Vetiver

A System To Mitigate Storm Damage and Control Water Pollution

Below: Vetiver Grass roots, showing the difference between the infertile, non-invasive *Chrysopogon zizanioides* (long root system) and a fertile variety native to SE Asia, *Chrysopogon nemoralis* (short roots), both after 12 months of growth.

The Vetiver System's Role In California: Infrastructure Protection, Soil Erosion Prevention & Comprehensive Water Pollution Control

The "Vetiver System" is an effective, low cost, multifunction bioengineering technology that protects infrastructure and wetlands by enhancing control over soil and water management. Vetiver is a uniquely dense, erect, deeply rooted clump grass that is infertile and non-invasive. Planting vetiver grass, *Chrysopgon zizanioides* (*aka Vetiveria zizanioides*) in slim hedges along the contour lines of sloped land reinforces the dynamic processes of water flow and sediment deposition. Global experience, including during Hurricane Mitch (Central America, 1998) confirms the ability of the Vetiver System to protect vital infrastructure from the effects of extreme weather events: http://www.vetiver.org/LAVN_disaster.htm. Several applications of the Vetiver System can provide protection from the effects of large scale, powerful storms in California. Buffer strips of vetiver grass around crops trap sediment and sediment-borne agrochemicals and keep them out of valuable wetlands. Constructed wetlands of vetiver grass can polish pre-treated wastewater effluents to a tertiary quality. Vetiver hedges are fire-resistant and can be used in fire breaks, continuing to protect against erosion even when burnt off. A summary of the Vetiver System was presented at the International Soil Conservation Conference in Brisbane, Australia in 2004: http://www.vetiver.com/AUS_Sediment.pdf

Vetiver hedges protecting hillside in Santa Barbara, CA

The Vetiver Network International (TVNI) is an international nonprofit 501(c)(3), non-government organization chartered in the state of Virginia, USA. Since 1989, TVNI's mission has been to support research on vetiver grass and its many applications, to document the uses of vetiver grass, and to disseminate that information widely through its website www.vetiver.org and through more than forty affiliated national level vetiver networks. In recent years, TVN has expanded its scope of activity to include applying the Vetiver System (VS) to specific problem areas. Technical advisors are available from TVNI to assist in project design and implementation. Additional information is available by contacting TVNI. Contact information for scientists familiar with vetiver grass applications is also available on request

S. China landfill before treatment

S. China landfill after vetiver treatment

Vetiver grass has a wide range of remarkable properties that are rarely found in a single species. A series of applications, collectively known as "The Vetiver System", can address a number of important soil and water conservation issues. This document summarizes those that are most relevant to California's problems and provides links to supporting documents.

Bridge protected by vetiver hedges

Prevention of mudslides after wildfires: Vetiver contour hedges continue to stabilize sloped land after a wildfire that strips the slopes of vegetation, even though the hedges may be burned to ground level. Recovery is swift. Meanwhile, the intact root mass of the hedge below ground level prevents slippage of the slope and disastrous mudslides. Experience in Australia, where seasonal brushfires are a problem, suggests that vetiver grass fire breaks would be appropriate in California: www.vetiver.com/TVN_Fire.pdf

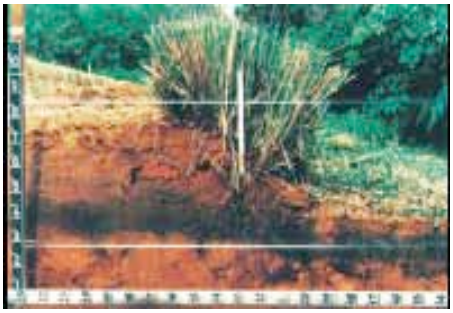
Comprehensive water pollution control: Contour hedges of vetiver grass on sloped land throughout the landscape control runoff and reduce soil loss by as much as 90%. Vetiver hedges planted as "buffer strips" around crops, such as cotton or sugar cane, trap soil particles and sediment-borne agrochemicals, preventing an important *nonpoint source* of pollution from migrating offsite. http://www.vetiver.com/PRVN_IVC2_19.PDF Constructed wetlands of vetiver can be managed to treat *point source* pollution, such as pre-treated wastewater effluents, to a tertiary quality. See http://www.vetiver.com/ICV3-Proceedings/AUS_sewage.pdf Even highly toxic landfill leachate can be intercepted and treated by vetiver hedges. http://www.vetiver.com/ICV3-Proceedings/AUS_Landfill.pdf This remarkable plant can help reduce water pollution *across the entire spectrum of sources*.

