

The Greater Yellowstone Area
Watershed Vulnerability Modeling Project

By

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OBJECTIVES AND STUDY AREA

On November 29, 2000 a multi-regional task force of hydrologists and soil scientists reviewed a variety of products from the Inland Water Ways Initiative (IWWI) relating to the Greater Yellowstone Area (GYA.) They examined six geographical products (Watershed Vulnerability, Watershed Geomorphic Integrity, Watershed Water Quality, Damaged Stream Segments, and Crucial Stream Segments.) Errors in these spatial data and their database attributes were generally found to be amenable to relatively minor editing. The exception is the Watershed Vulnerability data, which has major cross-administrative boundary differences, significant data gaps, and some major inconsistencies related to the quality and scale of data available at the time of ratings. Many of these ratings were made based on professional judgment and manual methods, and some of the rating individuals have since moved on.

Since these ratings were made, data quality and digital support methods have improved dramatically. The Interagency Spatial Analysis Center (ISAC) proposed to use these data, geographic information systems (GIS), and a modeling approach to build a model of watershed vulnerability for the entire GYA. Some specifications of this model follow:

- The most consistent system of rating vulnerability uses landtype-level data to aggregate sensitive lands to a watershed level. Landtypes or Ecological Land Units (ELU) in TEUT's (Terrestrial Ecological Unit Inventories) have the necessary information to provide the relevant criteria for the IWWI vulnerability layer. The model uses the "Landscape Model of the Greater Yellowstone" which includes digital, TEUI spatial and attribute data for 90 percent of all GYA administrative units. For those units where TEUI mapping is not complete or is at too broad a scale for this project, we will complete that mapping or model the relevant criteria.
- Criteria will include the "highly dissected" lands, not used in some earlier ratings.
- Watershed boundaries (HUC6) will be upgraded to currently available data. However, the model will be created for existing HUC6's also, since the other ratings maps are based on this earlier data, and we need to maintain consistency with these maps.

We proposed the project at the December meeting of the Greater Yellowstone Coordinating Committee, and accepted in February of 2001. It was funded in April of that year. This report shares results of the project. This report is in final draft form. Results were reviewed in December 2001 by the Greater Yellowstone Hydrologist Group. A final review will take place at their February 2002 meeting and the final report will be published at that time. Current data are available from the authors.

The Greater Yellowstone Area (GYA) can be defined in many different ways. For this study, we defined it as a block of federal land centered on Yellowstone National Park, with some included private lands that are surrounded by other federal lands (Figure 1.) Only federal and some included private lands are used because the data used in determining vulnerability is complete only for those lands and we want to be consistent with the earlier 1999 IWWI study.

To standardize the GYA for the study, we used a digital coverage (called GYAFS_BDY) of the area to define boundaries. We modified this from a 2000 coverage obtained from the Geometrics Service Center in Salt Lake City, which created it from Forest and National Park spatial data. The Extent (Table 1) and location (Figure 1) of GYA administrative units are based on this coverage.

These figures are approximate and may not be in complete agreement with more detailed work or with other coverages. However, they are of sufficient accuracy for this study. As in many large, complex studies using multiple data sources, figures given later in this study may vary from these totals. This is often because of small data and version differences, but may also be due to differences in definitions and sources of data. These differences are explained where they occur.

Some administrative units are only partially within the GYA. Not all area within these administrative units is included (Figure 1.) Only the Madison District of the Beaverhead-Deerlodge National Forest is used. For the Caribou-Targhee N. F., the non-contiguous portions of the Caribou National Forest are not used, as well as the lands west of IWW1 watershed 170402150604 on the western extension of the Targhee National Forest. For the Custer N. F., only the Beartooth District is included.

Table 1. Land Area by Administrative Unit as used in this study

Administrative Unit	Total Area (Acres)*
Beaverhead-Deerlodge N.F.	750,581
Bridger-Teton N.F.	3,462,802
Caribou-Targhee N.F.	2,094,976
Custer N.F.	525,302
Gallatin N.F.	2,124,751
Grand Teton N.P.	333,139
National Elk Refuge	25,343
Red Rock Wildlife Refuge	58,811
Shoshone N.F.	2,466,963
Yellowstone N.P.	2,197,031
Total Administrative Area	14,039,699

* Unit areas are for the Greater Yellowstone Area only.

Private lands within administrative coverage	282,237
Total Area from Administrative Coverage	14,321,936

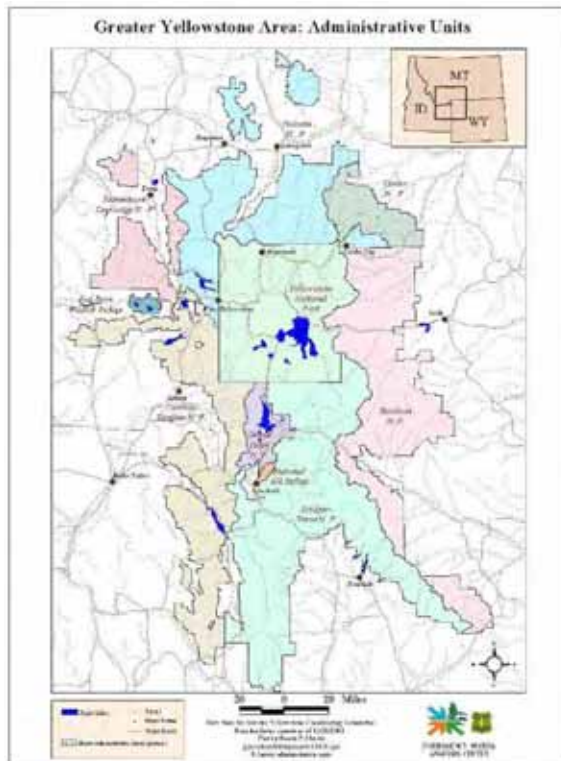


Figure 1. Greater Yellowstone Area: Administrative Units

METHODS

The IWWI Criteria and their Interpretation for This Model

Criteria given in Inland West Watershed Initiative (IWWI) literature are applied in this model for all lands in the GYA. One of our objectives is to develop a model to map these criteria uniformly across the entire area. Furthermore, all ratings are to be based on properties of the landscape, not interpretations of those properties. This will maximize consistency across management units, minimize subjective input on the part of project personnel, and allows re-mapping of the model as data and criteria change.

The following discussion is taken from an unpublished document provided by the IWWI Denver project team in 1999. This is titled "Inland West Watershed Reconnaissance." The term "watershed vulnerability" refers to the inherent risks of conditions becoming degraded if certain sensitive lands in a watershed are disturbed. This is not dependent on existing conditions, but only on the potential landscapes have for degradation. Ratings are based on the proportion of "sensitive lands" in a given watershed. This term refers to areas where disturbances pose a high probability of degrading watershed soil-hydrologic functions. Ratings include: Low = less than 20% of the watershed is in sensitive lands; Moderate= 20 to 50% are in sensitive lands; and High= more than 50% are in sensitive lands.

Lands must meet at least one of three criteria for designation as "sensitive." These criteria include "highly dissected" slopes, "highly-erodible soils", or "landslide deposits and potential landslides."

Highly Dissected Slopes

Lands that are highly dissected have relatively dense stream networks. Their presence indicates running water has had a prominent role in landscape development. Any disturbance in these areas is likely to be close to a stream channel, increasing likelihood of sedimentation. The definition of "highly dissected" is open to discussion. In some circles it indicates slopes have deeply-incised drainageways. Some define it as a condition where all table or mountain lands have been dissected by streams, or other geomorphological process. Some refer to it as a condition where drainageways are closely spaced on steep slopes. Some specialists refer to areas where topographic maps indicate many crevasses, regardless of source. It can be interpreted as dissection frequency, depth of dissection, or a combination of these terms.

The objectives of this modeling effort include developing repeatable, quantitative measures applicable consistently over the entire GYA. Also, we want to emphasize the presence of stream channels without the additional interpretations needed for a classification of geomorphological process. Therefore we have defined "highly dissected" in terms of drainage density only, using a published guide (Haskins, et. al., 1998.)

Under Dissection Frequency Class, the following ratings are given.

- Un-dissected (0 channels per mile)
- Slightly Dissected (1-3 channels/mile) (1760 – 5280 ft/drainage) or (537 – 1609 m/drainage)
- Moderately Dissected (3-10 channels/mile) (528 – 1760 ft/drainage) or 161 – 536 m/drainage)
- Highly Dissected (more than 10 channels/mile) (less than 528 ft/drainage) or less than 161 m/drainage)

The “highly dissected” frequency class is probably significant to hydrologic functioning at a watershed level. Using a digital representation of topography, we manually digitized these areas on-screen at a scale of 1:100,000, using a minimum map unit of 320 acres (129 ha.) This area was selected because it is relatively small compared to the average area of HUC6 watersheds, our summary unit, and is large enough to contain enough drainageways that we can determine drainage density. This level of detail is equivalent to the “Landscape” level in the National Hierarchical Framework of Ecological Units published by the Forest Service (ECOMAP, 1993.)

We consider fluvial dissection as the only process significant in increasing landscape sensitivity. Though dissection of landforms can relate to many landscape forming processes. Some of these are glaciation, mass-wasting, fault-controlled colluviation (slow, particle-based downhill movement), snow avalanche-scouring, or running water (fluviation). In the GYA, glaciation is the primary non-fluvial process involved in landscape dissection. This process left many apparently dissected areas that may or may not be sensitive today. Therefore glacial dissection was not used as mapping criteria.

Landscape sensitivity is sometimes related to climatic and geologic cycles not operating today. For example, some highly-dissected lands in relatively dry country were formed during post-glacial periods of high rainfall, and their character is “relict” from this time period. Little rainfall occurs today, so the landforms are relatively stable and lack sediment-transporting agents. We would prefer to differentiate this “relict” dissection from that which indicates sensitivity. To model this on a landscape basis, we would identify highly-dissected land areas that are in habitat types indicating relatively-dry current climatic conditions. These could be eliminated from further analysis. However, because “highly-dissected” is a relatively specific requirement in the IWWI criteria, we have not included this as differentiating. This will result in a probable over-estimation of “sensitive” lands using this criterion.

No existing inventories contain sufficient geomorphological description to be used for the delineation of highly-dissected lands as defined above. Criteria and terminology varied across surveys depending on their objectives and time-scale. No GYA-wide landform maps exist at the level of detail required for this project. Therefore we looked at ways of delineating an independent inventory of this single-factor characteristic.

Use of stream net development functions in GIS appears to work in small areas, but our trials indicate results are inconsistent over areas as large as a National Forest, which is small compared to the GYA. Though analysis of crenulations on contour maps shows promise for automating this process, there is no methodology developed that is usable on corporate equipment. Though the science of landform morphometry is advancing, only relatively simple measures oriented towards small areas have been developed. Because of the need for synthesis of many visual cues required in

delineating dissection, manual delineation remained the only practical way to delineate these kinds of landforms.

We used GIS to make this process practical for the land area known as the GYA. Delineations were derived from interpreting a georeferenced "hillshade" image at a 30 m resolution. These hillshades are designed to shade the part of the topography facing away from an imagined "sun." A disadvantage of this orientation is that some of the topography is in "shade." To mitigate this problem, a high sun angle was used in the model, and two hillshades were used with opposite sun angles (Figure 2) computed with an opposite sun orientation to obtain a complete picture of dissection. Excessive DEM errors (banding and data dropouts) occurred in the southern part of the study area. These problems were overcome by obtaining a more current DEM for that part of the study area.

The dissection criteria were applied to the contour, perpendicular to the longest dimension of a candidate landform. For mapping efficiency we determined that a 200 m drainageway density was more practical than the 161 m spacing specified above, and used that for the delineation criterion. Though visibility at the scale of mapping was the only criteria we used for strength of dissection, it is likely that only drainageways having more than about 100 meters of relative relief would be visible and measured in this study. The final coverage was created by digitizing on-screen as in ARC™.

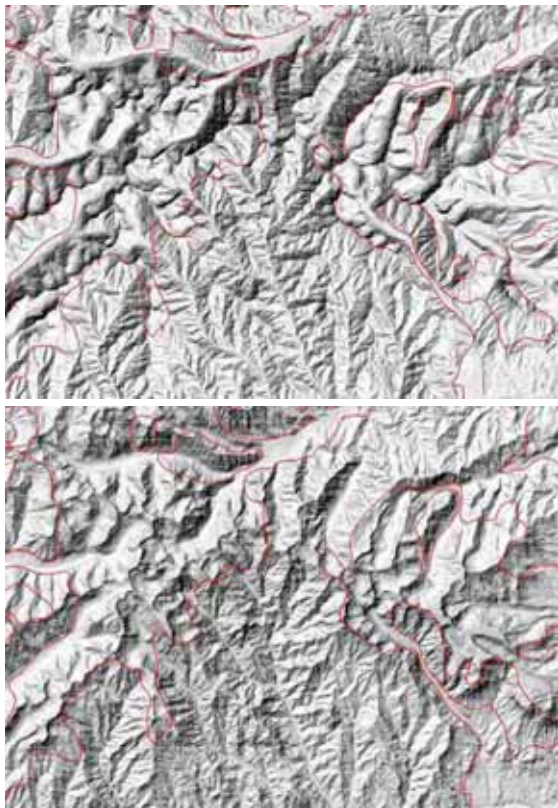


Figure 2. 1:100,000 scale view of hillshades and highly-dissected lands (upper is from sun azimuth of 135 deg and the lower is from an azimuth of 315 deg.)

Highly-Erodible Soils

Technically, “soil-erodibility” is an inherent property of the soil itself. Soil properties that affect infiltration, permeability, total water capacity, dispersion, splash, abrasion, and transport also affect erodibility. Actual “soil-erosion hazard” can be high or low with a given soil-erodibility, depending on slope, land cover, weather and climate conditions, landforms (including degree of dissection) and kind of disturbance (Kirkby and Morgan, ed., 1980.) For example, some soils on high-elevation tundra have high organic content, moderate textures, and a relatively low erodibility. However the high precipitation and short growing season mean that even with a relatively low erodibility, soils, will erode quickly if disturbed, and have a very long recovery period (Davis and Shovic, 1996.)

The example emphasizes that, with some exceptions, forested erosion and sedimentation events are significantly related to the environmental factors within which the soils exist, rather than solely from inherent properties of the soils themselves. This variability is an inherent weakness in using soil erodibility alone as an indicator of “sensitive” lands. However, since this is a relatively specific requirement in the IWWI document, we have used only soil properties to rate this factor. This will result in a probable under-estimation of “sensitive” lands using this criterion.

Properties affecting water erodibility include soil texture, organic matter content, size and stability of structural aggregates of the exposed layer, permeability of the subsoil, and depth to a slowly permeable layer. An approximation of an index of soil erodibility can be obtained by using soil texture (silt and very fine sand content, sand content), organic matter content, soil structure, and permeability (Kirkby and Morgan, ed., 1980.) Soils with high silt and very fine sand contents tend to have high erodibility factors, whereas sandy or clayey soils have rather low factors. Erodibility is also related to organic materials in the soil. Soils with high organic matter contents have somewhat lower factors than soils with low contents. Shallow soils are more erodible because of lower water-holding capacity and effective permeability.

These properties are mapped in different ways across the GYA in a variety of soil surveys and ecological unit inventories. The individual inventories have been integrated into one standardized spatial model, called the GYA Landscape Model (Shovic and Urie, 2001.) Though properties affecting soil erodibility are not directly mapped or described in this model, they can be inferred using the technical classification of soils, using Soil Taxonomy (USDA, 1999.) We used the soil classification to create a relative rating of erodibility at the landscape level, based on the above theory, standardized interpretive models (USDA, 1992, pp. 21-25; 1993, p. 297) and field experience in the GYA.

In taxonomic terms (USDA, 1999), any soils with a surface layer having a relatively high organic component with a significant base saturation (the Mollisol soil order, or a Mollic subgroups) are excluded from the highly-erodible class, unless shallow to bedrock (see below.) Soils with high silt and very fine sand contents tend to have the highest erosion potential. In terms of taxonomic description, this would include the “coarse-silty” and “fine-silty” particle size classes. Rock fragments significantly reduce the inherent erodibility of soils (Kral and Hawkins, ed. 1984.) Therefore, any soil Family having greater than 35 percent rock fragments is not considered highly-erodible. This would include all “skeletal” soil Families. All soils with bedrock close to the surface are susceptible to erosion (“Lithic” subgroups.) Soils with a significant component of volcanic ash tend to have high erodibility (the Andisol soil order.) Soils with a lesser amount are considered to be

only moderately erodible (Andic subgroups.) Soils formed in hydrothermal materials are always considered highly-erodible. This is because of their unusual mineralogy and shallow depth class.

Methods for Spatial Definition of Erodibility

The existing GYA Landscape Model provided sufficient information on soil erodibility and landslides for most of the study area. However, there are some gaps where information was not available at the time of publication. We made efforts to provide complete coverage at the cost of lower resolution in some areas, and estimated properties through a consistent and repeatable process for others.

A VISUAL BASIC™ program was written to make the criteria application process consistent, repeatable, and easily changed (Appendix One.) This program reads each of the 1,703 map unit records, determines if any major soil meets the erodibility criteria, and writes to another field if it does so. Soils information is searched from a summary field or in any of three major component fields. The presence of component information overrides a summary if it also exists, as we assume it is more detailed. A few map units lack soils information. These are flagged as well. The “highly-erodible” lands are represented as a field in the attribute table for the landscape model coverage.

A limitation of this method is that a map unit may be flagged for erodible soils even if only a small (though significant) part of that map unit actually has those soils. This may result in an overestimation of actual erodibility in a watershed. Since the model was predicated on use of landtypes as “atomic” objects (having a single property), this was not considered. However, because future model objectives may change, a modification was written for future use. If component proportions were present, the areal contribution each component having “highly-erodible” soils was weighted by its component proportion. For example, if Soil Component One was 30 percent of the map unit, and was in the erodible class, the proportion of erodible soils was that proportion. However, if Component Two was also “highly-erodible”, and had a proportion of 20%, the total in the map unit would be 50%. Up to 15 % of any one map unit can be “dissimilar inclusions”. These were not included in this analysis, so no cumulative proportion will add to 100%, unless generated from a soil summary field. For map units having only soil summary information, each criterion rule that fires raises the cumulative proportion by 33% to a maximum of 99%. This approximates the contribution of more than one erodible soil in the summary.

Landslides

Presence of landslides and potential for landslides are both used as criteria for unstable slopes. Existing landslides may indicate a pre-disposition towards additional slope failures when disturbed. The presence of landslides on the landscape is relatively easily mapped as they have distinct visible characteristics, and are listed as properties of map units in GYA inventories. The potential for landslides, however, is more difficult to define, because it is an interpretation based on those properties. Because it is an interpretation, and criteria for those interpretations are not contained in the GYA landscape model, potential for landslides is not mapped in this model. This probably results in an under-estimation of “sensitive” lands using this criterion.

Spatial definition of landslides was relatively straightforward. Massive earth movements (“landslides”) are described and classified in a number of relatively standard ways (e.g. Thornbury, 1969; Haskins, et. al., 1998.) Therefore, after a review of the database terms in the GYA model, a

search query was created to find map unit records having terms relating to potential mass movement. These terms include “landslide”, “mass wasting”, “earthflow”, “slumps”, “rock slides”, and “block glide”, or words using these terms, present in any of nine fields in the database. See query # 54 (landslides filter for later manual selection) in Appendix Two. Once these were selected, each map unit record was manually examined to determine if mass movement was a dominant component of the map unit. If landslides made up more than a “small” or “included” part of the unit, the unit was flagged as a landslide. Landslides are represented as a field in the attribute table for the landscape model coverage.

