MAPPING LAND USE/LAND COVER IN THE AMBOS NOGALES STUDY AREA

By Laura M. Norman and Cynthia S.A. Wallace

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Abstract

The Ambos Nogales watershed, which surrounds the twin cities of Nogales, Arizona, United States and Nogales, Sonora, Mexico, has a history of problems related to flooding. This paper describes the process of creating a high-resolution, binational land-cover dataset to be used in modeling the Ambos Nogales watershed. The Automated Geospatial Watershed Assessment tool will be used to model the Ambos Nogales watershed to identify focal points for planning efforts and to anticipate ramifications of implementing detention reservoirs at certain watershed planes.

Introduction

Watersheds located along the Arizona-Sonora border of the United States and Mexico are especially susceptible to flooding and erosion during the summer monsoon season. Soils in this semi arid region typically have high caliche content (hard deposit of calcium carbonate), making them relatively impermeable and leading to enhanced runoff and increased risk of flash floods and debris flows. Homes, livelihoods, and even lives are threatened by these hazards. In Ambos Nogales (fig. 1), landslides and erosion of roads and hillslopes threaten surface water quality, contaminating streams with sediments and included toxins. Sewers in Nogales, Sonora, are not equipped to handle some loads and have caused fecal contamination of ground-water supplies in times of flood. In the face of climate change and imminent urban growth, scientists can offer prediction scenarios of what might happen during extreme events.

In order to determine the effects of flooding scenarios and urban growth for future planning, a model will be applied. The Kinematic Runoff and Erosion (KINEROS2) Model was developed by the U.S. Department of Agriculture-Agricultural Research Service (USDA-ARS) to simulate runoff, infiltration, interception, and erosion based on precipitation events (Woolhiser and others, 1970). This model can be applied within a GIS to represent spatial distribution within a watershed using the Automated Geospatial Watershed Assessment (AGWA2) Tool (Miller and others, 2002; Semmens and others, 2008). Four inputs are required to run the model (1) watershed elements (for example, topography and slope), (2) soil types, (3) precipitation information, and (4) land-cover data. Land-cover data is not readily available at a high enough resolution to simulate processes within this small watershed.

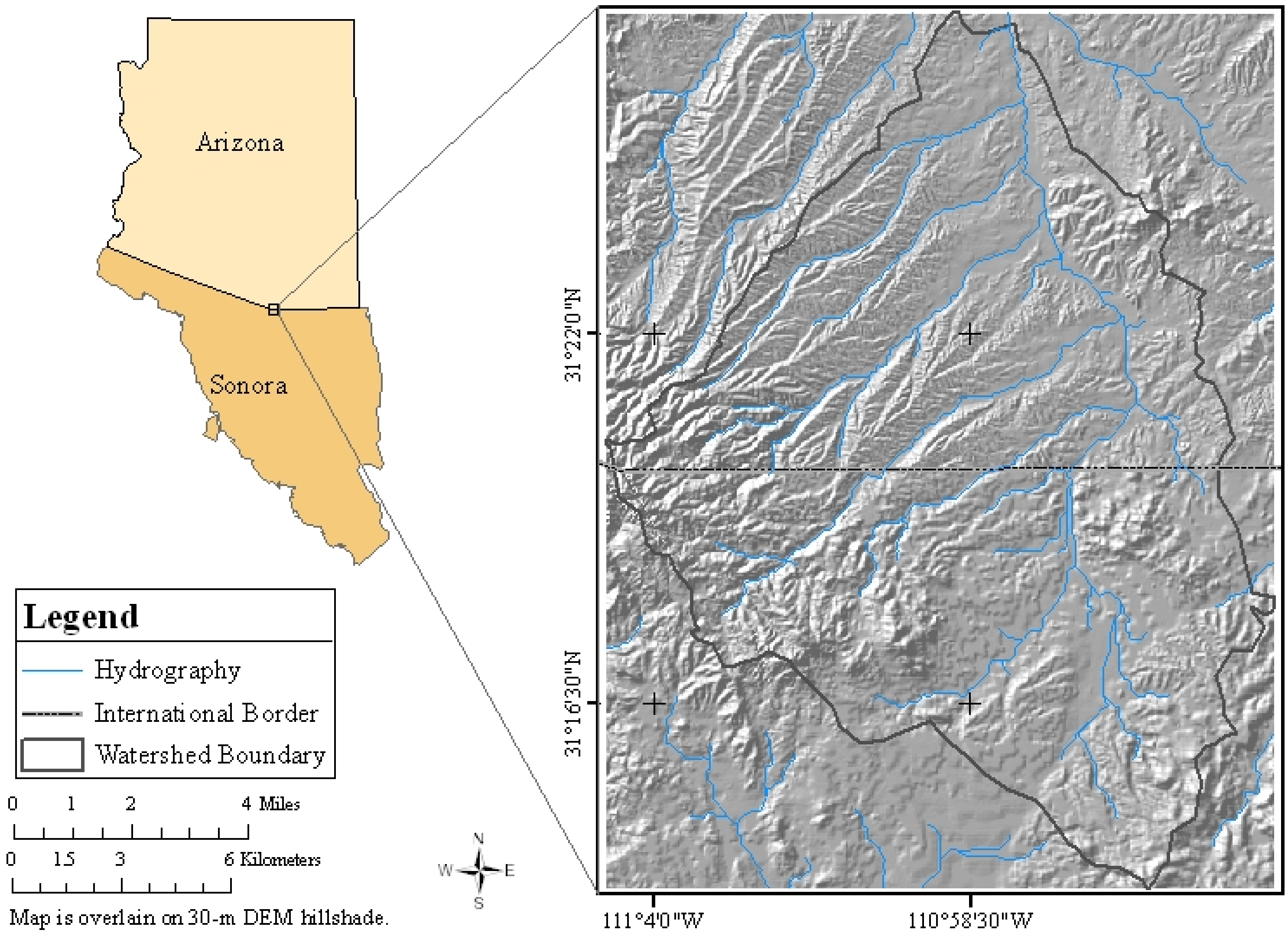


Figure 1. Location map of the Ambos Nogales watershed along the International border of Arizona, United States, and Sonora, Mexico.

Land Use/Land Cover

An integer grid dataset representing the distribution of land-cover classes across the study area is required for input to AGWA2. Several datasets are supported by AGWA2 natively, including the North American Landscape Characterization (NALC; Lunetta and Sturdevant, 1993)**,** Multi-Resolution Land Cover Characterization (MRLC; Loveland and Shaw, 1996), and Gap Analysis Program (GAP; Gaydos, 1996) land covers. The National Land Cover Data (NLCD; Vogelmann and others, 2001) is a dataset that maps the conterminous United States into 21-classes of land cover. The spatial resolution is 30-meters derived from Landsat Thematic Mapper (TM) satellite imagery. We acquired NLCD data for Nogales, Arizona (fig. 2).

