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# Landslides of Nebraska

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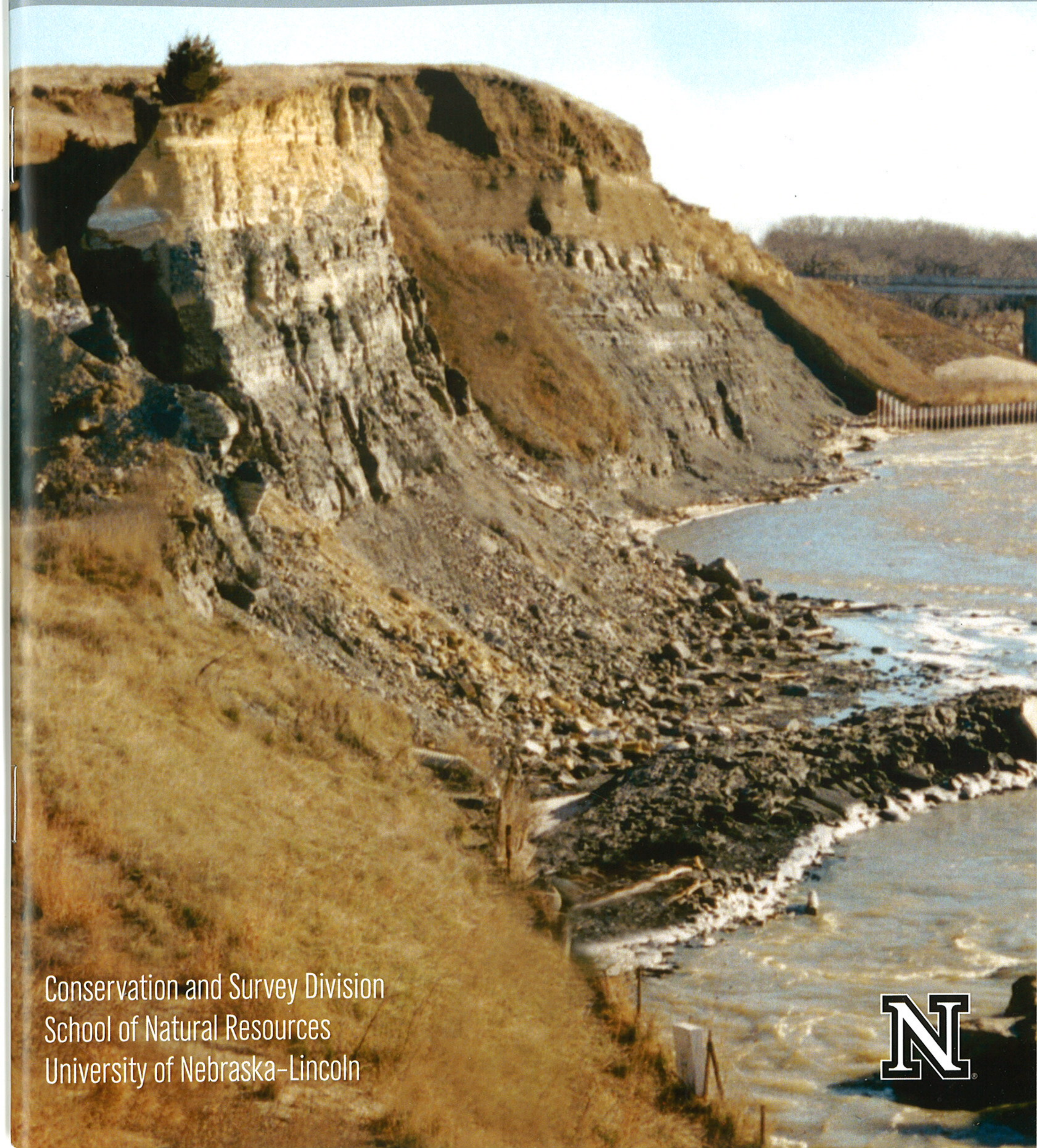
Educational Circular No. 22



Conservation and Survey Division
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The Conservation and Survey Division (CSD) of the School of Natural Resources at the University of Nebraska–Lincoln is the Nebraska agency given the responsibility designated by statute to perform research in natural resources. Landslides are defined as natural hazards by the United States Geological Survey (USGS). CSD is responsible for gathering data relevant to landslide research, to produce maps, publish reports, and generate public awareness regarding this natural hazard. The Division is authorized to make agreements with federal, state, local agencies and to cooperate with investigations and research within the state of Nebraska.

The Conservation and Survey Division provides educational programs and information to all citizens. Publications of the division are available through the Conservation and Survey Division, 101 Hardin Hall, University of Nebraska–Lincoln, Lincoln, NE 68583-0961. Contact the address above, phone : (402) 472-3471, or e-mail csdsales@unl.edu. The Conservation and Survey Division web site is: http://snr.unl.edu/csd/.



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**Factors for Converting English Units to the International System of Units (IS)**

| Multiple English Units | By Length | To obtain IS units |
|---|---|---|
| inches (in) | 25.40 | millimeters (mm) |
| feet or foot (ft) | 0.3048 | meters (m) |
| miles (mi) | 1.609 | kilometers (km) |
| acres | 4047.00 | square meters ($m^2$) |
| square miles ($mi^2$) | 2.590 | square kilometers |
| acre-feet (acre-ft) | 1233.00 | cubic meters ($m^3$) |
| gallons per minute (gpm) | 0.00006309 | cubic meters per second ($m^3$/sec) |

*Cover photo: Rock slump just below Spencer Dam in Boyd County along north side of Niobrara River. Note graben on left, toe on right bottom, and U.S. Highway 281 at right top. Rock exposure is a part of Cretaceous Pierre Shale Formation, Montana Group. Light colored material is weathered Pierre Shale.*

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# INTRODUCTION

### DESCRIPTION

The term "landslide" is used in this report to describe a mass of earth materials that moves downward and outward due to gravity. The term "landslide" is a general term in that not all landslides actually slide. In fact some fall, topple or flow. The term "slope movement" has been proposed by some researchers to describe those failures that do not technically "slide". In this publication the term landslide is used for all.

### FINANCIAL AND HUMAN LOSSES DUE TO LANDSLIDES

Ground failures caused by landslides occur in virtually every state in the United States, (Brabb,1984; Brabb and Harrod, 1989). The United States Geological Survey (U.S.G.S.) estimates that landslides in the United States cause at least $2 billion annually in economic losses and 25 to 50 deaths per year (Spiker and Gori, 2003). Total estimated landslide-related costs in Nebraska were in excess of $4.6 million for the research period 1981 to 2002 as reported in an open-file report by the United States Geological Survey and seven state geological surveys,including the Nebraska Survey (Highland,2006); http://pubs.usgs.gov/of/2006/1032/pdf/nebraska.pdf,. No official reported landslide-related deaths have been recorded in the state, however, close encounters have occurred. Landslide data for Nebraska can be accessed on line at http://www.snr.unl.edu/csd and are included in a data file maintained by the U.S.G.S. at the National Landslide Center located in Denver, Colorado. http://landslides.usgs.gov/landslide.html.

### HISTORY

Landslides are known to be major geologic processes that change surface topography. Many affected areas become rolling, irregular, and hummocky, making it fairly easy to recognize former landslide sites in the field by eye or by using remote sensing methods. (Fleming and Varnes, 1991; Gribble and McLean, 1988; Schuster and Kockelman, 1996). Landslides are described as natural hazards, (U.S.G.S., 1981, 1982).

The general public does not know much about landslides in Nebraska or elsewhere. While they are seldom spectacular, landslides occur regularly in some areas of Nebraska, (Map 1). I began studying Nebraska landslides in 1981 with encouragement from a U.S.G.S. geologist, Earl Brabb. My studies included locating, classifying, mapping, analyzing aerial photographs, visiting with state and county Departments of Roads personnel and entering data into a computer data base that is available on line, as noted above. In some areas, particularly along river valleys in northeastern Nebraska, landslides were too numerous to include in the data base or in this Educational Circular.

### REPORT PURPOSES

The purposes of this report are to make citizens aware that landslides occur within the state, to provide locations of landslides and hazardous areas in the state, and to educate homeowners, builders, policy makers and the general public on ways to mitigate landslide hazards. (Schuster and Kockelman, 1996).

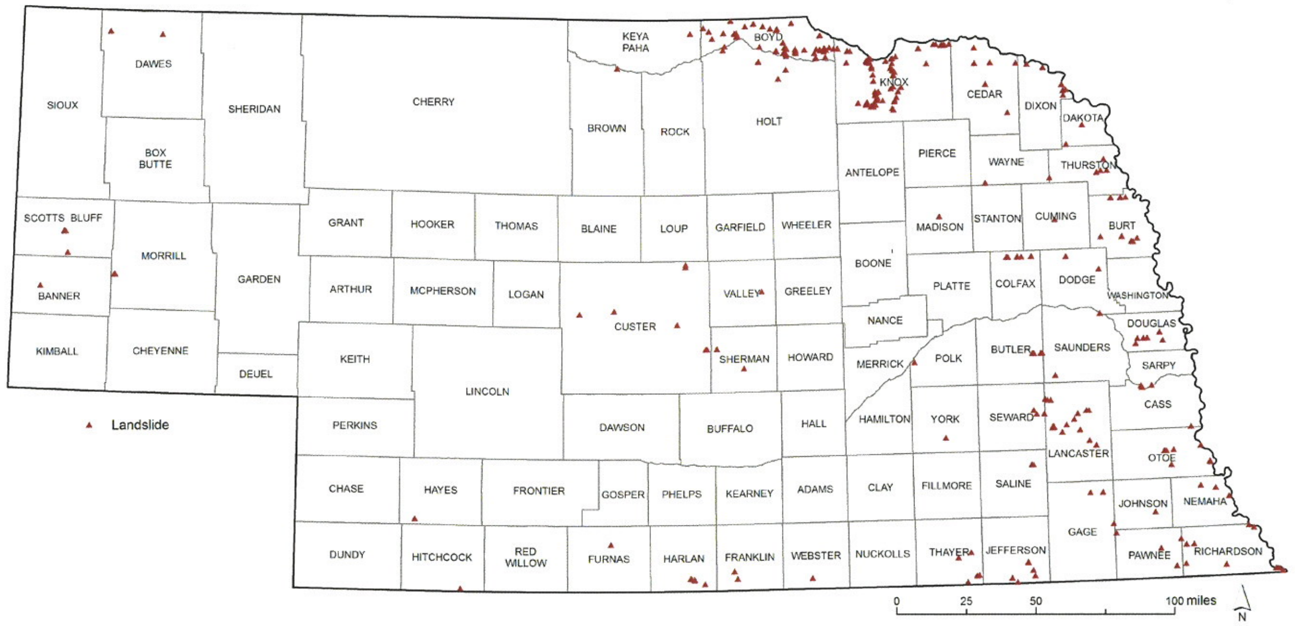
### CAUTIONS

Individuals using this report should be aware that it may be possible to build or develop in areas designated in this report as landslide prone. I recommend that they use on-site evaluations and obtain a geotechnical reconnaissance report by qualified geological/ engineering consultants familiar with landslide mitigation before planning to build or develop.

### NOMENCLATURE

The landslide classification and nomenclature used in this report (Fig.1) are based on those proposed by (Varnes (1978) and Cruden and Varnes, (1996).

**Map 1. Landslides in Nebraska**




*Source: Conservation and Survey Division, School of Natural Resources, University of Nebraska–Lincoln*

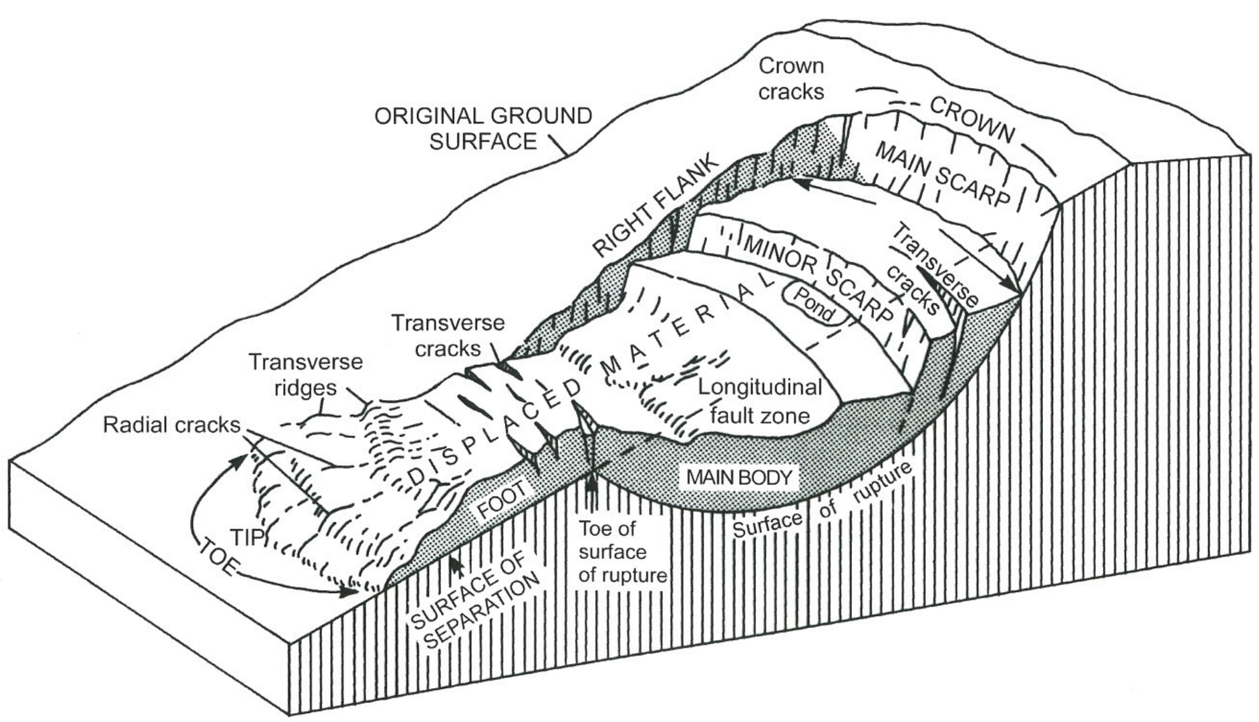



*Fig. 1. Block diagram showing features and nomenclature (after Varnes, 1978).*



## LANDSLIDE CLASSIFICATION

The classification system used in this research is "Varnes Classification of Slope Movements". Varnes used "Types of Materials" and "Types of Movement" to define six major types of slope movements. (Fig. 2). The types of materials include: 1. bedrock; and 2. engineering soils. The latter consist of unconsolidated materials that may cover bedrock including soils, loesses, clays, glacial deposits, sands and gravels. The types of movement are: 1. falls; 2. topples; 3. slides (rotational and translational); 4. lateral spreads; 5. flows; and 6. complex slides - a combination of 2 or more of the above.

| TYPE OF MOVEMENT | | | TYPE OF MATERIAL | | |
|---|---|---|---|---|---|
| | | | BEDROCK | ENGINEERING SOILS | |
| | | | | Predominantly coarse | Predominantly fine |
| Falls | | | Rock fall | Debris fall | Earth fall |
| Topples | | | Rock topple | Debris topple | Earth topple |
| Slides | Rotational | few units | Rock slump | Debris slump | Earth slump |
| | Translational | many units | Rock block slide | Debris block slide | Earth block slide |
| | | | Rock slide | Debris slide | Earth slide |
| Lateral Spreads | | | Rock spread | Debris spread | Earth spread |
| Flows | | | Rock flow (deep creep) | Debris flow (soil creep) | Earth flow (soil creep) |
| Complex | | | Combination of two or more principal types of movement | | |

*Fig. 2. Classification of slope movements (After Varnes, 1978).*

## BEDROCK GEOLOGY

### STRATIGRAPHY

This Educational Circular focuses only on those oldest to youngest geologic units that were observed to be landslide prone and exposed in Nebraska. (Burchett and others, 1972; Burchett and others, 1973; Burchett and others, 1975; Swinehart and others, 1985; Burchett and others, 1986; Eversoll and others, 1988; Burchett and others, 1988; Diffendal, 1991; Swinehart and Diffendal, 1995; Diffendal, and others, 1996; Swinehart and Diffendal, 1997; Diffendal, 1999; Souders, 2000; and Diffendal and others, 2008.