The Landscape Model Used in the Vulnerability Analysis

The Landscape Model and Data Additions for this Project

The 2000 GYA Landscape Model (Shovic and Urie, 2001) is a systematic compilation and integration of ecotype, landtype, and soils survey information for the entire Greater Yellowstone area. It contains a single spatial coverage and a single linked database having standardized language, field descriptions, and a level of quality control. Information on vegetation, landforms, soils, geologic features, and climate can be extracted from this model. As published, it contains only those landscape data that were completed and published before 2000. Some gaps remained in the GYA. Since then more data have become available in draft form. The quality of these additional data was sufficient for inclusion in this model, so the following additions were made. See Figure 3 for a map of the 2000 data and the modified data used in this project. See Figure 1 for each administrative unit's location.

Bridger Teton National Forest: All existing inventory areas were of sufficient detail for this project save those in the Teton and Gros Ventre Wilderness Areas. These were older, reconnaissance surveys and are at a much lower resolution than the remainder of inventories in the GYA. They were used here due to lack of better information. Some ratings on the Bridger-Teton National Forest were potentially inaccurate. Landscape data were very broadly defined in the northern portion of the Forest. This probably resulted in an under-assessment of vulnerability in this area. There also may be some missing landslide data in the map units representing the Flat Creek area south of the wilderness. Vulnerability ratings may be higher than shown here.

Custer National Forest: The Custer portion of the Absaroka-Beartooth Wilderness Area is now in process of being inventoried. About 1/3 of the area has a draft inventory of sufficient resolution to be used in this exercise. Though detailed soil information was absent, erodibility and landslide occurrence were estimated from aerial photography, existing adjoining information, and the hillshade image.

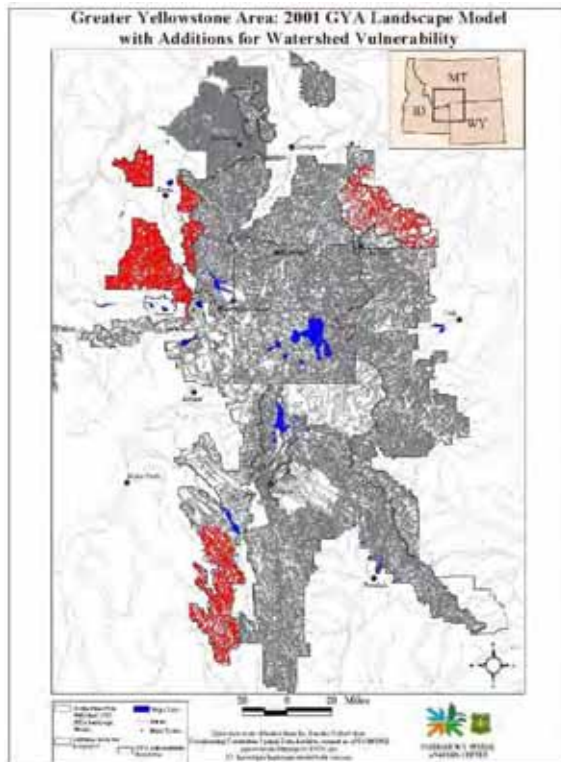


Figure 3. Greater Yellowstone Area: 2001 GYA Landscape Model with Additions for Watershed Vulnerability

Most of the criteria for erodible soils are not likely to apply to the heavily glaciated, rocky remainder of the area. However, it is likely there will be shallow soils having high erodibility on steep, glaciated slopes. Therefore a reconnaissance inventory was completed on this area using the hillshade image and surrounding mapping at a scale of 1:100,000. This identified landslides and highly-erodible soils by landform, slope gradient, and slope shape.

Caribou National Forest (part of the Caribou-Targhee National Forest): Though digital spatial information is available, tabular attributes are not in an easily imported form. For this project, the spatial information was appended to the existing model, and appropriate attribute information was manually entered.

Beaverhead National Forest (Madison District, part of the Beaverhead-Deerlodge National Forest: This inventory is in the final stages of completion. Draft spatial information was edge-matched and appended to the model. Draft digital attribute information was obtained and was formatted for this model. This information may change somewhat for the final publication, but is considered sufficient for the present study.

Gallatin National Forest: The term "lithic" was not used in the soil definitions used in the present version of the digital database. However, shallow soils were described for map units in the accompanying publication, and were manually entered. Six map units were missing soils information. Soil components for these map units were projected from surrounding map unit information.

Yellowstone National Park: No adjustments were made.

Grand Teton National Park: No adjustments were made.

Shoshone National Forest: No adjustments were made.

Red Rocks National Wildlife Refuge: This administrative unit, though in the Greater Yellowstone Area, was not analyzed. No soils information was available.

National Elk Refuge: This area was analyzed, because soils and landslide information was available through the Grand Teton National Park and Teton County inventories.

Data Completeness

Two kinds of data are flagged as "no data" in our project. The first kind includes mapped lakes and large streams in the Landscape Model. These have no soil or landslide data but do have validity for calculations within watersheds. The second includes existing landscape map units lacking attribute data or areas within the project boundary having no spatial data. This category represents a true "no data" status in this project. Excluding lakes and streams, soil erodibility and landslides data coverage for the GYA was nearly complete, with only four percent of the entire area missing data (Table 2). Figure 4 shows the distribution of this missing data. The southeast portion of the Shoshone National Forest, though inventoried, has no digital spatial data (about 248,000 acres; "G" on Figure 4.) Another 97,688 acres has spatial data but no attribute data ("F" on Figure 4.)

Table 2. Lands with No Soils Data in The GYA (excluding lakes and streams)

Administrative Unit	No Landscape Data (Acres)	Total Unit Area (Acres)*	Percentage of Total Area***	Comments
Beaverhead-Deerlodge N.F.	161,323	750,581	21.5%	Landscape data missing in North Madison Range
Bridger-Teton N.F.	17,166	3,462,802	0.5%	Landscape data missing south of Jackson
Caribou-Targhee N.F.	1,522	2,094,976	0.1%	
Custer N.F.	-	525,302	0.0%	
Gallatin N.F.	-	2,124,751	0.0%	
Grand Teton N.P.**	-	333,139	0.0%	
National Elk Refuge	-	25,343	0.0%	
Red Rock Wildlife Refuge	58,811	58,811	100.0%	No landscape data
Shoshone N.F. @	345,668	2,466,963	14.0%	Landscape data missing in SE
Yellowstone N.P.	-	2,197,031	0.0%	
Totals	584,490	14,039,699	4.2%	

* Unit areas are for the Greater Yellowstone Area only.

** Includes John D. Rockefeller Parkway

*** Figures do not include 75,996 acres with no landscape data on private lands within Unit boundaries.

@ Includes about 248,000 acres of missing spatial data, with the remainder having spatial data but no attribute data.

A part of the Beaverhead-Deerlodge National Forest (161,323 acres) was missing attribute data. This missing data is concentrated in the northeast part ("B" on Figure 4), but some are scattered throughout the area. The area just south of Jackson was missing attribute data (17,166 acres; "E" from Figure 4) though spatial data were present. The Red Rock Wildlife Refuge has no landscape data (58,811 acres; "H" on Figure 4). This is because it is has been added to the GYA in the last year, too late for inclusion in the landscape model.

Large blocks of non-federal land within GYA boundaries have no landscape data ("C" and "D") and are not included in the missing data analysis (see Table 1). However, smaller, un-mapped areas make up 75,996 acres of missing data. These are scattered throughout the GYA and are not excluded from analysis. Spatial and attribute data from one large block of private land outside of GYA boundaries (but inside the landscape model boundaries) was excluded by query ("A" on Figure 4). Another area just south of Jackson is private, but was included in the landscape model.

Some ratings on the Bridger-Teton National Forest were potentially inaccurate. Landscape data were very broadly defined in the northern portion of the Forest. This probably resulted in an under-assessment of vulnerability in this area. There also may be some missing landslide data in the map units representing the Flat Creek area south of the wilderness. Vulnerability ratings may be higher than shown here.

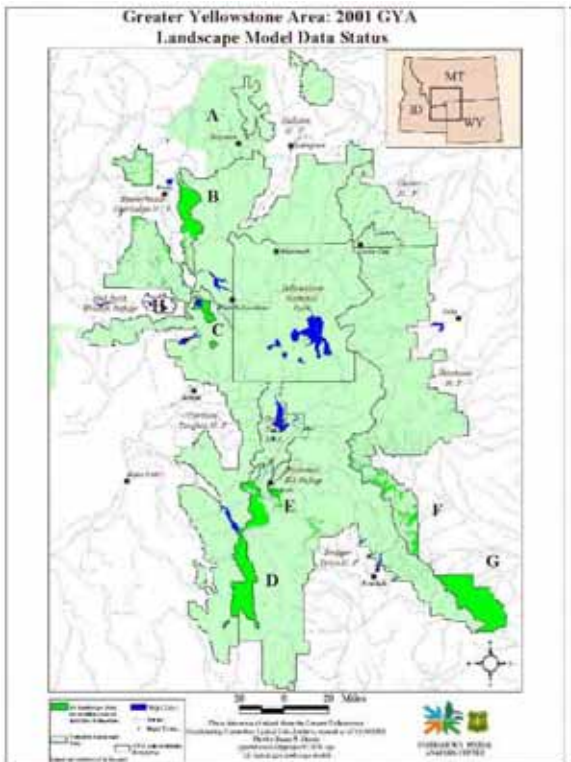


Figure 4. Greater Yellowstone Area: 2001 GYA Landscape Model Data Status.

Watershed Data

IWWI Watershed Data and GYA Watershed Data

Two watershed coverages were used in this study, each one providing a base from which rate vulnerability by watershed using the landscape model. The first (Figure 5) is from the IWWI project (termed IWWI Watersheds) completed using data gathered in 1999. This was compiled at the 6th Hydrologic Unit Code level, and is commonly called the HUC6 watershed layer. This was used as the spatial base for the first part of the study, that of delineating watershed vulnerability with the "sensitive" lands coverage from the landscape model. There are areas of missing data, notably in Grand Teton National Park and the surrounding area. Also, administrative boundaries define watersheds, notably around Yellowstone National Park.

The IWWI data were provided in a series of coverages, one for each administrative unit. We did not have the resources to append and edgemark all of them, so our analysis was completed by individual units and totaled for the GYA. With this in mind, we calculated there are about 1,130 total watersheds in the IWWI coverages with a total area of about 13,500,000 acres and an average size of about 13,000 acres. Note that watersheds are clipped at unit boundaries, resulting in an under-reporting of average size. Also, we intersected these coverages with the landscape model, resulting in somewhat lower numbers of reported watersheds and areal extent.

We compiled the second coverage (termed GYA Watersheds) from watershed data developed in 2001 by federal and state administrative units. We appended and edgemarked these data, and used only that data within the GYA administrative unit coverage (Figure 6.) There are some data gaps, notably in the western part of the Caribou-Targhee National Forest. This is because data were in process of completion and not ready at time of publication.

We used this second coverage in the second part of the study, delineating watershed vulnerability with the new "sensitive" lands coverage from the same landscape model used above. There are about 765 total watersheds in the GYA watershed coverage (within the GYA boundary) with a total area of about 12,600,000 acres and an average size of about 16,800 acres. Again, we intersected this coverage with the landscape model, resulting in relative under-reporting of these figures later in the analysis.

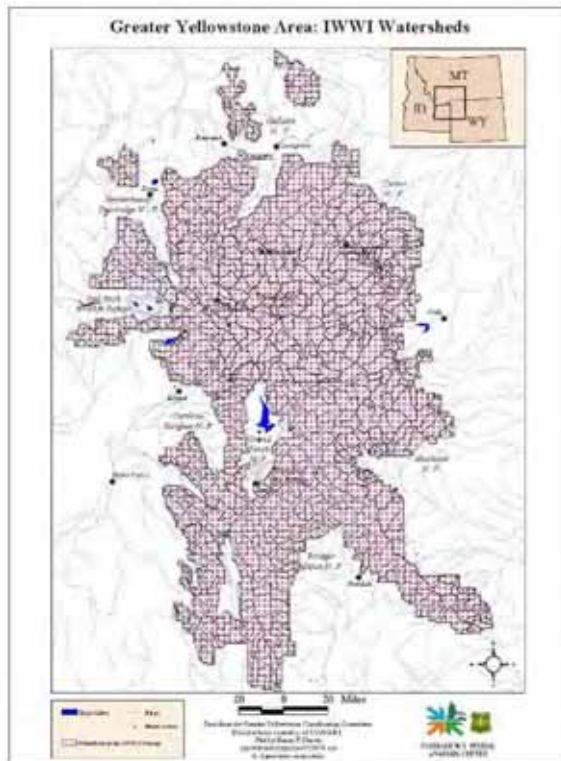


Figure 5. Greater Yellowstone Area: IWWI Watersheds

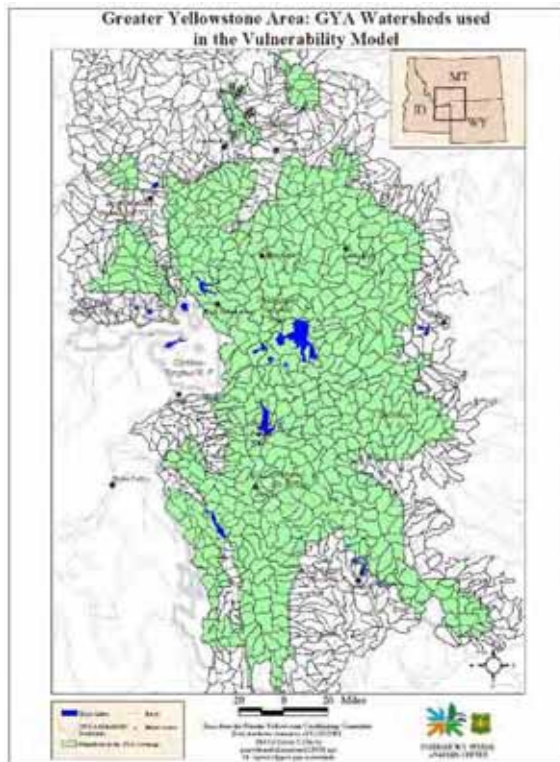


Figure 6. Greater Yellowstone Area: GYA Watersheds used in the Vulnerability Mode

Comparison of The Two Watershed Coverages

There are advantages in using the newer watershed coverage. The GYA coverage is considerably updated in terms of individual delineations (Figure 7). Note that delineations are apparently more detailed. Watersheds have been corrected within units (“D” vs. “C”). Cross-boundary joins have been improved (“E” vs. “F”). Data holes (“A”) and boundaries based solely on administrative units (“B”) have been removed. Finally, watersheds for Grand Teton National Park and the National Elk Refuge have been added.

However, there are some disadvantages. Overall completeness for the GYA coverage is 5.6 percent less than that for the IWWI coverage (Table 3), primarily due to lack of data for the western portion of the Caribou-Targhee National Forest (Figure 6). The data in Table 3 are taken from Table 4 and Table 5. These tables show the missing watershed data compiled by administrative unit. Areal extent for both coverages has been modified by those reductions related to absence of watershed data only, and not for the landscape model.

Table 3. Area Covered by IWWI HUC6 and GYA HUC6 Watersheds

Administrative Unit	IWWI Watershed Coverage (Acres) *	GYA Watershed Coverage (Acres)*	Difference in Coverage (Acres)	Percentage Difference in Coverage
Beaverhead-Deerlodge N.F.	749,581	750,466	885	0.1%
Bridger-Teton N.F.	3,459,073	3,325,482	(133,592)	-3.9%
Caribou-Targhee N.F.	2,094,976	1,124,442	(970,534)	-46.3%
Custer N.F.	524,633	525,302	669	0.1%
Gallatin N.F.	2,116,407	2,124,485	8,079	0.4%
Grand Teton N.P.**	-	333,122	333,122	100.0%
National Elk Refuge	-	25,343	25,343	100.0%
Red Rock Wildlife Refuge	-	(0)	(0)	0.0%
Shoshone N.F.	2,465,963	2,466,951	988	0.0%
Yellowstone N.P.	2,181,108	2,155,581	(25,527)	-1.2%
Totals without Private Lands	13,591,742	12,831,174	(760,568)	-5.6%
Private Lands within coverage	233,685	282,237	48,552	20.8%
Totals with Private Lands	13,591,742	13,113,411	(478,331)	-3.5%

* These data are taken from Table 4 and Table 5. Areal extent for both coverages has been modified by those reductions related to absence of watershed data only, and not for the landscape model.

Table 4. Land Area by Administrative Unit as used for the Vulnerability Model with GYA Watershed Data

Administrative Unit	Total Area (Acres)*	Area Missing Watershed Data	Actual IWWI Watershed Area (Acres)	Percentage with Missing Data	Reason for “Missing Data” Designation
Beaverhead-Deerlodge N.F.	750,581	115	750,466	0.0%	no GYA watershed data
Bridger-Teton N.F.	3,462,802	137,320	3,325,482	4.0%	no GYA watershed data
Caribou-Targhee N.F.	2,094,976	970,534	1,124,442	46.3%	no GYA watershed data
Custer N.F.	525,302		525,302	0.0%	

		(0)		
Gallatin N.F.	2,124,751	266	2,124,485	0.0% no GYA watershed data
Grand Teton N.P.	333,139	17	333,122	0.0% no GYA watershed data
National Elk Refuge	25,343	(0)	25,343	0.0%
Red Rock Wildlife Refuge	58,811	58,811	(0)	100.0% no GYA watershed data
Shoshone N.F.	2,466,963	12	2,466,951	0.0% no GYA watershed data
Yellowstone N.P.	2,197,031	41,450	2,155,581	1.9% no GYA watershed data
Total Administrative Area	14,039,699	1,208,525	12,831,174	8.6%
Private lands within administrative coverage	282,237			
Total Area from Administrative Coverage	14,321,936			

* Unit areas are for the Greater Yellowstone Area only.

Table 5. Land Area by Administrative Unit as used for the Vulnerability Model with IWWI Watershed Data

Administrative Unit	Total Area (Acres)*	Area Missing Watershed Data	Actual IWWI Watershed Area (Acres)	Percentage with Missing Data	Reason for "Missing Data" Designation
Beaverhead-Deerlodge N.F.	750,581	1,000	749,581	0.1%	Edgematch artifacts
Bridger-Teton N.F.	3,462,802	3,729	3,459,073	0.1%	Edgematch artifacts
Caribou-Targhee N.F.	2,094,976	-	2,094,976	0.0%	
Custer N.F.	525,302	669	524,633	0.1%	Edgematch artifacts
Gallatin N.F.	2,124,751	8,344	2,116,407	0.4%	Edgematch artifacts
Grand Teton N.P.	333,139	333,139	-	100.0%	No IWWI Watershed Data
National Elk Refuge	25,343	25,343	-	100.0%	No IWWI Watershed Data
Red Rock Wildlife Refuge	58,811	58,811	-	100.0%	Outside IWWI Watershed Data
Shoshone N.F.	2,466,963	1,000	2,465,963	0.0%	Edgematch artifacts
Yellowstone N.P.	2,197,031	15,923	2,181,108	0.7%	No IWWI Watershed Data, on the W edge of park
Total Administrative Area	14,039,699	447,957	13,591,742	3.2%	

* Unit areas are for the Greater Yellowstone Area only.