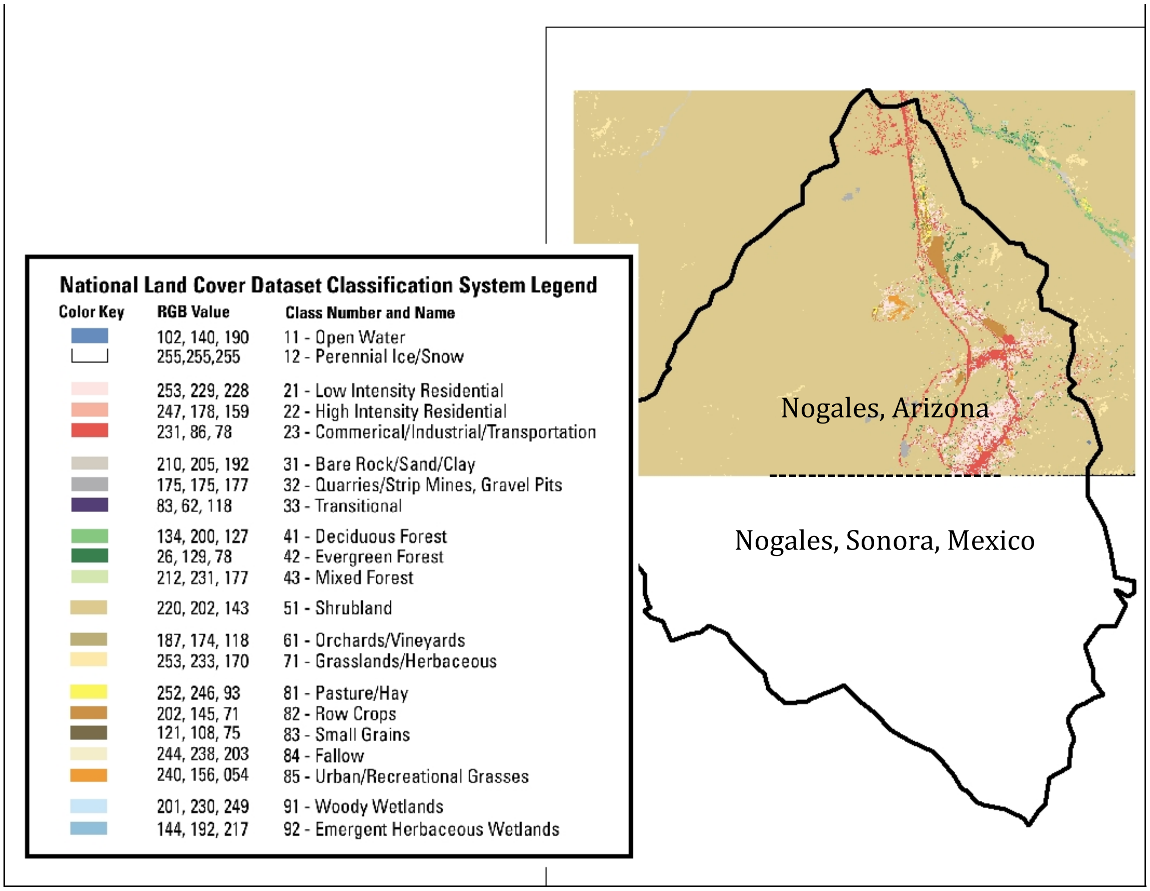


Figure 2: National Land Cover Data (NLCD) data for Nogales, Arizona, in the Ambos Nogales watershed.

The U.S. Geological Survey's (USGS) Border Environmental Health Initiative combined Mexico's Instituto Nacional de Estadística, Geografía, e Informática (INEGI) 1:250,000 Uso de Suelo (Land Use) dataset (1993) with NLCD (1992) to make a border-wide Binational Land Cover dataset (http://borderhealth.cr.usgs.gov/index.html, last accessed December 21, 2008). Eight land-cover classes were mapped to a generalized, modified Anderson Level I (Anderson and others, 1976) binational classification system to which both countries' Land Use/Land Cover (LULC) data could be reclassified (Parcher and others, 2006; Wilson, 2006; fig. 3).

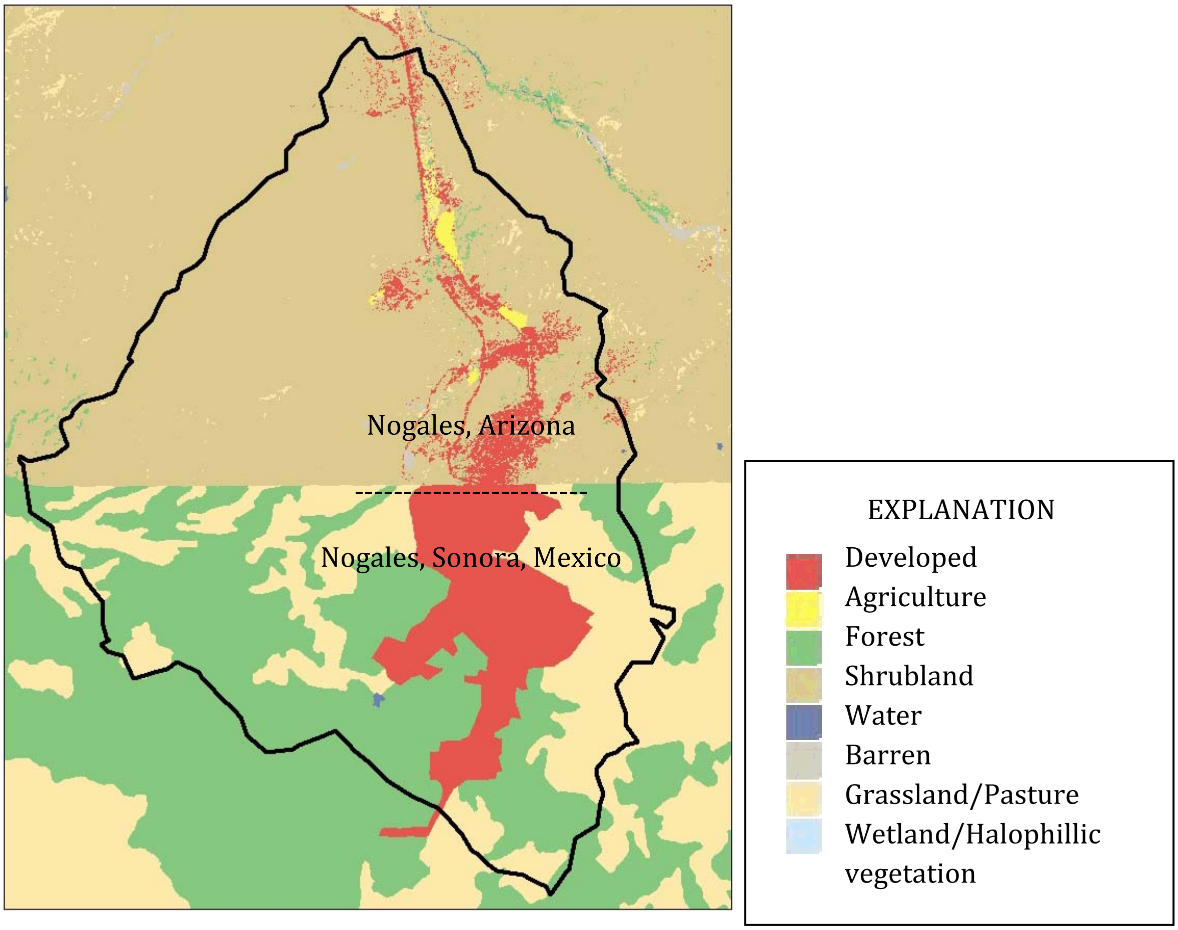


Figure 3. Binational Land-cover dataset for Ambos Nogales. Arizona, United States, and Sonora, Mexico.

The binational data has been reclassified and was derived entirely from Landsat interpretations; however, the original datasets were captured through different processes. The Mexican data were digitized polygons of land use, while the NALC data were classified using automated techniques resulting in a raster dataset. The LULC data represented by the polygons tend to present a more homogeneous picture of the landscape; the raster data represent more heterogeneity (Parcher and others 2006, Wilson 2006). While the binational dataset does provide a good qualitative representation of regional patterns in LULC, a more heterogeneous dataset is desirable to support the complexity needed for calculating hydrological parameters of a small watershed.