For definitions of geologic terms consult Diffendal and others, (1996) on line at http//digitalcommons.unl.edu/natrespapers/3. Diffendal (1999) also discusses the concepts of geologic time and history.

### PALEOZOIC ERA - PENNSYLVANIAN SYSTEM

*Missouri Series - Kansas City and Lansing groups*

Outcrops of both groups are exposed along the Missouri River bluffs near Omaha and along the lower Platte River from its mouth westward for approximately 25 miles. Rocks of both groups are composed primarily of a cyclic series of marine limestones and shales with lesser sandstones and coals. Most of the recorded landslides are rock slumps within weaker shale units. In some cases the underlaying shales slide or erode, causing overlying limestones to either fall or topple.

*Virgil Series - Douglas, Shawnee and Waubaunsee groups*
Exposures of the three groups are limited to southeastern Nebraska, mainly from the extreme southeast corner of the state up to near the mouth of the Platte River. Rocks of the three groups are found along the Missouri River bluffs and the main tributaries, the Nemaha and Platte rivers. Rocks in all three groups are primarily cyclic series of marine limestones and shales with lesser sandstones and coals. Landslides involving the groups are mostly rock slumps within the shale units. Rock falls and topples involving the limestones can occur when the underlying shales slide or erode.

## PALEOZOIC ERA - PERMIAN SYSTEM

*Big Blue Series, Admire, Council Grove and Chase groups*
Exposures of the rocks of these groups are limited to southeastern Nebraska along the Nemaha River bluffs and to a small area along the Missouri River bluffs near the mouth of the Platte River. Rocks in all three groups are cyclic series of marine limestones and shales with lesser sandstones and coals. However, landslides in the three are few, occurring as rock slumps, falls and topples.

## MESOZOIC ERA - LOWER CRETACEOUS SYSTEM

*Dakota Group*
The Dakota is the oldest Cretaceous unit in the state. Rocks consist mostly of marine sandstones with some shales and pebble conglomerates. Exposures occur in southeastern Nebraska along the Nebraska-Kansas border, along the Big Blue River and its tributaries, and along the Missouri River bluffs and valley uplands in northeastern Nebraska. Rock slumps in shale exposures were occasionally observed producing hummocky and rolling landscapes.

## MESOZOIC ERA - UPPER CRETACEOUS SYSTEM

*Colorado Group*
*Graneros Shale Formation*
The Graneros Shale is exposed in south-central Nebraska along the Nebraska-Kansas border and in the Missouri River bluffs in northeastern Nebraska. It is a gray calcareous shale with some thin sandstone and marine limestone layers and thin bentonite seams. Landslides occur as rock slumps, with a majority of slides located along the Missouri River bluffs in northeastern Nebraska and in south-central Nebraska along the Republican and Little Blue River valleys.

*Greenhorn Limestone Formation*
The Greenhorn Formation is exposed in south-central Nebraska and along the Missouri River bluffs in northeastern Nebraska. It consists of light gray marine limestones interbedded with gray calcareous shales. Locally the limestones can be more consolidated and massive. Observed landslides were rock falls or topples as a result of erosion or failures in the weaker underlying Granerous Shale.

*Carlile Shale Formation*
The Carlile Formation is exposed in northeastern Nebraska, along the Missouri River, and along the Republican River in south-central Nebraska. It consists of dark-gray to medium-gray marine shales, limestones and sandstones, with some thin-bedded siltstones. Observed landslides were rock slumps along the Missouri River in northeastern Nebraska.

*Niobrara Chalk Formation*
The Niobrara Formation is exposed in northeastern Nebraska along the Missouri River, along the Niobrara River, and along the Republican River valley and Medicine Creek and their tributaries in southwestern Nebraska. It is composed of marine chalk, limestone, shale with thin seams of bentonite. Landslides occur as rock falls, topples or complex slides.

*Montana Group*
*Pierre Shale Formation*
Exposures of Pierre Shale are located in northeast, southwest, south-central, and northwest Nebraska. It is composed principally of gray to black marine shale with thin seams of bentonite, shaley chalks, shaley limestones, thin sandstones, and gypsum. Most Pierre Shale landslides occur in northeastern Nebraska. The main reasons for numerous slides in the Pierre Shale include failures on low angle slopes (natural or man-induced), failures along bentonite seams, and excess water, (Bruce and Scully, 1966). Landslides occur as rock slumps or complex slides.

## CENOZOIC ERA - TERTIARY SYSTEM-OLIGOCENE SERIES

*White River Group*
*Brule Formation*
Exposures are on the valley sides in the Wildcat Hills, and the North Platte and Pumpkin Creek valleys. The formation is composed predominantly of volcaniclastic eolian and fluvially deposited sedimentary rocks.



Landslides in this unit occur as rock falls or topples.

## CENOZOIC ERA - TERTIARY SYSTEM-MIOCENE SERIES

*Arikaree Group*
Exposures of the group occur in the Panhandle and along parts of the Niobrara River Valley. These continental rocks are composed of volcaniclastic and fluvial, fresh water fine-to medium-grained sandstones and siltstones. The group also contains limestones, conglomerates, and volcanic ash beds. Landslides occur as rock falls or topples.

*Ogallala Group*
The Ogallala is exposed in scattered areas throughout the western two thirds of the state. It is composed of continental fluvial deposits including sandstone, siltstone, claystone, sand and gravel. It also contains less widespread diatomites and volcanic ashes, as well as calcareous and siliceous caliches. Landslides in the Ogallala Group occur as lateral spreads, rock falls and topples.

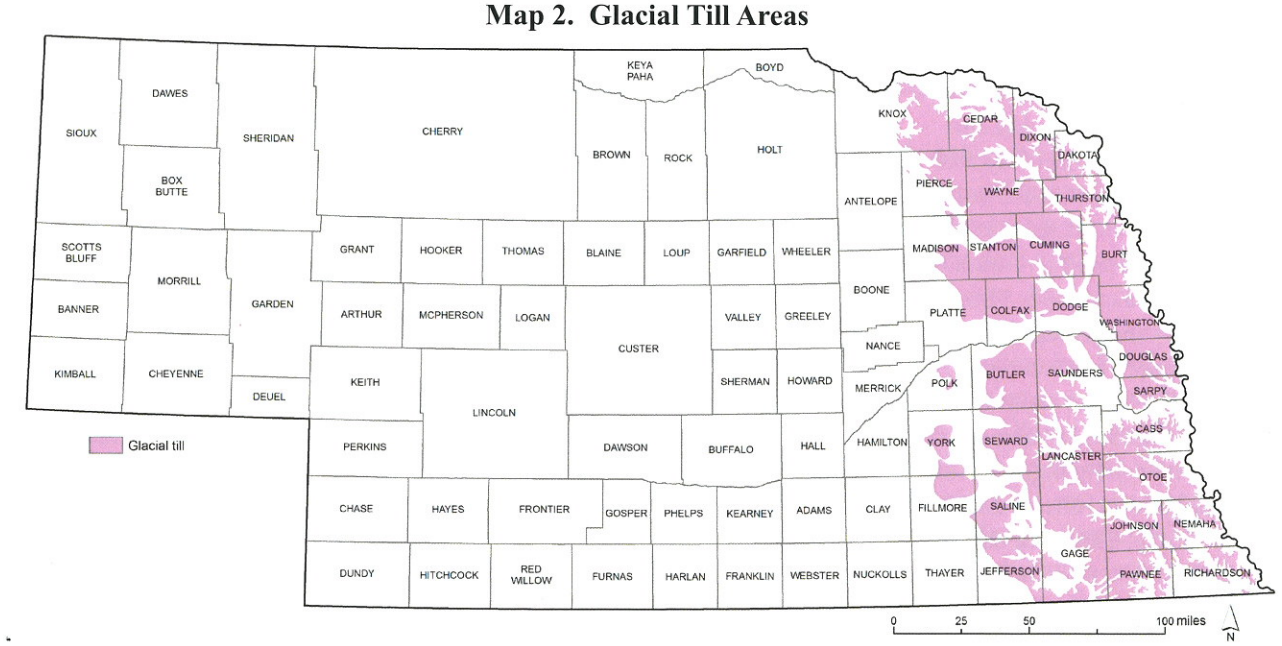
## CENOZOIC ERA - QUATERNARY PERIOD-PLEISTOCENE AND HOLOCENE SERIES

*Glacial Tills and Associated Sediments*
Pleistocene glacial deposits occur in the eastern third of the state (Map 2). These deposits include boulder clays (tills), silts, sand, gravels, and larger rocks left behind after ice sheets that covered major parts of Canada and the northern U.S. states during the several ice ages melted away. Landslides associated with glacial tills are mainly earth slumps and complex slides, especially where overlain by loess.

*Loesses*
Multiple loess deposits (Bignell, Peorian, Gilman Canyon, Loveland, Walnut Creek, Red Cloud and Fullerton), are widespread throughout the state (Map 3). Loess consists of eolian very fine silts and very fine sands. Paleosols (old soil horizons) are common within the loesses. Parts of some loess formations such as part of the Loveland Loess at and below the paleosol are more dense than younger, overlying loess. Water can build up at this interface causing the possibility of landslides if steep slopes and high precipitation occur. Surface and subsurface water drains are used to control and stabilize slides in loess. Loess landslides occur as earth slumps and complex slides.

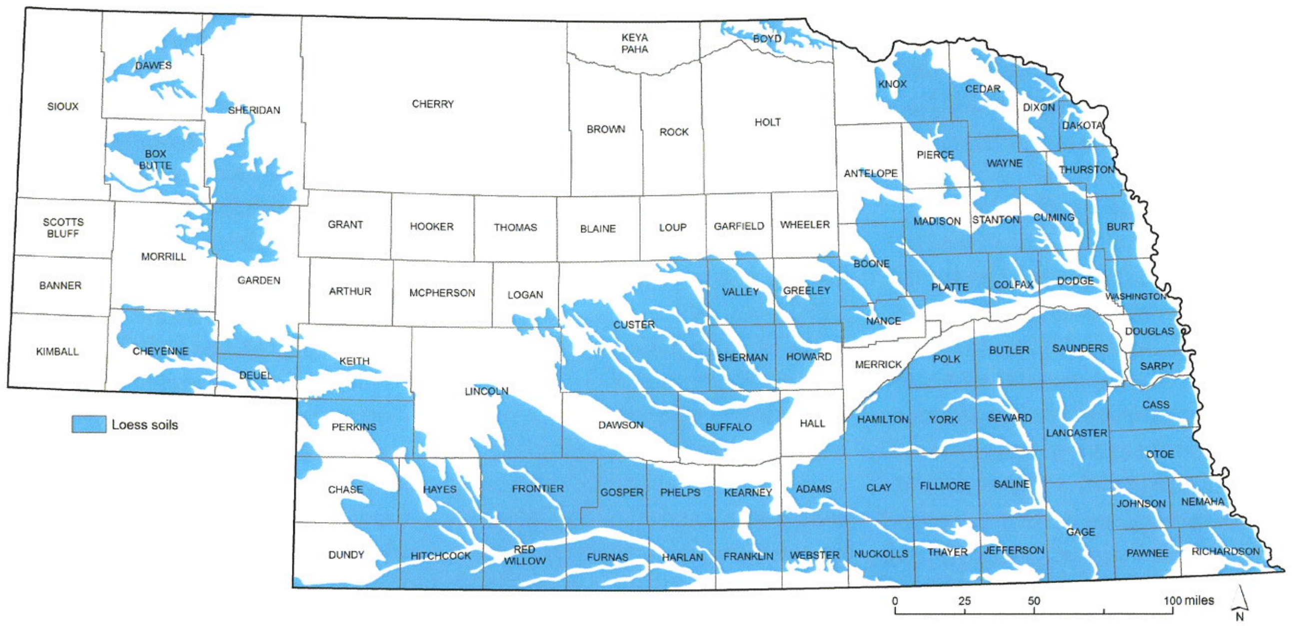
*Clays, Sands and Gravels*
Most clay, sand, and gravel deposits prone to landslides occur in the glaciated area of eastern Nebraska and northeastern Nebraska. Failures in clays are related to the presence of excess surface and subsurface water and can occur in low slope areas. Sand and gravel deposits usually fail due to fluctuating groundwater levels and eroding underlying materials. Landslides occur as earth slumps and complex slides in these materials.

