Soil & Water Management Module 3

Montana State University Extension Service

MANAGING FOR SOIL EROSION

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Introduction

This is the third module within the Soil and Water (*SW*) Management series provided by the Montana State University Extension Service and Rocky Mountain Certified Crop Adviser (CCA) program. Used in conjunction with the Nutrient Management (NM) modules, this series is designed to provide useful, applicable information for Extension agents, CCAs, consultants and producers within Montana and Wyoming on practices used to effectively manage soil and water resources. To enhance the learning objective and provide CCAs with continuing education units (CEUs) in Soil and Water Management, a quiz accompanies this module. Also, realizing there are many other sources of information pertaining to soil erosion, we have included an appendix at the end of the module listing additional resources and contacts. Concepts from the Rocky Mountain CCA Soil and Water Management Competency Areas covered in this module include: water and solute movement in soils, residue management practices, and water quality.

Objectives

After reading this module, the reader should be able to:

- Differentiate among the different types of wind and water erosion
- List physical factors which affect the rate of erosion
- Recognize how conservation practices impact water erosion and environmental quality
- Describe how residue management practices and cropping systems affect soil productivity
- Know how to estimate percent residue

Background

Erosion is a natural process that has sculpted landscapes for millions of years. For instance, many natural land features we observe today, such as the Grand Canyon, are the result of erosion. However, human alterations of land use and cover have caused erosion rates to increase for many areas of the world, resulting in considerable land and environmental degradation. An average of 1.3 billion tons of soil per year are lost from agricultural lands in the U.S. alone due to erosion, and in Montana and Wyoming, erosion rates on crop and pastureland are estimated to be 5.5 and 5.1 tons/ac-yr, respectively (USDA, 2000). Considering soil formation rates are estimated to be only 10–25% of these erosion rates (Jenny, 1980), loss and movement of soil by erosion is a major challenge for today's producers and land managers. Soil erosion over decades can have detrimental effects on

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productivity and soil quality because the majority of soil nutrients and soil organic matter (SOM) are stored in the topsoil, the soil layer most affected by erosion (*NM 4, NM 15*). While temporary solutions, such as increased fertilizer, have offset some of the effects of erosion on productivity, they are not complete substitutes for topsoil (Williams and Tanaka, 1996) and represent the greatest input cost for compensating yield losses caused by erosion (Pimentel et al., 1995). Erosion also impacts the environment beyond the farm. Runoff can carry fine sediments, nutrients (*NM 12*), and other pollutants (*SW 4*) to water sources, possibly degrading water quality. Siltation, or sedimentation, is a leading cause of stream and river impairment in Montana and the U.S. (EPA, 2000), as it can cause disturbances in aquatic ecosystems. These include the degradation of fish spawning grounds, the potential reduction of recreational activities, increased cost of domestic water purification and decreased life span of dams and levies. Furthermore, wind erosion reduces air quality and damages property due to abrasion and accumulation. Thus, in order to maintain long-term productivity and preserve soil and environmental quality, it is important to learn and implement practices that prevent and minimize erosion, rather than manage the effects of erosion after it has occurred. The focus of this module is to present best management practices (BMPs) for managing erosion on agricultural lands in Montana and Wyoming.

Soil Erosion Processes

Soil erosion is the physical movement of soil particles from one location to another, primarily due to forces of water or wind. The three main phases of soil erosion are detachment, transport and deposition. The severity of erosion depends upon the quantity of soil detached and the capacity of the wind or water force to transport it (Morgan, 1995). As both detachment and transport require energy (deposition occurs when energy is no longer available), the ability of soils to erode is based on 'erosivity,' the energy of the eroding agent (i.e., wind or water), and 'erodibility,' the soil's susceptibility to erosion. Types of erosion and the mechanics and factors affecting each type are described below.

Wind Erosion

Mechanics

Moving air has energy that can detach and transport soil particles. Detachment occurs when the energy exerted by wind exceeds the forces keeping the soil particles in place, such as weight and 'cohesion' (*SW 1*). Detachment can also occur via the impact of particles already in motion dislodging other particles. Once detached, soil can be transported in one of three ways: suspension, saltation, or creep (Figure 1). Suspension is the movement of fine particles (mainly clay-sized particles and organic matter) high into the air and over long distances. Suspension usually

