Binational Digital Soils Map of the Ambos Nogales Watershed, Southern Arizona and Northern Sonora, Mexico

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Abstract

We have prepared a digital map of soil parameters for the international Ambos Nogales watershed to use as input for selected soils-erosion models. The Ambos Nogales watershed in southern Arizona and northern Sonora, Mexico, contains the Nogales wash, a tributary of the Upper Santa Cruz River. The watershed covers an area of 235 km^2, just under half of which is in Mexico. Preliminary investigations of potential erosion revealed a discrepancy in soils data and mapping across the United States-Mexican border due to issues including different mapping resolutions, incompatible formatting, and varying nomenclature and classification systems. To prepare a digital soils map appropriate for input to a soils-erosion model, the historical analog soils maps for Nogales, Ariz., were scanned and merged with the larger-scale digital soils data available for Nogales, Sonora, Mexico using a geographic information system.

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Introduction

With the recognition of environmental and public-health problems in the two countries and along their common border, the United States and Mexico have agreed to act jointly to address these problems in a manner consistent with environmental protection, conservation, and sustainable-development principles (U.S. Environmental Protection Agency, 2002). Land-use management is the first opportunity to control non-point-source pollution. The amount and degree of water pollution in rivers is predictable on the basis of past and future trends in land-use change (Acevedo, 1999).

Using historical satellite imagery, in combination with other geospatial data, the causes and effects of land cover changes as related to hydrologic processes can be analyzed and quantified (Brady 2000; Brady and others, 2001). These digital data models require accurate representation of soil material in the area as input. They use a geographic information system (GIS) to examine three-dimensional visualizations of transport mechanisms within watersheds. The data provided on the digital soils map presented here constitute one of several essential watershed components supporting digital data modeling of the study area (figs. 1, 2).

This research, which is preliminary to modeling non-point-source pollution, details the process of automating historical aerial photographs to use the soil information inscribed on them, digitizing datasets, merging and translating binational data, and assigning required parameters to newly mapped soil "types." Our intention is to generate multiple iterations of erosion-potential gradients, utilizing remote sensing, a GIS, field-based data, and combinations of these methods to supply decisionmakers in the twin cities of Nogales, Ariz., and Nogales, Sonora, Mexico, with the most accurate representation of environmental sensitivity.

Study Area

The condition of the twin-city area of Nogales, Ariz., and Nogales, Sonora, Mexico (fig. 1), referred to as Ambos Nogales, typifies that of several populated border areas with their assortment of natural-resource issues. Ambos Nogales is contained within a watershed, or independent land area, that drains the Nogales Wash into the Santa Cruz River system (fig. 2), hereafter referred to as the Ambos Nogales watershed. The land around the Nogales Wash, which has its headwaters in Mexico and leads into the United States through the twin-city area, is used for various purposes. Low or medium density residential areas are located in Nogales, Ariz. and high-density residential areas in Nogales, Sonora, Mexico. Other land uses include industry, transportation, recreation, commerce, and agriculture. Agricultural use of the land has declined over the past 20 years, while residential and industrial use has increased. Land used for transportation and recreation purposes has also increased in area with the population and industrial growth (see URL http://www.scerp.org/scerp/docs/berr4.html).

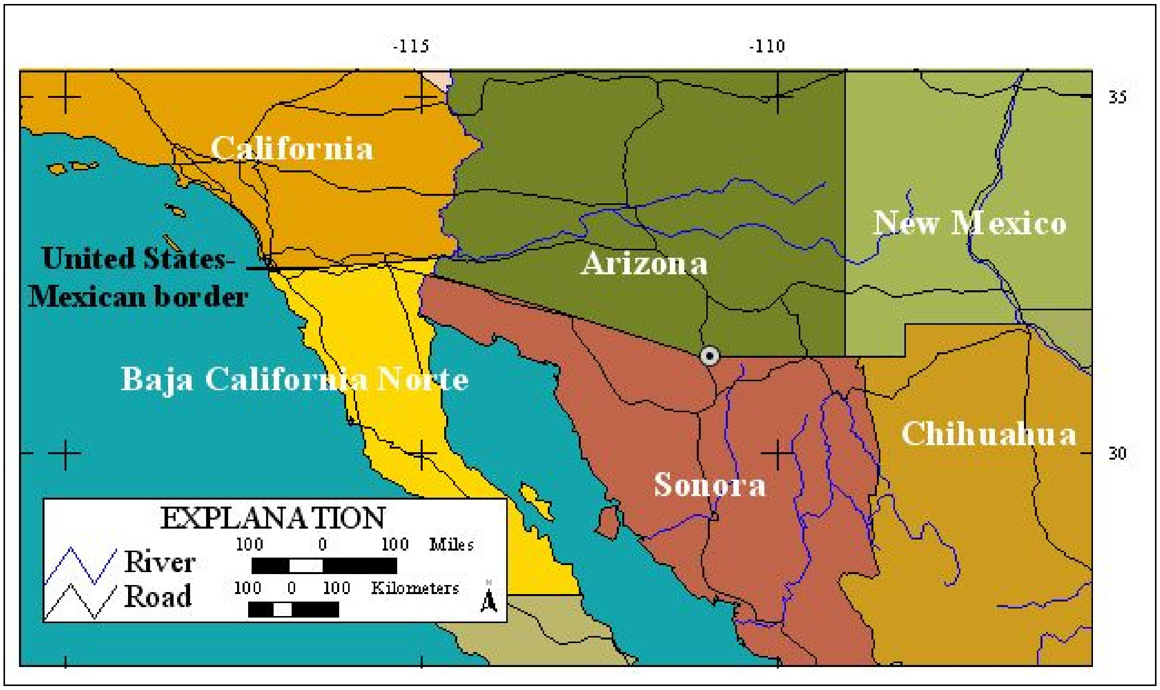

Figure 1. Map of Southern California-Arizona-New Mexico and Northern Sonora-Chihuahua, Mexico, showing location of Ambos Nogales (circled dot).

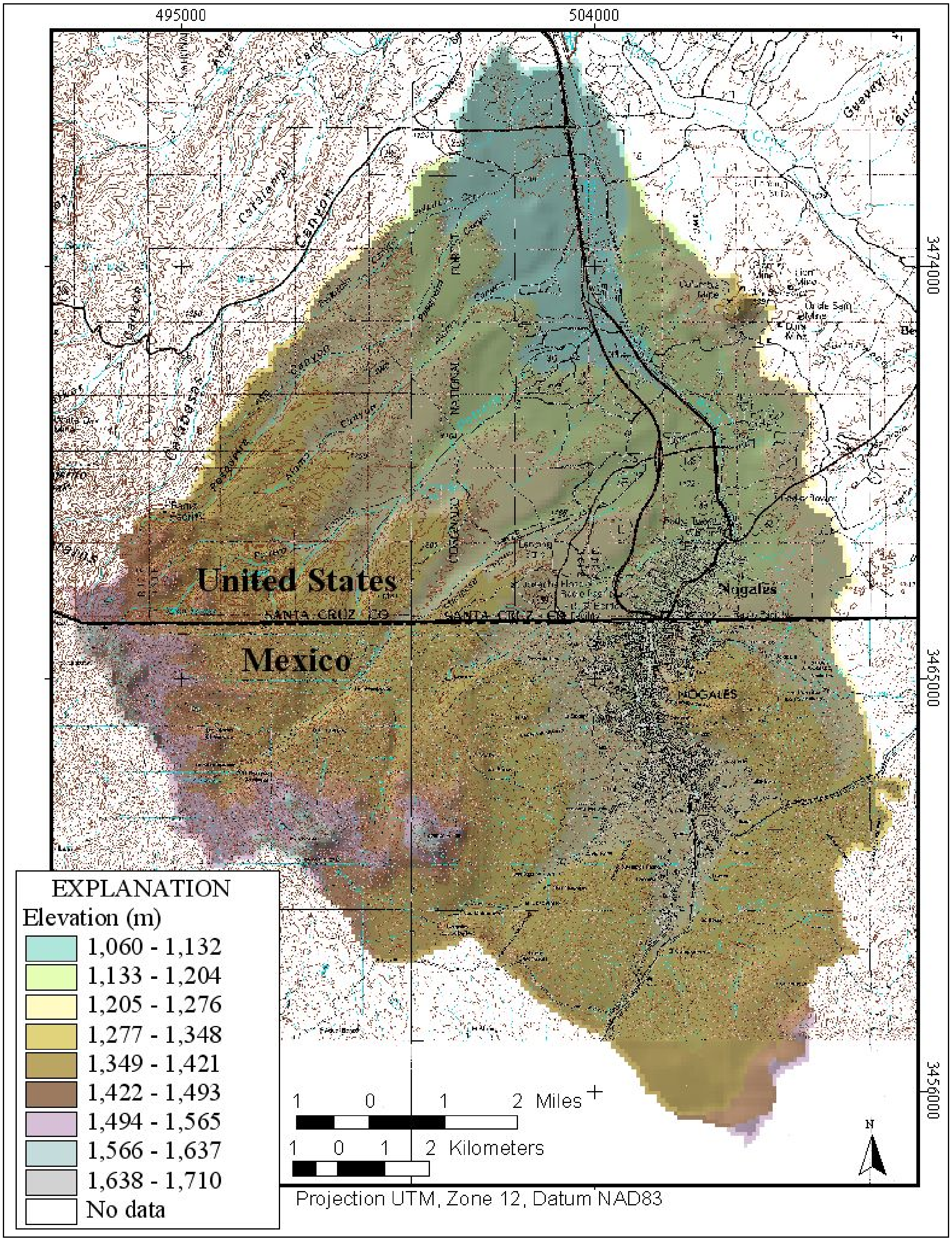

Figure 2. Hillshade-relief map of Ambos Nogales watershed based on a digital elevation model.

Nogales, Ariz.

High-resolution, seamless digital soils data for the Ambos Nogales watershed are unavailable (Brady and others, 2001a, 2002). The only existing digital data for the U.S. part of the watershed is the U.S. Department of Agriculture (USDA)'s State Soil Geographic (STATSGO) database, at a scale of 1:250,000 (fig. 3); the USDA also publishes a higher resolution digital dataset (Soil Survey Geographic {SSURGO} Database), that is not yet available for Nogales.

