Title

Reducing Runoff from Irrigated Lands: Erodibility of Agricultural Soils, with Examples in Lake and Mendocino Counties

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Erodibility of Agricultural Soils, with Examples in Lake and Mendocino Counties

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SOIL ERODIBILITY

Soil erosion is a major cause of water quality degradation throughout the United States. When assessing erosion in fields and orchards, it is important that you also take into account the soil's potential for erosion as well as the soil properties that you can manage to minimize erosion. Soil erosion is a result of several factors, including rainfall intensity, steepness of slope, length of slope, vegetative cover, and management practices. Besides all this, the inherent properties of a soil play a major role in the ability of water to detach and transport its soil particles. This intrinsic property is the soil's *erodibility.* Our purposes in writing this publication are to introduce you to the inherent properties of soil that influence its erodibility, briefly to explain which soil properties you may be able to manage to reduce a soil's erodibility, and to illustrate the geographic extent of soil erodibility predictions using digital soil survey data.

COMPONENTS OF ERODIBILITY (K-FACTOR)

In general, soil erosion is a three-step process. It begins with particle detachment, which is followed by particle transport and finally by deposition of transported particles in a new location. The first two steps are influenced to a large extent by the nature and properties of the soil. Four major soil properties that govern erodibility—texture (particle size distribution), structure, organic matter content, and permeability—have been identified through nationwide studies performed by USDA–ARS using rainfall simulation tests (USDA–NRCS, 2005). USDA–NRCS Soil Survey staff measure these properties and then use them to predict the soil's potential for erosion by water. This interpretation, called the *K-factor* (or *soil erodibility* in this publication), can be found in all soil surveys published in California. USDA–NRCS uses the following soil properties to derive the K-factor.

Texture

Soil texture is determined by the percentage (by weight) of sand, silt, and clay particles in a soil sample. The size of a soil particle determines whether it is sand, silt, or clay. Sand particles have a diameter of 0.05 to 2 mm. The diameter of a silt particle can range from 0.002 to 0.05 mm. Clay particles are smaller than 0.002 mm in diameter. Soil Survey staff often record the percentage of rock fragments greater than 2 mm in diameter to accompany their description of soil texture. Generally speaking, clay-rich soils are more than 40% clay particles, sandy soils are more than 55% sand, and loamy soils have percentages of sand, silt, and clay in the right proportions so that the influence of all particles is equal (Wildman and Gowans, 1978).

Soil texture is an important property contributing to soil's erodibility. Soils with a high content of silt, very fine sand (0.05 to 0.10 mm in diameter), or expanding clay minerals tend to have high erodibility. Erodibility is low for clay-rich soils with a low shrink-swell capacity because these clay particles mass together into larger

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aggregates that resist detachment and transport. Sandy soils with large amounts of fine, medium, or coarse sand particles (0.10 to 2.0 mm in diameter) also have low erodibility. Sand particles lack the ability to aggregate together, but because most sandy soils are highly permeable, water runoff is low, hence erosion is often slight. In addition, the large grain size of sandy soils means that it takes more energy to transport its particles than those of finer-textured soils. Medium-textured soils (loamy soils) tend to be most erodible because they have high amounts of silt and very fine sands. These soils tend to have moderate to low permeability and low resistance to particle detachment. If disaggregated, small particles (silts and clays) are easily transported. Rock fragments can also prevent erosion by protecting the soil from raindrop impact.

Structure

Soil structure is the aggregation of individual soil particles into larger aggregates of identifiable shape. Well-developed soil structure promotes a network of cracks and large pores that accommodate infiltrating water, resulting in reduced erosion due to decreased runoff. Good aggregation also holds particles together, enabling the soil to resist the detachment forces of water and raindrop impact.

Soil Organic Matter

Soil organic matter (SOM) is an aggregating agent that binds mineral particles together to develop structure in the soil. Undecomposed organic residues present at the soil surface protect the soil against raindrop impact. Highly decomposed organic material in the soil, called *humus,* acts as a glue to bind soil particles together into aggregates. Soils that are higher in SOM are more resistant to erosion.

