CITY OF BATTLEFIELD, MISSOURI
INDIVIDUAL SMALL MS4 STORMWATER MANAGEMENT PROGRAM

2004
PUBLIC EDUCATION

CITY OF BATTLEFIELD, MISSOURI
INDIVIDUAL SMALL MS4 STORMWATER MANAGEMENT PROGRAM

2004
WATER QUALITY

FOR MORE INFORMATION ABOUT:

Proper Disposal of Hazardous Wastes, Call:
(702) 734-5400 Environmental Technologies

Heavy Item Pickup Service, Call:
(702) 735-5151 Silver State Disposal

Plaque Attack Campaign, Call:
(702) 262-9047 Ext. 5
Clark County Conservation District

To Report Illegal Dumping, Call:
(702) 383-1027 Clark County Health District
Internet: www.cchd.org

Plaque Attack Campaign

Sponsored by

Conservation District of Southern Nevada
Regional Flood Control District
Nevada Division of Environmental Protection
Bus Stop Shelters of Nevada
Southern Nevada Water Authority
Moapa Valley Water District
Virgin Valley Water District
Neenah Foundry Company
City of Las Vegas
City of North Las Vegas
City of Henderson
City of Mesquite
Clark County
Anderson Dairy
Jensen Precast
3M

Clark County Conservation District
2357-A Renaissance Drive
Las Vegas, Nevada 89119
PHONE: (702) 262-9047 Ext. 5
FAX: (702) 736-7415
E-MAIL: cccd@earthlink.net

HOW CAN I HELP THE CONSERVATION DISTRICT?

We are always looking for volunteers to help protect our natural resources. If you would like to help, give us a call.

Prevent Stormdrain Pollution

Plaque Attack Campaign

STORMWATER QUALITY EDUCATION PROJECT

The Stormwater Plaque Attack Campaign is an important public awareness program to alert residents that dumping litter and hazardous materials into storm drains is harmful to our environment.

Storm drains are located throughout Clark County. Drains remove excess water from streets during rainy weather. Water from the storm drains flows through our washes to Lake Mead.

Plaque Attack Campaign

poured down storm drains have a negative impact on our environment.

Items most often dumped in storm drains:

REFUSE OR TRASH

Refuse and trash dumped into washes clog channels and can increase the possibility of flooding.

MOTOR OIL

When used motor oils are poured down storm drains, they flow to Lake Mead and may harm or kill underwater vegetation and aquatic life. One quart of oil can contaminate up to 250,000 gallons of water.

PAINT, ANTIFREEZE, PESTICIDES

These products can be toxic to wildlife and the environment when not disposed of properly.

FERTILIZER

Fertilizers can increase the growth of algae and reduce the amount of oxygen in the water needed by aquatic life.

THINGS YOU CAN DO

Small actions can influence the health of water. As a resident, you can:

JOIN THE EFFORT

Educate our community about storm drains.

AVOID RUNOFF

Yard chemicals and fertilizers can wash into ditches and storm drains. Use lawn and garden chemicals carefully. Avoid excess or unneeded applications.

PREVENT SOIL EROSION

Plant grass, trees, shrubs, flowers, or use bark chips, decorative rocks or other mulch to prevent soil erosion. Retain vegetation and organic matter such as pine needles on slopes. Plan your landscape to soak rainwater into the ground instead of running off.

CHECK YOUR CAR FOR FLUID LEAKS

Place a drip pan under your car. Oil or other leaking fluids can be absorbed with kitty litter and put in the trash.

RECYCLE USED AUTOMOTIVE OIL

Properly dispose of chemicals, oil, paint, antifreeze, or other toxic materials. Participate in Clark County's household hazardous waste collection events.

WASH CARS CAREFULLY

Wash cars with biodegradable soap, or at a commercial car wash that filters and recycles wash and rinse water.

CLEAN UP AFTER PETS

Dispose of pet waste in the trash.

ILLINOIS WATER ENVIRONMENT ASSOCIATION

The Illinois Water Environment Association (IWEA) is a member association of the Water Environment Federation, an educational and technical organization made up of 67 Member Associations throughout the world dedicated to protecting and preserving our global water environment. The IWEA was formed in 1980 to advance the fundamental knowledge of the water environment to help preserve and enhance the quality of Illinois' water resources. By stimulating public awareness of the relationship of our water resources to the public welfare, and the need for pollution prevention, resource recovery, preservation, conservation, and reuse of our water resources, we can help accomplish our mission.

NONPOINT SOURCE WATER POLLUTION
A CITIZEN'S PRIMER

What's the problem? Pollutants enter our rivers, streams and lakes from two primary sources. One source is the direct introduction of pollutants into water bodies from specific point sources such as the discharge pipes from factories and wastewater treatment plants. The other is called nonpoint source (NPS) and primarily occurs when water runs over land or through the ground, picks up pollutants, and deposits them in surface waters or introduces them into groundwater. Although less extensive than over land runoff, atmospheric pollutants directly deposited onto water bodies is another type of NPS pollution.

Can it be controlled? Point source pollution can be monitored and controlled. In contrast, NPS pollution comes from many diverse sources and consequently, controlling it is harder. Because it does not originate from industrial or municipal pipes that can readily be monitored, such pollution has largely been uncontrolled and unregulated. Today, NPS pollution remains the nation's largest source of water quality problems. The Illinois EPA, in their 1998 Environmental Conditions Report, indicates that 43.7% of the state's surveyed streams and rivers and 75.4% of inland lake acres assessed are impacted by nonpoint sources.

What are the sources? Major nonpoint sources of pollution in Illinois include excess farm and lawn chemicals that enter groundwater through the soil or into surface waters directly during heavy rains; storm water from paved surfaces in commercial and residential areas; uncontrolled storm water from construction sites; animal wastes; forestry operations; resource extraction; improper disposal of household and automotive products; leachate from land disposal operations and pollutants released directly into the atmosphere.

What are the pollutants? NPS pollutants include nutrients such as phosphorus and nitrogen from fertilizers; pesticides from agricultural lands; soils from construction sites, eroding stream banks and farmlands; salts from winter road deicing; petroleum hydrocarbons from leaking storage tanks and automobiles; trace metals and toxic chemicals from inadequately protected landfills; and airborne sulfur, nitrogen, PCBs, dioxins, mercury and other toxic metals from power plants, incinerators and cement kilns.

What are the effects? These pollutants contribute chemicals to our drinking water supply; cause oxygen depletion that affects aquatic life; block out sunlight that reduces plant growth and spawning areas for fish; pose a toxic threat to wild and domestic animal life; and provide for unsafe swimming and recreational areas.

What's the solution? Education and public involvement are the keys to effective solutions. We all bear responsibility for controlling and preventing NPS pollution. From the individual home owner to the public official, everyone has a stake in protecting our resources. So the solution begins with us. There are lots of ways to reduce and prevent NPS pollution. You can start by taking a close look at your family's life style and the practices around your home that might contribute to polluted runoff. Then look at the "Big Picture": land use practices in your watershed and local controls necessary for water quality protection.

What can you do? See over for guidance on what you, your family and your community can do.

What Can You and Your Family Do?

- Conserve water (reduce water used for landscape maintenance, yard equipment and car washing, etc.).
- If you have a septic system, inspect it annually and have it pumped out regularly.
- Learn your watershed address: the streams, rivers and lakes that receive runoff in your community.
- Use clean boating and fishing practices on our rivers and lakes.
- Don't litter since it is easily washed or blown into ditches and storm sewers.
- Car pool or take public transportation to reduce air emissions and gasoline leaks.
- Check for drips under your car and repair leaks to keep oils off pavements.
- Properly dispose of (or better yet recycle) used motor oil and other petroleum products.
- Reduce, Reuse and Recycle to keep wastes out of landfills and incinerators.
- Use pesticides sparingly and only after considering more natural methods.
- Limit fertilizer use on lawns and gardens or use natural fertilizers like compost.
- Only purchase the amounts of yard and garden chemicals needed for the year.
- Seed or mulch areas where soil can wash away to control erosion and runoff.
- Protect all vegetation that grows along ditch and shore lines to provide a "buffer strip."
- Clean up pet wastes to prevent nutrients and bacteria from washing into ditches and storm sewers.
- Never burn yard waste near ditches or lakes since ashes are high in nutrients and are easily blown away.
- Consider using yard waste on-site as mulch or compost.
- On icy pavements, first try chipping ice off. Use salt and sand sparingly.
- Limit hazardous products used by planning your purchases and buying the right amount for the job.
- Share or donate excess household hazardous products or safely dispose of them at collection sites.
- Conserve electricity to reduce power plant emissions.

What Can You and Your Community Do?

- Organize or join a local watershed planning and management committee. Contact your county Soil and Water Conservation District for information on existing committees or on how to organize one.
- Support the creation of stormwater utilities and user charge rate structures to provide capital projects and enhanced maintenance for improved flood control, capital projects for water quality control, and water quality management.
- Encourage land use planning to reduce the effects of urban sprawl.
- Encourage storm water management practices that reduce runoff pollution by allowing water to soak into the ground or by storing it in ponds or by reducing pollutants at their source through land use controls.
- Ensure that construction site soil erosion and sedimentation control ordinances are enforced and that permits are obtained from the Illinois EPA when required.
- Help organize and support community-based Household Hazardous Waste Collection sites.
- Advocate the conservative use of salt and sand for winter road maintenance. Promote the use of "anti-icing" techniques that apply de-icing compounds before precipitation to prevent ice from bonding to pavements.
- Support agricultural land and animal waste "best management practices" in your watershed.
- Support wetlands' preservation since they act as natural filters of pollution, provide habitat for threatened and endangered species and flood control.

If you would like further information about nonpoint source pollution problems and recommended prevention practices, or any of the other programs of the ***Illinois Water Environment Association***, write the ***IWEA***, P. O. Box 337, West Chicago, IL 60186-0337, telephone Larry Ziemba at 618/993.7200, or visit our web site http://chipsnet.com/users/iwea (our web site will be changing in late 1999, so contact us for the new address.)

Remember Only You Can Prevent Nonpoint Source Pollution

United States Environmental Protection Agency

Office of Water (4503F)

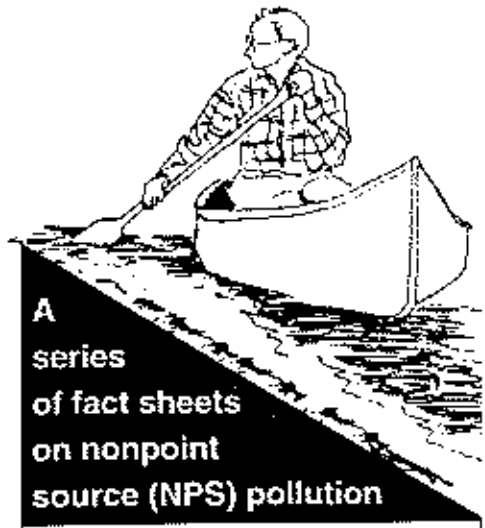
EPA-841-F-96-004A
March 1996

EPA Nonpoint Pointers

Understanding and managing nonpoint source pollution in your community

Pointer No. 1

Nonpoint Source Pollution: The Nation's Largest Water Quality Problem



A series of fact sheets on nonpoint source (NPS) pollution

Why is there still water that's too dirty for swimming, fishing, or drinking? Why are native species of plants and animals disappearing from many rivers, lakes, and coastal waters?

The United States has made tremendous advances in the past 25 years to clean up the aquatic environment by controlling pollution from industries and sewage treatment plants. Unfortunately, we did not do enough to control pollution from diffuse, or nonpoint, sources. Today, nonpoint source (NPS) pollution remains the Nation's largest source of water quality problems. It's the main reason that approximately 40 percent of surveyed rivers, lakes, and estuaries are not clean enough to meet basic uses such as fishing or swimming.

NPS pollution occurs when rainfall, snowmelt, or irrigation runs over land or through the ground, picks up pollutants, and deposits them into rivers, lakes, and coastal waters or introduces them into ground water.

Imagine the path taken by a drop of rain from the time it hits the ground to when it reaches a river, ground water, or the ocean. Any pollutant it picks up on its journey can become part of the NPS problem. NPS pollution also includes adverse changes to the vegetation, shape, and flow of streams and other aquatic systems.

The most common NPS pollutants are soils and nutrients that wash into water bodies from agricultural land, construction sites, and other areas of disturbance.

NPS pollution is widespread because it can occur any time activities disturb the land or water. Agriculture, forestry, grazing, septic systems, recreational boating, urban runoff, construction, physical changes to stream channels, and habitat degradation are potential sources of NPS pollution. Careless or uninformed household management also contributes to NPS pollution problems.

The latest *National Water Quality Inventory* indicates that agriculture is the leading contributor to water quality impairments, degrading 60 percent of the impaired river miles and half of the impaired lake acreage surveyed by states, territories, and tribes. Runoff from urban areas is the largest source of water quality impairments to surveyed estuaries (areas near the coast where seawater mixes with freshwater).

Three Leading Sources of Water Quality Impairment

Rank	Rivers	Lakes	Estuaries
1	Agriculture	Agriculture	Urban runoff
2	Municipal point sources	Municipal point sources	Municipal point sources
3	Stream/ habitat changes	Urban runoff	Agriculture

Source: National Water Quality Inventory, 1994

NPS pollution occurs when water runs over land or through the ground, picks up pollutants, and deposits them in surface waters or introduces them into ground water.

RELATED PUBLICATIONS

- Additional fact sheets in the Nonpoint Pointers series (EPA-841-F-96-004)
- EPA Journal, Vol. 17, No. 5, Nov/Dec 1991, (EPA-22K-1005)
- Managing Nonpoint Source Pollution: Final Report to Congress on Section 319 of the Clean Water Act (EPA-506/9-90)
- NPS News-Notes (EPA-841-N-92-003)
- Polluted (EPA-841-F-94-005)
- The Quality of Our Nation's Water: 1994 (EPA-841-S-95-004)
- The Watershed Protection Approach (EPA-503/9-92/002)

To order any of the above EPA documents call or fax the National Center for Environmental Publications and Information.

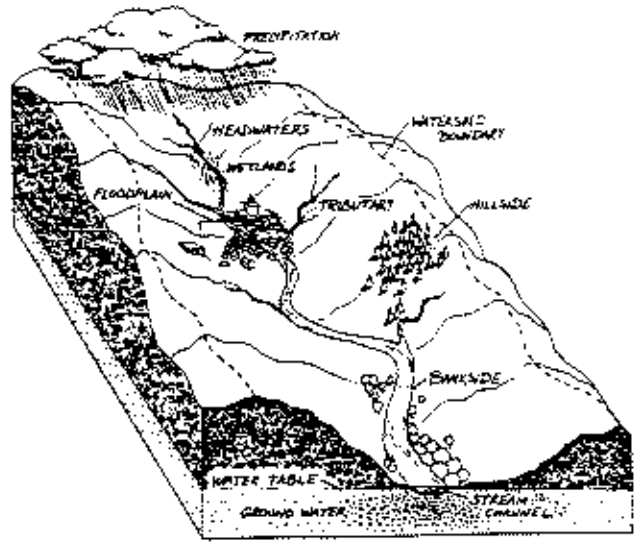
Tel (513) 489-8190

Fax (513) 489-8695

FOR MORE INFORMATION

U.S. Environmental Protection Agency
Nonpoint Source Control Branch
Washington DC 20460

Internet Address:
http://www.epa.gov/owow/nps/index.html



Schematic of a Watershed

The most common NPS pollutants are sediment and nutrients. These wash into water bodies from agricultural land, small and medium-sized animal feeding operations, construction sites, and other areas of disturbance. Other common NPS pollutants include pesticides, pathogens (bacteria and viruses), salts, oil, grease, toxic chemicals, and heavy metals. Beach closures, destroyed habitat, unsafe drinking water, fish kills, and many other severe environmental and human health problems result from NPS pollutants. They also spoil the beauty of healthy, clean water habitats. Each year the United States spends millions of dollars to restore and protect the areas damaged by NPS pollutants.

Progress

During the last 10 years, our country has made significant headway in addressing NPS pollution. At the federal level, the Nonpoint Source Management Program was established by the 1987 Clean Water Act Amendments, and the Coastal Nonpoint Pollution Program was established by the 1990 Coastal Zone Act Reauthorization Amendments. Other recent federal programs, as well as state, territorial, tribal and local programs also tackle NPS problems.

In addition, public and private groups have developed and used pollution prevention and reduction initiatives and NPS pollution controls, known as management measures, to clean up our water efficiently. Water quality monitoring and environmental education supported by government agencies, tribes, industry, volunteer groups, and schools have provided information about NPS pollution and have helped to determine the effectiveness of management techniques.

The watershed approach has also helped communities. It looks not only at a water body but also the entire area that drains into it. This allows communities to focus resources on a watershed's most serious environmental problems—which, in many instances are caused by NPS pollution.

Just as important, more citizens are practicing water conservation and participating in stream walks, beach cleanups, and other environmental activities sponsored by community-based organizations. In doing so, citizens address the Nation's largest water quality problem, and ensure that even more of our rivers, lakes, and coastal waters become safe for swimming, fishing, drinking, and aquatic life.

United States Environmental Protection Agency | Office of Water (4503F) | EPA-841-F-96-004B March 1996

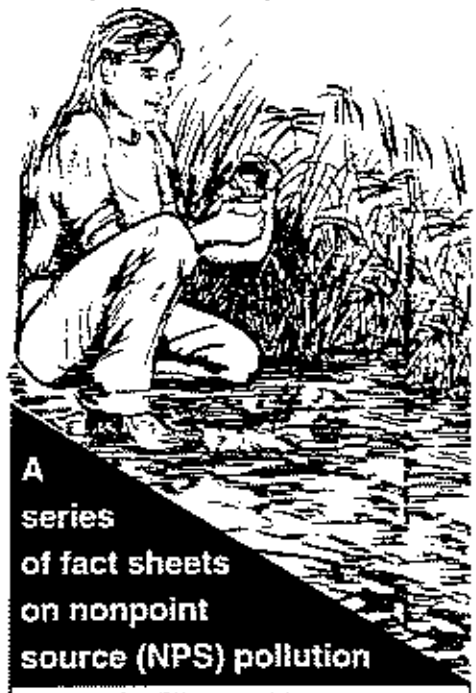
EPA

Nonpoint Pointers

Understanding and managing nonpoint source pollution in your community

Pointer No. 2

Opportunities for Public Involvement in Nonpoint Source Control



A series of fact sheets on nonpoint source (NPS) pollution

Over the last 25 years, communities have played an important role in addressing nonpoint source (NPS) pollution, the Nation's leading source of water quality problems. When coordinated with federal, state, and local environmental programs and initiatives, community-based NPS control efforts can be highly successful. To learn about and help control NPS pollution, contact the community-based organizations and environmental agencies in your area. These groups often have information about how citizens can participate in the following NPS control activities.

Volunteer Monitoring

Local groups organize volunteers of all skill levels to gather water quality data. This information can help government agencies understand the magnitude of NPS pollution. More than 500 active volunteer monitoring groups currently operate throughout the United States. Monitoring groups may also have information about other NPS pollution projects, such as beach cleanups, stream walks, and restoration activities.

When coordinated with federal, state, and local environmental programs and initiatives, community-based NPS control efforts can be highly successful.

Ecological Restoration

Ecological restoration provides opportunities for the public to help out with a wide variety of projects, such as tree planting and bank stabilization in both urban and rural areas. Restoration efforts focus on degraded waters or habitats that have significant economic or ecological value.

Educational Activities

Teachers can integrate NPS pollution curricula into their classroom activities. The U.S. Environmental Protection Agency (EPA), federal and state agencies, private groups, and nonprofit organizations offer teachers a wide variety of materials. Students can start on an NPS control project in the primary grades and pursue their work through intermediate and secondary levels.

Did you know that volunteers often collect information on the health of waterways and the extent of NPS pollution?

NPS pollution occurs when water runs over land or through the ground, picks up pollutants, and deposits them in surface waters or introduces them into ground water.

RELATED PUBLICATIONS

- Additional fact sheets in the Nonpoint Pointers series (EPA-841-F-96-004)
- Clean Water in Your Watershed, Terrene Institute, Washington, DC, 1993
- Cleaner Water Through Conservation (EPA-841-B-95-002)
- Compendium of Educational Materials on the Water Environment, Alliance for Environmental Ed., Inc., Marshall, VA, 1992
- EPA Journal, Vol. 17, No. 5, Nov/Dec 1991, (EPA-22k-1005)
- Environmental Resource Guide, Nonpoint Source Pollution Prevention, Air & Waste Management Assoc., Pittsburgh, PA
- Handle With Care, Terrene Institute, Washington, DC, 1991
- National Directory of Volunteer Environmental Monitoring Programs (EPA-841-B-94-001)
- The Quality of Our Nation's Water: 1994 (EPA-841-S-95-004)
- Xeriscape Landscaping (EPA-840-B-93-001)

To order any of the above EPA documents, call or fax the National Center for Environmental Publications and Information.

Tel (513) 489-8190

Fax (513) 489-8695

FOR MORE INFORMATION

U.S. Environmental Protection Agency
Nonpoint Source Control Branch
Washington DC 20460

Internet Address:
http://www.epa.gov/owow/nps/index.html

Water Conservation

Using technologies that limit water use in the bathroom, kitchen, laundry room, lawn, driveway, and garden can reduce the demand on existing water supplies and limit the amount of water runoff. More than 40 states now have some type of water conservation program to help citizens and businesses implement conservation practices. Government agencies, utilities, and hardware stores have information about products that help households conserve water.

Household Management

Learning to limit NPS pollution at the household level can reduce the overall impact of NPS pollution on water quality. Households, for example, can irrigate during cooler hours of the day, limit fertilizer applications to lawns and gardens, and properly store chemicals to reduce runoff and keep it clean. Chemicals and oil should not be poured into sewers. Pet wastes, a significant source of nutrient contamination, should be disposed of properly. Households can also replace impervious surfaces with more porous materials.

Public Meetings and Hearings

Decisions made during public hearings on stormwater permitting and town planning can determine a community's capability to manage NPS pollution over the long term. Laws or regulations may require federal, state, or local agencies to hold public hearings when permits are issued or when town plans are formed. Notices about hearings often appear in the newspaper or in government office buildings.

Community Organizations

Many communities have formed groups to protect local natural resources. These community-based groups provide citizens with information about upcoming environmental events in their watershed, such as ecological restoration, volunteer monitoring, and public meetings. Watershed-level associations are particularly effective at addressing a wide range of NPS pollution problems.

Environmental Information on the Internet

Citizens can obtain a great deal of environmental data and educational material through a computer linked to the World Wide Web. EPA's site (http://www.epa.gov) on the Web provides up-to-date information on Agency activities and enables citizens to find out about air and water quality data in specific communities.

EPA supports NPSINFO, a forum for discussion of NPS issues, including NPS education. Citizens with access to e-mail can subscribe to NPSINFO free-of-charge by sending an e-mail message to:

listserver@unixmail.rtpnc.epa.gov

and include in the body of the message:

subscribe NPSINFO (your first name) (your last name)

Other federal, state, tribal, and local agencies, as well as businesses and nonprofit groups, also provide environmental information on the World Wide Web.

United States Environmental Protection Agency | Office of Water (4503F) | EPA-841-F-96-004C March 1996

EPA

Nonpoint Pointers

Understanding and managing nonpoint source pollution in your community

Pointer No. 3

Programs for Nonpoint Source Control

A series of fact sheets on nonpoint source (NPS) pollution

States, territories, and tribes identify nonpoint source (NPS) pollution as responsible for more than half of the Nation's existing and threatened water quality impairments. To address these water quality problems, federal, state, tribal, territorial, and local governments provide technical assistance and fund programs to implement NPS controls. Other sources of funding are also available. The U.S. Environmental Protection Agency's Environmental Financing Information Network Center in Washington, DC (202/260-1020) can provide communities with specific information on how to design and fund the most appropriate NPS pollution strategy.

Federal Programs

U.S. Environmental Protection Agency (EPA)

EPA administers section 319 of the Clean Water Act, also known as the Nonpoint Source Management Program. Under section 319, states, territories, and tribes apply for and receive grants from EPA to implement NPS pollution controls. As of 1995, EPA had awarded more than $370 million under section 319 to address NPS pollution problems.

Government agencies provide technical assistance and fund programs to implement NPS controls.

EPA administers other sections of the Clean Water Act to help states, territories, and tribes to plan for and implement water pollution programs, which can include measures for NPS control. These include section 104(b)(3), Water Quality Cooperative Agreements; section 104(g), Small Community Outreach; section 106, Grants for Pollution Control Programs; section 314, Clean Lakes Program; section 320, National Estuary Program; and section 604(b), Water Quality Management Planning. Together with the National Oceanic Atmospheric Administration, EPA helps administer section 6217 of the 1990 Coastal Zone Act Reauthorization Amendments, a program that tackles nonpoint source pollution affecting coastal waters.

Did you know that communities rely on government programs and alternative sources of funding, such as investing in water conservation, to help control NPS pollution?

NPS pollution occurs when water runs over land or through the ground, picks up pollutants, and deposits them in surface waters or introduces them into ground water.

RELATED PUBLICATIONS

- Additional fact sheets in the Nonpoint Pointers series (EPA-841-F-96-004)
- Clean Water in Your Watershed, Terrene Institute, Washington, DC, 1993
- The Clean Water State Revolving Fund: Financing America's Environmental Infrastructure—A Report to Congress (EPA-832-R-95-001)
- The Quality of Our Nation's Water: 1994 (EPA-841-S-95-004)
- State and Local Funding of Nonpoint Source Control Programs (EPA-841-R-92-003)
- A State and Local Government Guide to Environmental Program Funding Alternatives (EPA-841-K-94-001)

To order any of the above EPA documents call or fax the National Center for Environmental Publications and Information.

Tel (513) 489-8190

Fax (513) 489-8695

FOR MORE INFORMATION

- EFIN Center (Telephone: (202) 260-0420)
- U.S. Environmental Protection Agency
  Nonpoint Source Control Branch
  Washington DC 20460

Internet Address:
http://www.epa.gov/owow/nps/index.html

National Oceanic and Atmospheric Administration (NOAA)

NOAA administers section 306 of the Coastal Zone Management Act that provides funds for water pollution control projects, including NPS management activities, in states with coastal zones. Together with the EPA, NOAA also helps administer section 6217 of the Coastal Zone Act Reauthorization Amendments. This requires the 29 states with approved Coastal Zone Management Programs to establish and implement Coastal Nonpoint Pollution Control Programs.

U.S. Department of Agriculture (USDA)

The USDA administers incentive-based conservation programs through the Consolidated Farm Services Agency, the Natural Resources Conservation Service, and the U.S. Forest Service to help control NPS pollution from agriculture, forestry, and urban sources.

U.S. Department of Transportation/Federal Highway Administration

Under the Intermodal Surface Transportation Efficiency Act of 1991, the Federal Highway Administration developed erosion control guidelines for federally funded construction projects on roads, highways, and bridges.

U.S. Department of the Interior

Within the U.S. Department of the Interior, the Bureau of Reclamation, the Bureau of Land Management, and the Fish and Wildlife Service administer several programs to help states manage NPS pollution by providing technical assistance and financial support. For example, the Fish and Wildlife Service administers the Clean Vessel Act, which provides grants to construct sewage pumpout stations at marinas.

Alternative Funding Sources

Some communities rely on a combination of alternative funding sources to implement NPS controls. In 1994, EPA published *A State and Local Government Guide to Environmental Program Funding Alternatives*. This brochure gives examples of how states can use the Clean Water State Revolving Fund, leases, grants, taxes, fees, and bonds to craft innovative and effective strategies to generate funds for NPS controls. In addition, government agencies can establish programs to encourage investments in water conservation technologies.

United States Environmental Protection Agency | Office of Water (4503F) | EPA-841-F-96-004D March 1996

EPA

Nonpoint Pointers

Understanding and managing nonpoint source pollution in your community

Pointer No. 4

The National Nonpoint Source Management Program

A series of fact sheets on nonpoint source (NPS) pollution

The Clean Water Act of 1972 helped clean up of many of our country's waters, often achieving dramatic improvements. Despite those successes, approximately 36 percent of the Nation's surveyed river miles, 37 percent of its surveyed lake acreage, and 37 percent of its surveyed estuarine square miles are not safe for basic uses such as swimming or fishing.

States, territories, and tribes estimate that at least half of these impairments, as well as significant ground water contamination, are caused by nonpoint source (NPS) pollution, making it the Nation's leading source of water quality problems. To address these problems, Congress amended the Clean Water Act in 1987. Congress established the NPS Pollution Management Program under section 319 of the amendments. The program provides states, territories, and tribes with grants to implement NPS pollution controls described in approved NPS pollution management programs.

Since EPA began awarding section 319 grants to implement management programs, recipients have directed approximately one-third of the funds toward controlling agricultural NPS pollution.

In 1990, the U.S. Environmental Protection Agency (EPA) began awarding grants to states, territories, and tribes with approved programs. By 1991, all 50 states and the territories had received EPA approval; by 1995, 7 tribes also had received approval. Since 1990, recipients of 319 grants have directed approximately 40 percent of awarded funds toward controlling NPS pollution from agricultural lands. In addition, nearly one-quarter of the money was used for general assistance purposes, including funding for outreach and technical assistance. Efforts to control runoff from urban sources, septic systems, and construction also received significant funding under section 319, as did projects to manage wetlands and NPS pollution from forestry, habitat degradation, and changes to stream channels.

In 1991, EPA established the National Monitoring Program to evaluate the effectiveness of NPS pollution control projects. Fourteen state-proposed projects will be evaluated over a six to 10-year period. The findings from this effort will help states, territories, and tribes develop more successful NPS pollution controls in other watersheds.

Did you know that at least 50% of water quality problems in the U.S. result from NPS pollution?

NPS pollution occurs when water runs over land or through the ground, picks up pollutants, and deposits them in surface waters or introduces them into ground water.

RELATED PUBLICATIONS

- Additional fact sheets in the Nonpoint Pointers series (EPA-841-F-96-004)
- Managing Nonpoint Source Pollution: Final Report to Congress on Section 319 of the Clean Water Act (EPA-506/9-90)
- Nonpoint Source Water Quality Contacts Directory, Conservation Technology Information Center, West Lafayette, Indiana
- The Quality of Our Nation's Water: 1994 (EPA-841-S-95-004)
- Section 319 National Monitoring Program Projects (EPA-841-S-94-006)
- Section 319 National Monitoring Program: An Overview, Water Quality Group, North Carolina State University, March 1995
- Section 319 Success Stories (EPA-841-S-94-004)

To order any EPA documents call or fax the National Center for Environmental Publications and Information.

Tel (513) 489-8190

Fax (513) 489-8695

FOR MORE INFORMATION

U.S. Environmental Protection Agency
Nonpoint Source Control Branch
Washington DC 20460

Internet Address:
http://www.epa.gov/owow/nps/index.html

As of 1995, EPA had awarded states, territories, and tribes $370 million under section 319 to implement NPS pollution control. Section 319 Success Stories provides examples of how states, territories, and tribes chose to use section 319 funds.

How Section 319 Works

Assessment Reports

All states, territories, and some tribes have met two basic requirements to be eligible for a section 319 grant, the first of which is to develop and gain EPA approval of a NPS pollution assessment report. In the assessment report, the state, territory, or tribe identifies waters impacted or threatened by NPS pollution. They also describes the categories of NPS pollution, such as agriculture, urban runoff, or forestry, that are causing water quality problems.

Management Programs

To meet the second requirement a state, territory, or tribe must develop and obtain EPA approval of a NPS pollution management program. This program becomes the framework for controlling NPS pollution, given the existing and potential water quality problems described in the NPS pollution assessment report. A well-developed management program supports activities with the greatest potential to produce early, demonstrable water quality results; assists in the building of long-term institutional capacity to address NPS pollution problems; and encourages strong interagency coordination and ample opportunity for public involvement in the decision-making process.

How to Get Involved

The addresses and telephone numbers of state and territory nonpoint source officials are listed in the *Nonpoint Source Water Quality Contacts Directory*. These individuals can inform citizens about section 319 program activities in their home state or territory. They can also let citizens know how to become involved in the periodic updates of section 319 NPS assessments and NPS management programs.

United States Environmental Protection Agency | Office of Water (4503F) | EPA-841-F-96-004E March 1996

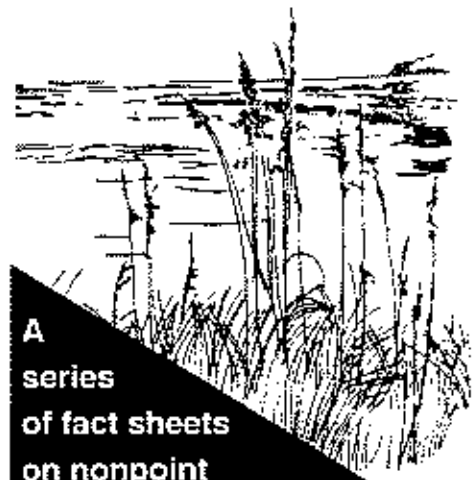
EPA

Nonpoint Pointers

Understanding and managing nonpoint source pollution in your community

Pointer No. 5

Protecting Coastal Waters from Nonpoint Source Pollution



A series of fact sheets on nonpoint source (NPS) pollution

Coastal waters provide homes for an amazing array of plants and animals and are recreational havens for more than 180 million visitors each year. Yet, high levels of pollution prevented people from swimming safely at coastal beaches on more than 12,000 occasions from 1988 through 1994, and the latest *National Water Quality Inventory* reports that one-third of surveyed estuaries (areas near the coast where seawater and freshwater mixing occurs) are damaged. Rapidly increasing population growth and development in coastal regions could be a source of even more coastal water quality problems in the future.

Coastal waters include estuaries, sounds, bays, lagoons, and other bodies of water that have a large percentage of seawater, as well as the Great Lakes.

A significant portion of the threats to coastal waters are caused by nonpoint source pollution (NPS). Major sources in coastal waters include agriculture and urban runoff. Other significant sources include faulty septic systems, forestry, marinas and recreational boating, physical changes to stream channels, and habitat degradation, especially the destruction of wetlands and vegetated areas near streams.

In 1990, Congress passed the Coastal Zone Act Reauthorization Amendments (CZARA) to tackle the nonpoint source pollution problem in coastal waters. Section 6217 of CZARA requires the 29 states and territories with approved Coastal Zone Management Programs to develop Coastal Nonpoint Pollution Control Programs. In its program, a state or territory describes how it will implement nonpoint source pollution controls, known as management measures, that conform with those described in *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*.

If these original management measures fail to produce the necessary coastal water quality improvements, a state or territory then must implement additional management measures to address remaining water quality problems. Approved programs will update and expand upon NPS Management Programs developed under section 319 of the Clean Water Act and

Did you know that by 2010, almost one-half of the U.S. population will live near coastal waters in regions that make up only 10 percent of our country's land areas?

NPS pollution occurs when water runs over land or through the ground, picks up pollutants, and deposits them in surface waters or introduces them into ground water.

RELATED PUBLICATIONS

- Additional fact sheets in the Nonpoint Pointers series (EPA-841-F-96-004)
- Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance (EPA-841-B-93-003)
- Global Marine Biological Diversity, Center for Marine Conservation, Island Press, Washington, DC, 1993
- Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters (EPA-840-B-92-002)
- The Quality of Our Nation's Water: 1994 (EPA-841-S-95-004)
- Testing the Waters V: Politics and Pollution at US Beaches, Natural Resources Defense Council, June 1995

To order any EPA documents call or fax the National Center for Environmental Publications and Information.

Tel (513) 489-8190

Fax (513) 489-8695

FOR MORE INFORMATION

U.S. Environmental Protection Agency
Nonpoint Source Control Branch
Washington DC 20460

Internet Address:
http://www.epa.gov/owow/nps/index.html

Coastal Zone Management Programs developed under section 306 of the Coastal Zone Management Act.

The coastal nonpoint program strengthens the links between federal and state/territory coastal zone management and water quality programs in order to enhance efforts to manage land management activities that degrade coastal waters and coastal habitats. State and territorial coastal zone agencies and water quality agencies have coequal roles, as do the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Environmental Protection Agency (EPA) at the federal level.

Coastal Nonpoint Pollution Control Programs

In 1995, coastal states and territories submitted their coastal nonpoint programs to EPA and NOAA for review and approval. States and territories are scheduled to implement the first phase of their approved program by 2004 and, if necessary, the second phase by 2009. Approved programs include several key elements, described below.

Boundary. The boundary defines the region where land and water uses have a significant impact on a state's or territory's coastal waters. It also includes areas where future land uses reasonably can be expected to impair coastal waters. To define the boundary, a state or territory may choose a region suggested by NOAA or may propose its own boundary based on geologic, hydrologic, and other scientific data.

Management Measures. The state or territory coastal nonpoint program describes how a state or territory plans to control NPS pollution within the boundary. To help states and territories identify appropriate technologies and tools, EPA issued *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*. This technical guidance describes the best available, economically achievable approaches used to control NPS pollution from the major categories of land management activities that can degrade coastal water quality. States or territories may elect to implement alternative measurement measures as long as they will achieve the same environmental results as those described in the guidance.