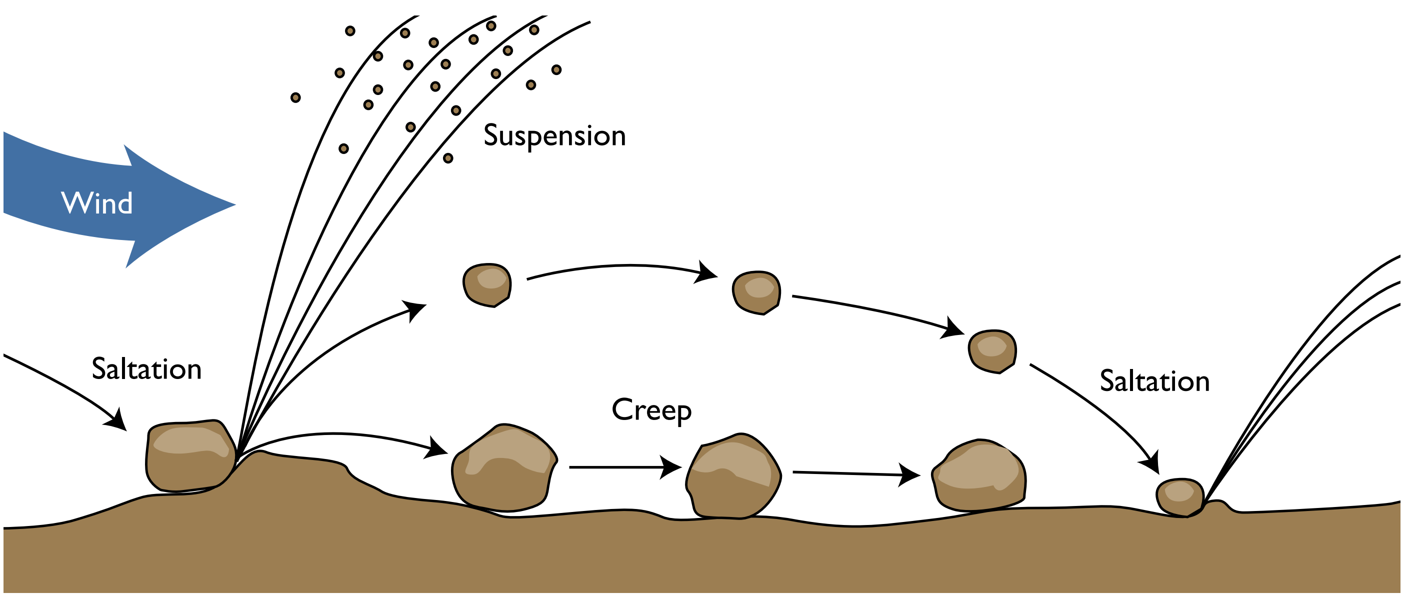

Figure 1. Different types of soil movement by wind. (From USDA, 1989)

accounts for less than 40% of wind transported particles, yet since most nutrients are associated with these small particles, suspension can significantly impact soil fertility (Troeh et al., 1999). Saltation occurs primarily with medium-sized grains (e.g., fine sand) 'bouncing' along the surface. The impact of saltating particles on the surface can cause other particles to become detached, causing an 'avalanche' of particles in motion downwind. Saltation typically accounts for the majority (55–70%) of total soil movement during a wind event (Morgan, 1995). Unlike suspension, particles moved by saltation typically stay on site and accumulate in stubble, in cultivation ridges, or along fence lines. Creep is the rolling movement of coarser sand-sized grains and aggregates over the surface. Creep can also cause particles to become dislodged, though usually not to the extent that saltation does, generally accounting for only 10–25% of soil movement (Morgan, 1995). Creep results in very little soil movement from the original site, but since aggregates can deteriorate during movement, detached smaller particles can be susceptible to further transport.

Factors Affecting Wind Erosion

Unlike many other areas of the U.S., soil loss from wind erosion is greater than soil loss from water erosion in the northern Great Plains. This is due to the semi-arid climate resulting in less vegetative cover and drier soils that are less cohesive and more easily carried away by wind. Other factors affecting wind erosion are wind characteristics (e.g., velocity and direction), surface conditions, soil properties, field length, and some cultivation practices.

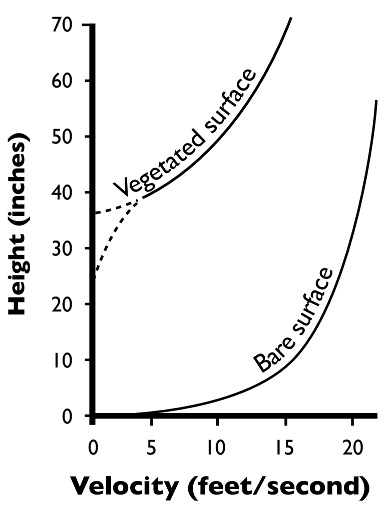

Figure 2. Change in wind velocity with height over a vegetated surface and a bare surface. The two dashed lines denote velocity within and above a vegetated surface, respectively. (Troeh et al., 1999)

