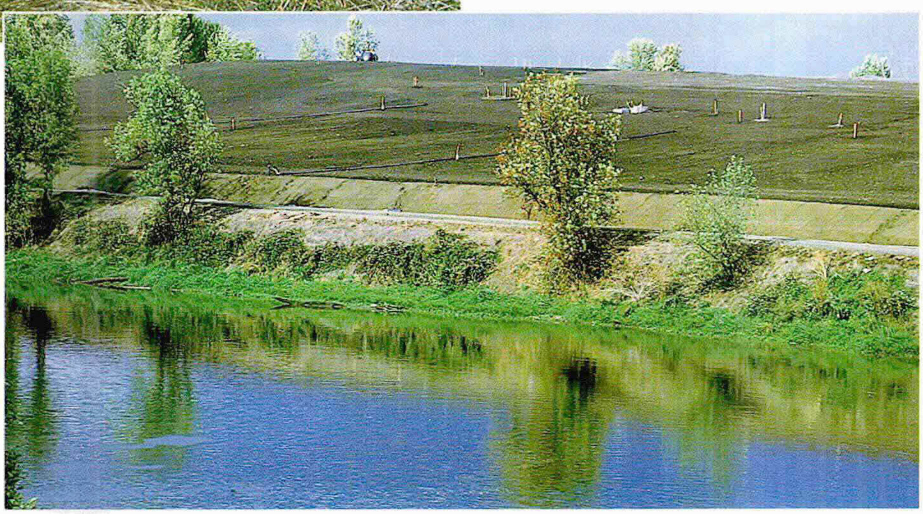
Maintenance and Research Are Critical

Brophy is still hopeful about reestablishment of native grasses. "I'm a grass nerd," she laughs. "I'll continue to go for any opportunity that comes along to establish native grasses." For starters, she says, a good restoration plan needs to include the high cost of maintenance: roguing out non-natives, hand-weeding, applying herbicides, and high mowing to remove the immature seed head from the faster-growing exotics. When the landfill was first closed in 1989, she points out, it was seeded with non-native perennial rye grass to stabilize the soil cap. Rye grass seed remains viable for years in the seedbank and continues to come back. "This is a tough nut to crack," she remarks. Yet in one test plot—a plot with loamy soils, good infiltration, and good soil depth—the native brome grass became dominant.

Much more research is needed, Wilson emphasizes. He is interested in the effect of growth hormones, such as gibberellic acid, on the meristematic tissues of native plants. Rye grass, he says, does not respond to gibberellin. Brophy thinks there needs to be more research on the standard practice of using fertilizers, because natives are not adapted to large amounts of nutrients. Lower nutrient levels can encourage symbiotic relationships between plants and microbes that allow plants to take advantage of less accessible nutrients, she adds.

Brophy is also interested in the role of mycorrhizae in symbiotic relationships that can help reestablish grasses. Studies on this topic find that without mycorrhizae, natives don't do as well. Some of the landfill's soil cap comprises recycled soil that was treated with heat to volatilize pollutants. The assumption was that the seedbank in these soils would have been destroyed. It wasn't. But the effect of this kind of heating on soil mycorrhizae is not known. On the other hand, an





Previous plantings and treatments with composted yard debris inoculated the landfill-capping soils with a large seedbank of non-native perennial grasses and other exotic plants.

experiment solarizing soil in-situ left the soil flora intact but seemed to kill the rye grass seeds. "So many factors affect an experiment," she notes, and rigorous, scientifically validated research requires control and replication, randomized testing, and statistical analysis of results. These things are costly but essential, she stresses.

Let Biology Inform Design Goals

It's important to get the biologists at the design table early, says Brophy, in order to consider soils, hydrology, and a broad range of other factors that can affect establishment of native grasses. Wilson adds that soils designed to meet rigorous engineering and safety requirements for a landfill cover might not inherently possess the attributes conducive to plant growth.