Private lands within administrative coverage	233,685
Total Area from Administrative Coverage	14,273,383

NOTE: These figures are from data queries and estimation.

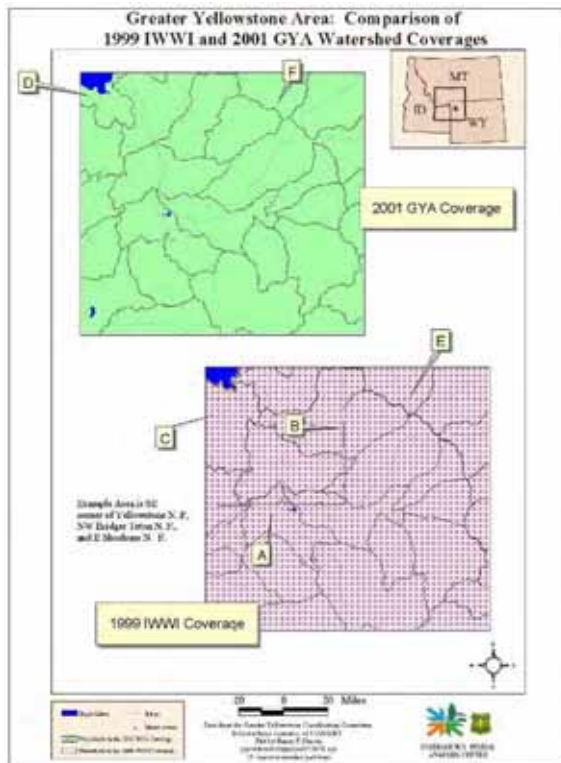


Figure 7. Greater Yellowstone Area: Comparison of 1999 IWWI and 2001 GYA Watershed Coverages

RESULTS

Calculations for Dissected Lands, Highly-Erodible Lands, Landslides, and Sensitive Lands in the GYA

Highly-erodible and landslide-prone areas are represented as attributes of polygons in the landscape model coverage. Dissected lands are a separate coverage. These two coverages were intersected to form a coverage having both attributes. The resulting attribute table was imported to ACCESS™ where we used a series of queries to clean the data, calculate areas for the three parameters, remove overlap, create a table of final attributes, and summarize for the tables given below (Table 6.) This series of queries are standardized, so when data changes it is convenient to redo these tables.

Table 6. Query List for Unit Calculations

Query	Record Source		
	(Table or Query)	Query Number*	Records
Create attribute table from relations	table	37	59,955
Select Valid Records from Attribute table	table	42	46,956
Initialize Sensitive Area Fields	table	43	59,955
Assigns Area based on Erodibility	42	44	7,704
Assigns Area based on Landslides and Dissection	42	45	9,649
Assigns No Data for Erodibility and Landslides	42	46	8,500
Re-assign sensitivity if dissected lands and no landscape data	42	47	7,050
Summarize Sensitivity (Vulnerability) by Unit (Table 10)	42	10	11
Summarize Dissection by Unit (Table 7)	42	33	10
Summarize Landslides by Unit (Table 9)	42	15	10
Summarize Erodible Soils by Unit (Table 8)	42	13	10

* Query descriptions and SQL are in Appendix Two.

Highly Dissected Lands

We delineated highly-dissected lands using the criteria listed above for the entire GYA defined above in Figure 1. Though we delineated lands on all Federal and most private lands, we excluded two large areas (“C” and “D” in Figure 4.)

One of the least dissected areas is Grand Teton National Park (Table 7.) Though from outward appearances this park is dominated by steep, rugged terrain, almost all of the mountainous area does not meet the criteria for “highly-dissected” land in terms of drainage density. This is probably due to relatively hard bedrock, recent uplift, and strong glaciation.

Most dissected lands occur in the Shoshone National Forest and the southern part of the Caribou-Targhee National Forest (Figure 8.) The Shoshone National Forest has large areas of relatively erodible volcanic rock, landscapes of greater age, and less glaciation, hence its high proportion of

dissected lands (29.5 percent.) The southern Caribou-Targhee National Forest is dominated by relatively weak sedimentary rocks with only scattered glaciation.

Table 7. Highly-Dissected Lands in The GYA

Administrative Unit	Highly-Dissected Acres	Total Unit Area (Acres) ^a	Percentage of Total Area
Beaverhead-Deerlodge N.F.	14,291	750,581	1.9%
Bridger-Teton N.F.	147,277	3,462,802	4.3%
Caribou-Targhee N.F. ***	343,580	2,094,976	16.4%
Custer N.F.	32,544	525,302	6.2%
Gallatin N.F.	168,062	2,124,751	7.9%
Grand Teton N.P.**	1,801	333,139	0.5%
National Elk Refuge @	-	25,343	0.0%
Red Rock Wildlife Refuge	-	58,811	0.0%
Shoshone N.F.	727,097	2,466,963	29.5%
Yellowstone N.P.	85,729	2,197,031	3.9%
Totals	1,538,017	14,039,699	10.8%

^a Unit areas are for the Greater Yellowstone Area only. Above figures do not include 17,489 highly-dissected acres in private lands within Unit boundaries.

** Includes John D. Rockefeller Parkway

*** Modified from query output: 17,636 acres removed outside of GYA administrative boundary.

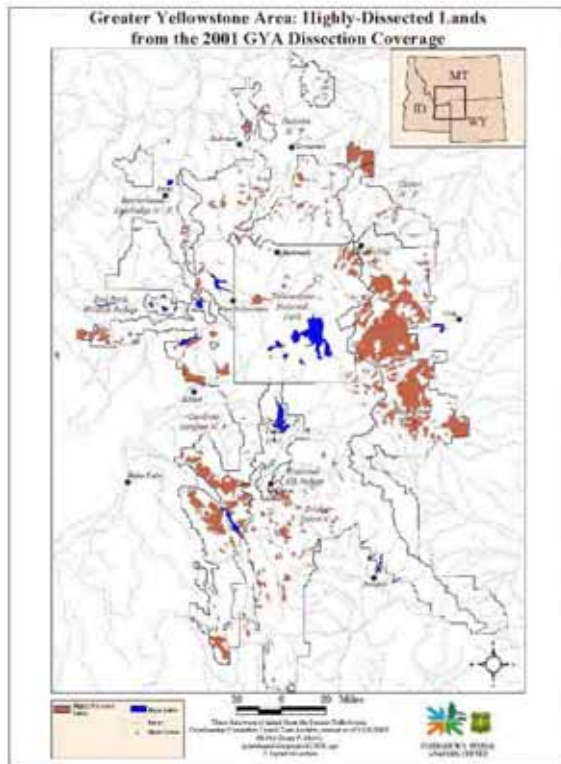


Figure 8. Greater Yellowstone Area: Highly-Dissected Lands from the 2001 GYA Dissection Coverage

Landslides and Highly-Erodible Soils in the GYA

We used the modified landscape model described above to delineate highly-erodible soils and landslides for the GYA. Each was independently calculated, so there may be overlap where highly-erodible soils occur on landslide terrain. Each was tallied by administrative unit (Table 8 and D.) Distribution is shown in Figure 9.

Table 8. Highly-Erodible Soils in The GYA

Administrative Unit	Erodible Soils (Acres)	Total Unit Area (Acres)*	Percentage of Total Area
Beaverhead-Deerlodge N.F.	96,713	589,259	16.4%
Bridger-Teton N.F.	523,422	3,445,636	15.2%
Caribou-Targhee N.F.	448,401	2,093,454	21.4%
Custer N.F.	241,585	525,302	46.0%
Gallatin N.F.	364,162	2,124,751	17.1%
Grand Teton N.P.**	80,727	333,139	24.2%
National Elk Refuge @	11,795	25,343	46.5%
Red Rock Wildlife Refuge ***	na	na	na
Shoshone N.F.	542,742	2,121,295	25.6%
Yellowstone N.P.	480,791	2,197,031	21.9%
Totals	2,790,337	13,455,209	20.7%

* Unit areas are for the Greater Yellowstone Area only. Since erodible soil is rated only where landscape data is present, adjusted areas are used for administrative units. These are from Table 2.

** Includes John D. Rockefeller Parkway

*** no soils data

@ Highly-erodible lands in the National Elk Refuge from manually-removed acres in Grand Teton N. P.

Overall, 21 percent of the GYA has highly-erodible soil. This is consistent with the kinds of soils commonly occurring in the region (shallow, silty, or dominated by volcanic ash.) However, soil erodibility is only one component of landscape erosional potential. Therefore some of these ratings may not necessarily correlate with data on actual or potential erosion in a given area. The highest proportion (46.5 percent) of erodible soils occurred in the National Elk Refuge. This is because high silt content in the soil which increases erodibility. However, this is not necessarily correlated to erosion hazard, as the entire Refuge is on slopes less than two percent, resulting in low potential for erosion under current land use. The next highest proportion (46 percent) occurred in the Custer National Forest, primarily due to soil depth.

About eight percent of the GYA contains landslides or areas of potential slides. The Beaverhead-Deerlodge National Forest and the Caribou-Targhee National Forest have the highest proportions of landslide terrain (18 and 14 percent; Table 9.) Its distribution appears to be related to uplifted sedimentary rocks, especially in the Caribou-Targhee National Forest (Figure 9.)

Table 9. Landslides in The GYA

Administrative Unit	Landslides (Acres)	Adjusted Total Unit Area (Acres)*	Percentage of Total Area
Beaverhead-Deerlodge N.F.	107,580	589,259	18.3%
Bridger-Teton N.F.	272,745	3,445,636	7.9%
Caribou-Targhee N.F.	295,574	2,093,454	14.1%
Custer N.F.	534	525,302	0.1%
Gallatin N.F.	139,602	2,124,751	6.6%
Grand Teton N.P.**	8,011	333,139	2.4%
National Elk Refuge	-	25,343	0.0%
Red Rock Wildlife Refuge ***	na	na	na
Shoshone N.F.	214,913	2,121,295	10.1%
Yellowstone N.P.	35,374	2,197,031	1.6%
Totals	1,074,333	13,455,209	8.0%

* Unit areas are for the Greater Yellowstone Area only. Since landslides are rated only where landscape data is present, adjusted areas are used for administrative units. These are from Table 2.

** Includes John D. Rockefeller Parkway

*** no soils data

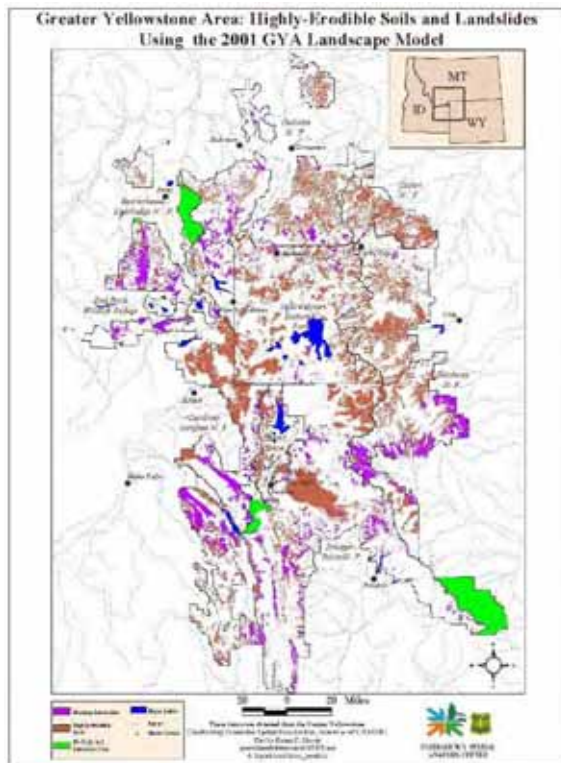


Figure 9. Greater Yellowstone Area: Highly-Erodible Soils and Landslides using the 2001 GYA Landscape Model

Sensitive Lands

Sensitive lands (i.e. vulnerable lands) are either highly-dissected, highly-erodible, or have a significant landslide component. They are a significant proportion of the GYA (36 percent; Table 10.) Totals in Table 10 do not correspond well to totals from Table 8, Table 9, and Table 7. This is because overlap may occur between highly-erodible soils, dissected lands, or landslides. This is evident from a comparison of Figure 8 and Figure 9. On a unit basis, about 1/2 of the Shoshone National Forest, the Caribou-Targhee National Forest and the National Elk Refuge are vulnerable, but all units have significant proportions of sensitive lands.

The Unit Areas used here are slightly less than in Table 1, to account for missing landscape data. Since dissected lands may overlap these “no data” areas, some of these lands may also be counted as “sensitive”. This may introduce some error, but comparing Figure 8 and Figure 9 shows this situation is uncommon.

Table 10. Highly-Sensitive Lands in The GYA

Administrative Unit	Highly-Sensitive Lands (Acres)	Adjusted Unit Area (Acres)	Percentage of Effective Unit Area
Beaverhead-Deerlodge N.F.	209,432	589,259	35.5%
Bridger-Teton N.F.	898,249	3,445,636	26.1%
Caribou-Targhee N.F.	985,082	2,093,454	47.1%
Custer N.F.	252,608	525,302	48.1%
Gallatin N.F.	628,202	2,124,751	29.6%
Grand Teton N.P.**	88,982	333,139	26.7%
National Elk Refuge	11,795	25,343	46.5%
Red Rock Wildlife Refuge ***	na	na	na
Shoshone N.F.	1,155,514	2,121,295	54.5%
Yellowstone N.P.	559,706	2,197,031	25.5%
Totals	4,789,570	13,455,209	35.6%

* Unit areas are for the Greater Yellowstone Area only. Above figures do not include 17,488 highly-sensitive acres on private lands within Unit boundaries. Adjusted Unit Area equals total area less area having no soil and landscape data from Table 2. These are only approximately correct because dissected lands may cover these “no data” areas, thus being counted as “sensitive lands” regardless of soil and landscape data status.

** Includes John D. Rockefeller Parkway

*** no soils data

@ Sensitive (Highly-erodible) lands in the National Elk Refuge from manually-removed acres in Grand Teton N. P.

Watershed Vulnerability using IWWI Watersheds and 2001 Landscape Model Data

Queries

We intersected the 2001 Landscape Model coverage with the IWWI Watershed coverage. Other than clipping part of the Caribou-Targhee outside of the GYA, the watershed coverage is the same one used in the older IWWI vulnerability analysis. This was to meet the objective of consistently applying landscape criteria to the entire GYA while maintaining compatibility and comparability with the older IWWI vulnerability analysis. Note that since this is an intersection process the results can only be used to produce an approximate listing of all IWWI watersheds, since a few watersheds fall outside of the landscape model's boundaries and are therefore lost to analysis.

We imported the resulting attribute table to ACCESS TM to facilitate analysis. Table 11 shows the query list used in the analysis. It is similar to the one in Table 6 other than calculations are on a HUC6 watershed basis, not solely on a unit basis. This structured sequence of queries facilitates future revisions of the model, since data changes do not affect the query definitions.

Table 11. Query List for Calculations of Missing Data Ratings and Vulnerability Ratings by 1999 IWWI HUC6 Watershed

Query	Record Source (Table or Query)	Query Number*	Records
Create attribute table from relations	table	26	73,967
Select Valid Records from Attribute table	table	29	72,610
Initialize Sensitive Area Fields	table	18	73,967
Assigns Area based on Erodibility	29	21	13,005
Assigns Area based on Landslides and Dissection	29	22	14,709
Assigns No Data for Erodibility and Landslides	29	19	9,568
Re-assign sensitivity if dissected lands and no landscape data	29	20	10,282
Sum 'No Data' by HUC6	29	1	1,120
Create Table of 'No Data' Ratings	1	24	1,120
Sum Vulnerability by HUC6	29	8	1,120
Create Table of Vulnerability Ratings	8	25	1,120
Sum vulnerability ratings by unit for IWWI watersheds (Table 12)	53	52	30

* Query descriptions and SQL are in Appendix Two.

Ratings for Data Completeness

The process for rating vulnerability was to first sum all vulnerable lands in a given HUC6 watershed, then calculate a proportion of the entire area in that watershed. A rating is given based on the relative proportions (high = > 50%; moderate = 20 - 50%; low = < 20%). Since there are some watersheds that have significant "no data" components, we also rated them for proportion of

missing landscape data. This rating is similar to that used in the vulnerability ratings. We decided that any watershed having a “high” missing data rating would be excluded from further analysis. Note that we included lakes and large streams as well as missing landscape data for the “no data” classification. Only one watershed rated a “high” classification due to lakes. This was watershed 10070001002009 whose boundary is Yellowstone Lake in Yellowstone National Park. This rating was ignored in subsequent calculations that removed highly-rated missing-data watersheds.

Excluding Yellowstone Lake, fifty-two watersheds were rated “high” in missing data (Appendix Four.) These are concentrated in the southeastern portion of the Shoshone National Forest where watersheds fell outside the boundary of the landscape model (Figure 10.) The remainder were on the Beaverhead-Deerlodge National Forest and south of Jackson, Wyoming where attribute data were missing from the landscape model. Appendix Three contains examples of missing data ratings by watershed. Full listings are published separately.

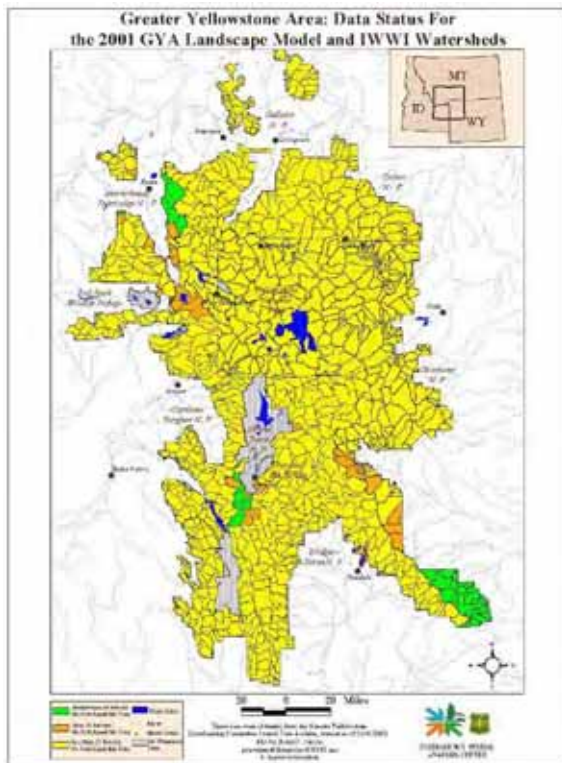


Figure 10. Greater Yellowstone Area: Data Status for the 2001 GYA Landscape Model and IWWI Watersheds.

Ratings for Watershed Vulnerability

The rating system for watershed vulnerability was similar to the methods used in determining data completeness. Note that vulnerability is rated on a unit and watershed basis, not a unit and polygon basis as in the sensitivity ratings given earlier in Table 10. Appendix Three contains examples of vulnerability ratings by watershed. Full listings are published separately.

Distribution of vulnerability over the GYA is shown in Figure 11. Table 12 shows watershed vulnerability ratings summed by administrative unit, based on the query in Table 11.