**Map 2. Glacial Till Areas**




*Source: Conservation and Survey Division, School of Natural Resources, University of Nebraska–Lincoln*

**Map 3. Occurrences of Loess**




*Source: Conservation and Survey Division, School of Natural Resources, University of Nebraska–Lincoln*

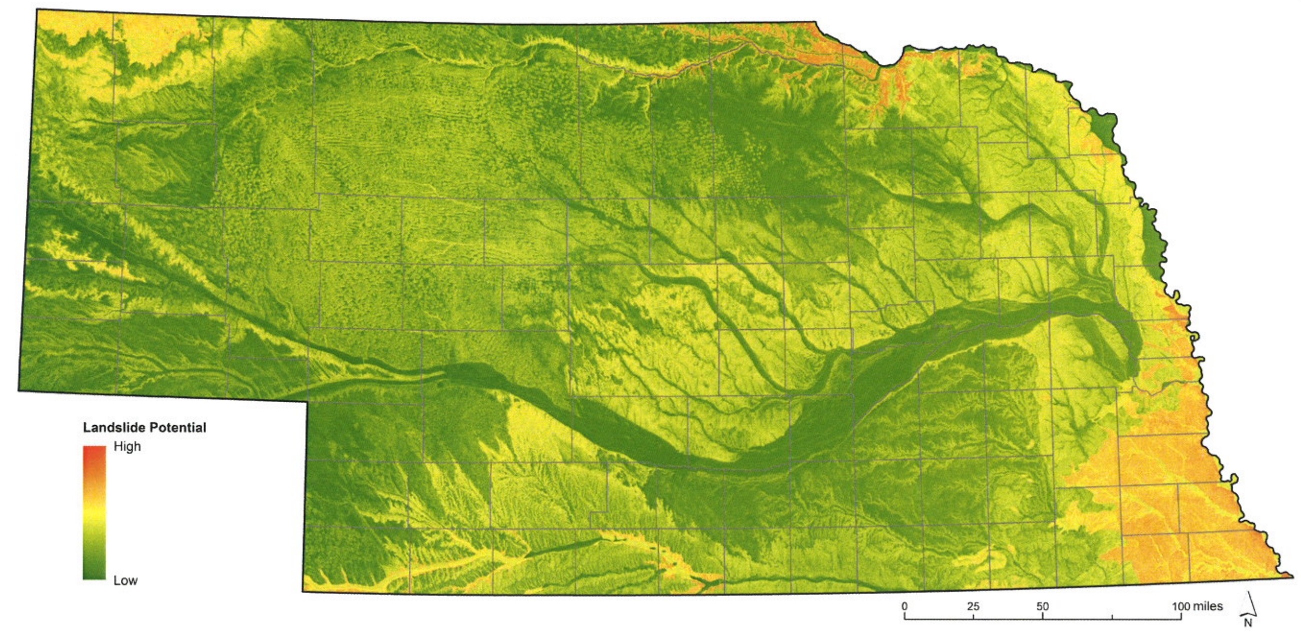
# LANDSLIDES IN NEBRASKA

Most landslides in Nebraska occur along federal, state and county roadways. Many occurring away from roadways have also caused damage to homes and other private buildings, to buried utilities (electric, gas, and telephone lines), and to farmland. Landslides in Nebraska are seldom spectacular, but can have a significant cost. Most of the roadway landslides are not large. However, one slide south of the town of Niobrara on Nebraska Highway 14 caused over $2 million to mitigate. The present relocated site continues to be monitored as a potential danger. Almost all still cause economical concerns for state and county highway road maintenance departments and for the general public. Landslide damage to public utilities, homes, buildings and private lands has occurred in the past and will become more common and costly as our population increases and more land in rural areas is developed in landslide-prone areas. These developments are located primarily in scenic areas adjacent to large bluffs, rivers or drainages and other areas noted in this report as being susceptible to landslides (Map 4). Landslide damage has occurred in some of our state parks and at a U.S. Army Corps of Engineers (USACE) Reclamation Area, (Eversoll, 1997, 2002), causing problems either in areas with steep slopes or where landslide-prone geologic materials occur. Damaged sites include roads, trails, and buildings adjacent to steep slopes and parking areas.

A majority of active landslides in Nebraska move fairly slowly (inches to a few feet per day), however, some do occur within a few hours. Most take weeks, months, or even years to develop. The exception, of course, would be rock falls and topples that are sudden and often instantaneous events. Landslides develop naturally when changes in the environment such as excess precipitation, groundwater changes, and inherent soil or rock weaknesses occur. Human activities account for many of Nebraska's landslides, including man-made changes in slopes and alteration of land, surface water, or groundwater conditions. Human-caused landslides and related damages will increase as future industrial and domestic developments occur in landslide hazard areas, (Schuster, and Kockleman, 1996). Other related factors, such as climate change, city and county zoning changes, roadway re-alignments, or grade changes will also alter the frequency of Nebraska landslides.



**Map 4. Landslide Susceptibility**




*Source: Conservation and Survey Division, School of Natural Resources, University of Nebraska–Lincoln*

# FACTORS INFLUENCING LANDSLIDES AND SLOPE INSTABILITY

Landslides are largely composed of bedrock, unconsolidated materials, soil and fill materials with varying amounts of water. In Nebraska, the conditions that are usually present whenever landslides occur include geological formations susceptible to landsliding, sloping land surfaces, influences of water, landslide triggers, and weather conditions. The sites become increasingly hazardous when all five conditions are present.

## GEOLOGICAL FORMATIONS SUSCEPTIBLE TO LANDSLIDES

Surficial geological formations (bedrock or sediments exposed at the land surface) that are prone to landsliding are shown on Maps 2-5.

## SLOPING LAND SURFACES

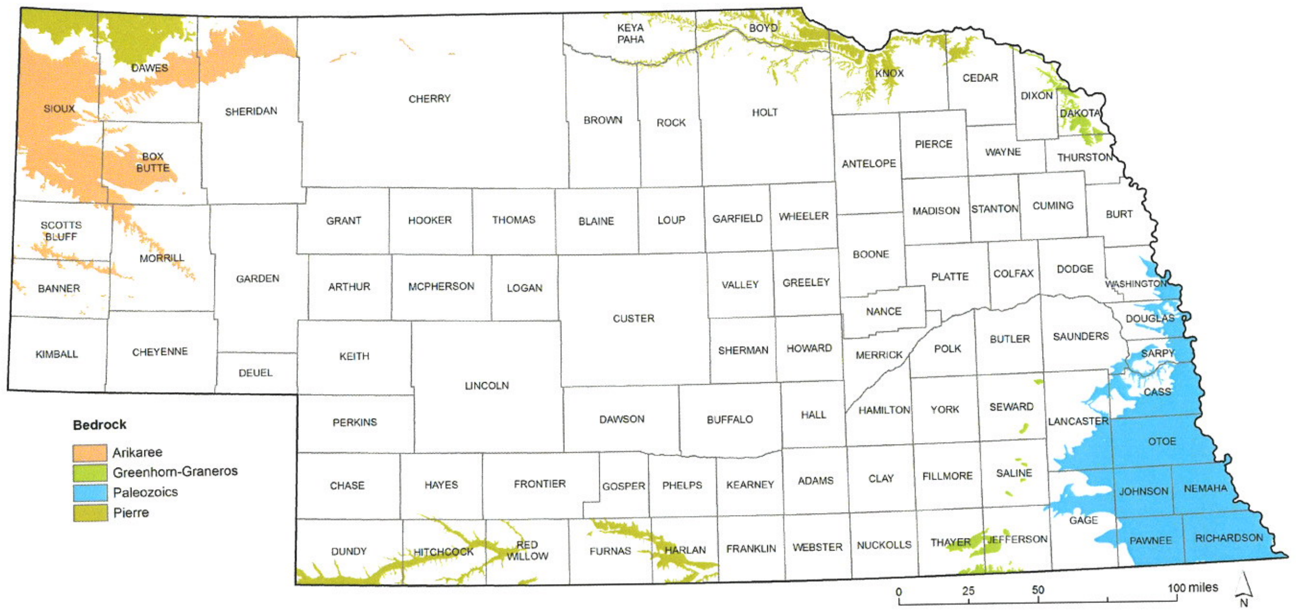
Slopes vary with the type of geological materials found at each slide site. Sandstone and limestone escarpments can be almost vertical without causing slides, but rock falls can occur if these rocks are fractured. Cretaceous Pierre Shale and other shale formations, however, can fail on very gentle slopes. (Bruce and Scully, 1966). Surface slopes in Nebraska are depicted on Map 6.

## INFLUENCE OF WATER

The presence of excessive water in the rock and sediment pore spaces increases the pore pressures within the materials reducing their shearing strength, adding to the weight of the materials, and possibly lubricating any existing failure planes. The excess water can be natural (precipitation) or man-induced run-off water from new housing developments, over-watering from sprinkler systems, improperly placed leaching fields, and from roads and parking lots.

Diverting and draining both surface and groundwater away from landslide-prone areas is a preventative method to mitigate landslides. Annual precipitation in Nebraska ranges from 14 inches in the western Panhandle to up to 30-35 inches in eastern Nebraska (Map 7). Higher precipitation and additional freeze and thaw events are two of the reasons that the Pierre Shale generates more slides in the northeastern part of Nebraska than in western Nebraska.

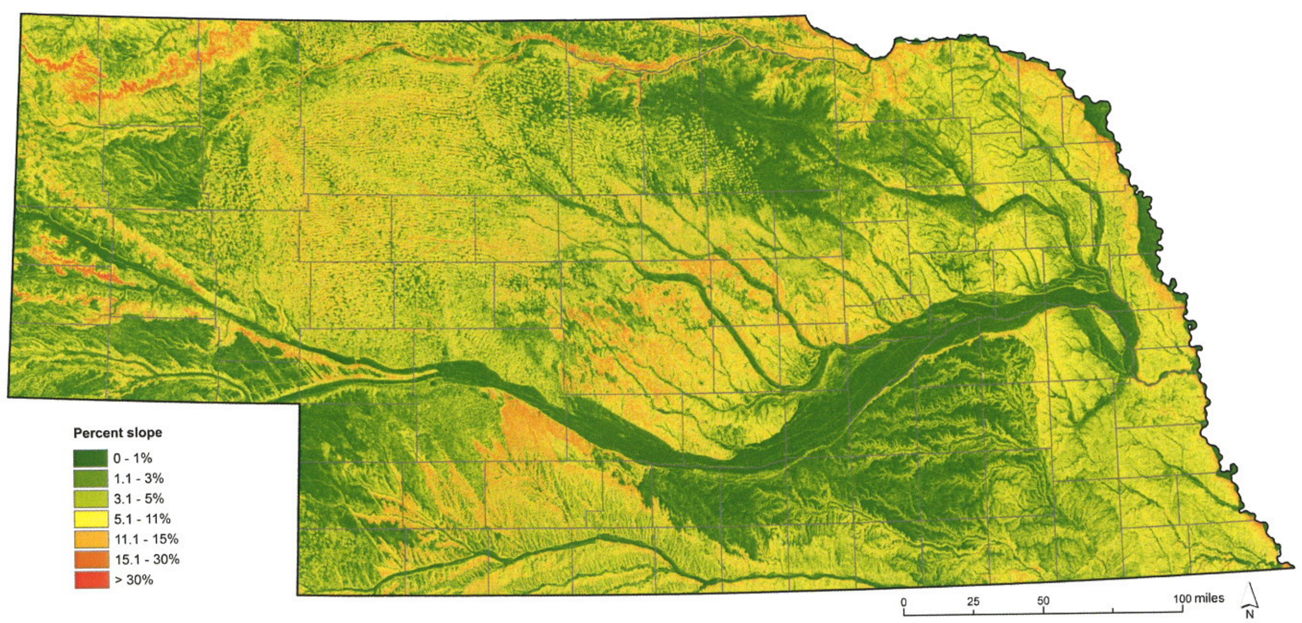
**Map 5. Bedrock Outcrops Susceptible to Landslides**




*Note: Because of the scale of this map areas shown as Arikaree in Western Nebraska do not include parts of Ogallala and White River groups where landslides may develop. Actual areas of landslides are greater than shown on this map.*

*Source: Conservation and Survey Division, School of Natural Resources, University of Nebraska–Lincoln*

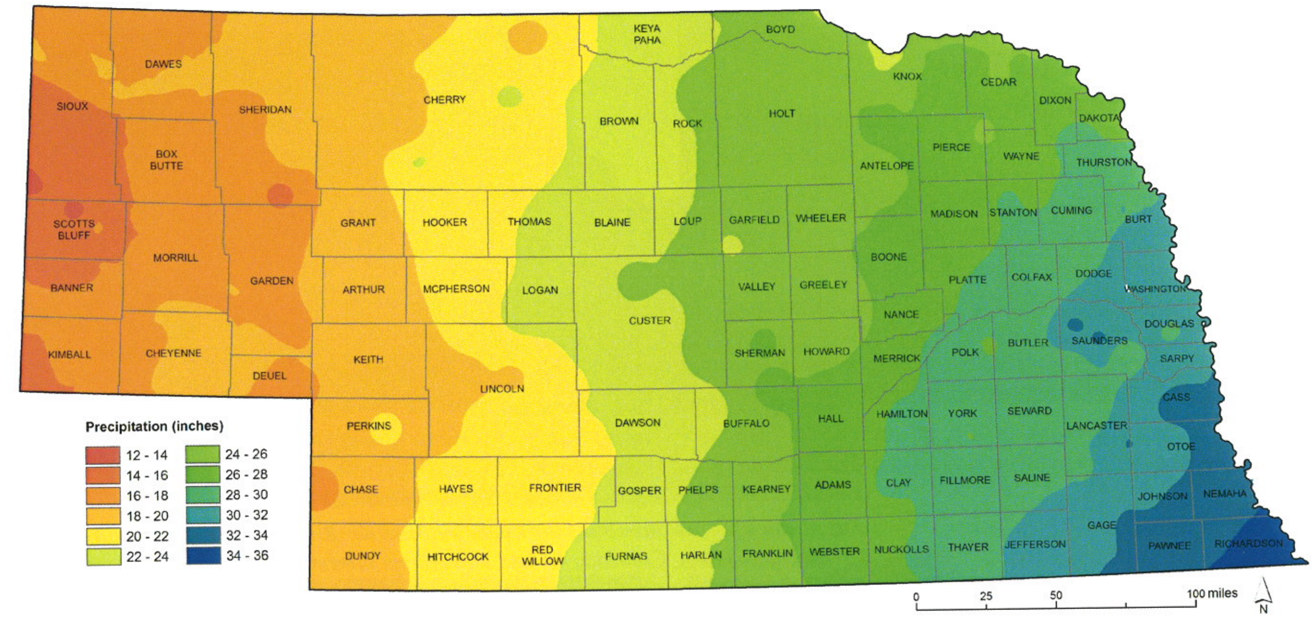
**Map 6. Surface Slope**




*Source: Conservation and Survey Division, School of Natural Resources, University of Nebraska–Lincoln. Derived from elevation data from U.S. Geological Survey*



**Map 7. Average Annual Precipitation, 1971-2000**




*Source: Conservation and Survey Division, School of Natural Resources, University of Nebraska–Lincoln. Derived from data from U.S.D.A./N.R.C.S. National Cartography and Geospatial Center*

### LANDSLIDE TRIGGERS

In addition, a triggering event may contribute to a landslide. A trigger is defined as an external stimulus. (Wieczorak, 1996). Triggers include earthquakes, vibrations from moving trucks or heavy equipment, thunder, intense rainstorms or sonic booms.