Create New Grass Communities

As for the species composition of created grasslands, Brophy thinks it may be realistic to come up with new grass communities composed of both natives and non-natives. She rattles off a list of two-dozen introduced species that she says will be with us forever, including tall fescue, perennial rye grass, annual bromes, and reed canarygrass. "For successful mixtures of native and non-native grasses, the non-natives need to be the kind that do not form monocultures by rhizomatous spread," Brophy says. "We need to find a way to use such non-natives to break up monocultures or use them in combination with more aggressive natives." Along the same lines, Wilson thinks that a community of non-native grasses and shallow-rooted native shrubs may be more likely to survive in the extremely well-drained conditions of a landfill cover.

Wilson and Brophy see great potential for new grass communities composed of aggressive natives and nonrhizomatous exotics in water-quality bioswales, wetland buffers, and other grasslands of urban environments. They are not fazed by the setbacks to native grassland establishment at the landfill. It could be a lot worse, Brophy points out: The landfill could be covered with Scots broom, Himalayan blackberry, Canada thistle, and other invasive exotics that could make it a source of noxious weeds for miles around.

High mowing and treatment with glyphosate herbicide were both successful. Here, sheep graze the mixed grasses.

Look at the Whole Ecosystem

Despite the species composition of its grasslands, signs are everywhere that wildlife is thriving on and near the landfill: deer tracks, coyote and otter scat, muskrat scent posts, beaver workings, tracks of riparian mammals,

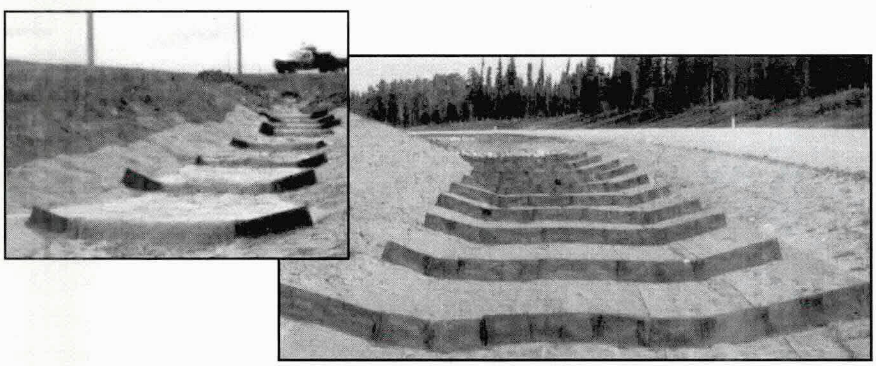
A survey of Western painted turtles, a sensitive species, found prime habitat in close proximity to potential nesting areas on the landfill.

and the whistles, rattles, and squeaks of myriad birds. Killdeer nest on the landfill's seldom-used gravel roads, and raptors hunt rodents and ground-feeding birds that thrive in the seed-rich prairie. On a single summer morning's walk through the fringing woodland at the landfill's edge, managers of the wildlife area count 35 species of birds. "The problem with invasives is not that they are *bad* plants," points out James Davis, naturalist for Portland's Smith and Bybee Lakes, "but that they cause a reduction in diversity."

Teresa DeLorenzo, turtle expert with the Northwest Ecological Research Institute in Portland who is directing the survey of Western painted turtles in the area, says the landfill provides a vital habitat component for almost every order of animal in the area. Whether it provides foraging areas, food, shelter, a quick stopover on a long migration, a nesting area, or a place to bask, any one of these elements could be a limiting habitat factor for a species.

In the case of the Western painted turtles, it is possible that the landfill may provide an undisturbed nesting area that could be critical to ensuring future recruitment of young in a setting that imposes increasing pressures on the remaining populations. Loss of habitat is a big concern, notes DeLorenzo. She cites an Oregon Department of Fish and Wildlife study of the state's other native turtle species, the Western pond turtle, which concluded that more than 99% of its Willamette Valley population had been lost. Although no comparable studies have been conducted for Western painted turtles, it is probable that the same level of disturbance has occurred with them, she says.