Table 12. GYA Watershed Vulnerability by IWWI HUC6 Watershed

Administrative Unit	Watershed Acres on Unit by Rating @	Vulnerability Rating	IWWI Watershed Area (Acres)*	IWWI HUC6 Watershed Area with High 'No Data' Status (Acres) ***	Effective Unit Area (Acres)	Percentage of Effective Unit Area
Beaverhead-Deerlodge N.F.	141,073	High	749,581	107,933	641,648	22.0%
	173,508	Low				27.0%
	320,913	Moderate				50.0%
Bridger-Teton N.F.	563,979	High	3,459,073	72,046	3,387,027	16.7%
	1,652,864	Low				48.8%
	1,170,958	Moderate				34.6%
Caribou-Targhee N.F.	919,853	High	2,094,976		2,094,976	43.9%
	451,017	Low				21.5%
	677,135	Moderate				32.3%
Custer N.F.	219,920	High	524,633		524,633	41.9%
	8,458	Low				1.6%
	296,358	Moderate				56.5%
Gallatin N.F.	298,980	High	2,116,407		2,116,407	14.1%
	715,892	Low				33.8%
	1,100,556	Moderate				52.0%
Grand Teton N.P.	-	High			-	na
	-	Low				na
	-	Moderate				na
National Elk Refuge	-	High			-	na
	-	Low				na
	-	Moderate				na
Red Rock Wildlife Refuge	-	High			-	na
	-	Low				na
	-	Moderate				na
Shoshone N.F.	1,216,234	High	2,465,963	247,376	2,218,587	54.8%
	269,369	Low				12.1%
	736,913	Moderate				33.2%
Yellowstone N.P. **	196,204	High	2,181,108	-	2,181,108	9.0%
	831,514	Low				38.1%
	1,153,392	Moderate				52.9%
Greater Yellowstone Area	3,556,243	High				27.0%
	4,102,621	Low				31.2%
	5,456,225	Moderate				41.4%

Totals	13,115,089	13,591,742	427,355	13,164,387
Private lands within Unit boundaries outside IWWI watersheds	233,685			
Unmapped Acres	77,676			

* Data from Table 5.

** Yellowstone Lake (84,446 acres) is delineated as a watershed (10070001002009), and contains no landscape data. However, this watershed would be rated as "low" vulnerability, so was manually included under the "low" rating sum.

*** Data from Appendix Four.

@ Includes only HUC6 Watersheds with "Low" or "Moderate" Nodata Status

The Shoshone National Forest came out highest (55%) in highly sensitive watersheds (Table 12). Yellowstone National Park came out lowest with nine percent. Highly sensitive watersheds make up 27 percent of the area of the overall GYA. Red Rock Wildlife Refuge, Grand Teton National Park, and the National Wildlife Refuge were not rated, since we had no watershed data in those units. However, we do have landscape data in the latter two.

Turning to the distribution of vulnerability in Figure 11, highly vulnerable watersheds are concentrated in the northern two-thirds of the Shoshone National Forest, primarily due to highly dissected lands (Figure 8.) Dissection also plays a major role in the "high" ratings for watersheds in the mid-section of the Caribou-Targhee National Forest.

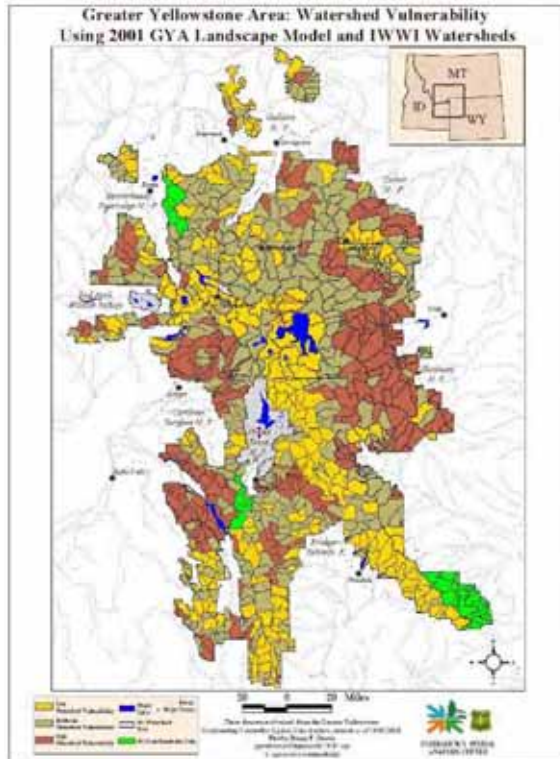


Figure 11. Greater Yellowstone Area: Watershed Vulnerability Using 2001 GYA Landscape Model and IWWI Watersheds

Watershed Vulnerability using GYA Watersheds and 2001 Landscape Model Data

Queries

We intersected the 2001 Landscape Model coverage with the GYA watershed coverage to meet the project objective of applying landscape criteria to the best watershed coverage available. This effectively updates both the vulnerability model and the watershed representation of the GYA. Note that since this is an intersection process the results can only be used to produce an approximate listing of all GYA watersheds, since a few watersheds fall outside of the landscape model's boundaries and are therefore lost to analysis.

As in the IWWI watershed-based analysis above, we imported the resulting attribute table to ACCESS™ to facilitate analysis. Table 11 shows the query list used in the analysis. It is similar to the one in Table 6 other than calculations are on a HUC6 watershed basis, not solely on a unit basis. This structured sequence of queries facilitates future revisions of the model, since data changes do not affect the query definitions.

Table 13. Query List for Calculations of Missing Data Ratings and Vulnerability Ratings by 2000 GYA HUC6 Watershed

Query	Record Source (Table or Query)	Query Number*	Records
Create attribute table from relations	table	38	70,926
Select Valid Records from Attribute table	table	41	55,974
Initialize Sensitive Area Fields	table	55	70,926
Assigns Area based on Erodibility	41	21	9,696
Assigns Area based on Landslides and Dissection	41	22	11,222
Assigns No Data for Erodibility and Landslides	41	19	8,908
Re-assign sensitivity if dissected lands and no landscape data	41	20	7,963
Sum 'No Data' by HUC6	41	1	753
Create Table of 'No Data' Ratings	1	24	753
Sum Vulnerability by HUC6	41	8	753
Create Table of Vulnerability Ratings	8	25	753
Sum vulnerability ratings by unit for IWWI watersheds (Table 14)	50	56	29

* Query descriptions and SQL are in Appendix Two.

Ratings for Data Completeness

The process for rating vulnerability was to first sum all vulnerable lands in a given HUC6 watershed, then calculate a proportion of the entire area in that watershed. A rating is given based on the relative proportions (high = > 50%; moderate = 20 – 50%; low = < 20%). Since there are some watersheds that have significant “no data” components, we also rated them for proportion of missing landscape data. This rating is similar to that used in the vulnerability ratings. We decided

that any watershed having a “high” missing data rating would be excluded from further analysis. Note that we included lakes and large streams as well as missing landscape data for the “no data” classification.

Forty-two watersheds were rated “high” in missing data (Appendix Five.) Large lakes and streams did not play a significant role in these watershed ratings (Figure 12.) The 42 watersheds are concentrated in the southeastern portion of the Shoshone National Forest where watersheds fell outside the boundary of the landscape model (Figure 12.) The remaining watersheds were on the Beaverhead-Deerlodge National Forest and south of Jackson, Wyoming where attribute data were missing from the landscape model. Appendix Three contains examples of missing data ratings by watershed. Full listings are published separately.

Both watershed coverages give similar, but not identical results in terms of missing data. This disparity occurs because watershed boundaries have been modified in the new GYA coverage, resulting in somewhat different included landscape data (Figure 10 and Figure 12.)

Ratings for Watershed Vulnerability

The rating system for watershed vulnerability was similar to the methods used in determining data completeness. Note that vulnerability is rated on a unit and watershed basis, not a unit and polygon basis as in the sensitivity ratings given earlier in Table 10. Appendix Three contains examples of vulnerability ratings by watershed. Full listings are published separately.

Distribution of vulnerability over the GYA is shown in Figure 13. Administrative boundaries are shown in the following map (Figure 14) to emphasize the seamless nature of the new watershed boundaries in Figure 13. Table 14 shows watershed vulnerability ratings summed by administrative unit, based on the query in Table 13. These administrative unit strata are approximate because unlike in the IWWI coverage, the GYA watershed boundaries do not always follow administrative boundaries.

Table 14. GYA Watershed Vulnerability by GYA HUC6 Watersheds Stratified by Administrative Units

Administrative Unit	Watershed Acres on Unit by Rating @	Vulnerability Rating	GYA Watershed Area (Acres)*	GYA HUC6 Watershed Area with High 'No Data' Status (Acres)***	Effective Unit Area (Acres)	Percentage of Effective Unit Area
Beaverhead-Deerlodge N.F.	151,154	High	750,466	117,066	633,400	23.9%
	189,018	Low				29.8%
	293,149	Moderate				46.3%
Bridger-Teton N.F.	475,559	High	3,325,482	53,099	3,272,383	14.5%
	1,528,394	Low				46.7%
	1,269,009	Moderate				38.8%
Caribou-Targhee N.F.	584,449	High	1,124,442		1,124,442	52.0%
	200,007	Low				17.8%
	344,621	Moderate				30.6%

Custer N.F.	218,429	High	525,302	525,302	41.6%
	7,826	Low			
	298,679	Moderate			
Gallatin N.F.	297,100	High	2,124,485	2,124,485	14.0%
	641,683	Low			
	1,157,463	Moderate			
Grand Teton N.P.	64,281	High	333,122	333,122	19.3%
	173,802	Low			
	95,228	Moderate			
National Elk Refuge	2,011	High	25,343	25,343	7.9%
	-	Low			
	23,332	Moderate			
Red Rock Wildlife Refuge	-		-	-	na
Shoshone N.F.	1,246,805	High	2,466,951	247,319	2,219,632
	215,590	Low			
	757,159	Moderate			
Yellowstone N.P.	131,177	High	2,155,581	2,155,581	6.1%
	953,413	Low			
	1,070,990	Moderate			
Greater Yellowstone Area	3,170,965	High			24.7%
	3,909,734	Low			
	5,309,629	Moderate			
Totals	12,390,328		12,831,174	417,484	12,413,690

Private lands within Unit boundaries

within GYA watersheds 243,237

Note: These administrative unit strata are approximate as watershed boundaries do not always follow administrative boundaries for the GYA watershed coverage.

* Data from Table 4.

*** Data from Appendix Five.

@ Includes only HUC6 Watersheds with "Low" or "Moderate" Nodata Status

The Shoshone National Forest came out highest (56%) in highly vulnerable watersheds (Table 14). Yellowstone National Park came out lowest with six percent. Highly sensitive watersheds make up 25 percent of the area of the overall GYA. Red Rock Wildlife Refuge was not rated, since we had no watershed data nor landscape data in that unit. Calculations for the Caribou-Targhee National Forest are skewed because of the high proportion of missing watershed data (46 %; Table 4.)

Turning to the distribution of vulnerability in Figure 13, highly vulnerable watersheds are concentrated in the northern two-thirds of the Shoshone National Forest, primarily due to highly dissected lands (Figure 8.) Dissection also plays a major role in the "high" ratings in the mid-section of the Caribou-Targhee National Forest.

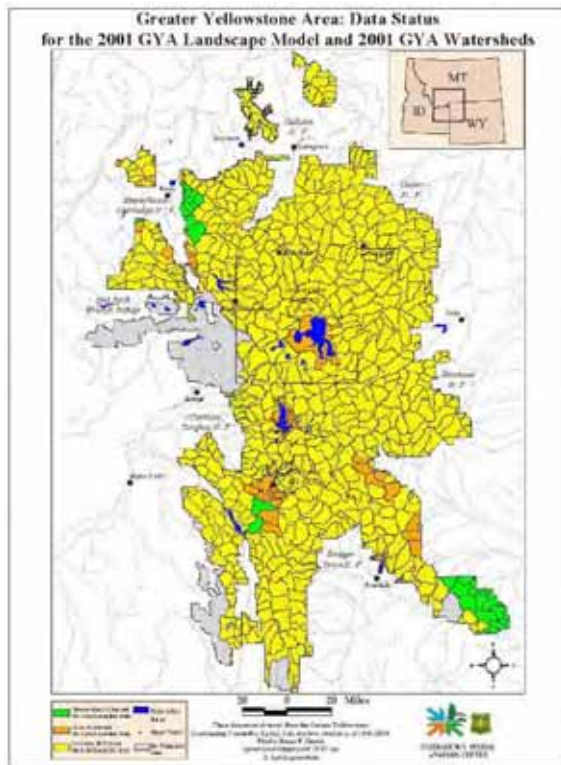


Figure 12. Greater Yellowstone Area: Data Status for the 2001 GYA Landscape Model and 2001 GYA Watersheds

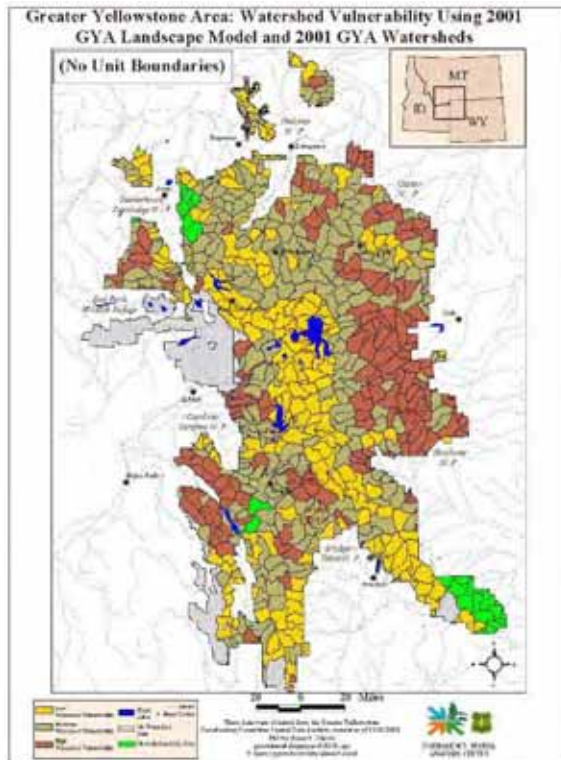


Figure 13. Greater Yellowstone Area: Watershed Vulnerability Using 2001 GYA Landscape Model and 2001 GYA Watersheds (No Unit Boundaries)

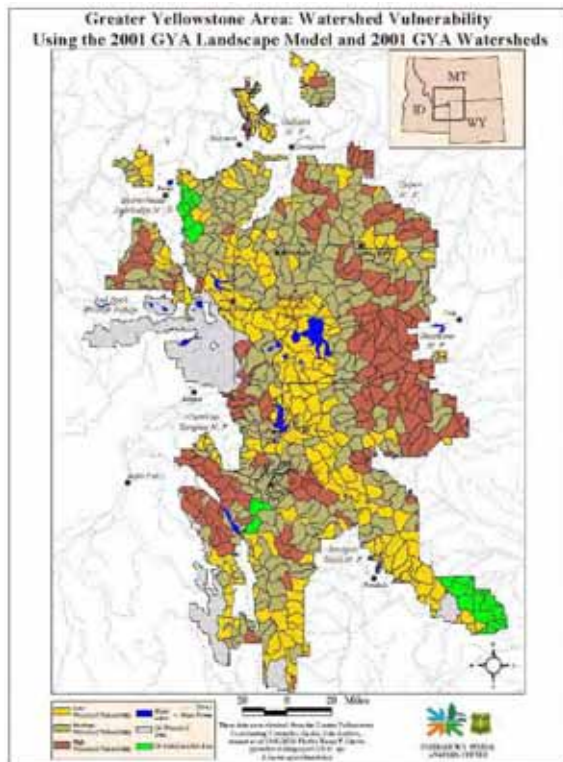


Figure 14. Greater Yellowstone Area: Watershed Vulnerability Using the 2001 GYA Landscape Model and 2001 GYA Watersheds

Watershed Vulnerability using IWWI Watersheds and IWWI Vulnerability Data

Vulnerability ratings for this 1999 map were provided by the Forest Service (Figure 15.) The IWWI watersheds coverages were provided by unit, with an attribute designating the vulnerability rating for each watershed. The ratings were completed by individual units using a variety of methods based on professional judgment, and sent to a central location for compiling. We created the map, adding formatting only. Note that this project rated units we considered outside of GYA boundaries, notably on the western and southern parts of the Caribou-Targhee National Forest, the eastern part of the Custer National Forest, and the entire Beaverhead portion of the Beaverhead-Deerlodge National Forest.

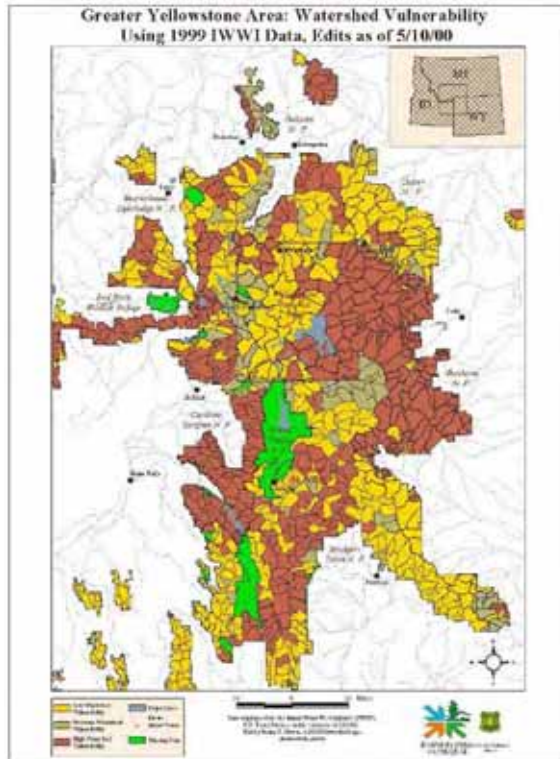


Figure 15. Greater Yellowstone Area: Watershed Vulnerability Using 1999 IWWI Data, Edits as of 5/10/00.

Comparison of Results for Each Model

Figure 15 shows the original vulnerability ratings done in 1999, using 1999 IWWI watershed data and 1999 IWWI vulnerability ratings. Note extensive boundary differences, due to analysis differences as well as watershed definitions. Also note the extensive missing data in the core of the GYA.

Figure 11 shows the results of the model using the 1999 IWWI Watersheds and the 2001 GYA Landscape Model. As is often the case, the use of more detailed and accurate data has reduced the overall number of watersheds rated “high.” Also, though the administrative boundaries are still evident, the ratings across them are much more consistent. There is a traceable process where we can identify exactly how any given polygon was rated for vulnerability. Also, these vulnerability ratings are consistent with the other ratings in the IWWI project, since they are based on the same watersheds. However, there is still missing data in the core of the GYA.

Figure 13 shows results of the model for the 2001 GYA watershed data and the 2001 GYA Landscape Model. As above, the use of more detailed and accurate data has reduced the overall number of watersheds rated “high.” Though there are still some data gaps (notably in the watershed data for the Caribou-Targhee), the core of the GYA has been filled in. Administrative boundaries are now absent, partially due to the use of GYA-wide watershed data and partially due to the use of consistent rating methods across the GYA. This map represents an ideal situation, when coupled with additional pending data from Idaho. However, all other ratings (e.g. geomorphic integrity, stream channel conditions) would also need revising to make this compatible with the other aspects of the IWWI ratings.