### WEATHER CONDITIONS THAT CONTRIBUTE TO LANDSLIDES

Excessive rain or snow accumulations do contribute to landslide events, especially in the forms of late Autumn and early Winter rains or snows, coupled with above average spring rains or snows and warmer temperatures. Heavy winter snow falls prevent deep frost and early thaws saturate unfrozen soils. Water saturates the soils and underlying materials, thereby increasing occurrences of landslides.

## TYPES OF NEBRASKA LANDSLIDES

Six types of landslides have been documented by the author in Nebraska. These are rock falls, topples, rock slumps, earth slumps, lateral spreads and complex slides. (Cruden and Varnes, 1996). No earth flows were included separately, however most of earth slumps and rock slumps contained earth flows at their lower ends.

### ROCK FALLS

Rock falls occur when rocks free-fall from a cliff or steep slope. (Figs. 3 - 12). Rock falls occur along rivers, roads, or in areas where erosion has caused steep bluffs or cliffs to form. In southeastern Nebraska, they occur in the Council Grove and Admire groups (Permian System) and in the Wabaunsee Group in (Pennsylvanian System ) rocks along the Missouri River and its tributaries. In northeastern Nebraska rock falls occur in the Cretaceous System, Greenhorn Limestone, and Niobrara Chalk formations along the Missouri River, and in south-central Nebraska along valley sides of the Republican River, Medicine

Creek, and the Little Blue River. In southwestern Nebraska they occur in Niobrara Chalk along the Republican River and Medicine Creek valley sides. In western Nebraska rock falls occur in the Upper Oligocene -Lower Miocene Series, White River and Arikaree groups in the Wildcat Hills area and in the Miocene Series, Ogallala Group in the western two thirds of Nebraska.

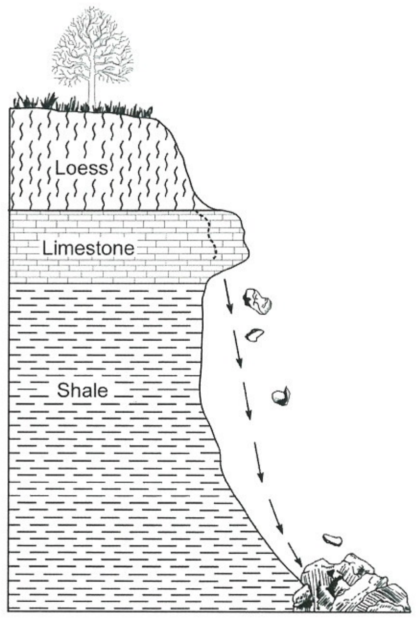



*Fig. 3. Side view of typical rock fall.*


*Fig. 4. Rock fall at Ponca State Park near the Missouri River boat ramp in Dixon County. Cretaceous System, Colorado Group, Greenhorn Limestone overlying Graneros Shale and Dakota Sandstone. Note small warning sign beside an unauthorized path.*

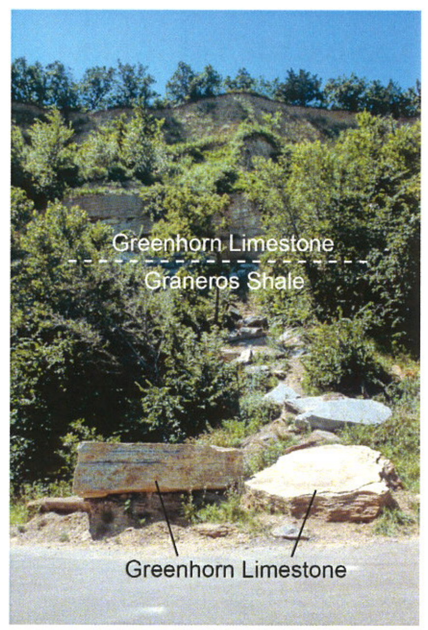



*Fig. 5. Same site as Fig. 4, two years later. Note additional fallen limestone blocks.*


*Fig. 6. Rock fall on county road near Gilead, Thayer County. Cretaceous Greenhorn Limestone overlying Graneros Shale.*




*Fig. 7. Same site as Fig. 6. A close up of a recent rock fall along the county road. The county road (in lower right corner) was partially blocked by the debris. Photo by Hebron Journal-Register, April 16, 1997.*


*Fig. 8. Rock fall in Wildcat Hills, Scottsbluff County. Tertiary System, White River and Arikaree groups, Brule, and Gering formations consisting principally of volcaniclastic eolian rocks of siltstone and silty sandstone; Gering includes fluvial deposits. House was built near edge of talus slope. Debris is resting around the home. Photo by John F. Shroder, Jr.*

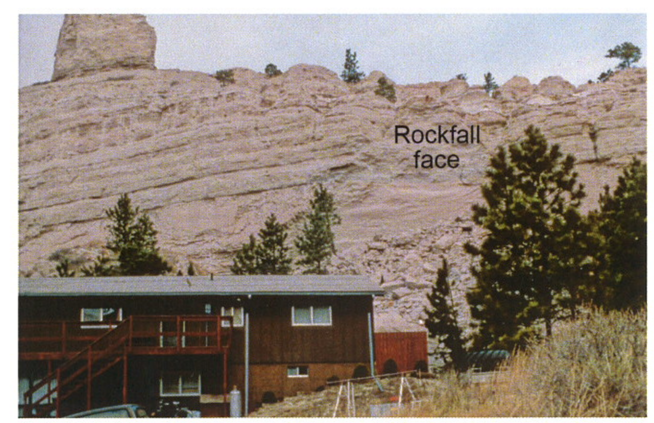



*Fig. 9. Same site as Fig. 8 showing cliff behind the home and debris from the rock fall. Photo by John F. Shroder, Jr.*

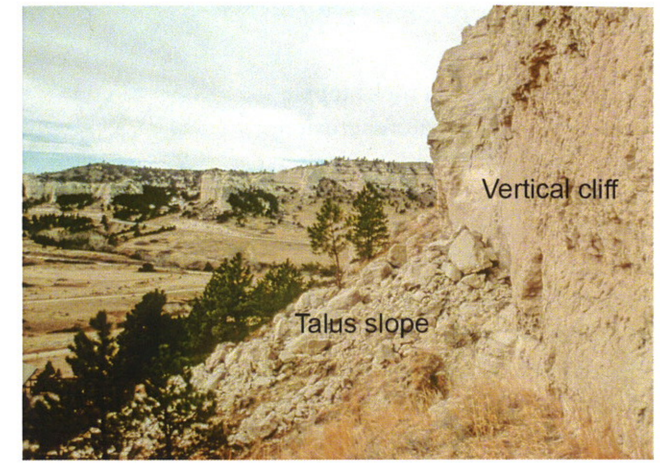



*Fig. 10. Same site as Fig. 8 showing vertical cliff and resulting talus slope. A few trees have been tilted by previous falls. Photo by John, F. Shroder, Jr.*


*Fig. 11. Rock fall at Scottsbluff National Monument in Scotts Bluff County, May, 2001. Tertiary System, Arikaree Group consisting of volcaniclastic eolian and fluvial sandy siltstone and silty sandstone deposits. Note people for scale and that trail around the end of the cliff was impacted. Photo by Scottsbluff Star Herald, May 8, 2001.*

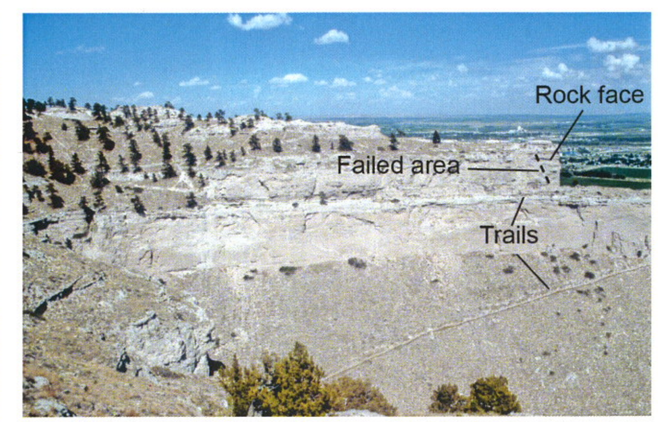



*Fig. 12. Same site as Fig. 11 showing bluff and rock face before the rock fall. Hiking trails along the bluff are noted.*

## TOPPLES

Topples occur when rocks topple over either due to natural erosion, steep slopes, or to undercutting by streams or humans (Figs. 13 and14). In some cases it is not possible to distinguish between a rock fall or a topple unless you are at the site at the time of occurrence. Topples can occur in eastern and southeastern Nebraska in Permian and Pennsylvanian System rocks along the Missouri River and its tributaries. In northeastern Nebraska they can occur in the Cretaceous System, Niobrara Chalk Formation along the Missouri River, and in southwestern Nebraska along the Republican River and Medicine Creek valley sides. Topples also occur in south-central Nebraska, along the Little Blue River in the Greenhorn Formation. They occur in the Panhandle in rocks of the White River, Arikaree and Ogallala groups along the valley sides of the North Platte River and Pumpkin Creek.

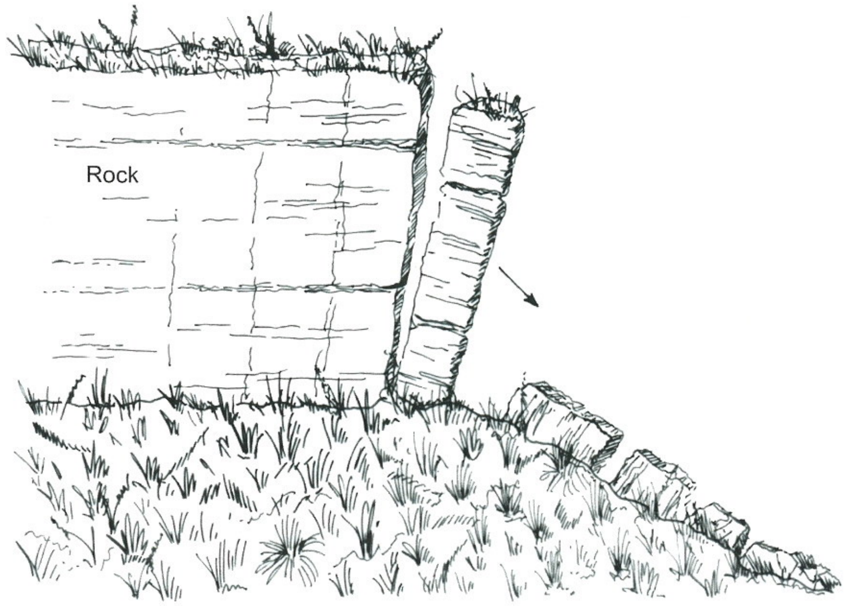



*Fig. 13. Sketch of topple.*

*Fig. 14. Topple near mouth of Bazile Creek in Knox County. Cretaceous System, Colorado Group, Niobrara Chalk Formation. Numerous topples and/or rock falls occur where formation is exposed along Missouri River Bluffs in northeast Nebraska. Note nearby road for scale. Area known locally as "Maidens Leap".*

## ROCK SLUMPS

Rock Slumps are masses of bedrock moving downward on a rotational failure plane (Figs. 15 - 40). Rock slumps usually have a characteristic concave scarp at the top, have a backward rotation movement, and have moved along a concave failure plane. Rock slumps in some shales, particularly the Cretaceous Pierre Shale, occur with no overburden. Most rock slumps in Nebraska occur in northeast Nebraska in the Pierre Shale and in eastern Nebraska in the glaciated areas. Rock slumps are one of the most common of all landslides, in Nebraska.



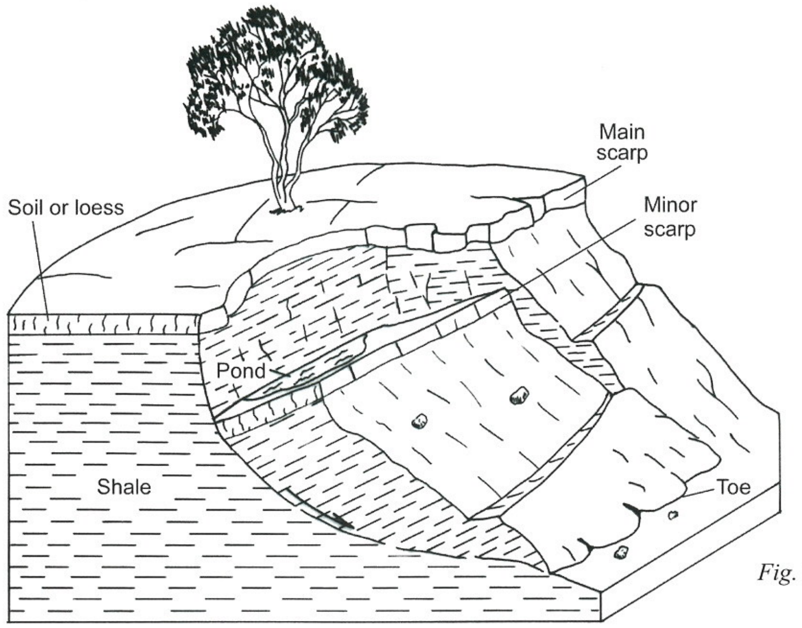



*Fig. 15. Block diagram of rock slump.*

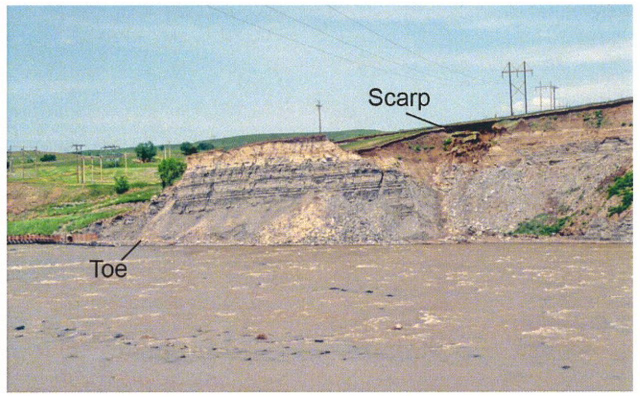



*Fig. 16. Rock slump below Spencer Dam in Knox County along the Niobrara River, site of many previous slides. Cretaceous System, Montana Group, Pierre Shale Formation. Light colored area near top is weathered Pierre Shale.*


