

CHAPTER 16.

LANDSLIDES AND OTHER MASS MOVEMENTS

16.1 LANDSLIDE AND MASS MOVEMENT DEFINED

The following definitions apply in the discussion of landslide and mass movement hazards:

- **Landslide**—A landslide is the sliding movement of masses of loosened rock and soil down a hillside or slope. Slope failures occur when the strength of the soils forming the slope is exceeded by the pressure, such as weight or saturation, acting upon them.
- **Mass movements**—A collective term for landslides, mudflows, debris flows, falls, sinkholes and lahars.

16.2 GENERAL BACKGROUND

Land sliding (or more properly, mass movement, which includes the earth flows and debris flows and translational/rotational slides typical of the Humboldt County area) is caused by a combination of geological and climatological conditions. This includes steep topography, as well as the encroaching influence of urbanization. The geological conditions of Humboldt County are dominated by an actively faulted and sheared older bedrock (Franciscan) overlain by younger, soft marine and fluvial sediments. The majority of the region has rapid uplift rates rivaled only by the Himalayan Mountains. The combination of large rain events with easily eroded Franciscan bedrock and overlying sediments with fast uplift rates makes the Eel River one of the highest sediment producing rivers in the world, carrying 15 times as much sediment as the Mississippi. The cool, rainy Pacific Northwest climate (averaging over 100 inches a year in places) ensures that soil moisture levels remain high throughout much of the year, and in fact are often at or near saturation during the wetter winter months. The region's steep topography reflects the rapid tectonic uplift and simultaneous erosional processes working. One of the most active erosive processes during this period has been mass wasting. This is the action of landslides and mudslides, which can be triggered by rain and ground shaking events. Finally, and probably of greatest significance, the vulnerable natural setting is being steadily invaded by human residential, agricultural, commercial and industrial development and the infrastructure that supports it.

A landslide is a mass of rock, earth or debris moving down a slope. Landslides may be minor or very large, and can move at slow to very high speeds. They can be initiated by storms, earthquakes, fires, floods, volcanic eruptions, and human modification of the land.

Mudslides or mudflows (or debris flows) are rivers of rock, earth, organic matter and other soil materials saturated with water. They develop in the soil overlying bedrock on sloping surfaces when water rapidly accumulates in the ground, such as during heavy rainfall or rapid snowmelt. Water pressure in the pore spaces of the material increases to the point that the internal strength of the soil is drastically weakened. The soil's reduced resistance can then easily be overcome by gravity, changing the earth into a flowing river of mud or "slurry." A debris flow or mudflow can move rapidly down slopes or through channels, and can strike with little or no warning at avalanche speeds. The slurry can travel miles from its source, growing as it descends, picking up trees, boulders, cars, and anything else in its path. Although these slides behave as fluids, they pack many times the hydraulic force of water due to the mass of material included in them. Locally, they can be some of the most destructive events in nature.

A sinkhole is a depression in the ground with no visible outlet. Its drainage is subterranean; its size is typically measured in meters or tens of meters, and it is commonly vertical-sided or funnel-shaped.

Landslides are caused by any of the following factors: change in slope gradient, increased load on the land, shocks and vibrations (ground shaking), change in water content, groundwater movement, frost action, weathering of rocks, and removing or changing the type of vegetation covering slopes. In general, Humboldt County landslide hazard areas occur where the land has characteristics that contribute to the risk of the downhill movement of material, such as the following:

- Bedrock that is easily erodible and contains shearing, jointing, and faulting that is slope parallel
- A slope greater than 15 percent
- Landslide activity or movement during the last 10,000 years
- Stream or wave activity, which has caused erosion, undercut a bank or cut into a bank to cause the surrounding land to be unstable
- Potential for, and reaction to, ground shaking
- The presence of an alluvial fan, which indicates vulnerability to the flow of debris or sediments
- The presence of impermeable soils, such as silt or clay, which are mixed with granular soils such as sand and gravel.

Figures 16-1 through 16-4 show common types of slides that can occur in Humboldt County. Humboldt's shoreline contains many large, deep-seated dormant landslides. Shallow slides are the most common and the most probable in Humboldt County. Occasionally however, large catastrophic slides occur in most parts of the county.