Enforceable Policies and Mechanisms. States and territories need to ensure implementation of the management measures. Mechanisms may include, for example, permit programs, zoning, "bad actor" laws, enforceable water quality standards, and general environmental laws and prohibitions. States and territories may also use voluntary approaches like economic incentives if they are backed by appropriate regulations.

Final Approval and Conditional Approval

In certain circumstances, NOAA and EPA may grant a program conditional approval for up to five years. Conditional approval provides a state or territory additional time to fully develop its management program while it begins initial program implementation. Conditional approval would include benchmarks for progress toward eventual full program development and approval.

United States Environmental Protection Agency | Office of Water (4503F) | EPA-841-F-96-004F March 1996

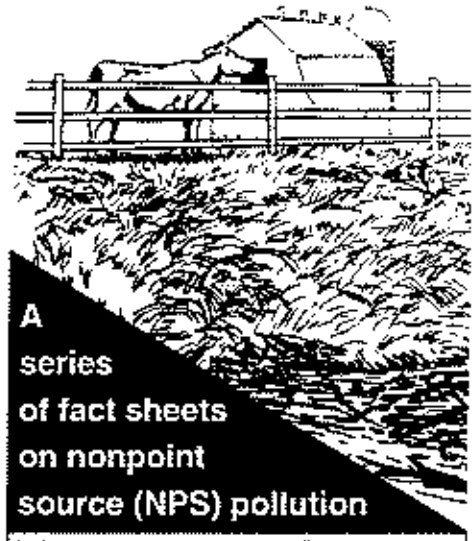
EPA

Nonpoint Pointers

Understanding and managing nonpoint source pollution in your community

Pointer No. 6

Managing Nonpoint Source Pollution from Agriculture



A series of fact sheets on nonpoint source (NPS) pollution

The United States has more than 330 million acres of agricultural land that produce an abundant supply of low-cost, nutritious food, feed, and fibre. American agriculture is noted worldwide for its high productivity, quality, and efficiency in delivering goods to the consumer. However, when improperly managed, agricultural activities can affect water quality.

The most recent *National Water Quality Inventory* reports that agricultural nonpoint source (NPS) pollution is the leading source of water quality impacts to surveyed rivers and lakes, the third largest source of impairments to surveyed estuaries, and also a major contributor to ground water contamination and wetlands degradation.

Agricultural activities that cause NPS pollution can result from confined animal facilities, grazing, plowing, pesticide spraying, irrigation, fertilizing, planting, and harvesting.

Agricultural activities that cause NPS pollution include confined animal facilities, grazing, plowing, pesticide spraying, irrigation, fertilizing, planting, and harvesting. The major agricultural NPS pollutants that result from these activities are sediment, nutrients, pathogens, pesticides, and salts. Agricultural activities also can damage habitat and stream channels. Impacts on surface water and ground water can be minimized by properly managing activities that can cause NPS pollution.

Numerous government programs are available to help people design and pay for management approaches to prevent and control NPS pollution. For example, over 40 percent of section 319 Clean Water Act grants were used to control agricultural NPS pollution. Also, several U.S. Department of Agriculture and state-funded programs provide cost-share, technical assistance, and economic incentives to implement NPS pollution management practices. Many people use their own resources to adopt technologies and practices to limit water quality impacts.

Managing Sedimentation. Sedimentation occurs when wind or water runoff carries soil particles from an area, such as a farm field, and transports them to a water body, such as a stream or lake. Excessive sedimentation clouds the water, which reduces the amount of sunlight reaching aquatic

Did you know that NPS pollution from agriculture is the leading source of impairments to surveyed rivers and lakes?

NPS pollution occurs when water runs over land or through the ground, picks up pollutants, and deposits them in surface waters or introduces them into ground water.

RELATED PUBLICATIONS

- Additional fact sheets in the Nonpoint Pointers series (EPA-841-F-96-004)
- Agriculture and Wetlands: A Compilation of Factsheets (EPA-503/9-92-003)
- Alternative Agriculture, National Research Council, National Academy Press, Washington, DC 1989
- Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters, Chapter 2 (EPA-840-B-92-002)
- Journal of Soil and Water Conservation, Vol. 45, No. 1, Jan/Feb 1990 (EPA-841-N-90-100)
- Livestock Grazing on Western Riparian Areas, EPA Region 8, Denver, CO
- The Quality of Our Nation's Water: 1994 (EPA-841-S-95-004)
- Soil And Water Quality: An Agenda for Agriculture, National Research Council, National Academy Press, Washington, DC, 1993
- USDA National Resources Inventory, Natural Resources Conservation Service

To order any of the above EPA documents call or fax the National Center for Environmental Publications and Information.

Tel (513) 489-8190

Fax (513) 489-8695

FOR MORE INFORMATION

U.S. Environmental Protection Agency
Nonpoint Source Control Branch
Washington DC 20460

Internet Address:
http://www.epa.gov/owow/nps/index.html

plants; covers fish spawning areas and food supplies; and clogs the gills of fish. In addition, other pollutants like phosphorus, pathogens, and heavy metals are often attached to the soil particles and wind up in the water bodies with the sediment. Farmers and ranchers can reduce erosion and sedimentation 20 to 90 percent by applying management measures to control the volume and flow rate of runoff water, keep the soil in place, and reduce soil transport.

Managing Nutrients. Nutrients such as phosphorus, nitrogen, and potassium in the form of fertilizers, manure, sludge, irrigation water, legumes, and crop residues are applied to enhance production. When they are applied in excess of plant needs, nutrients can wash into aquatic ecosystems where they can cause excessive plant growth, which reduces swimming and boating opportunities, creates a foul taste and odor in drinking water, and kills fish. In drinking water, high concentrations of nitrate can cause methemoglobinemia, a potentially fatal disease in infants also known as "blue baby syndrome." Nutrient management plans can help maintain high yields and save money on the use of fertilizers while reducing NPS pollution.

Managing Confined Animal Facilities. By confining animals to areas or lots, farmers and ranchers can efficiently feed and maintain livestock. But these confined areas become major sources of animal waste. Runoff from poorly managed facilities can carry pathogens (bacteria and viruses), nutrients, and oxygen-demanding substances that contaminate shellfishing beds and other major water quality problems. Ground water can also be contaminated by seepage. Discharges can be limited by storing and managing facility wastewater and runoff with an appropriate waste management system.

Managing Irrigation. Inefficient irrigation can cause water quality problems. In arid areas, for example, where rainwater does not carry residues deep into the soil, excessive irrigation can concentrate pesticides, nutrients, disease-carrying microorganisms, and salts-all of which impact water quality-in the top layer of soil. Farmers can control these effects by improving water use efficiency. Actual crop needs can be measured with a variety of equipment.

Managing Pesticides. Pesticides, herbicides, and fungicides are used to kill pests and control the growth of weeds and fungi. These chemicals can enter and contaminate water through direct application, runoff and wind transport. They can kill fish and wildlife, poison food sources, and destroy animal habitat. Integrated Pest Management (IPM) techniques based on the specific soils, climate, pest history, and crop for a particular field can limit pesticide use and manage necessary applications to minimize pesticide movement from the field.

Managing Livestock Grazing. Overgrazing exposes soils, increases erosion, encourages invasion by undesirable plants, destroys fish habitat, and reduces the filtration of sediment necessary for building streambanks, wet meadows, and floodplains. To reduce the impacts of grazing on water quality, farmers and ranchers can adjust grazing intensity, keep livestock out of sensitive areas, provide alternative sources of water and shade, and revegetate rangeland and pastureland.

United States Environmental Protection Agency

Office of Water (4503F)

EPA-841-F-96-004G
March 1996

EPA

Nonpoint Pointers

Understanding and managing nonpoint source pollution in your community

Pointer No. 7

Managing Urban Runoff

A series of fact sheets on nonpoint source (NPS) pollution

The most recent *National Water Quality Inventory* reports that runoff from urban areas is the leading source of impairments to surveyed estuaries and the third largest source of water quality impairments to surveyed lakes. In addition, population and development trends indicate that by 2010 more than half of the Nation will live in coastal towns and cities, some of which will have tripled in population. Runoff from these areas will continue to degrade coastal waters.

To protect surface water and ground water quality, urban development and household activities must be guided by plans that limit runoff and reduce pollutant loadings. Communities can address urban water quality problems on both a local and watershed level and garner the institutional support to help address urban runoff problems.

Nonporous urban landscapes like roads, bridges, parking lots, and buildings don't let runoff slowly percolate into the ground.

How Urban Areas Affect Runoff

Increased Runoff. The porous and varied terrain of natural landscapes like forests, wetlands, and grasslands trap rainwater and snowmelt and allow it to filter slowly into the ground. Runoff reaches receiving waters gradually. In contrast, nonporous urban landscapes like roads, bridges, parking lots, and buildings don't let runoff slowly percolate into the ground. Water remains at the surface, accumulates, and runs off in large amounts. When leaving the system and emptying into a stream, it erodes streambanks, damages streamside vegetation, and widens stream channels. This will result in lower water depths during non-storm periods, higher than normal water levels during wet weather periods, increased sediment loads, and higher water temperatures. Native fish and other aquatic life cannot survive in urban streams severely impacted by urban runoff.

Increased Pollutant Loads. Urbanization also increases the variety and amount of pollutants transported to receiving waters: sediment from development and new construction; oil, grease, and toxic chemicals from vehicles;

Did you know that because of impervious surfaces such as pavement and rooftops, a typical city block generates 9 times more runoff than a woodland area of the same size?

NPS pollution occurs when water runs over land or through the ground, picks up pollutants, and deposits them in surface waters or introduces them into ground water.

nutrients and pesticides from turf management and gardening; viruses and bacteria from failing septic systems; road salts; and heavy metals. Sediments and solids constitute the largest volume of pollutant loads to receiving waters in urban areas.

When runoff enters storm drains, it carries many of these pollutants with it. In older cities, this polluted runoff is often released directly into the water without any treatment. Increased pollutant loads can harm fish and wildlife populations, kill native vegetation, foul drinking water supplies, and make recreational areas unsafe.

Point and Nonpoint Distinctions

Two types of laws help control urban runoff: one focusing on urban point sources and the other on urban nonpoint sources. Point sources are addressed by the National Pollution Discharge Elimination System permit program of the Clean Water Act, which regulates stormwater discharges. Urban nonpoint sources are covered by nonpoint source management programs developed by states, territories, and tribes under the Clean Water Act. In states and territories with coastal zones, programs to protect coastal waters from nonpoint source pollution also are required by section 6217 of the Coastal Zone Act Reauthorization Amendments.

Measures to Manage Urban Runoff

Plans for New Development. New developments should attempt to maintain the volume of runoff at predevelopment levels by using structural controls and pollution prevention strategies. Plans for the management of runoff, sediment, toxics, and nutrients can establish guidelines to help achieve both goals. Management plans are designed to protect sensitive ecological areas, minimize land disturbances, and retain natural drainage and vegetation.

Plans for Existing Development. Controlling runoff from existing urban areas tends to be expensive compared to managing runoff from new developments. However, existing urban areas can target their urban runoff control projects to make them more economical. Runoff management plans for existing areas can first identify priority pollutant reduction opportunities, then protect natural areas that help control runoff, and finally begin ecological restoration and retrofit activities to clean up degraded water bodies. Citizens can help prioritize clean-up strategies, volunteer for restoration efforts, and help protect ecologically valuable areas.

Plans for On-site Disposal Systems. The control of nutrient and pathogen loadings to surface waters can begin with the proper design, installation, and operation of on-site disposal systems (OSDSs). These septic systems should be situated away from open waters and sensitive resources such as wetlands and floodplains. They should also be inspected, pumped out, and repaired at regular time intervals. Household maintenance of septic systems can play a large role in preventing excessive system discharges.

Public Education. Schools can conduct education projects that teach students how to prevent pollution and keep water clean. Education and public outreach can target specific enterprises, such as service stations, that have opportunities to control runoff on site. Many communities have implemented storm-drain stenciling programs that discourage people from dumping trash directly into storm sewer systems.

RELATED PUBLICATIONS

- Additional fact sheets in the Nonpoint Pointers series (EPA-841-F-96-004)
- Controlling Nonpoint Source Runoff From Roads, Highways, and Bridges (EPA-841-F-95-008a)
- Developing Successful Runoff Control Programs for Urbanized Areas (EPA-841-K-94-003)
- Economic Benefits of Runoff Controls (EPA-S-95-002)
- Fundamentals of Urban Runoff, Terrene Institute, Washington, DC, 1994
- Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters, Chapter 4 (EPA-840-B-92-002)
- Storm Water Fact Sheet (EPA-933-F-94-006)
- The Quality of Our Nation's Water: 1994 (EPA-841-S-95-004)

To order any of the above EPA documents call or fax the National Center for Environmental Publications and Information.

Tel (513) 489-8190

Fax (513) 489-8695

FOR MORE INFORMATION

U.S. Environmental Protection Agency
Nonpoint Source Control Branch
Washington DC 20460

Internet Address:
http//www.epa.gov/owow/nps/index.html

United States Environmental Protection Agency
Office of Water (4503F)
EPA-841-F-96-004H
March 1996

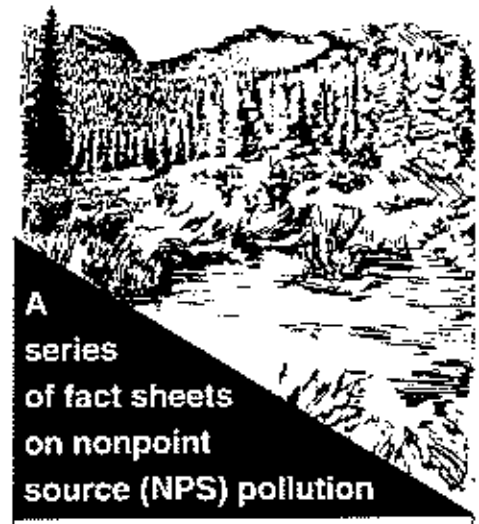
EPA

Nonpoint Pointers

Understanding and managing nonpoint source pollution in your community

Pointer No. 8

Managing Nonpoint Source Pollution from Forestry



A series of fact sheets on nonpoint source (NPS) pollution

Nearly 500 million acres of forested lands are managed for the production of timber in the United States. Although only a very small percentage of this land is harvested each year, forestry activities can cause significant water quality problems if improperly managed. The latest *National Water Quality Inventory* reports that forestry contributes to approximately 9 percent of the water quality problems in surveyed rivers and streams.

Sources of NPS pollution associated with forestry include removal of streamside vegetation, road construction and use, timber harvesting, and mechanical preparation for the planting of trees. Road construction and road use are the primary sources of NPS pollution on forested lands, contributing up to 90 percent of the total sediment from forestry operations. Harvesting trees in the area beside a stream can elevate water temperature and destabilize streambanks. These changes can harm aquatic life by limiting sources of food, shade, and shelter.

Following properly designed preharvest plans can result in logging activities that are both profitable and highly protective of water quality.

Did you know that streamside vegetation protects streams, lakes, and other waters from NPS pollution caused by forestry activities?

NPS pollution occurs when water runs over land or through the ground, picks up pollutants, and deposits them in surface waters or introduces them into ground water.

Preharvest Planning: Opportunities to Prevent NPS Pollution

To limit water quality impacts caused by forestry, public and private forest managers have developed site-specific forest management plans.

Following properly designed preharvest plans make logging both profitable and highly protective of water quality. Such plans address the full range of forestry activities that can cause NPS pollution. They clearly identify the area to be harvested; locate special areas of protection, such as wetlands and streamside vegetation; plan for the proper timing of forestry activities; describe management measures for road layout, design, construction, and maintenance, as well as for harvesting methods and forest regeneration.

Public meetings held under the authority of federal and state laws provide citizens with a good opportunity to comment on the development of forest management plans.

RELATED PUBLICATIONS

- Additional fact sheets in the Nonpoint Pointers series (EPA-841-F-96-004)
- Evaluating the Effectiveness of Forestry Best Management Practices in Meeting Water Quality Goals or Standards, USDA Forest Service, Miscellaneous Publication 1520, July 1994
- Forest Resources of the United States, 1992, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-234 (Revised)
- Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters, Chapter 3 (EPA-840-B-92-002)
- The Quality of Our Nation's Water: 1994 (EPA-841-S-95-004)
- Summary of Current State Nonpoint Source Control Practices for Forestry (EPA-841/S-93-001)
- Water Quality Effects and Nonpoint Source Control for Forestry: An Annotated Bibliography (EPA-841/B-93-005)

To order any of the above EPA documents call or fax the National Center for Environmental Publications and Information.

Tel (513) 489-8190

Fax (513) 489-8695

FOR MORE INFORMATION

U.S. Environmental Protection Agency
Nonpoint Source Control Branch
Washington DC 20460

Internet Address:
http://www.epa.gov/owow/nps/index.html

Factors Considered in the Preharvest Plan

Surveying the Site. Preactivity surveys can help identify areas that might need special protection or management during forestry operations. Sensitive landscapes usually have steep slopes, a greater potential for landslides, sensitive rock formations, high precipitation levels, snowpack, or special ecological functions such as those provided by streamside vegetation. Forestry activities occurring in these areas have a high potential of affecting water quality.

Timing. Because most forestry activities disturb soil and contribute to erosion and runoff, timing operations carefully can significantly reduce their impact on water quality. Rainy seasons and fish migration and spawning seasons, for example, should be avoided.

Establishing Streamside Management Areas (SMAs). Plans often restrict forestry activities in vegetated areas near streams (also known as buffer strips or riparian zones), thereby establishing special SMAs. The vegetation in an SMA is highly beneficial to water quality and aquatic habitat. Vegetation in the SMA stabilizes streambanks, reduces runoff and nutrient levels in runoff, and traps sediment generated from upslope activities before it reaches surface waters. SMA vegetation moderates water temperature by shading surface water and provides habitat for aquatic life. Large trees provide shade while alive and provide aquatic habitat after they die and fall into streams as large woody debris.

Managing Road Construction, Layout, Use, and Maintenance. Good road location and design can greatly reduce the transport of sediment to water bodies. Whenever possible, road systems should be designed to minimize road length, road width, and the number of places where water bodies are crossed. Roads should also follow the natural contours of the land and be located away from steep gradients, landslide-prone areas, and areas with poor drainage. Proper road maintenance and closure of unneeded roads can help reduce NPS impacts from erosion over the long term.

Managing Timber Harvesting. Most detrimental effects of harvesting are related to the access and movement of vehicles and machinery, and the dragging and loading of trees or logs. These effects include soil disturbance, soil compaction, and direct disturbance of stream channels. Poor harvesting and transport techniques can raise sediment production 10 to 20 times and disturb as much as 40 percent of the soil surface. In contrast, careful logging disturbs as little as 8 percent of the soil surface.

Careful selection of equipment and methods for transporting logs can significantly reduce the amount of soil disturbed and delivered to water bodies. Stream channels should be protected from logging debris at all times during harvesting operations.

Managing Replanting. Forests can be regenerated from either seed or seedlings. Seeding usually requires that the soil surface be prepared before planting. Seedlings can be directly planted with machines after minimal soil preparation. In either case, the use of heavy machinery can result in significant soil disturbance if not performed carefully.

United States Environmental Protection Agency | Office of Water (4503F) | EPA-841-F-96-004I March 1996

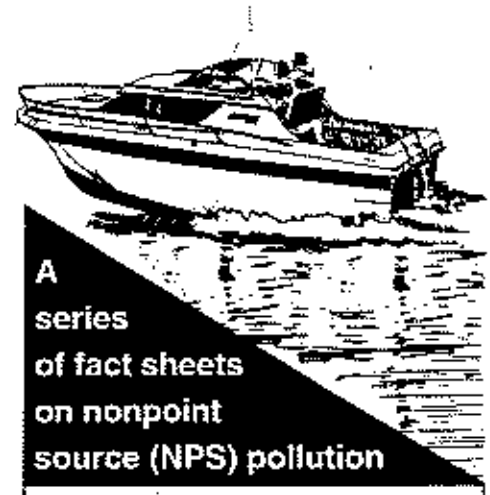
EPA

Nonpoint Pointers

Understanding and managing nonpoint source pollution in your community

Pointer No. 9

Managing Nonpoint Source Pollution from Boating and Marinas



A series of fact sheets on nonpoint source (NPS) pollution

Millions of people regularly enjoy recreational boating and more than 10,000 marinas dot the coastline and waterfront property of North America. The growing number of recreational boaters and marina managers must take special care to limit water pollution.

Individual boats and marinas usually release only small amounts of pollutants. Yet, when multiplied by thousands of boaters and marinas, they can cause distinct water quality problems in lakes, rivers, and coastal waters. The U.S. Environmental Protection Agency has identified the following potential environmental impacts from boating and marinas: high toxicity in the water; increased pollutant concentrations in aquatic organisms and sediments; higher erosion rates; more nutrients, leading to an increase in algae and a decrease in oxygen (eutrophication); and high levels of pathogens. In addition, construction at marinas can destroy sensitive ecosystems and bottom-dwelling aquatic communities.

Carefully fueling boat engines, recycling used oil, and discarding worn motor parts into proper receptacles can prevent needless petroleum spills.

Water pollution from boating and marinas is caused by poorly flushed waterways, boat maintenance, discharge of sewage from boats, storm water runoff from marina parking lots, and the physical alteration of shoreline, wetlands, and aquatic habitat during the construction and operation of marinas.

Proper marina planning and an informed boating public will limit pollution from these sources, promote long-term economic benefits and environmental health, and help recreational boating to remain a healthy, fun-filled experience. Clean boats, clean boating habits, and clean marinas benefit the entire boating community as well as aquatic life.

Did you know that the Clean Vessel Act provides grants to build sewage pumpout facilities at marinas?

NPS pollution occurs when water runs over land or through the ground, picks up pollutants, and deposits them in surface waters or introduces them into ground water.

Managing Boat Operation and Maintenance

A significant amount of solvent, paint, oil, and other pollutants can seep into the ground water or be washed directly into surface water. The chemicals and metals in anti-fouling paint can limit bottom growth. Many boat cleaners contain chlorine, ammonia, and phosphates — substances that can

RELATED PUBLICATIONS

- Additional fact sheets in the Nonpoint Pointers series (EPA-841-F-96-004)
- Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters, Chapter 5 (EPA-840-B-92-002)
- The Quality of Our Nation's Water: 1994 (EPA-841-S-95-004)
- Water Watch: What Boaters Can Do To Be Environmentally Friendly, National Marine Manufacturers Association, Washington, DC

To order any of the above EPA documents call or fax the National Center for Environmental Publications and Information.

Tel (513) 489-8190

Fax (513) 489-8695

FOR MORE INFORMATION

The State Organization for Boating Access, Washington, DC
Tel: (202) 944-4987

National Marine Manufacturers Association, Washington, DC
Tel: (202) 944-4985

Sea Grant college or university in your state

U.S. Environmental Protection Agency
Nonpoint Source Control Branch
Washington DC 20460

Internet Address:
http://www.epa.gov/owow/nps/index.html

harm plankton and fish. Small oil spills from motors and refueling activities contain petroleum hydrocarbons that attach to waterborne sediments. These persist in aquatic ecosystems and harm the bottom-dwelling organisms at the base of the marine food chain.

To reduce pollution from boats and marinas, boaters can use nontoxic cleaning products. Using a drop cloth, cleaning and maintaining boats away from the water, and vacuuming up loose paint chips and paint dust prevent paint and other chemical substances from entering waters. Carefully fueling boat engines, recycling used oil, and discarding worn motor parts into proper receptacles can prevent needless spills. Draining water out of all waterlines and tanks during winter eliminates the possibility of burst pipes. And perhaps most important, keeping boat motors well-tuned prevents fuel and lubricant leaks and boost fuel efficiency. These guidelines not only can keep water clean, but also can keep boats running smoothly.

Managing Boat Sewage and Waste

Often underestimated or ignored by the public, the discharge of sewage and waste from boats, can degrade water quality. Improper disposal of human waste can make water unsightly and unsuitable for recreation, destroy shellfishing areas, and cause severe health problems. Sewage discharged from boats also stimulates algae growth, which can reduce the available oxygen needed by fish and other organisms. Although fish parts are biodegradable, when many fish are gutted and cleaned in the same area on the same day, water quality problems can result, including algae growth.

Boaters should attempt to achieve zero discharge of all sewage into recreational waters. While on the boat, fecal matter and other solid waste should be contained in a U.S. Coast Guard-approved marine sanitation device (MSD). Upon return to shore, portable toilets should be emptied into approved shoreside waste handling facilities, and MSDs should be discharged into approved pumpout stations.

Managing Siting and Design for Marinas

Poorly planned marinas can disrupt natural water circulation and cause shoreline soil erosion and habitat destruction. To reduce activities that cause NPS pollution, marinas should be located and designed so that natural flushing regularly renews marina waters. In addition, predevelopment water quality and habitat assessments should be conducted to protect ecologically valuable areas. Grass and ground cover planting or, where necessary, structural stabilization measures can help prevent erosion during and after marina construction. Stormwater runoff can be controlled with pollution prevention strategies and containing hull maintenance areas. Marina fueling and sewage collection stations should be designed and maintained to make cleanup of spills easier. When completed, the final marina design should deliver the most desirable combination of marina capacity, services, and access, while minimizing environmental impacts and onsite development costs.

United States Environmental Protection Agency | Office of Water (4503F) | EPA-841-F-96-004J March 1996

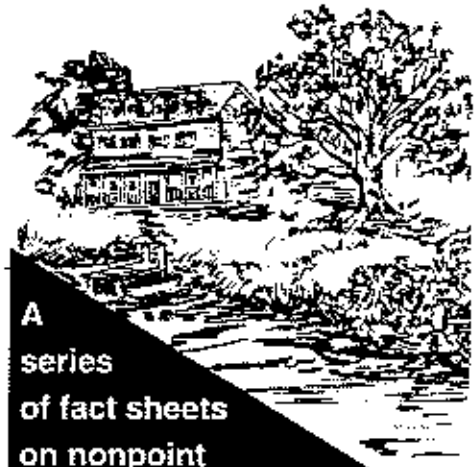
EPA

Nonpoint Pointers

Understanding and managing nonpoint source pollution in your community

Pointer No. 10

Managing Nonpoint Source Pollution from Households



A series of fact sheets on nonpoint source (NPS) pollution

The well-known stories about environmental problems tend to focus on big, recognizable targets such as smoking industrial facilities, leaking toxic waste dumps, and messy oil spills. As a result, people often forget about water pollution caused by smaller nonpoint sources—especially pollution at the household level.

However, nonpoint source (NPS) pollution is the Nation's leading source of water quality degradation. Although individual homes might contribute only minor amounts of NPS pollution, the combined effect of an entire neighborhood can be serious. These include eutrophication, sedimentation, and contamination with unwanted pollutants.

By preventing water from percolating down into the ground, paved surfaces cause runoff to collect and funnel into storm drains at high speeds, which can result in severe streambank erosion when it reaches the receiving waters.

To prevent and control NPS pollution, households can learn about the causes of such pollution and take the appropriate (and often money-saving) steps to limit runoff and make sure runoff stays clean.

Limit Paved Surfaces

Urban and suburban landscapes are covered by paved surfaces like sidewalks, parking lots, roads, and driveways. They prevent water from percolating down into the ground, cause runoff to accumulate, and funnel into storm drains at high speeds. When quickly flowing runoff empties into receiving waters, it can severely erode streambanks. Paved surfaces also transfer heat to runoff, thereby increasing the temperature of receiving waters. Native species of fish and other aquatic life cannot survive in these warmer waters.

To limit NPS pollution from paved surfaces households can substitute alternatives to areas traditionally covered by nonporous surfaces. Grasses and natural ground cover, for example, can be attractive and practical substitutes for asphalt driveways, walkways, and patios. Some homes effectively incorporate a system of natural grasses, trees, and mulch to limit

Did you know that homes with xeriscape landscapes use natural contours and native plants to conserve water, limit runoff, and reduce chemical use?

NPS pollution occurs when water runs over land or through the ground, picks up pollutants, and deposits them in surface waters or introduces them into ground water.

RELATED PUBLICATIONS

- Additional fact sheets in the Nonpoint Pointers series (EPA-841-F-96-004)
- Clean Water in Your Watershed, Terrene Institute, Washington, DC, 1993
- Cleaner Water Through Conservation (EPA-841-B-95-002)
- Handle With Care, Terrene Institute, Washington, DC, 1991
- The Quality of Our Nation's Water: 1994 (EPA-841-S-95-004)
- Xeriscape Landscaping: Preventing Pollution and Using Resources Efficiently (EPA-840-B-93-001)

To order any of the above EPA documents call or fax the National Center for Environmental Publications and Information.

Tel (513) 489-8190

Fax (513) 489-8695

FOR MORE INFORMATION

U.S. Environmental Protection Agency
Nonpoint Source Control Branch
Washington DC 20460

Internet Address:
http://www.epa.gov/owow/nps/index.html

continuous impervious surface area. Wooden decks, gravel or brick paths, and rock gardens keep the natural ground cover intact and allow rainwater to slowly seep into the ground.

Landscape With Nature

Altering the natural contours of yards during landscaping and planting with non-native plants that need fertilizer and extra water can increase the potential for higher runoff volumes, increase erosion, and introduce chemicals into the path of runoff. In contrast, xeriscape landscaping provides households with a framework that can dramatically reduce the potential for NPS pollution.

Xeriscape incorporates many environmental factors into landscape design—soil type, use of native plants, practical turf areas, proper irrigation, mulches, and appropriate maintenance schedules. By using native plants that are well-suited to a region's climate and pests, xeriscape drastically reduces the need for irrigation and chemical applications. Less irrigation results in less runoff, while less chemical application keeps runoff clean.

Proper Septic System Management

Malfunctioning or overflowing septic systems release bacteria and nutrients into the water cycle, contaminating nearby lakes, streams, and estuaries, and ground water. Septic systems must be built in the right place. Trampling ground above the system compacts soil and can cause the system's pipes to collapse. Also, septic systems should be located away from trees because tree roots can crack pipes or obstruct the flow of wastewater through drain lines. Proper septic system management is also important, and a system should be inspected and emptied every 3 to 5 years.

By maintaining water fixtures and by purchasing water-efficient showerheads, faucets, and toilets, households can limit wastewater levels, reducing the likelihood of septic system overflow. Most water conservation technologies provide long-term economic and environmental benefits.

Proper Chemical Use, Storage, and Disposal

Household cleaners, grease, oil, plastics, and some food or paper products should not be flushed down drains or washed down the street. Over time chemicals can corrode septic system pipes and might not be completely removed during the filtration process. Chemicals poured down the drain can also interfere with the chemical and biological breakdown of the wastes in the septic tank.

On household lawns and gardens, homeowners can try natural alternatives to chemical fertilizers and pesticides and apply no more than the recommended amounts. Natural predators like insects and bats, composting, and use of native plants can reduce or entirely negate the need for chemicals. Xeriscape can limit chemical applications to lawns and gardens.

If chemicals are needed around the home, they should be stored properly to prevent leaks and access by children. Most cities have designated sites for the proper disposal of used chemicals.

United States Environmental Protection Agency | Office of Water (4503F) | EPA-841-F-96-004K March 1996

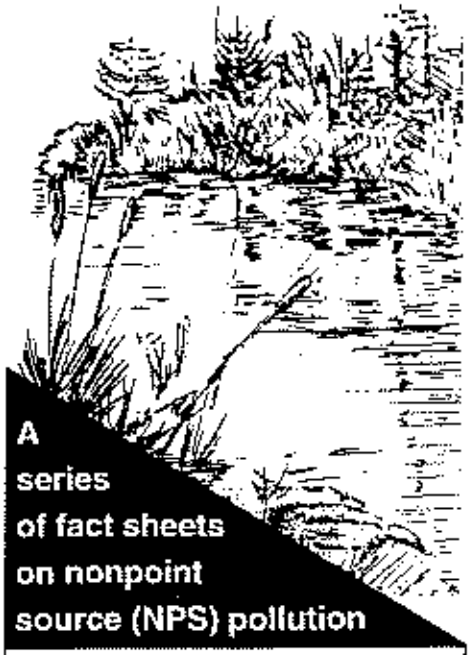
EPA

Nonpoint Pointers

Understanding and managing nonpoint source pollution in your community

Pointer No. 11

Managing Wetlands to Control Nonpoint Source Pollution



A series of fact sheets on nonpoint source (NPS) pollution

States, territories, and tribes identify nonpoint source (NPS) pollution as the Nation's leading source of surface water and ground water quality impairments. When properly managed, wetlands can help prevent NPS pollution from degrading water quality. Wetlands include swamps, marshes, fens, and bogs.

Properly managed wetlands can intercept runoff and transform and store NPS pollutants like sediment, nutrients, and certain heavy metals without being degraded. In addition, wetlands vegetation can keep stream channels intact by slowing runoff and by evenly distributing the energy in runoff. Wetlands vegetation also regulates stream temperature by providing streamside shading. Some cities have started to experiment with wetlands as an effective tool to control runoff and protect urban streams.

Properly managed wetlands can intercept runoff and transform and store NPS pollutants like sediment, nutrients, and certain heavy metals without being degraded.

Improper development or excessive pollutant loads can damage wetlands. The degraded wetlands can no longer provide water quality benefits and become significant sources of NPS pollution. Excessive amounts of decaying wetlands vegetation, for example, can increase biochemical oxygen demand, making habitat unsuitable for fish and other aquatic life. Degraded wetlands also release stored nutrients and other chemicals into surface water and ground water.

Did you know that wetlands receive significant amounts of NPS pollution because they are typically the lowest point on the landscape?

The U.S. Environmental Protection Agency (EPA) recommends three management strategies to maintain the water quality benefits provided by wetlands: preservation, restoration, and construction of engineered systems that pretreat runoff before it reaches receiving waters and wetlands.

NPS pollution occurs when water runs over land or through the ground, picks up pollutants, and deposits them in surface waters or introduces them into ground water.

Wetlands Preservation

The first strategy protects the full range of wetlands functions by discouraging development activity. At the same time, this strategy encourages proper management of upstream watershed activities, such as agriculture, forestry, and urban development. Several programs administered by EPA,

RELATED PUBLICATIONS

- Additional fact sheets in the Nonpoint Pointers series (EPA-841-F-96-004)
- Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters, Chapter 7 (EPA-840-B-92-002)
- The Quality of Our Nation's Water: 1994 (EPA-841-S-95-004)

To order any of the above EPA documents call or fax the National Center for Environmental Publications and Information.

Tel (513) 489-8190
Fax (513) 489-8695

To order the following EPA documents, call EPA's Wetlands Hotline at 1-800-832-7828.

- America's Wetlands (OPA-87-016)
- Constructed Wetlands for Wastewater Treatment and Wildlife Habitat (EPA-832-R-93-005)
- Natural Wetlands and Urban Stormwater: Potential Impacts and Management (EPA-843-R-001)
- Wetlands Fact Sheets (EPA-843-F-95-001)

FOR MORE INFORMATION

U.S. Environmental Protection Agency
Nonpoint Source Control Branch
Washington DC 20460

Internet Address:
http://www.epa.gov/owow/nps/index.html

the U.S. Department of Agriculture, the National Oceanic and Atmospheric Administration, the U.S. Army Corps of Engineers, and the U.S. Department of the Interior, as well as other government agencies, protect wetlands by either controlling development activities that would affect wetlands or providing financial assistance to people who wish to protect them. In addition, nongovernmental groups that purchase wetlands for conservation purposes, such as The Nature Conservancy, The Trust for Public Land, and local land trusts, are playing an increasingly important role in protecting water quality.

Wetlands/Riparian Restoration

The second strategy promotes the restoration of degraded wetlands and riparian zones with NPS pollution control potential. Riparian zones are the vegetated ecosystems along a water body through which energy, materials, and water pass. Riparian areas characteristically have high water-tables and are subject to periodic flooding and influence from the adjacent water body. They encompass wetlands and uplands, or some combination of these two landforms.

Restoration activities should recreate the full range of preexisting wetlands functions. That means replanting degraded wetlands with native plant species and, depending on the location and the degree of degradation, using structural devices to control water flows. Restoration projects factor in ecological principles, such as habitat diversity and the connections between different aquatic and riparian habitat types, which distinguish these kinds of projects from wetlands that are constructed for runoff pretreatment.

Engineered Systems

The third strategy promotes the use of engineered vegetated treatment systems (VTS). VTS are especially effective at removing suspended solids and sediment from NPS pollution before the runoff reaches natural wetlands.

One type of VTS, the vegetated filter strip (VFS), is a swath of land planted with grasses and trees that intercepts uniform sheet flows of runoff, before the runoff reaches wetlands. VFSs are most effective at sediment removal, with removal rates usually greater than 70%. Constructed wetlands, another type of VTS, are typically engineered complexes of water, plants, and animal life that simulate naturally occurring wetlands. Studies indicate that constructed wetlands can achieve sediment removal rates greater than 90 percent. Like VFS, constructed wetlands offer an alternative to other systems that are more structural in design.