We summarized ratings by unit for all three models in Figure 16, Figure 17, and Figure 18. Though individual units varied, the proportion of highly sensitive watersheds in the GYA was reduced by the new model (47% to 27% from Figures 17 and 16). This is likely due to a combination of more detailed data, more included land area, and more consistent application of criteria used for defining sensitivity, but could also be from the conservative application of the rather general criteria given in the IWWI documentation. The large difference between ratings for the Custer National Forest may be due to the more detailed data being used in the landscape model. Earlier IWWI estimates were made without the benefit of the digital landscape coverage used here (Figure 9).

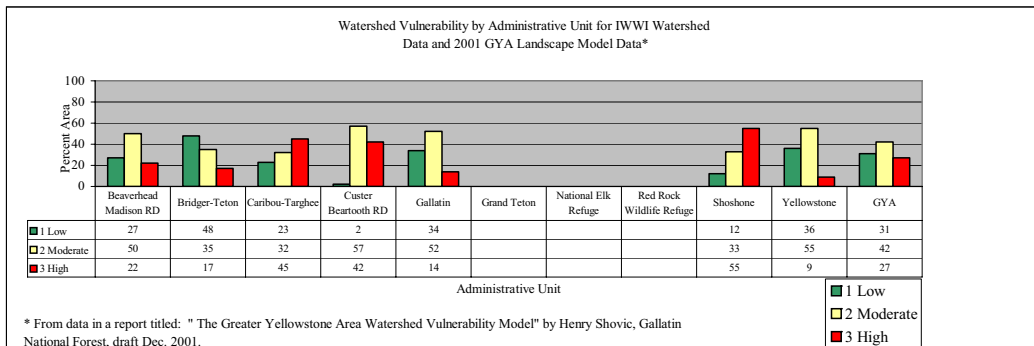


Figure 16. Watershed Vulnerability by Unit for IWWI Watershed Data and 2001 GYA Landscape Model Data (from Table 12.)

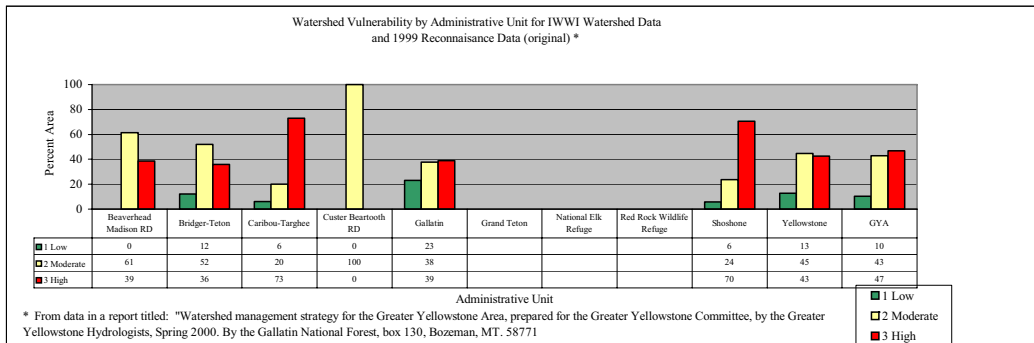
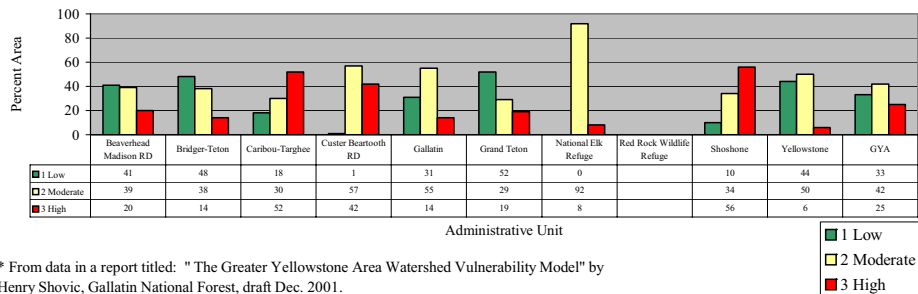


Figure 17. Watershed Vulnerability by Administrative Unit for IWWI Data and 1999 Reconnaissance Data (Original)

Watershed Vulnerability by Administrative Unit for GYA Watershed
Data and 2001 GYA Landscape Model



* From data in a report titled: "The Greater Yellowstone Area Watershed Vulnerability Model" by Henry Shovic, Gallatin National Forest, draft Dec. 2001.

Figure 18. Watershed Vulnerability by Administrative Unit for GYA Watershed Data and 2001 GYA Landscape Model (from Table 14.)

Here are a few specific comparisons between the original IWWI data and the new IWWI watershed-based data derived from Figure 17 and 16. In terms of watershed vulnerability, the Shoshone N. F. came out highest (55%) in highly sensitive watersheds versus 70 percent with the new model. This may be because of the systematic recognition of the highly dissected nature of most of the Forest (Figure 8.) Yellowstone National Park came out lowest with nine percent, versus a much more significant 43 percent. Though there is a recognized high erosion hazard in the eastern portion of the park (Figure 15) the criteria as established in the model did not emphasize that. Also, highly sensitive watersheds south of Yellowstone Lake were rated high partially due to the effects of the 1988 wildfires, not considered in the landscape model used here.

Some ratings on the Bridger-Teton National Forest were potentially inaccurate. Landscape data were very broadly defined in the northern portion of the Forest. This probably resulted in an under-assessment of vulnerability in this area. There also may be some missing landslide data in the map units representing the Flat Creek area south of the wilderness. Vulnerability ratings may be higher than shown here.

Finally, in terms of data completeness, landscape data was missing from about four percent of the entire GYA (Table 2.) Model results reflect this lack of data. It is unknown how much missing data are actually in the older IWWI results.

In terms of watersheds the IWWI watershed coverage actually was about five percent better than the newer GYA version of watersheds. In particular, watershed data was missing from the Caribou-Targhee because it was unavailable at publication time. However, Grand Teton N. P. and the National Wildlife Refuge were added, partially offsetting the C-T loss. No watershed or landscape data area available for the Red Rocks Wildlife Refuge, no doubt because of its relatively recent addition to the GYA.

CONCLUSIONS

In this project we proposed to use published digital resource data, geographic information systems (GIS), and a modeling approach to build a model of watershed vulnerability for the entire GYA. Our goals were to eliminate or reduce 1) cross-administrative boundary differences in ratings; 2) data gaps; and 3) inconsistencies relating to differences in methods, quality, and scale of data available when the original ratings were made. We also wanted to produce a repeatable, testable, and documented model that can be re-used when data or criteria change, using corporate software and data formats. Finally, we wanted to utilize the most up-to-date information available, recognizing all spatial data is in a state of flux. We accomplished this by using standardized criteria reflecting the IWWI objectives, quantitative spatial data from the GYA, and objective programming and query-based models. We also designed the models to be procedure-based, not data-based, thereby making use of the most current data during our project. The final report is CDROM-based, and includes all watershed data, all procedures, all database data, and this report.

Our report includes extensive documentation of the processes we used, as well as the products. Why go to this kind of detail? The answer lies in the nature of resource management in the 21st century. One of the most consistent and frustrating parts of resource management today is that there are so many moving targets. Data changes daily. Scientific conclusions that yesterday had the weight of fact, today are questioned. We finish a project only to find that next month the judgment-based conclusions we sweated over to make our resource recommendations are now challenged by new data in digital form.

This trend is illustrated well in the Inland Water Ways Initiative. The older data were compiled for a large-scale reconnaissance project. Best available watershed data were used. Each specialist used professional judgment and available data to judge vulnerability by watershed. Some units chose not to participate or had no available specialists to complete the project. Three years later we review the results and it is obvious some no longer meet our management objectives. We have better data and better models. However, the project is finished, the personnel are largely gone, and documentation is limited.

Hence our approach: we consciously designed it from the ground up as a work in progress. Most of our effort in the 2001 vulnerability models has gone into developing relatively data-independent processes as well as products. We have a professional "distance" from the results, in that we maximized use of documented property-based analysis, and used a minimum of direct input from specialists.

Undoubtedly there will be concern as to how well the data matches previous publications and how well it matches professionals' concerns. We welcome these comments, as all models are a result of a specific set of assumptions, criteria, procedures, and data - any one of which may be in error. The point is none of these are hard-coded, nor are they hidden from view. As data, management objectives, professional criteria, or analytical tools change, the models can change with them, providing a longevity and at least a partial solution to the high and increasing pace of resource management analysis in the digital world.

LITERATURE CITED

- Davis, C. E., Henry F. Shovic, 1996. Soil survey of the Gallatin National Forest. USDA. Natural Resources Conservation Service, Montana State Office, Bozeman, MT.
- ECOMAP. 1993. National hierarchical framework of ecological units. Administrative paper. Washington, DC. USDA. Forest Service, 20 pp.
- Greater Yellowstone Hydrologists. 2000. Watershed management strategy for the Greater Yellowstone Area, prepared for the Greater Yellowstone Committee. Gallatin National Forest, Box 130, Bozeman, MT. 58771
- Haskins, D. M, et. al. February 1998. A geomorphic classification system Vs. 1.4. USDA Forest Service, Geomorphology Working Group, USDA, Forest Service.
- Kirkby, M. J. and R. P. C. Morgan, Ed., 1980. Soil erosion. John Wiley and Sons, NY.
- Kral, M. K. and S. L. Hawkins, ed. 1984. Erosion and productivity of soils containing rock fragments. Soil Sci. Soc. Of Am. 677 South Segoe Road, Madison, WI 53711.
- Shovic, H. F. and Wendi Urie. 2001. Greater Yellowstone landscapes and soils (Landtype scale), version 1.1. Gallatin National Forest, Box 130, Bozeman, MT 59715.
- Thornbury, W. D. 1969. Principles of geomorphology. John Wiley and Sons, NY.
- USDA, 1992. National soil survey interpretations handbook. Draft. 430-VI-NSH, Sept. USDA. Natural Resources Conservation Service, WA DC.
- USDA, 1993. Soil survey manual. Agric. Hdbk. 18. USGPO, WA DC.
- USDA, 1999. Soil taxonomy. Agric. Hdbk. 436. USGPO, WA DC.

APPENDICES

Appendix One: VISUAL BASIC™ Program for Defining “highly-erodible” map units based on soil and properties.

Option Compare Text
Option Explicit

```

.....
Sub GYA_erodibility()
'This sub reads soils information and adds to s58GYALandform field in the GYA standard table.

'1.Showic
992401 version 1.0

'initialize and dimension
Dim GYAStandard As DAO.Recordset
Dim dbs As Database
Dim dbs = CurrentDb
Set GYAStandard = dbs.OpenRecordset("GYA model data with hwnf enuf clnt", dbOpenDynamic)
Dim soilname, totalprop, compprop, erodsoil, counter, i, j, lithic, landsldes, hydrothermal, otherskeletal, andisols, silty, nonsiltmnskmdl, wetest
GYAStandard.MoveFirst
counter = 0
lithic = 0
hydrothermal = 0
otherskeletal = 0
andisols = 0
silty = 0
nonsiltmnskmdl = 0
'Soil Erodibility check s10SoilComponentOne,s11SoilComponentTwo, s12SoilComponentThree, or s6SoilsSummary
'for the factors indicating "high" erodibility.
'if any are true, then place "highly erodible soil" in s58GYALandform field, otherwise place ""
'For any component the following selects for "high" erodibility
'If no rule fires, assume not highly erodible soils
'If no soils info, place "no soils data" in field.

checkeredibility:
soilname = ""
soiltext = ""
erodsoil = ""
landsldes = ""
i = 1
GYAStandard.Edit
totalprop = 0
'assign the proper field and do the check for each field
'use s6summary only if components are not present.
'If no component is present, check next component
Do While i <= 4
Select Case i
Case 1
soilname = GYAStandard!s10SoilComponentOne
If (IsNull(soilname)) Then soilname = ""
soiltext = soilname
If (soilname = "") Then GoTo nextsoilcomponent
compprop = GYAStandard!s14SoilComponentOne%
Case 2
soilname = GYAStandard!s11SoilComponentTwo
If (IsNull(soilname)) Then soilname = ""
soiltext = soiltext + soilname
If (soilname = "") Then GoTo nextsoilcomponent
compprop = GYAStandard!s15SoilComponentTwo%
Case 3
soilname = GYAStandard!s12SoilComponentThree
If (IsNull(soilname)) Then soilname = ""
soiltext = soiltext + soilname
If (soilname = "") Then GoTo nextsoilcomponent
compprop = GYAStandard!s16SoilComponentThree%
Case 4
If (soiltext <> "") Then GoTo recordwrite 'if components present then write record
soilname = GYAStandard!s6soilsSummary

```

```

If no components present, use summary
If (Null(soilname)) Then soilname = "" If no soil data present, flag and do next record
If (soilname = "") Then erodsoil = "no soils data", GoTo recorderwrite

End Select

Selection criteria for soils in component fields, if summary used, go to another criteria list to account for
'multiple soils in one field.

If i = 4 Then GoTo summary

'for all these, either erodsoil is flagged or it is left as it to allow for previous component evaluation.

'All lithic soils (skeletal or non-skeletal)are highly erodible
'All lithic soils (skeletal or non-skeletal)are highly erodible
If (soilname Like "lithic*") Then
lithic = lithic + 1
erodsoil = "highly erodible soil"
totalprop = totalprop + compprop
GoTo nextsoilcomponent
End If

'All hydrothermal (skeletal or non-skeletal) soils are highly erodible, as evidenced by "thermic" temps, but only for YELL and with non-standard
terms
If (soilname Like "hydroth*" Or soilname Like "Cryochrepts-HT*") Then
hydrothermal = hydrothermal + 1
erodsoil = "highly erodible soil"
totalprop = totalprop + compprop
GoTo nextsoilcomponent
End If

'nonskeletal soils high in silt are highly erodible.
'This is placed above skeletal check statements, because use of these terms precludes skeletal designation in Taxonomy. This
'also accounts for soils that are "silty" over "sandy-skeletal" or other strongly contrasting particle size class groups.
If (soilname Like "fine-silty") Then
silty = silty + 1
erodsoil = "highly erodible soil"
totalprop = totalprop + compprop
GoTo nextsoilcomponent
End If

If (soilname Like "coarse-silty") Then
silty = silty + 1
erodsoil = "highly erodible soil"
totalprop = totalprop + compprop
GoTo nextsoilcomponent
End If

'All other skeletal soils are not highly erodible
If (soilname Like "skeletal") Then otherskeletal = otherskeletal + 1: GoTo nextsoilcomponent

'non skeletal Andisols only, not Andic subgroups are highly erodible
If (soilname Like "cryands") Then
andisols = andisols + 1
erodsoil = "highly erodible soil"
totalprop = totalprop + compprop
GoTo nextsoilcomponent
End If

'non-skeletal, non-silty Mollisols, non-Andisol, and soils in Mollic subgroups are not highly erodible.
If (soilname Like "mollic*") Then nonmollicskmol = nonmollicskmol + 1: GoTo nextsoilcomponent
If (soilname Like "cryoll*" Or soilname Like "boroll*" Or soilname Like "xeroll*" Or soilname Like "aquoll*") Then nonmollicskmol =
nonmollicskmol + 1: GoTo nextsoilcomponent

'MsgBox ("no rule fired, record number = " & GYStandardSIMapUnitSymbol)

GoTo nextsoilcomponent
summary: 'for summary field only, go through criteria three times to approximate normal soil components.
'use 30% for each soil component, remove each already-used term to avoid double counting any criterion.
'The exception is where more than one criterion is met by a given soil in the summary. This will double count those.
totalprop = 0
j = 0

```

```

summarybegin:
  'For all these, either erodsol is flagged or it is left as is to allow for previous component evaluation.
  'All lithic soils (skeletal or non-skeletal) are highly erodible
  If (soilname Like "lithic*") Then
    lithic = lithic + 1
    erodsol = "highly erodible soil"
    totalprop = totalprop + 30
    soilname = ReplaceString_TSB(soilname, "lithic", " ", False) 'remove string from soilname
  End If

  'all hydrothermal (skeletal or non-skeletal) soils are highly erodible, as evidenced by "thermic" temps, but only for YELL and with non-standard
  terms
  If (soilname Like "hydroth*" Or soilname Like "Cryochepts-HT*") Then
    hydrothermal = hydrothermal + 1
    erodsol = "highly erodible soil"
    totalprop = totalprop + 30
    soilname = ReplaceString_TSB(soilname, "hydroth", " ", False) 'remove string from soilname
    soilname = ReplaceString_TSB(soilname, "Cryochepts-HT", " ", False) 'remove string from soilname
  End If

  'non-skeletal soils high in silt are highly erodible.
  'This is placed above skeletal check statements, because use of these terms precludes skeletal designation in Taxonomy. This
  'also accounts for soils that are "silty" over "sandy-skeletal" or other strongly contrasting particle size class groups.
  If (soilname Like "fine-silty*") Then
    silty = silty + 1
    erodsol = "highly erodible soil"
    totalprop = totalprop + 30
    soilname = ReplaceString_TSB(soilname, "fine-silty", " ", False) 'remove string from soilname
  End If

  If (soilname Like "course-silty*") Then
    silty = silty + 1
    erodsol = "highly erodible soil"
    totalprop = totalprop + 30
    soilname = ReplaceString_TSB(soilname, "course-silty", " ", False) 'remove string from soilname
  End If

  'All other skeletal soils are not highly erodible, except for Andisols
  If (soilname Like "skeletal*") Then
    otherskeletal = otherskeletal + 1
    soilname = ReplaceString_TSB(soilname, "skeletal", " ", False) 'remove string from soilname
  End If

  'non-skeletal Andisols only, not Andic subgroups are highly erodible
  If (soilname Like "cryande*") Then
    andisols = andisols + 1
    erodsol = "highly erodible soil"
    totalprop = totalprop + 30
    soilname = ReplaceString_TSB(soilname, "cryande", " ", False) 'remove string from soilname
  End If

  'non-skeletal, non-silty Mollisols, non-Andisol, and soils in Mollis subgroups are not highly erodible.
  If (soilname Like "mollic*") Then nonmolmonskml = nonmolmonskml + 1
  If (soilname Like "cryoll*" Or soilname Like "bozoll*" Or soilname Like "saxoll*" Or soilname Like "saqoll*") Then nonmolmonskml =
  nonmolmonskml + 1

  j = j + 1
  If j < 3 Then GoTo summarybegin

nextsolcomponent:
i = i + 1

Loop

recondetric:
If totalprop > 100 Then totalprop = 100
'check for previously assigned landslide designation, if there leave it
landslides = GYASstandardf58GYALandform
If landslides = "landslide" Then GYASstandardf58GYALandform = erodsol + ", " + landslides: GoTo nextst
GYASstandardf58GYALandform = erodsol
nextst: GYASstandardf67GeneralForest%j = totalprop
GYASstandardfupdate

```

```

GYAStandard.MoveNext
counter = counter + 1
If GYAStandard.EOF Then GoTo finish

GoTo checkersodibility
finish:

MsgBox ("end, total records = " & counter)

MsgBox ("values of lithic, hydrothermal, otherskeletal, andisols, sily, nonsilmonsksmol" & lithic & " " & hydrothermal & " " & _
" " & otherskeletal & " " & andisols & " " & sily & " " & nonsilmonsksmol)

End Sub

Function ReplaceString_TSB(strTextIn As String, strFind As String, strReplace As String, fCaseSensitive As Integer) As String
'Comments : replaces a substring in a string with another
'Parameters : strTextIn - string to work on
'             strFind - string to find
'             strReplace - string to replace with
'             fCaseSensitive - True for case sensitive search, False for case insensitive search
'Returns : modified string
'
Dim strTmp As String
Dim intPos As Integer
Dim intCaseSensitive As Integer

intCaseSensitive = If(fCaseSensitive, 2, 1)

strTmp = strTextIn
intPos = InStr(1, strTmp, strFind, intCaseSensitive)

Do While intPos > 0
    strTmp = Left$(strTmp, intPos - 1) & strReplace & Mid$(strTmp, intPos + Len(strFind))
    intPos = InStr(intPos + Len(strReplace), strTmp, strFind, intCaseSensitive)
Loop

ReplaceString_TSB = strTmp

End Function