16.3 HAZARD PROFILE

Common mass movement types in Humboldt County include the following:

- Translational Slides—A shallow translational sliding feature caused by groundwater pressures within a hillside and slope parallel weaknesses in bedrock near the surface.
- Rotational Slides—Deep-seated landslides and slumping with a rotational component caused by natural groundwater pressures within a hillside, removal of the slope toe, and removal of vegetation.
- Falls—Block falls of soil from high bluffs primarily along the near-vertical cliffs of the coastline and edges of river terraces.
- Flows—Shallow, rapid, liquid-like flow of the outer surface of a hillside slope consisting of coarse, fine-grained soils, or clays materials.

All of these slide types are common in Humboldt County and occur particularly in response to intense, short-duration storms, and/or in combination with larger earthquakes (greater than a 6.0 on the Richter Scale). The largest and most destructive are deep-seated slides, although they are less common than other types. The preponderance of landslides in the County occur from January through March after the water table has risen during the wet months. In addition to the coastal bluffs, land sliding is most prevalent around the slopes of the steep, northwest trending mountains and hills. Water is involved in nearly all cases; and human influence has been identified in many of the reported slides. In addition, the recognition of ancient dormant mass movement sites is important in the identification of areas most susceptible to flows and slides because they can be reactivated by earthquakes or by exceptionally wet weather. Also, because they consist of broken materials and frequently involve disruption of ground water flow, these dormant sites are more vulnerable to construction-triggered sliding than adjacent undisturbed material.

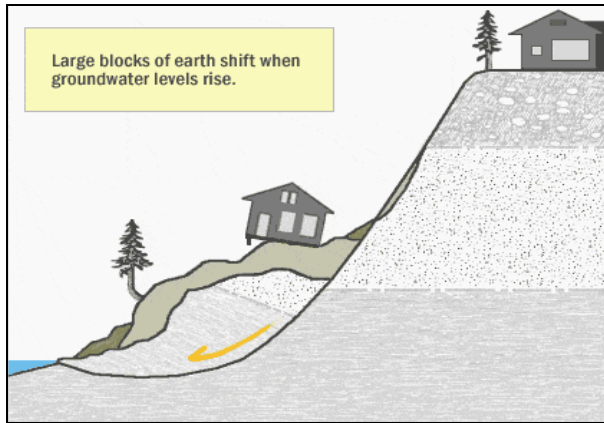


Figure 16-1: Large Rotational Slide (Deep Seated)