*Fig. 18. Pierre Shale rock slump at Spencer Dam site showing landslide scarp and a graben. U.S. Highway 281 bridge in background. View is downriver.*


*Fig. 17. Pierre Shale rock slump. Spencer Dam on left side. River constantly removes materials that reach the river. View is upriver.*


*Fig. 19. Rock slump at Spencer Dam site. The Pierre Shale weathered and unweathered (right) zones along with a graben (left). View is downriver.*

*Fig. 20. Pierre Shale slump at Spencer Dam site, showing toe of slide as it emerged out and into the Niobrara River. View is downriver with U.S. Highway 281 bridge in background, crossing the river. Two previous bridges were damaged by landslides.*

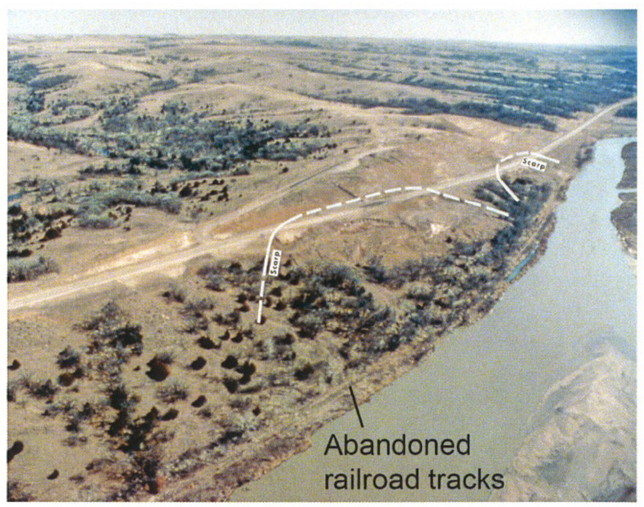



*Fig. 21. On Nebraska Highway 14, 2 miles south of Niobrara, Nebraska. Large rock slump occurred in 1985, when the highway was relocated. Older road is above impacted road. In 1993 a third road was built to the left of the older road. Cretaceous System, Montana Group, Pierre Shale Formation overlain by Pleistocene sands and gravels. Two slides shown gradually became one large slide. Note abandoned railroad line located along the Niobrara River bank that also had been impacted by previous landslides.*


*Fig. 22. Rock slump south of Niobrara involving Pierre Shale, Same site as Fig. 21. Shortly after road was constructed two small slides developed along Niobrara River valley side (right). Picture shows overnight settlement of the asphalt overlay.*

*Fig. 23. Rock slump south of Niobrara. Same site as Fig. 21. Showing the slide movement along Nebraska Highway 14. Truck for scale. Road continued to move and drop so drastically that it took over 11 ft of asphalt overlays to keep road open during construction of a new third road around the slide area.*

*Fig. 24. Rock slump south of Niobrara. Same site as Fig. 21. Picture was taken a few years after the old road was replaced. Vertical and horizontal movement is shown. (Person in top of picture for scale).*



*Fig. 25. Rock slump south of Niobrara. Same area as seen in Figs. 21-24 after 7 years. Old roadway is gradually moving downslope and breaking apart.*

*Fig. 26. Rock slump in Indian Cave State Park on a park road along the Missouri River in Richardson County. Permian System, Admire and Wabaunsee groups limestone and shale. Road was impacted by slide materials. Trees can be observed tilting above road. Missouri River bank on right side out of the picture. Road has been slightly relocated around the slide area.*

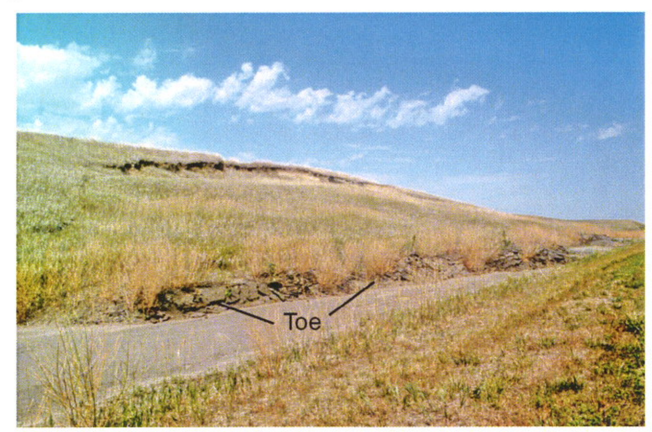



*Fig. 27. Rock slump near Verdel along Nebraska Highway 12. Cretaceous System, Montana Group, Pierre Shale Formation. Large slide in a low sloping area. Abandoned asphalt highway in the foreground shows the power of the moving mass of materials at toe of slide.*

*Fig. 28. Rock slump north of Bazile Mills along Nebraska Highway 13. Cretaceous System, Montana Group, Pierre Shale Formation. Typical landslide in Pierre Shale in a low sloping area. Slide materials have reached roadway several times previously.*

*Fig. 29. Rock slump adjacent to Nebraska Highway 15 bridge over the Missouri River north of Maskell. Cretaceous System, Colorado Group, Carlile Shale Formation. Slides adjacent to bridge abutment have occurred in a newly cut slope into the shale.*


*Fig. 30. Rock slump at Rattlesnake Hill along Missouri River in Cedar County. Cretaceous System, Colorado Group, Carlile Shale Formation. Pleistocene loess deposits overlying the Carlile Shale. A large natural slide along the Missouri River bluffs. (Person for scale). Note large scarp.*

*Fig. 31. Rock slump at Rattlesnake Hill. Nearly vertical scarp in Pleistocene loess deposits overlying the Cretaceous Carlile Shale showing broken tree roots and tilted trees.*

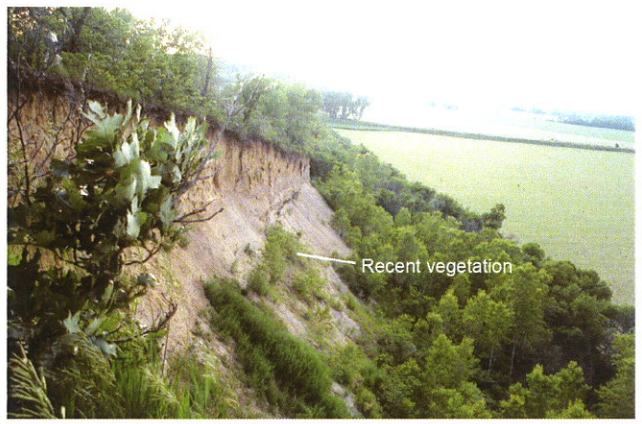



*Fig. 32. Rock slump at Rattlesnake Hill, view is upriver. This slide is adjacent to that shown in Figure 31. This is an older slide because there is vegetation growing below scarp.*

*Fig. 33. Rock slump at Rattlesnake Hill. Close-up of the vertical scarp in Pleistocene loess deposits. Some trees apparently dropped straight down into scarp. Person for scale.*


*Fig. 34. Rock slump at Rattlesnake Hill, view is downriver showing the flat Missouri River bottoms. Tilting of trees and grass covered slopes are evident. "Iona Volcano cliff" can be seen in the right top of the picture.*

*Fig. 35. Rock slump at Rattlesnake Hill. Toe of landslide showing displaced corn rows, tilted trees, bent fence and vegetation.*



*Fig. 36. Rock slump in Niobrara Sate Park, Knox County. Cretaceous System, Montana Group, Pierre Shale Formation. Slide scarp is approaching a park road. The entire park is underlain by Pierre Shale. Avoiding and mitigating slides in park is an ongoing project for park's maintenance department. Park is most affected by slides during periods of excessive precipitation in late winter and early spring.*

*Fig. 37. Rock slump in Niobrara State Park. Cretaceous, Pierre Shale. Park road has been offset by a slow moving slide in very low slope area.*

*Fig. 38. Rock slump on county road north of Center, Nebraska. Cretaceous System, Montana Group, Pierre Shale Formation. Bazile Creek is to left. Similar slides often occur along this 10 mile stretch of county road.*

*Fig. 39. Rock slump in abandoned "Devils Nest Development" in Knox County. Cretaceous System, Montana Group, Pierre Shale. Most of development was built on Pierre Shale, known landslide-prone formation. Slides impacted roads, homes, water, electrical and telephone services.*


*Fig. 40. Natural rock slumps in pasture land, Boyd County. Cretaceous Pierre Shale. Common occurrence in the area. Old slides are visible in the foreground forming the rolling hills. Photo by Tom Moser.*

## EARTH SLUMPS

Earth slumps in Nebraska occur in non- bedrock deposits, including unconsolidated soils, loesses, glacial tills, or sands and gravels moving downward as part of a rotational or translational failure plane (Figs. 41-54). Earth slumps, like rock slumps, have a concave main scarp. Landslides in loess may occur if the loess contains a buried soil (paleosol), the loess overlies an older and more compact loess, or if the loess overlies glacial till (Map 2). In all three cases water percolating downward builds up at these contacts with less permeable materials increasing the pore pressures, adding weight and lubricating the materials, thus possibly causing movement within the materials. Earth slumps are the second most common and widespread type of landslide in Nebraska.

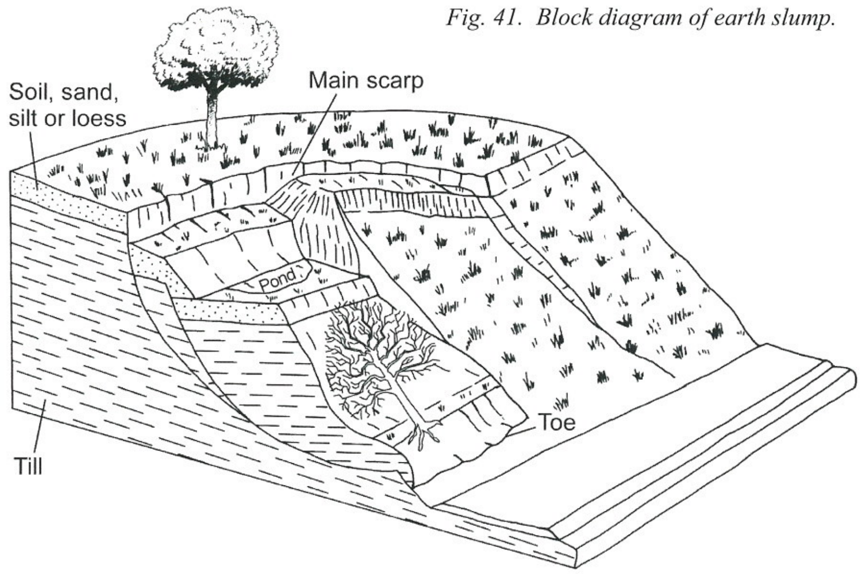



*Fig. 41. Block diagram of earth slump.*

*Fig. 42. Earth slump along Interstate 80 near Emerald, Lancaster County. Quaternary System, Holocene Series, Pleistocene loess with a possible paleosol underlain by Lower Cretaceous System, Dakota Group shale and sandstone deposits. Recurring slide, first noted a few years after I-80 was opened.*


*Fig. 43. Earth slump along Interstate 80 near Emerald. Same site as Fig. 42. Toe of slide nearly reached roadway. Tree roots may have curtailed further slide movements at top.*




*Fig. 44. Earth slump south of Fremont along the Platte River bluffs and just west of U.S. Highway 77, Saunders County. Quaternary System, Holocene Series, Pleistocene Loess underlain by thin seams of clay, silt, and very fine sand. Home was removed along with three other residences. Sewage laterals and underground sprinklers systems, seen in photo, are possible causes because water increased pore pressures, added weight, and lubricated slides.*


*Fig. 45. Earth slump site near Fremont along Platte River bluffs, same site as Fig. 44. Sewage tank and underground sprinkler pipes are visible on left of photo.*

*Fig. 46. Earth slump site near Fremont. Same site as Figs. 44-45. Toe of landslide showing tilted trees. Person for scale.*

*Fig. 47. Earth slump along U.S. Highway 34, six miles east of Seward, Seward County. Quaternary System, Holocene Series, Pleistocene loess overlaying glacial deposits. Recurring slide first noted in the 1960s. Majority of trees remained upright moving as a unit with slide materials.*

*Fig. 48. Earth slump along Nebraska Highway 35 east of Hoskins, Wayne County. Quaternary System, Pleistocene loess.*

*Fig. 49. Earth slump in Omaha near 108th and Pacific Streets along Big Papio Creek, Douglas County. Quaternary System, Pleistocene loess possibly underlain by a paleosol and/or glacial deposits. Tilted and uprooted trees in lower right. Slide caused homeowners to rebuild their backyards.*

*Fig 50. Earth slump in northwest Lincoln along Interstate I-180 in Lancaster County. Quaternary System, Pleistocene loess underlain by glacial deposits. Recurring slide.*

*Fig. 51. Earth slump same site as Fig. 50. Quaternary System, Pleistocene loess underlain by glacial deposits. Tree in middle appears to be upright, while others were tilted.*

*Fig. 52. Earth slump along BNSF Railroad west of Emerald, Lancaster County. Quaternary System, Pleistocene loess containing a paleosol and numerous silty clay seams. Scarp is nearly horizontal and high. Recurring Slide has closed the railroad numerous times. People for scale.*

*Fig. 53. Earth slump at same site as Figure 52, along BNSF Railroad. Quaternary System, Pleistocene loess. Numerous minor scarps are visible. Tracks were raised and drainage at toe was improved after slide occurred.*

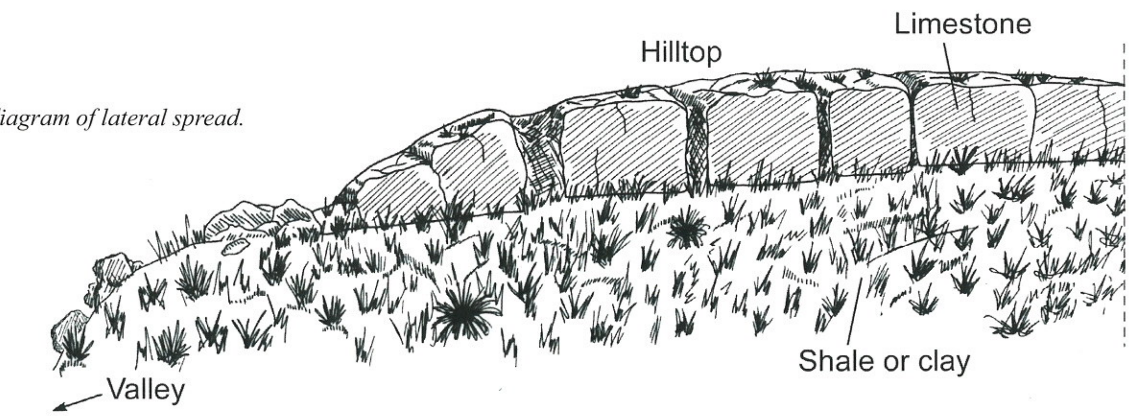
*Fig. 54. Earth slump along Nebraska Highway 92 east of Arnold, Custer County. Quaternary System, Pleistocene loess. Old stabilized slide apparently controlled by vegetation roots.*



**LATERAL SPREADS**

Lateral spreads are caused by lateral extensional movements within a fractured mass of rocks. Naturally occurring cracks widen during freeze-thaw events causing the rocks to move. The rocks are blocks of bedrock underlain by weaker materials that move laterally without a well-defined controlling basal shear surface or zone of plastic flow (Figs. 55-57). Their movements are extremely slow and regular. Lateral spreads occur in the Paleozoic rocks along the Missouri River and it's tributaries; in the Cretaceous Greenhorn Limestone along hill tops in south-central Nebraska; and in the Tertiary Ogallala Group in the Panhandle and southwestern Nebraska along the crests of hills.