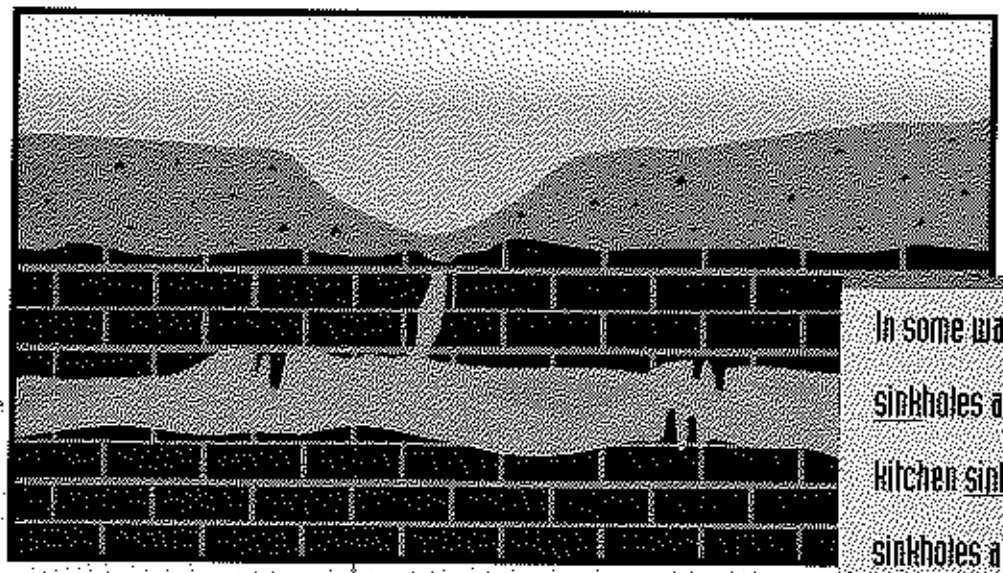
Saving a Precious Resource

Healthy wetlands benefit fish, wildlife, and humans because they protect many natural resources, only one of which is clean water. Unfortunately, over half of the wetlands in the lower 48 states were lost between the late 1700s and the mid-1980s, and undisturbed wetlands still face threats from development. To help prevent NPS pollution from further degrading the Nation's waters and to protect many other natural resources, wetlands protection must remain a focal point for national education campaigns, watershed protection plans, and local conservation efforts.

Watershed Committee *of the Ozarks*

Sinkholes–Inlets For The Underground Water System

Sinkholes are a feature of karst terrain. Karst is the name for a type of landscape where the bedrock is mostly limestone or dolomite, as it is in much of the Ozarks. These rocks will dissolve in rainwater that has become slightly acidic from contact with carbon dioxide as it seeps down through the soil. (The carbon dioxide comes from soil organisms breathing, just like we do.) Over thousands of years, rainwater percolating down through cracks and crevices in the bedrock will dissolve enough rock to form an underground network of pipes called conduits. Soil sinks into the enlarged ends of these conduits near the ground surface, forming sinkholes. Sinkholes can also form suddenly when an underground opening collapses. Sinkholes come in various shapes and sizes, but they share this common feature–they are the inlet points for the underground drainage system. This drainage system includes other familiar features of karst–springs, caves, and 'osing streams–streams that lose water directly into the groundwater system.



There are thousands of sinkholes in the Ozarks region. A recent study by Southwest Missouri State University indicated that there are at least 2,500 sinkholes in Greene county alone. In the eastern Ozarks, large sinkholes have wetlands developed on their floors, with distinct and unique species of plants growing there. In southwest Missouri, we have some very large, deep sinkholes, such as Devil's Den in Webster county and the Avin Sink near Nixa.

In some ways, sinkholes are like kitchen sinks–sinkholes are basins that will hold water, but usually only for a short time. The water finds its way to the drain (conduit) then flows through the underground drainage system toward the outlet, a spring. Some of this water may also seep down into the deeper groundwater. But unlike a sink, sinkholes continue to grow in size as they funnel more and more of the surface runoff into themselves.

In some ways, sinkholes are like kitchen sinks–sinkholes are basins that will hold water, but only for a short time.

Do you have a sinkhole on your property? Sinkholes vary so greatly in size and shape, it is sometimes hard to recognize them. Some sinkholes are acres in size; some are as small as a few feet across. Some are very shallow saucer-shaped depressions; others are funnel-shaped with very steep sides. There may or may not be a well developed swallow-hole or eye in the bottom of a sinkhole, indicating the actual opening into the conduit system. Often sinkholes in our area can be spotted by the presence of a circular grove of trees growing in the middle of a pasture. *Any depression* in the ground, in the Ozarks, should be treated as if it were a sinkhole.

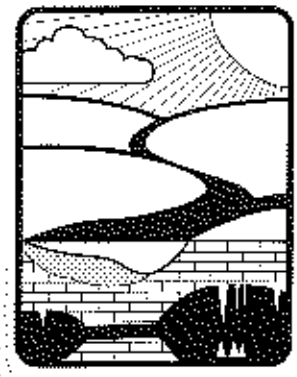
Because sinkholes drain rapidly, and because they have a direct connection with our groundwater (and often our drinking water), we need to be careful what goes into them. Sinkholes are <u>terrible</u> places to dump trash, for instance. Waste oil or other chemicals can be flushed directly into the groundwater, where they may easily pollute a spring or someone's drinking water well. Sinkholes are bad places to build sewage lagoons or to install septic tanks. In fact, the best thing to do with sinkholes is to <u>leave them alone.</u>

If you must build a home or other building in an area that drains to a sinkhole, leave a vegetated buffer area around the sinkhole to filter out sediment and pollutants that might wash off of lawns, driveways, or parking lots. Be very careful about applying fertilizers or pesticides in yards where they might be flushed into a sinkhole with the next rain.

Sinkholes are natural drainage points for our groundwater system, so should not be filled with dirt. If a sinkhole is plugged, water will not drain properly and will run off onto adjacent property, possibly causing flooding. Water that has been replenishing our groundwater supplies will now be diverted away as surface runoff. There are appropriate ways that collapsed sinkholes, which present hazardous conditions, can be filled so that the natural drainage abilities are maintained. For information on how to properly fill sinkholes, contact the Watershed Committee office.

Sinkholes are a natural and interesting feature of our karst landscape. They are also an essential part of our groundwater system. If we want to keep Ozark springs clean, we must protect sinkholes from pollution. Springs sustain the flow of Ozarks rivers, especially in dry times, so polluted spring water could affect fishing and swimming in our streams and lakes. Pollution in sinkholes can even threaten our health by showing up in our drinking water. For all of these reasons, we had better keep a watchful eye on our local sinkholes and make sure the runoff that enters them is as clean as possible.

What goes into a sinkhole, may come out in our taps. By recognizing sinkholes for what they are, and respecting them for what they do, we have an opportunity to see that our groundwater, streams, springs, and lakes will be clean enough for future generations to use and enjoy.



Watershed Committee *of the Ozarks*

300 W. Brower
Springfield,
Missouri 65802

417-866-1127

The Watershed Committee of the Ozarks is a not-for-profit citizens' advisory group dedicated to the protection of drinking water sources in the Springfield area.

Other publications available from the Watershed Committee:
<u>Watershed News</u>–Quarterly newsletter (free)
<u>Ozark Water Cycle</u>–A brochure discussing the proper design, installation and maintenance of septic tank systems (free)
<u>Water Protection At Home</u>–What you can do to prevent water pollution in your community (free)

United States Department of Agriculture

Soil Conservation Service

Columbia, Missouri

Urban Conservation Tips

Riprap

Description

Riprap is loose rock used to protect the soil surface. It can be used in severe situations to stabilize banks and prevent erosion when vegetation cannot. Riprap is an expensive alternative because of the costs of quarrying, transporting and placing the rock.

Application

Rock Chutes - Riprap-lined chutes are useful for channeling large flows of water over steep banks where there is no temporary storage available and where flow rates exceed the capacity of a practical size pipe. These chutes require a precise design which must include a level inlet and outlet section to prevent upstream and downstream erosion.

Streambank Protection - Riprap is an effective way to stabilize eroding streambanks. A stable toe at the bottom of the riprap hill must be established for the success of this measure. This requires that the riprap start at the bottom of a trench several feet below the creek bottom, or on bedrock if it is encountered. The weight of the rock should rest on the bank rather than on lower courses of rock. This can be accomplished by sloping the bank no steeper than 1.5 horizontal to 1 vertical.

Slope Stability - Steep slopes, whether natural or man-made, can be unstable and slide because of soil structure or subsurface seepage. A saturated layer of soil beneath the surface can act as a lubricated plane on which the upper layers of soil can slide. Riprap, when properly applied to these areas, can add needed weight to the surface as well as let the subsurface water flow safely away. This riprap application needs to be designed with a stable toe with special attention given to the underlying bedding system. If the slope is not subject to heavy overland flows, the rock can be smaller. If the slope is steeper than 2 horizontal to 1 vertical, other alternatives, such as a retaining wall, should be considered.

Pipe Outlets - Downstream scouring is inevitable where large pipes and culverts discharge great volumes of water unless some measure of protection is taken to dissipate the energy. A grouted riprap splash pad or a riprap-lined plunge pool of water to absorb the energy are comparatively inexpensive solutions.

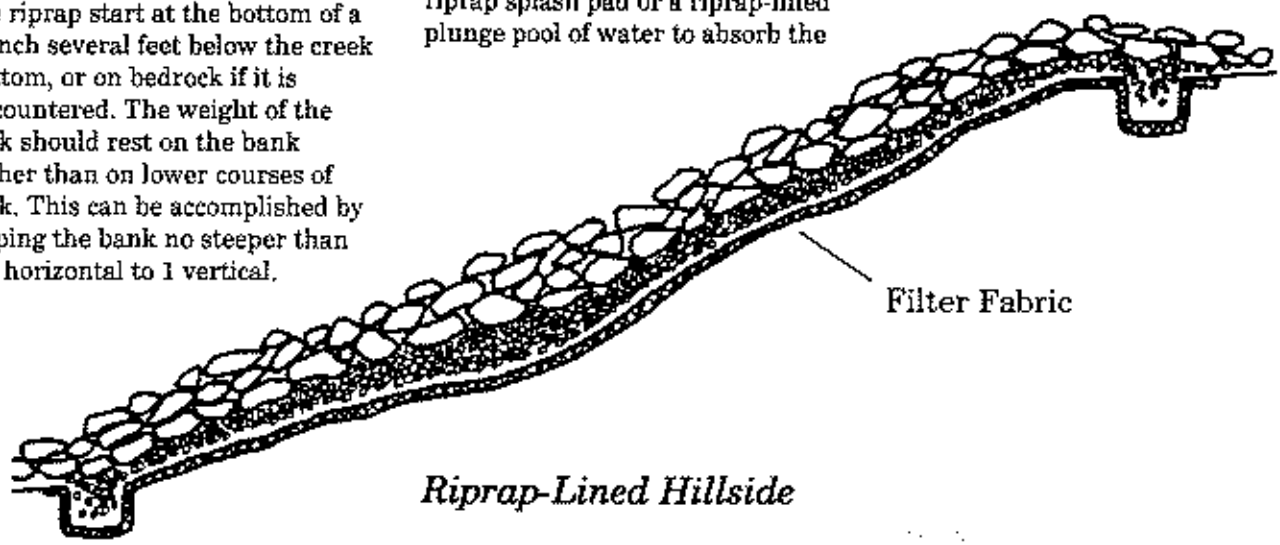
Construction

The thickness of the riprap layer and rock size is determined by specific site conditions. Generally, the riprap layer should be 50 percent thicker than the largest rock used. To assure the success of a riprap project, the design should be completed by someone fully trained and experienced in this line of work. In general, riprap is installed as follows:

The initial excavation for the job must be deep enough to include the thickness of the riprap layer, the bedding and the anticipated water depth. The final bottom grade of the excavation must be free of topsoil, roots, frozen material and other debris which could cause instability.

To be effective, riprap must

(over)



Riprap-Lined Hillside

protect the underlying soil from water flowing swiftly over the surface, and at the same time allow excess water within the soil to freely drain without displacing the soil particles. To accomplish this, the larger rock is underlain first with a bedding of well-graded gravel, sand mix or filter fabric.

Where riprap is subject to exceptionally fast-flowing water, a slurry of Portland cement and sand, called grout, can be poured over the rock surface. This further binds the rock fragments together. Grouting the rock also discourages vandalism, and prevents the intrusion of vegetative growth.

Maintenance

Riprap structures should be inspected periodically to make sure rock has not been displaced. If rock displacement is severe, and occurs quite often, grouting or larger rock may be warranted. Cracked, grouted riprap should be repaired as needed. Unwanted vegetation can be sprayed, but it often is advantageous to allow vegetation to gradually take over and obliterate the rock.

Where To Get Help

For more information about the use of riprap in urban areas, contact your local Soil Conservation Service office. It is listed in the telephone directory under "U.S. Government, Department of Agriculture."

United States Department of Agriculture

Soil Conservation Service

Columbia, Missouri

Urban Conservation Tips

Underground Drain Pipes

Description

Drainage systems featuring underground pipes are designed to intercept water and carry it to more desirable locations without causing soil erosion. Underground drain pipes can correct both surface and subsurface drainage problems. Surface drainage systems carry away surface water. Subsurface drainage systems intercept water below the surface.

Application

Underground drain pipes can be used to intercept subsurface moisture to lower a water table, or intercept seepage that contributes to wet surface conditions. In bottomland or flat land areas with isolated water-logged pockets, subsurface drainage systems are used to improve infiltration. Better infiltration means the surface will dry faster.

Underground drain pipes also are widely used to:

* Remove surface runoff caught by diversions, terraces and waterways.

* Carry away water exiting from gutter downspouts so that water falling from the downspouts does not erode the ground beneath the downspout.

* Remove standing water near buildings, airport runways and recreational areas.

* Catch and carry away subsurface moisture around foundations, a common cause of wet basements.

* Drain puddles and isolated wet areas.

* Control pests by eliminating stagnant water that acts as a breeding ground.

* Carry away water that enters the pipes through grates placed in streets, driveways and parking lots.

Construction Tips

Following are some things to consider when installing underground drain pipes as part of surface and subsurface drainage systems.

Surface Drainage Systems

* Grates are needed at the inlet to the pipes to keep debris out of the system. Domed grates are preferred.

* Solid pipes should be used. Pipes with holes are used only to intercept water beneath the surface, not as carriers of surface water.

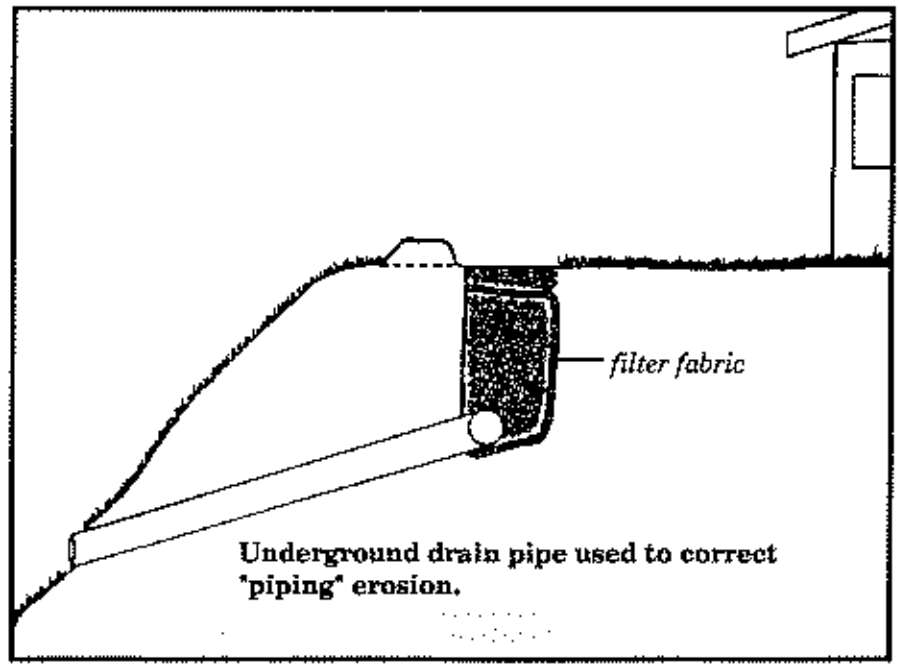
* Welded steel or corrugated metal grates will be necessary if vehicles will be driven over them.

* Soil used to fill around the pipes should be well compacted to prevent seepage along the outside of the pipe. Such seepage is referred to as piping erosion.

* Anti-seep collars (plates attached to the pipes) should be used to discourage erosion along the outside of the pipe.

* The water inlet should be large enough to handle the volume of water likely to reach the inlet

(over)



Underground drain pipe used to correct "piping" erosion.

during a storm.

* The outlet end of the pipe should be on a gentle slope, perhaps with a small rock apron, so that the water exiting the pipe does not cause erosion there.

* The water should exit the pipe at the surface. Only very sandy, porous soils can drain the water within the soil.

* Install a guard at the pipe's outlet to prevent rodents from entering the pipe.

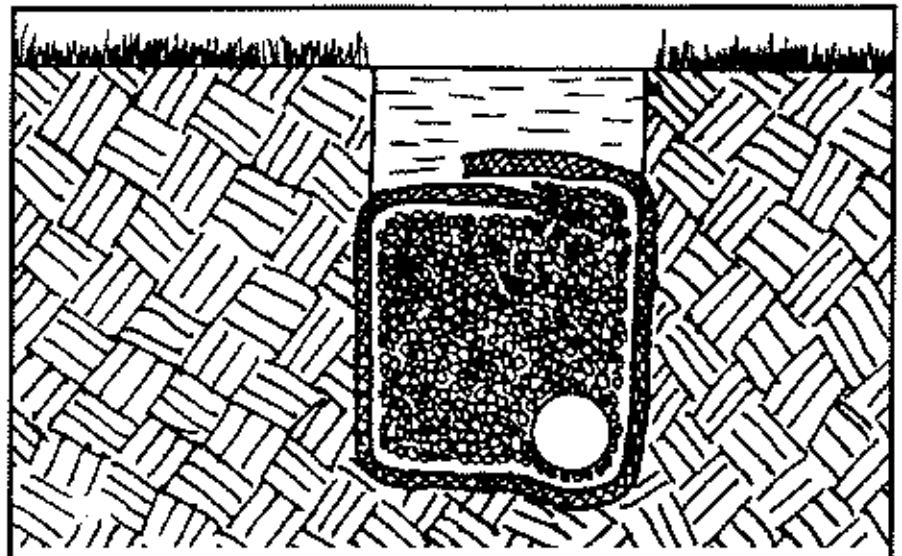
Subsurface Drainage Systems

* Pipes should be installed in a uniformly-sloping trench that drains to a natural outlet or to an outlet constructed to withstand the erosiveness of the exiting water.

* Pipe placed around houses needs to be carefully backfilled with one-inch diameter gravel or rock that does not contain lime dust.

* Use perforated pipe to allow underground water to enter the pipe. But use a section of solid pipe at the outlet of an underground drain pipe to help prevent soil erosion near the outlet.

* Wrap pipe and gravel in filter fabric to prevent fine soil particles from entering and clogging the drain pipe.



An underground drain pipe used to collect subsurface moisture.

* Care needs to be taken so that the pipe is not crushed when backfilling with rock and soil.

* Perforated pipe should not be used on grades in excess of 10 percent.

* Install guards at pipe outlets to keep rodents from entering the pipe.

* The trench should have a low area in its floor that will cradle the pipe.

* Riser pipes can be installed, or the gravel field around the pipe can be extended to the surface to collect water more efficiently.

Maintenance

Maintenance of surface and subsurface drainage systems utilizing underground pipes is a must. Be sure to keep both outlets and inlets clear of trash, and inspect the systems after storms. Promptly remove debris, which can gather at the inlets of underground drain pipes. Be sure sediment or trash does not plug the outlets, and cause water to back up in the line.

Where To Get Help

For more information about underground drain pipes, contact your local Soil Conservation Service office. It is listed in the telephone directory under "U.S. Government, Department of Agriculture."

United States Department of Agriculture

Soil Conservation Service

Columbia, Missouri

Urban Conservation Tips

Retaining Walls

Description

Retaining walls are vertical walls that stabilize slopes created by construction or streambank erosion. They are used in areas where flat land is valuable, as they allow the space between the retaining wall and the top of the hill to be filled.

Construction

Retaining walls must have enough strength and stability to resist being fractured or displaced by the soil it is designed to hold in place. The pressure against the wall increases in relation to the height of the wall, and as extra loads, such as tractors or buildings, are placed on the soil above the wall. Large retaining walls require detailed and complex engineering analysis.

A site investigation will help determine what type of retaining wall should be constructed in a particular area. The site conditions most critical to retaining walls are the soil's stability and drainage. Soils prone to landslides and heaving can adversely affect retaining walls. In fact, they can make a site unfavorable altogether.

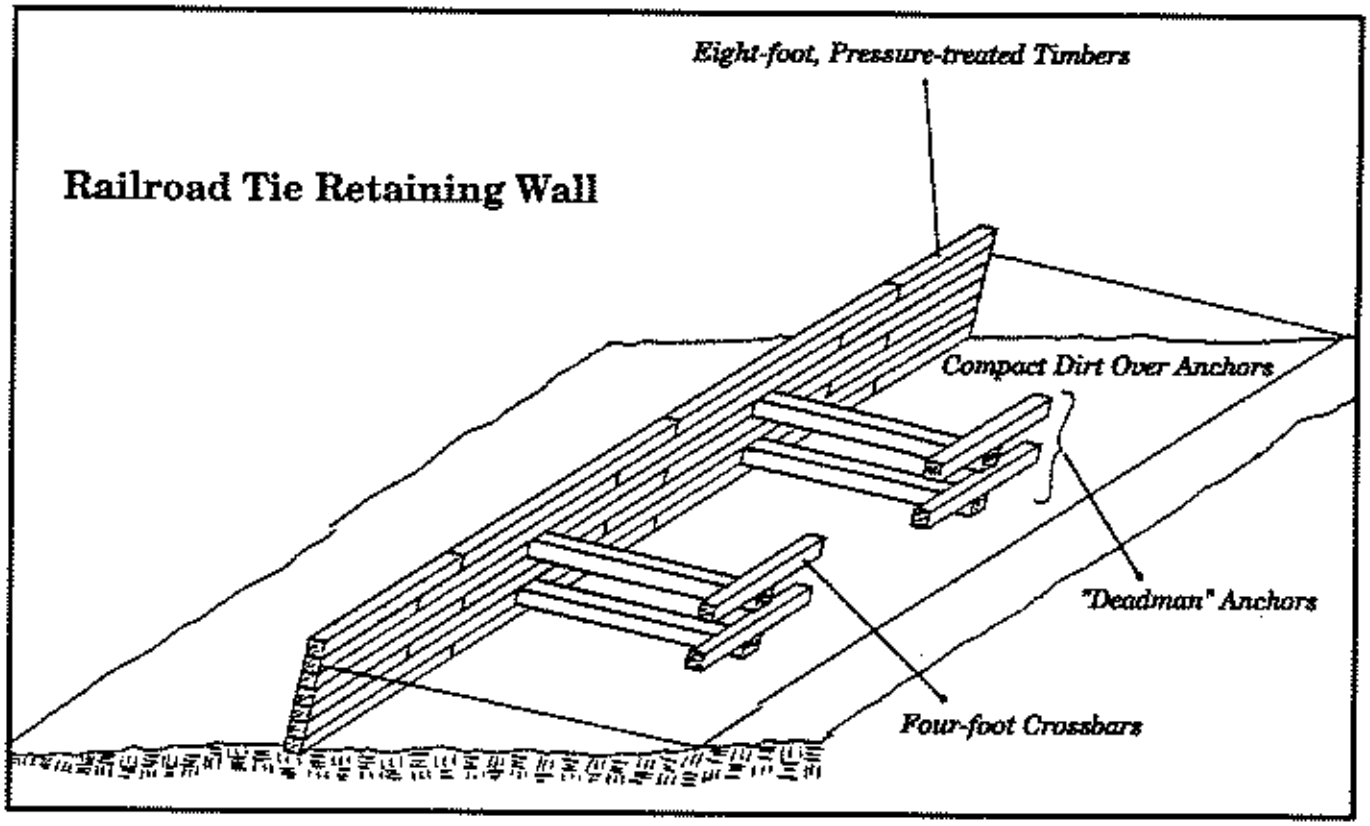
A site's drainage features, both surface and subsurface, also are important. Subsurface moisture can create a build-up of water pressure that can cause the retaining wall to tilt or collapse. Surface water cascading over the top of a retaining wall also may affect the structure if the soil at the foot of the wall is not protected against erosion.

Here are some tips to consider when building retaining walls:

* Excessively high walls are expensive to build because of high soil pressure. This often can be avoided by building multiple walls. For instance, two five-foot retaining walls could be built instead of one 10-foot wall.

* Place weep holes in the retaining wall to help drain away excessive water and to prevent water table build-up. Use gravel

(over)



wrapped with filter fabric to keep soil from flushing out through the weep holes.

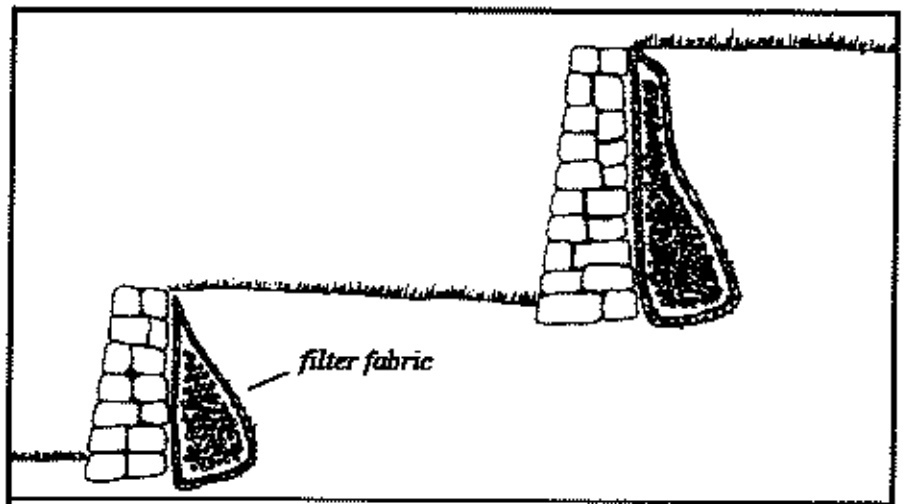
* Backfill with coarse material, such as sand and gravel. It won't swell when wet, doesn't need to be compacted to fill the voids and provides excellent internal drainage.

* Don't plant trees above the wall because pressure from their expanding root systems may damage the wall.

* Make sure soil used to fill around the retaining wall is well compacted.

* Retaining walls may be constructed using many different materials. Rock and mortar, brick and mortar, reinforced concrete, railroad ties and heavy timber, steel bins and gabions (rock-filled wire cages) are among the most common.

* Stabilize the retaining wall by using an anchor or "deadman." Another technique is to make the wall massive enough that it cannot be displaced by the soil.



Sometimes it is cheaper and easier to build two smaller walls instead of one large wall.

* Tilt the retaining wall slightly into the hill to compensate for soil pressure against the wall.

Maintenance

Regardless of the type of retaining wall used, good maintenance is necessary. Typical maintenance begins with periodic examinations of the wall and careful monitoring of any defects. Any needed repairs should be done immediately.

Where To Get Help

For more information about retaining walls, contact your local Soil Conservation Service office. It is listed in the telephone directory under "U.S. Government, Department of Agriculture."

United States Department of Agriculture

Soil Conservation Service

Columbia, Missouri

Urban Conservation Tips

Diversions

Description

Diversions are channels built across hills. They may have berms on their downhill sides. Diversions intercept runoff water and carry it to stable outlets such as storm sewers or protected natural channels. Redirecting the runoff protects downhill areas from soil erosion and excessive wet conditions.

Applicability

Diversions intercept surface and shallow, subsurface water flows, control runoff and erosion on urban areas and construction sites, divert water from buildings and other improvements, enlarge or reduce watersheds draining into ponds, function as grass filter strips and channel water away from gullies and critically eroding areas.

Construction Tips

When constructing diversions, consider the following construction tips to ensure that your diversions will operate properly.

* Provide a stable outlet - such as grass, concrete or other non-erosive surfaces - for diversion of water.

* Apply lime and fertilizer according to a soil test, then seed and mulch the area. Contact your local University of Missouri Extension Service office for soil test information.

* Take aesthetics into consideration before construction.

* During the construction of earthen diversions, compact the soil well.

* If necessary, stockpile the topsoil and spread it over graded areas to make it easier to re-establish vegetation.

* Set on contour or grade so that the channel behind the diversion is stable.

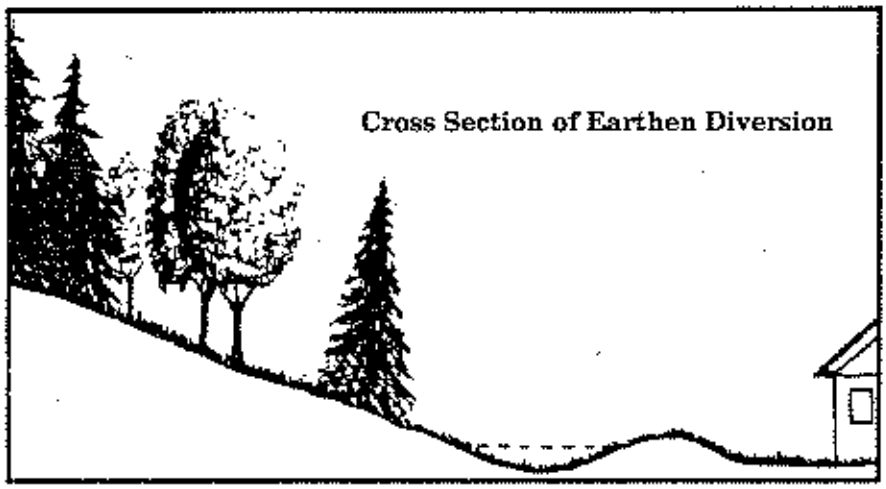
Railroad Tie Diversions

* One railroad tie should be set at least halfway into the ground. Additional height is attained by adding railroad ties to the top.

* Additional rows of railroad ties should be spiked so that they are not moved by flowing water.

* Seams or joints between railroad ties should be sealed to keep out water.

Railroad Tie Diversion



Cross Section of Earthen Diversion

Maintenance

Sediment should be cleaned out of diversion channels to keep the diversion working.

Vegetative linings common to all diversions require mowing, spraying and other practices to maintain the desired plant cover, and to control woody vegetation that may choke or obstruct channels. In addition, maintaining the correct plant cover in the channel will help prevent channel erosion and "piping" erosion from developing along woody plant roots.

Where To Get Help

For more information about diversions for urban areas, contact your local Soil Conservation Service office. It is listed in the telephone directory under "U.S. Government, Department of Agriculture."

United States Department of Agriculture

Soil Conservation Service

Columbia, Missouri

Urban Conservation Tips

Controlling Construction Site Erosion

Description

Erosion and sedimentation go hand-in-hand. Both are costly enemies to developers and to the community. Erosion removes topsoil and creates gullies, greatly increasing the cost of establishing grass.

Sediment that leaves a construction site fills road ditches, clogs culverts and storm sewers and pollutes lakes and streams. It is much more expensive to remove sediment from these areas than to prevent sediment from leaving a construction site. The following information provides practical methods for controlling erosion and trapping sediment on construction sites. Select the methods that are appropriate for your site. Then incorporate those methods into an erosion and sediment control plan.

Application

The longer an area is allowed to remain bare of vegetation, the more severe and cumulative the effects of erosion and sedimentation become. Therefore it is desirable to keep the period between grading and vegetative establishment as short as possible. The following vegetative and non-vegetative methods are used to protect soil from erosion.

Vegetative Soil Cover

Vegetative methods are the least expensive means of erosion control. Establishing grass or other vegetation protects soil from the impact of falling raindrops and helps hold the soil in place. Temporary and permanent vegetative covers may be used.

Temporary seedings provide quick cover to control erosion before the final grading and landscaping of a lot. It also is used when permanent seeding is not desired or when it is not the right time of the year to establish the desired permanent vegetation. Wheat and rye are common, temporary cover crops. They are seeded at a rate of 150 pounds per acre, or about four pounds per 1,000 square feet.

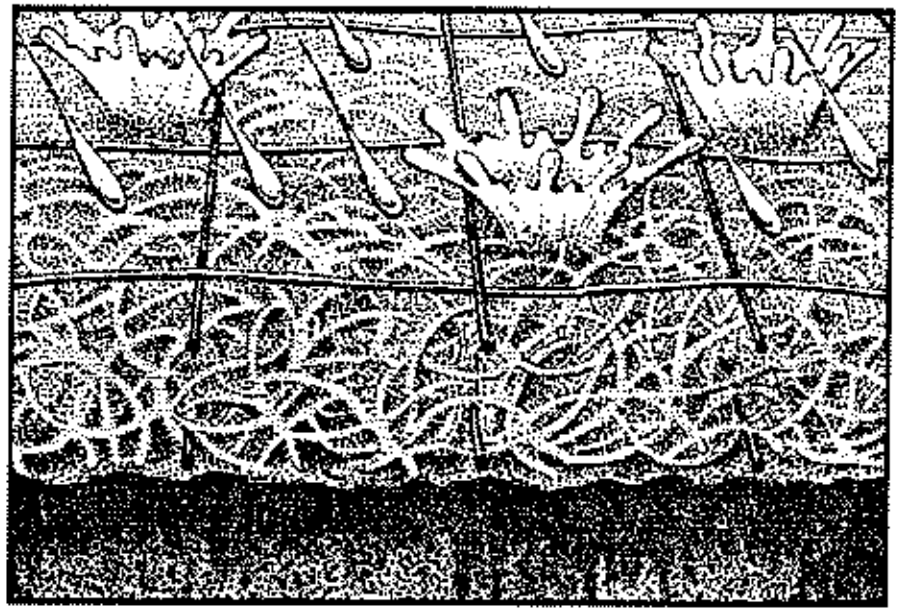
Establishing permanent vegetation may include seeding grass or other species, putting down sod or planting trees and shrubs. Success requires careful species selection, proper seedbed preparation and follow-up care.

Non-vegetative Soil Cover

Non-vegetative soil cover methods include using various mulches and a wide variety of manufactured soil erosion-control blankets. The primary purpose of mulch is to protect the soil from the impact of falling raindrops, and to provide an environment conducive to plant growth. Mulch helps plants grow by retaining moisture and by shading soil from the sun.

Mulch also is used when an area is seeded with vegetation. In those cases, the seed is spread first. Then mulch is applied. Straw is the most commonly used mulch because it is widely available and is relatively inexpensive. Hay, wood

(over)



Mulch and erosion control blankets, like the one above, protect the soil from the impact of raindrops and aid plant growth.

chips, wood shavings, shredded bark, jute fibers, coconut fibers and shredded newsprint also have proven successful as mulches.

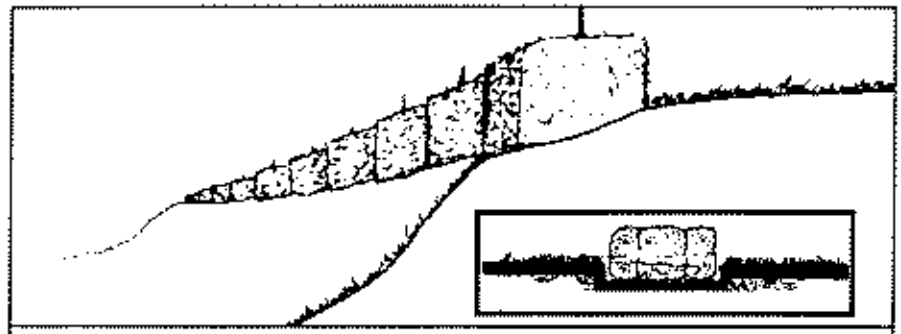
Straw mulch should be applied uniformly over an area at a rate of about two tons per acre, or two bales per 1,000 square feet. On large areas, the straw can be distributed with a mechanical mulch blower. In some communities, these blowers can be rented from the local soil and water conservation district for a nominal fee.

Some degree of "tacking" usually is required to attach the mulch to the surface to prevent straw from blowing away or washing down the hill. Tacking is done by spraying the surface with a commercially available tacking agent or by disking lightly with a straight disk, an implement pulled behind a tractor with disk-shaped blades aligned parallel to the direction of travel.

Erosion control blankets are used where steep hills or storm water runoff make it difficult to keep conventional straw mulch in place. These blankets consist of a natural or synthetic fiber material that is sandwiched between a permanent or degradable netting. Strips of the blanket material are unrolled down the hill and anchored into the soil on the uphill side. In all cases, success with erosion control blankets requires strict adherence to the manufacturer's installation instructions.

Runoff Control

Erosion from construction sites results from uncontrolled water that detaches soil particles and carries them away. These problems can be alleviated by controlling the flow of water by using diversions, waterways and underground drains. Information sheets that outline those procedures are available from your local Soil Conservation Service office.



Straw bales can be used to trap sediment around construction sites. The insert shows how the bales should be embedded.

Sediment Control

The two most common methods for preventing sediment from leaving a construction site are sediment filters and sediment basins. Keep in mind, however, that it always is better to prevent erosion from occurring than to catch the sediment it causes.