Wind velocity is the most important wind factor affecting erosion; higher wind velocity equates to higher wind energy and erosivity. However, not all wind will cause erosion. The minimum threshold velocity for wind erosion to occur is between 8 and 30 miles per hour, depending upon soil and surface conditions (Troeh et al., 1999). Velocity is lowest near the ground due to surface roughness, and increases sharply with height. Thus, wind velocity over smooth soils is greater and more erosive than over rough soils because fewer 'obstacles' slow wind velocity at the surface. Figure 2 shows wind velocity profiles above a bare surface and a vegetated surface. Wind velocities are substantially lower above the vegetated surface for a given height due to the vegetation absorbing some of the wind's energy and essentially raising the 'aerodynamic' surface to a height of approximately 70% of the plant height, causing little or no wind to occur at the soil surface (Troeh et al., 1999). Other elements contributing to soil roughness are aggregates and ridges.

Soil properties that affect erodibility include texture, moisture and aggregation. Silt and fine sand particles are most prone to erosion due to their smaller mass than larger particles, and less cohesiveness between particles than fine, clay-like particles (Morgan, 1995). Moisture increases cohesive forces between particles, making them more difficult to dislodge. Aggregation reduces erosion by binding potentially erodible particles together into larger particles which resist detachment and transport. Aggregate stability (how well the aggregate is bound) will also affect its erodibility and is related to chemical and organic compounds in the soil (*NM 8, SW 1*). Soils with 2% or greater SOM content are less erodible than soils with less SOM due to greater aggregate stabilization (Morgan, 1995). Field length and size also play a role in the amount of soil eroded. Large, continuous fields allow more material to become detached and transported than fields that incorporate obstacles to impede wind speed and trap moving particles. Such obstacles may include shelterbelts, cover crops, surface residue and strip farming, and will be discussed further in the management section.

Lastly, tillage can influence wind erosion by disturbing the soil surface, causing dislodged particles to be more susceptible to transport by wind (Figure 3). Wind erosion during tillage is most severe when soil moisture is low, fine textured soils predominate, and few nonerodible materials are present. In addition, tilling on steep slopes may result in considerable soil losses.

Figure 3. Direct effect of tillage on wind erosion in central Montana.

Because coarse particles fall out of suspension sooner than fine particles as water velocity slows, they are more apt to remain on the field while fine particles are moved farther downstream.

Three main forms of water erosion are sheet, rill and gully erosion. Sheet erosion is the removal of a thin layer of soil from the surface and is caused by 'overland' flow moving uniformly across the surface. As the sheet erosion continues, water begins to concentrate in small channels, or rills, and rill erosion occurs (Figure 5). Rills tend to be uniformly distributed over the field and are defined as being small enough to be smoothed over by cultivation practices. The concentration of running water causes rill erosion to be more erosive than sheet erosion. Gully erosion occurs when larger quantities of runoff concentrate and create large channels in the landscape. Gullies are relatively permanent features that cannot be removed by tillage.

Water Erosion

Mechanics

Mechanics of water erosion are often a two-fold process. Raindrops falling on the soil surface can cause particles to detach and splash upward (Figure 4). Upon returning to the soil, splashed particles disperse and clog soil pores, causing surface crusting and a reduction in the soil's infiltration rate. The pounding action of rain may also compact the soil, further decreasing infiltration. When water is applied in excess of the soil's infiltration rate, water will puddle and run off, leading to additional detachment and transport of particles by the force of flowing water. Particle transport by water requires a critical speed to effectively carry sediment; when water velocity slows below this speed, deposition occurs.

Figure 4. A magnified view of a raindrop hitting a soil surface. The raindrop impacts the soil with enough force that fine particles are detached and splashed upward. (Photograph from Finkel, 1986)

Factors Affecting Water Erosion

Water erosion is affected by precipitation patterns, soil properties, slope and vegetative cover. Although water causes less overall soil erosion in the northern Great Plains than wind, one large rain event can cause severe erosion to occur. Intensity, duration and frequency of rain events all appear to play a role in the amount of soil that erodes. In general, the most severe erosion occurs when rains are of relatively short duration, but high intensity. Heavy raindrop action coupled with more water falling than the soil can infiltrate can lead to high surface runoff and large losses of soil. Long, low intensity storms can also be highly erosive due to saturated soil conditions causing increased runoff (Morgan, 1995).

Soil properties affecting water erosion include those that influence infiltration and soil stability, such as texture, organic matter, aggregation, soil structure and tilth. These properties and their effect on infiltration were discussed in *SW 1*. Runoff is influenced by the amount and velocity of the flow, which in turn, is dependent on the slope of the land. Because fast moving water can carry more sediment than slow moving water, there is a greater potential to lose a larger amount of material on steep slopes than gradual slopes.