Permeability

Permeability is a measure of the rate at which water percolates through a soil. It is a function of texture, structure, and soil bulk density. Water rapidly enters highly permeable soils, reducing runoff and, therefore, soil erosion. The permeability of the subsoil is also an important consideration. A subsurface horizon that is slowly permeable to water can cause a perched water table to develop during a large storm or irrigation event. When even a highly permeable soil is saturated because of a perched water table, infiltration slows down and surface runoff becomes a major path for hydrologic flow, increasing soil erosion. The terms *permeability* and *infiltration* are not synonymous. Infiltration describes the *entry* of water into soil, whereas permeability describes the ease with which water or other materials *move through* soil.

MANAGEMENT PRACTICES TO REDUCE SOIL ERODIBILITY

Several best management practices can be implemented to reduce soil erosion (see Grismer, O'Geen, and Lewis, 2005; O'Geen and Schwankl, 2005). There are few practices that actually reduce the erodibility of soil and no economically sound management options for altering soil texture. You can, however, manage structure, SOM content, and permeability in a cost-effective manner to reduce erodibility. You can improve soil structure by adding aggregating agents such as organic matter, polyacrylamide (PAM), or gypsum. Soil structure can also improve if you minimize soil disturbances by practicing no-till or conservation tillage or by limiting traffic across the soils. Unsatisfactory management practices such as frequent, heavy traffic, traffic when the soil is wet, or intense tillage can degrade the soil structure and accelerate erosion.

As stated earlier, increasing SOM promotes structure and also protects the soil surface from raindrop impact when applied as a mulch. Management practices that bolster SOM levels (such as conservation tillage, no-till, addition of compost or mulch, conversion to perennial crops, and utilizing cover crops) also improve soil structure and can lead to improved permeability.

You can improve the permeability of topsoil by using the same management practices described above for managing soil structure and SOM. These techniques do not work well to increase permeability in the subsoil, however. In many instances, you can enhance subsoil permeability through deep tillage with a ripper, disk, or slip plow or through excavation with a backhoe (Wildman, 1976).

For more information on methods to reduce soil erodibility, consult the companion *Orchard floor management to reduce erosion* (O'Geen et al., In press).

SPATIAL PATTERNS OF SOIL ERODIBILITY

The USDA–NRCS Cooperative Soil Survey has mapped soils and developed interpretations such as soil erodibility for many of the agricultural counties in California. Figures 1 through 4 were generated from the USDA–NRCS digital soil survey database and depict interpretations of soil erodibility for Lake and Mendocino Counties and the extent of prime farmland. Data used to develop these maps, available from the USDA–NRCS SSURGO database for many counties in California, are intended for field-scale county and regional planning. The data within each digital soil survey are identical to those in published soil surveys for the respective counties.

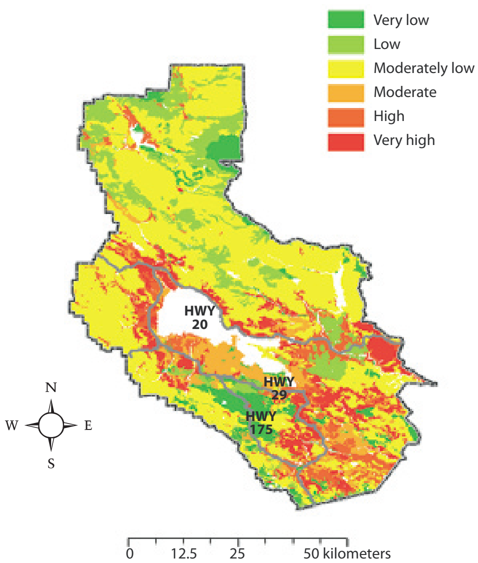

Figure 1. Soil erodibility (K-factor) in Lake County, California (USDA–NRCS SSURGO data).

Figures for soil erodibility values (K-factors) are interpretations derived by USDA–NRCS Soil Survey staff. Erodibility values are derived solely from soil properties and do not include factors such as slope, rainfall amount and intensity, surface cover, or management practices. Soil properties considered for this interpretation include surface texture, rock fragment content, permeability, soil structure, and organic matter content. As a result, this interpretation only reflects the intrinsic properties of a soil body and represents the best-case scenario in terms of erodibility of the landscape.