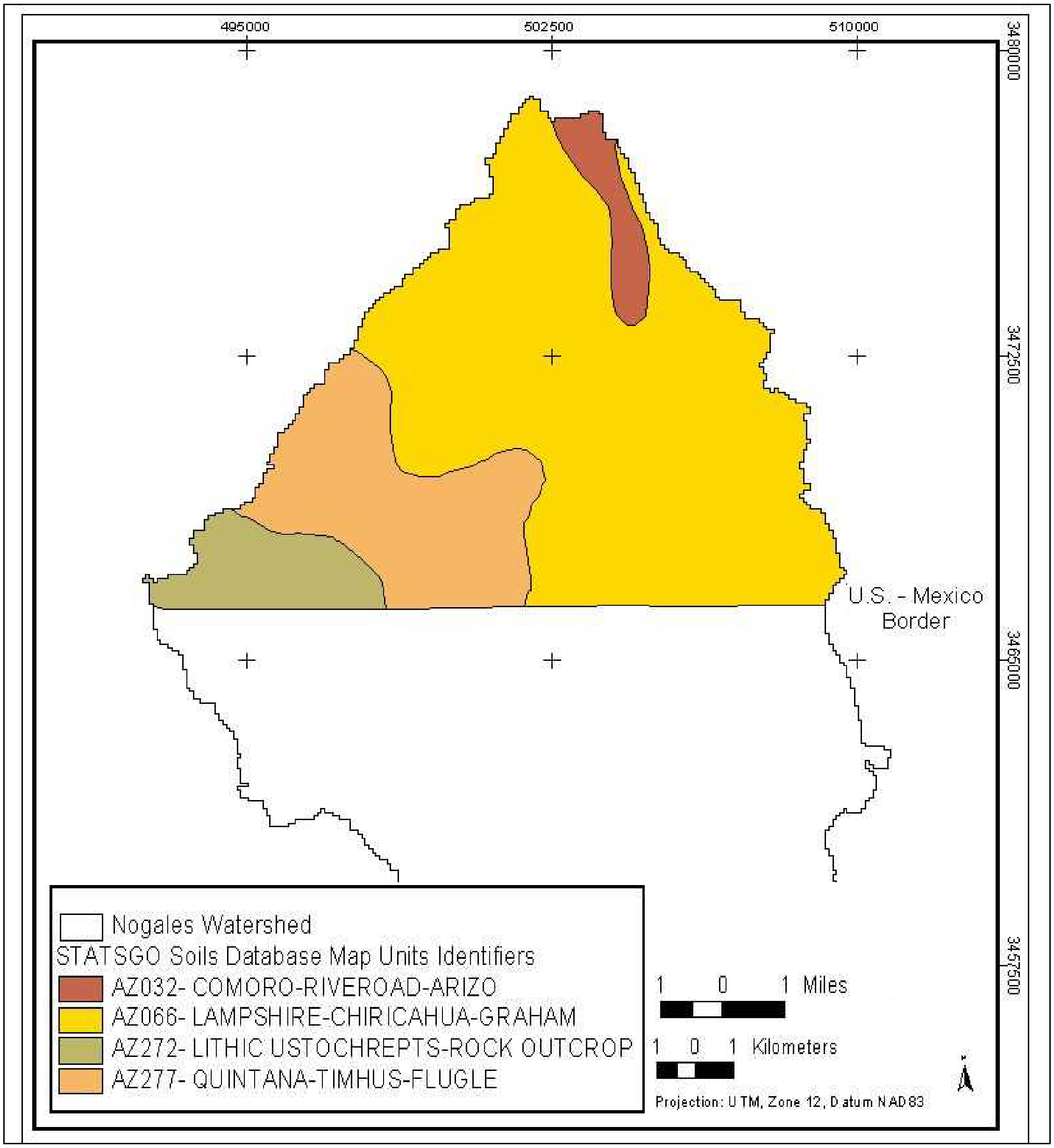

Figure 3. U.S. Department of Agriculture's State Soil Geographic database describing Nogales, Ariz.

The most accurate soil information for the study area was available from 1:20,000-scale maps (U.S. Soil Conservation Service and U.S. Forest Service, 1979) that were created according to the site conditions in 1971 (fig. 4). Aerial photography was used to map polygonal soil types according to field test sites. The maps from which this dataset was made had not been rectified for distortion or registered to a coordinate system.

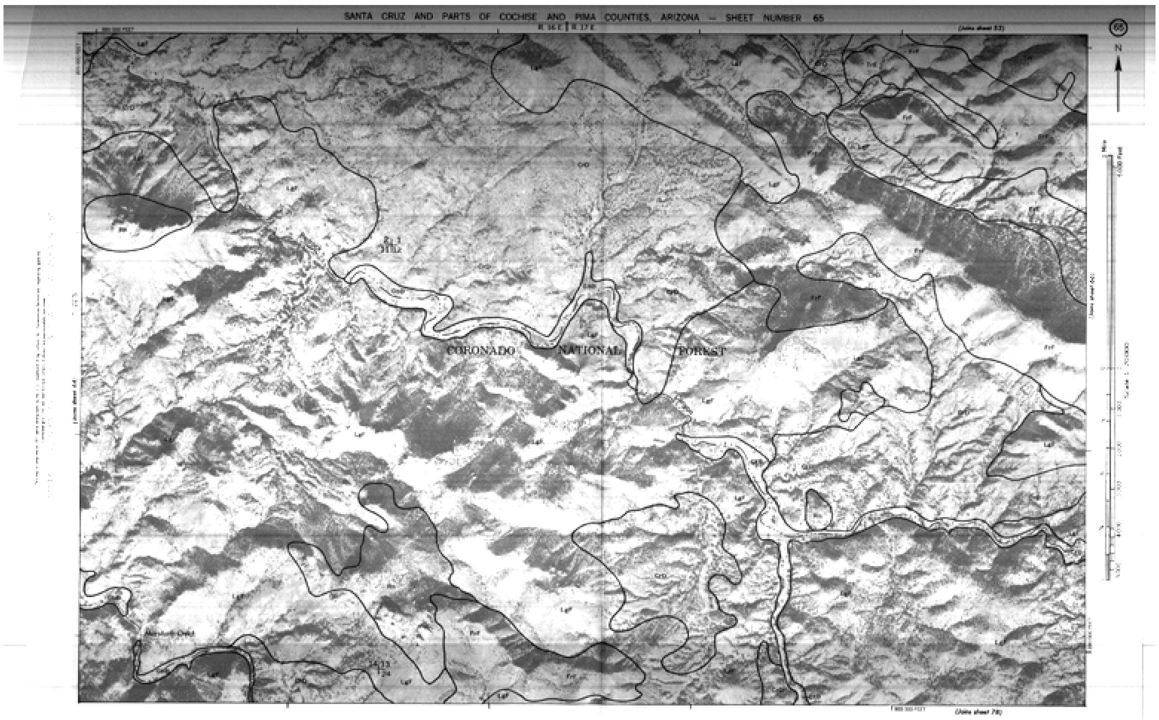

Figure 4. Typical map scanned from aerial photographs of Coronado National Forest, Ariz.

The 1979 soils maps were automated for future incorporation into the hydrologic model within a GIS. A total of seven maps (11 by 17 in.) cover the study area, each of which was scanned into tagged image file format (TIFF) by using an eight-bit black-and-white drum scanner at 100 dpi. The program ERDAS IMAGINE was used to import the images according to procedures of Norman and others (2002). CD-ROMs containing USGS digital orthophoto quarter quadrangles (DOQQs) were used to register and rectify the scanned soils maps. Ground-control points (GCPs) were established by matching known locations on the soil maps to the same locations identified on a DOQQ. The aerial photographs were taken some 30 years before the DOQQs, and buildings, trees, and waterways had all changed considerably. Therefore, the easiest and most accurate objects to identify were roads and intersections of roads with other features, which appeared to have the same shape over time, although some forest roads had fallen out of use or been paved or widened.

A third-order polynomial transformation requires a minimum of 10 GCPs to be defined; however, the accuracy increases as more points are entered and widely distributed. An average of 80 GCPs were identified on each aerial photograph and cross-referenced with the source data for this study. The digital transformation was performed with the cubic convolution method of resampling to associate the aerial photograph with pinpoints of known coordinates and to adjust the map to accurate proportions. This method transformed the scanned soils maps into registered images. The cubic convolution method resamples by using an algorithm that recognizes the data files of 16 pixels in a 4-by-4 window, creating the most accurate output when rectifying aerial photographs (ERDAS, Inc., 1997).

Error still exists despite the large number of GCPs used to control the transformation. The difficulty in accurately fitting images over mountainous terrain from aerial photographs accounts for some of the error in rectification. Error also exists in the DOQQs owing to possible error in input for the rectification that created them (digital elevation model, aerotriangulation control and methods, photo-source camera calibration, scanner calibration, and aerial photographs), and new error was introduced in the resampling process. However, the photographs edge-matched positively, and roads, rivers, trees, and soil polygons merged together when mosaiked to create a cohesive map (fig. 5). The raster geometric correction was successful for use in this project. The final .IMG file was converted and compressed within ARC/INFO to TIFF format and laid out onscreen with known vector coverages of digitized roads and rivers overlaid to check for accuracy and error.

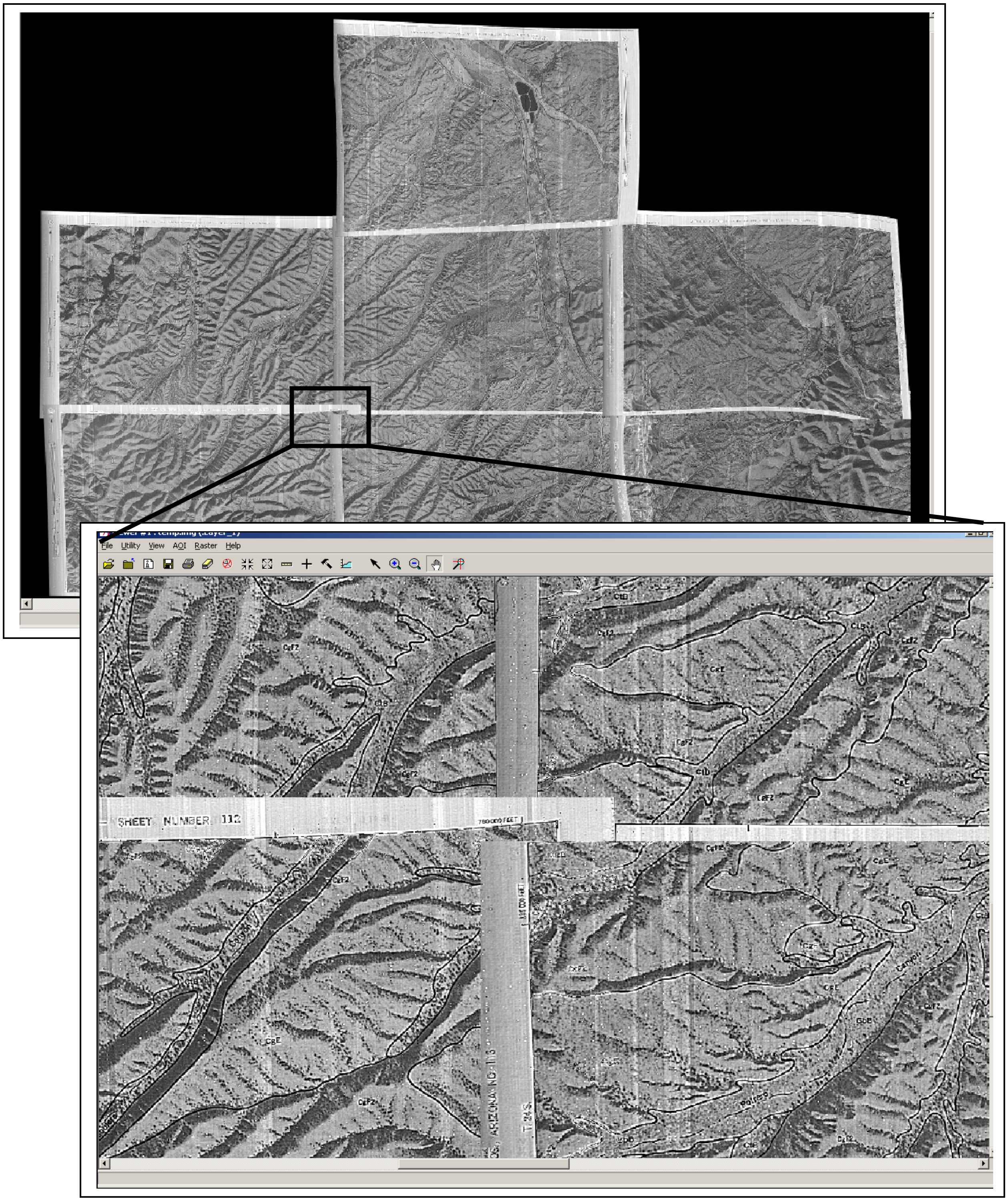

Figure 5: Mosaicked registered images describing soil conditions in the U.S. part of the Ambos Nogales watershed, after othogonalization.