Other threats to viable turtle populations



from human disturbances include fishing; loss of aquatic, riparian, and upland habitat to agriculture and all forms of development; loss of turtles to cars; and the potential for turtles to be poisoned by toxins, such as the chlorinated hydrocarbons of pesticides, that are conveyed in stormwater. These toxins become concentrated in turtles' fat, and during overwintering when the turtles draw on their fat reserves, they can become poisoned by them. Exposure to human sewerage puts turtles at risk of estrogenization, a response to human female hormones whereby the sexual maturity of male turtles is prevented. Predation of hatchlings by non-natives such as bullfrogs and largemouth bass is a problem, as is disturbance of nests by feral dogs and cats and unnaturally high urban populations of raccoons, skunks, and coyotes.

Many of these stresses exist at some level in areas surrounding the landfill, even in the protected wildlife area. DeLorenzo pauses, then offers, "This sounds like a really strange thing to say about a landfill, especially one that is burbling methane, but it is an absolutely critical wildlife habitat."

Vanessa Brock, a college student assisting with the turtle survey, points to where a prison will soon be built on filled wetlands next to the wildlife area. She shades her eyes against the sun and looks out over the glittering lakes to the soft green grasslands of the landfill on the opposite shore. She notes that as development presses closer, the undisturbed riparian edges and upland prairies of the landfill will become an even more important refuge. **EC**

The fringe of riparian forest near open water and an expansive grassland provide habitat for 97 species of birds.

Martha S. Mitchell, CPESC, is a natural resource planner and principal of Clear-Water West in Portland, OR.

New Buffalo, Michigan, 1983 (Before)

Beachfront Reinforcement

By Janice Kaspersen

The science and the industry of protecting eroding coastlines generate tremendous controversy. Some innovative erosion control methods, and a new spirit of cooperation among local beach protection projects and the Army Corps of Engineers, may be calming the waters.

On an undeveloped sandy beach, coastal erosion and restoration is an endless natural process. During storms, large swells remove sand from the frontal dunes and shift it offshore. The sandbars created or enlarged by this process dissipate wave energy, helping to reduce further beach erosion. In calmer weather, smaller waves move some of the sand back up onto the beach, rebuilding the frontal dune. Often this process is seasonal, with harsher winter storms tearing away beach sand and gentler summer waters nudging it back.

How much this process is aggravated, or even triggered, by human activity is a matter for debate. Some geologists and coastal engineers claim onshore development—buildings, parking lots, and erosion control structures themselves—speeds coastal erosion. Others say offshore coastal engineering practices, such as dredged navigation channels, breakwaters, groins, and jetties, are the worse culprits. Where a structure is—onshore or offshore—might be less important than how it affects the migration of sand.

Still, most experts agree on three things. First, coastal erosion—much of it, anyway—is a natural process. Second, it wouldn't be nearly the problem it is today if houses, roads, and other structures hadn't been built so close to the ocean on what is essentially a constantly moving line of demarcation between land and sea. Third, since these structures *do* exist in places they probably shouldn't, we somehow have to find ways to protect them.

As Martha Mitchell points out in her May 1999 article in *Erosion Control* ("Coastal Erosion: Truths Written in Sand"), treatments for shoreline erosion fall into three broad categories: hard (sea walls, groins, breakwaters); soft (beach nourishment and bioengineering); and preventative (zoning changes to prevent intrusive development from triggering or speeding up natural erosion). Coastal communities around the country are trying—and often combining—all three.

A Soft Solution Gaining Ground

Beach nourishment, an increasingly popular option, is the practice of adding material—from offshore or inland—to restore coastal areas lost to erosion and to protect landward structures. Done well, it is more than simply dumping sand onto the beach. It increases beach width or elevation, taking into account beach cross-section, shape of the offshore profile, present erosion rate, wave parameters, dune height, grain size of the imported sand (coarser is generally better), sediment characteristics, and many other factors. Sand can be placed directly onto the beach or seaward of the existing beach to create a sandbar or a submerged mound; bars and mounds reduce wave height and energy and are created with the expectation that the sand they contain will eventually be deposited onto the beach. The conditions that led to a net loss of sand before nourishment took place will likely continue, however, and maintaining a beach in this way is usually an ongoing process.

First used at Coney Island in 1922 and common in places where