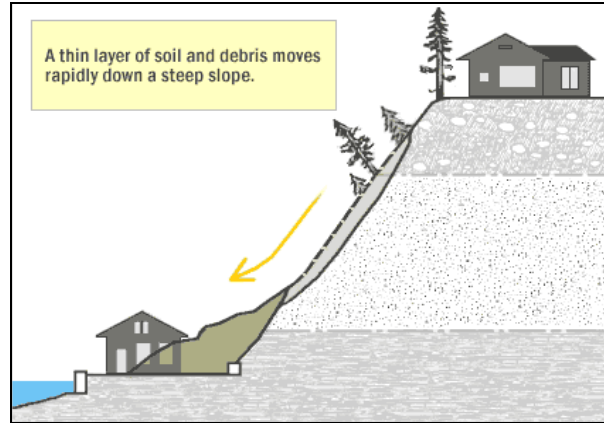


Figure 16-2: Flows

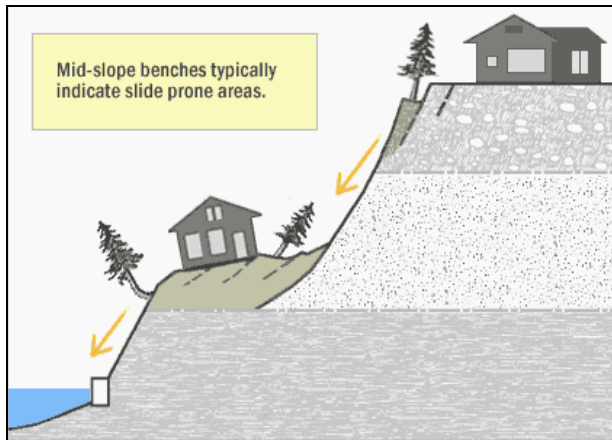


Figure 16-3: Slumps (Small Rotational) Slides

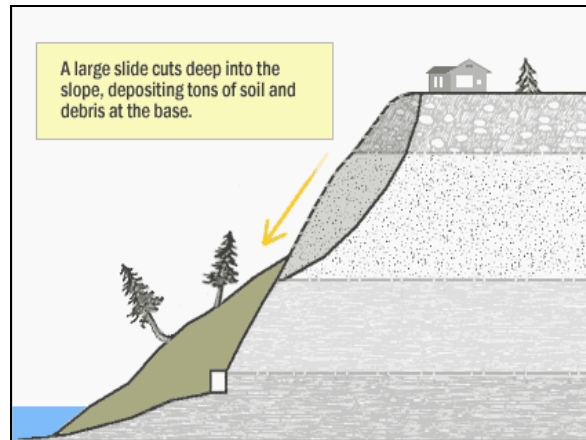


Figure 16-4: Translational Slides

Flows and slides are commonly categorized by the form of initial ground failure, but they may travel in a variety of forms along their paths. The velocity of movement may range from a slow creep of centimeters per year to many meters per second (more commonly), depending on slope angle, material and water content.

16.3.1 Past Events

Landslide activity is a frequent event in Humboldt County, with the severity ranging from minor to severe. The most recent severe and widespread landslide damage in the county occurred during the winter storm of 2005-06. Humboldt County was declared and designated a county for "California Severe Storms, Flooding, Mudslides, and Landslides" by FEMA after this event. This designation was in large part due to the record high rains and winds of the 2005-06 winter storms resulting in thousands of large and small scale landslides along every major transportation corridor of the County (U.S. Highways 101, 299, 96 and 36). The result was millions of dollars in damage and much of the County cut off from the outside world. Drainage systems and catchment basins could not handle the volume of runoff, focusing the water's energy against vulnerable slopes and manmade structures. In some cases, saturated soils simply became overloaded with the weight of rainwater and collapsed. Private homeowners, particularly in areas where the natural drainage has been paved or otherwise modified, also reported significant damage.

The landslide and mudslide/debris flow activity during winter storms of 2005-06 caused widespread disruption of surface transportation. The closing of roads in places for almost a week resulted in widespread goods shortages to Eureka and the Humboldt Bay area where the majority of the County's population resides. Slides cut off not only road transport of goods, but also services and utilities. 100-mph wind gusts blew over tens of thousands of trees, which in turn knocked out power lines. Power couldn't be serviced until roads were cleared of trees and landslides. Many people were consequently without power for a week or more. Given the shipping volume (some hazardous) by road through Humboldt County, it was fortunate that no serious chemical spills occurred.

U.S. Highway 101, the main transportation corridor in northern coastal California and Humboldt County, traverses a landslide-prone area. Landslides along this corridor, especially at Confusion Hill (Figures 16-5 and 16-6), have been an ongoing problem for decades and regularly shut down the highway (ten times in winter of 2003-04). The associated costs are estimated to be over a quarter million dollars per day in travel delay and added vehicle operating costs. Over \$14 million in emergency work has been conducted in the area to keep the highway road open in 2007 alone, and \$33 million in the last 10 years. A \$65 million highway bridge construction project is currently being constructed by the California Department of Transportation (Caltrans) to bypass the Confusion Hill slide area.

16.3.2 Location

Figure 16-7 shows relative slope stability throughout Humboldt County, indicating areas of the County that are more susceptible to landslides based on their soils and the steepness of slope. This map should be used with caution, as site-specific conditions can make some locations in low to moderate instability areas highly unstable and some locations in high instability areas less unstable.

16.3.3 Frequency

Landslides are often triggered by other natural hazards such as earthquakes, heavy rain, floods or wildfires. The frequency of a landslide is related to the frequency of these triggering events. In Humboldt County, although landslides typically occur during and after major storms, they also occur naturally in average rainfall years in remote and non-human impacted areas. Recent major events occurred during the winter storms of 1963-64, 1982-83, 1992, 1998, 2005-06, each of which generated hundreds of slides.

16.3.4 Severity

Landslides destroy property, infrastructure and transportation systems, and can take the lives of people. Slope failures in the United States result in an average of 25 lives lost per year and an annual cost to society of about \$1.5 billion. The 2005-06 storms in Humboldt County caused millions of dollars in damage due to falls, slides, and mud and debris flows. This was about half of all damage caused by the storm. The landslides caused by the storm also caused tens of millions of dollars of damage to road infrastructure.

16.3.5 Warning Time

Mass movements can occur suddenly or slowly. Some methods used to monitor mass movements can provide an idea of type of movement and amount of time prior to failure. It is also possible to determine what areas are at risk during general time periods. Assessing the geology, vegetation, and amount of predicted precipitation for an area can help in these predictions.



Figure 16-5: Confusion Hill slide, view from airplane, winter 2005-06.



Figure 16-6: Confusion Hill Slide, view looking south on U.S. Highway 101, winter 2005-06.