In Lake County, the soil erodibility of mountainous terrain is moderately low to very low, particularly in portions of the county north of Clear Lake. Here, soils with low erodibility ratings are more resistant to the erosive effects of water. This results partly from the relatively large amount of rock fragments that armor the soil against raindrop impact. In addition, many of these soils have a coarse-textured topsoil that rapidly accommodates infiltrating water. The central and southern portions of Lake County are much more variable. Erodibility values there range from very low to very high (Figure 1). Highly erodible areas have loamy surface textures (high in silt and very fine sand), lower permeability, or very few rock fragments. As a result, highly erodible soils are more susceptible to the erosive forces of water, so preventive measures should be considered.

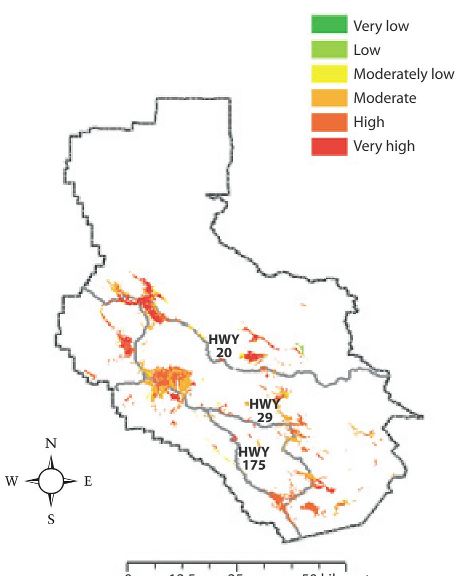

Figure 2. Soil erodibility of prime farmland in Lake County, California (USDA–NRCS SSURGO data).

Figure 2 illustrates the erodibility of prime farmland in Lake County. Practically all of the county's prime farmland shows as moderately to very highly erodible, indicating that these soils are susceptible to erosion. A large part of this land is moderately erodible because it is made up of soil series such as Cole, Clear Lake, and the Wappo Variant, which have a clay-rich topsoil. Clay particles are less susceptible to erosion than other types because of their ability to form stable aggregates. These soils are still moderately erodible, however, because they contain expansive clays that can cause surface crusting.

In many instances, the soil properties that are characteristic of prime farmland are the same properties that cause a soil to be prone to erosion. Highly productive and highly erodible areas typically have a loamy surface soil texture, low rock fragment content, and moderate permeability. Tulelake, Still, Wolfcreek, Kelsey, and Lupoyoma soil series are examples of highly and very highly erodible prime farmlands with these characteristics.

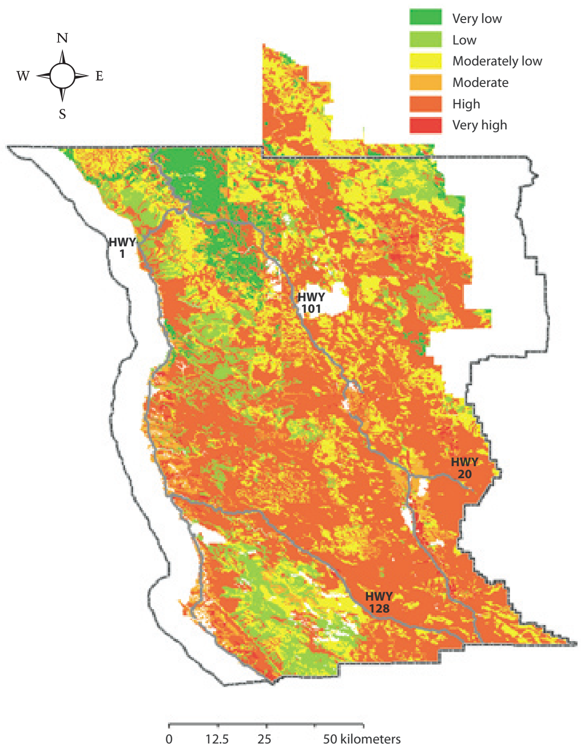

Figure 3. Soil erodibility (K-factor) in Mendocino County, California (USDA–NRCS SSURGO data).