```


Appendix Two: Database SQL Queries for the GYA Vulnerability Models

Query Identifier	Structured Query Language (SQL)	Data Source *	Query Name
1	SELECT Sum([Selects valid records].ACRES_NO_DATA) AS [Acres with No Data], Sum([Selects valid records].acres) AS [Total Acres], [Selects valid records].HUC6 FROM [Selects valid records] GROUP BY [Selects valid records].HUC6 ORDER BY [Selects valid records].HUC6;	IWWI, GYA	add no data acres by huc6
2	SELECT Sum([Selects valid records].ACRES_NO_DATA) AS [Acres with No Data], Sum([Selects valid records].acres) AS [Total Acres], [Selects valid records].HUC6, [Selects valid records].s70SurveyArea FROM [Selects valid records] GROUP BY [Selects valid records].HUC6, [Selects valid records].s70SurveyArea ORDER BY [Selects valid records].HUC6, [Selects valid records].s70SurveyArea;	IWWI, GYA	add no data acres by huc6 and unit
3	SELECT Sum([Selects valid records].ACRES_NO_DATA) AS [Acres with No Data], Sum([Selects valid records].acres) AS [Total Acres], [Selects valid records].s70SurveyArea FROM [Selects valid records] GROUP BY [Selects valid records].s70SurveyArea ORDER BY [Selects valid records].s70SurveyArea;	IWWI, GYA	add no data acres by Unit
4	SELECT Sum([Selects valid records].ACRES_NO_DATA) AS [Acres with No Data], Sum([Selects valid records].acres) AS [Total Acres] FROM [Selects valid records];	IWWI, GYA	add no data acres for GYA
5	SELECT [Selects valid records].HUC6, Sum([Selects valid records].acres) AS [Total Acres] FROM [Selects valid records] GROUP BY [Selects valid records].HUC6;	IWWI, GYA	add total acres by HUC6
6	SELECT Sum([add total acres by HUC6].[Total Acres])) AS [Total Area for HUC6], Avg([add total acres by HUC6].[Total Acres]) AS [Average HUC6 Size], Min([add total acres by HUC6].[Total Acres]) AS [Minimum HUC6 Size], Max([add total acres by HUC6].[Total Acres]) AS [Maximum HUC6 Size] FROM [add total acres by HUC6];	IWWI, GYA	add total acres within HUC6 avg max min by HUC6
7	SELECT Sum([Selects valid records].acres) AS SumOfacres FROM [Selects valid records];	IWWI, GYA	add total after removals
8	SELECT Sum([Selects valid records].ACRES_VULN) AS [Total Vulnerable Acres], Sum([Selects valid records].acres) AS [Total Acres], [Selects valid records].HUC6 FROM [Selects valid records] GROUP BY [Selects valid records].HUC6;	IWWI, GYA	add vulnerable acres by huc6
9	SELECT Sum([Selects valid records].ACRES_VULN) AS [Total Vulnerable Acres], Sum([Selects valid records].acres) AS [Total Acres], [Selects valid records].HUC6, [Selects valid records].UNIT FROM [Selects valid records] GROUP BY [Selects valid records].HUC6, [Selects valid records].UNIT ORDER BY [Selects valid records].HUC6, [Selects valid records].UNIT;	IWWI	add vulnerable acres by huc6 and unit
10	SELECT Sum([Selects valid records.erdoble, landslides, dissection].ACRES_VULN) AS [Total Vulnerable Acres], Sum([Selects valid records.erdoble, landslides, dissection].acres) AS [Total Acres], [Selects valid records.erdoble, landslides, dissection].s70SurveyArea FROM [Selects valid records.erdoble, landslides, dissection] GROUP BY [Selects valid records.erdoble, landslides, dissection].s70SurveyArea ORDER BY [Selects valid records.erdoble, landslides, dissection].s70SurveyArea;	IWWI	add vulnerable acres by Unit area

11	SELECT Sum([Selects valid records erodible, landslides, dissection].ACRES_VULN) AS [Total Vulnerable Acres], Sum([Selects valid records erodible, landslides, dissection].acres) AS [Total Acres] FROM [Selects valid records erodible, landslides, dissection];	IWWI, GYA	add vulnerable acres for GYA from Unit area
12	SELECT Sum([Selects valid records erodible, landslides, dissection].acres) AS SumOfACRES FROM [Selects valid records erodible, landslides, dissection] WHERE: ((([Selects valid records erodible, landslides, dissection].DISSECTION)="high"));	UNIT	adds dissected area for GYA
13	SELECT Sum([Selects valid records erodible, landslides, dissection].acres) AS SumOfACRES, [Selects valid records erodible, landslides, dissection].s70SurveyArea FROM [Selects valid records erodible, landslides, dissection] WHERE: ((([Selects valid records erodible, landslides, dissection].Erodible_landslides) Like "**highly erodible soil**")) GROUP BY [Selects valid records erodible, landslides, dissection].s70SurveyArea ORDER BY [Selects valid records erodible, landslides, dissection].s70SurveyArea;	UNIT	adds erodible soil area by unit
14	SELECT Sum([Selects valid records erodible, landslides, dissection].acres) AS SumOfACRES FROM [Selects valid records erodible, landslides, dissection] WHERE: ((([Selects valid records erodible, landslides, dissection].Erodible_landslides) Like "**highly erodible soil**"));	UNIT	adds erodible soil area for GYA
15	SELECT Sum([Selects valid records erodible, landslides, dissection].acres) AS SumOfACRES, [Selects valid records erodible, landslides, dissection].s70SurveyArea FROM [Selects valid records erodible, landslides, dissection] WHERE: ((([Selects valid records erodible, landslides, dissection].Erodible_landslides) Like "**landslides**")) GROUP BY [Selects valid records erodible, landslides, dissection].s70SurveyArea ORDER BY [Selects valid records erodible, landslides, dissection].s70SurveyArea;	UNIT	adds landslides area by unit
16	SELECT Sum([Selects valid records erodible, landslides, dissection].acres) AS SumOfACRES FROM [Selects valid records erodible, landslides, dissection] WHERE: ((([Selects valid records erodible, landslides, dissection].Erodible_landslides) Like "**landslides**"));	UNIT	adds landslides area for GYA
18	UPDATE: iwwi_huc6_and_gyajoindis_ and_attributes SET iwwi_huc6_and_gyajoindis_ and_attributes.ACRES_VULN = 0, iwwi_huc6_and_gyajoindis_ and_attributes.ACRES_NO_DATA = 0;	IWWI	assigns 0 to ACRES_VULN and ACRES_NO_DATA
19	UPDATE: [Selects valid records] SET [Selects valid records].ACRES_NO_DATA = [acres] WHERE: ((([Selects valid records].Erodible_landslides)="no soils data"));	IWWI, GYA	assigns acres_no_data for no soils data
20	UPDATE: [Selects valid records] SET [Selects valid records].ACRES_NO_DATA = 0 WHERE: ((([Selects valid records].DISSECTION)="high"));	IWWI, GYA	assigns acres_no_data back to 0 if high dissection
21	UPDATE: [Selects valid records] SET [Selects valid records].ACRES_VULN = [Selects valid records].[acres] WHERE: ((([Selects valid records].Erodible_landslides)="highly erodible soil"));	IWWI, GYA	assigns erodible no reduction
22	UPDATE: [Selects valid records] SET [Selects valid records].ACRES_VULN = [ACRES] WHERE: ((([Selects valid records].Erodible_landslides) Like "**landslides**")) OR ((([Selects valid records].DISSECTION)="high"));	IWWI, GYA	assigns landslides or dissected acres
24	SELECT [add no data acres by huc6].HUC6, [add no data acres by huc6].[Acres with No Data], [add no data acres by huc6].[Total Acres], [Acres with No Data]/[Total Acres] AS Percentage, If([Percentage]>50,"High", (If([Percentage]>20,"Moderate", "Low"))) AS Rating INTO iwwiNo_Data_Percentages_HUC6 FROM [add no data acres by huc6] ORDER BY [add no data acres by huc6].HUC6;	IWWI, GYA	Calculate percentage no data by HUC6
25	SELECT [add vulnerable acres by huc6].HUC6, [add vulnerable acres by huc6].[Total Vulnerable Acres], [add vulnerable acres by huc6].[Total Acres], [Total Vulnerable Acres]/[Total Acres] AS Percentage, If([Percentage]>50,"High", (If([Percentage]>20,"Moderate", "Low"))) AS Rating INTO iwwiVulnerable_Percentages_By_HUC6 FROM [add vulnerable acres by huc6] ORDER BY [add vulnerable acres by huc6].HUC6;	IWWI, GYA	Calculate percentage vulnerable by HUC6

26	SELECT iwwi_huc6_and_gya_join_diss.*, [area]*0.000247 AS acres, [GYA model data with bvnf csnf cbnf].*, 1.1 AS ACRES_VULN, 1.1 AS ACRES_NO_DATA INTO iwwi_huc6_and_gyajoindiss_and_attributes FROM [GYA model data with bvnf csnf cbnf] RIGHT JOIN iwwi_huc6_and_gya_join_diss ON [GYA model data with bvnf csnf cbnf].s1MapUnitSymbol = iwwi_huc6_and_gya_join_diss.LABEL;	IWWI	iwwi_huc6_and_gyajoindiss_and_attributesmak e
27	UPDATE [Selects records with attributes] SET [Selects records with attributes].ACRES = [ACRES]*([Perc_Of_Unit_Erodible]/100) WHERE ((([Selects records with attributes].[Erodible, landslides] Like "highly erodible soil*"));	IWWI	reduces erodible acres by percentage of unit
28	SELECT gya_huc6_and_gyajoindiss_and_attributes.*, [gya_huc6_and_gyajoindiss_and_attributes].s1MapUnitSymbol AS Expr1, iwwi_huc6_and_gya_join_diss.*, [GYA model data with bvnf csnf cbnf].s1MapUnitSymbol FROM gya_huc6_and_gyajoindiss_and_attributes, [GYA model data with bvnf csnf cbnf] RIGHT JOIN iwwi_huc6_and_gya_join_diss ON [GYA model data with bvnf csnf cbnf].s1MapUnitSymbol = iwwi_huc6_and_gya_join_diss.LABEL WHERE ((([gya_huc6_and_gyajoindiss_and_attributes].s1MapUnitSymbol) Is Null) AND (([GYA model data with bvnf csnf cbnf].s1MapUnitSymbol) Is Null));	IWWI	Selects records with no attributes
29	SELECT iwwi_huc6_and_gyajoindiss_and_attributes.* FROM iwwi_huc6_and_gyajoindiss_and_attributes WHERE (((iwwi_huc6_and_gyajoindiss_and_attributes.HUC6) Is Not Null) AND ((iwwi_huc6_and_gyajoindiss_and_attributes.LABEL) <> "CBNFP") AND (iwwi_huc6_and_gyajoindiss_and_attributes.LABEL) Not Like "GLCO*"));	IWWI	Selects valid records
30	SELECT Sum([Selects records with no attributes].ACRES) AS SumOfACRES, [Selects records with no attributes].LABEL AS Expr1 FROM [Selects records with no attributes].LABEL; GROUP BY [Selects records with no attributes].LABEL;	IWWI	totals from Selects records with no attributes
31	SELECT Sum([AREA]*0.000247) AS [Total Acres], gyafs_bdy.MAP_NAME FROM gyafs_bdy GROUP BY gyafs_bdy.MAP_NAME;	GYA, IWWI	add admin acres from by unit
32	SELECT Sum([AREA]*0.000247) AS [Total Acres], gyafs_bdy_gyahuc6_clip.MAP_NAME FROM gyafs_bdy_gyahuc6_clip GROUP BY gyafs_bdy_gyahuc6_clip.MAP_NAME;	GYA	add admin acres from clipped by unit
33	SELECT Sum([Selects valid records erodible, landslides, dissection].acres) AS SumOfACRES, [Selects valid records erodible, landslides, dissection].s70SurveyArea, [Selects valid records erodible, landslides, dissection].DISSECTION FROM [Selects valid records erodible, landslides, dissection] GROUP BY [Selects valid records erodible, landslides, dissection].s70SurveyArea, [Selects valid records erodible, landslides, dissection].DISSECTION HAVING ((([Selects valid records erodible, landslides, dissection].DISSECTION)="high")) ORDER BY [Selects valid records erodible, landslides, dissection].s70SurveyArea;	UNIT	adds dissected land area by unit
36	SELECT [add admin acres from by unit].[Total Acres], [add admin acres from clipped by unit].*, [add admin acres from by unit].[Total Acres]-[add admin acres from clipped by unit].[total acres] AS [Acres Not in GYA_HUC6], [Acres Not in GYA_HUC6]*100/[add admin acres from by unit].[Total Acres] AS [Percentage Not in GYA_HUC6] FROM [add admin acres from by unit] INNER JOIN [add admin acres from clipped by unit] ON [add admin acres from by unit].MAP_NAME = [add admin acres from clipped by unit].MAP_NAME;	GYA	calculates percentage admin not in gya_huc6

37	SELECT gyajoindisshape*, [area]*0.000247 AS acres, [GYA model data with bvfnf csnf cbnfl]* INTO gyajoindisss_and_attributes FROM gyajoindisshape LEFT JOIN [GYA model data with bvfnf csnf cbnfl] ON gyajoindisshape.LABEL = [GYA model data with bvfnf csnf cbnfl].s1MapUnitSymbol;	GYA	gyajoindisss_and_attributesmake
38	SELECT gya_huc6_and_gyajoindisss.*, [area]*0.000247 AS acres, [GYA model data with bvfnf csnf cbnfl]*, 1.1 AS ACRES_VULN, 1.1 AS ACRES_NO_DATA INTO gya_huc6_and_gyajoindisss_and_attributes FROM [GYA model data with bvfnf csnf cbnfl] RIGHT JOIN gya_huc6_and_gyajoindisss ON [GYA model data with bvfnf csnf cbnfl].s1MapUnitSymbol = gya_huc6_and_gyajoindisss.LABEL;	GYA	gya_huc6_and_gyajoindisss_and_attributesmake
39	SELECT gya_huc6_and_gyajoindisss_and_attributes.*, gya_huc6_and_gyajoindisss_and_attributes.s1MapUnitSymbol FROM gya_huc6_and_gyajoindisss_and_attributes WHERE (((gya_huc6_and_gyajoindisss_and_attributes.s1MapUnitSymbol) Is Null));	GYA	Selects records with no attributes
40	SELECT Sum([Selects records with no attributes].acres) AS SumOfACRES, [Selects records with no attributes].LABEL FROM [Selects records with no attributes] GROUP BY [Selects records with no attributes].LABEL;	GYA	totals from Selects records with no attributes
41	SELECT gya_huc6_and_gyajoindisss_and_attributes.* FROM gya_huc6_and_gyajoindisss_and_attributes WHERE (((gya_huc6_and_gyajoindisss_and_attributes.LABEL) Is Not Null And (gya_huc6_and_gyajoindisss_and_attributes.LABEL) Not Like "GLCO*") AND ((gya_huc6_and_gyajoindisss_and_attributes.HUC6) Is Not Null));	GYA	Selects valid records
42	SELECT gyajoindisss_and_attributes.* FROM gyajoindisss_and_attributes WHERE (((gyajoindisss_and_attributes.LABEL) Is Not Null And (gyajoindisss_and_attributes.LABEL) Not Like "GLCO*"));	UNIT	Selects valid records erodible, landslides, dissection
43	UPDATE gyajoindisss_and_attributes SET gyajoindisss_and_attributes.ACRES_VULN = 0, gyajoindisss_and_attributes.ACRES_NO_DATA = 0;	UNIT	Unit area: assigns 0 to ACRES_VULN and ACRES_NO_DATA
44	UPDATE [Selects valid records erodible, landslides, dissection] SET [Selects valid records erodible, landslides, dissection].ACRES_VULN = [Selects valid records].[acres] WHERE ((([Selects valid records erodible, landslides, dissection].Erodible_Landslides)="highly erodible soil"));	UNIT	Unit area: assigns erodible no reduction
45	UPDATE [Selects valid records erodible, landslides, dissection] SET [Selects valid records erodible, landslides, dissection].ACRES_VULN = [ACRES] WHERE ((([Selects valid records erodible, landslides, dissection].Erodible_Landslides) Like "**landslides*") OR ((([Selects valid records erodible, landslides, dissection].DISSECTION)="high"));	UNIT	Unit Area: assigns landslides or dissected acres
46	UPDATE [Selects valid records erodible, landslides, dissection] SET [Selects valid records erodible, landslides, dissection].ACRES_NO_DATA = [acres] WHERE ((([Selects valid records erodible, landslides, dissection].Erodible_Landslides)="no soils data"));	UNIT	Unit area: assigns acres_no_data for no soils data
47	UPDATE [Selects valid records erodible, landslides, dissection] SET [Selects valid records erodible, landslides, dissection].ACRES_NO_DATA = 0 WHERE ((([Selects valid records erodible, landslides, dissection].DISSECTION)="high"));	UNIT	Unit area: assigns acres_no_data back to 0 if high dissection
48	SELECT Sum([add area by unit by rating by gya_huc6].[Total Acres]) AS [SumOfTotal Acres], [add area by unit by rating by gya_huc6].MAP_NAME FROM [add area by unit by rating by gya_huc6] GROUP BY [add area by unit by rating by gya_huc6].MAP_NAME;	GYA	adds huc6 area by unit
49	SELECT Sum([wwi_huc6_and_gyajoindisss_and_attributes.acres] AS SumOfacres, iwwi_huc6_and_gyajoindisss_and_attributes.UNIT FROM iwwi_huc6_and_gyajoindisss_and_attributes GROUP BY iwwi_huc6_and_gyajoindisss_and_attributes.UNIT;	IWWI	add area by unit iwwi