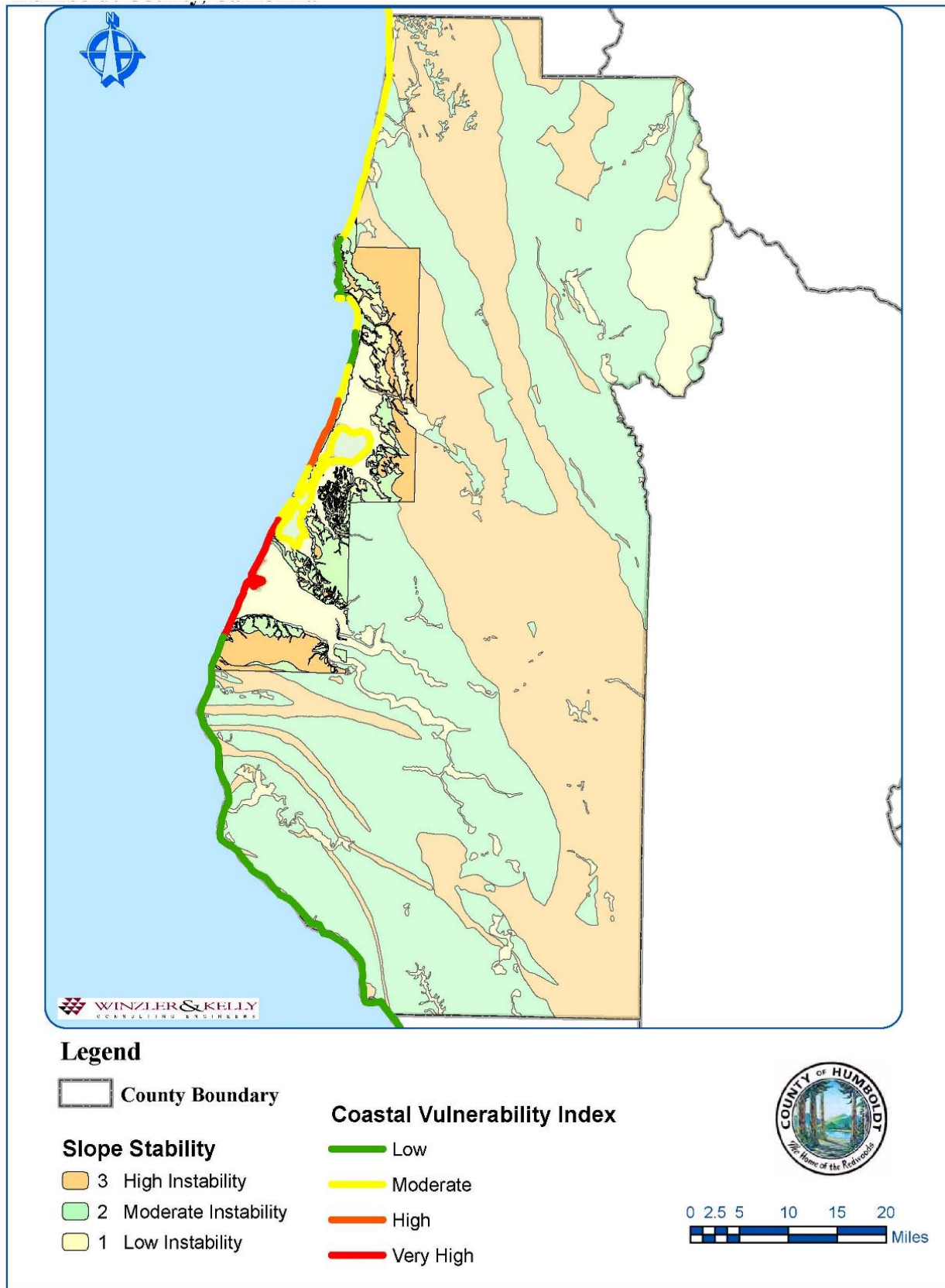


Figure 16-7: Slope Stability

16.4 SECONDARY HAZARDS

Landslides can cause secondary effects such as blocking access to roads, which can isolate residents and businesses and delay emergency response or commercial, public and private transportation. This can result in economic losses for businesses. Vegetation or poles on slopes can be knocked over, resulting in possible losses to power and communication lines. Landslides also have the potential of destabilizing the foundation of structures, which may result in monetary loss for residents. They also can damage rivers or streams, potentially harming water quality, fisheries and spawning habitat.