Similar to its effect on wind erosion, vegetative cover reduces detachment by intercepting raindrops and dissipating their energy. In addition, surface vegetation and residue act as dams that slow water flow and promote deposition.

Figure 5. **Sheet and rill erosion on a bare field.** (Photograph by L. Betts, USDA Natural Resources Conservation Service)

Estimating Erosion

Estimating soil erosion is important for determining erosion severity and its influence on land use and management plans. For instance, four of the factors affecting the NRCS phosphorus index, and hence manure application rates (*NM 13*), are related to soil erosion. Erosion is often best estimated with models, due to the number of variables involved. The two most commonly used models for the western U.S. are the Revised Universal Soil Loss Equation (RUSLE), used to estimate water erosion, and the Wind Erosion Equation (WEQ). Both RUSLE and WEQ are defined by equations where a number of factors affecting erosion are taken into account to determine average annual erosion rates. Factors include climate, soil erodibility, surface roughness, length of field, vegetative cover, and in some scenarios, an erosion control practice. Because some amount of erosion is inherent regardless of land use and management, the Soil Loss Tolerable Value, or 'T value,' was developed to create a base line to compare management-induced soil erosion. The T value is the amount of soil loss in tons per acre that is acceptable to maintain long-term productivity. T values vary by soil type and are dependent upon soil formation factors such as climate, geography, and the time required for new soil to form. For help in determining values for soil loss variables and T values for a particular area, contact your local NRCS office.

Managing Erosion

Key points for managing any type of erosion are to reduce the erosivity of the eroding agent, decrease the soil's susceptibility to erosion, and prevent particle transport. Using BMPs that focus on these key points will be most effective for managing erosion. The following gives an overview of a number of BMPs used to manage erosion in the northern Great Plains.

Residue Management

One of the most valuable tools for managing erosion involves the use of plant residues. Residue refers to any type of vegetative cover left remaining on the field and may include standing stubble, dispersed straw, living vegetation or mulch. Practices that maintain residue on the surface are less susceptible to soil erosion than practices that remove excess residue. Figure 6 shows the reduction in soil lost via erosional processes as the amount of residue cover increases. For example, a field with 20% cover will have a 50% reduction in soil loss compared to a bare field. This effect of residue cover on reducing soil loss occurs for a variety of reasons. As previously discussed, surface residue absorbs some of the energy of wind, falling raindrops and running water, so that less energy is directed toward the soil. Intact root systems further stabilize soil particles. Soil moisture is conserved under residue management due to increased infiltration and decreased evaporation as a result of less wind and more canopy shading. Additionally, standing residue during winter months will capture and retain snow better than

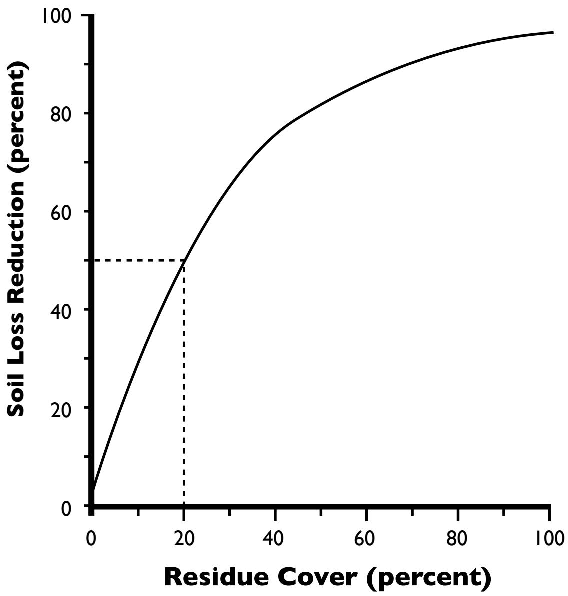

Figure 6. Percent soil loss reduction increases with increasing residue cover. (From Dickey et al., 1986)

a bare field, leading to greater moisture retention and soil protection. Types of residue management and their impact on soil erosion are discussed below.

Tillage

A large contributor to soil erosion in the northern Great Plains is excessive tillage on croplands. 'Conventional tillage,' in which less than 15% residue cover remains (Fawcett and Towery, 2003), buries surface residues, leaving agricultural soils unprotected and exposed to erosional processes. In contrast, conservation tillage leaves more than 30% of crop residue on the surface, which provides coverage and protection of the soil surface. Varying types of conservation tillage are reduced till, ridge till, mulch till, strip till and no till. Many of these were covered in *NM 12* and *NM 15.*

In addition to providing soil coverage, conservation tillage often leads to an improvement in soil structure because of reduced mechanical disturbance (Magdoff and Weil, 2004), and an increase in SOM content and aggregation. For example, Schillinger (2001) found surface clod mass to be, on average, twice as great in minimum tillage (3-5 tillage treatments) than in conventional tillage (8 tillage treatments). Results were attributed to less clod destruction by tillage equipment and greater residue cover in the minimum till plots.