Sediment filters, commonly called silt fences, are used around the perimeters of construction sites and around inlets to storm sewers to remove sediment from the surface water leaving the construction sites. One of the most effective products available consists of a reinforced mesh fabric attached to wooden stakes. The stakes are driven into the ground to form a fence-like barrier. The lower edge of the mesh fabric is placed in a trench so that it is at least six inches below the ground. Soil is packed around the bottom of the fence to keep water from running under the fabric. These filters take up little space, and are effective when properly installed.

Straw bales also are used around the perimeters of construction sites to trap sediment. The effectiveness of this method often is reduced because of improper installation. Like silt fences, straw bales must be set in trenches and anchored with stakes to keep surface water from running around or under the barriers.

Grass filter strips sometimes are grown around the perimeters of construction sites where space and time for establishment permit them. The size of the grass filter strips should be proportional to the drainage areas. While not as effective as silt fences, grass filter strips filter sediment from low-velocity storm water flow, especially when used in conjunction with other erosion-reducing measures. The grass strips work only with evenly dispersed flows of water. They will not work in ditches or areas where water flows rapidly.

Where To Get Help

Keeping soil on construction sites is vastly cheaper than cleaning up the sediment caused by soil erosion. When sediment is allowed to run off construction sites, the community bears the burden and expense of cleaning up the choked storm sewers, ditches, lakes and streams. The methods covered here have proven to be cost effective in the communities where they have been used.

For more information about erosion control methods and sediment pollution control methods for construction sites, contact your local Soil Conservation Service office. It is listed in the telephone directory under "U.S. Government, Department of Agriculture."

United States Department of Agriculture

Soil Conservation Service

Columbia, Missouri

Urban Conservation Tips

Rock Chutes

Description

Rock chutes are channels protected from erosion by rock. The channels are used to carry water down a slope without creating a gully. The rock protects the soil, permitting water velocities which normally would erode even sod-covered soil.

Construction

Rock chutes have been used successfully on grades as steep as 3:1 (three feet horizontally for each vertical foot).

Failures can result from improper rock size, poor quality rock, unstable chute outlets, undermining, improper placement, settlement, undersized capacity, channel linings that are too thin, poor alignment and lack of maintenance.

Recommended rock size is based on the anticipated velocity of the water the channel is to carry. Bigger rock is used for greater velocities, which can be decreased by making the channel wider.

Rock for rock chutes must be dense and durable so it will not break easily.

Various rock sizes should be distributed randomly. Smaller rocks fill the voids between the larger rocks, causing the rocks to interlock. Rock of only one size is not suitable.

There are a number of alternatives to rock chutes. They should be used when they would be more economical than rock. Other useable materials include concrete, concrete blocks, steel, aluminum, treated wood and gabions (rock-filled wire baskets).

Rock has one advantage over other materials. It can shift to adjust to slight movement, whereas a more rigid material might crack.

It is important that the end of the rock chute be stable and on a gentle slope. This keeps water leaving the chute from eroding the soil at the end of the chute. The velocity of the water at the end of the chute should not be fast enough to erode vegetated soil.

The channel through the steep section of a rock chute should be as straight as possible. When water flows at a high velocity, curves must be designed carefully to prevent water from jumping out.

The rock chute should be 50 percent thicker than the largest rock used. The rock should be placed on sand or gravel and on a fabric liner if the area contains fine-textured soils.

Maintenance

Rock chutes should be inspected periodically, usually after each heavy storm. They especially should be inspected after the first storm because displacement is most likely then. Blockages should be removed promptly, and necessary repairs made.

Where To Get Help

For more information about rock chutes, contact your local Soil Conservation Service office. It is listed in the telephone directory under "U.S. Government, Department of Agriculture."

Rock Chute Cross Section

United States Department of Agriculture

Soil Conservation Service

Columbia, Missouri

Urban Conservation Tips

Waterways and Lined Channels

Description

A waterway is a natural or constructed channel that transports water over land without causing soil erosion. Waterways are used to carry concentrated, flowing surface water to adequate outlets. Gullies form in areas where waterways are needed if the areas are not protected from the moving water.

Most often, vegetation in a waterway is all that is needed to control the runoff. But if the flowing water causes erosion in the waterway, linings of cast-in-place concrete, riprap, gabions (rock-filled wire baskets) or similar permanent linings should be used.

Construction

If lined channels are necessary, it is important to install the lining according to the manufacturer's or engineer's guidelines. The following tips will help you get good results from vegetated waterways.

* Use fiber mats or temporary check dams to protect the waterway from soil erosion until the vegetation is established.

* Make sure the bottom of the waterway is smooth with no falls, especially at the bottom.

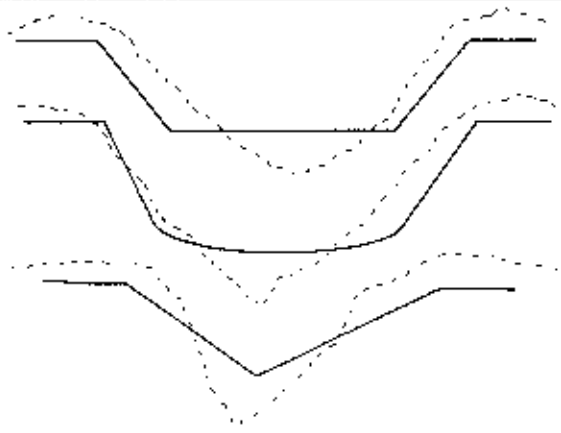
* Save topsoil, and spread it over the finished waterway. It is easier to establish vegetation in good soil.

* Before seeding, apply lime and fertilizer to the waterway according to the results of a soil test, available from the University of Missouri Extension Service.

* Use a type of vegetation that is suitable for the soil and moisture conditions at the site.

* Remove brush and debris from the waterway. Don't bury it in the waterway. Decomposition of buried material causes settlement.

* Try to avoid destroying important woody cover for wildlife when installing a waterway.



This drawing shows cross sections of (from top) trapezoidal, parabolic and v-shaped waterways. The dashed lines represent original surface conditions.

Maintenance

A high fertility program, including heavy nitrogen fertilization, helps grass compete with weeds and legumes, and maintain a thick, vigorous stand.

Control weeds and brush by cutting them or by using herbicides. Contact your local University of Missouri Extension Service office for herbicide recommendations.

To prevent the grass from being smothered from accumulated growth, keep the grass cut to a moderate height. Mow frequently enough so that the grass clippings do not smother the grass.

Gullies can be caused by construction irregularities, by sediment deposits, by using the waterway as a pathway or play area and by unstable outlets that drop off at the lower end of the waterway. Control unstable outlets by grading and seeding them.

Gullies must be filled and reseeded or covered with sod. Material used to fill gullies must be well compacted. Overfilling slightly will allow for settling, and will divert water somewhat until the new grass is established. Sediment deposits should be removed before they damage the grass.

Where To Get Help

For more information about constructing and maintaining waterways and lined channels, contact your local Soil Conservation Service office.

CITY OF BATTLEFIELD, MISSOURI
INDIVIDUAL SMALL MS4 STORMWATER MANAGEMENT PROGRAM

2004
LAWN CARE

HORTICULTURAL
MU Guide
PUBLISHED BY MU EXTENSION, UNIVERSITY OF MISSOURI-COLUMBIA muextension.missouri.edu/xplor/

Home Lawn Watering Guide

Brad S. Fresenburg, John H. Dunn and Erik H. Ervin
Department of Horticulture

As much as 80 percent of the water used around the home during summer is for outside uses. Watering the lawn is the main outside water use. During dry summers, local water authorities may cut off water for outside use or only allow watering on certain days. Both measures are necessary and effective means to reduce water consumption and relieve the strain on city water supplies.

To avoid severe loss of turf and to conserve water, homeowners should manage their lawns each year in anticipation of water restrictions.

This guide offers cultural practices that will reduce the need for irrigation while improving the competitiveness and appearance of your lawn.

Quick facts on lawn watering

- Lawns in Missouri may require as much as 1 to 1½ inches of water per week from irrigation or rainfall during summer to remain green and actively growing.
- When managed properly, tall fescue requires 25 percent less water and zoysiagrass requires 50 percent less water than Kentucky bluegrass to maintain a green, actively growing lawn in Missouri.
- Turfgrasses in Missouri rank as follows in resistance to leaf wilting and browning during summer dry periods — buffalograss, bermuda, zoysia, tall fescue, Kentucky bluegrass, perennial ryegrass.
- During extended periods of summer drought, dormant lawns (browned-out leaves) containing Kentucky bluegrass, tall fescue or perennial ryegrass should receive 1½ inches of irrigation every two weeks to maintain hydrated grass crowns and allow for full lawn recovery when more favorable moisture and temperature return in the fall.
- Deeper roots draw moisture from a larger volume of soil and therefore require less supplemental irrigation.
- Taller grass has deeper roots and a lower tendency to wilt.
- Taller grass provides shading of the soil surface and reduces lethal temperatures near the base of grass plants.
- Lawns mowed weekly at a taller mowing height are less likely to be scalped. Scalped lawns lose density and have shallow root systems.

Learn to read a lawn and know when to water

Purple-blue wilting leaves, footprints that stay, and folded or rolled leaves are signs that lawns should be thoroughly watered if grasses are to remain green and actively growing.

Turf water use rates are high during sunny and windy days with low relative humidity. In situations where lawns are not watered and rainfall is limited, grasses first show symptoms of wilt and later turn completely brown.

When soil lacks moisture, grass blades first turn bluish purple, indicating plant wilt.

Another early sign of insufficient water in the plant occurs when footprints remain in the lawn for several hours. Leaves with plenty of water quickly return to their rigid upright shape, while leaves lacking water will remain trampled for a period of time.

Leaves also may be folded or rolled lengthwise along the blade, indicating a lack of plant water.

If high temperatures and dry conditions continue without rain or irrigation, the above-ground portion of grasses will turn entirely brown and die. Grasses are said to be dormant during this browned-out stage, since the lower portion of the plant usually remains alive but not growing. Thorough watering will bring the lawn out of dormancy and new growth will resume from the below-ground base of grass plants.

Even though grasses are dormant, watering restrictions that result in extended dry periods can cause large ground cracks, severe soil drying, and excessive loss of turf cover even when watering is resumed later in the summer or early fall.

Summer dormancy of grasses is a mechanism that helps a lawn survive, but it does not guarantee that a lawn will fully recover from the browned-out stage.

Dormant lawns should receive at least 1 inch of

water every two or three weeks during summer to prevent complete turf loss. Grasses may not show a noticeable greening, but that amount of irrigation should be sufficient to hydrate the lower plant portions and increase the recovery once adequate moisture is available.

Wet wilt is another type of wilt to look for. Wet wilt occurs when the soil is obviously wet, but the root system is not able to keep pace with the water demands from the atmosphere. The curling of leaves from wet wilt looks very similar to wilt caused by lack of soil moisture. Waterlogged lawns that have a shallow root system are susceptible to wet wilt. Do not add more water when lawns are wilting and soil moisture appears to be adequate; it will only aggravate the problem by starving the root zone of oxygen.

Prepare for a drought

Management practices in the fall and spring determine the drought tolerance of the lawn in summer. To reduce the need for irrigation, your lawn management program should maximize root volume and depth in preparation for summer drought. By the time summer rolls around, there is little you can do to help a lawn except mow and irrigate properly.

The following lawn care tips will help reduce the need for irrigation and increase the chance of surviving summer drought.

1. Avoid the temptation to irrigate in spring just to get grass growing. Allow it to green up naturally. Mow frequently and avoid scalping. Do not begin to irrigate until dry conditions of early summer cause obvious turf wilt that lasts for more than one day.

In the spring, atmospheric water demands are low and moderate wilting of turf does not damage the lawn. If in the spring the soil is allowed to dry slightly and the grass to wilt some, a deeper and more hardy root system will develop. Such a root system will be necessary to reduce the need for summer irrigation and to survive drought conditions or when city water restrictions are imposed.

2. Mow grass as tall and as frequently as possible with a properly sharpened blade to produce a dense cover with a deep root system. Taller grass has a deeper root system that draws moisture from a larger volume of soil and results in less need for irrigation.

Grass height should never be less than 2½ inches after mowing. Mow frequently enough so that clippings are 1 to 1½ inches long. Raise the mower height if grass has grown too tall since the previous mowing. A lawn mowed at heights of 3 to 3½ inches will have a better chance of surviving prolonged drought and water restrictions.

Most homeowners mow lawns once a week regardless of the mowing height. Taller mowing heights are less likely to cause turf scalping, especially when grass leaves are rapidly growing in the spring. Dull mower blades and scalped turf result in an unattractive lawn that too many homeowners try to correct with over-irrigation.

3. Apply nitrogen fertilizer to cool-season grasses (Kentucky bluegrass, tall fescue and perennial ryegrass) primarily in the fall.

Some nitrogen may be applied in the spring if the lawn is sparse and bare soil is visible. Avoid summer application of nitrogen. Nitrogen fertilizer applied in the spring and summer causes additional leaf growth, which uses stored plant energy that normally would be used to produce roots needed for water uptake during summer.

4. Test the soil to ensure an adequate amount of phosphorus and potassium. Additional applications of potassium — 1 pound of K_2O per 1,000 square feet — in April and again in May or June will also improve the summer performance of lawns.

5. Core aerify tight soils and thatched turf in the fall or spring to increase water and air movement into the soil. This builds better root systems. Avoid summer coring in the absence of water, since it may cause excessive drying and drought stress.

6. Limit thatch removal by power raking or verticutting to fall or early spring or fall, since water demands are low and turf recovery is rapid. Do not severely power-rake lawns in the late spring or summer or they will require excessive irrigation to remain alive. When necessary, severe power raking and seeding should be done in September.

7. Select grasses that require less summertime irrigation to remain attractive. Zoysia is a warm-season grass and tall fescue is a cool-season grass. Both are noted for the ability to make an attractive summer lawn with less irrigation.

Select a sprinkler that best fits your needs

Automatic irrigation systems with pop-up sprinklers are often associated with excessive irrigation. This is not necessarily true, since properly designed and operated systems supply water uniformly over an entire area without wasted runoff.

Missouri soils generally have low water infiltration rates. Automatic controllers can be set to supply several short cycles so that the total amount of water desired is supplied without runoff.

The most common type of watering occurs with hose-end sprinklers. Some studies have shown that the average homeowner applies 2.5 times the amount of water that is required for turf growth when using hose-end sprinklers.

There are several types of hose-end sprinklers (see Figure 1). Select one that best fits your size and

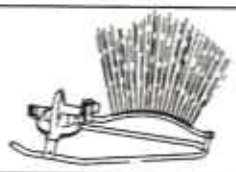
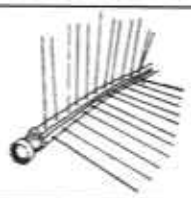
Sprinkler type	Comments
Rotary or impulse 	Rotary head shoots water out in a pulsating action. Some have adjustable screw or paddle that breaks up jet stream and disperses water pattern. Can be set to water partial circles. Best for large areas. Accurately distributes water when placed in an overlapping triangular pattern.
Traveling 	Path guided by hose placement. Traveling action covers a large area without assistance. Requires level ground and overlapping pattern to evenly distribute water. Used primarily on large lawns. Can easily be manipulated for large irregular lawn shapes. Wheel drive types are not suitable for newly seeded lawns where soft soil conditions result in stuck sprinklers.
Whirling-head 	Deposits largest amount of water closest to spray head. Use a 50 percent overlapping pattern. Deposits larger amount of water in short period of time and requires frequent movement. Good for watering tight locations.
Stationary 	Water applied in irregular pattern even with overlapping moves. Difficult to water large areas uniformly. Good for spot-watering tight locations. Deposits a large amount of water in a short period of time and requires frequent movement.
Oscillating 	Delivers water in a rectangular pattern. Deposits most of the water near sprinkler head. Difficult to achieve even water pattern on large areas that require sprinkler relocation. Can be adjusted to water smaller rectangular areas and other tight locations.
Soaker hose 	Flat pin-holed hose sprays fine streams of water. Requires several moves to water medium-sized lawn. Delivers water slowly — good for hard-to-wet locations. Can be manipulated to water irregular areas and long tight areas along house or walks.

Figure 1. Some sprinkler types and their applications.

shape of lawn and then operate it efficiently. All hose-end sprinklers can be attached to inexpensive timers that can be used to shut off unattended sprinklers and avoid over-irrigation.

How much water to apply

Once you have decided on the best sprinkler for your size and shape of lawn, you must decide how long to operate a sprinkler in a certain location. This is best achieved by knowing how many inches of water your system puts out in a certain amount of time. To do this, place shallow, straight-sided containers (tuna cans work well) or rain gauges in a grid pattern around the sprinkler. Operate the sprinklers (use overlapping patterns where needed) for a given amount of time and measure the amount of water captured (see Figure 2).

Measure the depth of water in the cans with a ruler or read directly from the rain gauges. Then use the following example to determine your water application rate in inches per hour. For example, a sprinkler that delivers a quarter-inch of water in 45 minutes has a delivery rate of one-third of an inch per hour.

An alternative approach would be to measure the area that your sprinkler pattern covers and the length of time it takes to fill a 1-gallon container directly from the sprinkler. For example, a sprinkler that covers 235 square feet and takes 1 minute and 15 seconds to discharge 1 gallon of water has a delivery rate of one-third of an inch per hour.

In the above examples, sprinklers should be operated approximately three hours in each location to supply 1 inch of irrigation water per week.

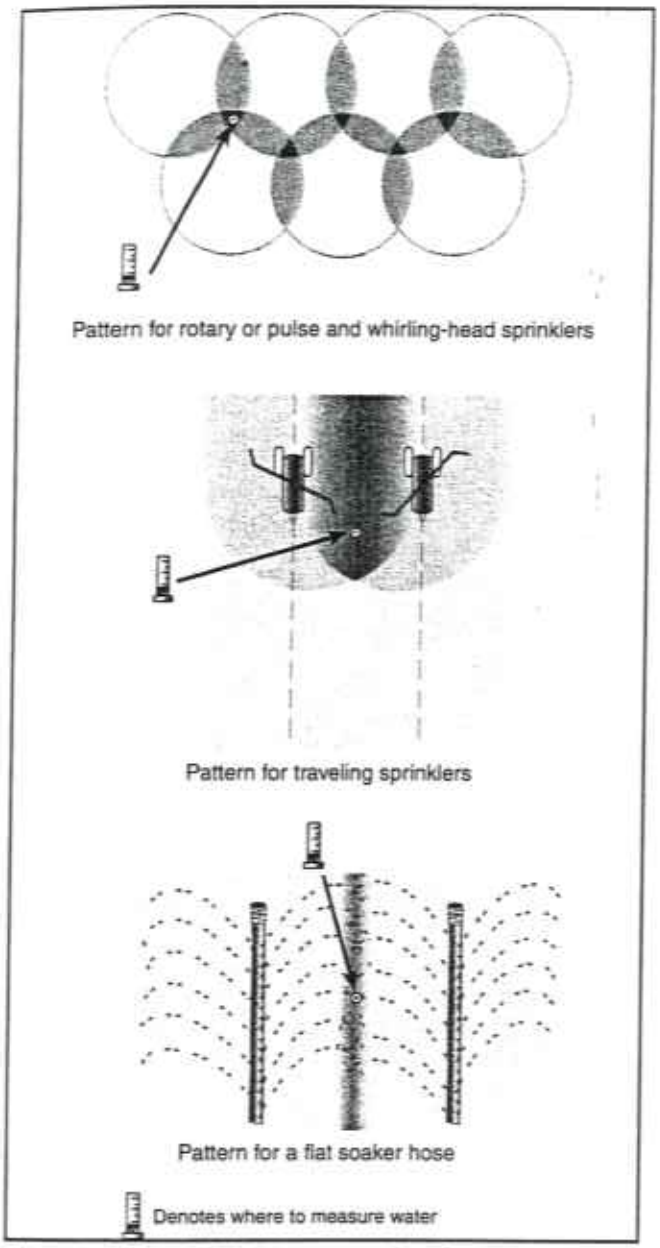


Figure 2. Proper sprinkler pattern overlap of 50 percent.

Most soils in Missouri will take in only about ½ inch of water per hour. If your sprinkler system delivers more than that amount, move it to a different location more frequently, after each time ½ inch of water has been applied. Repeat the process until the full amount of water desired has been applied.

Rotary sprinklers that are set to deliver a half or quarter sprinkler pattern will discharge two or four times the amount of water on a given area. Operate rotary sprinklers with half patterns for half the amount of time and sprinklers with quarter patterns for one-quarter the amount of time.

The utility water meter connected to your home can also be used to check how effectively water is being applied. It accurately measures water in cubic feet. When no other water is being used in the home, water a known area for a set amount of time and use these conversion factors to determine your water application rate. Some helpful facts to have are:

- 624 gallons (83.3 cubic feet) of water are required to apply 1 inch of water on 1,000 square feet of lawn.
- 7.48 gallons = 1 cubic foot of water.

Once the decision has been made that a lawn has sufficiently wilted and irrigation is needed, supply enough water to last a week. Depending on the type of sprinkler and soil water infiltration rate, several sprinkler changes may be required over a two- or three-day period to supply the amount of water desired.

If no rainfall occurs, continue to irrigate on a weekly schedule. If rainfall occurs, delay the next irrigation until symptoms of wilt are present. Even though water application is discussed on a weekly basis, it is not crucial that water be applied every seven days. Keep the application schedule flexible and irrigate based on the determination of lawn wilting and soil moisture.

Use Table 1 to determine the amount of irrigation that will be needed for your lawn situation.

Table 1. Approximate lawn water requirements.

Lawn type	Green turf[1] (inches of water per week)	Dormant turf[2] (inches of water per week)
Perennial ryegrass	1.5	1.0
Kentucky bluegrass	1.2	0.7
Tall fescue	0.8	0.5
Zoysia or bermuda	0.5	0.2
Buffalograss	0.3	0.2

[1]Lawn remains green and growing.
[2]Lawn may turn brown, but will not die.

Once the decision has been made to irrigate, use the above recommendations to guide irrigation scheduling and how much water to supply. Should puddles or runoff occur before the total amount of water is applied, stop irrigating and resume only after the ground has absorbed the free moisture. Lawn areas that are moist, firm and have no visible water are ready for a repeat irrigation cycle. Areas that are soft and produce squashy footprints when walked on are not ready to receive additional irrigation.

A day after watering, check a few different locations in the yard to determine how well your irrigation program is distributing water in the root zone. With a shovel, cut a slender 2-inch wedge 6 to 8 inches deep. This wedge of soil, roots and turf can be replaced easily without damage to the lawn after inspection.

Estimate the moisture content at different depths in the soil profile by pressing together a golf-ball-sized amount of soil. If drops of water can be

squeezed from the soil ball, you may be irrigating too much of too often. Soils that hold together without crumbling and appear moist have been irrigated properly. Soils that appear dry, dusty and do not form a ball when squeezed have not received enough irrigation or the water is running off the surface of the lawn and not into the root zone.

Adequate soil moisture at 6 to 8 inches deep is sufficient to maintain grasses during the summer. A foot-long slender screwdriver pushed into the ground in several locations can also give a quick assessment of the moisture condition of the soil. The screwdriver will easily penetrate to the soil depth that has received sufficient water. The screwdriver test can also be used to help determine where and when there is a need for irrigation.

Conserve water by knowing when to water

1. The best time to water a lawn is from 6 to 8 a.m. During this time the water pressure is highest, disruption of the water pattern from wind is low, and water lost to the atmosphere by evaporation is negligible. Watering early in the morning also has the advantage of reducing the chance of turf diseases that require extended periods of leaf moisture. Avoid irrigation during midday and windy conditions.

2. Move sprinklers frequently enough to avoid puddles and runoff. Difficult-to-wet areas such as slopes, thatched turf and hard soils may benefit from application of a wetting agent to improve surface penetration of water.

3. Water only when the plant tells you to. Become familiar with areas of the lawn that wilt first (blue/purple leaves, rolled leaves, foot printing). Water within a day of observing these symptoms.

4. Water problem areas by hand to postpone the need for irrigation of the entire lawn. Some areas of a lawn usually wilt before others. These areas, or "hot spots," may be caused by hard soils that take up water slowly, slopes, southern exposures and warmer areas next to drives and walks. Lawns that have unusual shapes also may require some hand watering to avoid unnecessary watering of paved surfaces, mulched beds and buildings. Soaker hoses that have a narrow pattern and supply water at a slow rate may be useful in these areas.

Watering new lawns

Newly seeded or sodded lawns require special irrigation. A newly seeded lawn should be watered daily and may need as many as four light waterings in a single day. Keep the seedbed moist, but not saturated, to a depth of 1 to 2 inches until germination occurs (green cast to lawn and seedlings are ¼ to ½ inch tall).

Seedlings of a new lawn must not be stressed to the point of wilt. Continue with light applications of water — ⅛ to ¼ inch — one to four times a day.

Apply straw (one bail per 1,000 square feet) at time of seeding to help shade the ground and prevent rapid drying of the soil surface. Straw also will reduce seedling damage from the force of large sprinkler drops. Watering with a light mist is best for establishing new lawns. As seedlings reach 2 inches in height, gradually reduce the frequency of watering and water more deeply. After the new lawn has been mowed two or three times, deep, infrequent waterings are the best.

Newly sodded lawns require watering one or two times a day. Begin irrigation immediately after laying sod. Plan your sodding operation so that a section of laid sod can be watered immediately, while other areas are being sodded.

Sod should be watered so that the sod strip is wet as well as the top inch of soil below the sod. The first irrigation will take about an inch of water to achieve complete wetting of the sod. After watering, lift up pieces of sod at several locations to determine if it has been adequately irrigated. Continue watering one to two times a day with light irrigations to prevent wilting and to ensure a moist soil just below the sod layer.

As sod becomes established and roots penetrate and grow in the soil, gradually reduce the frequency of watering but wet the soil deeper. After sod has been mowed two or three times, deep, infrequent watering should be practiced. During hot, windy conditions, establishing sod may require several light mistings per day to prevent wilt and potentially high lethal temperatures. In this case, light misting, just to wet the leaf surface and not to supply water to the soil, cools the grass plant as water is evaporated from the leaves.

Do not over-irrigate (saturate) the soil because that will inhibit sod roots from growing into the soil. If the sod cannot be watered on a daily basis, thoroughly water the sod and soil to a depth of 6 inches. This will delay the rooting time of sod but will reduce the chance of rapid drying and severe loss of grass.

Summary

Good lawn care practices save water and harden turf in preparation for dry periods or local lawn watering restrictions. Taller mowing and fall nitrogen fertilization develop a hardy and efficient root system that reduces the need for supplemental irrigation.

Irrigation schedules should be kept flexible and associated with identification of lawn wilting. Choose a sprinkler that best fits your lawn size and shape. The amount of water a sprinkler applies should be determined to accurately water lawns. Newly seeded or sodded lawns require daily irrigation during establishment.

HORTICULTURAL
MU Guide
PUBLISHED BY MU EXTENSION, UNIVERSITY OF MISSOURI-COLUMBIA muextension.missouri.edu/xplor/

"Don't Bag It" Lawn Care

Erik H. Ervin and Christopher J. Starbuck
Department of Horticulture

Many homeowners believe grass clippings need to be removed to have a healthy, vigorous lawn. By following the steps in the "Don't Bag It" lawn care program, you can have a beautiful lawn without collecting your grass clippings.

"Don't Bag It" lawn care facts

- Yard wastes, such as leaves, grass clippings and branches, have been banned from Missouri landfills since January 1, 1992, and nationally since March 1995.
- Yard waste accounts for approximately 20 percent of all waste materials.
- Up to 25 percent of your lawn's total fertilizer needs are supplied by clippings left on the lawn.
- Clippings contain 80 to 85 percent water and decompose quickly.
- MU research shows clippings do not contribute to thatch problems.
- Average mowing time can be reduced by 30 percent when grass clippings are not bagged.
- Besides saving time, you also save money by not having to purchase bags or pay for extra trash removal.

Clipping management and thatch

Although turfgrass experts tell us that returning grass clippings to the lawn is an accepted part of lawn maintenance, many people still believe grass clippings cause thatch. Thatch is a layer of undecomposed or partially decomposed grass roots, stems, crowns, runners and lower shoots that build up between the soil surface and actively growing green turf. Grass clippings contain 80 to 85 percent water and decompose more quickly than other grass plant parts.

Research at MU and other universities indicates that grass clippings do not contribute to thatch. However, it is important to understand that if a thatch layer greater than ½ inch is already present, clippings can further speed its formation.

A lawn that has a thatch layer that is more than half an inch thick should be dethatched before you begin recycling grass clippings to the lawn. Dethatch cool-season lawns (Kentucky bluegrass, tall fescue, perennial ryegrass) in early fall and warm-season lawns (zoysia, Bermuda) in early to mid summer. Thatch is best removed by power raking, verticutting or coring. For more detailed information on thatch, refer to MU publication G 6708, *Thatch Enemy of Lawns*.

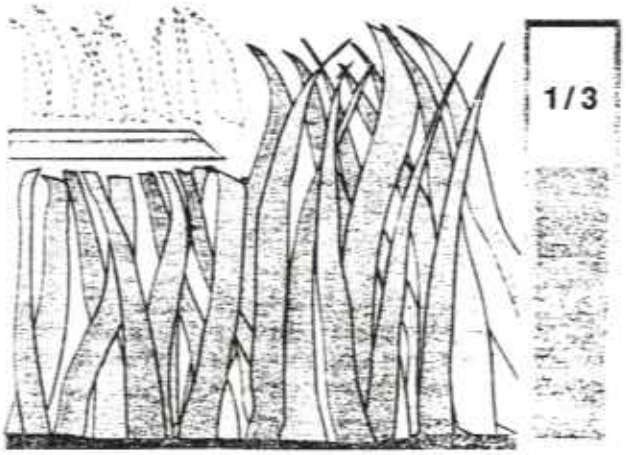


Figure 1. Mow your lawn frequently so that you do not remove more than one-third of the total plant height.

"Don't Bag It" in three easy steps

Step 1: Mowing

Returning clippings to the lawn usually means mowing more than once a week during the few weeks of rapid growth in spring and early summer. Grass clippings should be less than 1 inch, or no more than one-third of the total plant height, to ensure rapid decomposition (Figure 1). Mowing more frequently is not as much extra work as you might think, because lawns mowed at the proper height cut more easily and quickly. Mowing infrequently damages the lawn by removing too much of the plant at one time. When mowed regularly, clippings filter down through the grass, decompose rapidly and recycle nutrients back into the soil.

For cool-season grasses (Kentucky bluegrass, tall fescue, perennial ryegrass), the "Don't Bag It" lawn care plan recommends that mowers be set at 2½ to 3½ inches. When you set your mower at a high cutting

Figure 2. Composting your yard wastes results in an abundance of healthy fruits and vegetables from your garden, a safer environment, less money spent on fertilizers and bags, and more time to enjoy what you are creating.

height, the grass plant produces a deep and efficient root system that can reduce the need for extra water. Taller mowing also helps to "shade out" many weeds. Simply remember to set your mower at a tall setting so clippings fall easily into the lawn.

Warm-season grasses, such as zoysia and Bermuda, should be mowed at 1½ to 2½ inches. In the spring (prior to green-up), warm-season lawns should be mowed at a low setting on your mower. This dead leaf and stem tissue should be removed from the lawn. Mowing at a low setting in spring increases the green-up rate, reduces thatch accumulation and allows for easier and more uniform mowing during the growing season. As the season progresses, mowing height should be adjusted upward so that by September you are mowing at 2 to 2½ inches. Warm-season lawns should be left tall (2 to 2½ inches) in the fall. Raising your mower height throughout the growing season will result in a thick, vigorous turf.

Clippings should be uniformly distributed rather than deposited in clumps. Mowing the lawn when the grass is dry and using a properly sharpened mower blade will spread clippings evenly. Dull mower blades increase injury to grass plants and give the lawn an unsightly brown appearance. Mowing when the lawn is under drought or heat stress can also injure grass plants.

Be cautious about removing the bagging attachment from any lawn mower. Because many mowers have bagging attachments that affect mower safety, it is very important to understand manufacturer guidelines before considering removal of the bagger attachment. Some manufacturers have adapter or converter kits that can be purchased to change from a bagging mower to a nonbagging type. **Never assume your mower is still safe to operate after removing the bagging attachment. Refer to your owner's manual or equipment dealer.**

In autumn, it is not always necessary or even desirable to remove all fallen tree leaves. Instead, increase mowing frequency to mulch leaves back into the lawn. This practice recycles essential nutrients that were mined by deep tree roots back to the soil surface, making them available to shallow, fibrous turfgrass and tree roots. University research has shown that mulching tree leaves into lawns has no detrimental effects on thatch or soil pH. Of course, there are some limitations of this practice. Avoid mulching leaves into the lawn when leaves are wet or when deposition is so large (more than a 2-inch-high layer) that turf-smothering clumps are left on the lawn.

Step 2: Fertilizing

Fertilize your lawn to provide uniform, moderate growth throughout the growing season. A properly fertilized lawn will have a healthy, dense stand of turf that reduces weeds and recovers quickly from insect or disease injury.

Remember, soil testing is recommended every three years. Select a lawn fertilizer based on soil test results. Without a soil test, use a lawn fertilizer with an approximate ratio of 1:1:1 to 2:1:1 or 3:1:2 (nitrogen: phosphorus: potassium). For example, a 3:1:2 fertilizer would have a label analysis of 21-7-14. Contact your local University Extension center for information on soil testing. Consult MU publicationG 6954, *Soil Testing for Lawns* .

The number of fertilizer applications you make will depend on how you want your lawn to look, the type of grass, and soil type. Typically each fertilizer application should supply 1 pound of nitrogen per 1,000 square feet of turf.

Cool-season grasses. Fertilize cool-season grasses at the following maintenance levels:

- Low maintenance: October, May.
- Average maintenance: September, October, May.

September and October are the most important times to fertilize cool-season grasses. Fertilizing at this time will prolong the green color into the winter months and encourage root development and thickening of the turf.

Early spring fertilization, especially with high rates of nitrogen, can result in a flush of green growth and rapid clipping production. It may be necessary to collect clippings until growth slows. While the lawn may look beautiful for awhile, the plants' energy reserves are depleted by this rapid shoot growth.

Consequently, the lawn is less tolerant of summer stresses. Early spring (March-April) fertilizer applications should only be made if the lawn has not been fertilized since the previous spring.

Fertilizing should be done in late spring (May) after the spring growth surge is over.

May applications should be made using fertilizer products that contain 30 to 50 percent of the nitrogen in a slow-release form. Examples of slow-release forms of fertilizer include sulfur-coated urea, urea formaldehyde, IBDU, natural organic fertilizers or any other slow-release or slowly soluble nitrogen material. **Note:** When applying crabgrass preventer in early spring (mid-March to mid-April), it is best to purchase a material that does not contain a fertilizer. The fertilizer will result in excessive top growth. For more information on fertilizing cool-season grasses, consult MU publication G 6705, *Cool-Season Grasses: Lawn Maintenance Calendar.*

Warm-season grasses. Fertilize warm-season grasses when the grass is actively growing. These grasses are dormant and turn golden brown during the cooler part of the year.

- Average maintenance: May-August.

Zoysia should be fertilized during the warm months — May through August. Early spring (March/April) fertilization benefits weeds and promotes premature top growth before the roots begin to grow. Late fertilization (after September 1) may delay the natural dormancy before winter.

The May application should be made using fertilizer products that contain 30 to 50 percent of the nitrogen in a slow-release form. For more information on fertilizing zoysia, consult MU publication G 6706, *Establishment and Care of Zoysiagrass Lawns.*

Step 3: Watering

Good lawn care practices can save water and prepare turf for dry summer months. Taller mowing and proper fertilization result in a deep and efficient root system that reduces the need for additional water.

For cool-season lawns to remain green and actively growing during the driest part of the summer, about 1 to 1½ inches of water are needed per week from irrigation or rainfall. Most hose sprinklers deliver ¼ to ½ inch of water per hour. Lawns watered too frequently tend to develop shallow root systems.

The best time to water is early morning. Less water is lost by evaporation, and disease incidence is reduced.

When managed properly, warm-season grasses require up to 50 percent less water than cool-season grasses to maintain a green, actively growing lawn during summer months in Missouri. For additional information, see MU publication G 6720, *Home Lawn Watering Guide.*

When to collect clippings

Leaving grass clippings on the lawn is highly recommended; however, there are times when clippings may need to be collected:

- When the lawn is diseased, removing clippings can decrease the population level of disease organisms.
- If the lawn must be mowed when wet or if the grass is excessively tall, clippings will mat together and may not be evenly distributed. The lawn may be damaged under clumps of clippings.
- If your lawn mower is unsafe to operate without the bagging attachment, you should continue to collect grass clippings.

Ways to use grass clippings

Mulching. A layer of grass clippings can provide an effective mulch around garden plants and between rows of flowers, vegetables and small fruits. Mulching helps to reduce weeds, conserve moisture and modify soil temperature. However, care should be taken to avoid mulching too thickly. Excessive mulch can inhibit moisture and oxygen penetration into the soil and may produce offensive odors. Apply no more than a 1-inch layer of clippings at a time. Total mulch depth should not exceed 3 to 4 inches. Clippings from lawns treated with a herbicide or herbicide/fertilizer combination should not be used immediately as a mulch. For example, clippings from a lawn treated with 2,4-D should not be used as a mulch until the chemical has broken down (see Table 1). For addition-

Benefits of mulches

- Control weeds.
- Conserve soil moisture.
- Reduce soil erosion.
- Improve water penetration into the soil.
- Protect against extreme heat and cold.
- Increase organic matter in the soil over time.