50	SELECT Sum([AREA]*0.000247) AS [Total Acres], gyafs_bdy_and_gya_huc6_fed_land_only.MAP_NAME, GYAVulnerable_Percentages_By_HUC6.Rating, GYAVulnerable_Percentages_By_HUC6.HUC6 FROM GYANo_Data_Percentages_HUC6 RIGHT JOIN (GYAVulnerable_Percentages_By_HUC6 LEFT JOIN gyafs_bdy_and_gya_huc6_fed_land_only ON GYAVulnerable_Percentages_By_HUC6.HUC6 = gyafs_bdy_and_gya_huc6_fed_land_only.HUC6) ON GYANo_Data_Percentages_HUC6.HUC6 = GYAVulnerable_Percentages_By_HUC6.HUC6 WHERE (((GYANo_Data_Percentages_HUC6.Rating)<>"High")) GROUP BY gyafs_bdy_and_gya_huc6_fed_land_only.MAP_NAME, GYAVulnerable_Percentages_By_HUC6.Rating, GYAVulnerable_Percentages_By_HUC6.HUC6 ORDER BY gyafs_bdy_and_gya_huc6_fed_land_only.MAP_NAME, GYAVulnerable_Percentages_By_HUC6.Rating DESC, GYAVulnerable_Percentages_By_HUC6.HUC6;	GYA	add area by unit by rating by gya_huc6
52	SELECT Sum([add area by unit by rating by iwwi_huc6],[Total Acres]) AS [Sum of Acres], [add area by unit by rating by iwwi_huc6],[MAP_NAME], [add area by unit by rating by iwwi_huc6].Rating FROM [add area by unit by rating by iwwi_huc6] GROUP BY [add area by unit by rating by iwwi_huc6].[MAP_NAME], [add area by unit by rating by iwwi_huc6].Rating;	IWWI	adds huc6 area by unit by rating_iwwi_huc6
53	SELECT Sum([iwwi_huc6_and_gyafs_bdyunion].[AREA]*0.000247) AS [Total Acres], iwwi_huc6_and_gyafs_bdyunion.MAP_NAME, iwwiVulnerable_Percentages_By_HUC6.Rating, iwwi_huc6_and_gyafs_bdyunion.HUC6, iwwi_huc6_and_gyafs_bdyunion.MAP_NAME FROM iwwiNo_Data_Percentages_HUC6 RIGHT JOIN (iwwi_huc6_and_gyafs_bdyunion RIGHT JOIN iwwiVulnerable_Percentages_By_HUC6 ON iwwi_huc6_and_gyafs_bdyunion.HUC6 = iwwiVulnerable_Percentages_By_HUC6.HUC6) ON iwwiNo_Data_Percentages_HUC6.HUC6 = iwwiVulnerable_Percentages_By_HUC6.HUC6 WHERE (((iwwiNo_Data_Percentages_HUC6.Rating)<>"High")) GROUP BY iwwi_huc6_and_gyafs_bdyunion.MAP_NAME, iwwiVulnerable_Percentages_By_HUC6.Rating, iwwi_huc6_and_gyafs_bdyunion.HUC6 ORDER BY iwwi_huc6_and_gyafs_bdyunion.MAP_NAME, iwwiVulnerable_Percentages_By_HUC6.Rating DESC, iwwi_huc6_and_gyafs_bdyunion.HUC6;	IWWI	add area by unit by rating by iwwi_huc6

54	<p>SELECT [GYA model data with bvnf csnf cbnf].s1MapUnitSymbol, [GYA model data with bvnf csnf cbnf].s19.LandformSummary, [GYA model data with bvnf csnf cbnf].s21.LandformOne, [GYA model data with bvnf csnf cbnf].s22.LandformTwo, [GYA model data with bvnf csnf cbnf].s23.LandformThree, [GYA model data with bvnf csnf cbnf].s6SoilsSummary, [GYA model data with bvnf csnf cbnf].s5MapUnitNotes, [GYA model data with bvnf csnf cbnf].s27ParentMaterialSummary, [GYA model data with bvnf csnf cbnf].Erodible_Landslides FROM [GYA model data with bvnf csnf cbnf] WHERE: ((([GYA model data with bvnf csnf cbnf].s23.LandformThree) Like "*"slide*" Or ([GYA model data with bvnf csnf cbnf].s23.LandformThree) Like "*"mass*" Or ([GYA model data with bvnf csnf cbnf].s23.LandformThree) Like "*"earth*" Or ([GYA model data with bvnf csnf cbnf].s23.LandformThree) Like "*"flow*" Or ([GYA model data with bvnf csnf cbnf].s23.LandformThree) Like "*"slump*" Or ([GYA model data with bvnf csnf cbnf].s23.LandformThree) Like "*"unstable*") OR ((([GYA model data with bvnf csnf cbnf].s22.LandformTwo) Like "*"slide*" Or ([GYA model data with bvnf csnf cbnf].s22.LandformTwo) Like "*"mass*" Or ([GYA model data with bvnf csnf cbnf].s22.LandformTwo) Like "*"earth*" Or ([GYA model data with bvnf csnf cbnf].s22.LandformTwo) Like "*"flow*" Or ([GYA model data with bvnf csnf cbnf].s22.LandformTwo) Like "*"slump*" Or ([GYA model data with bvnf csnf cbnf].s22.LandformTwo) Like "*"unstable*") OR ((([GYA model data with bvnf csnf cbnf].s21.LandformOne) Like "*"slide*" Or ([GYA model data with bvnf csnf cbnf].s21.LandformOne) Like "*"mass*" Or ([GYA model data with bvnf csnf cbnf].s21.LandformOne) Like "*"earth*" Or ([GYA model data with bvnf csnf cbnf].s21.LandformOne) Like "*"flow*" Or ([GYA model data with bvnf csnf cbnf].s21.LandformOne) Like "*"slump*" Or ([GYA model data with bvnf csnf cbnf].s21.LandformOne) Like "*"unstable*") OR ((([GYA model data with bvnf csnf cbnf].s19.LandformSummary) Like "*"slide*" Or ([GYA model data with bvnf csnf cbnf].s19.LandformSummary) Like "*"mass*" Or ([GYA model data with bvnf csnf cbnf].s19.LandformSummary) Like "*"earth*" Or ([GYA model data with bvnf csnf cbnf].s19.LandformSummary) Like "*"flow*" Or ([GYA model data with bvnf csnf cbnf].s19.LandformSummary) Like "*"slump*" Or ([GYA model data with bvnf csnf cbnf].s19.LandformSummary) Like "*"unstable*") OR ((([GYA model data with bvnf csnf cbnf].s6SoilsSummary) Like "*"slide*" Or ([GYA model data with bvnf csnf cbnf].s6SoilsSummary) Like "*"earth*" Or ([GYA model data with bvnf csnf cbnf].s6SoilsSummary) Like "*"flow*" Or ([GYA model data with bvnf csnf cbnf].s6SoilsSummary) Like "*"slump*" Or ([GYA model data with bvnf csnf cbnf].s6SoilsSummary) Like "*"unstable*") OR ((([GYA model data with bvnf csnf cbnf].s5MapUnitNotes) Like "*"slide*" Or ([GYA model data with bvnf csnf cbnf].s5MapUnitNotes) Like "*"earth*" Or ([GYA model data with bvnf csnf cbnf].s5MapUnitNotes) Like "*"flow*" Or ([GYA model data with bvnf csnf cbnf].s5MapUnitNotes) Like "*"slump*" Or ([GYA model data with bvnf csnf cbnf].s5MapUnitNotes) Like "*"unstable*") OR ((([GYA model data with bvnf csnf cbnf].s27ParentMaterialSummary) Like "*"slide*" Or ([GYA model data with bvnf csnf cbnf].s27ParentMaterialSummary) Like "*"earth*" Or ([GYA model data with bvnf csnf cbnf].s27ParentMaterialSummary) Like "*"flow*" Or ([GYA model data with bvnf csnf cbnf].s27ParentMaterialSummary) Like "*"slump*" Or ([GYA model data with bvnf csnf cbnf].s27ParentMaterialSummary) Like "*"unstable*");</p>	GYA, IWW1	landslides filter for later manual selection
55	<p>UPDATE gya_huc6_and_gya9indices_and_attributes SET gya_huc6_and_gya9indices_and_attributes.ACRES_VULN = 0, gya_huc6_and_gya9indices_and_attributes.ACRES_NO_DATA = 0;</p>	GYA	assigns 0 to ACRES_VULN and ACRES_NO_DATA
56	<p>SELECT Sum([add area by unit by rating by gya_huc6].[Total Acres]) AS [SumOfTotal Acres], [add area by unit by rating by gya_huc6].MAP_NAME, [add area by unit by rating by gya_huc6].Rating FROM [add area by unit by rating by gya_huc6] GROUP BY [add area by unit by rating by gya_huc6].MAP_NAME, [add area by unit by rating by gya_huc6].Rating;</p>	GYA	adds huc6 area by unit by rating

*

- UNIT = Based on 2001 Landscape data, not on Watershed data (contained in "gyaHuc6_and_gyajoinidiss summaries.mdb")
- GYA = Based on 2001 Landscape data and 2001 GYA Watershed database (contained in "gyaHuc6_and_gyajoinidiss summaries.mdb")
- IWWI= Based on 2001 Landscape data and 1999 IWWI Watershed data (contained in "iwwiHuc6_and_gyajoinidiss summaries.mdb")

Multiple designations mean queries are universal between databases.

Appendix Three. Summaries of Vulnerability and Data Completeness by IWWI and GYA Watersheds: Examples of Reports contained on the publication CD.

These reports are examples of data available in electronic form. The first and last page of each report is included here. The first reports are for the IWWI coverage and GYA landscape Model. The second set is for the GYA watershed coverage and the GYA landscape Model. Totals in these reports do not correspond exactly to tables in the model analysis. This is because these reports also include watersheds having "high" no data levels and do not include sensitive lands in the GYA that are not in the GYA watershed coverage.

GYA Watershed Vulnerability (IWWI HUC6)

Ratings for Watersheds or portions thereof in Federal ownership only.

Henry F. Shovic, Interagency Spatial Analysis Center

<i>HUC6</i>	<i>Sensitive Lands (Acres)</i>	<i>Total Acres</i>	<i>Percentage of</i>	<i>Watershed Vulnerability Rating</i>
10020001070	180.0	279.3	64.5	High
10020001070	75.7	288.7	29.3	Moderate
10020001080	63.7	183.8	34.7	Moderate
10020001080	0.0	67.0	0.0	Low
10020001100	29.7	519.4	5.7	Low
10020001100	0.0	30.3	0.0	Low
10020001100	0.0	153.5	0.0	Low
10020001180	0.0	4.2	0.0	Low
10020001190	0.0	76.9	0.0	Low
10020001190	0.4	1.0	39.9	Moderate
10020001190	0.0	3.5	0.0	Low
10020001190	0.0	29.2	0.0	Low
10020001190	683.3	2531.9	27.0	Moderate
10020001190	424.4	1243.3	34.1	Moderate
10020001190	3305.5	5038.4	65.6	High
10020001190	5624.7	17430.1	32.3	Moderate
10020001200	0.0	1.7	0.0	Low
10020001200	2397.0	2956.0	81.1	High
10020001210	800.7	5451.7	14.7	Low
10020001210	19.4	22.1	88.0	High
10020001210	749.9	1319.1	56.8	High
10020001220	0.0	1298.1	0.0	Low
10020001220	1757.8	4448.3	39.5	Moderate
10020002170	6777.3	13209.2	51.3	High
10020002180	980.9	1833.0	54.1	High
10020002180	1730.7	8482.3	20.4	Moderate
10020003010	66.8	802.1	8.3	Low
10020003010	3732.6	10054.3	37.1	Moderate
10020003010	1936.4	6782.2	28.6	Moderate
10020003020	2752.3	13203.6	20.8	Moderate
10020003030	40.0	134.4	29.8	Moderate
10020003040	2275.8	10305.2	22.1	Moderate
10020003040	1210.8	4574.0	26.5	Moderate
10020003050	2043.1	8816.9	23.2	Moderate
10020003050	2.9	260.8	1.1	Low
10020003070	248.3	2559.7	9.7	Low
10020003070	0.0	119.7	0.0	Low
10020003080	5632.8	16463.3	34.2	Moderate
10020003080	4122.3	11584.1	35.6	Moderate
10020003090	17235.5	32665.1	52.8	High
10020003100	17607.7	34508.7	51.0	High
10020003100	8248.0	12992.8	63.5	High
10020003110	7699.0	27370.7	28.1	Moderate
10020003110	8051.9	10427.4	77.2	High

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<i>HUC6</i>	<i>Sensitive Lands (Acres)</i>	<i>Total Acres</i>	<i>Percentage of</i>	<i>Watershed Vulnerability Rating</i>
17040214040	902.2	4586.2	19.7	Low
17040214040	7200.8	11528.6	62.5	High
17040214040	5121.8	9996.1	51.2	High
17040214040	3069.6	5985.0	51.3	High
17040214040	5859.9	8500.6	68.9	High
17040214040	8229.8	19918.8	41.3	Moderate
17040214040	2643.1	5896.3	44.8	Moderate
17040214040	127.2	7267.6	1.8	Low
17040214041	2153.2	5179.5	41.6	Moderate
17040214060	11.8	1578.1	0.7	Low
17040214060	6163.1	33145.6	18.6	Low
17040214060	0.0	1908.0	0.0	Low
17040214060	262.4	8969.2	2.9	Low
17040214060	4719.1	16811.5	28.1	Moderate
17040214060	1004.9	3782.9	26.6	Moderate
17040215020	6.8	3042.0	0.2	Low
17040215030	0.0	1562.0	0.0	Low
17040215030	2197.4	9564.4	23.0	Moderate
17040215030	0.0	13116.0	0.0	Low
17040215030	551.0	15649.6	3.5	Low
17040215040	1855.7	12484.3	14.9	Low
17040215040	1808.6	15381.6	6.6	Low
17040215050	200.0	3021.9	6.6	Low
17040215050	0.0	14240.9	0.0	Low
17040215050	795.7	9480.8	8.4	Low
17040215050	847.7	21280.3	4.0	Low
17040215050	1655.5	5772.8	28.7	Moderate
17040215060	921.5	944.9	97.5	High
17040215060	8340.5	8354.5	99.8	High
17040215060	5986.4	12534.4	47.8	Moderate
17040216020	0.0	5231.0	0.0	Low
17040216020	0.0	425.4	0.0	Low
17040216030	0.0	7284.9	0.0	Low
17040216030	0.0	9212.6	0.0	Low
17040216030	0.0	17344.5	0.0	Low
17040216040	0.0	13026.6	0.0	Low
17040216050	0.0	1348.7	0.0	Low
17040216060	438.5	10455.8	4.2	Low
Statistics: Total	4,695,914.3	Total	13,505,540.8	Average 34.9

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GYA Landscape Data Completeness (IWWI HUC6)

Ratings for HUC6 Watersheds or portions thereof in Federal ownership only. Henry
F. Shovic, Interagency Spatial Analysis Center

HUC6 Watershed	Acres with Incomplete Landscape Data	Total Acres	Percentage of Total Acres	Rating for missing data: low < 20%; mod 20-50%; high >50%
10020001070	0.0	279.3	0.0	Low
10020001070	0.0	288.7	0.0	Low
10020001080	0.0	183.8	0.0	Low
10020001080	0.0	67.0	0.0	Low
10020001100	0.0	519.4	0.0	Low
10020001100	0.0	30.3	0.0	Low
10020001100	0.0	153.5	0.0	Low
10020001180	0.0	4.2	0.0	Low
10020001190	0.0	76.9	0.0	Low
10020001190	0.0	1.0	0.0	Low
10020001190	0.0	3.5	0.0	Low
10020001190	0.0	29.2	0.0	Low
10020001190	75.2	2,531.9	3.0	Low
10020001190	57.4	1,243.3	4.6	Low
10020001190	223.3	5,038.4	4.4	Low
10020001190	156.9	17,430.1	0.8	Low
10020001200	0.0	1.7	0.0	Low
10020001200	32.6	2,956.0	1.1	Low
10020001210	1,439.5	5,451.7	26.4	Moderate
10020001210	0.0	22.1	0.0	Low
10020001210	0.0	1,319.1	0.0	Low
10020001220	173.3	1,298.1	13.4	Low
10020001220	322.7	4,448.3	7.3	Low
10020002170	333.6	13,209.2	2.5	Low
10020002180	34.6	1,813.0	1.9	Low
10020002180	109.8	8,482.3	1.3	Low
10020003010	309.5	802.1	38.6	Moderate
10020003010	728.6	10,054.3	7.2	Low
10020003010	740.1	6,782.2	10.9	Low
10020003020	1,339.9	13,203.6	10.1	Low
10020003030	78.5	154.4	58.4	High
10020003040	1,503.1	10,305.2	14.6	Low
10020003040	905.6	4,574.0	19.8	Low
10020003050	1,224.2	8,816.9	13.9	Low
10020003050	257.5	260.8	98.7	High
10020003070	1,890.1	2,559.7	73.8	High
10020003070	98.4	119.7	82.2	High
10020003080	2,773.4	16,463.3	16.8	Low
10020003080	3,500.9	11,584.1	30.2	Moderate
10020003090	889.5	32,665.1	2.7	Low
10020003100	1,507.9	34,508.7	4.4	Low
10020003100	603.2	12,992.8	4.6	Low
10020003110	264.5	27,370.7	1.0	Low
10020003110	297.0	10,427.4	2.8	Low
10020003110	109.5	8,880.4	1.2	Low

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<i>HUC6 Watershed</i>	<i>Acres with Incomplete Landscape Data</i>	<i>Total Acres</i>	<i>Percentage of Total Acres</i>	<i>Rating for missing data: low < 20%; mod 20-50%; high >50%</i>
17040207120	0.0	6,079.3	0.0	Low
17040207120	0.0	12,378.5	0.0	Low
17040207120	0.0	12,055.1	0.0	Low
17040207130	0.0	11,404.4	0.0	Low
17040207130	0.0	19,338.5	0.0	Low
17040207130	0.0	11,309.9	0.0	Low
17040214030	0.0	5,202.6	0.0	Low
17040214040	0.0	999.1	0.0	Low
17040214040	0.0	4,586.2	0.0	Low
17040214040	0.0	11,528.6	0.0	Low
17040214040	0.0	9,996.1	0.0	Low
17040214040	0.0	5,985.0	0.0	Low
17040214040	0.0	8,500.6	0.0	Low
17040214040	0.0	19,918.8	0.0	Low
17040214040	0.0	5,896.3	0.0	Low
17040214040	0.0	7,267.6	0.0	Low
17040214041	0.0	5,179.5	0.0	Low
17040214060	0.0	1,578.1	0.0	Low
17040214060	0.0	33,145.6	0.0	Low
17040214060	0.0	1,908.0	0.0	Low
17040214060	0.0	8,969.2	0.0	Low
17040214060	0.0	16,811.5	0.0	Low
17040214060	0.0	3,782.9	0.0	Low
17040215020	0.0	3,042.0	0.0	Low
17040215030	0.0	1,552.0	0.0	Low
17040215030	0.0	9,564.4	0.0	Low
17040215030	0.0	13,116.0	0.0	Low
17040215030	0.0	15,649.6	0.0	Low
17040215040	0.0	12,484.3	0.0	Low
17040215040	0.0	15,381.6	0.0	Low
17040215050	0.0	3,021.9	0.0	Low
17040215050	0.0	14,240.9	0.0	Low
17040215050	0.0	9,480.8	0.0	Low
17040215050	0.0	21,280.3	0.0	Low
17040215050	0.0	5,772.8	0.0	Low
17040215060	0.0	944.9	0.0	Low
17040215060	0.0	8,354.5	0.0	Low
17040215060	0.0	12,534.4	0.0	Low
17040216020	0.0	5,231.0	0.0	Low
17040216030	0.0	425.4	0.0	Low
17040216030	0.0	7,284.9	0.0	Low
17040216030	0.0	9,212.6	0.0	Low
17040216030	0.0	17,344.5	0.0	Low
17040216040	0.0	13,026.6	0.0	Low
17040216050	0.0	1,348.7	0.0	Low
17040216060	0.0	10,455.8	0.0	Low
Statistics: Total	545,167.3	Total	13,505,540.8	Average 3.9

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GYA Watershed Vulnerability (GYA HUC6)

Ratings for Watersheds or portions thereof in Federal ownership only.