16.5 EXPOSURE

The slope stability map (Figure 16-7) was used to determine the Countywide exposure of population and structures to landslides. The map shows areas of relative instability based on soil types and geological structure. Highly unstable areas are spread throughout the County and are not necessarily only associated to areas of steepest slope. GIS coverage for slope stability is missing in several areas at the edges of the county. Thus, a population of 607 people and 422 houses were not classified under any slope category, less than 1 percent of the total County population and homes.

16.5.1 Population

A geographic analysis of demographics was performed using GIS data and mapping. Population figures (in census blocks) were cross-referenced with the map displaying degree of slope stability (Figure 16-7). The results of this analysis are displayed in Table 16-1. At least 29 percent of the County population lives in areas of high slope instability.

Landslide Risk	Population		Houses	
	Number	% of County Total	Number	% of County Total
High	32,042	29%	16,055	29%
Moderate	58,792	53%	29,794	55%
Low	20,467	18%	8,781	16%
Total	111,300	100%	54,630	100%

16.5.2 Property

Parcels Exposed to Unstable Slopes

An analysis of parcels was done to determine the number and value in highly unstable slope areas. Table 16-2 shows the parcels exposed to unstable slopes in Humboldt County. There are 14,317 parcels on highly unstable slopes in Humboldt County, 12,900 of which are in unincorporated areas. Altogether about \$760 million in property is exposed to areas of high landslide potential.

Unstable Slopes and Zone Type

Table 16-3 shows the value of commercial, residential, and industrial parcels exposed to highly unstable slopes by jurisdiction. Valued at over \$663 million, residential zoning in Humboldt County has most of the value associated with highly unstable slope exposure (87 percent).

**TABLE 16-2.
HUMBOLDT COUNTY PARCELS EXPOSED TO HIGHLY UNSTABLE SLOPES**

Jurisdiction	Number of Parcels	Total Area (Acres)	Value
Arcata	197	224	\$28,475,594
Blue Lake	255	93	\$24,032,922
Eureka	0	0	\$0
Ferndale	7	3	\$128,081
Fortuna	0	0	\$0
Rio Dell	0	0	\$0
Trinidad	44	28	\$1,545,333
Tribes	411	24,584	\$8,650,703
Unincorporated County	12,900	900,684	\$696,950,198
Total	14,317	925,616	\$759,782,831

**TABLE 16-3.
HUMBOLDT COUNTY EXPOSED TO HIGHLY UNSTABLE SLOPES BY ZONING TYPE**

Jurisdiction	Value Commercial	Value Residential	Value Industrial	Value Other	Total
Arcata	\$1,523,544	\$26,330,007	\$439,216	\$182,827	\$28,475,594
Blue Lake	\$751,745	\$21,612,605	\$561,361	\$1,107,210	\$24,032,922
Eureka	\$0	\$0	\$.0	\$0	\$0
Ferndale	\$59,991	\$68,090	\$-	\$-	\$128,081
Fortuna	\$0	\$0	\$.0	\$0	\$0
Rio Dell	\$0	\$0	\$.0	\$0	\$0
Trinidad	\$0	\$1,545,333	\$0	\$0	\$1,545,333
Tribes	\$8,637	\$8,642,065	\$0-	\$0	\$8,650,703
Unincorporated County	\$40,285,677	\$605,028,186	\$41,723,118	\$9,913,218	\$696,950,198
Total	\$42,629,594	\$663,226,286	\$42,723,694	\$11,203,256	\$759,782,831

Land Use Exposed to Steep Slopes

Table 16-4 shows the general land use of parcels exposed to landslides for all unincorporated areas of Humboldt County. Lands used for timber related, rural residential, and single family residential land uses are the most vulnerable; while lands used for schools, gravel mining, industrial, and camping are less vulnerable. The predominant land uses for parcels in the unincorporated County are timber and residential related. This table presents data only for parcels exposed to steep slopes in unincorporated Humboldt County.

TABLE 16-4. UNINCORPORATED PARCELS EXPOSED TO HIGH INSTABILITY BY LAND USE TYPE			
Land Use Type	Unincorporated Area	Land Use Type	Unincorporated Area
Agriculture	77	Multi family residential	44
Camp	1	Multi family residential - vacant	2
Church	12	Open space/parks	886
Commercial	79	Public	188
Commercial - vacant	154	Rural residential	2788
Golf course	5	Rural residential - vacant	1852
Gravel mining	2	School	1
Grazing/timber	1203	Single family residential	794
Heavy industrial	14	Single family residential – vacant	2421
Heavy industrial - vacant	15	Timber production	3152
Light industrial	7	Tribal lands	78
Light industrial - vacant	3	Vacant	9
		Grand Total	13,787

16.5.3 Critical Facilities

Most of the critical facilities in the County are located in the City of Eureka and the unincorporated parts of the County (see Table 16-5). As Tables 16-5 through 16-7 show, almost 11 percent of these are in areas of high slope instability.