Table 1. Persistence of some common herbicides in soil.

Common name	Trade names	Longevity in soil (months)
Benefin	Balan	4–8
DCPA	Dacthal	4–8
Bensulide	Betasan	6–12
Glyphosate	Roundup, Kleenup	<1
2,4-D	(many formulations)	1–2
MCPP	(many formulations)	1–2
Dicamba	Banvel	3–12

Source: *Composting and Mulching: A Guide to Managing Organic Yard Wastes.* C. Rosen, N. Schumacher, R. Mugaas, and S. Proudfoot. 1988. St. Paul, Minn.: University of Minnesota, Extension Service, Department of Soil Science.

al information on mulching, see MU publication G 6960, *Mulches*.

Composting. As additions to a compost pile, grass clippings are excellent because of their relatively high nitrogen content (Figure 2). However, they should not be the only compost component. Because of their tendency to mat, grass clippings are difficult to compost if they are layered too thickly. A pile of grass clippings can produce a foul odor because of a lack of oxygen. Mixing grass clippings with carbon-containing materials such as leaves or sawdust will ensure efficient composting. For a detailed discussion of composting, refer to MU publication G 6956, *Making and Using Compost*.

For further information

See the following MU publications:

G 6700, *Cool-Season Grasses: Lawn Establishment and Renovation*

G 6705, *Cool-Season Grasses: Lawn Maintenance Calendar*

G 6706, *Establishment and Care of Zoysiagrass Lawns*

G 6708, *Thatch: Enemy of Lawns*

G 6720, *Home Lawn Watering Guide*

G 6725, *Grasses in Shade: Establishing and Maintaining Lawns in Low Light*

G 6750, *Home Lawn Weed Control*

G 6954, *Soil Testing for Lawns*

G 6956, *Making and Using Compost*

G 6958, *Grass Clippings, Compost and Mulch: Questions and Answers*

G 6960, *Mulches*

OUTREACH & EXTENSION
UNIVERSITY OF MISSOURI
COLUMBIA

■ Issued in furtherance of Cooperative Extension Work Acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. Ronald J. Turner, Director, Cooperative Extension, University of Missouri and Lincoln University, Columbia, MO 65211. ■ University Extension does not discriminate on the basis of race, color, national origin, sex, religion, age, disability or status as a Vietnam era veteran in employment or programs. ■ If you have special needs as addressed by the Americans with Disabilities Act and need this publication in an alternative format, write ADA Officer, Extension and Agricultural Information, 1-98 Agriculture Building, Columbia, MO 65211, or call (573) 882-2792. Reasonable efforts will be made to accommodate your special needs.

AGRICULTURAL
MU Guide
PUBLISHED BY MU EXTENSION, UNIVERSITY OF MISSOURI-COLUMBIA muextension.missouri.edu/xplor/

Controlling Nuisance Moles

Robert A. Pierce II, Extension Fish and Wildlife Specialist
School of Natural Resources

Moles are small mammals that spend most of their lives in underground burrows. They are seldom seen by humans. When seen, they frequently are mistaken for mice or shrews. The eastern mole (*Scalopus aquaticus*) is the only species that lives in Missouri. It is found throughout the state (Figure 1).

Figure 1. Eastern mole.

The most conspicuous features of the mole are its greatly enlarged, paddlelike forefeet and prominent toenails, which enable it to "swim" through the soil. Moles have strong legs, short necks and elongated heads. They lack external ears, and their eyes are so small that at first glance they appear to be missing.

A mole's fur is soft and brownish to grayish with silver highlights. When brushed, the fur offers no resistance in either direction, enabling the mole to travel either backward or forward within burrows.

Moles prefer moist, sandy loam soils in lawns, gardens, pastures and woodlands. They generally avoid heavy, dry clay soils. They construct extensive underground passageways — shallow surface tunnels for spring, summer and fall; deep, permanent tunnels for winter use. Nest cavities are located underground, connecting with the deep tunnels.

Because moles have high energy requirements, they have large appetites. They can eat 70 to 80 percent of their weight daily. They actively feed day and night at all times of the year. Moles feed on mature insects, snail larvae, spiders, small vertebrates, earthworms, and occasionally small amounts of vegetation. Earthworms and white grubs are preferred foods.

Mole activity in lawns or fields usually shows up as ridges of upheaved soil. The ridges are created where the runways are constructed as the animals move about foraging for food. Burrowing activity occurs yearround, but peaks during warm, wet months. Some of these tunnels are used as travel lanes and may be abandoned immediately after being dug. Mounds of soil called molehills may be brought to the surface of the ground as moles dig deep, permanent tunnels and nest cavities.

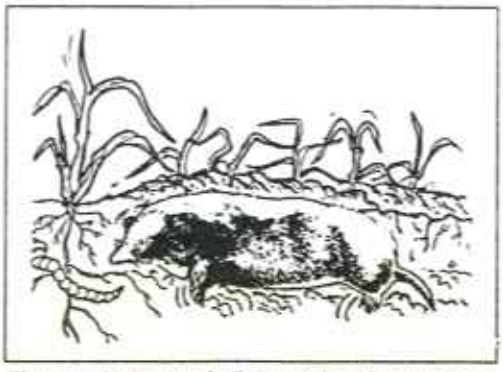


Figure 2. Moles "swim" through soil, often near the ground surface. They may sometimes damage plants by exposing roots to drying.

Moles breed in late winter or spring and have a gestation period of about four to six weeks. Single annual litters of two to five young are born in March, April or May. Young moles are born hairless and helpless, but growth and development occur rapidly. About four weeks after birth, the moles leave the nest and fend for themselves.

Moles in the natural environment cause little damage. They are seldom noticed until their tunneling activity becomes apparent in lawns, gardens, golf courses, pastures, or other grass and turf areas.

Moles often are more of a nuisance than a financial liability. The ridges of their tunnels make lawn mowing difficult. Since the roots are disturbed, grass may turn brown and unsightly (Figure 2). Moles rarely eat flower bulbs, ornamentals or other vegetative material while tunneling, but plants may be physically disturbed as moles tunnel in search of animal organisms in the soil. Mole activity may indirectly damage vegetation, but their feeding on insects and other soil organisms is beneficial.

Shrews and meadow voles frequently use mole tunnels as runways and travel lanes. Shrews, like moles, are insectivorous and eat little vegetation. Meadow voles eat a wide variety of vegetative matter and may damage plant life. Moles, shrews

and meadow voles can be similar in appearance. Because of this, and since they often share the same habitat, you should know how their habits differ so that you can identify each species in case it becomes necessary to control them.

Mole activity

The mole activity people usually see is of two kinds — raised ridges or surface tunnels and mounds. These raised ridges or surface tunnels are unique to moles. No other animal leaves this evidence of its presence. However, mole activity often is confused with that of the pocket gopher, which also is found in Missouri.

Moles leave cone-shaped mounds on the surface of the ground. These usually are not numerous. Most often these mounds contain coarse soil and earth clods.

Mounds are constructed as shown in Figure 3. The mole pushes this soil to the surface, especially when digging deep runs. These deep runs lead to a nest or provide tunnels for use in the winter or during the hot times of the summer. In building these mounds, the mole pushes the soil up through the center, much as a volcano is formed.

People often confuse pocket gopher mounds with mole mounds. Pocket gophers are rodents and have different feeding habits than moles. Traps designed to catch moles usually will not catch pocket gophers, or vice versa. Therefore, it is important to correctly identify which animal you have in the damage situation. In some areas, both animals exist in the same place.

The pocket gopher does not construct raised ridges or surface tunnels. Pocket gophers dig two kinds of tunnels — one about 5 to 8 inches under the surface and other deeper tunnels that may go down several feet below the surface.

Unlike the mole, the pocket gopher constructs many mounds. These mounds are of finely sifted soil. Sometimes they can be rather large, but most often they contain about one-half gallon of soil. The pocket gopher digs a main tunnel, then a lateral side tunnel to create the mound, thus getting rid of soil accumulated in digging the underground tunnels.

Figure 4 shows side views of a mole mound and a pocket gopher mound. Remember, you need to use the right trap for the right animal — a mole trap for a mole and a pocket gopher trap for a pocket gopher.

Damage prevention and control techniques

The mole seems to possess a natural shrewdness and ability to sense danger. This trait makes moles a challenge to trap.

Cultural methods and habitat modification. In practice, packing the soil with a roller or reducing soil moisture may make an area less habitable for moles. Because moles feed largely on insects and worms, the use of certain insecticides to control these organisms may reduce their food supply, causing them to leave the area. However, before leaving, the moles may increase their digging in search of food, thereby possibly increasing damage to turf or garden areas.

Diazinon used at a rate of one pound active 4 percent granules, or 40 pounds per acre on lawns and around gardens, has been a recommended insecticide for controlling white grubs, thus reducing burrowing activity of moles that seek them for food. The future availability of Diazinon remains in question. Contact your University Outreach and Extension center for recommended procedures when using insecticides. The user should follow all pesticide precautions and restrictions on the label.

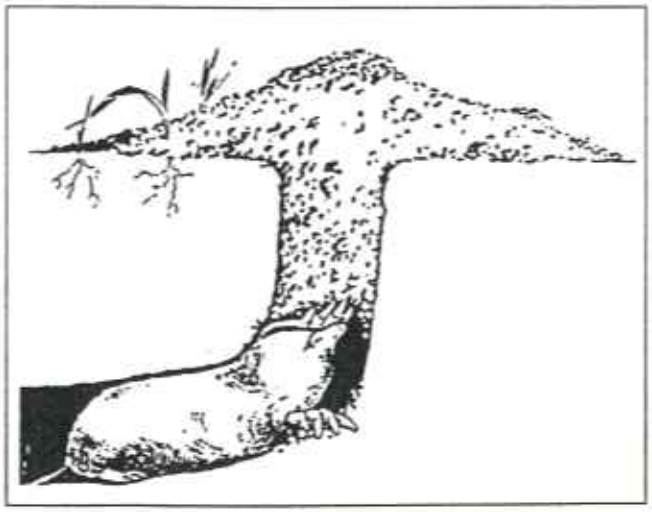


Figure 3. Moles push dirt through vertical tunnels onto the surface of the ground. Mole mounds are good places to use fumigants, since they are believed to mark deep runs or nest areas.

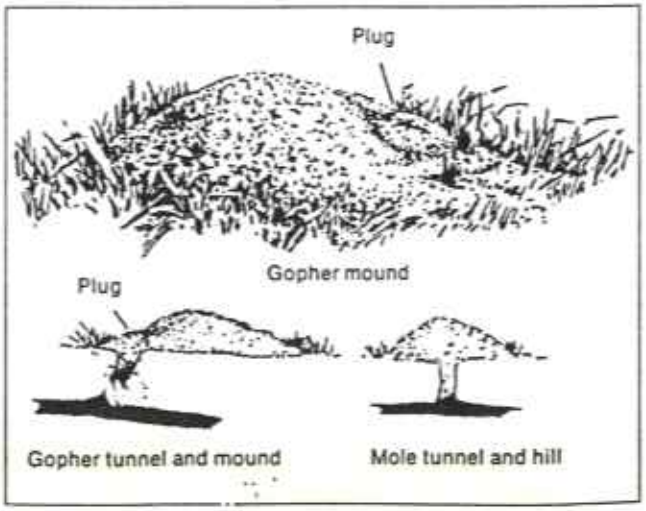


Figure 4. Comparison of a gopher mound and a mole hill.

Repellents. The repellent Thiram is federally registered for protecting bulbs from mole damage. Mole repellents with castor oil as the active ingredient are now on the market and may potentially prevent eastern mole damage under certain circumstances. In using any repellent, follow directions and application rates provided on the package label. Also be aware that using any repellent for controlling moles has limitations and may not eliminate damage or effectively control the problem.

Mothballs or moth flakes occasionally are suggested as mole repellents. When placed in the mole's runways, they are said to cause the mole to leave. But there is little information to substantiate their effectiveness.

Toxicants. There are a number of difficulties in poisoning moles. Since moles normally do not consume grain, seeds or nuts, poison baits are seldom effective. One poison is federally registered for use against moles. The toxicant is zinc phosphide. Ready-to-use grain baits containing this ingredient are often sold at nurseries or garden supply stores.

Fumigants. Fumigants are also federally registered for use against moles. They are aluminum phosphide, calcium cyanide and gas cartridges.

Most of these are restricted-use pesticides. These fumigants are much more effective if the material is placed in the deep mole burrows, not the surface runways.

Since state pesticide registrations vary, check with your University Extension center for information on toxicants and repellents legal in your area. Care should be taken when using chemicals and the label instructions should be read, understood and followed.

Traps

Trapping is the most successful and practical method to get rid of moles and eliminate damage.

There are three excellent mole traps on the market. Each of these, if properly handled, will give good results. These traps each depend on the same mechanism for releasing the spring.

A broad trigger-pan springs the trap as the mole upheaves the depressed portion of the surface burrow over which the trap is set. The brand names of these traps are: Harpoon mole trap, Out O' Sight and Nash (choker loop) mole trap (Figure 5).

The Harpoon trap has sharp spikes that impale the mole when driven into the ground by the spring. The Out O' Sight trap has scissorlike jaws that close firmly across the runway, one pair on either side of the trigger-pan. The Nash trap has a choker loop that tightens around the mole's body.

These traps are well suited to moles because they take advantage of the mole's natural habits. The mole springs the traps by following its natural instinct to reopen obstructed passageways. Another advantage

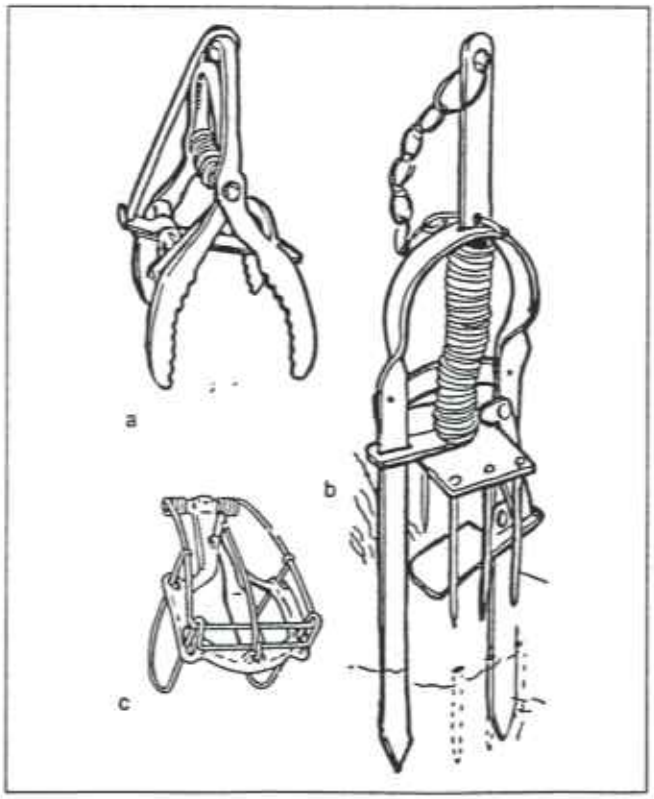


Figure 5. Different mole traps available include (a) Out O'Sight (scissor-jawed), (b) Harpoon, and (c) Nash (choker loop).

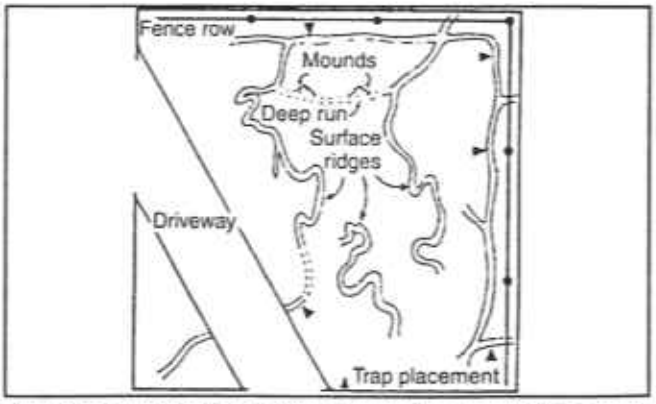


Figure 6. A network of mole runways in a yard. The arrows indicate good locations to set traps. Avoid the twisting surface ridges and do not place traps on top of mounds.

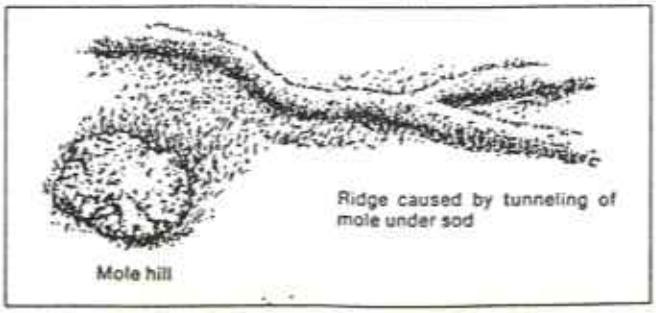


Figure 7. Mole sign.

of the traps is that they can be set without arousing the animal's suspicions, since you do not have to enter or put anything into its burrow.

The success or failure of these traps depends largely on the operator's knowledge of the mole's habits (see Figures 6 and 7) and the trap mechanism.

To set a trap properly, select a place in the surface runway where there is evidence of fresh work and where the burrow runs in a straight line. To place the trap, dig out a portion of the burrow, locate the tunnel and replace the soil, packing it firmly beneath where the trigger-pan of the trap will rest.

With the Harpoon trap, raise the spring, set the safety catch and push the supporting spikes into the ground, one on either side of the runway (Figure 8c). The trigger-pan should just touch the earth where the soil is packed down. Now release the safety catch. Do not step on or otherwise disturb any other portion of the mole's runway.

In setting a scissor-jawed trap, dig out a portion of a straight surface runway and repack it with fine soil as shown in Figures 8a and 8b. After setting this trap, secure it with a safety hook with its jaws forced into the ground. It should straddle the runway (Figure 9a) until the trigger-pan touches the packed soil between the jaws. The points of the jaws are set about an inch below the mole's runway, and the trigger-pan should rest upon the portion as previously described.

Take care to see that the trap is in line with the runway so the mole will have to pass directly between the jaws. In heavy clay soils, be sure to cut a path for the jaws (Figure 9b) so they can close quickly. The jaws of this trap are rather short, so be sure the soil on the top of the mole run is low enough to bring the trap down nearer to the actual burrow. Set the trigger on all mole traps with a hair trigger (Figure 10). This is the last and most important step. Release the safety hook. Be careful when handling these traps.

In setting a choker trap, it usually is necessary to dig a hole across the tunnel. Make it a little deeper than the tunnel and just the width of the trap (Figure 8b). A garden trowel is useful for this. Note the exact direction of the tunnel from the open ends and place the set trap so that its loop encircles this course (Figure 11). Block the excavated section with loose, damp soil from which all gravel and debris have been removed. Pack the soil firmly underneath the trigger-pan with your fingers and settle the trap so that the trigger rests on the built-up soil. Finally, fill the trap hole with enough loose dirt to cover the trap level with the trigger-pan and to exclude all light from the mole burrow.

If a trap fails to produce after two days, it can mean (1) the mole changed its habits and is no longer using the runway, (2) the runway was disturbed too much, or (3) the trap was improperly set and the mole

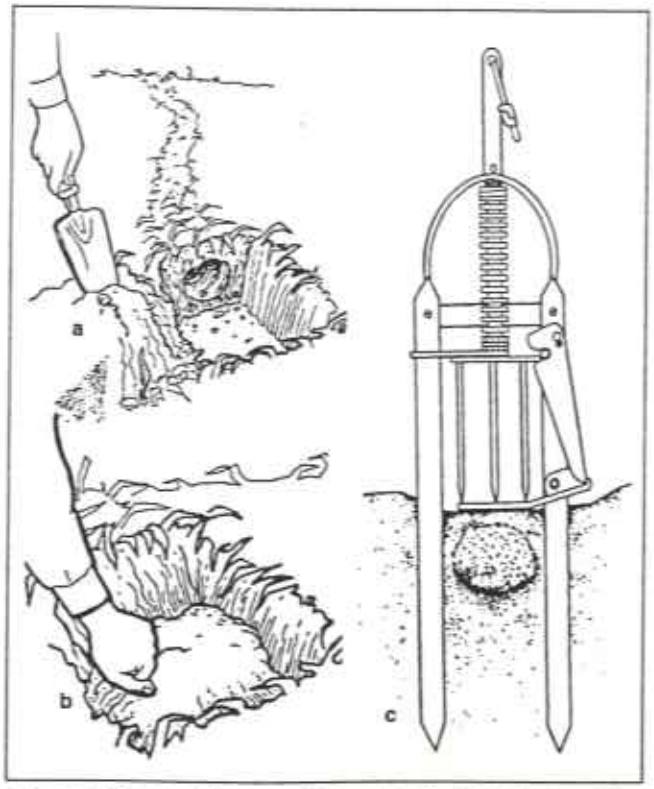


Figure 8. (a) Excavating a mole tunnel is the first step in setting a trap. (b) Replace the soil loosely in the excavation. (c) The harpoon-type trap is set directly over the runway so that its supporting stakes straddle it and its spikes go into it when tripped.

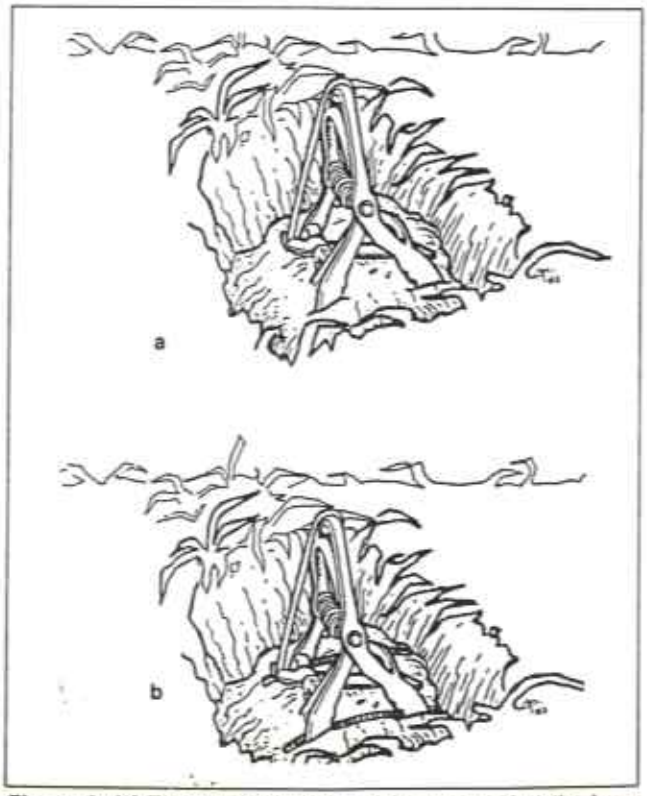


Figure 9. (a) The scissor-jawed trap is set so that the jaws straddle the runway. (b) In heavy soils, make a path for the jaws to travel so they can close quickly.

detected it. In any event, move the trap to a new location. A video demonstrating the correct methods of trapping nuisance pocket gophers and nuisance moles is available by contacting your local University Outreach and Extension center.

If one cares to take the time, moles can be caught at work early in the morning or evening where fresh burrowing operations have been noted. Approach very quietly where the earth is being heaved up. Strike a spade into the ridge behind the animal and throw the animal out onto the surface.

A mole occasionally can be driven to the surface by pouring a stream of water from a hose or ditch into an open burrow for some time. Another method is to bury a three-pound coffee can or a wide-mouth quart glass jar in the path of the mole and cover the top of the burrow with a board (Figure 12).

Other methods

Nearly everyone has heard of some sure-fire home remedy for controlling animals, especially moles. In this category are the many and varied materials recommended for placement within the burrow system. In theory, such things cause the mole to die or at least leave.

Suggested remedies have included using broken bottles, ground glass, razor blades, thorny rose branches, bleaches, various petroleum products, sheep dip, household lye, and even human hair. Others include mole wheels, pop bottles, windmills, bleach bottles with wind vents placed on sticks, and other similar gadgets. Though colorful and sometimes decorative, these add nothing to the arsenal of effective mole control methods.

Other cure-alls are the "mole plant," or caper spurge (*Euphorbia lathris*), and the castor bean. Advertisers claim that when planted frequently throughout the lawn and flower beds, such plants supposedly act as living mole repellents. No known research supports this claim.

Several electromagnetic devices or "repellers" have been marketed for the control of rats, mice, gophers, moles, ants, termites and various other pests. The claimed effects on rodents include stopped feeding and reproduction, disorientation, and dormancy or death by dehydration. These same devices were reported to have no harmful effects on domestic livestock, cats, dogs, bees, earthworms or other "useful" animals and insects. Scientific testing has not confirmed any of these claims.

Unfortunately, there are no "short cuts" or "magic wands" when controlling moles. Some garden experts, frustrated by lack of knowledge about trapping, recommend the use of chewing gum inserted in mole burrows. There is no proof that this is effective and on a trial basis it has proven ineffective.

Economics of damage and control

Before initiating a control program, be sure the mole you are after is truly out of place. The mole plays an important role in the management of soil and of grubs that destroy lawns.

One of the most abundant small mammals, the mole works the soil and subsoil. This tunneling and shifting of soil particles permits better aeration of the soil and subsoil, carrying humus farther down and bringing the subsoil nearer the surface where the elements of plant food may be made available.

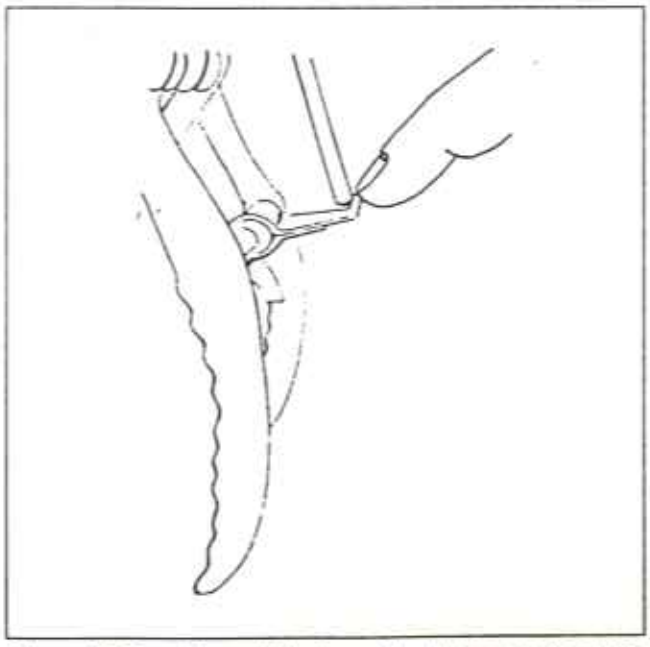


Figure 10. Regardless of the type of mole trap used, set the trigger so it will spring easily. A hair trigger setting on the scissor-jawed trap is shown here.

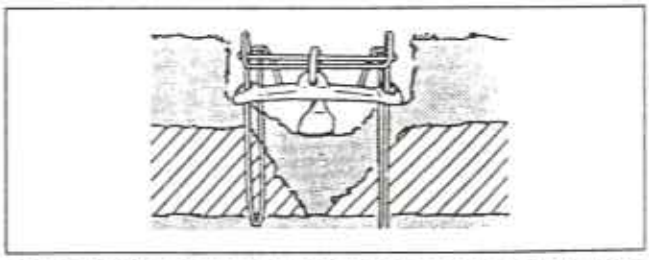


Figure 11. The choker loop trap is set so that the loop encircles the mole's runway.

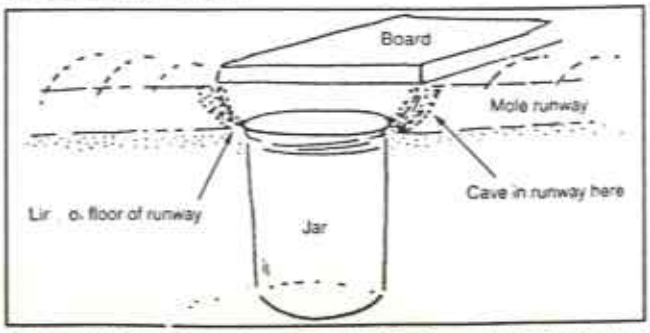


Figure 12. A mole can be captured alive in a pit trap. Be sure to use a board or other object to shut out all light. Cave in the runway just in front of the jar on both sides.

In addition, a large percentage of the diet of moles is made up of white grubs, those scourges of grass and other valuable plant roots. Stomach analyses have revealed that nearly two-thirds of the moles studied had eaten white grubs, with one mole eating as many as 175.

If the individual mole is not out of place, mark it down as an asset and proceed accordingly. If you do have moles where you don't want them, remove the moles. But if excellent habitat is present and nearby mole populations are high, control will be difficult. Often other moles will move into areas that have become vacant.

Information in this publication is adapted from *Controlling Nuisance Moles*, F. Robert Henderson, Extension Bulletin C-701, Cooperative Extension Service, Manhattan, Kansas.

OUTREACH & EXTENSION
UNIVERSITY OF MISSOURI
COLUMBIA

■ Issued in furtherance of Cooperative Extension Work Acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. Ronald J. Turner, Director, Cooperative Extension, University of Missouri and Lincoln University, Columbia, MO 65211. ■ University Outreach and Extension does not discriminate on the basis of race, color, national origin, sex, religion, age, disability or status as a Vietnam era veteran in employment or programs. ■ If you have special needs as addressed by the Americans with Disabilities Act and need this publication in an alternative format, write ADA Officer, Extension and Agricultural Information, 1-98 Agriculture Building, Columbia, MO 65211, or call (573) 882-8237. Reasonable efforts will be made to accommodate your special needs.

HORTICULTURAL
MU Guide
PUBLISHED BY MU EXTENSION, UNIVERSITY OF MISSOURI-COLUMBIA muextension.missouri.edu/xplor/

Cool-Season Grasses

Lawn Maintenance Calendar

John H. Dunn and Erik H. Ervin
Department of Horticulture

Lawns may be maintained at different levels of quality according to individual preference, but good lawns seldom "just happen." This summary outlines major steps required to maintain a year-round high-quality lawn.

The practices refer primarily to cool-season grasses, such as Kentucky bluegrass, perennial ryegrass, tall fescue and fine fescue. For bermudagrass and zoysiagrass lawns, see MU publication G 6706, *Establishment and Care of Zoysiagrass Lawns.*

Timing is approximate for central Missouri; it may vary two weeks or more from one area to another in the state or from year to year.

March

- As needed, start mowing at recommended heights (see Table 1).
- Use broadleaf herbicides for perennial and winter annual weeds not controlled in the fall.
- Overseed thin spots early if missed last fall. (Do not overseed with perennial or annual ryegrass.)
- Watch for moles; traps are the only effective means of control.

April

- Aerate if thatch is 1 inch deep or soil is compacted.
- Use crabgrass preventers (preemergence herbicides) by April 15. Start top-dressing low spots as grass grows.

May

- Fertilize if needed when spring growth begins to slow. Use a slow-release form of nitrogen, such as polymer- or sulfur-coated urea, urea formaldehyde, or a natural organic to improve lawn quality without promoting excessive leaf growth.
- Apply postemergence broadleaf herbicides for control of summer annual weeds. If needed, start postemergence control of crabgrass, goosegrass, or nutsedge near the end of the month (see G 6750, *Home Lawn Weed Control*).

Table 1. Recommended mowing heights for cool-season grasses in Missouri.

Turfgrass	Mowing heights (inches)*
Tall fescue	2.5–3.5
Kentucky bluegrass	2.0–3.0
Perennial ryegrass	2.0–2.5
Creeping red fescue	2.0–3.0
Chewings fescue	2.0–3.0
Hard fescue	2.0–3.0
Sheep fescue	2.0–3.0

* Mowing heights may be adjusted according to climatic conditions, level of maintenance, and intended use.

- Watch for first brood of sod webworm. Apply insecticides about 10 days after major moth flight if damage to turf is seen.

June

- Start watering as needed. Water infrequently to a soil depth of 6 inches. Overwatering can be harmful, but water frequently enough to prevent drought stress. Kentucky bluegrass under stress is susceptible to disease. Don't start watering if you cannot continue full season.

Rapidly growing lawns need frequent mowing. Let clippings remain unless they are excessive.

July

Continue frequent mowing as needed and irrigate only enough to prevent turf wilting. When irrigation is needed and conditions are hot and humid, water between 6:00 a.m. and 10:00 a.m. to reduce disease occurrences.

- Search for white grubs in brown areas.

Dead turf in those areas can easily be peeled from the surface. If 5 to 10 grubs appear in 1 square foot, treat with an appropriate insecticide near the end of the month. Thoroughly irrigate to move the insecticide into the zone where grubs are active.

August

- Fall seeding and sodding is best; prepare seedbed now.

Continue watering and insect control, if necessary. Make plans for fall lawn renovation. Select and purchase grass seed and fertilizer. If lawns are to be totally renovated, kill all vegetation with a glyphosate (Roundup®) application near midmonth.

- Have soil test performed if you are unsure of basic fertility level.
- Thoroughly water dormant lawns in last week to start fall growth.

September

- This is an important time to fertilize. Apply 1–1½ pounds nitrogen per 1,000 square feet.
- Plant or seed new lawns early; keep well watered.
- Aerate where needed to relieve compaction.
- Rake; dethatch; kill weed patches; overseed thin spots. Resume top-dressing, if needed.

October-November

- This is the best time to apply broadleaf herbicides, especially for chickweed control.
- Mow at regular heights until growth stops; mulch tree leaves into turf.
- Apply lime if soil test indicates need.

Fertilize moderately by applying 1 pound of nitrogen per 1,000 square feet after cool days slow leaf growth. Nutrients at this time will encourage root growth and thickening of turf. Soluble nitrogen fertilizers (containing urea, ammonium nitrate or ammonium sulfate) are used more efficiently by turf in late fall.

- Keep leaves from packing and smothering grass.
- Irrigate, if necessary, so that turf goes into winter with moist — not wet — soil.
- Recondition lawn mower; store with clean oil.

Use soluble fertilizer or calcium chloride instead of salt for melting winter ice.

Maintenance

The following steps should provide satisfactory lawns if they are followed properly.

Fertilization

In the past, too much emphasis has been given to spring as the best time to fertilize Kentucky bluegrass. If a lawn is stunted and has a pale to yellowish green appearance, a very moderate feeding at this time would be advisable.

On the other hand, fertilizing a lawn that already had moderate vigor at the time most of us get "spring gardening fever" will stimulate excessive, succulent growth. Excessive leaf growth usually occurs at the expense of new root growth; this places the plant at a further disadvantage for summer and needlessly increases the amount of mowing required. Turf becomes more susceptible to disease and other stresses that will take their toll during summer.

When to fertilize

All lawns should be fertilized in the fall. Additional late winter or early spring fertilization may be necessary if fall applications were missed. Fertilization at this time will be influenced by desired level of turf appearance, turfgrass species, soil type, irrigation intensity, and fertilizer carrier.

As indicated in Table 2, late spring fertilizer applications may be desirable and even necessary depending on the condition of the turf. When an application is required, do so about mid to late May, after the spring growth surge is over.

Table 2. Fertilizer application schedule.

Turf type	Total lb N per year	Apply at recommended rates* Sept.	Oct.	Nov.	May
Common type Kentucky bluegrass	2–3	•	•		•
Higher quality bluegrass	3–4	•	•	•	•
Red and other fine fescues	1–2	•	•		•
Kentucky bluegrass and fine fescue mixtures	2–3	•	•		•
Tall fescue or perennial ryegrass	3–4	•	•	•	•

* Rates usually supply approximately 1 lb N/1,000 sq ft. (In May,

Nitrogen fertilizer

These materials fall into two basic groups: soluble and slow-release. **Soluble** types are available quickly to plants even at low temperatures they stimulate rapid growth and are depleted quickly. Steady, uniform growth requires frequent, light applications. **Slow-release** types of several different forms release nutrients to plants over a long period of time.

Lawn specialty fertilizers often contain 24 to 50 percent of the total nitrogen in slow-release form and the remainder in quickly soluble forms. This combination gives immediate response in cool weather while the remainder is available over a longer period.

When 35 to 50 percent or more of the nitrogen is a slow-release type, rates may be increased up to 50 percent. With these fertilizers, frequency of application may sometimes be reduced.

A precaution should be observed: Nitrogen sources from urea (quickly soluble) should not be confused with urea-formaldehyde, UF, (slowly available).

Rates and frequency

Recommendations are usually based on amounts required to supply a given amount of nitrogen per 1,000 square feet of lawn. Most lawn fertilizers are "complete" in that they contain the three major nutrients: nitrogen (N), phosphorus (P) and potassium (K) and, therefore, the amount of phosphorus and potassium applied is determined by the ratio of these two elements to nitrogen.