The soils data that had been inscribed on the aerial photographs were then automated through onscreen digitizing in the program ARCEDIT (fig. 6). The distance command identified acceptable tolerances; node snap was set to closest 100 m, and weed and grain tolerances to 15 m. The user-friendly graphical user interface called ARCTools was employed for the initial digitizing. Topologic errors were corrected manually by using command-line editing, and the topology was built.

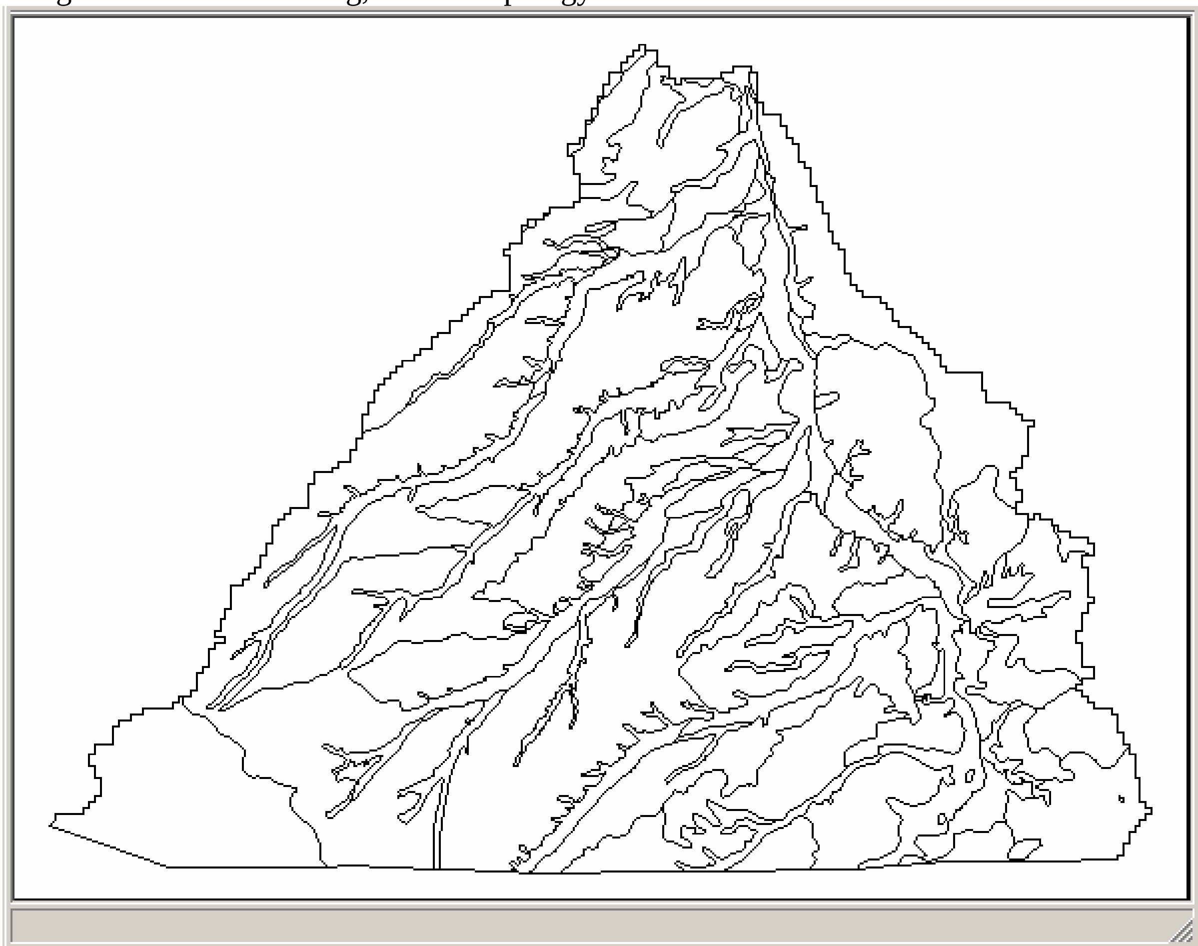

Figure 6. Newly created soils-polygon coverage showing soil features for the U.S. part of the Ambos Nogales watershed.

Polygons were then attributed according to the soil units shown on the map. User-defined items were added to the newly digitized soil-coverage feature-attribute table to define the map-unit descriptions: soil series, slope angle, and previous erosion. Labels were created, and attribution of the new soils coverage was completed by using a form-based interface provided within the program ARCEdit. The projection was defined according to the reference DOQQ that fostered it as Universal Transverse Mercator, zone 12, datum NAD83. The soil coverage is not meant to be used or displayed at any scale larger than 1:20,000 (for example, 1:10,000; see fig. 7). The 17 soil types mapped for the Nogales, Ariz., area are listed in table 1 along with their defining characteristics.

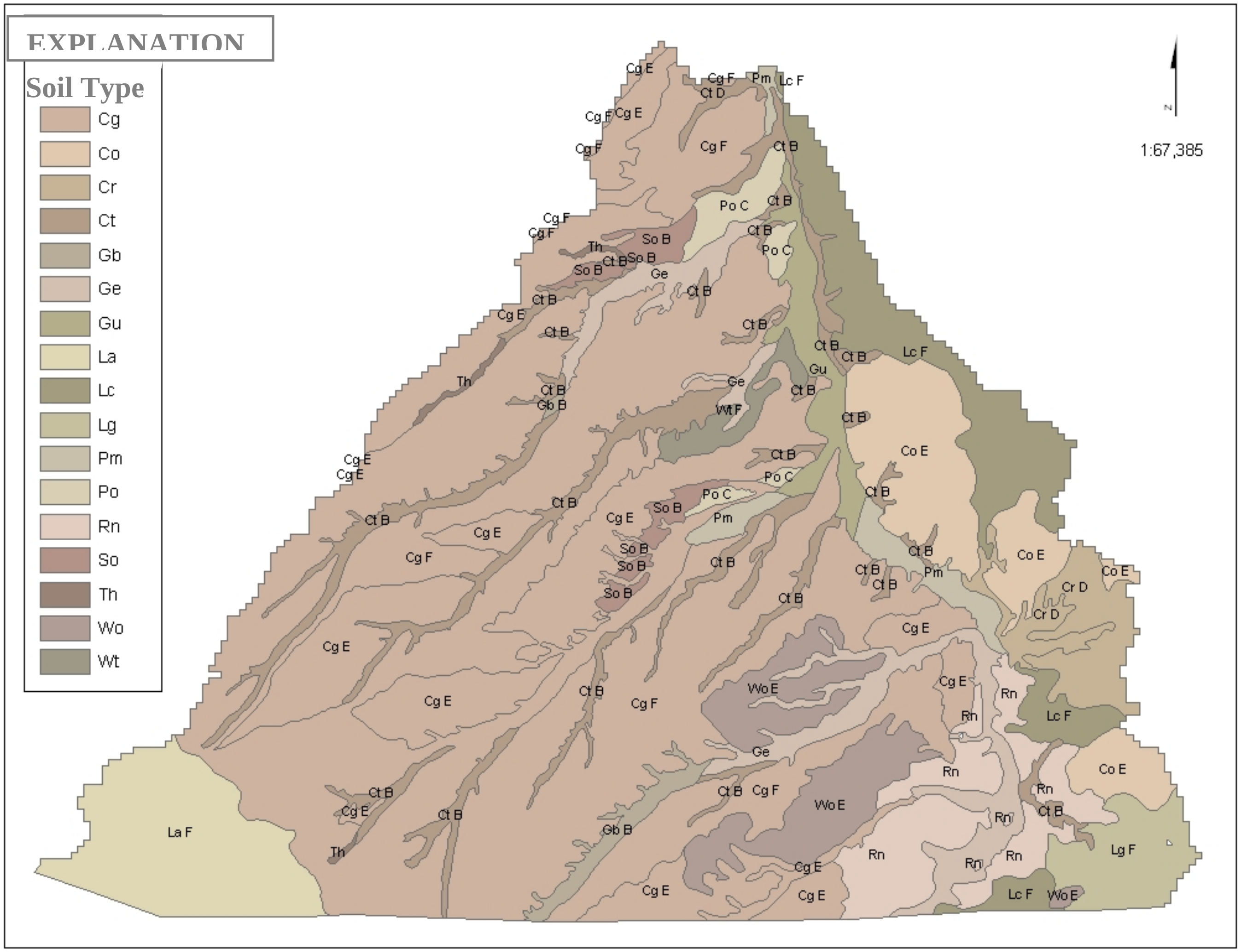

Figure 7. Soils map of the U.S. part of the Ambos Nogales watershed.

Table 1. Soil-association descriptions (U.S. Soil Conservation Service and U.S. Forest Service, 1979).