*Fig. 55. Block diagram of lateral spread.*



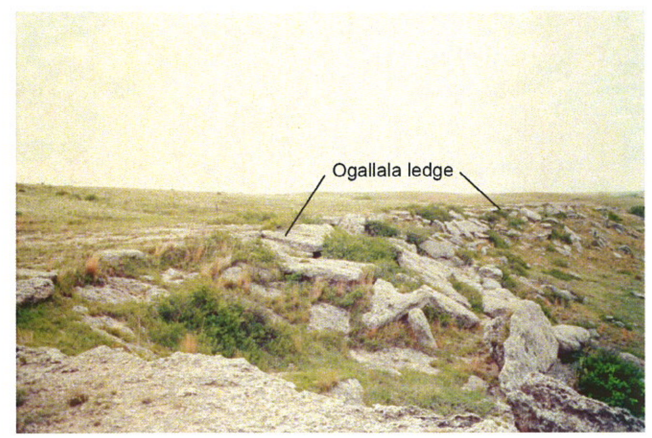




*Fig. 56. Lateral spread southeast of Trenton, Hitchcock County. Miocene Series, Ogallala Group. Silty sandstone ledge along a hill adjacent to nearby stream. Note fairly flat background and more steeply sloping land on the right side of picture. Joints and cracks in the Ogallala allow water to enter and this freezes further widening joints/cracks. Subsequent additional weathering and erosion of the underlying materials causes them to move downhill.*


*Fig. 57. Lateral spread southeast of Hamlet, Hayes County. Ogallala outcrop of consolidated silty sandstone at top of slope has been pushed out by freeze-thaw processes and has moved downhill.*

## COMPLEX SLIDES

A complex landslide is a combination of more than one of the principal types. Most complex slides in Nebraska involve earth slumps and rock slumps (Figs. 58-66). In many instances it is difficult to separate these combined slides because underlying formations or materials may have been covered and remain unrecognized.

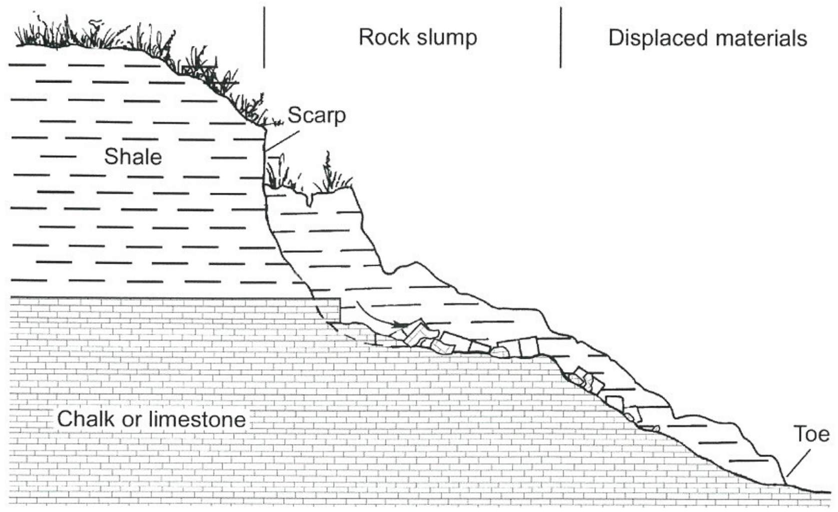



*Fig. 58. Side view of a complex landslide.*


*Fig. 59. Complex slide at Niobrara State Park, Knox County. Cretaceous System, Montana Group, Pierre Shale Formation. View is from top of the scarp looking downhill to Missouri River. Abandoned railroad line at the bottom of slide converted into a trail system (see Fig. 61).*

*Fig. 60. Complex slide at Niobrara State Park, Knox County. Pierre Shale Formation showing slide-displaced materials. Scarp in upper right. Missouri River on left. View is down-river, Person for scale near the bottom left corner.*


*Fig. 61. Complex slide in Niobrara State Park (same site as Figure 59). Toe of the slide showing displaced materials and pieces of the underlying Niobrara Chalk carried downward by slide. Person for scale.*



*Fig. 62. Complex slide along county road, north of Johnstown, Brown County. Montana Group, Pierre Shale Formation overlain by Pleistocene unconsolidated deposits. A large slide along the southern valley side of Niobrara River.*

*Fig. 63. Complex slide north of Johnstown (same site as Figure 62). Pierre Shale overlain by unconsolidated Pleistocene deposits. Tilted trees and materials from slide being eroded and carried downstream by the river. Professor John F. Shroder, Jr. and his students from University of Nebraska-Omaha's Geology Department have extensively studied site.*

*Fig. 64. Complex slide adjacent to Lincoln Municipal Airfield, Lancaster County along Oak Creek. Quaternary Period, Pleistocene loess materials overlying glacial deposits. View is upstream. Professor William J. Wayne from the University of Nebraska's Geology Department discovered slide in the 1970's. He and his students studied and documented slide movements.*

*Fig. 65. Complex slide (same site as Fig. 64). View is downstream showing salts (white) that formed on displaced materials. Note person for scale.*

*Fig. 66. Complex slide (same site as Figs. 64-65). View is from top of scarp downward to Oak Creek. Notice that slide toe has been pushed into creek causing narrowing of channel and erosion on the far bank. City of Lincoln in background.*

## METHODS CURRENTLY USED IN NEBRASKA

Several methods are used in Nebraska to attempt to control or stabilize landslides depending upon various conditions at each site (Rahn,1985; Knockelman, 1990; Leighton, 1990; Holtz and Schuster, 1996; Cruden and Varnes, 1996; Slossen, and others, 1992). The initial step is to determine the cause(s) of the landslide including geologic formations, existing slope, and surface and groundwater conditions, (Burns, and others, 1989; Turner and Schuster, 1996). In most cases the result of this determination will influence the method or methods used to control or stabilize that particular slope failure. Removal of displaced materials in slide areas is always the initial step in stabilization. These materials are usually wet and unconsolidated and should be replaced with more stable materials.

Following this removal of displaced materials one or more of the following measures can be used in the stabilization or control process. Efforts can be made to control subsurface drainage and surface water movements, to flatten or modify slopes, to build retaining structures including those made from reinforced earth or rock, to construct earth or rock buttresses and counterweight structures, to build retaining walls (gabions), to fill former slide areas with lighter weight fill, to plant vegetation whose roots will anchor materials, or to avoid the site.

*Subsurface drainage*
The two most commonly used methods used to literally drain and control subsurface water from the site are by drilling either horizontal or vertical wells, depending upon geologic materials and on-site conditions. The first method, drilling horizontal wells, is preferred. In this method nearly horizontal holes are drilled into the slide area and perforated pipes, usually 1 to 6 inches in diameter, are installed (Diviney,1990; Holtz and Schuster, 1996). The holes are drilled upward into the slide to intercept water-bearing strata. In this way they perform as gravity drains of water, serving to relieve pore pressures and to decrease weight within the slide (Fig. 67).
The second method, drilling vertical wells, allows for intercepting the water zones in the potential slide area and removing water from the affected areas. This water is discharged into drains away from the slide area (Fig. 67). These wells vary in size from a few inches to many feet in diameter. Submersible or sump pumps are used with water level controls to remove the water and to move it away from potential or actual slide areas.

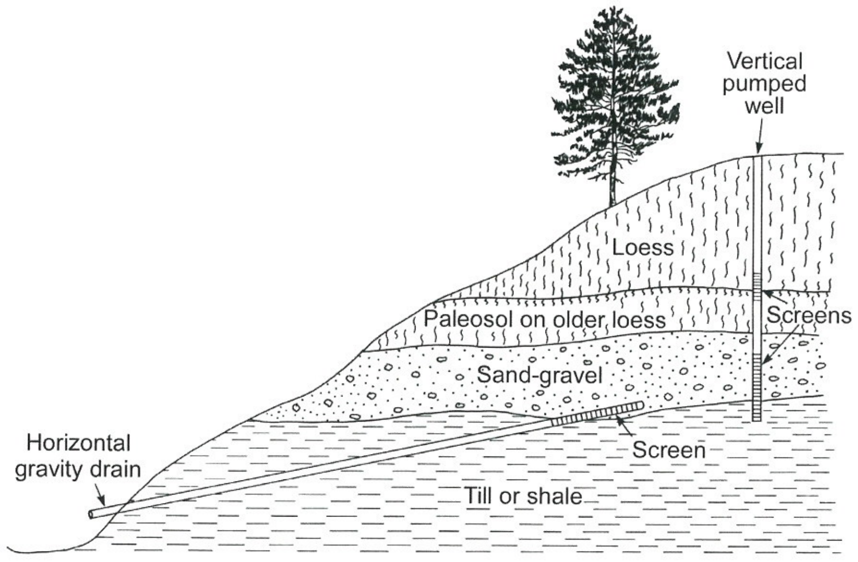



*Fig. 67. Side view of vertical and horizontal drilled drains.*



*Surface water controls*
Various methods are used to control surface water flow away from a site. A common method is to construct interceptor drains (lined or unlined) above the landslides to collect surface water and direct it diagonally away from the slide. Trench drains are also used to control subsurface water. Trenches 6-12 inches wide are dug into the slide, ending near the failure plane (Holtz and Schuster, 1996). At the bottom of the trench a geomembrane/geotex liner (large sheets of sealable, impervious rubber or synthetic compounds) and drainage pipes are installed. The trenches are backfilled half-way with rocks or sand and gravel, followed by clay to the surface (Fig. 68).

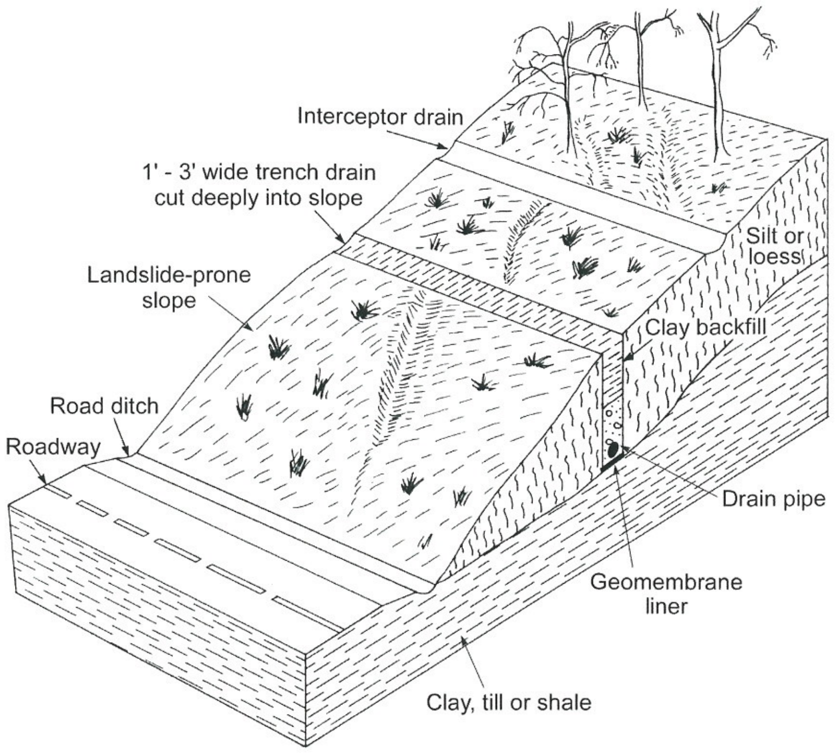



*Fig. 68. Block diagram of interceptor drains and trench drains.*

*Flattening or modification of slopes*
Flattening or other modification of slopes are commonly used to stabilize existing slides or to produce new slopes with a reduced general slope angle in landslide-prone areas (Johnson and DeGraff, 1988; Holtz and Schuster, 1996; Keaton and Beckwith, 1996). The flattening of the slope results in unloading at the top of the slope by removing surficial materials, thereby reducing some of the potential slide's driving gravity forces (Fig. 69).

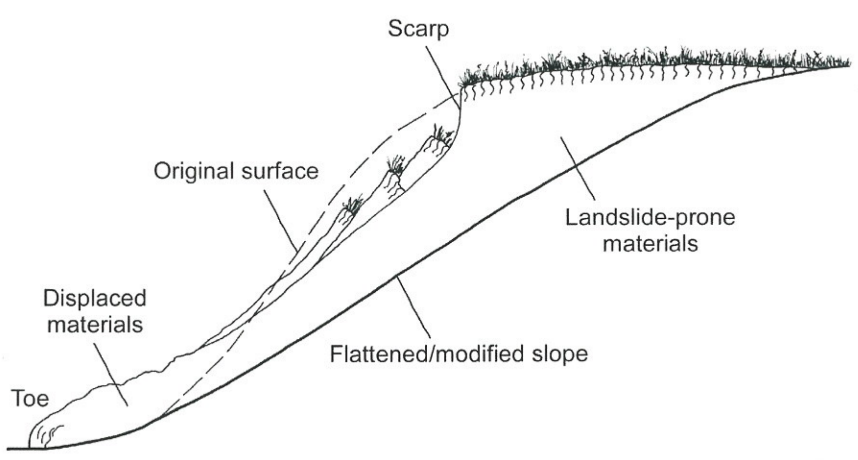



*Fig. 69. Side view of slope flattening or modification.*

*Retaining Structures*

Retaining structures are commonly used to control slides at or near the toe where slides are adjacent to roads or structures. They are designed to restrain further movement of the slide (Fig. 70). They should be combined with some form of a drainage system. Many types of structures or walls are used including reinforced poured concrete walls, crib type walls, pilings (steel or timber), and stacked masonry or stone walls (Holtz and Schuster, 1996).