TABLE 16-5. NUMBER OF CRITICAL FACILITIES IN JURISDICTIONS				
Jurisdiction	Low Instability	Moderate Instability	High Instability	Total
City of Arcata	43	25	2	70
City of Blue Lake	6	0	1	7
City of Eureka	147	1	0	148
City of Ferndale	6	0	0	6
City of Fortuna	41	1	0	42
City of Rio Dell	11	7	0	18
City of Trinidad	7	0	1	8
Tribes	20	15	4	39
Unincorporated Areas	257	176	84	517
Total	538	225	92	855

**TABLE 16-6.
NUMBER OF CRITICAL FACILITIES IN EACH SLOPE STABILITY CATEGORY**

Type of Facility	Low Instability	Moderate Instability	High Instability	Total
Medical and Health Services	25	5	1	31
Government Function	20	7	2	29
Protective Function	45	31	11	87
Schools	58	15	10	83
Societal Function	13	7	4	24
Hazmat	15	3	1	19
Other Critical Function	120	20	9	149
Total	296	88	38	422

**TABLE 16-7.
NUMBER OF CRITICAL INFRASTRUCTURE FACILITIES IN EACH SLOPE STABILITY CATEGORY**

Type of Facility	Low Instability	Moderate Instability	High Instability	Total
Water Supply	7	3	2	12
Water Storage	25	37	19	81
Waste Water	15	2	1	18
Power	9	3	3	15
Fuel storage	66	8	4	78
Communications	6	4	0	10
Bridges	104	79	25	208
Other Critical Infrastructure	4	0	0	4
Total	236	136	54	426

16.5.4 Infrastructure

A significant amount of infrastructure (roads, bridges, and utilities) can be exposed to mass movements. Landslides have the potential to block egress and ingress on roads, causing isolation for portions of or even the entire County. Roadway blockages caused by landslides can also create traffic problems, resulting in delays for emergency vehicles and for public and private transportation. This could result in economic losses for businesses. Other potential problems resulting from landslides are power and communication failures creating problems for vulnerable populations as well as businesses or potential loss of life in emergency situations.

Roads

Most of the major roads in Humboldt County are exposed to mass movement hazards. Access to major roads is crucial to life-safety after a disaster event and can help to provide resilience during response and recovery operations

Bridges

Landslide events can significantly impact road bridges. Mass movements can knock out bridge abutments or significantly weaken the soil supporting them, making them hazardous for use or creating conditions in which bridges are obstructed. Many bridges in areas of high to moderate landslide risk are important because they provide the only ingress and egress to large areas.

Power Lines

Power lines are generally elevated above steep slopes; nonetheless the towers supporting them can be subject to landslides. A landslide can trigger the soil underneath a tower to fail, causing it to collapse, and ripping down the lines. Pacific Gas & Electric lines pass through many highly unstable slope areas.

16.5.5 Environment

Environmental problems as a result of mass movements can be numerous. Landslides fall into streams and significantly impact surrounding fish and wildlife habitat, and affect water quality for short to long periods of time.

16.5.6 Other Assets at Risk

Natural Resources

Natural resources are highly valued by residents of Humboldt County for their contribution to the local quality of life, and as an economic development asset that attracts tourist-related expenditures. Landslides are part of the natural environment. However, when they occur they can destroy natural assets that are highly valued by the community.

Agricultural and Timber Resources

Agricultural resources include rangelands, timberlands, cultivated farmlands and dairy lands. Agricultural lands are an important element of the Humboldt County identity and economy. Landslides can have major consequences to such resources, primarily timberland due to the large percentage of such land in remote locations on steep slopes. Roads accessing timberlands are often susceptible to slides and frequently are contributing factors to landslides. Landslide activity on these roads can remove them from production.