Cg: Caralampi gravelly sandy loam
10-60 percent slopes
A1: (0-2 in.) dark brown gravelly sandy loam
B2: (2-9 in.) dark brown-reddish brown very gravelly sandy clay loam
B23/24: (9-23 in.) yellowish-red very gravelly sandy clay loam
B31/32: (23-42 in.) light reddish-brown very gravelly sandy loam
In small pockets in the north central part of the study area

Co: Chiricahua Series: Chiricahua cobbly sandy loam
10-45 percent slopes
A1: (0-3 in.) dark brown cobbly sandy loam
B21t: (3-11 in.) dark reddish-brown gravelly heavy clay loam or clay
B22t: (11-19 in.) dark reddish-brown gravelly clay loam
C: (19-28 in.) pink-reddish-yellow strongly weathered granite
R: (28 in.) extremely hard granite bedrock
In a small pocket in the northern part of the study area

Cr: Chiricahau-Lampshire
0-20 percent slopes
A1: (0-3 in.) dark brown cobbly sandy loam
B21t: (3-11 in.) dark reddish-brown gravelly heavy clay loam or clay
B22t: (11-19 in.) dark reddish-brown gravelly clay loam
C: (19-28 in.) pink-reddish-yellow strongly weathered granite
R: (28 in.) extremely hard granite bedrock
Andesite –tuff bedrock, fractured
In all parts of the study area

Ct: Comoro Series: Comoro soils
0-5 percent slopes
Ap: (0-14 in.) grayish-brown sandy loam
C1: (14-23 in.) grayish-brown sandy loam
C2: (23-36 in.) grayish-brown light sandy loam
IIC: (36-60 in.) light brownish-gray gravelly sandy loam
In all parts of the study area

Gb: Grabe Series: Grabe-Comoro complex
0-5 percent slopes
A1: (0-3 in.) dark grayish-brown loam-gravelly sandy loam

A12: (3-18 in.) dark grayish-brown loam
A13: (18-48 in.) dark-brown loam
C: (48-60 in.) brown sandy loam
In all parts of the study area

Ge: Grape Series: Grabe soils
0-5 percent slopes
A1: (0-3 in.) dark grayish-brown loam-gravelly sandy loam
A12: (3-18 in.) dark grayish-brown loam
A13: (18-48 in.) dark-brown loam
C: (48-60 in.) brown sandy loam
In the southeast part of the study area

Gu: Guest Series: Guest soils
0-3 percent slopes
A11: (0-3 in.) very dark grayish-brown clay
A12: (3-14 in.) dark grayish-brown clay
A13: (14-34 in.) dark reddish-gray clay
C: (34-68 in.) brown gravelly heavy clay loam
In the eastern part of study area

La: Lampshire Series: Lampshire very gravelly sandy loam
0-50 percent slopes
A1: (0-8 in.) grayish-brown very cobbly loam
R: (8-12 in.) pinkish-gray fractured, extremely hard andesite bedrock
The surface is about 50-60 volume percent gravel

Lc: Lampshire-Chiricahua association
15-50 percent slopes
A1: (0-8 in.) grayish-brown very cobbly sandy loam-cobbly sandy loam
R: (8-12 in.) pinkish-gray fractured extremely hard andesite –tuff bedrock
In much of the western part of study area.

Lg: Lampshire-Graham-Rock outcrop association
20-60 percent slopes
A1: (0-8 in.) grayish-brown very cobbly sandy loam-cobbly sandy loam
R: (8-12 in.) pinkish-gray fractured extremely hard andesite –tuff bedrock
10-25 % gravel, 20-50% cobbles, 0-2 % stones
In the northern part of the study area

P**m: Pima Series: Pima soils**

0-3 percent slopes
Ap: (0-15 in.) dark grayish-brown clay loam
A1: (15-26 in.) dark grayish-brown clay loam
AC: (26-38 in.) dark grayish-brown loam
C1: (38-46 in.) grayish-brown fine sandy loam
C2: (46-60 in.) grayish-brown very fine sandy loam
In the northern and eastern parts of the study area

Po: Pinaleno Series: Pinaleno gravelly sandy loam
0-10 percent slopes
A1: (0-4 in.) brown gravelly sandy loam
B21t: (4-10 in.) reddish-brown gravelly sandy clay loam
B22t: (10-31 in.) yellowish-red very gravelly sandy clay loam
B3ca: (31-60 in.) light reddish-brown very gravelly heavy sandy loam
The surface is covered by 30-50 volume percent gravel

Rn: Rock outcrop-Lithic Haplustolls association
15-60 percent slopes
Hills and mountains consisting of rhyolite, andesite, granite, dacite, limestone, quartzite, tuff, and bedded tuff conglomerate
In the central part of the study area

So: Sonoita Series: Sonoita gravelly sandy loam
1-20 percent slopes
A11: (0-2 in.) brown gravelly sandy loam
A12: (2-4 in.) brown gravelly sandy loam
B21: (4-10 in.) reddish-brown gravelly sandy loam
B22: (10-17 in.) reddish-brown gravelly sandy loam
B23t: (17-26 in.) reddish-brown gravelly sandy loam
B24tca: (26-40 in.) reddish-brown gravely sandy loam
B25tca: (40-62 in.) light brown gravelly sandy loam
B3ca: (62-70 in.) yellowish-red gravelly sandy loam
In the southwestern corner of the study area

Th: Torrifluvents and Haplustolls
0-5 percent slopes
Surface layer of sandy loam, loam, or clay loam with rock fragments
Under surface layer stratified sand, sandy loam, loam, sandy clay loam
Unconsolidated recent alluvium on fan deltas, frequent changes because of flooding
In small pocket in the southwestern part of study area

Wo: White House-Caralampi complex
10-35 percent slopes
A1: (0-3 in.) brown cobbly-very gravelly clay loam
B1/21t: (3-22 in.) reddish-brown clay loam
B22tca: (22-26 in.) dark-red-mottled red (pink) clay-clay loam
B31/32: (26-49 in.) mottled red and pink-mottled yellowish-red clay loam-gravelly sandy clay loam
Cca: (62-78 in.) mottled red and pinkish-white gravelly sandy clay loam
Surface layer gravelly, cobbly, very cobbly sandy clay loam
In much of the north-central and the western parts of the study area

Wt: White House Hathaway association
20-45 percent slopes
A1: (0-3 in.) brown gravelly loam
B1/21t: (3-22 in.) reddish-brown clay loam
B22tca: (22-26 in.) dark-red-mottled red (pink) clay-clay loam
B31/32: (26-49 in.) mottled red and pink-mottled yellowish-red clay loam-gravelly sandy clay loam
Cca: (62-78 in.) mottled red and pinkish-white gravelly sandy clay loam
Surface 15-50 volume percent gravel, 0-15 volume percent cobbles, and a few stones
In much of the southwestern part of the study area

Nogales, Sonora, Mexico

The detailed soils mapping available for the Nogales, Ariz., area did not exist for Nogales, Sonora, Mexico. According to a report by the Nogales, Sonora, Mexico, City Hall (Plan de Desarrollo Municipal, 2000-2003), the predominant soils in the Mexican part of the watershed are Lithosol (I) and Regosol Eutrico (Re), with a textural average of 30 cm in depth. Lithosol, which is abundant in the southern part of the municipality is characterized by the presence of abundant stony materials (lítica); its susceptibility to erosion depends on the slope of the land and vegetation. Regosol, which occurs in the northern and central parts of the municipality, contains some lítica; the soil's fertility and agricultural usefulness depend on its depth.

A digital map of generalized soil types for all of Mexico at a scale of 1:1,000,000 was the only map available that covered the study area. This map, which was derived from classification units related to the 1970 FAO/UNESCO soil map of the world, modified by the Directorate of the Geography of the National Territory (DDGTENAL), and digitized by the Instituto National de Estadistica Geografia e Informatica (INEGI) in 1997, describes the Nogales area (fig. 8). The chemical or physical phase associated with some of the soils units is also included (table 2).

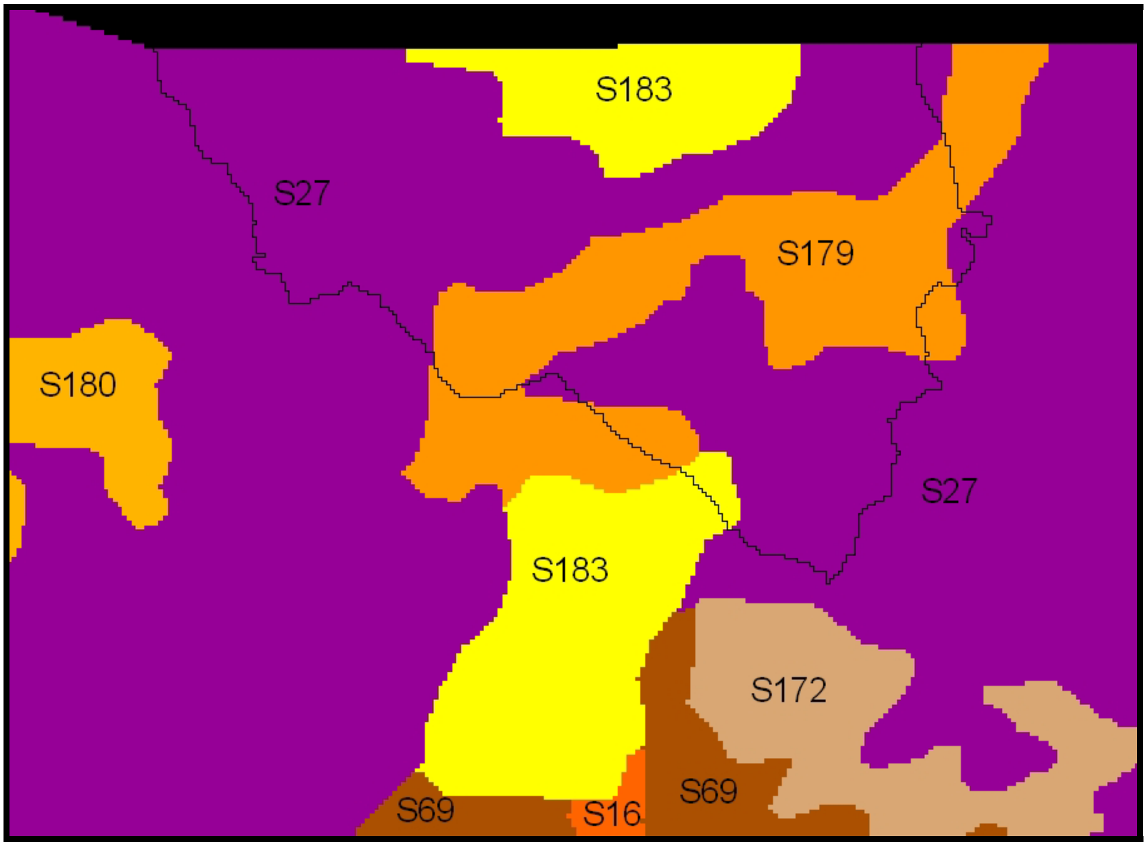

Figure 8. Soils map of Nogales, Sonora, Mexico (Instituto National de Estadistica Geografía e Informatica, 1997).

Table 2. Order and number of class-texture-depth-phases of physical or chemical-units of classification (Instituto National de Estadistica Geografía e Informatica, 1997).