Protection of embankments: Vetiver contour hedges may be deployed to protect levees and the banks of canals and lakes against soil erosion from wave action from lateral water movement. How does vetiver do this? Vetiver's massive root system generally holds the upper 3-4 meters of soil in place and can not be dislodged by moving water. Vetiver roots have an average tensile strength of 75 MPa, which increases the average shear strength of the surrounding soil between 30 and 40%. The effect is to stabilize the levee, dam or other soil structure against scouring by water or wind. The use of the Vetiver System for dike stabilization on the Mekong river is documented in: http://www.vetiver.com/VNN_truong_jan2005.pdf

Protection of civil works: Vetiver grass planted at the interface between soil, concrete structures (culverts, drains, bridge supports) and moving water prevents undermining and loss of structural integrity. After years of testing, the ministries of transportation of five southern Chinese provinces have standardized on the Vetiver System to substitute for more expensive conventional civil works, such as bench terracing, gabions, masonry and concrete cladding of slopes and rip-rap. In Madagascar the vetiver system enables the third steepest railroad in the world to survive regular cyclones without significant interruption of service. See http://www.vetiver.com/ICV3-Proceedings/MAD_rail_stab.pdf2.pdf

The many applications that comprise the Vetiver System derive from the *special characteristics* of the plant that lend themselves to protection of infrastructure and control of water-related pollution:

- Vetiver grass has stiff, erect stems that enable a hedge to stand up to high velocity water flows and prevent scouring of the soil. The dense stems and leaves form a "filter strip", a porous barrier that traps soil particles and agrochemicals, such as pesticides that are adsorbed onto the particles;
- Fine, dense, penetrating roots anchor the soil profile up to four meters deep, preventing wind and water erosion of soils;
- Vetiver grass is a "climax" plant that recovers quickly from fire damage, but does not lose its ability to check soil erosion and prevent mudslides during the recovery phase, making it an ideal plant for *fire breaks*;
- Vetiver grass can be used in constructed wetlands as a biological sink for to remove residual N and P and other pollutants from pre-treated wastewater effluents;
- High tolerance to salinity (50% yield reduction at 20 dS/m; lethal at 45 dS/m) facilitates the use of vetiver grass to stabilize coastal dunes and beaches.
- Vetiver grass is an infertile, perennial, non-invasive plant that is incapable of migrating from its planting site or becoming a weed. The working life of a vetiver hedge is indefinite and requires little maintenance



Profile of a vetiver contour hedge

Above: More than 40 cm of soil has been trapped at the face (to the left) of this three year old vetiver contour hedge in Malaysia. The original soil level is indicated by the black subsoil band, while the white marker indicates the original centerline of the hedge, now 60 cm wide.

Wastewater effluent polishing (China)

Coastal dune stabilization (Viet Nam)

Canal bank protection (Viet Nam)

Special characteristics of Vetiver Grass

What makes vetiver grass special? The answer is found in the roots, in the plant's remarkable set of physiological and ecological characteristics and in its inherent ability to clone itself without becoming a weed and without attracting pests.

Vetiver grass has a massive, finely structured root system that is unique among grasses. With no rhizomes or stolons that spread to the sides, the plant's roots grow straight down in a mass as dense as the amount of leaves it produces above the ground. These roots generally penetrate 3 to 4 meters (depending on soil type) into the soil before thinning out. New roots and shoots develop from the root crown and from nodes on the stems when the plant is buried by trapped sediment at the face of a contour hedge. The plant continues to grow and fill in at the higher level of the newly deposited sediment, eventually forming a terrace that helps to retain soil moisture and reduce runoff.