Procedures

The NALC data are Landsat Multi-Spectral Scanner (MSS) time-series triplicates that were acquired in 1973, 1986, and 1991 (+/- one year). Pixel size for all images is 60 meters. NALC triplicates were acquired for Path 36, Row 38. The dataset from October 7, 1992 were used for this processing (fig. 4).

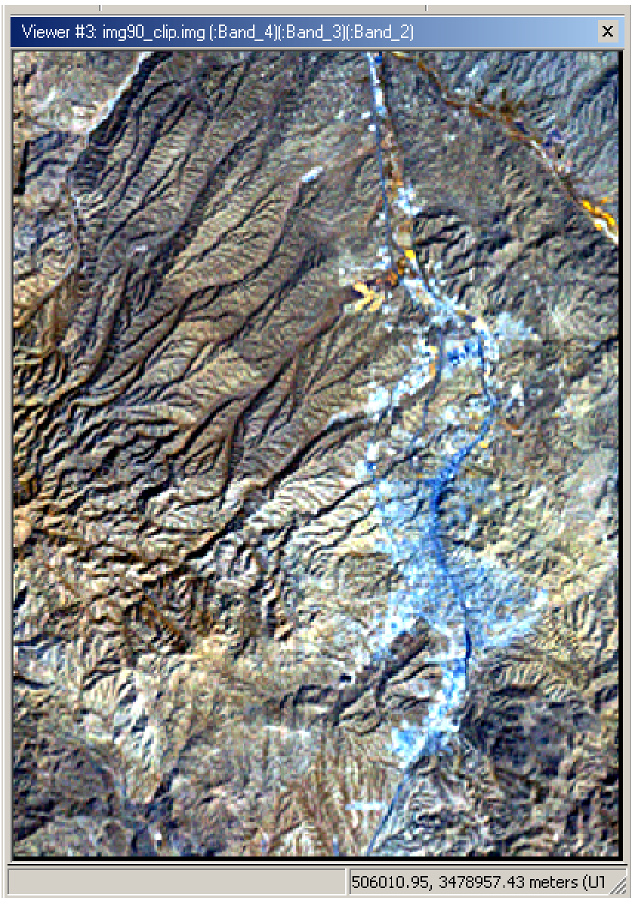


Figure 4. North American Landscape Characterization (NALC) image over Ambos Nogales, Arizona, United States, and Sonora, Mexico, acquired on October 7, 1992, by using Landsat Multi-Spectral Scanner data.

Using ERDAS IMAGINE 9.1 software, we extracted forty-five samples of land cover, based on dead-reckoning, and compared them with the classification scheme available from the NLCD using the Area of Interest (AOI) tool editor (fig. 5), to represent the full range of land cover in the watershed. The AOI feature allows the user to draw polygons around distinct features and relate the signatures back to a known reference.

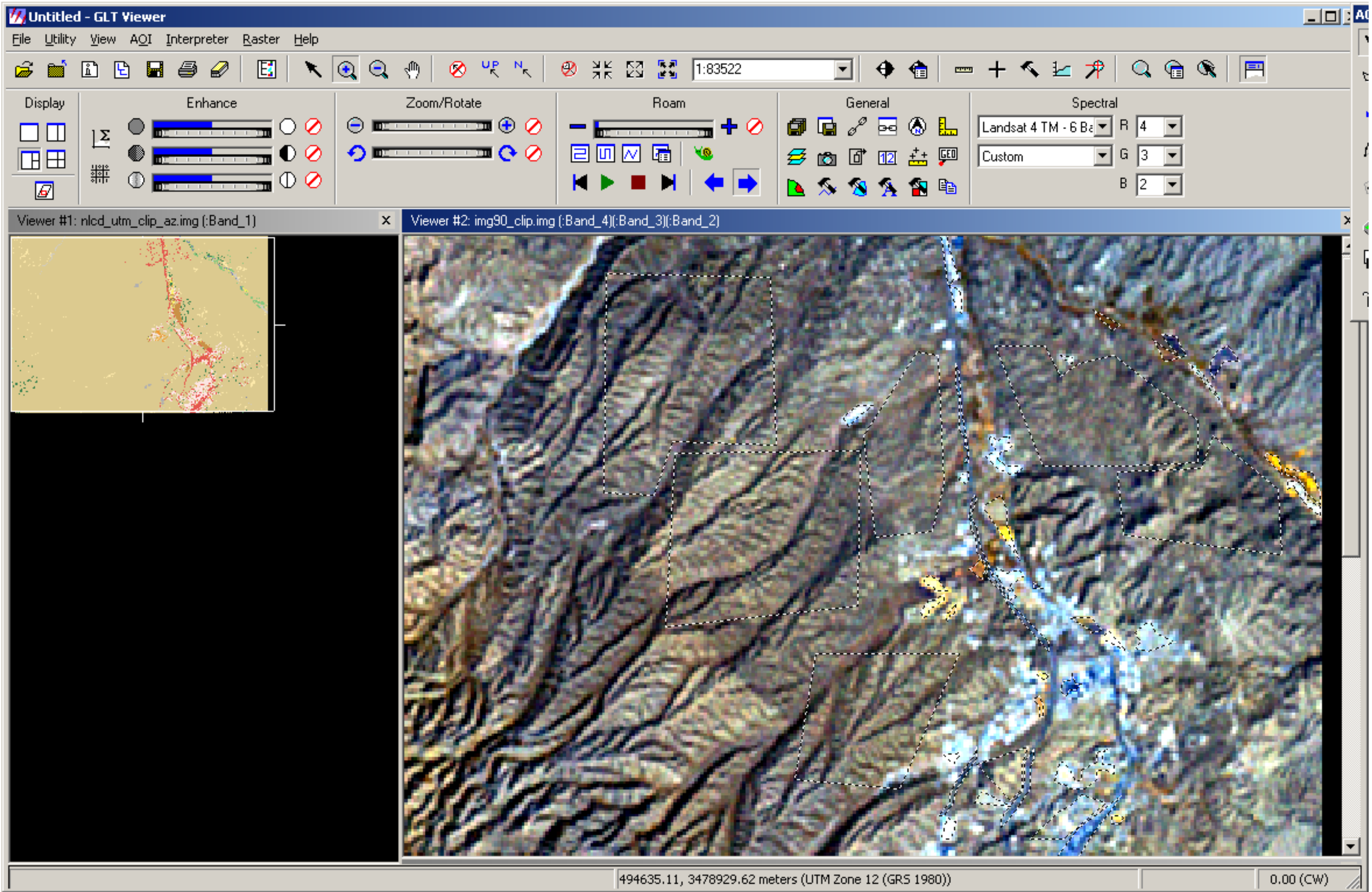
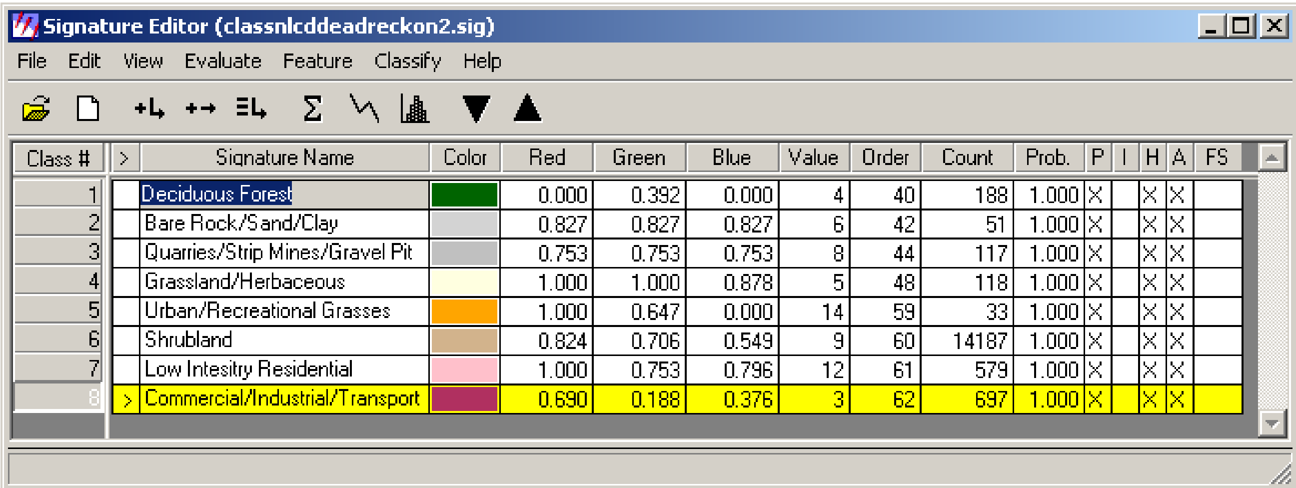