Stubble Height

As previously mentioned, standing residue will reduce wind speed more than residue laying flat on the ground, and is an important component of residue management. Taller stubble decreases wind velocity at the surface, provides more cover and improves microsite growing conditions, all of which can positively affect crop yields. Results from a northern Great Plains study found that stubble height during the growing season significantly affected spring wheat grain yield and water use efficiency (WUE) (Cutforth and McConkey, 1997; Figure 7). Tall stubble (average height 15 inches) increased yield by 12% compared to cultivated (disk tilled) stubble, while yield in the short stubble treatment (average height 6 inches) was intermediate between treatments. A similar trend was observed for WUE, which was significantly higher in the tall stubble treatments compared to the cultivated stubble. Short stubble treatment WUE was intermediate but not significantly different than WUE in the other treatments. Both yield and WUE results were attributed to favorable microclimate growing conditions provided by the stubble, such as lower surface temperatures and reduced evapotranspiration losses due to decreased wind velocity on the surface. Based on the conclusions of this study, keeping stubble height as tall as practical may help maximize yield and water use and decrease erosion in conservation tillage systems.

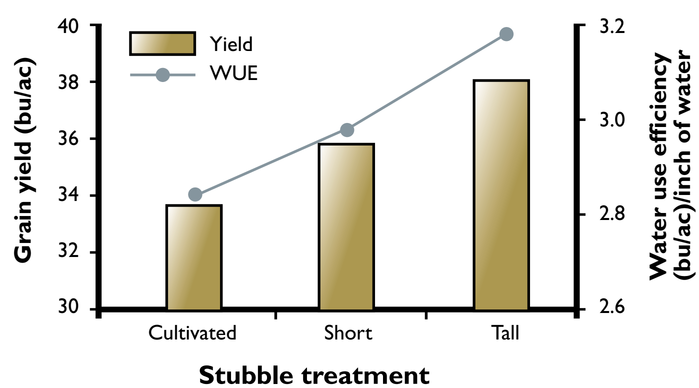

Figure 7. Effect of cultivated, short, and tall stubble on spring wheat grain yield (yellow bars) and water use efficiency (blue line). (Cutforth and McConkey, 1997)

Cropping Systems

Crop-fallow systems have been a common practice in the northern Great Plains for replenishment of soil water and weed control. However, erosion problems have increased in many fallow systems due to the lack of cover for extended periods. Flexible or annual cropping decreases soil erosion by reducing or eliminating a fallow period, thus providing vegetative cover for longer periods during the year. Another alternative to crop-fallow is to grow a cover crop during fallow periods to provide soil protection and, in the long-term, increase water infiltration and reduce runoff. Flexible cropping and cover crops are detailed in *NM 15*.

Strip farming, the practice of growing crops in strips with fallow in-between, can decrease erosion by reducing wind speed and breaking up the field length, which reduces particle detachment by controlling soil avalanching (Figure 8). To control wind erosion, strips should be planted in straight lines and perpendicular to the prevailing wind. In most areas of Montana and Wyoming, this means establishing strips in a north-south direction since winds are most commonly from the west. Strip width will vary with climate, field conditions and machinery, and can be established with the aid of WEQ models.

Residue Burning

A long-standing practice for managing excess residue has been to burn it. Burning allows a producer to reduce excess residue to ease seeding and plowing, partially control plant diseases, weeds and insects, and increase short-term nutrient availability. However, it is believed that repeated, long-term residue burning (>15 years) may cause soil erosion to increase over time due to a reduction in SOM content and overall soil quality (Fasching, 2001).

Figure 8. **Strip farming in northern Montana.** Strips are planted in a north-south direction to reduce wind erosion. Light strips are this year's stubble and dark strips are last year's stubble.

Figure 9. Example of line-transect method in a wheat residue field.