Vetiver also has special characteristics that are useful in managing solid waste and wastewater. Vetiver is at home in a marsh environment: it tolerates anoxic environments and high concentrations of toxic substances such as heavy metals and ammonia that will kill most plants. Vetiver grass may be used in constructed wetlands to "polish" pre-treated wastewater effluents to a high quality or to intercept and treat highly toxic leachates from landfills or "brownfields" sites.

Physiological characteristics

Vetiver grass is a "climax plant," which survives extreme ecological conditions under which other plants perish: it will tolerate prolonged drought, fire, flood, submergence and extreme temperatures from -15°C to 55°C. In some cases it may be the only plant to survive. In a warm climate, such as Southern California, vetiver grass is capable of recovering quickly after being affected by drought, flooding, fire, frost and exposure to salt and adverse soil conditions.

Vetiver grass is adapted to an exceptionally wide range of pH. It can grow in soils with an acidity of 3.0 and can survive in alkalinities with a pH as high as 10.5 to 11. Vetiver can tolerate a high level of soil salinity, soil sodicity and acid sulfate, making it a uniquely hardy plant. For salt tolerance, refer to: www.vetiver.com/AUS_Salt%20Tolerance.pdf

Ecological characteristics

It is a general principle that plants intended for use in environmental protection or agriculture be investigated for their potential to become weeds or intermediate hosts for pests that affect economically important crops. Because the few seeds that vetiver grass produces are not viable and the absence of pests that affect it, the plant has been approved by the USDA for use in the US. "Sunshine" vetiver is the name of the Louisiana variety of *Chrysopogon zizanioides.* After several years of observation, it was officially released in 1995 by the USDA Golden Meadow Plant Material Center in Louisiana. Refer to http://plant-materials.nrcs.usda.gov/lapmc/releases.html The South Eastern Exotic Pest Plant Council, declared in May 2001 that "Sunshine", vetiver, i.e., *Chrysopogon zizanioides,* is acceptable because of its non-invasiveness for use in the southeastern region of the US. Refer to: www.se-eppc.org/fslist.cfm.
See also http://user.aol.com/vetivernet/vip/dnadiv.htm and http://www.vetiver.org/USA-USDA-NRCS_Sunshine.pdf

Because of its special characteristics, vetiver grass can be considered as a "nurse plant" on wastelands or disturbed soils, where it may be the *only* plant that will grow in that setting. Planted as a single or series of contour hedges, vetiver grass stabilizes the erodible ground and creates a micro-climate that favors the re-establishment of native plants. The Vetiver System is used to remediate mine sites and to stabilize highway and railway embankments, bridges, and even to rehabilitate rock quarries. After native trees and shrubs have established themselves on these sites, they begin to shade the vetiver hedge, replacing it as the stabilizing agent. Consequently, vetiver is highly regarded as a non-invasive pioneer plant useful for land rehabilitation.

Vetiver System in California: Infrastructure Protection, Soil Erosion Prevention and Comprehensive Water Pollution Control

This image shows the massive root zone of an 18 month old clump of Vetiver grass from Southern China. Note that the roots are fine, fibrous, vertical in orientation, and without lateral roots.

The leaves and stems have been cut off the top. The clump itself is composed of several hundred individual "slips", or sprigs, that grow side by side to make up the clump.

When planted in hedges along the contour of slopes, the massive underground root zone creates vertical barriers as deep as four meters that prevent slippage of the soil on the slope.

Vetiver grass is not invasive, has infertile seeds, and does not have lateral roots. Vetiver hedges remain in the same place and do not move without human intervention. With minimal maintenance, they last for generations

Flume trial by USDA-ARS in 1991 showing water backed up 30 cm high behind the hedge, demonstrating the effect of its dense, stiff stems on water flow

vetiver contacts

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***Santa Barbara**. The owners wanted to plant fruit trees and vegetables on this steep hillside, but needed to protect the slope. With the Vetiver System, not only have they been able to do the planting, but also the house is now protected from damage from intense storm runoff and slope slippage. Shear strength was improved up to 40%.*

In California there are at least 50 applications of the Vetiver System for slope stabilization, where properly applied they have been successful and have achieved the original objectives.

Drainage canals in Quang Ngai, Vietnam using vetiver protection

Before hedges

After hedges