S16: Deep average soils of texture, locally with gravel or stones in the surface. Haplic Phaeozem, Eutric Regosol, Eutric Fluvisol, Lithosol, Calcaric Regosol, Haplic Xerosol, Luvic Xerosol, Chromic Vertisol, and Calcaric Phaeozem.
S27: Generally very thin average soils of texture, commonly rocky. Lithosol, Eutric Regosol, Calcaric Regosol, Luvic Xerosol, Eutric Cambisol, Calcic Cambisol, Haplic Phaeozem, Chromic Vertisol, Haplic Xerosol, and Luvic Yermosol.
S69: Deep soils of gross texture possibly with gravel and (or) stones in the surface. Eutric Regosol, Calcaric Regosol, Lithosol, Chromic Vertisol, Haplic Phaeozem, Rendzina, Eutric Fluvisol, Calcaric Fluvisol, Haplic Yermosol, and Calcaric Phaeozem.
S172: Deep average soils of texture. Lithosol, Haplic Phaeozem, Eutric Castanozem, Rendzina, Chromic Vertisol, Chromic Luvisol, Eutric Regosol, Eutric Cambisol, and Chromic Cambisol.
S179: Thin soils of gross texture, limited by coherent rock. Eutric Regosol, Haplic Phaeozem, Luvic Xerosol, Haplic Xerosol, Haplic Yermosol, and Lithosol.
S180: Thin average soils of texture, limited by coherent rock or hard strata with concreteness. Eutric Regosol, Haplic Xerosol, Haplic Phaeozem, Luvic Xerosol, Luvic Yermosol, and Lithosol.
S183: Deep average soils of texture, commonly with gravel and (or) stones in the surface. Eutric Regosol, Haplic Phaeozem, (Calcic Castanozem?), Eutric Cambisol, Calcic Cambisol, Luvic Xerosol, Eutric Fluvisol, Orthic Luvisol, and Chromic Luvisol.

Methodology

To prepare a digital map of soils for the entire watershed, the high- and low-resolution maps were merged together within a GIS. New attributes, focused on soil properties, were used to assign necessary information for the universal soil loss equation (USLE) and spatially explicit delivery model (SEDMOD).

Assigning Soil Parameters to Polygons

USLE Parameters

Many erosion studies have applied the USLE within a GIS to predict the spatial variation in surface erosion in order to assess watershed conditions (Cowen, 1993; Brooks and others, 1997). The USLE is an empirical formula used to predict potential average annual soil loss (in tons per acre per year) (Wischmeier and Smith, 1978). Originally, the equation was developed for use in calculations for agricultural experimental plots. In this study, the equation is used to locate and quantify potential sources of eroded material within a watershed that might affect water quality and watershed function. The amount of erosion is calculated on a cell-by-cell basis in the first model and is then used as input to the second model for sediment-delivery calculations. The USLE formula to calculate soil loss is as follows:

$$A = R * K * L * S * C * P,$$

where A is the annual soil loss (in tons per acre per year), R is the rainfall-erositivity factor, K is the soil-erodibility factor, L is the slope-length factor, S is the slope-gradient factor, C is the cover-management factor, and P is the erosion-control-practice factor. This formula is appropriately suited to be applied in a grid-based environment where map algebra can be performed. The models chosen for use in this study defined the necessary objectives to be met by using a GIS.

The *K factor,* or soil erodibility factor, is calculated to account for sand and silt content, organic-matter content, soil structure, and permeability; soils data must also contain information about texture or clay content. The *K factors* derived from “U.S. Soil Conservation Service Technical Notes, Phoenix Ariz., September 1, 1976,” were added as an item to this coverage’s attribute table (table 3) for the soil types in Nogales, Ariz.

Table 3. K factors for soil types in Nogales, Ariz.

Soil Type	K Factor
Cg: Caralampi gravelly sandy loam	0.17
Co: Chiricahua Series: Chiricahua cobbly sandy loam	0.37
Cr: Chiricahau-Lampshire	0.34
Ct: Comoro Series: Comoro soils	0.2
Gb: Grabe Series: Grabe-Comoro complex	0.22
Ge: Grabe Series: Grabe soils	0.24
Gu: Guest Series: Guest soils	0.37
La: Lampshire Series: Lampshire very gravelly sandy loam	0.32
Lc: Lampshire-Chiricahua association	0.34
Lg: Lampshire-Graham-Rock outcrop association	0.21
Pm: Pima Series: Pima soils	0.37
Po: Pinaleno Series: Pinaleno gravelly sandy loam	0.32
Rn: Rock outcrop-Lithic Haplustolls association	0
So: Sonoita Series: Sonoita gravelly sandy loam	0.2
Th: Torrifluvents and Haplustolls	0
Wo: White House-Caralampi complex	0.27
Wt: White House Hathaway association	0.35

A soil erodibility nomograph (Wischmeier and others 1971) was used to estimate *K factors* from various characteristics of the soils in the soil profiles within the watershed boundaries for Nogales, Sonora, Mexico (table 4).

Table 4. K factors for soil types in Nogales, Sonora, Mexico.

Soil Type	K Factor
S27: Generally very thin, average soils of texture, commonly rocky.	0.270
S179: Thin soils of gross texture, limited by coherent rock.	0.200
S183: Deep average soils of texture, commonly with gravel and (or) stones in the surface.	0.140

SEDMOD Parameters

The SEDMOD calculates a sediment delivery ratio (SDR) that can be used to calculate the amount of eroded material, which is available for transport and is deposited along hillslopes and streams (Fraser, 1999). An SDR is not homogeneous across a watershed, but varies with changes in watershed area and slope (Ostercamp and Toy, 1997). The SEDMOD allows for the calculation of this spatial variation by using a GIS. The SDR is multiplied by the predicted amount of erodable soil to calculate non-point-source sources and sinks within a watershed.

The SDR evaluates deposition that occurs in overland flow before reaching the stream channels (Haan and others, 1981). Many factors are addressed when calculating this ratio: water availability, texture of eroded material, ground cover, slope shape, gradient and length, surface roughness, and other on site factors, according to the Stiff diagram (U.S. Forest Service, 1980). The SEDMOD incorporates these parameters into a cell-by-cell calculation of derivations for changes over space. Two necessary inputs are soil texture (clay content) and predicted soil loss, estimated by using the USLE, according to Fraser (1999) (fig. 9; see table 5).

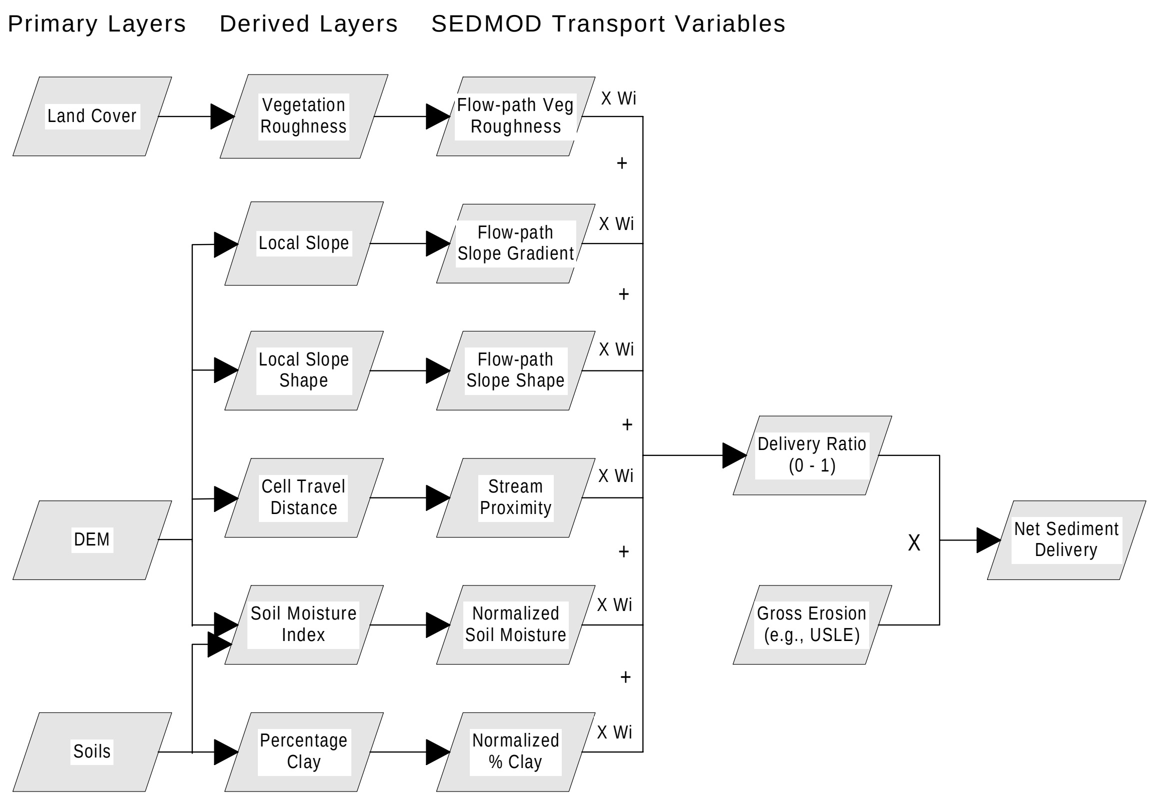

Figure 9. Diagram illustrating GIS overlay steps required to estimate net sediment delivery (Fraser, 1999).

Table 5. Primary soil data used for input to the SEDMOD, according to Fraser (1999).

Soil Texture	Percentage of surface soil layer with clay-size particles, derived from tables contained in U.S. Soils Conservation Service soil surveys.
Soil Loss	Predicted *gross erosion*, or gross non-point-source pollutant loading from each watershed cell (results of USLE). This layer can be multiplied by SEDMOD's delivery ratio to estimate net stream-delivered erosion (or non-point-source pollutant loading).

We estimated the clay content for each soil type by using a soil texture triangle (fig. 10). Clay content is read from left to right across the triangle, and the intersection of the three sizes on the triangle gives the texture class or vice versa. This procedure was used to assign soil textures in Nogales, Ariz. (table 6) and Nogales, Sonora, Mexico (table 7).

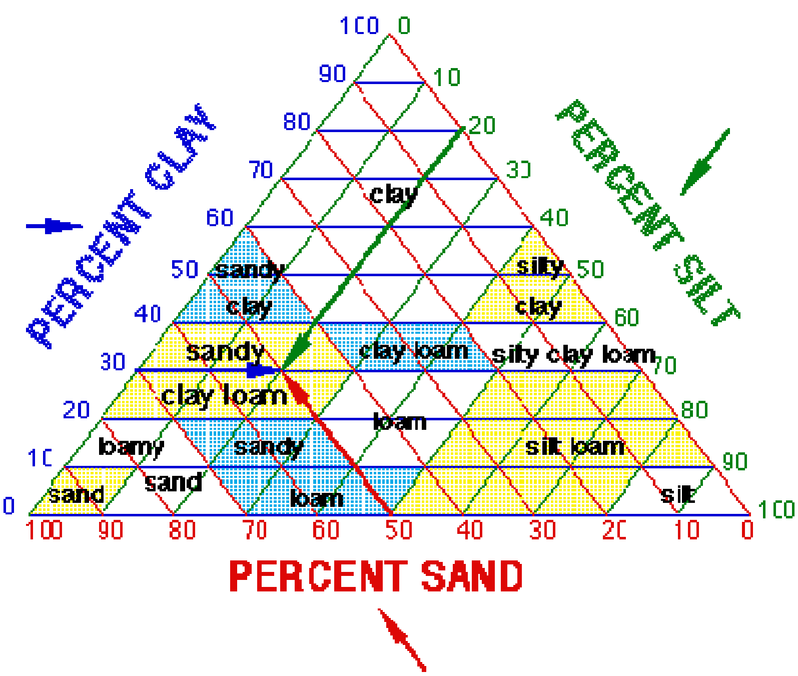

Figure 10. Soil-texture triangle (URL http://www.clac.edu.eg/CLAC-man/soil_triangle.htm).