Estimating Percent Residue Cover

Estimating the percentage of residue remaining on a field can help a producer establish a baseline value of percent residue cover and track changes with time and residue management practices. The line-transect method is one of the easiest and most accurate methods to use. This method consists of laying a marked tape or rope across a representative section of the field and counting the number of marked units (inches, feet or meters) that are directly over residue. The number of units where residue is present, relative to the number of total units, results in the percentage of residue cover. For the example shown in Figure 9, one could observe the presence of residue at every 1 foot increment (e.g., 12", 24"). In this case, 24" would be counted as a residue point, but not 12". Based off just these two points, percent cover would be 50%. However, if every inch was counted, percent cover would be closer to 70% using the line-transect method. Because of the small sampling area depicted in Figure 9, neither of these measurements is accurate for a large field. A measuring length of 100 feet is most commonly used as it is easy to count foot increments and covers enough area to be fairly representative, although other lengths and increments can be used depending on field conditions. To increase accuracy, the measuring process should be repeated in three or more other areas of the same field and averaged to obtain a general percentage for the whole field (Shelton et al., 1998). Sampling numerous points over a longer distance should smooth out field heterogeneity. Other methods for estimating cover are direct observation and photography. Although these methods can be useful when a quick approximation of cover is needed, caution should be used in utilizing them as they often under- or overestimate coverage. See the appendix for more information on estimating percent residue cover.

Figure 10. A shelterbelt of caragana in north central Montana.

Erosion Control with Vegetation

Shelterbelts

Shelterbelts placed perpendicular to the prevailing wind direction can effectively control erosion by reducing wind velocity, trapping material and breaking up field lengths. Belts may be composed of grasses, shrubs, or trees. Deciding which type and variety of plant to use will depend upon climate and moisture factors, and nutrient and pest management. For the general climate of the northern Great Plains, perennial grasses, such as tall wheatgrass (*Elytrigia elongata*), have proved successful at reducing wind erosion, protecting vegetation, and trapping snow (Aase and Pikul, 1995). Caragana (*Caragana arborescens*), a nitrogen-fixing shrub, is another common shelterbelt plant for this region due to its winter hardiness and tolerance to drought (Figure 10). Please see the appendix for a listing of other appropriate shelterbelt plants.

Vegetative Filter Strips

Off-site damage from water erosion can be managed through the use of vegetative filter strips (VFS). Discussed in *NM 12,* these strips, or buffer zones, are widths of vegetation that reduce off-field transport and deposition of sediment and other pollutants by reducing water flow velocity and trapping sediment. Placed at the bottom of a field or just above the tail water ditch in an irrigated system, VFS have been shown to be effective for reducing sedimentation in runoff water. For instance, a Montana study found that VFS reduced sedimentation in runoff water by 75-80% compared to bare fallow fields (Fasching and Bauder, 2001). In general, sedimentation in runoff decreases as VFS width increases. The optimum width depends upon field conditions such as slope and length, and the amount of water moving through the system; steeper slopes and larger fields draining greater amounts of water will require wider strips. A minimum width of 10 feet is recommended for flat fields (< 1% slope) with a 30:1 drainage area to filter strip ratio (USDA-NRCS, 1988). In addition, VFS must also be able to have enough vegetative growth to function during the first large rain or irrigation event.

To ensure adequate growth, fall may be the best time to plant a VFS.

Tillage Management

There may be times that some limited tillage can be beneficial in controlling erosion. For instance, a one-time tillage pass can cause aggregates and clods from below the surface to be turned upward, temporarily increasing surface roughness. This type of tillage works best if the soil is of fine to medium texture and there is adequate soil moisture (Fenster and Gaddis, 1983). If the soil is too coarse or dry though, tillage can exacerbate detachment. To prevent further soil loss, tillage should be avoided during windy periods and on highly erosive slopes.

Erosion Control in Irrigated Systems

Irrigation-induced erosion can be managed by improving irrigation practices, compacting furrows, keeping crop residues in the furrow or using amendments. Two amendments used to reduce erosion in irrigated systems are gypsum and polyacrylimide (PAM). Discussed in *SW 2*, gypsum ($CaSO_4 \cdot H_2O$) can help flocculate (clump

Figure 11. The effects of PAM-treated soil water and non-treated soil water. (Photograph from NWIRSL, Kimberly, ID)

Q & A #1

Is PAM used in dryland systems for erosion control?

Some research has found PAM to work in dryland/rainfed areas to reduce erosion. However, effectiveness varies. For instance, one study found that when dry granular PAM was mixed with the surface soil and simulated rain was applied, soil loss from treated areas was reduced, but neither run-off or infiltration were affected (Yu et al., 2003). Thus, because of its rather low solubility and the water, labor and equipment costs associated with its application, PAM is likely not an economical method for erosion control on most dryland operations in Montana and Wyoming.