Cultural Resources

The Humboldt County General Plan Cultural Resources Section provides an overview of culturally sensitive resources in the county (Humboldt County, 1984):

Before European settlement, the Humboldt County area was one of the most culturally diverse regions of California, being home to nearly a dozen distinct peoples. In large part, Native American tribes occupied distinct areas conforming largely to the natural watershed basins. Culturally sensitive areas are sites and regions of special importance to Native Americans, primarily coastlines and riverbanks with outstanding religious or resource-producing importance. Over 32,000 acres of land in Humboldt County are designated as culturally sensitive, with notable concentrations along the Lower Klamath,

the Lower Trinity, lower end and North Fork of the Mad, and the Van Duzen Rivers, and the eastern shore of Humboldt Bay.

Culturally sensitive areas exist on both public and private lands. While some locations are publicly identified, others are held as confidential information by Native American organizations. Many cultural sites are at risk of incidents of landslides and mass movements, which can destroy artifacts and structures.

The North Coast Information Center at the Yurok Tribe maintains records of 2,040 cultural resource sites, including cemeteries, villages, and lithic scatters (surface-visible concentrations of stone chips, flakes, and tools). Three-quarters of these resources are located along rivers and major tributaries; the remainder is located in flat mountainous areas or prairies. High-density sites (villages, cemeteries, and ceremonial and gathering areas) are concentrated in the Hoopa and Yurok reservations, Karuk tribal lands and riverine areas. Ridgelines along rivers and creeks, where traveling between villages likely occurred, and lithic scatters around Trinidad, Humboldt Bay, the Eel delta, and Shelter Cove are considered medium-density resource sites. In addition to these resources, the County is home to a World Heritage Site designated by the United Nations (the World's Tallest Tree at Redwood National Park), 48 structures or locations listed on the National Register of Historic Places, and 13 California Historic Landmarks.

Scenic Resources

There are a broad range of scenic resources in Humboldt County, including the coastline and Pacific Ocean, mountains, hills, ridgelines, inland water features, forests, agricultural features, and distinctive rural communities. Many of these resources are exposed and vulnerable to landslides, or mass movements, and can be directly impacted by a landslide, or access to the resource area.

Coastal Views

Humboldt County's varied and extensive coastline allows for a wide range of scenic vistas from State Highway 101 and from beaches, state parks and Coastal Access points. The County's Local Coastal Program includes a technical study on visual resources. The study includes a detailed inventory of local visual resources along the coastline and identifies areas as "highly scenic" and "visually degraded areas" (Humboldt County, 1979). A more recent discussion of Humboldt County's existing scenic resources, viewshed evaluation and policy discussion is contained in the *Natural Resources and Hazards Discussion Paper* document prepared for use in the General Plan Update (Dyett and Bhatia, 2002). Landslides could visually impact these views or prevent access to views.

Forests

Forestlands define much of the visual landscape of Humboldt County. Redwood National Park, Six Rivers National Forest, Redwoods State Park, and Kings Range National Conservation Area are all significant, protected forests within the County. Forestland is abundant well beyond these protected areas. The scenic value of these natural resources, viewed both from within or from outside, is of great importance. Landslides are a natural part of forest lands and can have an impact.

Scenic Highways

Several highways in Humboldt County have unique scenic qualities because of their natural setting. A scenic road is defined as a roadway that, in addition to its transportation function, provides opportunities for the enjoyment of natural and scenic resources. Scenic roads direct views to areas of exceptional beauty, natural resources or landmarks, or historic and cultural interest. Although no highways in Humboldt County are "officially designated" as California State Scenic highways, several State Highways are eligible for official designation: Route 36 from Route 101 near Fortuna to the Trinity County line; Route 96 from Route 299 at Willow Creek north to Siskiyou County; Route 101 for its entire

length in Humboldt County; and Route 299 from Arcata to Willow Creek. Local Humboldt County roadways also have significant scenic view values (Dyett and Bhatia, 2002). Because these routes are frequently located in less developed areas, they are frequently susceptible to landslides.

16.6 VULNERABILITY

16.6.1 Population

Due to the nature of census block group data, it is difficult to determine demographics of populations vulnerable to mass movements. In general, all persons who are exposed to landslide hazards are also vulnerable. Due to Humboldt County's increasing population density and the fact that many man-made structures are built on "view property" atop or below bluffs and on steep slopes subject to mass movement, more lives are now endangered by this hazard than ever before. Public education and outreach efforts in this regard will need to be particularly focused on the economically and, due to age or disability, inherently most vulnerable community members.

16.6.2 Property

The effects of slide and flow activity seen during the winter storms of 2005-06 indicate significant vulnerability to such hazards. Countywide, the millions of dollars in damage attributable to mass movement during those storms affected private property and public infrastructure and facilities.