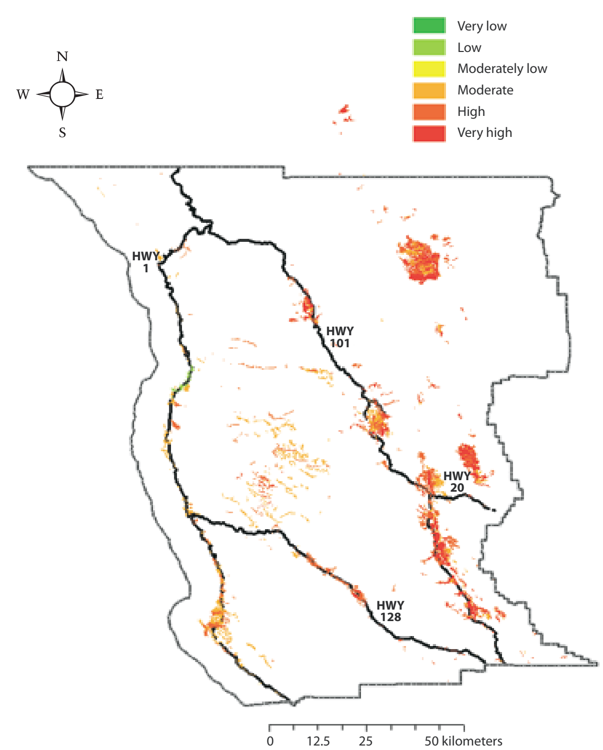

Figure 4. Soil erodibility of prime farmland in Mendocino County, California (USDA–NRCS SSURGO data).

Mendocino County has a much larger proportion of erodible land than Lake County. A significant portion of the land area in this county is designated as highly erodible (Figure 3). A major reason for this difference in prevalence of erodible land appears to be the general lack of rock fragments to protect the soil surface from raindrop impact in Mendocino County soils. In addition, the soils are high in very fine sands and silt because they were formed from fine-grained sandstone. Regions of very low to moderately low erodibility are present in the northwest, northeast, and southwest corners of the county.

Figure 4 shows the erodibility of prime farmland in Mendocino County. Prime farmland is limited in the county, and as in Lake County, much of the prime farmland is moderately to very highly erodible. Crispin, Pinole, and Cole series are examples of local soils that have a loamy surface texture, ideal for crop growth and water use efficiency, but highly prone to soil erosion. Loamy soils have a wide range in pore size distribution, optimizing the availability of water for plants (Wildman and Gowans, 1978). Loamy soils are more susceptible to erosion because they are often less permeable, they lack stable aggregates, and they contain fine particles (silts and very fine sands) that are easily transported by water. Sirdrak, Gielow, and Redvine soils are examples of very low to moderately erodible prime farmland soils. These soils are less susceptible to erosion because of their coarse surface texture and high permeability. Careless management, however, can accelerate soil erosion, even for soils with low erodibility.

Actual erosion rates can differ significantly from the inherent soil erodibility (K-factor) values reflected in the maps shown here. Slope plays a major role in the likelihood of soil erosion. For example, the potential for soil erosion of a Manzanita loam on a 2 to 5% slope is very different from that of a Manzanita loam on a 5 to 15% slope. The erosion hazard for an agricultural soil such as Manzanita with a slope between 0 and 5% is often slight, but the same soil can have a moderate to high erosion hazard at slopes above 5%.

As previously mentioned, it is always important to be aware of site characteristics that influence soil erosion, such as slope, rainfall (intensity and duration), vegetative cover, and soil surface management. The information in this publication is intended for use in conjunction with companion outreach materials that document sediment control techniques (O'Geen, Pritchard, Elkins, and Pettygrove, 2005; Grismer and O'Geen, 2005; O'Geen and Schwankl, 2005). Our purpose for this publication is to help you determine where you need to establish erosion control strategies. For example, you have to take special management steps to address soils with high and moderate erodibility. Soils with low erodibility may not require such intensive erosion control practices. A general awareness of soil erosion issues is important, regardless of a soil's erodibility rating.

The USDA–NRCS maps of soil erodibility shown here do not reflect actual soil erosion, but they can serve as management guides to enhance the awareness of landowners. Soil survey information gives only a model of the soil and landscape, not an exact representation of the features and properties of soil at any one specific location. For this reason, these maps and the data behind them should be used for planning rather than for implementing policy. The maps in this publication are best interpreted as erodibility patterns across the landscape. For field-specific information it is best to perform an on-site investigation of the soil. Get in touch with the Area Soil Scientist in your local or regional USDA–NRCS office for information on conducting a site investigation.

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