Figure 5. ERDAS IMAGINE 9.1 AOI tool editor and example of samples in Nogales, Arizona.

From the 45 samples identified, we merged the samples into 8 signatures that correlate with the NLCD classes occurring in the Ambos Nogales watershed: (1) Deciduous Forest, (2) Bare Rock/Sand/Clay, (3) Quarries/Strip Mines/Gravel Pit, (4) Grassland/Herbaceous, (5) Urban/Recreational Grasses, (6) Shrubland, (7) Low Intensity Residential, and (8) Commercial/Industrial/Transport (fig. 6).



Class #	>	Signature Name	Color	Red	Green	Blue	Value	Order	Count	Prob.	P	I	H	A	FS
1		Deciduous Forest		0.000	0.392	0.000	4	40	188	1.000	X		X	X	
2		Bare Rock/Sand/Clay		0.827	0.827	0.827	6	42	51	1.000	X		X	X	
3		Quarries/Strip Mines/Gravel Pit		0.753	0.753	0.753	8	44	117	1.000	X		X	X	
4		Grassland/Herbaceous		1.000	1.000	0.878	5	48	118	1.000	X		X	X	
5		Urban/Recreational Grasses		1.000	0.647	0.000	14	59	33	1.000	X		X	X	
6		Shrubland		0.824	0.706	0.549	9	60	14187	1.000	X		X	X	
7		Low Intesitry Residential		1.000	0.753	0.796	12	61	579	1.000	X		X	X	
8	>	Commercial/Industrial/Transport		0.690	0.188	0.376	3	62	697	1.000	X		X	X	

Figure 6. Signature Editor in ERDAS IMAGINE 9.1 and 8 signatures.

We applied a supervised classification, using these 8 signatures and the minimum distance rule, to map each pixel in the MSS scene into one of the 8 classes to create a new map of land cover in the watershed (fig. 7).

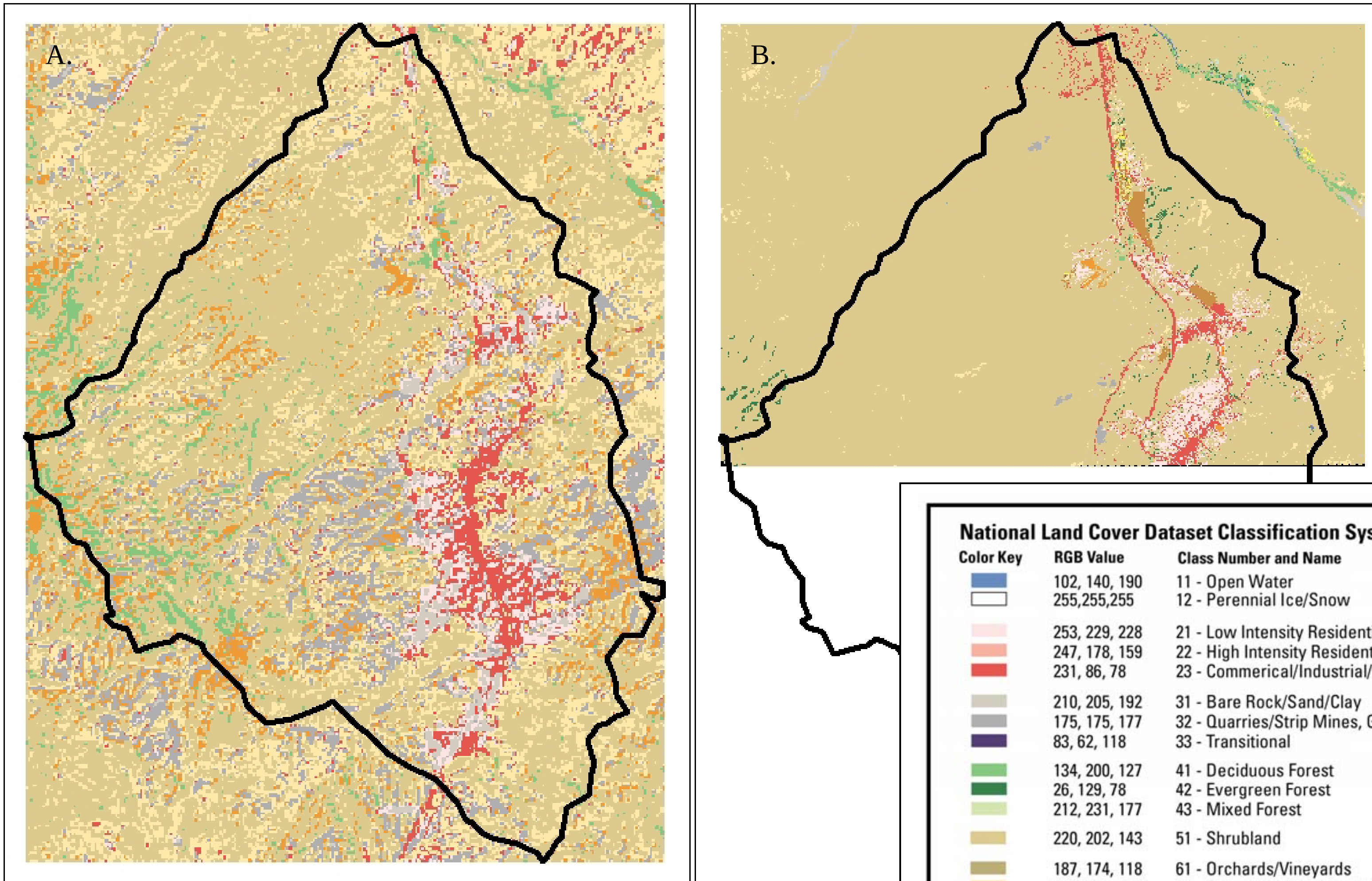


Figure 7. National Land Cover Data Maps. A., Ambos Nogales watershed land cover (60-m resolution), Arizona, United States, and Sonora, Mexico; B., Ambos Nogales watershed land cover (30-m resolution), Nogales, Arizona.

To check the accuracy of the newly created binational land-cover map, we developed a stratified sampling regime by assigning random points (reference pixels) to the classified image. ERDAS IMAGINE 9.1 uses a square window to select the reference pixels and the number of points is stratified to the distribution of thematic layer classes. Congalton (2001) and Congalton and Green (1999) suggest using a minimum sample size of 50 per class.

