



The Flood-Tolerance of Trees

Physiological responses and tolerance mechanisms of trees to flooding were studied extensively from the 1940's through the mid-1970's. These studies helped foresters understand the impact of flooding on trees and suggested future investigations. But the state-of-the-art has not developed sufficiently to issue a precise statement on the adaptability of a species to a specific flooding situation. In fact, conclusions are often at variance.

Such apparent discrepancies are caused by the physiological responses of the tree as it interacts with environmental conditions. Since these interactions are not well understood, predictions of flood tolerance must be in general terms. A look at tree and flood characteristics indicates the complexity of interactions. Various characteristics of a tree and how they affect tolerance to floods follow:

Height — Tree height, as compared to water depth, is the most obvious. Injury increases as water covers foliage. Some species that survive months standing in several feet of water may succumb in less than a month when foliage is completely covered.

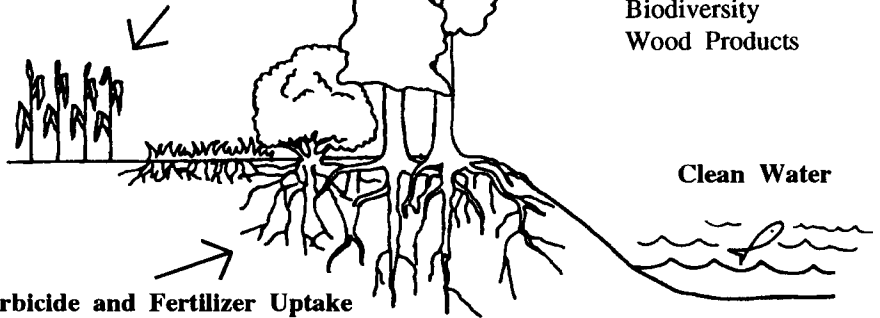
Vigor — Flood tolerance generally increases with the age of the tree, until it begins to lose vigor with overmaturity. Healthy, vigorous trees show the greatest resistance to flooding and saturated soil. Both the very small and overmature tree classes show the greatest susceptibility. Insect and disease attacks and adverse soil conditions also affect vigor, as do excessively wet or dry soils or soils with poor permeability.

Roots — Survival and growth of flooded roots are indicative of a species' ability to adjust to long periods of floods. Some species maintain normal roots in an active or dormant condition. Others rely upon new secondary and adventitious roots that may form from the root collar or

(See *Flood Tolerance* on page 5)

Riparian Buffer Zone

Herbicide and Fertilizer Addition



Herbicide and Fertilizer Uptake and Filtering By Root System

Other Benefits:
Soil Conservation
Wildlife
Biodiversity
Wood Products

The Growing Concern Over Water Quality

For the past several decades, water quality has been a growing concern worldwide. In the United States, the concern has heightened enough to prompt legislative action to deal with the problem.

The Water Pollution Control Act of 1948, or "Clean Water Act", and its subsequent amendments through 1987 have demonstrated strong Congressional determination to improve the quality of our water resources. These laws aided the identification and clean-up of point source contaminants by requiring states to establish and enforce water quality standards by requiring specifications and licensing for discharge of effluents and by funding the installation of municipal sewage treatment plants.

With the point source pollutant problem improving, attention has now turned to a more difficult problem,

addressing nonpoint source pollution. Nonpoint source pollutants are more difficult to trace to specific locations since they enter our water supply as components of run-off and ground water flow. Currently, nonpoint source pollutants such as sediment, nutrients, pesticides, herbicides, and animal wastes account for more than 75 percent of the pollution in our nation's waters.

Best Defense

Although there has been intensive efforts to reduce fertilizer application in fields, we are still faced with the impossibility of stopping all erosion of sediments, chemicals, and wastes from upland sites. In addition to in-field practices, we still need to provide buffer or catch zones for these pollutants before they reach our streams,

(See *Water Quality* on page 5)

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Message From the Manager

A column of important events and programs
as reported by CSA Program Manager Bill Rietveld

It's Been A Big Year

As we wind up our second fiscal year as a Center, there are a lot of accomplishments to reflect on. We have finally reached the stage where we are reporting to you what we are accomplishing, rather than what we are preparing to do. Also, it's important to emphasize that it's a capital *WE*, because most of the accomplishments are team accomplishments — Center research and technology transfer folks working together with numerous cooperators and partners.