together) soil particles and increase infiltration, thereby reducing surface runoff and sediment loss. PAM is a water soluble, organic substance that aggregates soil and increases infiltration at low concentrations. It also acts as a flocculating agent that, when in a solution, causes suspended particles to draw together and settle (Figure 11). In a PAM-treated system, this effect causes sediment to fall out at the bottom of the furrow and not remain in the runoff water. The most common form of PAM used in agriculture is anionic (negatively charged), dry powder PAM. Anionic PAM has low solubility in water, making it effective for staying in place rather than being dissolved and carried away. Dry powder can be applied as a 'patch' (a 5-6 foot placement of powder on the furrow ditch surface directly below the inflow point) or mixed in with irrigation water, which requires thorough mixing and turbulence to distribute evenly. When used in furrow irrigation systems, PAM has been found to reduce runoff soil loss by an average of 94% and increase water infiltration by an average of 15%, when applied at the NRCS recommended rate of 1 lb/ac or 10 parts per million (Lentz and Sojka, 1994). For sprinkler systems, liquid PAM can be used at a rate of 2 to 4 lb/ac (Bjorneberg, pers. comm.). PAM requires certain application and handling procedures to protect human and environmental health, and PAM products should be purchased according to the registration and labeling requirements of your state.

Managing Erosion on Grazed Lands

The main factors influencing erosion on grazed lands are type of grazing systems, stocking rate, forage type and growth patterns, and soil characteristics. Overgrazing leaves little vegetative cover to protect the soil from erosion (Figure 12), and heavy animal traffic can compound the problem by compacting the soil. Rotational grazing systems may prevent overgrazing and leave vegetation intact better than continuous grazing systems (*NM 15*). Forages with extensive root systems will help stabilize soil and improve soil structure. Fine-textured soils are most susceptible to compaction and should be monitored on a yearly basis to assess infiltration (*SW 4*). Amendments and cultivation practices may be able to alleviate compaction in these areas.

Figure 12. Comparison of the effect of grazing on vegetation. Land right of fence has been grazed and land left of the fence has not.

Conservation Compliance and Erosion Control Programs

A number of erosion control incentives and programs have been introduced in recent years to control erosion on highly erodible lands (HEL) (Q & A #2). Introduced in the 1985 Farm Bill, 'Conservation Compliance' (pertains to land cropped before 1985) and 'Sodbuster' (pertains to land cropped after 1985) programs require producers with HEL cropland to apply and maintain soil conservation practices in order to receive farm support payments. There is not a fixed erosion standard to meet under these programs, but rather a flexible approach in which both the severity of the soil erosion and cost of reducing it are taken into account. Where erosion can be reduced to the T level without making production unprofitable, producers are required to develop basic conservation plans; for areas where the T level can't be met without substantial costs, an alternative plan in which erosion is significantly reduced needs to be applied (Claassen et al., 2004). Many producers have been able to meet these requirements rather inexpensively by incorporating conservation tillage, residue management and other BMPs into their operations. Environmental Quality Incentives Program (EQIP) money from the NRCS may also be available to help producers adopt conservation practices.

Also introduced in the 1985 and 1990 Farm Bills were land retirement programs, such as the Conservation Reserve Program (CRP), that give producers an alternative to keeping HEL in production. CRP allows producers to convert sections of environmentally sensitive HEL cropland to non-cropped land by planting long-term cover species that will help decrease soil erosion, conserve water and provide habitat for wildlife. In return, participants are provided with rental payments and cost-share assistance. As a result of providing permanent vegetation on these lands, researchers estimate that erosion rates on CRP land in Montana and Wyoming are, on average, only 0.2 tons/ac-yr, a rate well below that of erosion rates on cultivated cropland (USDA, 2000). Similar reserve programs include the Grassland Reserve Program (GRP), intended for pasture and rangeland, and the Wetland Reserve Program (WRP). Please see 'Web Resources' in the appendix for more information on conservation compliance, land retirement programs and EQIP funding.

Based on the USDA's National Resources Inventory report (2000), there has been a general decline in soil erosion rates across the U.S. since the implementation of conservation compliance incentives and programs. For instance, the report estimated annual soil erosion rates on U.S. cropland (both HEL and non-HEL) from 1982 to 1997 decreased by 38% (Figure 13). In Montana, estimated average annual wind erosion on cultivated cropland decreased from 7.2 tons/ac-yr in 1992 to 3.8 tons/ac-yr in 1997, representing a 47% reduction (USDA,

Q & A #2

How is HEL determined?

HEL is defined as land that has an erodibility index (EI) of 8 or larger. EI is the ratio of inherent erodibility, the amount of soil loss that would occur on land that was continuously clean tilled throughout the year, to the T value. Thus, EI includes both the susceptibility of the soil to erode and the potential for damage from erosion (Claassen et al., 2004).

2000). Estimates for cultivated cropland in Wyoming indicated a 22% decrease in wind erosion losses between 1987 and 1997. While much of this reduction can be attributed to conservation practices, land retirement programs, and associated management, it is important to note that other factors, such as climate, land use changes, economics, and changing technology, are also likely to have had an influence. Therefore, more extensive studies are required to fully understand the effects of soil conservation practices and programs on erosion control.