This creates a CellArray that lists two sets of class values for the randomly selected points from the classified map file. One set of class values is the land-cover class from the new map, and the other set of class values (reference values) is determined from higher resolution images by the analyst.

For each randomly selected point, we manually compared the classification on the NCLD map of Nogales, Arizona, the 1995-1996 Digital Orthophoto Quarter Quadrangles (DOQQs) of Nogales, Arizona, from the USGS, and of Nogales, Sonora, from INEGI to identify the reference points. These orthophotos are taken at a 1-m resolution and can be zoomed in on to determine actual composition of land use. Some points were not accurately classified.

A large area south of the International border was classified as Quarries/mines, but according to the DOQQ, reference point #98 is located in areas of widely dispersed mesquite or creosote surrounded by bare soil, a land cover reclassified as Shrubland and Bare rock/Sand/Clay (fig. 8).

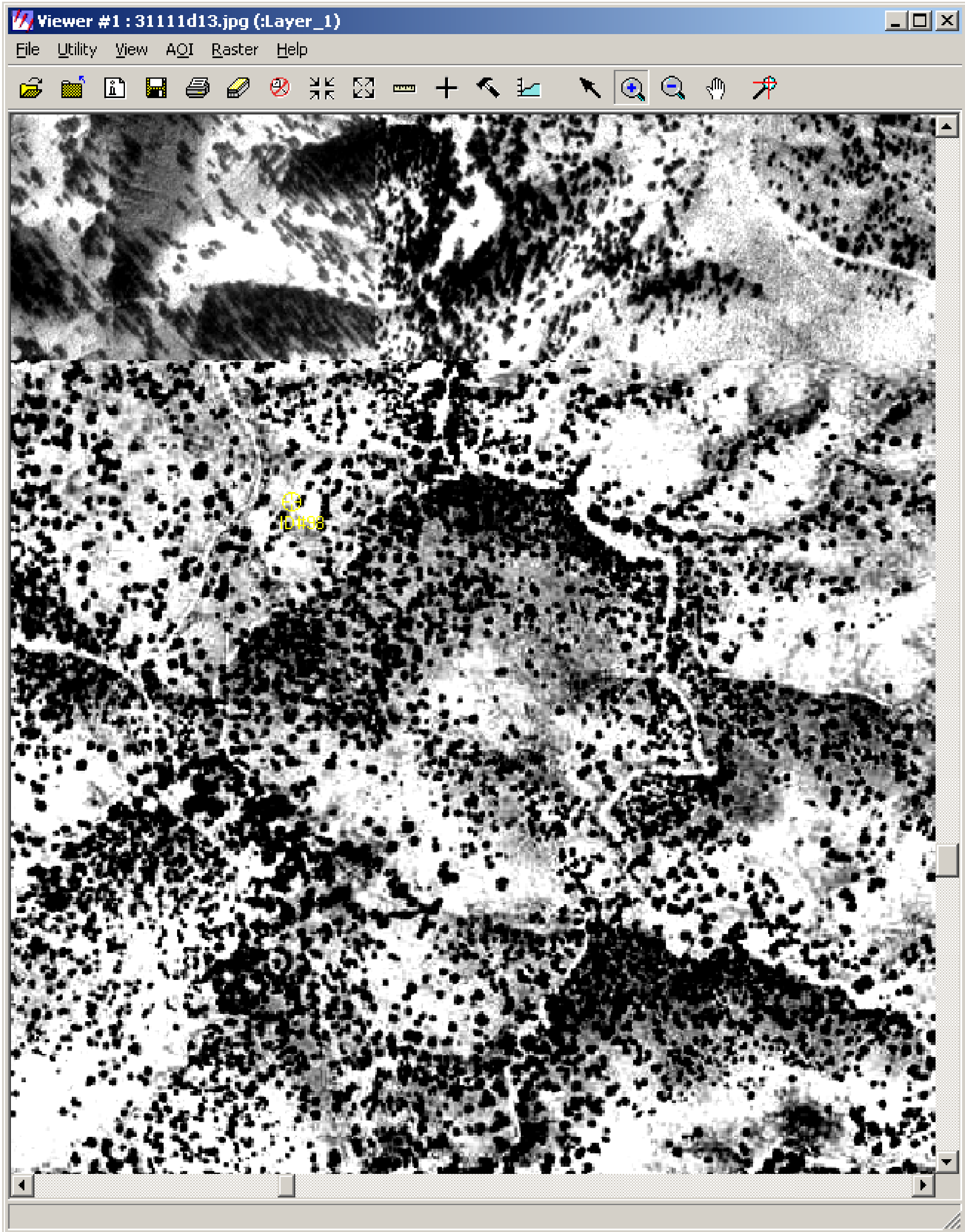


Figure 8: DOQQ of area south of the U.S.-Mexico border.

Additionally, in Nogales, Sonora, a lot of area that is residential is classified as Bare (fig. 9) because the neighborhood design (bare soils, raw housing materials) varies from the design normally seen in the U.S. We left these Sonora residential areas classified as bare because it most accurately represents the terrain, especially since this map will be used as input to a hydrological model (not particularly created for urban planning purposes; fig. 10).

Figure 9. Residential area in Nogales, Sonora, that was classified as Bare Rock/Sand/Clay.

Figure 10: Picture of colonias at the U.S.-Mexico border in Ambos Nogales showing lack of pavement on roads in this watershed.

(http://www.worldproutassembly.org/archives/2006/12/children_cross.html, last accessed December 21, 2008).

Accuracy Assessment Report

An error matrix was created to evaluate the new map's accuracy, to compare the reference class values to the assigned class values, and to identify errors of inclusion (commission errors) and exclusion (omission errors) present in the map (Congalton and

Green, 1999; table 1). A commission error occurs when an area is misclassified to an incorrect category. An omission error occurs when an area is excluded from the class to which it belongs. In addition to showing errors of omission and commission, the error matrix can be used to compute overall accuracy (table 2). Finally, the Kappa coefficient expresses the proportionate reduction in error generated by a classification process compared with the error of a completely random classification (table 3).

Table 1. Error Matrix

	Commercial/ Industrial/ Transport	Deciduous Forest	Grassland/ Herbaceous	Bare Rock/ Sand/ Clay	Quarries/ Strip Mines/ Gravel Pit	Shrubland	Low Intensity Residential	Urban/ Recreational Grasses	Classified total
Commercial/ Industrial/ Transport	**46**	0	0	1	0	3	0	0	**50**
Deciduous Forest	0	**46**	1	0	0	3	0	0	**50**
Grassland/ Herbaceous	0	0	**33**	0	0	17	0	0	**50**
Bare Rock/ Sand/ Clay	1	1	0	**47**	0	1	0	0	**50**
Quarries/ Strip Mines/ Gravel Pit	1	0	3	10	**6**	28	2	0	**50**
Shrubland	1	1	0	0	0	**48**	0	0	**50**
Low Intensity Residential	0	0	0	1	0	0	**49**	0	**50**
Urban/ Recreational Grasses	0	2	18	2	0	21	1	**6**	**50**
Reference total	**49**	**50**	**55**	**61**	**6**	**121**	**52**	**6**	**400**

Table 2. Accuracy Totals.