As envisioned, the Center is now a fully integrated program, linking the activities of Forest Service Research and State and Private Forestry (S&PF) — in support of our mission to advance the use of agroforestry in sustainable land use systems. This is a cornerstone accomplishment, and we gratefully acknowledge the support and commitment to agroforestry from S&PF. We feel strongly that this "Center of Excellence" approach will enhance efficiency and leverage funding through partnerships and client involvement, for everyone's benefit.

We accomplish the Center's research mandates in two ways: 1) in-house research by our Research Work Unit, and 2) through multidisciplinary research teams. The in-house research effort is solidly on track developing genetically stress and pest resistant, multi-purpose conservation trees and tree health management systems for rural and community environments. During the past year we have made great progress in forming multidisciplinary research teams to accomplish our additional research responsibilities mandated in the 1990 Farm Bill. These teams include: 1) riparian buffer systems — to protect water quality; 2) modeling of agroforestry systems — to evaluate the benefits of agroforestry under different climate change scenarios; 3) drought tolerance screening — application of ecophysiology techniques to accelerate screening tree genotypes for drought tolerance; 4) propagation of genetically pest resistant conservation trees; 5) interactions between agroforestry systems and agricultural crops; and 6) integrated conservation/production systems

— a cooperative agroforestry R&D effort with INIFAP scientists in northern Mexico. The basic formula for these teams, consisting of university, agency, and NGO partners, is to focus on a project, obtain funding from various sources, and do the work together. These team efforts leverage our funding and human resources two to one, and will support numerous graduate students, post-docs, interns, and university faculty working together to attain team goals. The role of the Center is to catalyze and facilitate these team efforts.

Noteworthy technology transfer accomplishments to date include: establishing 18 cost-shared agroforestry demonstrations in ten states and funding another 20 in eight states, to be established next spring (38 total to date); contracting eight assessments of the potential of agroforestry in sustainable land-use systems; and a "Working Trees in Agriculture" display and leaflet (in cooperation with Northeastern Area S&PF) for the National Farm Progress Show. Attendance at the show is expected to surpass 300,000. Again, it is important to emphasize that these are team accomplishments that would not be possible without the vital support and participation by State Foresters, Soil Conservation Service, Soil and Water Conservation Districts, university cooperators, and State and Private Forestry specialists in Washington, D.C., Forest Service Regions and Northeastern Area. In addition, the Center has maintained the flow of current and useful information in the form of *Inside Agroforestry*, our quarterly newsletter, articles in other newsletters, publications, presentations, news releases, and a soon-to-be-released conservation tree planting video.

With new partnerships being formed, we expect the accomplishments to increase geometrically in future years. I'm very excited and proud of what has been accomplished so far and the prospects for the future. People wonder how our small team can accomplish so much. The answer is, it's a capital *WE* (teamwork), plus involvement, partnerships, cooperation, and networking.

Agroforestry and Sustainable Systems — Call for Poster Papers

Agroforestry and Sustainable Systems, a symposium designed for researchers, practitioners, technical specialists, and educators, will be held August 7-10, 1994 in Fort Collins, Colorado. It will focus on how trees, integrated into sustainable agricultural land-use systems in the semiarid west, will enhance agricultural productivity, natural resource conservation, and natural and human environments.

Symposium sponsors invite submission of volunteer poster papers that address the general theme of *Agroforestry and Sustainable Systems*. Papers may report domestic research, technology transfer, innovative applications, surveys, education, and training activities.

The abstract should be no longer than one page and emphasize objectives and results.

Due to limited space available, **all posters must be submitted for approval by February 15, 1994. Final abstracts are due by May 1, 1994.**

To submit an abstract or for more information on poster papers, contact: Bruce C. Wight, SCS, National Windbreak Forester, 100 Centennial Mall North, Room 152, Lincoln, NE 68508-5315, 402-437-5315.

For more information on the Symposium, contact: Kim Isaacson at the Center.

Agroforestry's Role in Clean Water — A Kansas Point of View

By John K. Strickler

Extension Forester, State and Extension Forestry
Kansas State University

The role of forest lands and forestry practices on water quality and quantity in forested watersheds has been well researched and documented. However, the role of Great Plains forests and their management from the water quality standpoint has not been well researched nor given extensive consideration. Perhaps because of the relatively scarce and scattered nature of forests in the Plains, it was felt that their impact on water quality would be quite minor. Yet, I hope to encourage you to give this issue more thought and consideration.

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— John K. Strickler

There is little doubt in my mind that water quality and quantity issues are going to be one of the major, if not *the* major, driving force in Great Plains agriculture in the '90's. More specifically, the issue of forestry and nonpoint source pollution is the water quality issue that agriculture and forestry must address.