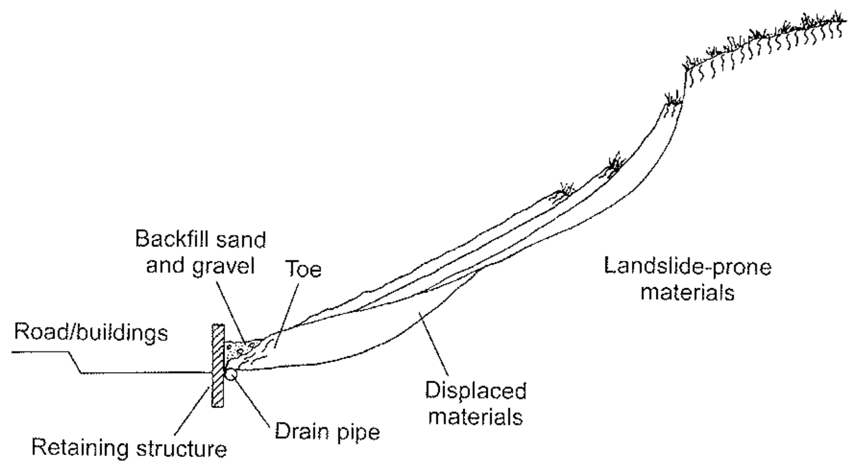



*Fig. 70. Side view of retaining structure.*

*Reinforced earth/rock structures*

Reinforced earth/rock structures (Gedney and Weber, 1978; Holtz and Schuster, 1996) are geotechnically engineered walls backfilled with alternating layers of selected backfill and tensile reinforced strips of galvanized metal or reinforcement geogrids (variously sized grids made with long lasting materials including polypropylene and other plastics reinforced with yarns and/or carbon coatings and manufactured in various sizes). These structures are commonly used in combination with some form of a concrete, metal, or wood retaining wall (Fig. 71). They are currently designed either along roadways or in urban areas where high cuts are made to accommodate proposed houses, buildings or roads.

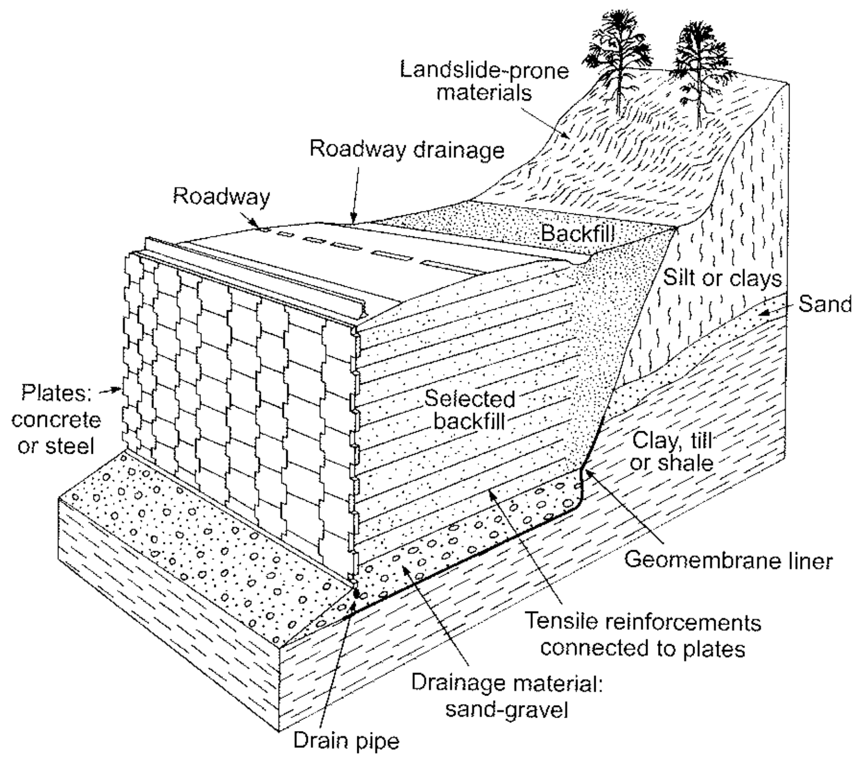



*Fig. 71. Block diagram of reinforced earth/rock structure (modified from Gedney and Weber, 1978).*



*Earth/rock buttresses and counterweight structures*

Buttresses and counterweight structures are designed to load the toe of the slide to control further movement of the slide (Fig. 72). Control is accomplished by using rip-rap rocks or boulders as dead weight after the site is cleared of undesirable materials. A geomembrane liner (rubber or other water proof composite materials manufactured into large sealable sheets) is installed overlain by the deadweight materials that range from limestone rip-rap to large boulders or pieces of broken concrete. A drainage system is included in the design to efficiently remove excess water from the slide area. This method is also designed to control sliding below a roadway or a structure where the counterweight materials are placed directly on or at the toe of the slide (Schuster and Krizek, 1978; Gedney and Weber, 1978).

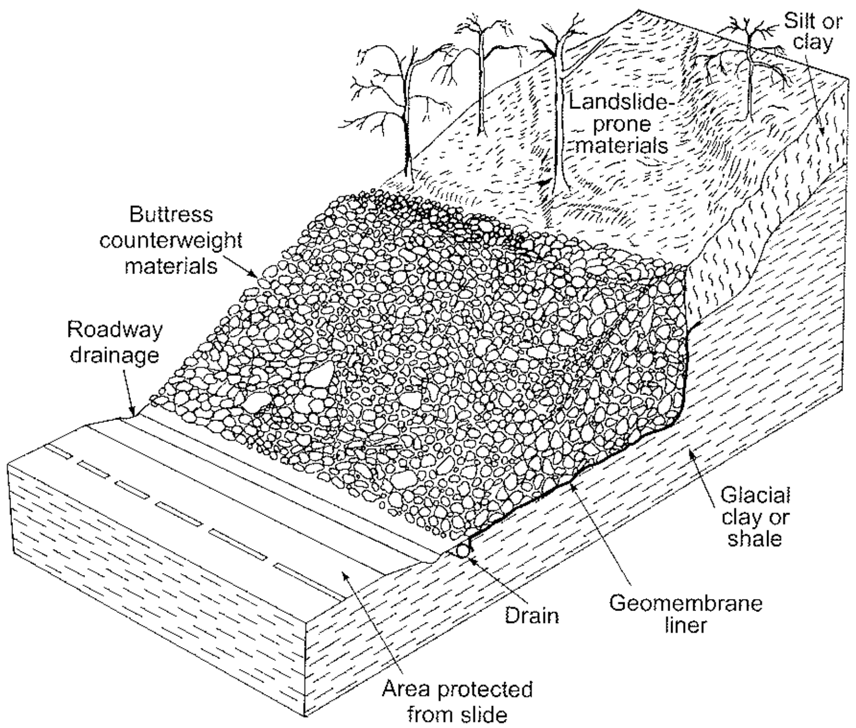



*Fig. 72. Block diagram of earth/rock buttress and counterweight structure (modified from Gedney and Weber, 1978).*

*Gabions*

Gabions are retaining walls constructed using rock-filled, cubically or rectangularly prismatically-shaped metal cages or cribs for the protection of embankments in landslide areas (Rogers, 1992). They are placed below the slide areas and backfilled with porous materials to allow water to drain out of the area and to provide a suitable barrier to sliding materials from above or behind the gabions. Geomembrane liners are installed behind and beneath the gabions (Fig. 73).

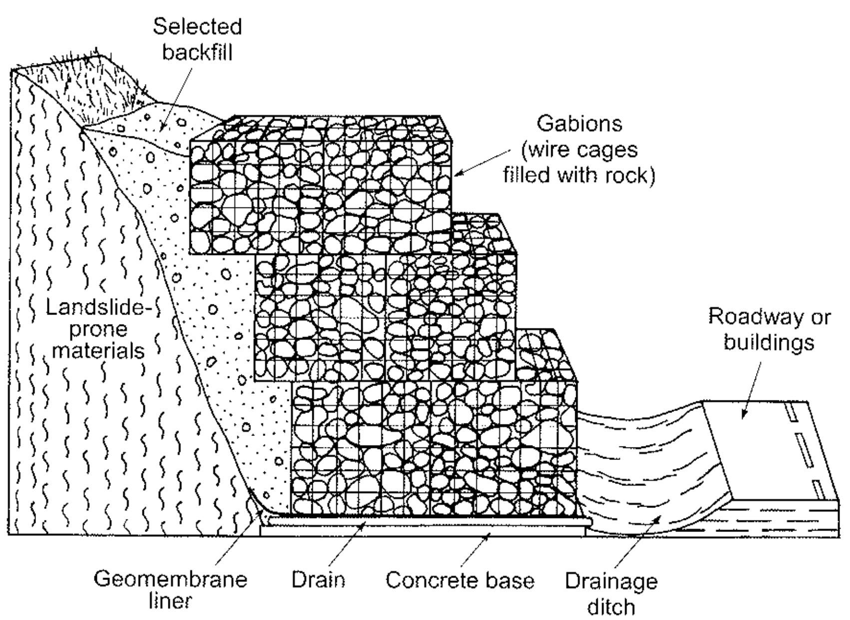



*Fig. 73. Block diagram of gabions.*

*Lightweight fills*
This type of fill is used when restoring a failed slope. It is designed to lighten the weight of the fill in the affected areas. It can be composed of materials that are lighter than regular fill, such as expanded shale, cinders, shredded tires or expanded polystyrene blocks or EPS (Aaboe, 1985; Aaboe and Frydonlund, 1988; and Yeh, 1989). The EPS blocks usually are large and are fabricated in 2 ft x 4 ft x 8 ft blocks for ease of installation (Colorado Dept. Transportation, 1988).

For remediating failed slopes using lightweight materials, slide displaced materials first must be removed. Geomembranes and drains are then installed and overlain by fill materials. This is followed by emplacement of the EPS blocks covered with a sub-base and roadway (Fig. 74).

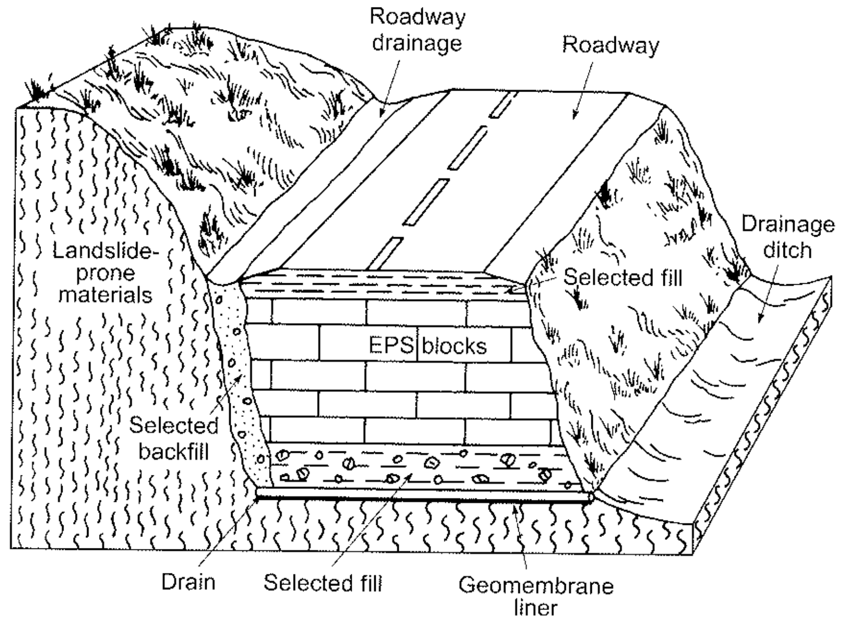


*Fig. 74. Block diagram of a lightweight fill.*

*Vegetative Control*
A common method to stabilize slopes is to plant grasses, forbs, and trees with different root lengths on the slide area (Riestenberg, 1994; Holtz and Schuster, 1996). The plant's root systems increase the tensile and shearing strength of the soil preventing erosion and dissipating the subsoil moisture to form a more stable slope.

*Avoidance*
It may be possible to avoid landslide-prone areas by either moving the roadway alignment or grade or, in the case of buildings, moving to a less hazardous area. The U.S.G.S. (Holtz and Schuster, 1996), and state geological surveys (Killey and others, 1985; Ohio Dept of Natural Resources and Geological Survey, 1986; West Virginia Geological and Economic Survey, 1976; Rheams and others, 1987; Eversoll, 1990, and this Educational Circular) show areas with landslide potential across the U.S. so that builders can better plan development.

*Combinations*
In some areas combinations of landslide stabilization and control methods are used to mitigate slides.

## OTHER METHODS

The following stabilization and mitigation methods apparently have not been used in Nebraska, however they are used in other states and may be used in the future at sites in Nebraska. These include confinement of materials with wire mesh, flexible wire netting, earth berms, stabilization with rock bolts, or changes to land use management. Evaluators should also be willing to consider using new and experimental methods when they are reported to be useful. I will describe each of these methods below, both in current use and in potential future use.

*Wire mesh confinement*
Wire mesh netting can be used to prevent rock falls from further falling onto roads or buildings below the slide (Nelson and Selvage,1989; Yarnell, 1991). The specially



designed wire mesh is anchored with rocks bolts above the affected areas and is draped down over the steep slope ending at roadside ditches or behind buildings. It is considered a passive control of rock falls (Fig. 75).