Two fertilizers with label analyses of 20-5-10 and 12-12-12 would contain 20 and 12 percent N, 5 and 12 percent P, and 10 and 12 percent K, respectively. For the first fertilizer, the N:P:K ratio would be 4:1:2, and the second would be 1:1:1. The amount of fertilizer required to apply 1 pound nitrogen to 1,000 square feet can be calculated by dividing 100 by the percentage of nitrogen in the fertilizer (100 ÷ 20 = 5 pounds fertilizer per 1,000 sq ft).

Suggested annual fertilization schedule

For routine maintenance where soil test or experience indicates no major deficiencies, use a lawn fertilizer with an approximate ratio of 3:1:1 or 4:1:1 or 4:1:2 at the recommended rate according to the schedule in Table 2.

Where soil test indicates low phosphorus or potassium levels or where basic fertility levels are not known, use fertilizer with a ratio that more closely approximates 1:1:1 or 2:1:1 or 3:1:2. If lawn application rates are not given on the container, amounts to apply can be calculated as in the example above.

Lime

Do not apply lime routinely to established lawns unless a soil test indicates a need. Excess can be as harmful as deficiency. Established lawn soils seldom need to be limed unless a soil test indicates a moderately to severely acid soil of pH 5.5 or lower.

Where lime is needed, apply finely ground or specially pelletized agricultural limestone at rates up to 50 pounds per 1,000 square feet. If more is required, make separate applications about six months apart. Limestone can be applied almost any time, but fall or early winter is the best time.

Mowing

Mowing height and frequency directly affect lawn quality. The common practice of mowing a lawn short, under the assumption it will require less frequent cutting, is responsible for much lawn deterioration.

If cut too closely, there is not enough leaf surface to manufacture necessary foods for balanced growth. For this reason, a standard guide is to never remove more than one-third of the green leaf area with a single mowing. If a mowing is missed, cut only half the way back to the intended heights, then re-mow in a couple of days to regular level. Recommended mowing heights are presented in Table 1.

Clippings seldom need to be removed. With proper mowing, clippings filter down to the soil surface, decay and recycle nutrients back to the soil. Remove clippings when they remain on the surface or when excessive thatch is already causing a problem.

Watering

Kentucky bluegrasses, fescue and other cool-season grasses naturally protect themselves by going into a semidormant stage during periods of high temperature or drought. They cease growth and turn brown, but bounce back quickly with sufficient water and cooler temperatures, as long as they have not been severely thinned by excessive summer traffic.

Except in cases of extreme prolonged drought, tall fescue and Kentucky bluegrass do not need water to stay alive during the summer. However, their appearance suffers. During dormancy, drought-tolerant weeds such as plantain, thistles and dandelion dominate lawns.

Because of its deep, extensive root system, tall fescue remains green longer into the summer than other nonirrigated cool-season grasses.

Kentucky bluegrass has many underground stems, called rhizomes. Each rhizome can produce several new bluegrass shoots that result in turf thickening in autumn when water becomes available following summer dormancy.

The principal purpose of summer watering is to maintain an attractive green surface. Watering will not substitute for poor fertility or improper mowing, and can encourage crabgrass and other weeds. Extra growth stimulated by watering increases fertility requirements, thatch accumulation and disease pressure.

If you cannot give attention to management, let the turf follow its natural tendencies to go dormant during summer. (Plants are brown in appearance from lack of water, but not necessarily dead.) Homeowners who have a lawn care service should not allow their lawn to enter drought dormancy.

Rules for watering

- Shallow, frequent sprinkling to add a little water each day is not generally recommended. It encourages shallow, weak roots, crabgrass and some diseases.

Irrigate to the full depth of the root system often enough to prevent wilting. (See MU publication G 6720, *Home Watering Guide.*)

- Kentucky bluegrass and fine leaf fescue roots may not reach depths greater than 4 to 6 inches during the summer. About 1 inch of water (620 gallons per 1,000 sq ft) can be stored in an average Missouri

soil to this depth, and this should last about a week.

A reasonable guideline for summer lawn irrigation is to apply enough water in addition to natural rainfall to total 1 inch per week. Greater frequency with lesser amounts may be required on sandy soils that cannot store this much.

- Don't guess at how much water is being applied to reach the desired wetting depth. Place tall, straight-sided cans in the sprinkler pattern. Measure water depth in the cans to determine the amount of water applied.

Thrust a small probe (screwdriver) into the soil. Decreased resistance to the probe in wetted soil can help gauge depth of wetting.

- Some sprinklers apply water faster than soil can absorb it. Few established lawn soils in Missouri can absorb ½ inch per hour; many absorb much less. To prevent waste, move portable sprinklers frequently. Properly engineered permanent irrigation systems with timing controls for "interval watering" do the best job. A soaker hose is also an excellent choice.
- Steep slopes, hard spots and hot areas require special attention. Mechanical aeration, extra slow watering and use of wetting agents may help water infiltration.

Aeration

On clay- or silt-type soils, or any turf receiving constant traffic, soil surface sealing and compaction can seriously impair turf growth. Grass roots are injured because air, water and fertilizers cannot reach them in sufficient quantities. Mechanical aeration to reduce compaction is essential for continued turf health.

Aeration is best done by power equipment that pulls out small cores of soil. Machines that cut vertical grooves every 3 to 4 inches will relieve surface sealing. Power equipment is usually available at rental stores. Lawn care companies may also provide these services to their customers.

For small areas, suitable hand equipment is available, but using it is hard work. Even a spading fork plunged into the soil at 3-inch intervals when the soil is lightly moist — not wet — is far better than nothing at all.

Aeration should be done at least once a year where compaction is a problem. Fall is the best time for Kentucky bluegrass and tall fescue lawns, but aeration will be highly beneficial anytime the grass is actively growing and is not under heat and drought stress.

Thatch control

Thatch is a layer of undecayed and decayed plant parts at the soil surface. It forms a barrier to water and air movement in the manner of a thatched roof.

Thatch is primarily a problem of intensely fertilized and watered lawns. These practices promote excessive lateral growth of stems (stolons and rhizomes) and shallow roots; these shallow stems and roots are the main cause of thatch because they are resistant to decay. Properly mulched leaf clippings decay readily and do not contribute to thatch. Aggressive species, like Kentucky bluegrass and bermudagrass, and those that produce plant tissues resistant to decay, like zoysiagrass, are prone to thatch.

Thatch removal should be initiated whenever accumulation exceeds ½ inch. Early fall is the preferred time for dethatching bluegrass lawns.

For additional information on thatch, see MU publication G 6708, *Thatch — Enemy of Lawns.*

Top-dressing

Top-dressing is the periodic addition of a thin layer (¼ to ½ inch) of soil or compost to the surface of growing turf. Top-dressing to mix soil with accumulating plant debris hastens thatch decay. Shallow depressions in turf can be gradually leveled by this practice as well.

Top-dressing may be done immediately after coring, dethatching or slicing. Never bury the existing turf with too much top-dressing soil. After top-dressing, at least three-fourths of the grass plant should be exposed to sunlight.

Rolling

Rolling is not desirable for smooth, even lawns. Surface compaction is common in many lawns without adding to the problem by heavy rolling. Rolling moist soil causes maximum compaction — a fine way to build roadways but not soils for turf.

When late winter freezing and thawing have resulted in "heaving" young plants out of the ground, or if mole activity is serious, rolling may be required. In such cases, roll soon after spring thaw when the soil surface is relatively dry, and use as light a roller as possible. Don't roll more than is absolutely necessary.

Weed control

The best weed control is a healthy, dense, competitive turf. Cultural practices to achieve this will keep out most weeds.

Chemical weed killers are useful, but should not be relied upon entirely to cure lawn weed problems (see MU publication G 6750, *Home Lawn Weed Control*). Suggestions for timing herbicide application for several common weed problems are indicated in the calendar of this guide.

Relative merits of using fertilizer-herbicide (weed and feed) or fertilizer-insecticide combinations should be considered carefully before they are used indiscriminately. In many cases, at least one of the ingredients

may not be needed or will be used at an inopportune time.

Renovation

If your lawn is less than acceptable but contains at least 40 percent desirable grasses, you may be able to replant without preparing a completely new seedbed. Start in August with steps similar to the following:

- Kill weeds and undesired grasses with appropriate herbicides. (If only annual weeds are present, skip this step.)
- Remove dead vegetation and prepare seedbed with vertical renovating machine or heavy rake, set deep enough to bring soil to the surface. Clear off all debris.
- Add fertilizer and lime according to soil test and rake in. In late August or early September, scatter seed or desirable variety and drag or rake into loosened soil surface.
- Water thoroughly and treat as a newly seeded lawn.
- If the original problem was due to soil itself, poor drainage or excessively thick thatch, till the lawn and start over following steps for establishing a new lawn. (See MU publication G 6700, *Cool-Season Grasses: Lawn Establishment and Renovation.*)

Disease and insect problems

Prevention is the best approach to disease problems in home lawns. Often by the time the disease is diagnosed, the damage has been done.

Controlling thatch, avoiding frequent, light irrigation and fertilizing properly for healthy but not succulent grasses are simple lawn-grooming practices that may aid disease prevention.

Two major insect pests are white grubs and sod webworm. White grubs are described in MU publication G 7200, *White Grubs in the Lawn.* Treating lawns every year with insecticides to prevent insect infestations is neither necessary nor advised.

Routine inspection of the lawn for white grubs and sod webworms is advised. Treat only after the insects have been properly identified, and only when they are in sufficient numbers to cause a noticeable loss of turf.

OUTREACH & EXTENSION
UNIVERSITY OF MISSOURI
COLUMBIA

■ Issued in furtherance of Cooperative Extension Work Acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. Ronald J. Turner, Director, Cooperative Extension, University of Missouri and Lincoln University, Columbia, MO 65211. ■ University Outreach and Extension does not discriminate on the basis of race, color, national origin, sex, religion, age, disability or status as a Vietnam era veteran in employment or programs. ■ If you have special needs as addressed by the Americans with Disabilities Act and need this publication in an alternative format, write ADA Officer, Extension and Agricultural Information, 1-98 Agriculture Building, Columbia, MO 65211, or call (573) 882-7216. Reasonable efforts will be made to accommodate your special needs.

Show-Me Yards & Neighborhoods - Yard Certification Checklist

Name_____

Address_____

_____

Phone number_____

Does your yard measure up?

Show-Me Yards & Neighborhoods (SMY&N) honors model landscapes as certified Show-Me Friendly Yards and provides a Show-Me Yard sign to those homeowners.

To be certified as a Show-Me Yard, your landscape must:
Collect at least 36 inches on this Yardstick Checklist
Receive full points for practices marked with 2 asterisks**
Receive partial credit for practices marked with 1 asterisk*
Comply with all existing codes and laws

Mowing for a Healthier Environment

Mow lawns high to encourage a deeper, more drought and pest tolerant root system.**	2"
Sharpen mower blades monthly so grass blades heal and recover.	1"
Lawn mower engine serviced twice annually to reduce emissions contributing to air pollution.*	2"
Use an electric lawn mower instead of one powered by gasoline.	4"

Water Efficiently

Irrigate lawn and landscape only when they wilt. Apply <3/4 inches of water per application.	3"

For a yard that uses an irrigation system (in-ground or hose-end sprinklers):

Calibrate irrigation/sprinkler system to apply <3/4 inches of water.**	3"
Put a rain gauge in your yard to track irrigation amounts.**	2"
Install a rain shut-off device for in-ground irrigation systems.**	2"
Make sure irrigation system waters lawn areas separately from plant beds.	2"
Use drip or micro-irrigation in plant and flower beds.	2"

For a yard that does not use an irrigation system:

Design and maintain a landscape that exists predominantly on rainfall once plants are established.	6"

Mulch

Maintain a 2-3" layer of organic mulch over tree roots, shrubs and plant beds, leaving a 2 inch space between the plant base and the mulch.*	2"
Create self-mulching areas under trees where leaves can remain as they fall.	1"
Use by-product mulches or recycled mulches.	1"
Replenish mulch once or twice a year to maintain 2-3" depth.	1"

Recycle

Whenever possible, recycle grass clippings by allowing them to remain on the lawn.**	2"

Use leaves and pine needles found in your yard as mulch.	2"
Create and maintain a compost pile with yard clippings, leaves, kitchen scraps, etc.	3"
Wildlife	
Plant vines, shrubs, and trees that provide cover, nesting areas or food sources for birds, Butterflies and other wildlife.	3"
Provide a water source, such as a bird bath or a small pond for wildlife.	1"
Provide wildlife shelters such as a bat house, bird house, brush pile, etc.	1"
Identify five kinds of wildlife (insects, reptile, birds, etc.) that live in your yard.	2"
Yard Pests	
Treat only affected plants or lawn areas with pesticide applications. Avoid indiscriminate spraying.**	3"
Check your landscape every 1-2 weeks for signs of problems.	2"
Learn to identify 5 beneficial insects that provide natural control of harmful pests.	2"
Use environmentally friendly pesticides such as horticultural oils and insecticidal soaps.	2"
Use non-chemical approaches to pest controls, such as pruning off affected areas, hand removing insects, etc., whenever possible.	3"
Right Plant - Right Place	
Ensure that your landscape does not contain plants identified by legal code as invasive exotics such as kudzu, privet, and wintercreeper.**	
Replace problem-prone plants with low maintenance native or non-native species.	2"
Group plants according to their water and maintenance needs.	2"
Determine how much grass you need for children, pets, and recreation. Replace the rest with low maintenance ground covers, shrubs, mulch , or other porous surfaces.	3"
Use trees and shrubs to shade southern and western walls of home and air conditioner compressor.	1"
Use deciduous trees on southern exposures to allow the sun to passively heat your home in winter.	1"
Reduce yard waste by choosing plants that will not require frequent pruning at maturity..	1"
Preserve native plants when building on a new site. Maintain a protective "do not disturb" barrier under the dripline of trees.	3"
Fertilizing	
Fertilize as needed to maintain quality of lawns and landscape plants.*	2"
Use natural organic or other slow release fertilizers.*	2"
Use iron instead of nitrogen to make you lawn green during the summer.	1"
Stormwater Runoff	
Direct downspouts and gutters to drain onto the lawn, plant beds, or containment areas.*	1"
Plant groundcovers or use mulch on thinly vegetated areas to decrease erosion.*	2"
Use mulch, bricks, flagstones, gravel, or other porous surfaces on walkways, patios or drives.	1"
Collect and use rainwater to irrigate plants.	2"
Create swales or terracing to catch and filter stormwater.	3"
Pick up after pets to reduce bacterial and nutrient pollution in stormdrain systems.	1"
Clean up oil spills and leaks using cat litter on driveways.	2"
Sweep grass clippings, fertilizer, and soil from driveway onto lawn. Remove trash from street gutters.	2"

On the Waterfront

Remove invasive exotic aquatic plants by cutting, pulling or raking. Remove dead plant material form water after using herbicides to reduce pollution.	2"
Establish a border of low maintenance plants between your lawn and the waterline to absorb nutrients and to provide wildlife habitat.**	2"
Establish a 10–30 foot "no fertilizer" zone along the waterline.*	2"
Where feasible, plant native vegetation in the zone along the waterfront.	4"
TOTAL INCHES	_____

Please return to:
Choose Environmental Excellence
c/o Barbara Lucks
840 Boonville Avenue
Springfield, MO 65802

CITY OF BATTLEFIELD, MISSOURI
INDIVIDUAL SMALL MS4 STORMWATER MANAGEMENT PROGRAM

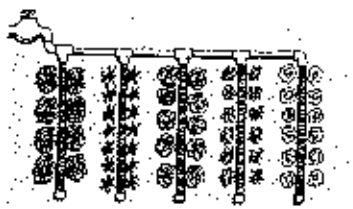
2004
LANDSCAPING

Use the Best Watering Method

While soils vary greatly in their ability to hold water, your garden and lawn should receive enough water to wet the soil to the bottom of the root zone each time you water — generally 1 inch per week. Determine this by digging a hole 5 to 6 inches deep in the watered area the day *after* watering so the water has a chance to seep in. Adjust weekly watering to your soil needs.

Avoid watering by hand — it often wastes water as there is excess runoff, and water does not penetrate beyond the top 1 inch of soil. This irrigation practice harms plants by forcing root growth too close to the surface. If you must water by hand, place a 5-gallon bucket with a few holes in the bottom next to the plant and fill it with water; when it is has drained, move it to the next plant and refill.

Properly used sprinkler systems can deliver a large quantity of water in a short time. They have the disadvantage, however, of excessive evaporation, both during watering and from the plant and soil surface. Early morning watering minimizes water loss. However, sprinkler systems that deliver the water from overhead are the most effective means of watering turfgrass. Be sure to position sprinklers to shower areas of vegetation, not driveways, streets, or patios. Water until the soil is moist 6 inches deep, usually 1 inch per week applied at one time.



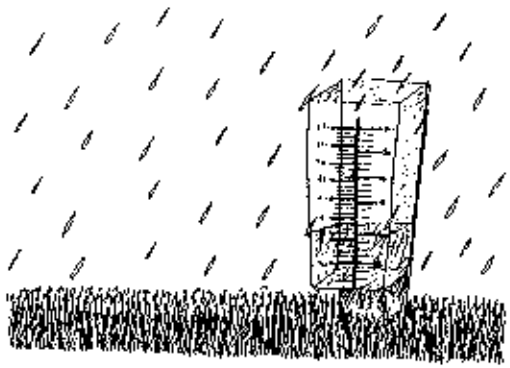
Trickle or drip irrigation systems and ooze hoses are very efficient, slowly applying water to vegetable and ornamental gardens. Soil moisture can be maintained at a level most suitable to plant uptake. If properly installed and maintained, little water is lost to evaporation or runoff and water use can be reduced by up to 50 percent. For many situations, the expense of installing a good-trickle irrigation system will be compensated by reduced water usage, less replacement of plant materials, and less work. On any irrigation system, replace leaky parts promptly.

Printing of this bulletin
was sponsored by

**Virginia Nurserymen's Association,
providing Professional Nurserymen's Certification**

For more information on selection, planting, cultural practices, and environmental quality, contact your local Virginia Cooperative Extension Office. If you want to learn more about horticulture through training and volunteer work, ask your Extension agent about becoming an Extension Master Gardener. For monthly gardening information, subscribe to *The Virginia Gardener Newsletter* by sending your name and address and a check for $5.00 made out to "Treasurer, Va. Tech" to The Virginia Gardener, Department of Horticulture, Virginia Tech, Blacksburg, VA 24061-0349. Horticultural information is also now available on the Internet by connecting with Virginia Cooperative Extension's gopher server at *gopher.ext.vt.edu*.

The development of this series was funded by ES-USDA Smith Lever 3(d) National Water Quality Initiative Funds and the Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation.



Measure the Quantity of Water

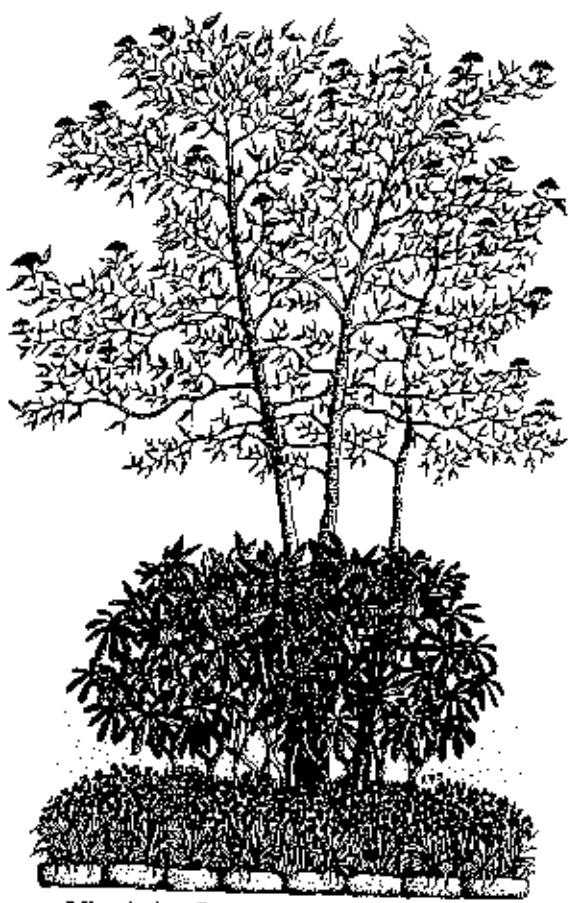
To measure the amount of water — whether from a sprinkler or rain — use a rain gauge or a tin can set in the lawn or garden area to be measured. The soil has received an inch of water when the water in the container is an inch deep.

Reprinted 1997 Publication 426-713

VT/0297/0697/2.5M/97(894)/426713

Virginia Gardener

Creating a Water-Wise Landscape



Virginia Cooperative Extension

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

VIRGINIA STATE UNIVERSITY

Creating a Water-Wise Landscape

What is Water-Wise Landscaping?

Water-wise landscape design and management focus on working with nature and natural forces (such as rainfall) to create an aesthetically pleasing, livable landscape, while using less water from the local supply.

Minimizing the need for watering in your landscape requires careful observation, planning, and common sense. Several principles for water-wise landscaping include choosing the best design and plants, preparing soils, and watering properly for efficient water use.

Water-wise landscaping is also known as xeriscaping, a word tradenamed by the National Xeriscape Council. The word is a combination of the prefix xero- or xer- meaning dry or dryness and the suffix -scape meaning scene or view.

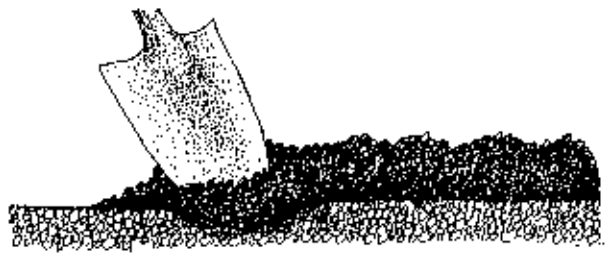
Plan Your Landscape

The first step in any successful landscape is a good plan. Observe the site and take notes on the current use of different areas or their desired use. Indicate high-use areas, desirable views, environmental concerns (such as wind direction, slopes, dense shade), and traffic flow through the yard. Sketch the property, including any permanent structures, trees, and shrubs that you plan to leave, grass areas, driveways, and sidewalks.

Based on your notes, develop a plan that meets your needs for use, appearance, and budget. Consider maintenance and water requirements in making your decisions. For example, maintaining a high-quality lawn area for entertaining will require frequent fertilizing and mowing, as well as high water use. A more maintenance-free choice for get-togethers is a deck or patio, but don't overdo the use of wood or concrete on your land. Leave plenty of vegetative surface for rain to reach the soil and soak in; otherwise, runoff and erosion problems are created. Whatever plan you develop, the cost can be distributed over a period of time if you implement your design over several years.

Prepare Soil Adequately

Good soil is the basis for healthy plants and optimum use of water. The key to good soil is the addition of organic matter, such as compost. Sandy soil will hold water and nutrients better if organic matter is incorporated. Clay will absorb water faster, reducing runoff and erosion, if it is loosened with organic matter. Incorporate approximately 2 to 3 inches of compost, shredded leaves, or other fine organic material to the soil annually.



In locations with established trees and shrubs, it is difficult to incorporate organic matter, but applying and maintaining a 2- to 3-inch layer of an organic mulch (coarse leaves, shredded bark, pine needles, or wood chips) will gradually improve the soil as the humic acid formed by the decomposing material leaches into the ground.

Select Plants Wisely

Decide on the trees, shrubs, and ground covers for your water-wise landscape based on their natural ability to grow well in your area. Select plants that do well with little or no addition of water. Consider native plants as well as introduced species for residential landscapes. Your local Extension agent and nursery personnel can help you identify suitable plants for your location.

Limit plants with high water demands to small areas that can be watered efficiently. Grouping plants by water requirements is one way to guard against overwatering some plants and underwatering others.

In general, ground covers require less water than turfgrass, so replacing some of your lawn with a ground cover will conserve water. If you have large deciduous trees in your yard and want to reduce work and water, go natural — allow leaves to accumulate as they would in nature. Plant a few understory shrubs (such as azaleas and rhododendrons), a few understory trees (such as dogwood), and quit raking!

Mulch Your Gardens

Use mulch to conserve soil moisture. Organic mulches help retain moisture so there is less need to water. They also recycle plant materials that might otherwise end up in the landfill. In addition, mulches control annual weeds that compete with desired plants for water. Organic mulches improve soil structure as they decompose and moderate the soil temperature, two factors that also help plants use water efficiently.

Use Optimum Cultural Practices

Proper mowing and fertilizing of the lawn help conserve moisture. Mowing at the proper height (do not remove more than one third of the grass at any one mowing) allows the grass to develop deeper roots that are more efficient in using soil moisture, and reduces annual weeds. Fertilizing *at the proper time* (your Extension agent or local nursery experts can help you determine this) encourages healthier turf that needs less watering.

Leaving shrubs in their natural forms reduces stress to the plants and, therefore, lessens their need for water.

Keeping weeds, insects, and diseases under control reduces the competition and stress to plants that increase their water demands.

These principles minimize the water demands in your landscape, help you save money and time, and reduce your impact on the local water supply.

Use Turfgrass Appropriately

Limit the amount of turfgrass you use in the landscape to areas in which grass provides a functional benefit (i.e., a play area for children) that exceeds the benefit of other ground covers or surfacing materials. Select turfgrass suitable to your climate and site.

Design the grass area to make watering easier. Long, narrow areas and small, odd shapes are hard to water efficiently. Avoid turf in the strip between the sidewalk and the road; most irrigation water will land on the paved surfaces and run off.

The Healthy Garden

BY WILLIAM OLKOWSKI

A Least Toxic Approach to Pesticides

Memories of Rachel Carson's *Silent Spring* or recent newsworthy reminders of the dangers of some pesticides may make you uncomfortable about using chemical controls against pests. Indeed, we believe non-chemical methods for controlling pests—crop rotations or hand-picking, for instance—are best. But there are situations in which non-chemical methods are ineffective or unworkable, and in such cases, many gardeners choose to use a chemical pesticide, either biological or synthetic. Though there are valid arguments for and against pesticides, we don't want to get into debate here. Rather, we'd like to focus on when, where, and how to use pesticides properly, and on criteria for selecting them.

The most important consideration is choosing the least-toxic product that will get the job done and using it only when necessary. By least toxic, we mean materials that are least disruptive of natural controls, least hazardous to human health, least harmful to non-target organisms, and least damaging to the environment.

Pesticides can play a short-term role

Chemical pesticides, whether aimed at bacteria or bugs, share a common limitation: They rarely offer permanent control. True, the Romans plowed the ground with salt after destroying Carthage in 146 B.C.E., and that was pretty permanent. But if you want to permanently reduce a pest problem in your garden and still retain the garden, you need to take a different approach. Food, water, habitat, and other supports for the pest must be modified for long-term results.

In the short run, however, least toxic chemical controls have their place. By temporarily shifting the balance between pest and natural enemy, the right chemical control used at the right time can pave the way for establishing long-term biological controls in the garden. Ladybeetles, lacewings, insect-eating nematodes, and other biological controls are commercially available and becoming popular for home garden use. But if the pest population is already high, you must knock the pest numbers down before releasing beneficials. You don't need to reach for a highly toxic pesticide to do this. Instead, use water sprays or an application of insecticidal soap or horticultural oil. The goal is to reduce the number of pests, not eliminate them. After all, you need to have some pest insects around to feed the beneficials when you release them or they fly in naturally.

Confine chemicals to intolerable situations

It makes sense to react quickly to vertebrate pests—deer, for example. But before you move fast against an insect pest, ask yourself two basic questions. Is it really necessary to control this pest? And if so, is there a simple alternative to insecticides? Don't overlook physical controls, such as handpicking the pest or pruning out portions of the infested vegetation. These non-chemical methods are often fast and satisfactory.

Confine chemical controls to situations in which the damage involved is, or will soon become, intolerable. The presence of a few recognized pest insects is not enough to signal doom. On the other hand, a large population beginning to cause visible destruction may be a different matter. You should consider what you expect of the result. Will the vegetable you're trying to protect be presented as a gift or serve as a centerpiece? Maybe some extra care to avoid obvious insect damage is desirable. Or is it going right into the cooking pot? If so, then who cares about a few holes or scars; minor cosmetic damage is a sign that no poison residues need concern you.

In any case, not all plants will be similarly affected by a pest. If you observe your plants carefully, you will see that, even among those of the same kind, responses to insect pests vary. Make it a practice to treat only those plants that are severely attacked.

There are many ways to avoid using pesticides that kill non-target organisms. The most obvious is to pick a material that either by its composition or its packaging is toxic to just one target pest. Bt is a good example, because it produces a disease specific to the insects listed on the label. Another example is insect growth regulators, which prevent molting in specific insects, such as whiteflies.

Baits, if packaged to reduce attractiveness to and access by other animals, are another good way to confine a chemical control to the target pest. In some bait stations, the active chemical is combined with a pheromone attractant to bring a specific insect pest to the bait station.

Know what you're working with

Don't grab the first pesticide you see that mentions your pest. Take your time, study the label. You are looking for the least toxic—yet still effective—material that will leave no residue to harm beneficial wildlife or yourself.

Be sure the material is registered for use against the pest you wish to control. Also check to see if the pesticide can be used on vegetables right up to the harvest period. And you need to know what kind of protective clothing, gloves, goggles, or respirator you will need while applying the pesticide, as well as the recommended application equipment.

Always check the label for the toxicity rating. A rating of IV means the chemical is practically non-toxic. Category III chemicals are considered slightly toxic and are labeled "Caution." Make every effort to confine your use to materials no

Feb/Mar. 99

more toxic than this. Category II chemicals are moderately toxic and are labeled "Warning." Category I materials are highly toxic and are labeled "Danger-Poison," with a skull and crossbones. There should be no need to use Category I materials around the house or garden.

The problem with relying on simple toxicity ratings, however, is that they tell only part of the story. The basis of these toxicity ratings is a measure of short-term reactions. Long-term effects may take years to appear. Also important is the length of time the material stays in the environment, whether it bio-accumulates (passes up the food chain in ever larger accumulations), and its synergistic effects when combined with other materials in your environment.

Bundle up no matter what pesticide you're applying. If wearing the equivalent of a space suit doesn't appeal to you, perhaps that's reason enough to seek a less toxic alternative.

Take time to protect yourself

It all but goes without saying that you must protect yourself from chemical pesticides, even when using comparatively benign materials like insecticidal soaps or insect-specific diseases like Bt. The most common problem associated with careless use of a pesticide is a skin reaction, typically a rash or a burn. But you also need to avoid eye and lung exposure. Any vapor that enters the lungs will be rapidly absorbed into the blood stream and distributed throughout the body. With some materials, there is a potential for damage to nerves or to body levels of the transmitter that enables signals to travel from nerve to nerve.

Wear gloves intended for handling chemicals, and store the gloves in disposable plastic bags between uses. The greatest hazard in applying chemical pesticides comes from spilling it accidentally on your unprotected clothing. Change out of contaminated clothing immediately. Spills or no spills, clothes worn while applying pesticides should be washed separately from the family laundry.

Use the least amount in the smallest area

Even a toxic material will cause little damage if you confine the pesticide to just the organism you wish to control. A good example of confining a pesticide to its target is using a soft paintbrush or a small piece of rag tied to a stick to wipe an herbicide on the leaves or branchlets of a perennial weed.

When purchasing pesticides, ignore inducements to save money by buying the large "economy" size. Buy the smallest amount that will do the job. Then mix up just the amount you will need. If a teaspoon is good, that doesn't mean two teaspoons are better. Avoid mixing up a gallon when all you will need is a cupful. The temptation is too great to use up the extra material by spraying it around places where it's not needed.

Be sure to store or dispose of the remaining materials properly. Never keep pesticides in unmarked containers or within reach of children and pets. Store all pesticides in their original package, but put paper or glass containers inside metal cans to avoid spills due to breakage or moisture. And bear in mind that left-over pesticides may lose effectiveness by the time you need them again.

Chemical controls can play a role in the healthy vegetable garden if you select materials that are least toxic to humans and the environment and are as species-specific as possible. But don't get carried away. Confine pesticide use to those situations where the damage is becoming intolerable and no non-chemical method is available. (If you have questions about a specific material, a good source of toxicity information is the EPA Hotline: 800/858-7378. You can also visit the National Pesticide Telecommunications Network website at http://ace.orst.edu/info/nptn.

Coauthors William Olkowski, Helga Olkowski, and Sheila Daar are directors of the nonprofit Bio-Integral Resource Center in Berkeley, California.

Non-toxic Pest Control Methods

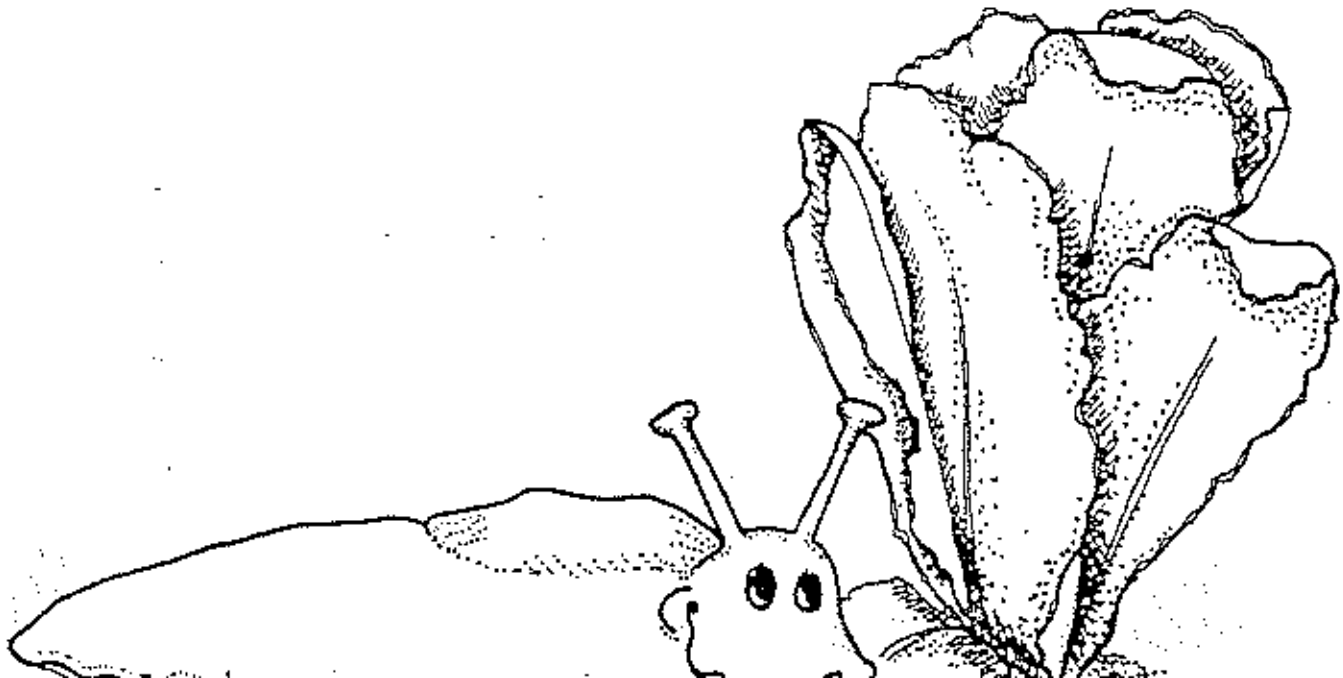
SLUGS

A. Remove plant debris or other potential hiding places. (Slugs love the dark and damp places.)

B. Use traps:
   1. Beer trap- place a shallow dish of beer in the ground. Slugs are attracted by the scent and drown. Highly effective!
   2. Board trap- place a flat wooden board anywhere in your garden. By morning slugs will be gathered there for easy removal and disposal.

C. Use barriers:
   1. Abrasive materials- sprinkle abrasive materials around your prized plants. (Crushed eggshells, coarse sawdust and ashes all work well.)
   2. Copper wire or foil- Slugs will not cross copper. If plants are grown in containers you can put foil around the lip of the pot, or wrap a few coils of wire around the entire container.
   3. Powdered ginger- Slugs will not cross powdered ginger. It should be sprinkled around the bases of plants you wish to protect.

D. Search and destroy:
   1. Take a flashlight out after dark (of course slugs feed mainly at night) and kill them one by one. This method is very satisfying! You can do them in with either a generous sprinkle of salt or a spritz with a mixture of 50% water and 50% white vinegar.



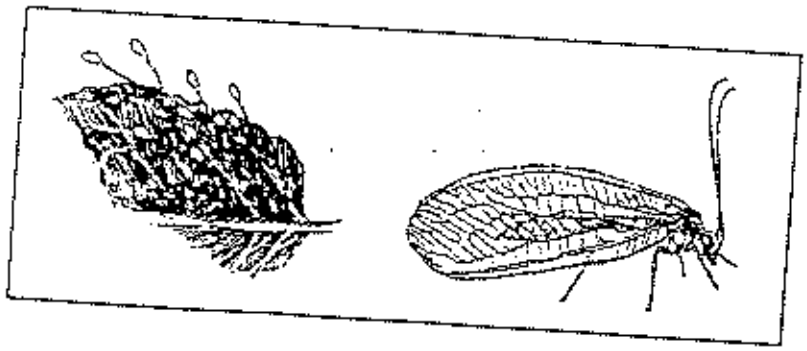
APHIDS AND SPIDER MITES

A. Soap Mixtures- Mix 3 tablespoons of Ivory Snow (laundry soap) per gallon of water and spray directly on aphids. They do not die immediately, but will slowly dehydrate. (Soap sprays may cause scorching in some plants, so be sure to rinse plants thoroughly with plain water after a few hours.)