Summary

Soil erosion, either by wind or water, can cause substantial declines in productivity and soil quality due to the loss of topsoil. Erosion can also adversely affect water and air quality due to off-farm transport and deposition. Although estimates have shown a decrease in national soil erosion rates over the last two decades, soil continues to erode at much higher rates than it is formed in many areas. Therefore, it is important to continue managing for erosion through the implementation of one or more BMPs that conserve soil and reduce erosion. Such BMPs include those that increase residue cover through tillage, cropping and grazing practices; utilize vegetation to reduce erosive energy and catch sediment; and employ amendments to decrease sedimentation in runoff. Through the use of these practices, erosion can be managed in the northern Great Plains, leading to increased productivity, decreased costs and a healthier environment.

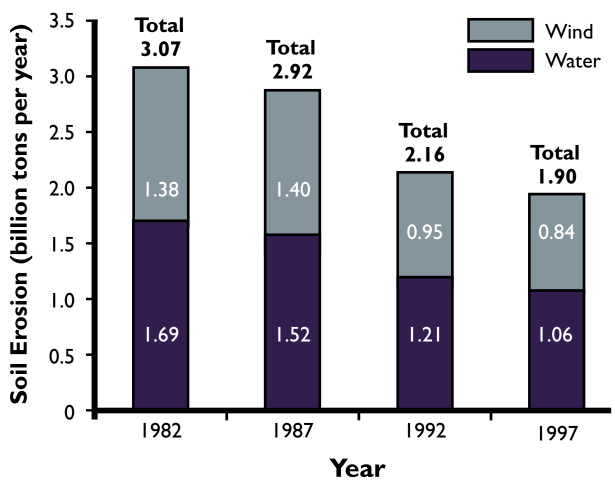

Figure 13. Change in soil erosion on U.S. cropland (including CRP land) over a 15 year period. (USDA, 2000)

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Appendix

Books

Soil and Water Conservation: Productivity and Environmental Protection, 3rd Edition. F.R. Troeh, J.A. Hobbs, and R.L. Donahue. 1999. Prentice Hall. Upper Saddle River, New Jersey. 610 p. Approximately $100.

Extension Materials

The following Extension materials are available and can be obtained at the address below. (Shipping rate varies depending on quantity, see http://www.montana.edu/publications/)

MSU Extension Publications
P.O. Box 172040
Bozeman, MT 59717-2040

See also **Web Resources** below for online ordering information.

Conservation Tillage: Drills for Montana Farmers. 1989. 2B 1328. $4.50

Conservation Tillage: Questions and Answers. 1992. EB 8 $3.00

Understanding Wind Erosion and Its Control. 1984. MT198363AG Free

Emergency Wind Erosion Control. 1984. MT198364AG Free

Environmental Costs of Crop-Fallow Agriculture. 1983. MT198322AG Free

Facts About No-Till and Reduced Tillage. Reduced tillage and no-tillage farming can reduce fuel costs, provide soil and water conservation and allow for better use of labor. 1997. MT198344AG Free

Protect Soil With Vegetative Residues. 1984. MT198362AG Free

Windbreaks for Montana: A Landowner's Guide. 1986. 2B0366 Free

Soil and Water Management Modules (1-3). 4481-1, 4481-2 and 4481-3 can be obtained from Extension Publications or on-line in PDF format at www.montana.edu/wwwpb/pubs/4481.html/. Free

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Web Resources

The Conservation Technology Information Center (CTIC) website administered by Purdue University. http://www.ctic.purdue.edu/

University of Nebraska's Neb Guide site with articles pertaining to estimating percent residue cover. http://ianrpubs.unl.edu/fieldcrops/g1132.htm

USDA's Northwest Irrigation and Soils Research Lab website with links to information about erosion control in irrigated systems. Large amount of information on the use of PAM. http://www.nwisrl.ars.usda.gov/

USDA NRI website access to past NRI reports. http://www.nrcs.usda.gov/technical/NRI/

National NRCS website with information on conservation and cost-assistance programs for erosion control. http://www.nrcs.usda.gov/programs/

Montana and Wyoming NRCS Home Pages with links to information about soil conservation programs, EQIP funding, and estimating soil erosion. www.mt.nrcs.usda.gov and www.wy.nrcs.usda.gov

Montana NRCS website listing conservation trees and shrubs. http://www.mt.nrcs.usda.gov/technical/ecs/forestry/conservtrees.html

Alberta, Canada's Agriculture, Food, and Rural Development website with information about vegetative shelterbelts varieties for the northern Great Plains. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex981?opendocument

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