When we in Kansas hear the term “nonpoint source pollution,” we tend to think of our major land uses — agricultural cropping with associated soil erosion and fertilizer and pesticide use — or maybe urban runoff. We seldom think much about trees and forests as a factor. Yet, while making up only three percent of the total land area in Kansas, forests can play a significant role in the control of nonpoint source pollution. Most significant are the streamside or riparian woodlands that are receiving increased attention nationwide.

In the Great Plains, the bulk of the natural forests occur as riparian vegetation adjacent to streams. These woodlands are a buffer between the stream channel and the major land use

-- cropland, range, or pastureland in most cases. In eastern Kansas, these riparian forests are more extensive, but as we move west, they become more closely confined to the streambanks. In more arid regions, the riparian vegetation often becomes shrubs and native grasses.

Riparian forests or buffer strips lying between the stream and cropland have a number of positive effects on water quality. They:

- Tend to slow and spread the water flow during flooding, leading to silt deposition within the riparian zone rather than in the stream.

- Act as filter strips by trapping sediment and absorbing water runoff from adjacent cropland before it reaches the stream.

- Serve as buffers or traps to hold nutrients and pesticides from overland runoff and shallow groundwater zones. One study showed wooded riparian areas as narrow as 50 feet wide removed most nitrogen flowing through from cropland.

- Stabilize streambanks and thus reduce the sediment load created by rapid bank erosion.

- Provide extremely valuable wildlife habitat — for both game and non-game species, including migratory songbirds. These streamside forests support the most diverse variety of wildlife of any habitat type in the Great Plains.

- Help to make streams suitable for diverse fish and aquatic populations. By shading and maintaining lower water temperatures in summer and higher temperatures in winter, these forests create a more suitable climate for complex aquatic ecosystems.

- Provide other benefits such as timber products and recreation.

I am suggesting here that forested buffer or filter strips should be considered as a possible best management practice (BMP) for cropland to reduce nonpoint source pollution. Retention and establishment of riparian forests are factors that should be part of many water protection plans in the Great Plains.

The first priority on accomplishing this should be on maintaining and properly managing existing riparian forests. Clearing vegetation and channelizing streams create serious erosion and flooding problems and the

solutions are very costly. Where riparian vegetation has been eliminated, re-establishment of forested filter strips is an option that should be considered. On the other hand, retention and proper management of these forests is relatively cheap and easy. Proper management can provide for selective and controlled harvesting of timber, though within the immediate streamside zone, water quality considerations should be given top priority.

Grazing in riparian forests is another issue I'd like to address. Restriction, or preferably elimination of grazing from riparian woodlands can be highly beneficial to water quality. Grazing eliminates ground cover and natural forest reproduction as well as greatly diminishing the absorption qualities of forested soils.

Of course, cattle watering and feeding in the riparian forest zone can also contribute to water quality problems by providing direct entry of livestock waste into the water. We need to explore cost-share alternatives and incentives to encourage landowners to change grazing practices in streamside forests. These might include:

- Planting trees away from the riparian zone to provide alternative livestock shelter.

- Cost-sharing for fencing of riparian zones to exclude livestock.

- Cost-sharing on alternative water supplies away from the stream.

I realize that this will not receive instant acceptance, but if we are serious about non-point source pollution, we have to objectively look at alternatives to current practices.

I also realize that the emphasis in many cases on nonpoint source pollution is going to be on cropland treatment and management — as it should be. We Great Plains foresters are used to being considered a little different or odd in an agriculturally dominated environment. But I would urge you to give full consideration to the role that trees, forests, and forestry can play in Great Plains water quality efforts. They can be valuable and useful tools as we address the nonpoint source pollution problem. In fact, I believe that the interface of the water quality issue with forests presents one of the greatest opportunities for Great Plains forestry in all of my 32 years in Kansas.

Hospital Gets 2,900-Tree Windbreak

Editor's note: The Agroforestry Center is working with numerous cooperators throughout the Great Plains to establish demonstrations of needed agroforestry practices under local conditions. This article illustrates the value that the demonstrations will have to the economy, environment, and people.