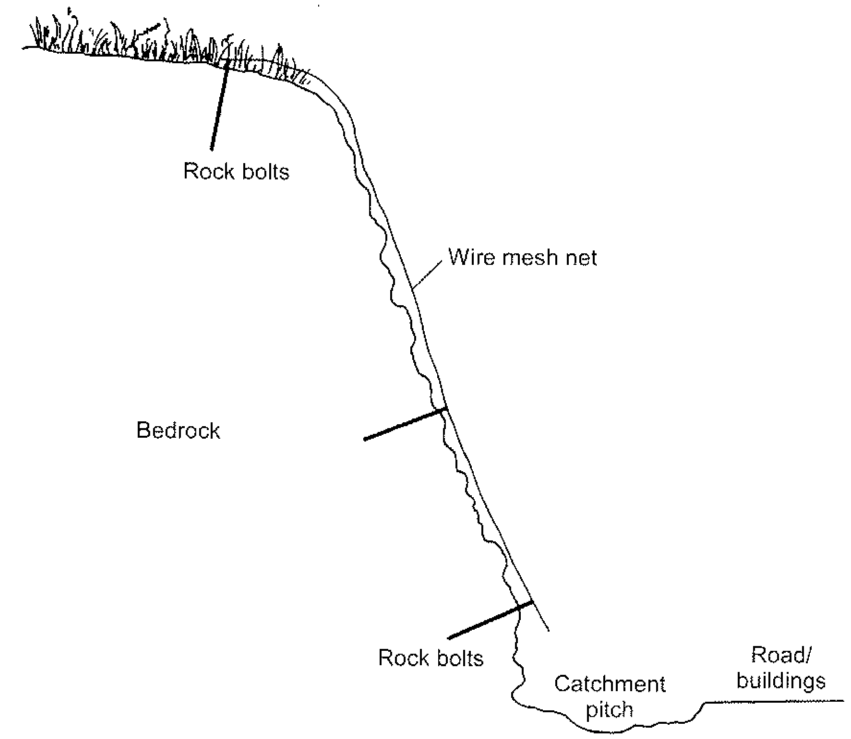


*Fig. 75. Side view of wire-mesh-netting confinement.*

*Flexible wire netting barriers*
Flexible wire netting barriers are constructed of variously shaped wire nets supported by concrete, wood, or steel posts emplaced vertically (Hearn, 1991; Yarnell, 1991). They are erected perpendicular to the slide to catch and to stop sliding materials with a flexible netting system (Fig. 76).

*Earth berms*

Earth berms, are constructed on the slopes below areas subject to landsliding (Wyllie, 1991). They are designed to capture and control rolling or falling materials (Fig. 77).

*Rock bolts*
Rock bolts are used to secure rock faces or individual blocks by drilling deeply into the rocks and inserting special bolts that expand into the rocks. The bolts are attached to plates at the rock face, thus preventing further movement (Wyllie and Norrish, 1991; Holtz and Schuster, 1996).

*Land use management*
Land use management by federal, state, or local control agencies involves the use of geo-engineered plans, grading and building permits, codes, public education, and additional landslide research and publication of landslide-prone areas to mitigate landslides (Schuster and Kockelman, 1996).

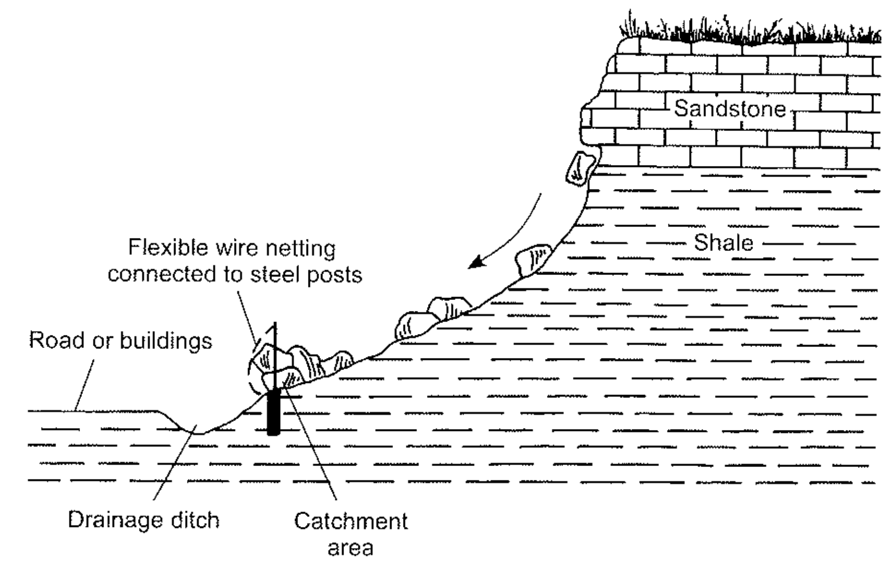


*Fig. 76. Side view of a flexible wire net barrier.*

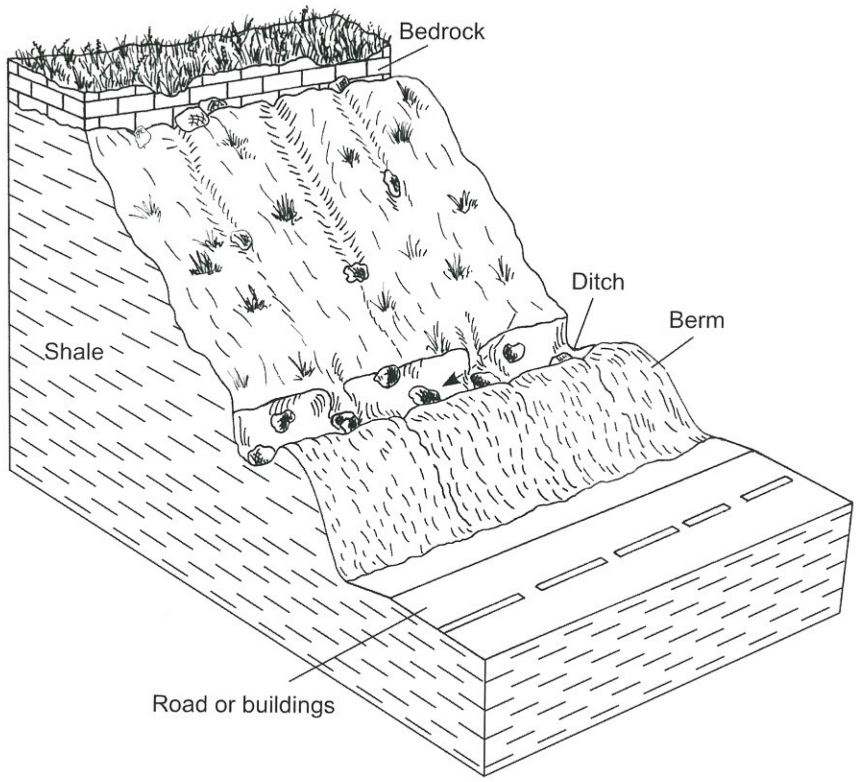



*Fig. 77. Block diagram of an earth berm.*

*New methods*

New methods include freezing part of the sliding materials, using chemicals for soil stabilization, and electro-osmotic stabilization of loose silts (Casagrande, and others, 1961). These methods have been used with varying success. Proposed new methods and ideas can be found in professional publications and in brochures from geological engineering companies and federal and state agencies.

## CONCLUSIONS

A clearer understanding of landslides and a citizen-awareness of landslide hazards may help to mitigate landslide losses. Further research aimed at continued mapping and classification of landslides and developing improved stabilization and mitigation techniques is absolutely necessary. The geologic community of Nebraska needs to continue to collaborate with organizations and agencies to share information on landslides and mitigation methods.

There are several steps that should be taken to increase awareness by Nebraska citizens of landslide hazards in the state. We need to educate all on potential problems associated with landslides, locations that may be landslide-prone and on ways to stabilize and mitigate slides. People should be taught how to read and interpret data and maps in this and other publications. We need to get this and other landslide information out to highway engineers, planners, and geologists so that they can better understand and plan roadways that avoid landslide-prone areas, mitigate damage, and stabilize and repair landslide damages when they do occur.

Although rare in Nebraska, homes and other buildings have been damaged and in a few instances removed due to landslides. In addition, overhead and buried public and private utility lines as well as pipelines carrying various products have been impacted by landslides in parts of Nebraska. Awareness of these hazards may reduce their occurrences in the future.



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# NEBRASKA LANDSLIDE INVENTORY FORM

NEBRASKA LANDSLIDE INVENTORY

COUNTY____________________ LOCATION __ __ __ __ Sec.____ Twp.___ Rge.___

Latitude________ Longitude______________ Located on___________ Topo map

SOURCE OF INFORMATION (Personal observation, publ., newspaper article, etc.)

_______________________________________________________________

_______________________________________________________________

DATES Examined or checked_______________________________________
and investigators name _________________________________________

Classification of slope movements (Check the type that fits best)

| | Bedrock | Debris | Earth |
|---|---|---|---|
| Fall........................ | ______ | _____ | ____ |
| Topple...................... | ______ | _____ | ____ |
| Rotational Slide............ | ______ | _____ | ____ |
| Translational Slide......... | ______ | _____ | ____ |
| Lateral Spreads............. | ______ | _____ | ____ |
| Flows....................... | ______ | _____ | ____ |
| Complex..................... | ______ | _____ | ____ |

GEOLOGY (Type of geologic materials; use stratigraphic names if known)

_______________________________________________________________

_______________________________________________________________

IS THE SLIDE: Active ___ Inactive ___ Natural ___ Man-induced__ Both ___

DATE OF LAST MOVEMENT, IF KNOWN_________________________________

ESTIMATED SIZE
Length: from top of slide to toe at lower part of slope_______________
Width: measured perpendicular to length at widest place_______________

CAUSE OF SLIDE: Road cut ___ Stream cut ___ Railroad cut ___ Lake shore ___
Steep slope ___ other ___ explain _______________________________

Estimated cost of Damage ____________________ Repair________________

(Picture of slide): ___ yes ___ no, located in file____________________

ADDITIONAL COMMENTS OR INFORMATION:_____________________________

_______________________________________________________________

_______________________________________________________________

_______________________________________________________________

*Form designed by author to document landslide data.*

## ABOUT THE AUTHOR


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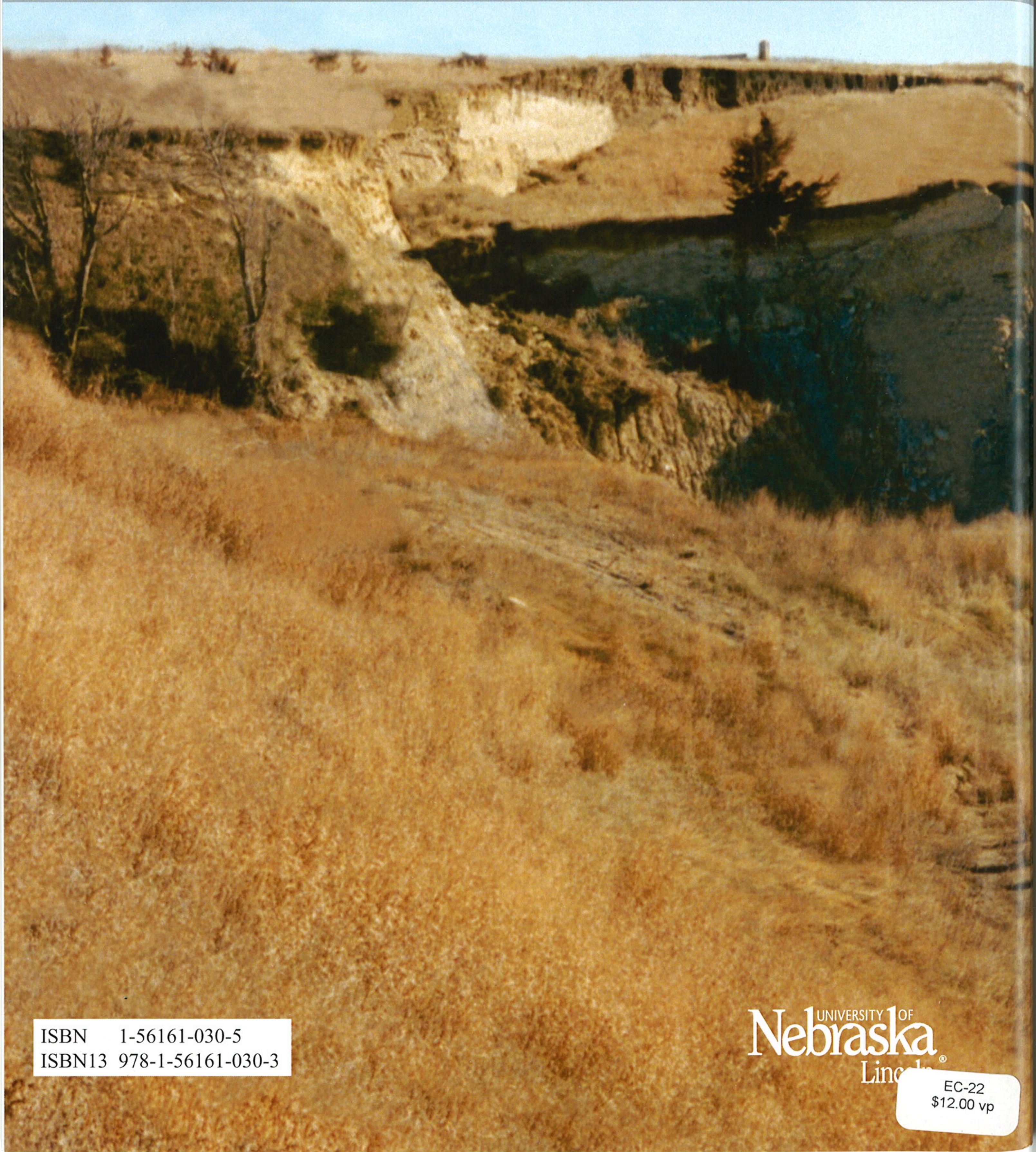
Duane is a retired research geologist and professor emeritus in the School of Natural Resources Survey Unit. His work in geology has multiple applications. In Nebraska, he provides expertise to citizens and companies in locating private water wells and encouraged well designs that meet legal requirements that protect groundwater aquifers. He advises citizens and companies about uses of geothermal energy, especially closed loop systems for homeowners.

His current research involves evaluating landslides in Nebraska. Work in this area culminates in reports and maps depicting landslide-prone areas throughout Nebraska. He works with the Nebraska Department of Roads and with counties that are affected by roadway landslides on or near their right-of-ways. Eversoll also advises and educates rural and urban residents about landslide-prone areas that may impact their homes or businesses. He provides information about mitigation to either avoid or prevent natural hazards such as landslides to all clientele.

In addition to these projects, Duane provides geological education across the state, including geological seminars and field trips for many organizations and groups. These seminars and trips have been given to participants to earn continuing education credits required by the Nebraska Department of Roads, by the Nebraska Department of Human Health Services, the Nebraska Water Well Contractors Licensing Board and the Nebraska On Site Waste Water Association.

Eversoll is involved with the National Association of State Boards of Geology (ASBOG). He served on their board from 2000-2005, as President in 2004 and as Chair of the Strategic Planning Committee, 2008-present. He is a Fellow of the Geological Society of America (GSA) and represents ASBOG in GSA's Associates Group. He was chair of GSA's Engineering Geology Division from 2002-2003. Eversoll is also a member of the Association of Engineering Geologists (AEG) and the Nebraska Geological Society.



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