Table 6. Clay content derived from soil horizon A descriptions and the soil-texture triangle.

Soil Series	Soil Surface Description	Clay Content (vol pct)
Cg: Caralampi gravelly sandy loam	A1: (0-2 in.) dark brown gravelly sandy loam	10
Co: Chiricahua Series: Chiricahua cobbly sandy loam	A1: (0-3 in.) dark brown cobbly sandy loam	10
Cr: Chiricahau-Lampshire	A1: (0-3 in.) dark brown cobbly sandy loam	10
Ct: Comoro Series: Comoro soils	Ap: (0-14 in.) grayish-brown sandy loam	10
Gb: Grabe Series: Grabe-Comoro complex	A1: (0-3 in.) dark grayish-brown loam-gravelly sandy loam	10
Ge: Grape Series: Grabe soils	A1: (0-3 in.) dark grayish-brown loam-gravelly sandy loam	10
Gu: Guest Series: Guest soils	A11: (0-3 in.) very dark grayish-brown clay	70
La: Lampshire Series: Lampshire very gravelly sandy loam	A1: (0-8 in.) grayish-brown very cobbly loam	20
Lc: Lampshire-Chiricahua association	A1: (0-8 in.) grayish-brown very cobbly sandy loam-cobbly sandy loam	10
Lg: Lampshire-Graham-Rock outcrop association	A1: (0-8 in.) grayish-brown very cobbly sandy loam-cobbly sandy loam	10
Pm: Pima Series: Pima soils	Ap: (0-15 in.) dark grayish-brown clay loam	35
Po: Pinaleno Series: Pinaleno gravelly sandy loam	A1: (0-4 in.) brown gravelly sandy loam	10
Rn: Rock outcrop-Lithic Haplustolls association	Hills and mountains consisting of rhyolite, andesite, granite, dacite, limestone, quartzite, tuff and bedded tuff conglomerate	0
So: Sonoita Series: Sonoita gravelly sandy loam	A11: (0-2 in.) brown gravelly sandy loam	10
Th: Torrifluvents and Haplustolls	Surface layer of sandy loam, loam, or clay loam with rock fragments	35
Wo: White House-Caralampi complex	A1: (0-3 in.) brown cobbly-very gravelly clay loam	35
Wt: White House Hathaway association	A1: (0-3 in.) brown gravelly loam	20

Table 7. Clay content assigned-soil types in Nogales, Sonora, Mexico.

Soil Type and Description	Clay Content (vol pct)
S27: Generally very thin, average soils of texture, commonly rocky	15
S179: Thins soils of gross texture, limited by coherent rock	10
S183: Deep average soils of texture, commonly with gravel and (or) stones in the surface	5

Results

Merging Datasets

The two polygonal coverages from Nogales Ariz., and Nogales, Sonora, Mexico, were converted into the same projection and stitched together at the United States-Mexican border (fig. 11). Polygons were joined across the border along with the attributes assigned to them, including the soil type (fig. 11) and the *K factor* and soil texture (clay content) (fig. 12), resulting in a digital soils map suited as input to the SEDMOD.

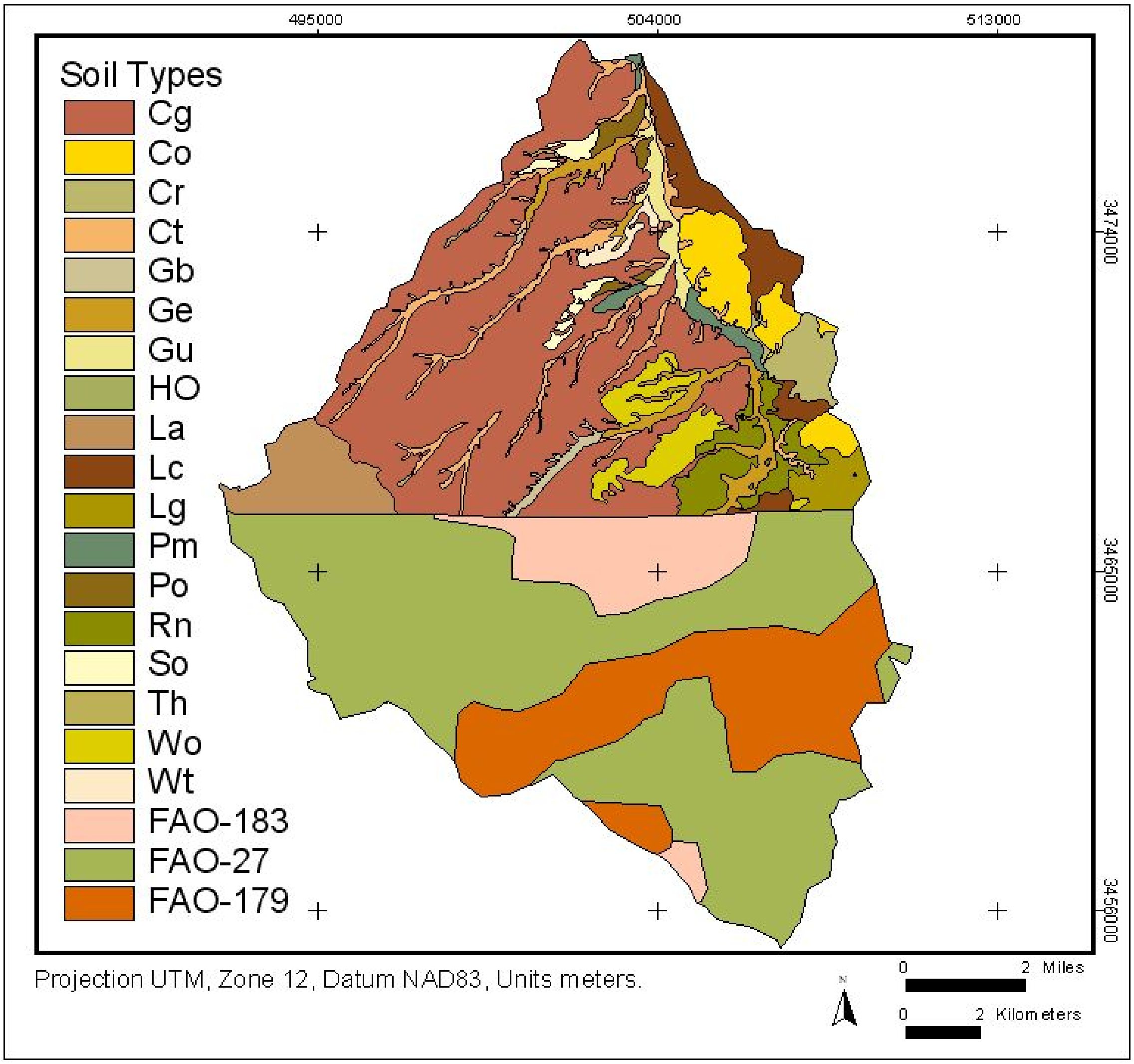

Figure 11. Final soils map of the Ambos Nogales watershed

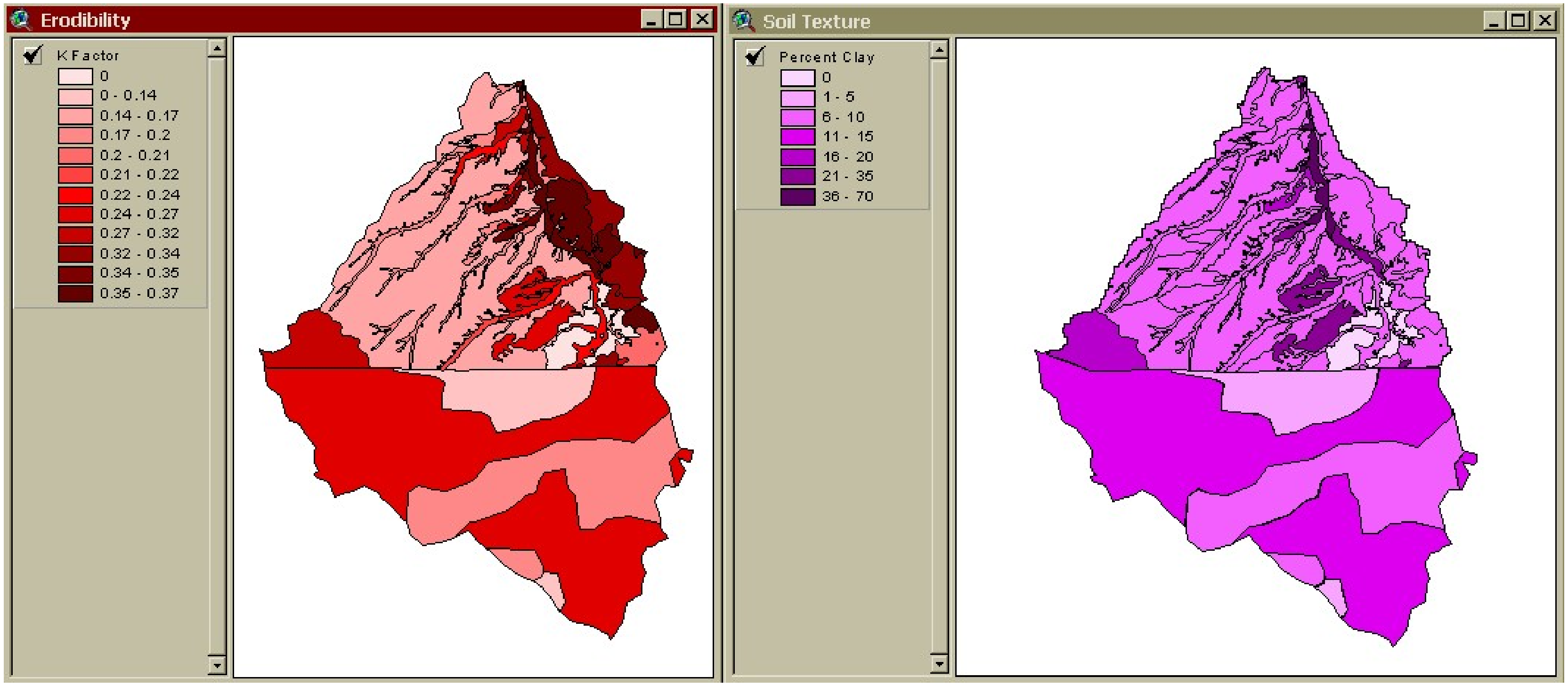

Figure 12. Maps showing K factor (soil erodibility) and soil texture (clay content) in the Ambos Nogales watershed

GIS Documentation

The digital soils dataset for the Ambos Nogales watershed includes an attribute table containing relevant information (table 8). The data coverage, which contains polygons, arcs, and node features, has been converted to a polygon shapefile format for ease in distribution.