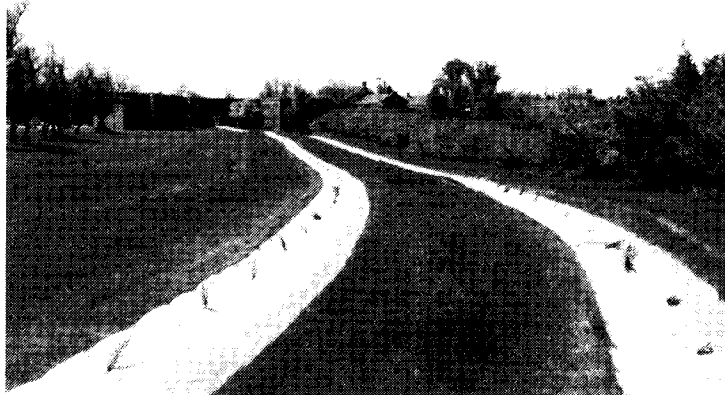
Even with all of the flooding in Iowa this spring and summer, Woodward State Hospital and School in Woodward, Iowa, got its windbreak. Over 362 full-time mentally and physically handicapped residents and about 800 full-time local employees will benefit from the renovation

and expansion of a declining two-row windbreak around their facility.

The hospital is located on 80 to 90 acres of ground and is the largest employer in the area. It contains local industry, classrooms, and living quarters for employees and patients. In cooperation with the Iowa Department of Natural Resources and the Center for Semiarid Agroforestry, the hospital has expanded a struggling two-row honeysuckle windbreak by adding two rows of

eastern red cedar and one row of a norway spruce/white pine combination.

One of the things that John Walkowiak, Urban Forester with the Iowa Department of Natural Resources, really likes about the project is its large size. He says that the grounds are like a community in itself and in order to expand the windbreak, the facility gave up approximately 11 acres of



The struggling two-row honeysuckle windbreak around Woodward State Hospital and School has been expanded into five rows by adding two rows of eastern red cedar and one row of a norway spruce/white pine combination.

high-quality farmground. The break will now stretch 2 1/2 miles around the entire facility and will add much needed density and height to the existing windbreak.

Despite the constant rain, 2,900 trees were planted the first week of May during a three-day dry spell. Walkowiak says that "I sure wish that the weather would give us a break" because inbetween storms they are still trying to put down the remaining 1/3 of the fabric weed barrier that needs to be applied. As of this writing, they have had a 90 percent tree survival rate and haven't had to water the trees much yet.

Wood chip mulch will be put on part of the break while the remainder will be left uncovered. This will be a good test to see if wood mulch is needed, in combination with light or dark colored fabric, to minimize weed competition. So far, with the abundant rainfall, the light colored fabric has held up well. However, in some places grass is growing underneath and has pushed the fabric up. Late this summer, plans were to to restable and put down one to two inches of wood mulch.

The windbreak will provide wind and snow protection, beautify the landscape, and increase wildlife habitat for the hospital. It will aid in reducing utility bills, conserving energy, and lowering snow removal costs. The planting and maintenance will primarily be supplied by the normal grounds crew but will involve some of the residents that are physically capable of volunteering.

The project will further serve as a technology transfer demonstration site of proper use of conservation forestry tree planting and maintenance for use by natural resource professionals and as a public awareness demonstration for what conservation tree plantings can do for communities.

New Hope for Chestnuts and Elms

A breakthrough discovery by scientists at the Roche Institute of Molecular Biology could result in restoring native chestnuts to the American landscape. Chestnuts have virtually disappeared since a fungal disease was accidentally introduced from Asia in 1904. The new discovery uses a genetically engineered virus that alters the genetic makeup of the chestnut-killing fungus, reducing its virulence. Because of the reproductive abilities of the blight-fighting virus, scientists hope that once introduced, it will spread naturally, enabling the return of American chestnuts. The method used for manipulating the genetic machinery of these microscopic organisms also shows promise for use as a natural control of Dutch elm disease and various agricultural disease problems. Permission for greenhouse and field trials is being sought from the USDA, with three to five years predicted for completion of the tests.

Source: Arbor Day, January/February, 1993

on the trunk near the water surface. Species unable to maintain normal roots or grow new ones quickly die.

Recovery — Rate of recovery following drainage is a factor in tolerance. Trees need to build up food reserves for future stress conditions — flood, drought, insects, and diseases — and young trees must produce height growth to get their foliage above flood levels. Environmental conditions often limit recovery. If the soil drains rapidly, and soil moisture is maintained near field capacity, the surviving root system will initiate new growth and recovery will be rapid. However, if the soil remains saturated, the root system may deteriorate. At the opposite extreme, if soils dry quickly because of drought conditions, adventitious roots may be of little benefit. The tree is then dependent upon survival of the secondary root system.

Variations — Little is known about tolerance variations within a species. Flood tolerance may well be an inherited trait that could explain the discrepancies in reports on survival.