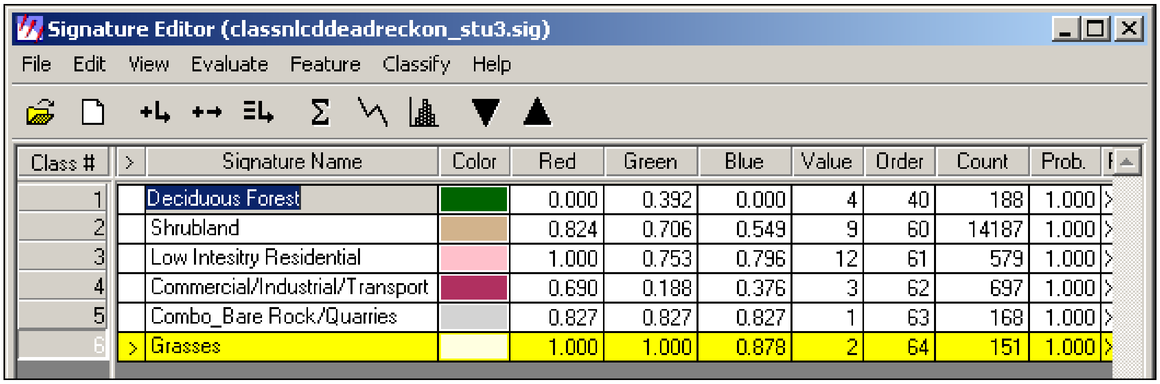
	Reference totals	Classified totals	Number correct	Producers accuracy, in percent	Users accuracy, in percent
Commercial/ Industrial/ Transport	49	50	46	93.88	92
Deciduous Forest	50	50	46	92.00	92
Grassland/ Herbaceous	55	50	33	60.00	66
Bare Rock/ Sand/ Clay	61	50	47	77.05	94
Quarries/ Strip Mines/ Gravel Pit	6	50	6	100.00	12
Shrubland	121	50	48	39.67	96
Low Intensity Residential	52	50	49	94.23	98
Urban/ Recreational Grasses	6	50	6	100.00	12
Totals	400	400	281		

Table 3. Conditional Kappa for each Category.

Class Name	Kappa
Commercial/ Industrial/ Transport	0.9088
Deciduous Forest	0.9086
Grassland/ Herbaceous	0.6058
Bare Rock/ Sand/ Clay	0.9292
Quarries/ Strip Mines/ Gravel Pit	0.1066
Shrubland	0.9427
Low Intensity Residential	0.9770
Urban/ Recreational Grasses	0.1066

The Overall Kappa (K^) Statistic was 0.66. This implies that the classification process is avoiding 66 percent of the errors that a completely random classification generates (Congalton, 2001). The overall classification accuracy was calculated to be 70.25 percent.

We were not satisfied with these results and so went back to the drawing board. The majority of error appeared to be with the Quarries/Strip Mine/Gravel Pit class and the Urban/Recreational Grasses class. The samples were merged into 6 signatures from the original 8 (1) Deciduous Forest, (2) Shrubland, (3) Low Intensity Residential, (4) Commercial/Industrial/Transport, (5) Combo Bare Rock/Quarries, and (6) Grasses (fig. 11).



Class #	>	Signature Name	Color	Red	Green	Blue	Value	Order	Count	Prob.
1		Deciduous Forest		0.000	0.392	0.000	4	40	188	1.000
2		Shrubland		0.824	0.706	0.549	9	60	14187	1.000
3		Low Intesitry Residential		1.000	0.753	0.796	12	61	579	1.000
4		Commercial/Industrial/Transport		0.690	0.188	0.376	3	62	697	1.000
5		Combo_Bare Rock/Quarries		0.827	0.827	0.827	1	63	168	1.000
6	>	Grasses		1.000	1.000	0.878	2	64	151	1.000

Figure 11. Screengrab of ERDAS IMAGINE Signature Editor with 6 classes.

In the modified Anderson Level I binational classification scheme, the Anderson Level I rangeland class is sometimes split into two classes: shrubland and grassland/pasture. We considered further combining classes to merge grasslands and shrubs, but felt that given the hydrological modeling application, it would be more accurate to keep 2 separate classes.

We applied a supervised classification using these 6 signatures and the minimum distance rule to acquire a second pass cross-border land-cover map. Accuracy statistics were computed for the new map (Tables 4-6).

Table 4. Error Matrix

	Commercial/ Industrial/ Transport	**Deciduous Forest**	**Shrubland**	**Low Intensity Residential**	**Combination Grasses**	**Combination Bare**	**Classified Total**
Commercial/ Industrial/ Transport	**46**	0	3	0	0	1	50
Deciduous Forest	0	**46**	3	0	1	0	50
Shrubland	1	1	**48**	0	0	0	50
Low Intensity Residential	0	0	0	**49**	0	1	50
Combination Grasses	0	2	38	1	**57**	2	100
Combination Bare	2	1	29	2	3	**63**	100
Reference Total	49	50	121	52	61	67	**400**

Table 5. Accuracy Totals.

	Reference totals	Classified totals	Number correct	Producers accuracy, in percent	Users accuracy, in percent
Commercial/ Industrial/ Transport	49	50	46	93.88	
Deciduous Forest	50	50	46	92.00	92
Shrubland	121	50	48	39.67	92
Low Intensity Residential	52	50	49	94.23	96
Combination Grasses	61	100	57	93.44	98
Combination Bare	67	100	63	94.03	57
Totals	400	400	309		

Table 6. Errors of omission, commission, and percent correct.

	Errors of omission, in percent	Errors of commission, in percent	Percent correct
Commercial/ Industrial/ Transport	6.12	8.16	93.88
Deciduous Forest	8.00	8.00	92.00
Shrubland	60.33	1.65	39.67
Low Intensity Residential	5.77	1.92	94.23
Combination Grasses	6.56	70.49	93.44
Combination Bare	5.97	55.22	94.03
Totals	**22.75**	**22.75**	**77.25**

The Overall Kappa (K^) Statistic was 0.7275—the classification process is avoiding 72.75 percent of the errors that a completely random classification generates and the overall classification accuracy was calculated to be 77.25 percent. The Ambos Nogales area is dominated by both shrubland and grassland around bare areas of transportation and urban sprawl (figs. 12 and 13), which is now represented in our new map.

Figure 12. Image of property at the U.S.-Mexico border between Marisposa Rd. and I-19 in Nogales, Arizona (http://www.loopnet.com/Arizona/Nogales-commercial-real-estate/?LinkCode=18400, last accessed June 21, 2008).

Figure 13. Photo of development land taken near Highway 82 in Nogales, Arizona (http://www.loopnet.com/Arizona/Nogales-commercial-real-estate/?LinkCode=18400, last accessed June 21, 2008).

In order to make the dataset acceptable as input to AGWA2, some further manipulation of the dataset was necessary. AGWA2 accepts NLCD datasets as input using a look-up table for the MRLC (fig. 14).