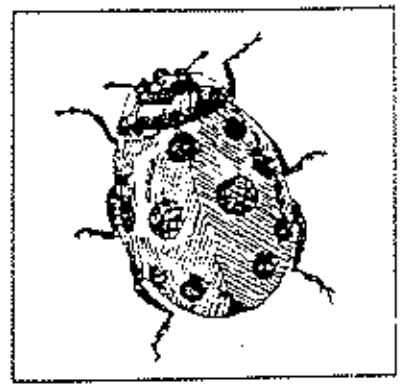
B. Yellow sticky traps- Aphids are attracted to the color yellow (since yellow is the color of a sick plant). Use this to your advavtage by coating a yellow piece of paper or cloth with vaseline and laying it in a pie pan at the base of an affected plant. Aphids will fly toward it and get stuck.

C. Encourage their natural enemies such as ladybugs or lacewings by:
-not using pesticides
- attracting them with pheromones

Green Lacewing



Ladybugs



CATERPILLARS

A. Bt- this is a naturally occurring bacteria which is lethal to most caterpillars and completely harmless to people. It is available in products such as dipel dust.

B. Collars- protect young plants from cutworms by placing cardboard collars around them. Be sure to press the collar at least 1 inch into the soil and leave at least an inch. exposed.

C. Repellents:
   1. Try a mixture of some or all of the following.
      -onion
      -horseradish root or leaves
      -garlic
      -mint
      -hot peppers
      -cedar chips

   Make a "tea" out of these and apply to plants to repel pests.

D. Search the garden at night with a flashlight. Caterpillars are especially active after a rain so search and destroy them on damp nights.

BEETLES AND BEETLE-LIKE BUGS

A. Diatomaceous earth- sprinkle it liberally on affected plants. It scratches through the waxy layer on beetles and dehydrates them. Available at most gardening stores if you remember how to pronounce it! (Very effective, but will not work if it becomes wet so it must be reapplied after rain.)

B. Repellents: try some of the same repellents used for caterpillars

C. Soap sprays: use the same mixture used for aphids and spider mites.

Insects and Diseases

AGRICULTURAL
MU Guide
PUBLISHED BY MU EXTENSION, UNIVERSITY OF MISSOURI-COLUMBIA muextension.missouri.edu/xplor/

White Grubs in the Lawn

Bruce A. Barrett and Erik H. Ervin
Departments of Entomology and Horticulture

White grubs are the larval or immature stage of several species of soil-inhabiting beetles (Scarabaeidae) that are similar in general appearance and habits. The larvae or grubs pass through three stages (instars), are crescent-shaped (Figure 1), and live in the soil, where they feed on the roots of many important ornamental and agricultural plants.

The earliest symptom of white grubs feeding on turfgrass roots is a gradual thinning and weakening of the stand. Damage may progress from thinning to small patches of dead grass to the sudden wilting of the grass even with adequate soil moisture. Aside from turf damage the grubs cause directly, their presence in high numbers can attract birds (e.g., starlings, grackles, crows) and mammals (e.g., moles, shrews, chipmunks, skunks, raccoons) that can cause further damage as they tear at the turf in search of the grubs for food.

This guide discusses the life history and control of two species of white grubs found infesting turfgrass in Missouri-the southern masked chafer and May or June beetles.

Southern masked chafer *(Cyclocephala immaculata)*

Adult southern masked chafers (SMCs) are yellow-brown in color and about 0.5 inch long and 0.25 inch wide. They are robust and stout-bodied. The adults do not feed and are not a pest of foliage.

The SMC has a 1-year life cycle and is thus correctly referred to as the "annual" white grub. By late March, overwintering third-instar grubs begin migrating upward near the soil surface to feed. They continue feeding on grass roots and organic matter until May, then move back deeper into the soil to pupate.

Adults emerge from the soil June through early August. The adults emerge at about dusk and swarms of males fly low over the turf in search of females. Eggs usually are laid in the top 2 inches of soil. The developing grubs will reach the final instar (third) in late summer and early fall. Most damage to turf is done in September and early October when the grubs are full-sized (about an inch long) and feeding vigorously. Feeding continues until temperatures force the grubs to migrate 5 to 10 inches deep in the soil to hibernate.

Figure 1. Third-instar (mature) grub.

May or June beetles *(Phyllophaga* spp.)

Numerous species of May or June beetles (M-JB) are turfgrass pests. Ten major species have been found in Missouri. Unlike SMC adults, adults feed on and can be serious pests of, shade trees and ornamental shrubs. Adults look much like SMC adults (heavy-looking, stout-bodied) but are usually larger. The smallest M-JB species is about 0.5 inch long, and the largest can be about 1 inch long. The adult body is light to dark brown, and the head is dark brown.

Depending on the species, it takes 1 to 4 years to complete one generation. The most common M-JB species have a 3-year life cycle. Below is a generalized M-JB life cycle based on observations in the Midwest:

Year 1. In early May, overwintering adults begin emerging from the soil to feed and mate. Adult emergence continues through June, sometimes into July depending on the species. The adults are nocturnal in their activities, and as such, most people see the adults only when they are attracted to porch or window lights at night. During the day the adults can be found buried

in the soil or sod. A female will lay on average about 50 eggs over a 1- to 3-week period. Eggs are deposited 3 to 4 inches in the soil. Newly hatched larvae (first instar) first feed on the organic material found in the soil, but soon will turn to feeding on roots. By August the grubs have developed into the second instar. In late fall they burrow deep into the soil to hibernate. Minor turf damage can occur late in the summer of the first year.

Year 2. By late March and April, the overwintering second-instar grubs have moved back to the soil surface and resumed feeding. By June they develop into third-instar larvae. This is the time of the grubs' life cycle when they feed most actively on roots and cause the most turf damage. Most species feed 4 to 6 months during this time of their life cycle. In late September and October they migrate into the soil to hibernate. Depths of soil penetration for hibernation vary with the species.

Year 3. In late March overwintering third-instar grubs become active and move toward the soil surface for a brief feeding period. Minor turf damage can occur early in the summer as the mature larvae complete their feeding before pupation in late July. By September they develop into adults. These young adults remain underground until the following spring, when they emerge to feed and mate, completing their life cycle.

Identification

On the larval white grub, the ventral area of the last abdominal segment just below the anus is called the raster. The raster has spines, hairs and bare spots that are arranged in certain patterns among different species. These patterns can be used to identify grub species in the field. A hand lens, 10× or stronger, is the only piece of equipment needed. The rastral patterns of the SMC and M-JB are seen in Figure 2.

A reliable characteristic in separating adult SMC and M-JB grubs is the color of the clypeus (structure or area above the mouth parts). Adults of both species have a dark brown/black head. But in adult SMC, the dark colored head shades to a lighter brown clypeus, which makes the beetle appear to be wearing a mask. Conversely, the clypeus in most M-JB species is the same dark color as the rest of the head.

Control

The major factor influencing white grub density in turfgrass appears to be **soil moisture**; that is, in years with normal or above normal precipitation, grub populations tend to increase. This is because all white grub species require moist soil for their eggs to hatch. Young grubs are very susceptible to desiccation. Turf next to regularly watered ornamental plants is favored by the adults as oviposition sites.

This dependence on soil moisture by white grubs can be exploited as a type of **cultural control** option. In areas where turf can stand some moisture stress, do not water as much in the hot summer months, particularly

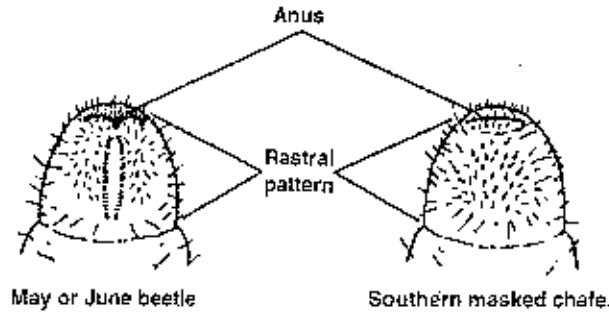


Figure 2. Rastral patterns found on the larval stage (grub) of May or June beetles and the southern masked chafer.

July and August when adults are laying eggs and young grubs are present.

Because damaging white grub populations tend to be sporadic from year to year, **preventative chemical control** applications are not really justifiable. But in areas where moderate to damaging levels of grubs have been perennial, preventative applications made in late May or June may be warranted. Some products that seem to have extended activity are isofenphos[1] (e.g., Oftanol), imidacloprid (e.g., Merit), and halofenozide (e.g., Mach 2).

Insecticides that have shorter residual periods (3 weeks or less) or must be ingested (preferably by small grubs) to be most effective are best used in a **curative chemical control** program. The successful use of these materials depends to a large degree on the proper timing of the applications (reapplication often necessary). These products must be applied shortly after egg hatch when the grubs are small and actively feeding. Remember, the smaller (younger) the grub, the easier it is to control. As a general rule, the recommended time to treat for grubs is about 4 weeks after the adult beetles start to emerge, the time when the eggs begin to hatch. For the SMC, this period is around late July to early August. Because emergence of M-JB adults can last for several weeks, chemical treatment for M-JB grubs is also recommended during late July and early August. Insecticides that appear to be effective as curative treatments include diazinon[2], ethoprop[3] (e.g., Chipco Mocap), trichlorfon[4] (e.g., Dylox), bendiocarb[5] (Turcam), halofenozide (e.g., Mach 2), and carbaryl (e.g., Sevin).

Notes

[1] For use by commercial applicators only.
[2] Not for use on golf courses or sod farms.
[3] Not for home lawn use.
[4] Some formulations for use by commercial applicators only.
[5] Restricted use pesticide, for use by commercial applicators only.

All chemical information is presented with the understanding that no endorsement of named products is intended, nor criticism implied of similar products that are not mentioned.

In recent years, several strains of insect parasitic nematodes in the genera *Steinernema* and *Heterorhabtitis* have offered somewhat effective **biological control** of white grubs. For these beneficial organisms to be most effective in managing white grub populations, it is critical that the labeled application instructions are followed exactly (e.g., time of day, soil moisture, size of grub, rates).

Chemical applications can be rendered useless if the material has not been thoroughly watered-in (0.5-inch), especially with liquid applications. The water not only moves the chemical down to the **thatch layer** (the final destination for most of the chemical), but it will often stimulate the grubs to move upward in the soil, closer to the thatch and toxicant. However, if the thatch layer is 0.75 inch to 1 inch thick, the grubs probably will not come into contact with lethal doses of the insecticide. It may be necessary to remove some of the thatch before a chemical application.

To determine if a chemical treatment is necessary, a **sampling** of the grub population is necessary. To do this, cut a 1 ft^2 piece of sod in each of several areas of the lawn, pull it back, count the number of grubs, and inspect their rastral patterns to determine species. Replace the sod squares back on the soil. If you have on average more than **10 SMC** grubs or more than **5 M-JB** grubs per square foot, then a chemical treatment is recommended. Remember, it is not unusual to have more than one species of white grub infesting the same lawn.

For further information

Brandenburg, R. L., and M. C. Villani. 1995. *Handbook of Turfgrass Insect Pests*. Lanham, Md.: Entomological Society of America.

Leslie, A. R. 1994. *Handbook of Integrated Pest Management for Turf and Ornamentals*. Boca Raton, Fla.: Lewis Publishers.

Tashiro, H. 1987. *Turfgrass Insects of the United States and Canada*. Ithaca, N.Y.: Comstock Publishing.

Watschke, T. L., P. H. Dernoeden, and D. J. Shetlar. 1995. *Managing Turfgrass Pests*. Boca Raton, Fla.: Lewis Publishers.

Before using any chemical please read the label carefully for directions on application procedures, appropriate rate, first aid, and storage and disposal. Make sure that the chemical is properly registered for the intended use.

OUTREACH & EXTENSION
UNIVERSITY OF MISSOURI
COLUMBIA

■ Issued in furtherance of Cooperative Extension Work Acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. Ronald J. Turner, Director, Cooperative Extension, University of Missouri and Lincoln University, Columbia, MO 65211 ■ University Outreach and Extension does not discriminate on the basis of race, color, national origin, sex, religion, age, disability or status as a Vietnam era veteran in employment or programs ■ If you have special needs as addressed by the Americans with Disabilities Act and need this publication in an alternative format, write ADA Officer, Extension and Agricultural Information, 1-98 Agriculture Building, Columbia, MO 65211, or call (573) 882-7216. Reasonable efforts will be made to accommodate your special needs.

HORTICULTURAL
MU Guide
PUBLISHED BY MU EXTENSION, UNIVERSITY OF MISSOURI-COLUMBIA muextension.missouri.edu/xplor/

Wildflowers in the Home Landscape

Denny Schrock
Department of Horticulture

The term "wildflower" may seem a contradiction when we use it to describe plants growing in the garden. How can a plant be wild when it is growing in cultivation? Needless to say, the word means different things to different people. All plants we grow were at some time wild somewhere. In modern use, however, a wildflower is a plant that has not undergone any change or improvement by humans and usually is still found growing natively somewhere in the region where it is being cultivated.

Why grow wildflowers?

Some people consider wildflowers hardy and durable and believe they can be grown in the garden with little care. This often is the reason given for growing them. For some plants this is true, but others need very specific conditions to grow and thrive. If they are not given these special conditions, they will decline and eventually die.

Many sites in the landscape are too shaded or too extensive for popular garden flowers. Wildflowers often are well adapted to these sites and do not need extensive maintenance if a less "manicured" landscape appearance is acceptable.

Conservation of wildflowers

Wildflowers are found in a wide range of habitats. Those that are rare, threatened or endangered should never be removed from their native habitat. Anyone interested in growing wildflowers should select those that can be grown from seeds or propagated in other ways for use in the garden. Avoid digging from native locations unless native locations are being destroyed for some reason.

Many people enjoy the wildflowers in their native habitat and are content to leave them untouched. Certainly, areas of natural preservation are important and should be encouraged and maintained. However, many home landscapes have areas that already have some native wildflowers, which can be set aside to introduce other wildflowers.

There are a number of reputable garden wildflower producers. In addition to mail-order sources, you may have wildflower nurseries near your home.

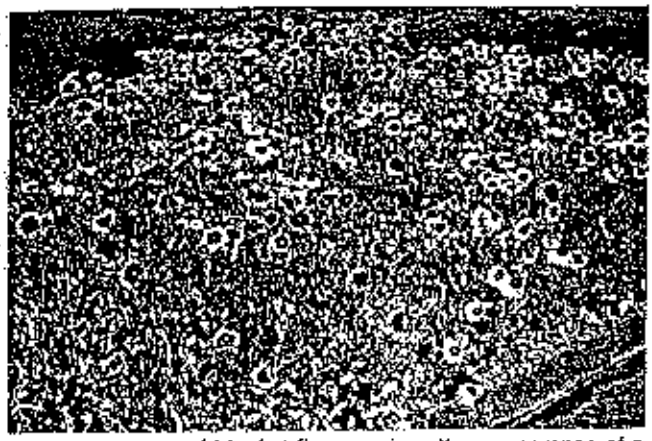
The Missouri primrose is a native wildflower well adapted to home landscapes.

Always check with local nurseries and garden centers to determine whether local sources are available. Some dealers dig plants from the wild and sell directly, or perhaps hold plants that have been dug from the wild for a few months or a year before selling them. For the sake of conservation, plants from seeds or propagated from native stock for many years should be preferred to those that are dug from wild stands. Plants not dug from the wild may cost more, but they will be more successful in the garden and you will not be encouraging depletion of natural stands.

Characteristics in landscapes

If you are interested in developing a wildflower area in your landscape, several characteristics of these plants should be considered:

- No plant chosen for the garden should be a noxious weed. Neither should a plant be so aggressive that it will invade other areas or crowd out desirable nearby wildflowers. Plants that are particularly aggressive are noted in the following tables.
- The plant must be either a perennial or an annual that self-seeds in order to maintain itself from year to year. This quality helps eliminate yearly attention to fill bare spaces.
- The plant should have some showy characteris-



A large expanse of blanket flowers gives the appearance of a naturally occurring meadow.

tics to make it desirable in the wildflower area. The showy part may be flowers, leaves, stems or seed structures.

- The plant must have a good root system so it can endure dry periods without watering and also help in conserving soil and preventing erosion.
- The wildflower plant should not be poisonous to humans or animals.
- The plant must be well adapted to the conditions available. It must be shade tolerant for the woodland garden, sun and drought tolerant for the meadow garden, water tolerant for the bog garden or other special conditions.
- In some conditions, the plant must be able to compete and persist when mixed closely into other vegetation, such as grasses in the case of meadow plants, or trees in the case of woodland plants.

Designing the wildflower garden

Many wildflowers may be used in combination with other perennials or annual flowers in a perennial border. Many people, however, prefer to have an area designed specifically for wildflowers to develop a naturalistic look with relatively low maintenance.

If you have an opportunity to visit native sites or state forests, note the plants that grow there. Compare the sites of plants you prefer to the area or areas in your own landscape. For instance, if your site is wooded and contains a lot of shade, then a woodland wildflower garden may be your only choice (see Table 2). If the site is sunny and dry, a meadow, prairie or field collection of plants may be most suitable (see Table 1 for a listing of some sunny-site species).

Wildflowers are not tolerant of foot or animal traffic. Paths should be developed so that you or your guests may walk among them, but not on them. They should not be used in areas where animals may frequently run over them. Most wildflowers cannot endure the crushed foliage and soil compaction that can result from such locations.

The actual placement of plants in the design is very flexible. Nature is very random and the wildflower garden should convey this appearance. Clusters, clumps or individual placements are quite useful. Perhaps the only arrangement to be avoided is that of plants in rows or precise geometric forms.

Woodland and meadow wildflowers

Woodland wildflowers have these basic needs: (1) light shade, (2) adequate moisture, (3) soil high in organic matter, (4) well-drained soil, and (5) a leaf mulch or other organic mulch that persists throughout the year.

Meadow or field wildflowers have a different set of needs: (1) full sun for at least 6 to 8 hours each day, (2) adequate moisture early in the season, but more drought tolerant later, (3) tolerant of poor to average soils in most cases (they may be weakened by overfertilization), (4) well-drained soils, and (5) protection by nearby noninvasive plants rather than mulch, although light mulch may also be used.

Shade. Most woodland wildflowers do not grow in dense shade. They are at their most attractive in light shade, which in nature tends to be near the edge of the forest or under tall trees with high branching. The more limited the moisture supply, the more important is the shade during the heat of the day for good growth and survival. Some woodland wildflowers that flower in early spring become dormant by midsummer and will not be seen again until next season. These often grow before a dense canopy of leaves develops and can be used in more heavily shaded locations.

Moisture. Many native wildflowers are able to sustain considerable drying. However, others such as trillium, jack-in-the-pulpit and May apple will grow and develop best where there is adequate moisture, particularly while they are growing rapidly or flowering. These plants also will go dormant in midsummer when dry conditions develop. Tree roots can be very competitive for moisture, so be prepared to give them some additional moisture, particularly during establishment or drought periods.

Most meadow wildflowers listed in Table 1 are for the dry field or meadow. However, a few of those listed are suitable for the low, wet area. These are noted in the table and are by no means the only ones that might be used.

Soil. Wildflowers are adapted to certain native soils and normally can endure in conditions similar to the ones in which they grow in the wild. In the case of woodland wildflowers, organic matter is quite important. They normally grow in locations where leaves and other plant debris accumulates and becomes a part of their soil environment and a mulch. Organic matter helps hold moisture and helps soil stay loose and well-aerated. Liberal amounts of organic matter should be added to prepare woodland wildflower

gardens. Leaf compost is particularly suitable.

Most woodland wildflowers need well-drained soil, but there are those that grow along creeks in wooded areas that tolerate or may need wetter conditions. Cardinal flower, jewelweed and forget-me-not are prime examples of this group, but it is best to know individual plant needs to fit them into the proper soil moisture requirement. The tables briefly indicate whether a plant needs wet, moist or relatively dry conditions to survive best.

Acidity. Wildflowers that thrive in Missouri generally can be expected to need soil that is somewhat acid. Most plants listed will grow best in a pH range from about 5.5 to 6.2. However, most wildflowers are adaptable and are tolerant of an even wider pH range. It usually is not necessary to lime soils that are to be used for wildflowers unless the native soil is unusually acid. A soil test to determine existing soil conditions is important in starting wildflowers in a new location where wildflowers may not have been grown previously.

Mulch. Woodland wildflowers should not be grown in bare soil as is often done with popular garden flowers. They need a mulch or the protection of another low-growing, noncompetitive plant nearby. Mulches keep soil cooler, maintain more uniform moisture and aid in winter protection. Oak leaves are a very durable and suitable mulch for many of them, although most woodland wildflowers will benefit from a mulch of any type of leaf cover.

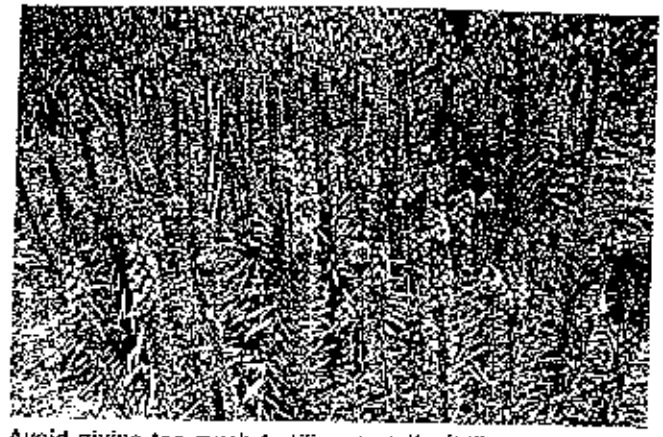
A mulch is less necessary for meadow or field wildflowers. However, they benefit from the protection of nearby low-growing plants. In Table 1, mulches are mentioned primarily for winter protection of species more suitable to warmer portions of the state.

Field or meadow wildflower gardens

The field or meadow wildflower garden is different from woodland wildflower gardens. It is composed of a wide range of plants that flower in full sun or must have at least 6 hours of full sun each day to grow and flower well. Soils for these plants generally can be less fertile and lower in organic matter. Field wildflowers may grow better in better soils, but they also are more tolerant of poor growing conditions.

Another characteristic of this group of plants is that many can be easily seed propagated or sown directly. The most commonly available wildflower seed mixes generally are intended for this type of wildflower garden.

While the meadow wildflower garden may be grown from divisions of larger plants, the seeding method should not be overlooked, particularly if larger areas are to be covered economically. Although seeds of meadow wildflowers may be planted at any time, August and September are very favorable.



Avoid giving too much fertilizer to tall wildflowers such as gayfeather to prevent stems from falling over.

Many weed seeds will not germinate in fall while the wildflowers will germinate and get a head start on the spring weeds. Some require chilling conditions before germination, but will receive this during the winter and germinate early next spring.

Since deep cultivation tends to bring up more weed seeds, it is not essential for planting wildflowers unless the soil has been extremely compacted. After a sunny area has been selected, rake the area with a garden rake or other equipment to loosen only the surface. This need be no more than about ½ inch deep. Broadcast the seeds or wildflower mix over the prepared area. After seeding, lightly rake over the area to establish good contact between the seeds and the soil. Water the area lightly to settle the soil and begin the germination process.

If the area selected already has perennial grasses and broadleaved weeds on it, the weeds should be pulled out or killed before seeding. Weeds can be killed by spot treating with a glyphosate herbicide (Roundup). The grass also may be killed at that time or left in place on slopes or areas where wildflowers are wanted, but erosion may occur if the grass is eliminated.

Some field wildflowers can exist in combination with grasses. They should not be planted with grasses that grow aggressively during cool fall and spring weather, such as fescue and rye grass. These vigorous cool-season grasses will crowd out the small wildflower seedlings during this period when they will grow very little. If this is to be done, mow the vegetation as short as possible. Remove the clippings and rough up the surface with a stiff rake, hoe, dethatcher, or other equipment. Broadcast the seeds over the area, rake them in, and water lightly.

These types of wildflower seeds should begin germination in two to three weeks after planting. Maintain frequent light watering during the germination period to keep the soil surface moist but not overly wet if natural rainfall is inadequate.

Meadow wildflowers are of two types: those that

are perennial and return each year from the same plants and those that are annuals, but reseed readily each year. Those that reseed must be allowed to finish flowering and develop fully matured seeds before they are cut down in summer or fall.

In the spring after wildflower seedlings have become established, a preemergence herbicide might be used to reduce the development of annual grasses such as crabgrass in the area. This is most critical during the first season, but is less essential as the wildflowers become well established and soil is not disturbed.

Propagating wildflowers

Collecting native plant seeds. When a sizable group of wildflowers is found, selective collection of seeds will have little or no effect on the reproduction of the area. Once established, you will be able to get additional seeds from your own plants. Seed collection can become an interesting hobby. It may be necessary to keep a careful eye on developing seeds, to pick them after seed heads begin to brown but before seeds drop out. Wildflowers may be very obvious in bloom, but often become hard to find by the time that seeds are mature, so some advance scouting and marking may be necessary. Seed stalks are best left on the plants for at least a month after flowering, but may take longer.

After collecting seed structures, open them to examine seeds contained. There are many different forms and sizes of seeds, but they generally should be fairly plump and firm if they are viable. Some plants may not produce seeds if conditions have not been favorable during the pollination or development stages.

Many wildflower seeds have a dormant period and will not germinate immediately. However, if planted promptly after harvest, this dormancy may not develop and rapid germination will occur. In the tables where midsummer or early fall planting is suggested, this really means prompt planting after harvest of the seeds.

If dormancy is natural or does develop, this means that some type of chilling will be required before the germination can be completed. Summer or fall planting is one way to fulfill these needs easily. If chilling is required, those seeds that need it will not germinate in fall, but will germinate early in spring.

Some seeds have a hard seed coat that must break down naturally in the soil before germination can occur. With these types of seeds, a process called scarification can be done to speed germination. Very hard seed coats often are found in plants of the legume family and can be bypassed by filing a small area on individual seeds, cutting a nick into the coat with a knife, or treating with acid. There are many techniques that can be used, but nature will do the job if given time.

Named cultivars of wildflowers, such as *Echinacea purpurea* 'Bravado,' must be asexually propagated to maintain the characteristics of the plant.

Asexual propagation. Any type of plant increase that does not involve seeds is known as asexual propagation. Several methods are suitable to wildflowers, depending on the plant involved.

Division — This technique is probably the most suitable and easiest method for multiplying many wildflowers. It should not be done when the plants are in flower, but when they are dormant and not actively growing. Many of the spring-blooming woodland wildflowers should be divided in the fall as growth ceases, or at that time of year when the natural growth is yellowing and collapsing.

Do not divide plants more than necessary to multiply them and keep them healthy. At the proper time, carefully lift the clump from the garden with a spade. Remove excess soil and trim back any dead top growth. Some plants that produce multiple offsets in the crown such as black-eyed-susan can be divided by pulling them apart. Woodier plants may have to be cut apart with a knife or pruning shears. After division, the smaller plants should be replanted immediately at the same depth at which they were previously growing.

Root cuttings — This is a technique suitable for a few wildflowers with fleshy roots. Butterfly weed is one that can be multiplied by this technique.

In most plants, root cuttings should be made in early spring before topgrowth begins. Remove some of the largest roots from a clump. Ideally in most plants the roots should be thick, at least the diameter of a pencil. Cut them into pieces about 3 inches in length. Plant them in a pot, flat or coldframe either horizontally or in the same position they were growing. Do not plant them upside down. The top should be at soil level with the root preferably in a vertical position. A mixture of half sand and half peatmoss works well for many plants.

In several weeks, shoots should develop from the roots. Do not be in a rush to move them into the garden. Let them get well developed.

The spreading nature of wild sweet william lends itself well to propagation by division.

Stem cuttings — This type of propagation is used less for wildflowers than for many other plants. However, it is still useful in some cases. Generally, young basal shoots make more suitable stem cuttings than older, more mature or flowering stems. The methods for rooting these cuttings are the same as for softwood cuttings of many ornamental plants. See MU publication G6970, *Home Propagation of Garden and Landscape Plants*, for more details of rooting plants from softwood cuttings. Information in this area is limited, so trial and error may be a necessary means for determining possibilities with untested species.

Suggestions for home gardens

Tables 1 and 2 list wildflowers that may be grown in home wildflower gardens. Table 1 lists meadow or field wildflowers best suited for full sun; Table 2 lists those suitable for the woodland or lightly shaded locations. There are many other wildflowers that could be included, but space does not permit. For the most part, those that are easily grown and not invasive have been selected. However, a few that are difficult and some that tend to be aggressive are included for suiting all needs or locations.

Brief information on bloom time, color, height, soil conditions, propagation and special considerations are included. In each table plants are listed alphabetically by common name with scientific name added after the common name.

Common names are variable, so it is possible that you may know a certain plant listed with another name. Also many plants closely related to plants listed may be quite suitable. For instance, purple coneflower is listed, but several other plants known as coneflowers, including gray-head coneflower, pale coneflower, Mexican hat and thin-leaved coneflower (also called brown-eyed-susan), could be used in similar sites. The possibilities for using native plants seem almost endless.

Wildflower seed mixes may contain seeds not found in these tables. These are mainly flowers that can be found growing natively in Missouri. However, those in mixes may also be quite suitable for our location but may not normally be found unless introduced. Use the plants suggested in the tables as a guide to a beginning garden, but do not be limited by it.

Explanation of tables

Bloom time — This is approximate and will vary between different localities. In some cases, where the period is extended, major bloom will be early in the period given with scattered bloom following during the time indicated.

Major color — Note this is "major" color. Other shades and colors may exist, particularly if other species of the same genus are chosen.

Height in inches — This is another very variable character, but an indication is given as a guide to possible placement in the garden. Under very good growing conditions or special situations, heights can vary.

Soil type — This column does not really give soil type as much as conditions necessary within existing soils that are available. Rich indicates a need for high fertility, average indicates most existing soils will suffice, poor indicates tolerance to low fertility or a need to avoid high fertility.

Where humus is listed, plants need a soil fairly high in organic matter. If this does not occur naturally, organic matter should be added at planting time and mulch should be maintained.

Moisture conditions also are indicated in this column. Wet means that it needs standing water or at least can tolerate standing water for part of the time. Moist indicates that plants should not be allowed to become too dry. Dry and well drained means that the plant cannot tolerate periods of standing water or excessive moisture for even short periods of time without some damage.

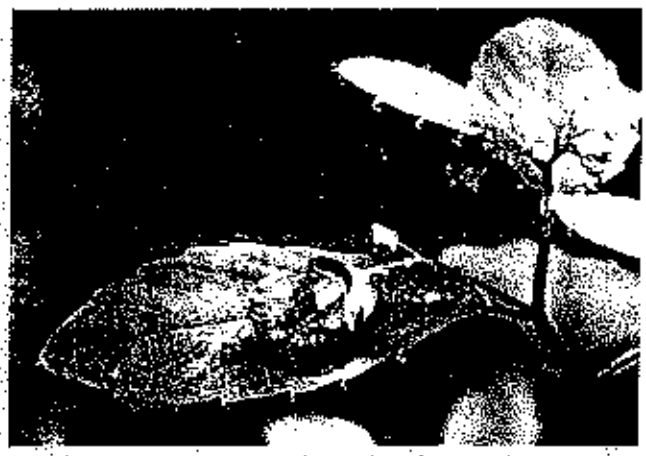
Propagation — Indicates the main or easiest methods for reproduction. Timing also is given where appropriate.

Comments — Used to add statements for additional information. These include unique plant characteristics, other propagation information, special sites suitable, need for winter mulch, weedy or difficult type of plant as well as other items that might be useful.

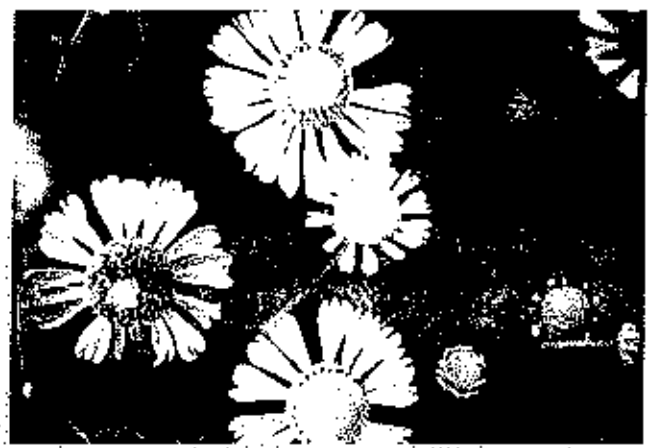
Table 1. Meadow and field wildflowers suitable for sunny, open locations.

Meadow wildflowers	Bloom time	Major color	Height (inches)	Soil type	Propagation	Comments
Beard tongue (*Penstomon* species)	May to July	White, pink, purple	18–48	Average, well drained	Divide fall or early spring.	Self-sows easily. Takes light shade or full sun.
Bee balm, Bergamot (*Monarda* species)	June to August	Lavender, pink, red	24–48	Average, well drained	Divide early spring. Seed fall.	Tolerates light shade, many soil types
Black-eyed susan (*Rudbeckia hirta*)	June to October	Golden yellow	12–24	Average, well drained	Seed in fall.	Self-sows easily. Avoid excess fertilization.
Blanket flower (*Gaillardia grandiflora*)	May to October	Yellow, red	12–24	Poor to average; dry, well drained	Seed spring or fall.	Excellent for hot dry areas. Performs best with routine deadheading.
Blue false indigo (*Baptisia australis*)	May	Blue	24–48	Average, well drained	Divide fall. Seed spring.	Also white and yellow species. Black seed pods
Blue sage (*Salvia azurea*)	August, September	Azure blue	36–48	Average, well drained	Seed or division in fall.	Attractive, long slender flower species.
Blue star (*Amsonia illustris*)	April, May	Light blue	18–36	Moist but well drained	Seed or division	Shiny leaves very attractive.
Butterfly weed (*Asclepias tuberosa*)	May to September	Orange	12–36	Average dry, well drained	Divide fall. Sow seed in late summer.	Perfect drainage important. Tolerates light shade.
Cardinal flower (*Lobelia cardinalis*)	July to September	Bright red	24–36	Average wet	Sow seeds in late summer.	Must be kept moist at all times. Mulch.
Coreopsis (*Coreopsis lanceolata*)	May to August	Yellow	12–36	Average, well drained	Sow seeds in late summer.	Self sows readily. Drought tolerant, soil tolerant.
False dragon head (*Physostegia virginiana*)	May to September	Pink, white	36–48	Average moist	Divide early spring Seed late spring	Also called obedient plant Spreads easily
Gayfeather, Blazing star (*Liatris species*)	July to October	Lavender pink	24–40	Fertile, well drained	Divide in spring. Seed in fall.	Good flower for cutting. Mulch for winter.
Goldenrod (*Solidago species*)	July to October	Yellow, white	12–60	Poor to average, well drained	Divide fall. Seed in fall.	Self sows easily. Tolerates light shade.
Gray-head coneflower (*Ratibida pinnata*)	May to September	Yellow	36–48	Poor to average	Seed in fall Division.	Gray disks with drooping yellow ray floret petals
Indian paint brush (*Castilleja coccinea*)	April to July	Red, orange	8–24	Average moist	Seed in fall. Do not cover.	Annual. Difficult.
Missouri coneflower, Missouri black-eyed susan (*Rudbeckia missouriensis*)	June to October	Yellow	18	Average, well-drained	Seed in fall.	Common wildflower in Ozark region of Missouri.
Missouri primrose (*Oenothera macrocarpa*)	May to July	Yellow	8–10	Average dry, well drained	Seed late spring. Cuttings in July.	Large flowers, evening bloom. Good rock garden plant.
New England aster (*Aster novae-angliae*)	July to September	Violet	36–60	Average moist	Divide late fall. Seed in late fall.	Top shoots in late spring to create lower, bushier plant

Continued on next page



Jewelweed, found in moist shady sites, is sometimes used to relieve itching.



Helenium, or sneezeweed, warms the late summer garden with its yellow, orange or bronze daisylike blooms.