Determining flood tolerance is further complicated by the diverse characteristics of floods. These include: the season, duration of flooding, water level, left-over sedimentation, temperature and oxygen content of flood waters, and mechanical injuries left by the flood.

Trees often recover rapidly from slight injuries, such as twig dieback. Although flood injuries vary, other early symptoms include leaf-tip and stem twisting, red coloration, chlorosis, and leaf wilting. Dieback of roots and twigs and the formation of dead spots in the bark may follow, and if flooding continues, the entire tree eventually dies. Some trees may not follow this pattern; leaf wilting can be followed directly by the death of the tree. With these more severe injuries, recovery may take a year or longer. Reduction of vigor may render a tree unusually susceptible to adverse environmental conditions. Until vigor is restored, such a tree is especially susceptible to insect and disease attacks, drought, and additional flooding.

Source: Adapted from "Flood-Tolerant Tree," *Journal of Forestry*, March, 1987, by William L. Loucks, Extension Forester, Environmental Forestry, Department of Forestry, Kansas State University.

ivers, and lakes.

Riparian forests provide this buffer zone. Extremely complex ecosystems, riparian forests play a major role in controlling nonpoint source pollution.

Riparian Areas

Recent research has shown that riparian forests improve the quality of water resources in several ways. They function simultaneously, as filters, sources, transformers, and sinks.

As a *filter*, riparian forests remove sediment and other suspended solids from surface runoff. Sediment is the most common and most easily recognized of nonpoint source pollutants. Sediments suspended in water reduce or block penetration of sunlight, thereby adversely affecting the growth and reproduction of beneficial aquatic plants.

Sediment deposited on stream bottoms interfere with the feeding and reproduction of bottom dwelling fish and aquatic insects, weakening the food chain. Large deposits of sediment fill river and stream channels and floodplains, thereby increasing the potential for flooding.

Several mechanisms of sediment removal are at work in the riparian forest. Some sediment settles as the flow speed is reduced by the many obstructions encountered in the forest litter. Additional sediment is filtered by the porous soil structure, vegetation, and organic litter as the runoff flows over and into the floor of the forest.

Phosphorous is also reduced by the filtering action of the forest. Since phosphorous will bond to small soil particles, approximately 80 percent can be trapped with the soil particles as they move through the forest buffer.

Riparian forests function as a *source* when they provide energy to streams in the form of dissolved carbon compounds and particulate organic detritus. These materials are critical to processes within the stream itself, helping to restore and maintain nature's equilibrium. Benthic detritivores, the stream bottom bacteria, fungi, and invertebrates that feed on the detritus, form the basis of the aquatic food chain. They pass on energy when they are consumed in turn by larger benthic fauna and eventually by fish. Thus, the stream-side forest functions as an important energy source for the entire aquatic food chain from the headwaters to

estuary.

Riparian forest buffers function as a *transformer* when chemical and biological processes occurring within the forest change the chemical composition of compounds. For example, under oxygenated soil conditions, bacteria and fungi in riparian forests convert nitrogen in runoff into mineral forms. These forms of nitrogen then are synthesized into proteins by plants or bacteria. When soil moisture creates aerobic conditions in the litter and surface soil layers, denitrifying bacteria convert dissolved nitrogen into various nitrogen gases, returning the gases to the atmosphere.

These forests also transform toxic chemicals such as pesticides to non-toxic forms. Because of continued improvements in the formulation and management of pesticides, only small amounts leave the area of application. Pesticides in runoff are converted to non-toxic compounds by microbial decomposition, oxidation, reduction, hydrolysis, solar radiation, and other biodegrading forces at work in the soil and litter of riparian forests. While scientists have understood the biological processes at work in the forest, additional data are necessary to fully quantify their importance with respect to pesticide degradation.

Finally, riparian forests can function as a *sink* when nutrients are taken up by plants and sequestered in plant tissue. Estimates indicate 25 percent of nitrogen removed by forests assimilated in tree growth, which is stored for extended periods of time in woody tissue and possibly removed as logs or other forest products. Nitrogen and other nutrients also pass through the food chain when plant tissues are consumed by animals and converted to animal tissues. In wetter areas, nutrients in leaf litter can be stored for longer periods as peat.

There are other benefits of riparian forests that are easier understood, such as wildlife habitat, recreation, aesthetics, and timber production, but the benefits less often seen, like improving nonpoint source pollution, could be the most important to humankind in the long haul.

Source: *Growing Green Forestry Newsletter*, July/August, 1993