Table 8. Description and data type of the derived fields identifying polygon features (soil type, erodibility, and soil-texture).

ITEM NAME	ITEM TYPE	ATTRIBUTE DESCRIPTION
Soil Type	Character	Description according to Tables 1 and 2
K Factor	Floating point	Soil erodibility factor
% Clay	Integer	Soil texture factor based on clay content

References Cited

Acevedo, William, 1999, Analyzing land use change in urban environments: U.S. Geological Survey Fact Sheet 188-99, 4 p.

Brady, L. M., 2000, GIS analysis of spatial variability of contaminated watershed components in a historically mined region, basin and range province, Southeast Arizona: Tucson, University of Arizona, master’s thesis, 127 p.

Brady, L. M., 2001, Twin cities of Nogales: A border-shed analysis in GIS: Arizona Hydrological Society Symposium, Tucson, Ariz., 2001, Proceedings: poster.

Brady, L. M., Gray, Floyd, Wissler, C. A. and Guertin, D. P., 2001, Spatial variability of sediment erosion processes using GIS analysis within watersheds in a historically mined region, Patagonia Mountains, Arizona: U.S. Geological Survey Open File Report 01-267, 51 p.

Brady, L. M., Gray, Floyd, Castaneda, Mario, and Bolm, Karen, 2001a, Critical U.S. - Mexico borderland watershed analysis: ESRI Annual International User Conference, 21st, San Diego, Calif., Proceedings.

Brady, L. M., Gray, Floyd, Castaneda, Mario, Boltman, Mark, and Bolm, K. S., 2002, Preliminary United States-Mexico border watershed analysis, twin cities area of Nogales, Arizona and Nogales, Sonora: U.S. Geological Survey Open File Report 02-112, 48 p.

Brooks, K.N., Ffolliott, P. F., Gregersen, H. M. and Thames, J. L., 1997, Hydrology and the management of watersheds, (2nd ed.): Ames, Iowa State University Press, 502 p.

Cowen, Jeffrey, 1993, A proposed method for calculating the LS factor for use with the USLE in a grid-based environment: 1993 Environmental Systems Research Instititute User Conference Proceedings, p. 65-74.

ERDAS, Inc., 1997, ERDAS field guide (4th ed.): Atlanta, Ga., 660 p.

Fraser, R.H., 1999. SEDMOD: a GIS-based delivery model for diffuse source pollutants: New Haven, Conn., Yale University Ph,D, Thesis, 99 p.

Haan, C.T., Barfield, B.J., and Hayes, J.C., 1981, Design yydrology and sedimentology for small catchments: New York, Academic Press, 588 p.

Instituto National de Estadistica Geografía e Informatica, 1997, Soils map of Mexico; scale 1:1,000,000 {URL http://www.cep.unep.org}.

Norman, L.M., Wissler, C.A., Guertin, D.P., and Gray, Floyd, 2002, Digital soils survey map of the Patagonia Mountains, Arizona: U.S. Geological Survey Open-File Report 02-324, 24 p., scale 1:24,000.

Osterkamp, W.R. and Toy, T.J., 1997, Geomorphic considerations for erosion prediction: Environmental Geology, v. 29, no. 3/4, p. 152- 157.

U.S. Environmental Protection Agency, 2002, Border 2012; U.S.-Mexico Environmental Program: (URL http://www.epa.gov/usmexicoborder/pdf/2012_english_web.pdf.)

U.S. Forest Service, 1980, An approach to water resources evaluation of non-point silvicultural sources; a procedural handbook: Washington, D.C. Environmental Protection Agency Report EPA-600/8-80-012, 850 p.

U.S. Natural Resources Conservation Service, Official soil series descriptions (OSD): URL http://soils.usda.gov/technical/classification/osd {Accessed Sept. 7, 2004}.

U.S. Soil Conservation Service and U.S. Forest Service, 1979, Soil survey of Santa Cruz and parts of Cochise and Pima Counties, Arizona: 100 p.

Wischmeier, J.R. Johnson, C.B., and Cross, B.V., 1971, A soil erodibility nomograph for farmland and construction sites: Journal of Soil and Water Conservation, v. 28, p. 189-193.

Wischmeier, W.H., and Smith, D.D., 1978, Predicting rainfall erosion: a guide to conservation planning: U.S. Department of Agriculture, Agronomy Handbook 537.

Appendix: Metadata

Binational Digital Soils Map of the Ambos Nogales Watershed
Metadata also available as
Metadata:

- Identification_Information
- Data_Quality_Information
- Spatial_Data_Organization_Information
- Spatial_Reference_Information
- Entity_and_Attribute_Information
- Distribution_Information
- Metadata_Reference_Information

Identification_Information:
Citation:
Citation_Information:
Originator:
Laura M. Norman , D. Phillip Guertin , David Peña Hernández , Alberto Suàrez Barnett , and Kelly Ashton-Reis
Publication_Date: Unknown
Title: Binational Digital Soils Map of the Ambos Nogales Watershed
Edition: 1
Geospatial_Data_Presentation_Form: vector digital data
Series_Information:
Series_Name: Scientific Investigations Map
Issue_Identification: I-xxxx
Publication_Information:
Publication_Place: Menlo Park, CA
Publisher: U.S. Geological Survey
Online_Linkage: <http://wgsc.wr.usgs.gov/wrgeog_pubs/>
Larger_Work_Citation:
Citation_Information:
Originator:
Laura M. Norman , D. Phillip Guertin , David Peña Hernández , Alberto Suàrez Barnett , and Kelly Ashton-Reis
Publication_Date: 2004
Title: Binational Digital Soils Map of the Ambos Nogales Watershed
Geospatial_Data_Presentation_Form: vector digital data
Series_Information:
Series_Name: Scientific Investigations Map
Issue_Identification: I-XXXX
Publication_Information:
Publication_Place: Menlo Park, CA
Publisher: USGS
Online_Linkage: <http://wgsc.wr.usgs.gov/wrgeog_pubs/>

Description:
Abstract:
A map of soil parameters in digital format was derived for the international watershed of Ambos Nogales generated to run in selected models. The Ambos Nogales watershed is located in southern Arizona and northern Sonora, Mexico and describes the Nogales wash, a tributary of the Upper Santa Cruz River. The Nogales Wash watershed covers 235 square kilometers, just under half of the area is in Mexico. Investigations of potential erosion revealed a discrepancy in soils data found at the international border of the watershed, in part due to low-resolution, formatting, variable nomenclature and classification systems. Historical analog soils data were automated to create a higher-resolution digital soils survey map of the Nogales, Arizona and merged with lower resolution data describing soils in Nogales, Sonora.
Purpose:
To model soil erosion and sedimentation for future planning purposes.
Time_Period_of_Content:
Time_Period_Information:
Multiple_Dates/Times:
Single_Date/Time:
Calendar_Date: unknown
Currentness_Reference: 1970
Status:
Progress: Complete
Maintenance_and_Update_Frequency: None planned
Spatial_Domain:
Bounding_Coordinates:
West_Bounding_Coordinate: -109.568835
East_Bounding_Coordinate: -109.512347
North_Bounding_Coordinate: 31.378782
South_Bounding_Coordinate: 31.295863
Keywords:
Theme:
Theme_Keyword_Thesaurus: none
Theme_Keyword: Soil
Theme_Keyword: Binational
Theme_Keyword: Model Parameters
Place:
Place_Keyword: Arizona
Place_Keyword: Sonora
Place_Keyword: Nogales
Access_Constraints: N/A
Use_Constraints:
This digital database is not meant to be used or displayed at any scale larger than 1:24,000 (for example, 1:12,000). Any hardcopies utilizing this dataset shall clearly indicate their source. If the user has modified the data in any way, he is obligated to describe the types of modifications he has performed on the hardcopy

map. User specifically agrees not to misrepresent this dataset nor to imply that changes he made were approved by the U.S. Geological Survey.
Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Laura M. Norman
Contact_Organization: U.S. Geological Survey
Contact_Position: Cartographer, GIS Specialist
Contact_Address:
Address_Type: mailing address
Address: 520 N Park Ave, Ste #355
City: Tucson
State_or_Province: AZ
Postal_Code: 85719
Country: USA
Contact_Voice_Telephone: 520 670 5510
Contact_Facsimile_Telephone: 520 670 5571
Contact_Electronic_Mail_Address: lmbrady@usgs.gov
Hours_of_Service: 9-5
Native_Data_Set_Environment:
Microsoft Windows 2000 Version 5.0 (Build 2195) Service Pack 4; ESRI ArcCatalog 8.2.0.700
Cross_Reference:
Citation_Information:
Originator:
U.S. Department of Agriculture: Soil Conservation Service and Forest Service in cooperation with Arizona Agricultural Experiment Station
Publication_Date: April 1979
Title:
Soil survey of Santa Cruz and parts of Cochise and Pima counties, Arizona
Geospatial_Data_Presentation_Form: map
Publication_Information:
Publisher: U.S. Department of Agriculture
Larger_Work_Citation:
Citation_Information:
Publication_Information:
Publication_Place: USGS
Cross_Reference:
Citation_Information:
Originator:
modified by the Directorate of the Geography of the National Territory (DDGTENAL) and digitized by the Instituto National de Estadistica Geografia e Informatica (INEGI)
Publication_Date: 1997
Title: 1970 FAO/UNESCO soil map of the world
Geospatial_Data_Presentation_Form: raster digital data

Data_Quality_Information:

Attribute_Accuracy:

Lineage:

Source_Information:

Source_Citation:

Citation_Information:

Originator:

U.S. Department of Agriculture: Soil Conservation Service and Forest Service in cooperation with Arizona Agricultural Experiment Station

Publication_Date: April 1979

Title:

Soil survey of Santa Cruz and parts of Cochise and Pima counties, Arizona

Geospatial_Data_Presentation_Form: map

Publication_Information:

Publisher: U.S.D.A.

Other_Citation_Details:

The most accurate soil information for the study area was in hard copy. This was available as 1:20,000 scale maps in the "Soil Survey of Santa Cruz and Parts of Cochise and Pima Counties, Arizona" (USDA, SCS & FS, 1979), a product of the U.S. Department of Agriculture's Soil Conservation Service and Forest Service in cooperation with the Arizona Agricultural Experiment Station. These maps were created according to the site conditions in 1971. Aerial photography was used to map polygonal soil types according to field test sites.