Table 1. Meadow and field wildflowers suitable for sunny, open locations. (Continued)

Meadow wildflowers	Bloom time	Major color	Height (inches)	Soil type	Propagation	Comments
Purple coneflower *(Echinacea purpurea)*	July to October	Reddish purple	24–36	Average, well drained	Divide fall. Seed in late summer.	Durable, long lasting. Drainage important.
Purple prairie clover *(Petalostemon purpurea)*	June to September	Rose-purple	24–36	Poor to average	Seed in fall.	Common clover. Easily grown.
Rattlesnake master, Button snakeroot *(Cryngium yuccafolium)*	July through August	Greenish white	18–48	Average, well drained	Seed or divide in fall.	Attractive seed heads provide late summer and fall interest.
Rose verbena *(Verbena canadensis)*	March to November	Rose, magenta	6–12	Poor to average, well drained	Seed fall or early spring.	Self-sows. Needs full sun. Cannot compete with tall plants. Mulch.
Shooting star *(Dodecatheon meadia)*	April, May	Pink	12–18	Rich, dry and well drained	Divide late summer. Seed midsummer.	Drought tolerant. Cannot compete with large plants. Mulch.
Showy evening primrose *(Oenothera speciosa)*	May, June	Pink, white	6–12	Poor to average, well drained	Divide early spring. Seed fall or early spring.	Spreads easily. Mulch for winter protection.
Skullcap *(Scutellaria incana)*	June to August	Purple	24–30	Average, well drained	Seed in fall.	Seeds shaped like a cap, hence its name.
Sneezeweed *(Helenium autumnale)*	August to November	Yellow	48–72	Average moist	Divide spring.	Rank grower. Suitable for background use.
Spiderwort *(Tradescantia virginiana)*	April to July	Blue	12–24	Poor to average, well drained	Divide early fall. Sow seed promptly.	Tolerates light shade. Cut flower stems for repeat bloom.
White upland aster *(Aster ptarmicoides)*	July to September	White	24–30	Average, well drained	Division in fall or spring.	Drainage important. Can grow in almost pure sand.
Wild pink *(Silene caroliniana)*	April to May	Rosy pink	6–8	Acid, well drained	Seed in fall or spring.	Excellent drainage important. Suitable for rock gardens.
Yarrow *(Achillea species)*	June to September	White, pink, yellow	12–36	Average, well drained	Divide fall. Seed at harvest.	Mulch. Tolerates light shade.
Yellow coneflower *(Echinacea paradoxa)*	June, July	Yellow	24–36	Average, well drained	Seeds or division.	An uncommon native plant suitable for gardens.

Mayapple graces the spring woodlands with white blossoms.

Goldenrod is attractive to butterflies and, despite popular belief, seldom causes problems with allergies.

Table 2. Woodland wildflowers suitable for a wildflower garden in a shaded or lightly shaded location.

Woodland wildflowers	Bloom time	Major color	Height (inches)	Soil type	Propagation	Comments
Bellwort *(Uvularia grandiflora)*	April, May	Yellow	12–14	Moist, humus	Divide midsummer.	Mulch. Attractive foliage.
Bloodroot *(Sanguinaria canadensis)*	March, April	White	6–10	Humus, dry, well drained	Divide late fall.	Sow seeds after collection. Needs sun.
Celandine poppy *(Stylophorum diphyllum)*	March to May	Yellow	10–18	Moist, humus	Seed or divide fall.	Needs constant moisture, mulch
Columbine *(Aquilegia canadensis)*	April, May	Red with yellow	24	Moist, rich humus	Seed in summer.	Difficult to transplant. Self-sows easily.
Dog-tooth violet *(Erythronium americanum)*	March, April	Yellow	4–10	Moist, humus	Divide offsets in late summer.	Needs spring sunlight. Four to 7 years to bloom from seeds.
Dutchman's breeches *(Dicentra cucullaria)*	April	White	4–12	Moist, humus	Divide early fall.	Needs constant moisture. Mulch.
False Solomon's seal *(Smilacina racemosa)*	April, May	White	12–36	Moist, rich humus	Divide late fall. Reseeds.	Arching growth. Red berries. Tall groundcover.
Fire pink *(Silene virginica)*	April, May	Brilliant red	24	Dry, sandy, well drained	Seeding difficult. Divide fall.	Fragrant. Needs some sun. Use mulch.
Goat's beard *(Aruncus dioicus)*	May, June	Creamy white	48–60	Moist, rich	Reseeds easily in shade.	Male and female plants.
Golden seal *(Hydrastis canadensis)*	April, May	White	12–15	Moist, rich, well drained	Divide fall. Seed in fall.	Endangered plant. Red berries.
Great blue lobelia *(Lobelia siphilitica)*	August, September	Blue	12–36	Wet, rich, humus	Divide in spring. Seed fall.	Also for wet meadows. Mulch for winter.
Green dragon *(Arisaema dracontium)*	April, May	Greenish yellow	12–48	Wet, rich, humus	Offsets in fall. Seed fall.	Full sun to light shade. Good near ponds.
Jack-in-the-pulpit *(Arisaema triphyllum)*	April, May	Pale green, purplish	6–24	Wet, rich, humus	Divide fall. Seed late summer.	Needs wet shaded site. Mulch.
Jacob's ladder *(Polemonium reptans)*	April, May	Blue-lavender	15	Moist, rich, humus	Divide fall. Seed late summer.	Moist woods or near ponds
Jewelweed *(Impatiens capensis)*	May to October	Orange	24–48	Moist, rich, humus	Seeds in spring.	Annual plant. Can become weedy.
May apple *(Podophyllum peltatum)*	April, May	White	12–18	Moist, rich, humus	Divide in fall.	Forms woodland groundcover. Needs constant moisture.
Rue anemone *(Anemonella thalictroides)*	April, May	White	4–6	Humus, well drained	Divide fall. Seed mid-summer.	Needs filtered light. Tolerates moist sites.
Solomon's seal *(Polygonatum canaliculatum)*	May, June	White	24–48	Rich, moist, humus	Divide fall. Sow seed when ripe.	Tolerates many conditions. *P. biflorum* useful.
Tall bellflower *(Campanula americana)*	June to October	Blue	Up to 72	Rich, moist, humus	Seed in late summer.	Annual. Reseeds easily. May become woody.
Toothwort *(Dentaria laciniata)*	March, April	White to pale lavender	4–12	Rich, moist, humus	Seed late summer.	Moderate shade, Mulch. Deeply cut leaves.
Violet *(Viola species)*	March to May	Blue, white, yellow	4–10	Rich, moist, humus	Divide fall. Seed in fall.	Grows almost anywhere. Self-seeds easily.
Virginia bluebells *(Mertensia virginica)*	March, April	Light blue	12–20	Well drained, humus, dry	Divide when plants turn yellow.	Sow seeds as soon as collected. In dry sites, mulch.
Wake robin, Trillium *(Trillium species)*	April, May	Maroon, white, yellow	8–16	Rich, humus, moist	Divide late summer. Seed when harvested.	Filtered light in spring. Shade thereafter. Mulch. Give good drainage.
Wild geranium *(Geranium species)*	April, May	Lavender	10–18	Rich, moist	Divide fall. Sow seeds when harvested.	Takes partial sun. Mulch. Cut rhizomes for division.
Wild sweet william *(Phlox divaricata)*	April, May	Blue, light violet	10–20	Moist, humus	Seed fall. Divide late summer.	Perennial. Easily grown.

OUTREACH & EXTENSION
UNIVERSITY OF MISSOURI
COLUMBIA

■ Issued in furtherance of Cooperative Extension Work Acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. Ronald J. Turner, Director, Cooperative Extension, University of Missouri and Lincoln University, Columbia, MO 65211.

Integrating Native Landscapes

Shoreline at Tellabs Bolingbrook Facility in Naperville, Illinois before and after landscape design.

by Jim Patchett

THE land planning and environmental services firm of Conservation Design Forum, Inc. (CDF) is dedicated to promoting the integration of native landscape systems as an alternative landscape treatment for private and public landscapes throughout the Midwest. A primary goal of this approach is to create cost-effective, functionally integrated, and aesthetically rich landscapes. The integration of native landscape systems, however, represents far more than just an alternative landscape treatment. Native landscapes are an important component of an environmentally sustainable, economically sensible approach to land planning and development for all types of land use, including commercial, corporate, and institutional campuses, parks and open space systems, and residential settings.

The proper design, installation, and management of native landscapes will create a living system, including a diverse community of plant species that can sustain itself and thrive in the unique temperature and moisture extremes of the Midwest. From an aesthetic point of view, native landscapes produce a constantly changing pattern of striking colors and textures throughout the seasons, including the winter landscape, which provides a study of warm tones and textures.

Native landscapes also can result in significant environmental benefits and cost savings. Typical environmental benefits include: reduced surface water runoff and downstream flooding; reduced soil erosion, including the redevelopment of organic topsoil; increased groundwater recharge; enhanced regional air and water quality; and increased biological diversity of both plants and animals. Long-term maintenance cost savings can also be significant, often resulting in 80-90% annual cost reductions once the native landscape system is properly established, a process that generally takes 5-10 years.

Background and Benefits of a Native Landscape Approach

Traditional landscape design standards throughout urban and suburban America are characterized by large expanses of grass lawn, regimented beds of ornamental shrubs, flowers, and ground covers, and a wide variety of introduced or non-native trees. This design philosophy, fostered in large part by influences from English and other European gardens, has been repeated over and over in both private and public environments. Common to all of these landscapes is the high level of maintenance required to preserve the desired appearance. This landscape development approach generally results in the necessity of frequent lawn watering and mowing, and the liberal application of chemical fertilizers, pesticides and herbicides, many of which are potentially hazardous to the

environment, as well as to humans. These traditional landscapes also require routine shearing, pruning, weeding, trimming and spraying associated with conventional shrub and planting beds. This situation not only creates an expensive mandatory cycle of perpetual care, it puts ever growing pressure on the diminishing capacity of landfills. Consequently, by reducing the quantity of turf grass lawn and ornamental or non-native plant species, an environment can be created that is visually attractive, easier to maintain, ecologically functional and appropriate to the local climate and terrain.

As mentioned above, the incorporation of native plant material into appropriate landscape settings provides a variety of benefits. These benefits generally can be grouped into three categories: natural; social; and economic. Natural benefits include such items as reduced surface water runoff and soil erosion, increased infiltration and groundwater recharge, enhanced air and water quality, and increased biological diversity. Social benefits include opportunities for increased public environmental education and awareness, regional flood control, and the promotion of an environmentally stable land development ethic. Economic benefits include such factors as the significant reduction of annual maintenance costs and the opportunity to scale back overall infrastructure needs, which reduces initial capital development costs.

Natural benefits include such items as reduced surface water runoff and soil erosion, increased infiltration and groundwater recharge, enhanced air and water quality, and increased biological diversity.

First, however, it may be helpful to explain what native or naturalistic landscaping represents. Native plants are those species that have adapted to a specific site or region for centuries or even thousands of years. They are dependable plants, adapted to the moisture, temperature, insects, wildlife and diseases of a particular region. Today, these species are quite rare, often relegated to small tracts of remnant land. Most of our native landscapes have been destroyed, or significantly degraded, due to agricultural and urban development. In disturbed areas, such as roadsides, meadows and fields, our native species have largely been replaced by a relatively small variety of Eurasian grasses and flowers. The biological value of these few weedy introduced plants is significantly lower than that associated with our diverse natural plant communities which were composed of an average of 700 - 1,000 native plants per county across the Midwest.

The growth character and adaptations of our native prairie and woodlands flowers, grasses, and sedges are quite unique. Most of the plant mass of a prairie community is underground. It is the extensive root system, which often reaches 10 feet or deeper, that is capable of penetrating the impermeable clay layers found throughout much of Midwest's glacial till. This intricate network of roots anchors the soil and creates countless avenues for water to move

Sears Prairie Stone Corporate Campus in Hoffman Estates, Illinois. Another example of sustainable land use planning.

from the surface layer into the root zone or for roots to mine deep groundwater supplies during times of drought. In contrast, traditional turf grass lawns possess dense, matted shallow roots that are incapable of penetrating deeply into the soil. With minimal pore spaces, rainfall tends to run off the land rather than to infiltrate into the soil layer. This creates a situation where frequent lawn watering is necessary, even shortly after a rainfall event.

What many of us do not realize is that most turf grass lawns are comprised of cool season grasses that are not native to North America and certainly not native to the upper Midwest. These cool season grasses, including Kentucky Blue Grass, are native to cool, moist regions of Europe and Asia. While cool temperatures and abundant moisture in the Spring are conducive to initial growth, conventional turf grasses must often rely on mechanical means, including watering and fertilization to survive a hot, extended dry period during the summer months. When weakened, these non-native grasses are often incapable of surviving attacks from pests and cannot resist the invasion of weeds.

Because established native systems do not need fertilizers, herbicides, pesticides, and watering to be maintained, the groundwater zone is not depleted and the overall environmental health of the site is improved. The incorporation of native plants into our landscape does not mean that they are maintenance free. The amount of care, however, is significantly reduced. Once established through proper installation and stewardship, these native ground and canopy covers will successfully choke out weedy competition. Soil erosion is reduced or eliminated and the means for rebuilding

a rich organic soil layer is reintroduced. Surface water runoff can be significantly reduced, which lessens the impacts of downstream flooding and improving the quality of water that leaves the site.

Once established... these native ground and canopy covers will successfully choke out weedy competition. Soil erosion is reduced or eliminated and the means for rebuilding a rich organic soil layer is reintroduced.

Suburban and urban environments often face air pollution concerns. Native systems can be very beneficial in terms of air quality enhancement. Prairie systems, for example, are highly efficient in their ability to remove carbon dioxide from the atmosphere and fix net amounts in their extensive root systems. This annual net accumulation of soil organic carbon (SOC) is responsible for the formation of the black, organic topsoil that was the foundation of our Midwest agricultural community. The prairie environment, often referred to as a virtual "clean air machine", is truly one of the more remarkable ecosystems in the world. Much the same is true for the native wetland, savanna, and woodland communities of the Midwest.

In addition to the many environmental benefits, a carefully selected palette of native plants will produce a variety of striking colors and textures throughout the season, which creates a pleasing aesthetic, as well as a healthy, biologically diverse system. The diverse palette of native plant materials associated with the various habitats can be selected and planted in a naturalized context, or they may be utilized in a more stylized or ornamental approach. The more ornamental approach can be particularly effective for providing appropriate accents or transitions between the refined elements of the built environment and the more natural qualities of the adjacent prairie or woodland environments.

By no means are we advocating the exclusion of ornamental species or the discontinuance of our traditional landscapes. We are advocating, however, a more environmentally sound balance between the use of native and traditional landscape elements. This balance can be achieved in many ways that can provide design and program flexibility to any site. It is our opinion that native landscapes can be integrated creatively into virtually all settings.

A native landscape is a vital component of a planning and development ethic firmly grounded in an understanding of the function of our natural systems. Integrating native landscape systems into built environments provides a starting point for uncovering our ecological past, which equips us to accommodate sustainable approaches to current and future uses of land. These are living landscapes that provide a constantly changing array of colors and textures throughout the year. They offer an opportunity for us all to reconnect ourselves to the function and beauty of our natural environments, and to understand better the importance of maintaining a sustainable cultural relationship without the earth's natural resources. **L&W**

For more information, contact Jim Patchett, Conservation Design Forum, Inc., 324 North York Rd., Elmhurst, IL 60126, (630)758-0355, fax (630)758-0320.

Tellabs Global Headquarters

Tellabs, Inc. took an early interest in adopting an integrated site planning, landscape design, and storm water management approach for their new 55-acre Global Headquarters complex, located in Naperville, Illinois. Many of the landscape and storm water management measures were originally introduced in the design and development of their Research Facility in Bolingbrook, Illinois in the early 1990's. Working closely with the project architects and engineers, CDF's team of landscape architects, environmental scientists, and hydrologists developed plans for the new global headquarters campus that rely on the comprehensive integration of storm water management, native landscape systems, and ecological restoration. This approach has allowed Tellabs to significantly reduce potentially harmful, traditional landscape maintenance practices and add valuable and rare habitat to the developing area.

The progressive storm water management system has been designed to accommodate water where it falls, allowing it to manifest itself as a resource, rather than generating a waste product to be dealt with elsewhere. Through the use of innovative storm water collection and treatment systems, in combination with the natural water conserving attributes of the deep-rooted native prairie and woodland plants, the goal is to restore, as nearly as possible, a pre-settlement form of hydrology back to the site. This would mimic the groundwater dominated pattern of hydrology that was prevalent historically throughout the region. Instead of a conventional storm water management system that conveys water from the site as quickly as the law allows, typically in an enclosed storm sewer system, the Tellabs approach will serve to improve water quality while minimizing the volume and velocity of runoff by modeling storm water systems on natural hydrological processes. Surface water runoff will be handled in a combination of naturalized swales, parking lot island bioswales that incorporate french drains with perforated pipes, and other infrastructure measures. These measures include dry wells and level spreaders designed to cleanse and absorb water on-site, thus dramatically reducing the amount of storm water that leaves the site. Diverse native plant communities cover most open space areas and incorporate walking trails, overlooks, and naturalized detention basins as amenities for employees.

The City of Naperville has been very receptive to all design solutions involving innovative storm water management techniques and would like Tellabs' site to be a standard for future development in the city. **L&W**

For more information, contact Doug Stanley, Tellabs Operations, Inc., 27555 Diehl Road, Warrenville, IL 60555, (630)848-7529.

United States Department of Agriculture

Soil Conservation Service

Columbia, Missouri

Urban Conservation Tips

Establishing Lawns

Description

Your success with establishing and keeping grass on disturbed areas will largely depend on the care you take during the establishment process. Most failures result from seeding at the wrong times, from not preparing an adequate seedbed or from planting the seed improperly. This guide outlines necessary steps in establishing and maintaining your lawn.

Begin by planning. Inventory trees and evaluate shady areas. Have your soil analyzed. Grass mixtures that do well in shade, have low fertility requirements and withstand droughty conditions can be bought at most garden centers. You can get a soil analysis for a nominal fee by contacting your local University of Missouri Extension Service office.

Remember, your success in this undertaking requires planting seed at the correct times. Plant cool-season grass lawns (bluegrasses, fescues, perennial ryegrasses) between August 15 and September 15. A target date to shoot for is Labor Day. These grasses can be planted in early spring to May 1, but you will have to water frequently to maintain your stand.

Application

After selecting your seed mixture, determining lime and fertilizer needs and picking a planting date, you are ready to establish your lawn. In the absence of a soil test, refer to the chart below for lime and fertilizer recommendations.

Apply the lime and fertilizer to the soil surface and work it into the ground at least three inches with a power tiller or disk. If power equipment is unavailable, rake the area as deeply as possible. Then smooth and roll the area to form a firm, fine seedbed.

Broadcast lawn seed uniformly at the recommended rate (see table on back). If you broadcast the seed with a cyclone spreader, apply seed at a one-half rate and cover the lawn two times using a crossing pattern (see illustration on back). This will help assure uniform coverage of the area to be seeded. After the seed is broadcast, lightly rake the soil with a flexible tine rake. Do not cover the seed too deeply. Most grass seeds only require one-fourth-inch coverage to germinate and grow. It's a good sign if, during raking, you see seed still on the surface.

Next, spread one or two bales of clean straw per 1,000 square feet. Immediately after seeding and mulching, soak with water. Keep the surface moist by watering daily, but do not water so much as to cause erosion. After grass emerges, watering should be less frequent and deeper to encourage root development deeper into the soil. Continue watering as needed during drought. Soaking the top four to six inches of soil once a week usually maintains a healthy stand of grass.

Lawn Establishment Recommendations

Soil Treatment	Rate per 1,000 Square Feet
Limestone	
Ground (agricultural grade)	50 lbs.
Hydrated	35 lbs.
Fertilizer	
10-10-10	15-20 lbs.
12-12-12	12-17 lbs.
Straw	100 lbs.

Maintenance

The last step is maintenance, your key to a healthy, long-lasting lawn. Do not mow closer than three inches during hot summer months, and maintain a two-inch minimum during the spring and fall. No more than one-third of the leaf should be clipped to maintain a leaf surface capable of properly utilizing sunlight for good growth.

The starter fertilizer you used when planting in the fall will be adequate for about two months. When seedlings show signs of

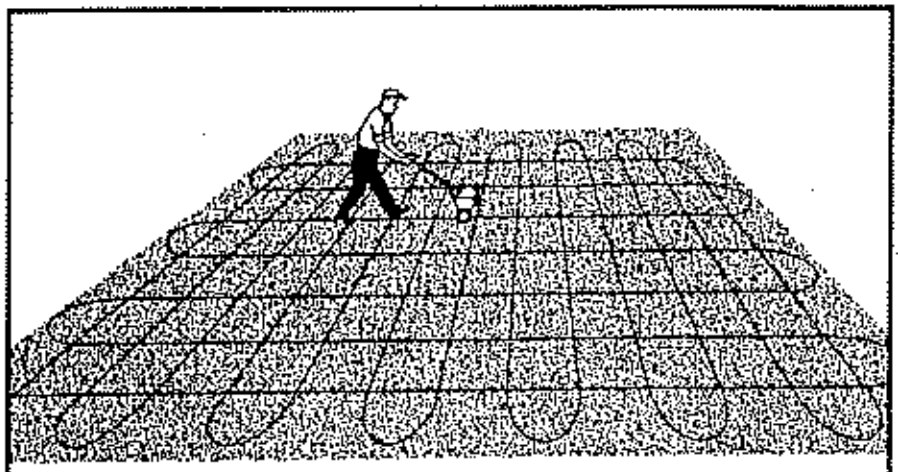
(over)

losing vigor, apply a lawn fertilizer mix at half the regular rate. After the lawn is fully established, late summer fertilization usually will be the most beneficial to the entire plant. Labor Day is a good target date for fertilizing.

Weed, insect and disease control in established lawns is a common practice in lawn maintenance. Consult your local garden center or University of Missouri Extension Service office for recommendations.

Where To Get Help

For more information about establishing lawns, contact your local Soil Conservation Service office or your local University of Missouri Extension Service office. The Soil Conservation Service is listed in the telephone directory under "U.S. Government, Department of Agriculture."



Spread seed and fertilizer in two directions to ensure that all areas of the lawn will be covered.

Grass Variety	Characteristics					Seeding Rates
	Tolerance		Level of Maintenance			
	flood tolerance	shade tolerance	high	medium	low	
Bluegrasses	*		*	*		2-3#/1,000sq.ft.
Ryegrasses				*	*	5#/1,000sq.ft.
Red Fescues	*	*	*	*		4#/1,000sq.ft.
Tall Fescues				*	*	7-8#/1,000sq.ft.
Mixture *Bluegrass* *Ryegrass* *Red Fescue*						3-4#/1,000sq.ft.

HORTICULTURAL
MU Guide
PUBLISHED BY MU EXTENSION, UNIVERSITY OF MISSOURI-COLUMBIA muextension.missouri.edu/xplor/

Mulches

Christopher J. Starbuck, Department of Horticulture

Mulches provide many benefits to plants. Benefits vary with the material used, the type of soil, the kind of plant and the cultural practices used. Mulches also may be used to make landscapes more attractive and usable and to reduce the amount of maintenance work (see Figure 1).

Why mulch?

- Surface insulation
  - to conserve moisture
  - to moderate extremes in temperature
  - to control weeds
- Soil amendment
  - to improve soil aggregation and granulation
  - to increase water absorption and retention
  - to prevent soil compaction and improve aeration
- Beautification
  - to make surface areas more attractive
  - to make surface areas more usable for paths, play and sitting areas
  - to make areas easier to maintain

Types of mulch

Many types of material, organic and inorganic, may be used as mulch. Organic mulches may break down in one season or less or persist for more than one season. The first type is used mainly in vegetable and flower gardens or around newly planted trees and shrubs. They are usually decomposed enough by the end of the growing season that they can be spaded or plowed under, increasing the organic matter content of the soil and thereby improving soil structure. Some common mulches of this type are listed in Table 1.

Organic mulches that persist for more than one growing season are more useful around permanent plants. These are summarized in Table 2.

Inorganic mulches may be gravel, crushed stone or some manufactured product (Figure 2). Most of these materials are not as beneficial to plants as the organic mulches are because they do not improve the structure or nutrient content of the soil. Black plastic mulch is not recommended for use in the landscape but may be useful in the vegetable garden. Spun-

Figure 1. Mulch beds can provide a unifying effect in the landscape (top) while keeping the soil cooler in summer and warmer in winter, an important benefit for flowering bulbs (middle). Mulch can also make an attractive walkway through the landscape (bottom).

Figure 2. One use for an inorganic mulch, such as gravel, is in a rock garden.

bonded or woven landscape fabrics (geotextiles) are better suited for landscape purposes. Normally these fabrics are covered with a more decorative mulch rather than used alone. Some commonly used inorganic mulches are summarized in Table 3.

Though not generally considered mulches, some low-growing groundcover plants produce many of the same benefits as mulch. They shade the soil surface, keeping it cool in summer and at the same time preventing evaporation. For more information on groundcovers, see MU publication G6835, *Selected Groundcovers for Missouri*.

Using mulches

On the whole, mulches should not be considered a fertilizer. Most of them release some nutrients as they decompose, but the fertilizer value is very small in relation to the physical effects. Where mulches are needed, use them for the mulch value and add fertilizer as a supplement.

The effectiveness of a mulch depends on the density and texture of the material used and the depth of the layer applied. A 2- to 4-inch layer of most products is needed to insulate the soil effectively and prevent weed growth.

In permanent locations, a layer of geotextile can be used under the mulch to prevent weed growth and make the mulch more effective (Figure 3). When landscape fabric is used, the mulch layer needs to be only about half as thick as in areas without it.

Mulching suggestions

Table 1. Relative value of mulches that break down in one season or less.

Material	Resistance to compaction	Attractiveness	Resistance to wind blowing	Availability	Source of weeds and disease	Fire hazard	Comments
Compost	B	B	A	A	C	No	Value varies with ingredients.
Corn stalks	A	F	B	C	A	Yes	Coarse and unsightly. Should shred or compost.
Hay	B	C	B	C	C	Yes	Good when available.
Lawn clippings	D	D	B	A	C	No	Compost first.
Leaf mold	B	B	A	A	C	No	Value varies with ingredients.
Leaves	F	B	D	A	B	Yes	Compost first.
Manure (well rotted)	B	B	A	C	F	No	Odor may be bad.
Peat moss	B	A	A	A	B	No	Universally available. Coarse grades best.
Rice hulls	B	C	D	D	C	No	Good when available.
Straw	A	D	D	B	D	Yes	Often contains grain seed.
Waste paper	C	F	F	A	A	Yes	Must be shredded. Unsightly

Key: A = Excellent; B = Good; C = Fair; D = Poor; F = Unsatisfactory

Table 2. Relative value of some persistent mulches.

Material	Resistance to compaction	Attractiveness	Resistance to wind blowing	Availability	Source of weeds and disease	Fire hazard	Comments
Bark chunks	A	A	A	A	A	No	Generally available. Expensive.
Cocoa shells	A	A	B	D	A	No	High potassium content may cause problems.
Corn cobs	B	D	B	C	B	No	Add nitrogen. Unsightly.
Cottonseed hulls	B	C	D	D	B	No	Hard to keep in place.
Pecan hulls	A	A	B	C	A	No	Locally available. Good.
Pine needles	A	B	B	C	B	Yes	Especially good on acid-loving plants.
Sawdust (coarse)	C	C	B	B	A	No	Add nitrogen. Use aged material.
Sawdust (fine)	D	C	D	B	A	No	Compacts too easily. Requires nitrogen.
Shredded bark	B	A	A	B	A	No	Good when available.
Wood chips	B	B	A	B	A	No	Inexpensive when available.
Wood shavings	B	B	B	C	A	Yes	Add nitrogen when spaded under.
Wood fibers	C	C	B	D	A	No	Add nitrogen. Coarse grade preferred.

Key: A = Excellent; B = Good; C = Fair; D = Poor; F = Unsatisfactory

Considering the growth requirements of the multitude of garden and landscape plants, obviously there is no one mulch that will be superior in all cases. The following general suggestions should help in selecting the right mulch.

Bulbs. Among garden bulbs, lilies benefit more from mulching than any other group. Two to 3 inches of wood shavings, straw, chopped hay or other lightweight material serve to lower the temperature of the soil in summer, conserve moisture and give winter protection to the more tender species.

Most other bulbs are sufficiently winter hardy but benefit from mulching for other reasons. Small, shallow-planted bulbs can be heaved out of the soil by alternate freezing and thawing. This effect can be largely prevented by light mulching. Mulches generally improve the appearance of flowering bulbs growing in a bed of otherwise barren soil. They offer a background for viewing the new spring growth and also reduce the spattering of plants with mud during rainstorms.

Evergreens. Plants that most need mulching are evergreen shrubs and young evergreen trees, especially the broad-leaved types. Mulches help prevent winter drying of these plants. Winter drying causes foliage to become scorched and discolored over winter and may cause the plant to die. Drying develops when foliage loses moisture faster than it can be taken up by the roots from a dry or frozen soil.

Plants that should almost always be mulched are azalea, boxwood, Chinese and Japanese hollies, Japanese andromeda and rhododendron. Exotic evergreens and those planted north of their best zone of adaptation should be kept well mulched year-round.

Coarse mulches should be used: wood chips, bark products, shavings, chopped corn cobs, pine needles, hedge trimmings or partially finished coarse compost. Mulches should be renewed in early winter. A layer 2 to 4 inches deep is adequate in most cases but can be more or less, depending upon site, soil, climatic zone and the plant itself. The mulched area should be at least as broad as the plant itself and preferably broader since most woody plants have root systems that reach beyond the spread of the branches.

Fruits. To keep young fruit trees growing well, maintain a mulched area 3 to 4 feet in radius around the base. Coarse materials such as hay, straw, wood or bark products are most useful. Keep mulch pulled away from the trunk of the tree. The mulch can be replenished in late March or early April before new weed growth appears. Grapes and berry bushes may be kept permanently mulched.

Strawberries should be mulched preferably with clean straw or with prairie hay in mid-December. Use enough mulch, loosely scattered, to barely hide the foliage. In spring when new leaves begin to grow, remove enough of the mulch to allow the plants to emerge.

Perennials. Most garden perennials benefit from summer mulches for preserving soil moisture and for reducing soil temperature. Perennials that most often need winter protection in Missouri include baby's breath, bellflower, chrysanthemums, delphinium, hardy gloxinia, hypericum, linum, lupine, oriental poppy, Stoke's aster, thrift and thyme.

Some perennials that are normally cold hardy are often damaged by alternate freezing and thawing of the soil, which may loosen or heave the plants and expose them to drying. Among these are aconite, coral bells and newly planted peony and plantain lily.

A few plants are extremely sensitive to damage by high summer soil temperatures or drought.

Figure 3. When landscape fabrics are used as a mulch, they will be more attractive if covered with another, decorative mulch.

Table 3. Inorganic mulching materials.

Material	Resistance to compaction	Attractiveness	Resistance to wind blowing	Availability	Source of weeds and disease	Fire hazard	Comments
Black plastic film	Tears	F	F	A	A	No	Must anchor. Unsightly.
Crushed rock	A	B	A	A	A	No	Many colors available. Avoid crushed limestone
Geotextile weed barrier	A	F	F	A	A	No	Must anchor. Best covered by other mulch.
Gravel	A	B	A	A	A	No	Use sparingly.
Volcanic rock	A	B	A	B	A	No	Small sizes moved by water.
Perlite	B	B	D	A	A	No	Good as soil amendment.
Vermiculite	C	C	D	A	A	No	Physical structure breakdown.

Key: A = Excellent; B = Good; C = Fair; D = Poor; F = Unsatisfactory

Delphinium, lupine, primrose and Siberian iris are among the most troublesome in this respect.

Two to 3 inches of straw, hay, wood shavings or partially composted leaves would be an appropriate mulch for most perennials. Pine needles or evergreen boughs are also effective. When using a heavy layer of mulch on perennials, gradually remove it during the onset of warmer weather in late winter. Heavy mulch left too long may cause early emergence of weak, tender growth. Such growth may be killed or permanently injured by late freezes.

Roses. Experienced rose growers recognize the improvement in vigor and appearance of roses as a result of summer mulching. The mulch layer should be about 2 inches deep and of fairly coarse material such as unfinished compost, aged sawdust, bark, milled wood fiber or tobacco stems.

By mid-November, provide adequate winter protection with a mound of finished compost, garden soil or coarse peat. The mound should be about 8 inches deep across the center of the plant. Mounds should be removed in early spring when overnight temperatures below about 28 degrees F are no longer expected. If later, unseasonably cold weather threatens and new, tender shoots have begun to grow, hasty covering may be needed.

Trees and shrubs. Trees and shrubs that gain most from mulching are new plantings, ones with shallow roots, and ones that suffer from extended drought or are otherwise damaged by high soil temperatures (Figure 4). Flowering dogwood and sugar maple are examples of plants whose leaves scorch easily in dry weather. Some leaves of birches, willow and tulip trees often yellow and drop during extended drought.

All trees and shrubs should be mulched at planting time to aid them in becoming established. A mulched area around the base of trees and shrubs makes mowing easier and helps prevent mower damage to the plant.

The material used for mulching is perhaps less important than the simple fact that the plants are mulched. Most coarse materials are satisfactory. Avoid materials such as sawdust, which packs tightly, and those too unsightly in the landscape.

Vegetables and annual flower gardens. The primary reason for mulching vegetable and flower gardens is to conserve soil moisture. Crops most practical to mulch are beans, peppers, sweet corn, tomatoes, vine crops and other long-term summer crops with large amounts of foliage. Long-term crops started in the cool season, including broccoli, cabbage, cauliflower and potatoes, will also yield better when they are mulched. Asparagus and rhubarb should be kept constantly mulched to conserve soil moisture and reduce weed problems.

Some of the best mulches for annual vegetable crops are composts, straw, hay or other materials that will be largely decomposed at the end of the season.

Figure 4. Newly planted trees benefit greatly from a ring of mulch around the base of the tree.

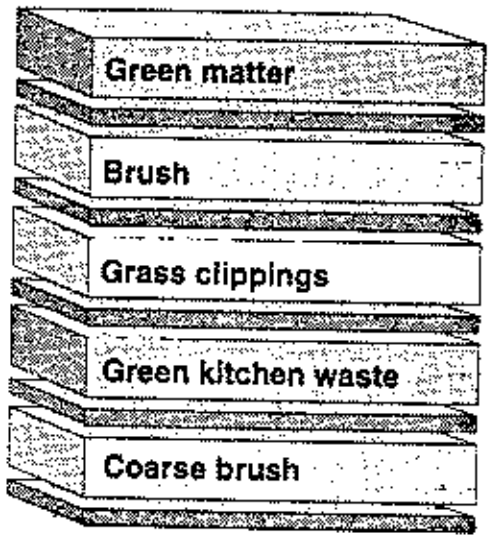
OUTREACH & EXTENSION
UNIVERSITY OF MISSOURI
COLUMBIA

■ Issued in furtherance of Cooperative Extension Work Acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. Ronald J. Turner, Director, Cooperative Extension, University of Missouri and Lincoln University, Columbia, MO 65211. ■ University Outreach and Extension does not discriminate on the basis of race, color, national origin, sex, religion, age, disability or status as a Vietnam era veteran in employment or programs. ■ If you have special needs as addressed by the Americans with Disabilities Act and need this publication in an alternative format, write ADA Officer, Extension and Agricultural Information, 1-98 Agriculture Building, Columbia, MO 65211, or call (573) 882-7216. Reasonable efforts will be made to accommodate your special needs.

Making a compost pile

A compost heap is an easy way to recycle your organic garbage into fertilizer rich in nutrients and oxygen. Just about anyone can create a heap, depending on needs and space availability:

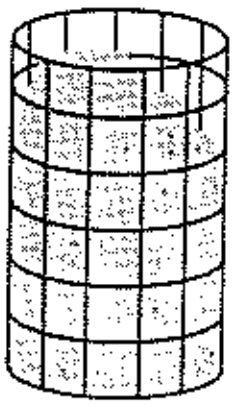
1. Select a shady place, out of the wind and within reach of water.
2. Create a container; ideal container should be 3 feet by 3 feet by 3 feet.
3. Create five layers of material, each layer a few inches deep. Separate the layers with dirt and manure.
4. Every few days turn the heap with a pitchfork. A regularly turned pile will become composted in three to six months. Use the material to pot plants, fertilize the garden or mulch flower or shrub beds.



Types of compost heaps

Wire receptacle

A simple compost receptacle is a cylinder of welded wire. To move composting material, lift cylinder, turn compost to aerate, then return it to the cylinder.

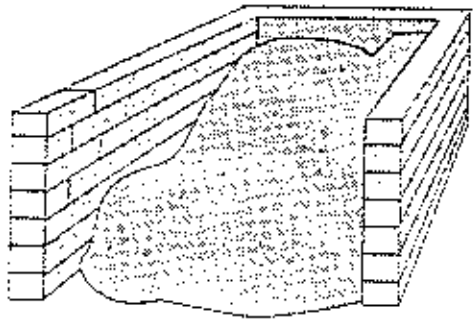


Plastic bag

Small-space gardeners can compost in a large plastic bag.

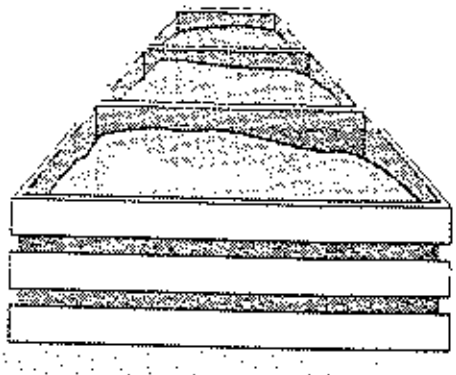
Cinder blocks

A low wall of cinder blocks keeps the compost pile neat.



Bin to bin

Classic set-up: new material (front), partly decomposed material (middle) and finished compost (back). Material is forked from bin to bin as decom- position progresses.



Trash can

A trash can with a lid is a good receptacle. Punch holes in the bottom so mixture can drain and raise the can off the ground. Add soil and scraps until can is full. Compost will be ready for use in three to four months.