Attributes of mrlc_lut

OID	CLASS	NAME	A	B	C	D	COVER	INT	N	IMPERV
0	11	Open Water	10	10	10	10	0	0	0	0
1	12	Perrenial Ice/Snow	98	98	98	98	0	0	0	0
2	21	Low Intensity Residential	77	85	90	92	15	0.1	0.15	0.4
3	22	High Intensity Residential	81	88	91	93	10	0.08	0.12	0.75
4	23	Commercial/Industrial/Transport	89	92	94	95	2	0.05	0.01	0.8
5	31	Bare Rock/Sand/Clay	96	96	96	96	2	0	0.01	0
6	32	Quarries/Strip Mines/Gravel Pit	78	85	90	92	2	0	0.01	0
7	33	Transitional	72	82	87	90	20	0	0.01	0
8	41	Deciduous Forest	55	55	75	80	50	1.15	0.015	0
9	42	Evergreen Forest	55	55	70	77	50	1.15	0.015	0
10	43	Mixed Forest	55	55	75	80	50	1.15	0.015	0
11	51	Shrubland	63	77	85	88	25	3	0.055	0
12	61	Orchards/Vinyards/Other	77	77	84	88	70	2.8	0.04	0
13	71	Grasslands/Herbaceous	49	69	79	84	25	2	0.015	0
14	81	Pasture/Hay	68	79	86	89	70	2.8	0.04	0
15	82	Row Crops	72	81	88	91	50	0.76	0.04	0
16	83	Small Grains	65	76	84	88	90	4	0.04	0
17	84	Fallow	76	85	90	93	30	0.5	0.04	0
18	85	Urban/Recreational Grasses	68	79	86	89	90	2.5	0.04	0.01
19	91	Woody Wetlands	85	85	90	92	70	1.15	0.06	0
20	92	Emergent Herbaceous Wetlands	77	77	84	90	70	1.15	0.06	0

Record: 1 Show: All Selected Records (0 out of 21 Selected)

Figure 14. MRLC look-up table available in AGWA2.

Classes in the new image were assigned class numbers according to this table (fig. 15).

Attributes of img90clipsuper-mindist-dead6.img

OID	Value	Count	Red	Green	Blue	Opac	Class_name	Class
0	0	0	0	0	0	0	Unclassified	0
1	1	4992	0.82745	0.82745	0.8274509	1	Combo_Bare Rock/Quarries	31
2	2	41440	1	1	0.8784313	1	Grasses	71
3	3	5854	0.69	0.19	0.38	1	Commercial/Industrial/Transport	23
4	4	3858	0	0.39	0	1	Deciduous Forest	41
5	5	0	0	0	0	0		0
6	6	0	0	0	0	0		0
7	7	0	0	0	0	0		0
8	8	0	0	0	0	0		0
9	9	57292	0.82	0.7	0.55	1	Shrubland	51
10	10	0	0	0	0	0		0
11	11	0	0	0	0	0		0
12	12	9978	1	0.75	0.8	1	Low Intesitry Residential	21

Record: 0 Show: All Selected Records (0 out of 13 Selected)

Figure 15. New "Class" attribute assigned to binational map.

The image was converted to GRID format, to polygon format, and back to GRID format, to replace the Value field with the new CLASS numbers. The new GRID, "mrlc_Nogales" is appropriate for use in the AGWA model (figs. 16 and 17).

Attributes of MRLC_Nogales

VALUE *	Rowid	COUNT	CLASS
1	0	4992	31
2	1	41440	71
3	2	5854	23
4	3	3858	41
9	4	57292	51
12	5	9978	21

Record: 1 Show:

Figure 16. Final attribute table for the raster binational land-cover input of Ambos Nogales, Arizona, United States, and Sonora, Mexico.

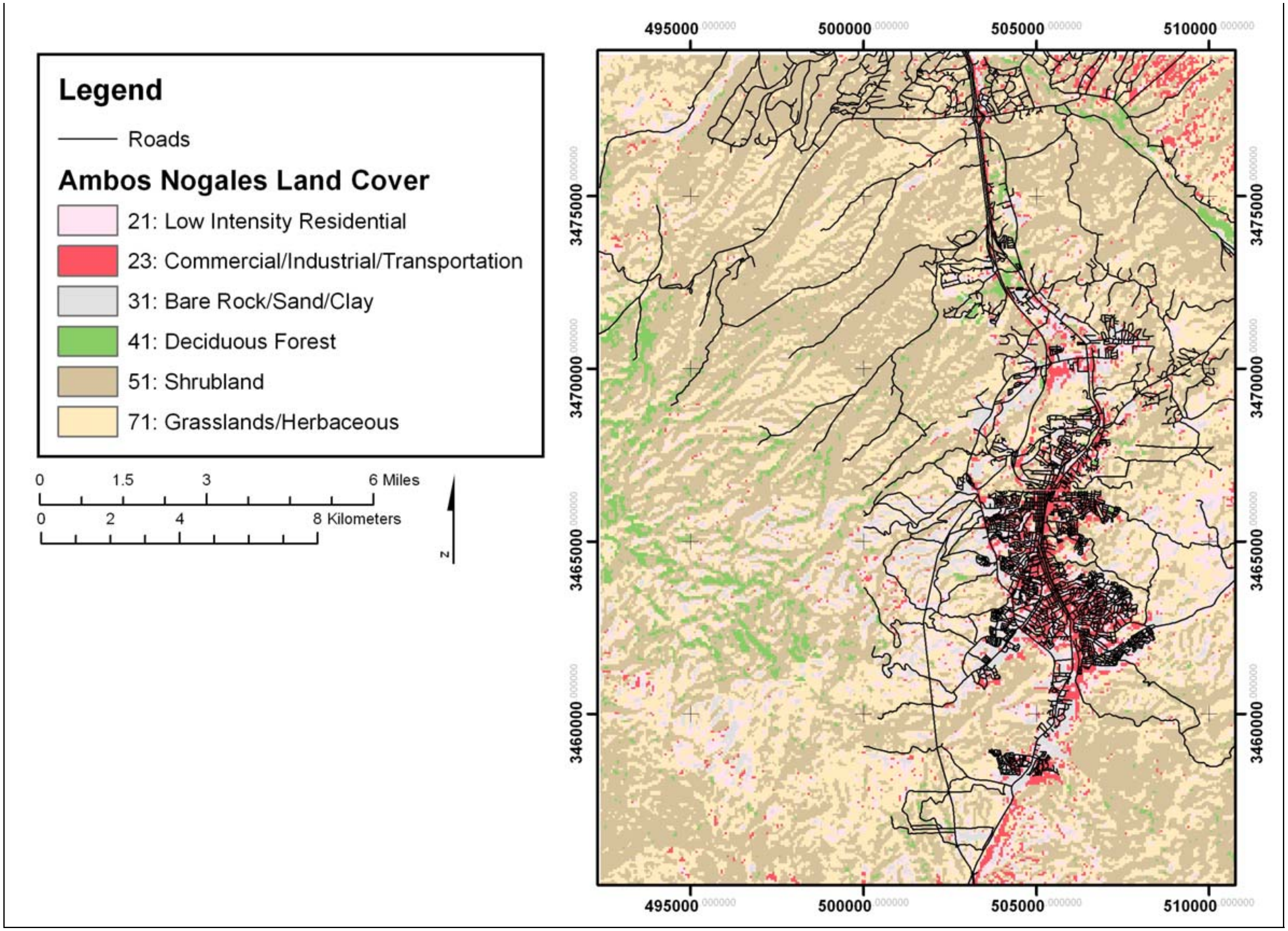


Figure 17. Final binational land-cover map of Ambos Nogales, Arizona, United States, and Sonora, Mexico, for input to AGWA2.

Conclusions

Environmental modeling across international borders can be challenging due to differences in language, nomenclature, scale, style, and priorities. Remotely sensed images can be used to create seamless data across administrative boundaries for input into models. This research paper describes procedures used to create a binational land use/land-cover map of use in the AGWA KINEROS2 model.