Source_Scale_Denominator: 1:20,000

Type_of_Source_Media: Maps drawn on aerial photos

Source_Time_Period_of_Content:

Time_Period_Information:

Single_Date/Time:

Calendar_Date: 1979

Source_Currentness_Reference: ground condition

Source_Citation_Abbreviation:

U.S. Department of Agriculture: Soil Conservation Service and Forest Service in cooperation with Arizona Agricultural Experiment Station, 1979

Source_Contribution:

Soils data in the Arizona portion of the watershed awere digitized and attributed according to the soil units on the map. User defined items were added to the newly digitized soil coverage feature attribute table to define the map unit descriptions: soil series. Labels were created and attribution of the new soils coverage was completed using a form-based interface provided by ESRI within ARCEDIT. The projection was defined according to the DOQQ that fostered it (UTM, Zone 12, Datum NAD83). The soil coverage is not meant to be used or displayed at any scale larger than 1:20,000 (e.g., 1:10,000).

Source_Information:

Source_Citation:

Citation_Information:

Originator: Secretaría de Infraestructura Urbana y Ecología (SIUE)
Publication_Date: 2000
Title: Plan de Desarrollo Municipal 2000-2003
Type_of_Source_Media: paper
Source_Citation_Abbreviation: Plan de Desarrollo Municipal 2000-2003
Source_Contribution:
According to a report by the City Hall in Nogales, Sonora (Plan de Desarrollo Municipal 2000-2003), the predominant soils in Nogales, Sonora are Lithosol (I) and Regosol Eutrico (Re), with a textural average of 30 cm. Lithosol is abundant in the southern region of the municipality and is characterized for the presence of abundant stony materials (lítica); its susceptibility to erosion depends on the slope of the land and vegetation developed. Regosol is located in the north and central regions of the municipality, presenting some lítica; the soil fertility and agricultural use is dependant on depth.
Source_Information:
Source_Citation:
Citation_Information:
Originator:
Soil Survey Division, Natural Resources Conservation Service, United States Department of Agriculture
Publication_Date: Unknown
Publication_Time: Unknown
Title: Official Soil Series Descriptions
Online_Linkage:
[Online WWW]. Available URL: " <http://ortho.ftw.nrcs.usda.gov/osd/>"
[Accessed 12 Nov 2003]
Source_Citation_Abbreviation:
Soil Survey Division, Natural Resources Conservation Service, United States Department of Agriculture; Official Soil Series Descriptions 2003
Source_Contribution:
The K factor, soil erodibility factor is a calculation formulated to account for percent sand and silt, percent organic material, percent structure and percent permeability; soils data must also contain information about texture or percent clay. These values were plugged into the attribute table for the soils types in Nogales, AZ
Source_Information:
Source_Citation:
Citation_Information:
Originator: Wischmeier, J.R. Johnson, C.B. and Cross, B.V.
Publication_Date: 1971
Title:
A soil erodibility nomograph for farmland and construction sites.
Series_Information:
Series_Name: Journal of Soil and Water Conservation
Issue_Identification: 28, 189-193.
Source_Citation_Abbreviation: Wischmeier and others 1971

Source_Contribution:
The Soil Erodibility nomograph was used to estimate K-values from the different characteristics of the soils in the soil profiles within the watershed boundaries for Nogales, Sonora
Source_Information:
Source_Citation:
Citation_Information:
Originator:
Instituto National de Estadistica Geografia e Informatica (INEGI)
Publication_Date: 1997
Title: Soils Map of Mexico 1:1000000
Geospatial_Data_Presentation_Form: vector digital data
Online_Linkage: <http://www.cep.unep.org/data/north/soils/mexsoils.html>
Source_Scale_Denominator: 1:1000000
Type_of_Source_Media: online
Source_Citation_Abbreviation:
Instituto National de Estadistica Geografia e Informatica (INEGI), 1997
Source_Contribution:
A digital soils map of Mexico at a scale of 1:1,000,000, derived from units of classification related to the 1970 FAO/UNESCO soil map of the world, was modified by the Directorate of the Geography of the National Territory (DDGTENAL) and digitized by the Instituto National de Estadistica Geografia e Informatica (INEGI) in 1997 and describes the Nogales area. In addition to the soil classes, the map units may be described by a chemical or physical phase..
Process_Step:
Process_Description:
The 1979 soil maps were automated for future incorporation into the hydrologic modeling within a GIS. The maps from which this dataset was made had not been rectified for distortion or registered to a coordinate system. Each map was scanned into tagged image file format (TIFF) using an 8-bit black and white drum scanner at 100 dpi. ERDAS IMAGINE was used to import the images. Automating these soils maps was done according to procedures described in Norman and others, 2002. CD-ROM's containing Digital Orthophoto Quarter Quads (DOQQ's) from the USGS were used to register and rectify the scanned soils maps. Ground Control Points (GCP's) were established by matching known locations on the soil maps to the same location identified on a DOQQ. The digital transformation was performed with the cubic convolution method of resampling to effectively associate the aerial photo with pinpoints to known coordinates and to adjust the map to accurate proportions. This method transformed scanned soils maps into registered images. Error still exists despite the high number of GCP's used to control the transformation.
Source_Used_Citation_Abbreviation:
U.S. Department of Agriculture: Soil Conservation Service and Forest Service in cooperation with Arizona Agricultural Experiment Station, 1979
Process_Date: 2003
Process_Step:

Process_Description:
Clay percentages are read from left to right across the triangle and the intersection of the three sizes on the triangle give the texture class or vice versa. This was used to assign texture values in both Nogales, Arizona and Nogales, Sonora
Process_Date: 2004
Process_Step:
Process_Description:
The two polygonal coverages were merged together into the same projection and effectively stitched together at the International border. Those attributes containing the K Factors, and Texture values, or percent clay area carried over in the GIS datasets for modeling processes in the future.
Process_Date: 2004
Process_Step:
Process_Description:
The k factor values derived from the USDA, SCS Technical Notes in Phoenix Arizona, Sept. 1, 1976, were added as an item to this coverage's attribute table for the soils types in Nogales, Ariz. The Soil Erodibility nomograph (Wischmeier and others 1971) was used to estimate K-values from the different characteristics of the soils in the soil profiles within the watershed boundaries for Nogales, Sonora.
Source_Used_Citation_Abbreviation: USDA, SCS Technical Notes in Phoenix Arizona, Sept. 1, 1976
Source_Used_Citation_Abbreviation:
Wischmeier, J.R. Johnson, C.B. and Cross, B.V. (1971). A soil erodibility nomograph for farmland and construction sites. Journal of Soil and Water Conservation, 28, 189-193.
Process_Date: 2003

Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: Vector
Point_and_Vector_Object_Information:
SDTS_Terms_Description:
SDTS_Point_and_Vector_Object_Type: G-polygon
Point_and_Vector_Object_Count: 84

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Horizontal_Coordinate_System_Definition:
Planar:
Grid_Coordinate_System:
Grid_Coordinate_System_Name: Universal Transverse Mercator
Universal_Transverse_Mercator:
UTM_Zone_Number: 12
Transverse_Mercator:
Scale_Factor_at_Central_Meridian: 0.999600
Longitude_of_Central_Meridian: -111.000000
Latitude_of_Projection_Origin: 0.000000
False_Easting: 500000.000000

False_Northing: 0.000000
Planar_Coordinate_Information:
Planar_Coordinate_Encoding_Method: coordinate pair
Coordinate_Representation:
Abscissa_Resolution: 0.000016
Ordinate_Resolution: 0.000016
Planar_Distance_Units: meters
Geodetic_Model:
Horizontal_Datum_Name: North American Datum of 1983
Ellipsoid_Name: Geodetic Reference System 80
Semi-major_Axis: 6378137.000000
Denominator_of_Flattening_Ratio: 298.257222

Entity_and_Attribute_Information:
Detailed_Description:
Entity_Type:
Entity_Type_Label: n_soils
Entity_Type_Definition:
Polygons used to describe soil types, and their attributes for Ambos Nogales
Attribute:
Attribute_Label: FID
Attribute_Definition: Internal feature number.
Attribute_Definition_Source: ESRI
Attribute_Domain_Values:
Unrepresentable_Domain:
Sequential unique whole numbers that are automatically generated.
Attribute:
Attribute_Label: Shape
Attribute_Definition: Feature geometry.
Attribute_Definition_Source: ESRI
Attribute_Domain_Values:
Unrepresentable_Domain: Coordinates defining the features.
Attribute:
Attribute_Label: AREA
Attribute_Definition: Area (meters)
Attribute:
Attribute_Label: PERIMETER
Attribute_Definition: Perimeter (meters)
Attribute:
Attribute_Label: SOIL9_
Attribute_Definition: Soil Type as classified
Attribute:
Attribute_Label: SOIL9_ID
Attribute_Definition:
The K factor, soil erodibility factor is a calculation formulated to account for percent sand and silt, percent organic material, percent structure and percent

permeability; soils data must also contain information about texture or percent clay. The Soil Erodibility nomograph was used to estimate K-values from the different characteristics of the soils in the soil profiles within the watershed boundaries for Nogales, Sonora
Attribute:
Attribute_Label: SOILTYPE
Attribute_Definition: Percent Clay
Attribute_Definition_Source:
Based on the descriptions provided for the soils types, the soil texture triangle was used to classify the texture class of the soil (percent clay).
Attribute:
Attribute_Label: K_FACT
Attribute_Definition:
Number Of Class-Texture-Depth-Phases Physical Or Chemical-Units Of Classification
Attribute_Definition_Source: INEGI, 1997
Attribute:
Attribute_Label: CLAY_P
Attribute:
Attribute_Label: MEX_SOIL

Distribution_Information:
Distributor:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: U.S. Geological Survey
Resource_Description: Downloadable Data
Distribution_Liability:
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Digital_Transfer_Information:
Transfer_Size: 0.018

Metadata_Reference_Information:
Metadata_Date: 20040803
Metadata_Review_Date: 20031204
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Laura M. Norman
Contact_Organization: U.S. Geological Survey
Contact_Position: Cartographer, GIS Specialist
Contact_Address:
Address_Type: mailing address
Address: 520 N Park Ave, Ste #355
City: Tucson
State_or_Province: AZ
Postal_Code: 85719
Country: USA
Contact_Voice_Telephone: 520 670 5510
Contact_Facsimile_Telephone: 520 670 5571
Contact_Electronic_Mail_Address: lmbrady@usgs.gov
Hours_of_Service: 9-5
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998
Metadata_Time_Convention: local time
Metadata_Access_Constraints: none
Metadata_Use_Constraints: none
Metadata_Extensions:
Online_Linkage: <http://www.esri.com/metadata/esriprof80.html>
Profile_Name: ESRI Metadata Profile

Generated by mp version 2.7.3 on Tue Aug 03 15:25:59 2004