As the population continues to grow, more people are building and living on or otherwise modifying land areas with marginal stability. Humboldt County's steep coastal bluffs and river and stream front properties are the sites of debris flows and other types of landslides, yet many of the landslides occurring there cannot be seen from aerial reconnaissance. These failures are only clearly visible from fairly close quarters on the ground. These are areas of intense development pressure. An accurate picture of where landslides were triggered during previous storms is vital in making intelligent land use planning decisions. Consideration of existing landslide susceptibilities and potential hazards will reduce the risk to people and property both now and with future development. In the past, many mass movement losses may have gone unrecorded because insurance companies do not cover such damages. Transportation network damage has often been repaired under the general category of "maintenance."

16.6.3 Infrastructure

Several types of infrastructure are exposed to mass movements, including transportation, water and sewer and power infrastructure. Disruption of transportation routes results in loss of commerce. Highly susceptible areas of the County include the mountain and coastal roads and transportation infrastructure. At this time, all infrastructure exposed to the landslide hazard is considered vulnerable.

16.6.4 Critical Facilities

There are 92 critical facilities exposed to highly unstable slope areas. A more in-depth analysis of the mitigation measures taken by these facilities to prevent damage from mass movements should be done to determine if they could withstand impacts of a mass movement.

16.7 FUTURE TRENDS IN DEVELOPMENT

The Humboldt County planning area has experienced a relatively low rate of growth in past years (less than 1 percent per year). Considering these historical trends and future population projections produced by the state, anticipated development trends for the planning area are considered low, consisting primarily

of residential development with the exception of the Eureka and Fortuna areas. Development trends in Humboldt County are not such that there is major concern about development in areas of high slope instability. However, any new development in the County is likely to be in areas of high slope instability.

16.8 SCENARIO

A mass movement event is most likely to occur during the late winter when the water table is high. A short intense storm could cause the saturated soil to move, resulting in landslides. Mass movements could affect bridges that pass over landslide prone ravines and knock out road service through the county. Most mass movements would likely be isolated events, affecting specific areas.

Major mass movements in Humboldt County occur as a result of soil conditions that have been affected by severe storms, groundwater or human development activities on steep unstable slopes. After heavy rains from November to December, soils become saturated with water. As water seeps downward through upper soils that may consist of permeable sands and gravels and accumulates on impermeable silt, it will cause weakness and destabilization in the slope. As rains continue, the groundwater table rises, adding to the weakening of the slope. Gravity, poor drainage, a rising groundwater table and poor soil exacerbate hazardous conditions.

The worst-case scenario for mass movement hazards in Humboldt County generally corresponds with a severe storm that had heavy rain and caused flooding. It is probable that private and public property including infrastructure would be affected.

Road obstructions caused by mass movements would likely occur, creating isolation problems for residents and businesses in populated but sparsely developed areas. Property owners exposed to steep slopes likely would suffer damage to either the property or the structure itself. In addition, landslides carrying vegetation such as shrubs and trees may cause a break in power or communication lines, cutting off power and communication access to residents.

Continued heavy rains and flooding would complicate this problem further. As resources within Humboldt County attend to problems with flooding, it is possible they may be unavailable to assist with landslides. This would worsen the problem of isolation for residents and disrupt commerce.

Based on historical events and the prevalence in the County of steep slopes with a potential for instability, it is likely that mass movements would occur anywhere in the county that has been affected by historical landslides and areas that have potential steep slopes.

16.9 ISSUES

The planning team has identified the following issues related to the landslide hazard that are consistent within the planning area:

- There is a risk of isolation of the entire County (worst case) or neighborhoods and communities due to the fact that large portions of the transportation infrastructure are in areas of high and moderate slope instability. This includes food shortages, loss of power, and severely reduced economic productivity.
- There are a large number of critical facilities (92) in the planning area that are in areas of highly unstable slopes and could have a significant amount of functional downtime post event. This not only creates a need for mitigation but a need for continuity of operations planning to develop procedures for providing services without access to essential facilities.

- There is a large value (\$663 million) of residential parcels located in areas of high slope instability.
- Landslides can cause a loss of water quality to the environment and for drinking purposes due to increased sediment delivery into surface waterways.
- The risk associated with the landslide hazard overlaps the risk associated with other hazards such as earthquake, flood and tsunami. This provides an opportunity to seek mitigation alternatives with multiple objectives that can reduce risk for multiple hazards.