Henry F. Shovic, Interagency Spatial Analysis Center

<i>HUC6</i>	<i>Watershed Sensitive Lands (Acres)</i>	<i>Total Acres</i>	<i>Percentage of</i>	<i>Watershed Vulnerability Rating</i>
10020001010	1785.5	7006.3	25.5	Moderate
10020001010	724.3	5553.5	13.0	Low
10020001010	15.5	15.8	98.2	High
10020001010	882.5	1799.9	49.0	Moderate
10020001010	17.7	44.4	39.9	Moderate
10020001010	0.0	4.8	0.0	Low
10020001010	2820.6	3902.4	72.3	High
10020001010	11.3	16.5	68.7	High
10020001011	0.0	7.2	0.0	Low
10020001011	0.0	2.1	0.0	Low
10020001020	4590.9	16497.7	27.8	Moderate
10020001020	3566.5	5552.4	64.2	High
10020001020	1221.0	3707.6	32.9	Moderate
10020001020	0.0	9.5	0.0	Low
10020001020	4.3	4.9	87.4	High
10020002050	1771.1	8838.2	20.0	Moderate
10020002050	976.3	1860.1	52.5	High
10020002050	8673.5	15499.9	56.0	High
10020003010	13950.1	33318.4	41.9	Moderate
10020003010	13217.3	26393.1	50.1	High
10020003010	15428.6	26526.2	58.2	High
10020003010	17421.0	32780.2	53.1	High
10020003010	7628.9	14550.9	52.4	High
10020003010	3606.2	9602.3	38.4	Moderate
10020003010	3825.8	10959.7	38.0	Moderate
10020003010	333.5	3161.4	10.5	Low
10020003010	4363.1	12841.7	34.0	Moderate
10020003030	167.2	2898.5	5.8	Low
10020003040	82.9	1103.8	7.5	Low
10020003040	5.5	282.3	1.9	Low
10020003040	1207.5	3526.2	34.2	Moderate
10020003040	958.2	5620.7	17.0	Low
10020003050	998.4	4185.0	23.9	Moderate
10020003050	1919.3	9788.4	19.6	Low
10020003050	3024.5	12788.8	23.6	Moderate
10020003050	1928.5	7805.1	24.7	Moderate
10020003050	4596.9	11700.8	39.3	Moderate
10020005010	135.8	2802.7	4.8	Low
10020005010	6.3	895.7	0.7	Low
10020005050	21.8	64.2	33.9	Moderate
10020005050	0.0	25.8	0.0	Low
10020005060	870.2	21190.0	4.1	Low
10020005060	0.0	8818.4	0.0	Low

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<i>HUC6</i>			<i>Percentage of</i>	<i>Watershed Vulnerability</i>
<i>Watershed</i>	<i>Sensitive Lands (Acres)</i>	<i>Total Acres</i>		
17040204010	3549.8	8844.4	40.1	Moderate
17040204020	4346.3	25700.5	16.9	Low
17040204020	2052.6	4478.3	45.8	Moderate
17040204020	2773.3	7316.8	37.9	Moderate
17040204020	0.0	52.7	0.0	Low
17040204020	956.8	8684.8	11.0	Low
17040204030	3224.5	12403.3	26.0	Moderate
17040204030	4003.7	11641.1	34.4	Moderate
17040204030	5867.7	15259.2	38.5	Moderate
17040204030	1180.8	1201.8	98.3	High
17040204030	993.3	1750.9	56.7	High
17040204030	571.3	7798.2	7.3	Low
17040204030	3690.3	8583.4	43.0	Moderate
17040204040	7047.2	22322.8	31.6	Moderate
17040204040	3441.3	11618.1	29.6	Moderate
17040204040	10130.2	13296.0	76.2	High
17040204040	6190.5	8595.0	72.0	High
17040204050	0.0	2174.3	0.0	Low
17040204050	0.0	1247.7	0.0	Low
17040204060	5484.9	13748.9	39.9	Moderate
17040204060	638.2	638.6	99.9	High
17040204060	110.3	11996.2	0.9	Low
17040204070	15709.7	16040.4	97.9	High
17040204070	619.4	632.4	98.0	High
Statistics: Total	4,362,629.8	Total	12,609,211.0	Average 34.2

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GYA Landscape Data Completeness (GYA HUC6)

Ratings for HUC6 Watersheds or portions thereof in Federal ownership only.

Henry F. Shovic, Interagency Spatial Analysis Center

<i>HUC6 Watershed</i>	<i>Acres with Incomplete Landscape Data</i>	<i>Total Acres</i>	<i>Percentage of Total Acres</i>	<i>Rating for missing data: low < 20%; mod 20-50%; high >50%</i>
10020001010	585.5	7,006.3	8.4	Low
10020001010	1,063.3	5,553.5	26.3	Moderate
10020001010	0.0	15.8	0.0	Low
10020001010	0.0	1,799.9	0.0	Low
10020001010	0.0	44.4	0.0	Low
10020001010	0.0	4.8	0.0	Low
10020001010	32.6	3,902.4	0.8	Low
10020001010	0.0	16.5	0.0	Low
10020001011	0.0	7.2	0.0	Low
10020001011	0.0	2.1	0.0	Low
10020001020	141.0	16,497.7	0.9	Low
10020001020	217.5	5,532.4	3.9	Low
10020001020	183.9	3,707.6	5.0	Low
10020001020	0.0	9.5	0.0	Low
10020001020	0.0	4.9	0.0	Low
10020002050	96.1	8,838.2	1.1	Low
10020002050	41.6	1,860.1	2.2	Low
10020002050	384.4	15,499.9	2.5	Low
10020003010	375.6	33,318.4	1.1	Low
10020003010	966.4	26,393.1	3.7	Low
10020003010	1,146.8	26,526.2	4.3	Low
10020003010	868.8	32,780.2	2.7	Low
10020003010	227.5	14,550.9	1.6	Low
10020003010	1,636.8	9,402.3	17.4	Low
10020003010	2,320.2	10,059.7	23.1	Moderate
10020003010	1,509.3	3,161.4	47.7	Moderate
10020003010	1,712.3	12,841.7	13.3	Low
10020003030	2,383.7	2,898.5	82.2	High
10020003030	886.4	1,103.8	80.3	High
10020003040	275.2	282.3	97.5	High
10020003040	321.9	3,526.2	9.1	Low
10020003040	841.0	5,620.7	15.0	Low
10020003050	930.4	4,185.0	22.2	Moderate
10020003050	1,566.6	9,788.4	16.0	Low
10020003050	1,125.0	12,788.8	8.8	Low
10020003050	1,054.7	7,805.1	13.5	Low
10020003050	1,034.3	11,700.8	8.8	Low
10020005010	767.4	2,802.7	27.4	Moderate
10020005010	609.1	895.7	74.7	High
10020005050	20.7	64.2	32.2	Moderate
10020005050	21.7	25.8	84.2	High
10020005060	1,939.1	21,190.0	9.2	Low
10020005060	1,464.3	8,818.4	16.6	Low
10020005060	828.3	1,758.0	47.1	Moderate

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<i>HUC6 Watershed</i>	<i>Acres with Incomplete Landscape Data</i>	<i>Total Acres</i>	<i>Percentage of Total Acres</i>	<i>Rating for missing data: low < 20%; mod 20-50%; high >50%</i>
17040105030	0.0	12,482.0	0.0	Low
17040105030	0.0	6,950.5	0.0	Low
17040105030	0.0	28,866.9	0.0	Low
17040105030	0.0	15,082.1	0.0	Low
17040203010	18.8	28,237.5	0.1	Low
17040203010	0.0	11,343.9	0.0	Low
17040203010	63.8	15,214.0	0.4	Low
17040203010	57.2	44,857.3	0.1	Low
17040203020	0.0	26,444.3	0.0	Low
17040203020	672.3	34,534.8	1.9	Low
17040203020	0.0	28,714.9	0.0	Low
17040203020	14.0	18,298.0	0.1	Low
17040203030	0.0	22,825.2	0.0	Low
17040203030	0.0	6,332.1	0.0	Low
17040203030	203.3	11,840.7	1.7	Low
17040204010	3.7	16,880.3	0.0	Low
17040204010	0.0	13,891.3	0.0	Low
17040204010	0.0	8,361.3	0.0	Low
17040204010	0.0	8,148.7	0.0	Low
17040204010	0.0	14,452.2	0.0	Low
17040204010	0.0	1,945.0	0.0	Low
17040204010	0.0	6,699.9	0.0	Low
17040204010	0.0	8,844.4	0.0	Low
17040204020	0.0	25,700.5	0.0	Low
17040204020	0.0	4,478.3	0.0	Low
17040204020	0.0	7,316.8	0.0	Low
17040204020	0.0	52.7	0.0	Low
17040204020	0.0	8,684.8	0.0	Low
17040204030	0.0	12,403.3	0.0	Low
17040204030	0.0	11,641.1	0.0	Low
17040204030	0.0	15,259.2	0.0	Low
17040204030	0.0	1,201.8	0.0	Low
17040204030	0.0	1,750.9	0.0	Low
17040204030	0.0	7,798.2	0.0	Low
17040204030	0.0	8,583.4	0.0	Low
17040204040	0.0	22,322.8	0.0	Low
17040204040	0.0	11,618.1	0.0	Low
17040204040	0.0	13,296.0	0.0	Low
17040204040	0.0	8,595.0	0.0	Low
17040204050	0.0	2,174.3	0.0	Low
17040204050	0.0	1,247.7	0.0	Low
17040204060	0.0	13,748.9	0.0	Low
17040204060	0.0	638.6	0.0	Low
17040204060	0.0	11,996.2	0.0	Low
17040204070	0.0	16,040.4	0.0	Low
17040204070	0.0	632.4	0.0	Low
Statistics: Total	543,382.7	Total	12,609,211.0	Average 5.2

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Appendix Four: IWWI HUC6 Watersheds Having “High” No Data Status

GYA HUC6 Watershed	Acres with No Data	Total Acres	Primary Unit
100200030301	78.5	134,351	Beaverhead-Deerlodge N. F.
100200030503	257.5	260,806	Beaverhead-Deerlodge N. F.
100200030701	1,890	2,560	Beaverhead-Deerlodge N. F.
100200030702	98	120	Beaverhead-Deerlodge N. F.
100200050504	675	1,155	Beaverhead-Deerlodge N. F.
100200070602	4,967	8,949	Beaverhead-Deerlodge N. F.
100200070603	251	291	Beaverhead-Deerlodge N. F.
100200070701	31,654	33,037	Beaverhead-Deerlodge N. F.
100200070801	1,864	1,865	Beaverhead-Deerlodge N. F.
100200070802	9,751	9,821	Beaverhead-Deerlodge N. F.
100200070903	10	10	Beaverhead-Deerlodge N. F.
100200071001	9,634	9,636	Beaverhead-Deerlodge N. F.
100200071002	14,799	17,306	Beaverhead-Deerlodge N. F.
100200071102	863	1,223	Beaverhead-Deerlodge N. F.
100200071202	20,608	21,105	Beaverhead-Deerlodge N. F.
100200072701	280	460	Beaverhead-Deerlodge N. F.
10070001002009	83,379	84,446	Yellowstone National Park
170401030101	16,702	23,602	Bridger Teton N. F.
170401030106	5,820	9,222	Bridger Teton N. F.
170401030107	8,320	8,733	Bridger Teton N. F.
170401030108	10,749	17,281	Bridger Teton N. F.
170401030203	4,252	6,484	Bridger Teton N. F.
170401030301	3,924	6,724	Bridger Teton N. F.
100800030105	522	522	Shoshone N. F.
100800020302	17	17	Shoshone N. F.
100800030102	14,515	14,515	Shoshone N. F.
100800020202	431	431	Shoshone N. F.
100800020201	17,993	17,993	Shoshone N. F.
100800030104	5,336	5,336	Shoshone N. F.
100800030101	28,501	28,501	Shoshone N. F.
100800030103	7,824	7,824	Shoshone N. F.
100800030209	5,035	5,035	Shoshone N. F.
100800030208	4,811	4,811	Shoshone N. F.
100800030207	1,551	1,551	Shoshone N. F.
100800030203	8,809	8,809	Shoshone N. F.
100800030201	23,744	23,744	Shoshone N. F.
100800030206	5,225	5,225	Shoshone N. F.
100800030205	17,052	17,052	Shoshone N. F.
100800030202	6,956	6,956	Shoshone N. F.
100800030204	9,958	9,958	Shoshone N. F.
100800030316	2,555	2,555	Shoshone N. F.
100800030305	7,814	7,814	Shoshone N. F.

100800030303	5,971	5,971	Shoshone N. F.
100800030306	4,965	4,965	Shoshone N. F.
100800030301	20,142	20,142	Shoshone N. F.
100800030304	5,089	5,089	Shoshone N. F.
100800030302	8,166	8,166	Shoshone N. F.
100800020701	6,232	6,232	Shoshone N. F.
100800030308	463	463	Shoshone N. F.
101800060209	13,383	13,383	Shoshone N. F.
101800060208	8,659	8,659	Shoshone N. F.
101800060203	2,737	2,737	Shoshone N. F.
101800060109	2,921	2,921	Shoshone N. F.
	478,202	511,801	

Beaverhead-Deerlodge N. F.	107,933	
Yellowstone National Park	84,446	Yellowstone Lake
Bridger Teton N. F.	72,046	
Shoshone N. F.	247,376	
	511,801	

Appendix Five: GYA HUC6 Watersheds Having “High” No Data Status

GYA HUC6 Watershed	Acres with No Data	Total Acres	Primary Unit
100200030302	2,384	2,899	Beaverhead-Deerlodge N. F.
100200030303	886	1,104	Beaverhead-Deerlodge N. F.
100200030401	275	282	Beaverhead-Deerlodge N. F.
100200050103	669	896	Beaverhead-Deerlodge N. F.
100200050502	22	26	Beaverhead-Deerlodge N. F.
100200071009	24,089	31,816	Beaverhead-Deerlodge N. F.
100200071104	665	1,007	Beaverhead-Deerlodge N. F.
100200071201	5,621	5,642	Beaverhead-Deerlodge N. F.
100200071202	11,376	11,694	Beaverhead-Deerlodge N. F.
100200071203	9,088	9,818	Beaverhead-Deerlodge N. F.
100200071204	5,493	5,592	Beaverhead-Deerlodge N. F.
100200071205	909	910	Beaverhead-Deerlodge N. F.
100200071301	12,996	15,330	Beaverhead-Deerlodge N. F.
100200071302	1,795	1,795	Beaverhead-Deerlodge N. F.
100200071303	9,984	9,996	Beaverhead-Deerlodge N. F.
100200071304	9,332	9,334	Beaverhead-Deerlodge N. F.
100200071305	2,012	2,013	Beaverhead-Deerlodge N. F.
100200071306	428	697	Beaverhead-Deerlodge N. F.
100200071401	3,535	6,215	Beaverhead-Deerlodge N. F.
170401030107	19,313	29,993	Bridger Teton N. F.
170401030109	16,354	23,105	Bridger Teton N. F.
100800020101	18,402	18,402	Shoshone N. F.
100800030204	522	522	Shoshone N. F.
100800030203	14,516	14,516	Shoshone N. F.
100800030202	12,873	12,873	Shoshone N. F.
100800030210	5,051	5,051	Shoshone N. F.
100800030207	6,774	6,774	Shoshone N. F.
100800030201	28,768	28,768	Shoshone N. F.
100800030209	4,796	4,796	Shoshone N. F.
100800030109	2,573	2,573	Shoshone N. F.
100800030206	18,787	18,787	Shoshone N. F.
100800030205	30,670	30,670	Shoshone N. F.
100800030208	17,064	17,064	Shoshone N. F.
100800030102	18,871	18,871	Shoshone N. F.
100800030103	4,983	4,983	Shoshone N. F.
100800030101	28,263	28,263	Shoshone N. F.
100800030105	466	466	Shoshone N. F.
100800020301	6,225	6,225	Shoshone N. F.
101800060206	13,390	13,390	Shoshone N. F.
101800060103	2,922	2,922	Shoshone N. F.
101800060205	8,666	8,666	Shoshone N. F.
101800060202	2,737	2,737	Shoshone N. F.

Total Area	384,744	417,484
Beaverhead-		
Deerlodge N. F.		117,066
Bridger Teton N. F.		53,099
Shoshone N. F.		247,319

Appendix Six. List of Data and Documents on the publication CD

- The GYA Landscape model report and data: in the folder GYA_LANDSCAPE_MODEL. This data does not have the additions used in the present study.
- This report: in MS WORD format: GYA_Watershed_Vulnerability_Report 030602.doc
- This report in Adobe Illustrator PDF format: GYA_Watershed_Vulnerability_Report 030602.pdf
- A zip file of ACCESS databases containing all queries and tables used in this study: Appendix Two lists queries used in this study, and the database in which each is contained. Links between these databases must be updated before use. The zip file is called vulnerability_databases.zip
 - gyaHuc6_and_gyajoinidss summaries.mdb applied to the GYA watershed coverage
 - iwwiHuc6_and_gyajoinidss summaries.mdb applied to the older IWWI watershed coverage
 - gyavulnmaps.mdb final tables used in the maps in the final report. These are extracted from results calculated in the above two databases.
 - iwwi.mdb vulnerability data directly from the IWWI study
 - bvnf_csnf_cbnfsoil_data.mdb gya landscape model attribute data and VISUAL BASIC programs for calculating erodibility
- Four reports in MS WORD format: These are exemplified in Appendix Three, but are presented here in complete form.
 - Acres with No Soil Data by HUC6 Watershed.rtf
 - iwwi Acres with No Soil Data by HUC6 Watershed.rtf
 - iwwi Vulnerability by HUC6 Watershed.rtf
 - Vulnerability by HUC6 Watershed.rtf
- Arcview 3.2 projects including specifications for all maps used in this study
 - gyavulnerabilityproject110101.apr
 - iwwished8x11.apr

No attempt was made to preserve paths or coverage names in these projects.

Spatial Data used in this study are in UTM zone 12 meters NAD27

- The GYA modified landscape model coverage

This was modified from the original landscape model as indicated in this report: This is an ARC/INFO coverage called gyaivwjoin. Its metadata is called gyaivwjoinmeta.html

- The IWWI watershed coverages

The IWWI watershed coverage is in two formats. The first is a shapefile called iwwi_huc6.shp. It has not been edgematched but is of sufficient accuracy for use in display. It is not usable in analysis.

The second format is the original unit ARC/INFO coverages received from the IWWI project managers. These are in a folder called `iwwi_huc6_data`. No metadata was forwarded with these coverages. More information is in the report.

- The GYA watershed coverages

The base GYA coverage is in shapefile format (`gya_huc6.shp`). We compiled this coverage (termed GYA Watersheds in the report) from watershed data developed in 2001 by federal and state administrative units. We appended and edgемatched these data. There are some data gaps, notably in the western part of the Caribou-Targhee National Forest. This is because data were in process of completion and not ready at time of publication. We clipped this coverage by the federal lands boundaries for the GYA, resulting in the two shapefiles shown below.

`gya_huc6_fed_lands_only.shp` This is a shapefile for the majority of the federal lands in the GYA.

`shnf_clippe_gya_huc6.shp` This is a shapefile for the southeastern part of the Shoshone National Forest.

- The GYA stream dissection coverage

This shapefile (`highdiss111401dissolved.shp`) was created by us for the GYA. It is at a scale of 1:100,000. Methods are given in the report. It was digitized on screen with a general line accuracy of 30 meters.