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Appendix A—Metadata

Identification_Information:
 Citation:
  Citation_Information:
   Originator: Laura Norman and Cynthia Wallace
   Publication_Date: Unknown
   Title: Land Use/Land Cover in the Ambos Nogales Watershed; Nogales, Arizona, United States and Nogales, Sonora, Mexico
   Geospatial_Data_Presentation_Form: raster digital data
   Online_Linkage: TBD
   Larger_Work_Citation:
    Citation_Information:
     Originator: Laura Norman and Cynthia Wallace
     Publication_Date: Unknown
     Title: Mapping Land Use/Land Cover in the Ambos Nogales Study Area
     Geospatial_Data_Presentation_Form: raster digital data
     Series_Information:
      Series_Name: Open File Report
     Publication_Information:
      Publisher: U.S. Geological Survey
 Description:
  Abstract: An integer GRID dataset representing the distribution of landscape classes across the Ambos Nogales Watershed was created. Six signatures that correlate with the Multi-Resolution Land Characteristics (MRLC) Consortium classes were identified using image processing techniques in ERDAS IMAGINE 9.1 software to develop a binational land cover dataset similar to the National Land Cover Dataset (NLCD). Data resolution is 60 m., based on the source Landsat MSS imagery in 1992.
  Purpose: This dataset was created to be used as input to the Automated Geospatial Watershed Assessment (AGWA) Tool, in order to predict runoff in this urbanizing watershed.
 Time_Period_of_Content:
  Time_Period_Information:
   Single_Date/Time:
    Calendar_Date: 10/07/92
  Currentness_Reference: ground condition
 Status:
  Progress: Complete
  Maintenance_and_Update_Frequency: None planned
 Spatial_Domain:
  Bounding_Coordinates:
   West_Bounding_Coordinate: -111.080090
   East_Bounding_Coordinate: -110.886233
   North_Bounding_Coordinate: 31.446346
   South_Bounding_Coordinate: 31.228667
 Keywords:

Theme:
Theme_Keyword: Land use
Theme_Keyword: Land Cover
Place:
Place_Keyword: Nogales
Place_Keyword: Sonora
Place_Keyword: Arizona
Place_Keyword: Mexico
Access_Constraints: None.
Use_Constraints: There is no guarantee concerning the accuracy of the data. Users should be aware that temporal changes may have occurred since this data set was collected and that some parts of this data may no longer represent actual surface conditions. Users should not use this data for critical applications without a full awareness of its limitations. Acknowledgement of the originating agencies would be appreciated in products derived from these data. Any user who modifies the data is obligated to describe the types of modifications they perform. User specifically agrees not to misrepresent the data, nor to imply that changes made were approved or endorsed by the U.S. Geological Survey. Please refer to <http://www.usgs.gov/privacy.html> for the USGS disclaimer.
Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Laura Norman
Contact_Organization: US Geological Survey
Contact_Position: Research Scientist
Contact_Address:
Address_Type: mailing and physical address
Address: 520 N. Park Ave., Ste #355
City: Tucson
State_or_Province: AZ
Postal_Code: 85719
Country: USA
Contact_Voice_Telephone: 5206705510
Contact_Electronic_Mail_Address: lnorman@usgs.gov
Native_Data_Set_Environment: Microsoft Windows XP Version 5.1 (Build 2600) Service Pack 2; ESRI ArcCatalog 9.2.2.1350
Data_Quality_Information:
Attribute_Accuracy:
Attribute_Accuracy_Report: The Overall Kappa (K^) Statistics was 0.7275-the classification process is avoiding 72.75 percent of the errors that a completely random classification generates and the overall classification accuracy was calculated to be 77.25%. The area is dominated by both shrubland and grassland around bare areas of transportation and urban sprawl , which is now represented in our map.
Logical_Consistency_Report: The accuracy of the dataset is based on the software's ability to detect land use signatures and the analysts's interpretation of features on the groud. Additional inaccuracy could occur in the original image it was processed from,

because even slight measurement inaccuracies of the ground features selected for ortho control can affect the final accuracy.
Completeness_Report: Data are limited to areas included in the Ambos Nogales study area as defined by a minimum bounding rectangle around the watershed.
Lineage:
Source_Information:
Source_Citation:
Citation_Information:
Originator: National Aeronautics and Space Administration (NASA) Landsat Pathfinder Program
Publication_Date: Unknown
Title: North American Landscape Characterization
Online_Linkage: http://GloVis.usgs.gov/
Type_of_Source_Media: remote sensing image
Source_Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: 19921007
Source_Citation_Abbreviation: NALC dataset from 10/07.1992 for Path 26, Row 38.
Source_Contribution: North American Landscape Characterization (NALC) data are Landsat Multi-Spectral Scanner (MSS) time-series triplicates that were acquired in 1973, 1986, and 1991 (+/- one year). Pixel size for all images is 60 meters. The data has been cast to the Universal Transverse Mercator (UTM) projection and is referenced to the North American Datum of 1927 (NAD27).
Process_Step:
Process_Description: Applied supervised classification, using signatures calculated from the NLCD of Nogales, Ariz., using the minimum distance rule, to acquire cross border signatures.
Process_Date: 20080501
Process_Step:
Process_Description: Created a CellArray that listed two sets of class values for 400 randomly selected points in the classified .img file. One set of class values was automatically assigned to these random points as they are selected (hidden in figure below-in order to get unbiased reference samples), and the other set of class values (reference values) was input .
Process_Date: 20080501
Process_Step:
Process_Description: Checked accuracy of classification using DOQQs and created accuracy report. We were not satisfied with these results and so we merged signatures. We applied a supervised classification using these 6 signatures and the minimum distance rule, to acquire a more accurate cross-border land cover map
Process_Date: 20080501
Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: Raster
Raster_Object_Information:
Raster_Object_Type: Grid Cell

Row_Count: 402
Column_Count: 307
Vertical_Count: 1
Spatial_Reference_Information:
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: row and column
Coordinate_Representation:
Abscissa_Resolution: 60.000000
Ordinate_Resolution: 60.000000
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: mrlc_nogales.vat
Entity_Type_Definition: Land use classes
Entity_Type_Definition_Source: Multi-Resolution Land Cover Characterization (MRLC)
Attribute:
Attribute_Label: Rowid
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: VALUE
Attribute_Definition: Internal ID # from image processing steps.
Attribute:
Attribute_Label: COUNT

Attribute_Definition: Number of GRID cells assigned to this value.
Attribute:
Attribute_Label: CLASS
Attribute_Definition: Class created to correspond with the NLCD data.
Attribute_Definition_Source: Multi-Resolution Land Cover Characterization (MRLC)
Distribution_Information:
Distributor:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Laura M. Norman
Contact_Organization: U.S. Geological Survey
Contact_Address:
Address_Type: mailing and physical address
Address: 520 N. Park Ave., Ste #104
City: Tucson
State_or_Province: AZ
Postal_Code: 85719
Country: USA
Contact_Electronic_Mail_Address: lnorman@usgs.gov
Resource_Description: Downloadable Data
Standard_Order_Process:
Digital_Form:
Digital_Transfer_Information:
Format_Name: GRID
Transfer_Size: 0.091
Ordering_Instructions: Data are available online at no charge via Internet download. Acknowledgement of the U.S. Geological Survey would be appreciated in products derived from these data
Metadata_Reference_Information:
Metadata_Date: 20080903
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Laura M. Norman
Contact_Organization: US Geological Survey
Contact_Address:
Address_Type: mailing and physical address
Address: 520 N. Park Ave, Ste #355
City: Tucson
State_or_Province: AZ
Postal_Code: 85719
Contact_Voice_Telephone: 5206705510
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998
Metadata_Time_Convention: local time
Metadata_Extensions:

Profile_Name: ESRI Metadata Profile
Metadata_Extensions:
Online_Linkage: http://www.esri.com/metadata/esriprof80.html
Profile_Name: ESRI Metadata Profile