

SWReGAP Land Cover Mapping Methods Documentation

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Functional Unit or Mapping Zone: Arizona 4

Organization: U.S. Geological Survey, Southwest Biological Science Center

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Date of Preparation: October 2004

1) Predictor layer preparation:

a) Image standardization:

Standardization from DN values to at-sensor reflectance was performed on Landsat 7 ETM+ imagery using methods presented by Huang et al (2001a), with the addition of a dark object subtraction step to remove atmospheric haze, as suggested by Chavez (1988, 1996). The equation used was as follows:

$$P_{\text{BandN}} = \frac{\pi((L_{\text{BandN}} * \text{Gain}_{\text{BandN}} + \text{Bias}_{\text{BandN}}) - (H_{\text{BandN}} * \text{Gain}_{\text{BandN}} + \text{Bias}_{\text{BandN}})) * D^2}{E_{\text{BandN}} * (\text{COS}((90 - \theta\pi/180)))}$$

Where,

P_{BandN} = Reflectance for Band N

L_{BandN} = digital number for Band N

H_{BandN} = digital number representing dark object for Band N

D = Normalized earth-sun distance

H_{BandN} = solar irradiance for Band N

b) Image dates and mosaicking:

Images were mosaicked using ERDAS Imagine 8.6 Mosaic Tool with "no outline" for type, and the "Overlay" option for overlap function.

Image dates and scenes were as follows:

ETM Scene (path/row)	Spring (yr. Julian date)	Summer (yr. Julian date)	Fall date (yr Julian date)
34/37	2000-105	2000-249	1999-310
35/36	2000-128	2000-156	1999-317
35/37	2000-128	2000-156	1999-317
36/36	2000-103	2000-167	1999-292
36/37	2000-103	2000-167	1999-292
37/35	2000-094	2000-158	1999-283
37/36	2000-110	2000-158	1999-283
38/35	2000-117	2000-165	1999-290
38/36	2000-101	2000-165	1999-290

The ERDAS Imagine mosaic files showing overlap arrangement can be found at:

AZ\ARCHIVE\AZ4\MOSAIC\AZ4_fa.mos
AZ\ARCHIVE\AZ4\MOSAIC\AZ4_sp.mos
AZ\ARCHIVE\AZ4\MOSAIC\AZ4_su.mos

In addition, a description of the overlap arrangement is presented in:

AZ\ARCHIVE\AZ4\MOSAIC\mosaic\AZ4_readme.txt

c) Image derived datasets:

Normalized Difference Vegetation Index (NDVI): Used a modified version of the NDVI model provided by ERDAS Imagine 8.6. This model performs the band ratio (band4-band3)/band4+band3) then scales the output by 200 to create a continuous unsigned 8-bit image ranging from 0-200. For an example of the *.gmd file go to AZ\ARCHIVE\AZ4\IMG_FILES.

Tasseled cap: Brightness, Greenness & Wetness band transformations were created using coefficients derived for the Landsat 7 ETM+ sensor, by Huang et al (2001b). An example of the *.gmd file can be found at AZ\ARCHIVE\AZ4\IMG_FILES.

All imagery derived predictor layers can be found at:

AZ\ARCHIVE\AZ4\IMG_FILES

d) DEM derived datasets:

Thirty-meter digital elevation models were obtained from the Eros Data Center, National Elevation Database (NED). The date for these data was October 1999. DEM's were converted from floating point grids to integer grids and mosaicked for the region, then clipped to the mapping area.

Aspect: A nine-class grid was created. Values 1=N, 2=NE, 3=E, 4=SE, 5=S, 6=SW, 7=W, 8=NW, 9=Flat

Landform: a 10-class landform grid was created from a topographic relative moisture index grid (values ranging from 0-28) (Manis et al 2001).

For modeling purposes all ArcInfo grids were converted to ERDAS Imagine .img files and can be found at:

AZ\ARCHIVE\AZ4\IMG_FILES\

2) Samples:

a) Sample collection methods:

USGS SBSC field crews collected the majority of samples on the ground, others came from existing data sources. Samples were assigned a label corresponding to either an Ecological System (Comer et al 2003) or a cover type uniquely defined for the SWReGAP project.

The SOURCE field in the \AZ\ARCHIVE\AZ4\TRAIN_DATA\az4_polys_all identifies the source for each sample. The PLOTNUM field indicates the unique identifier for that record. In the case of samples taken from existing data, the unique identifier was assigned either by the project generating the data or by the SWReGAP field team for the purposes of this project. Following is an explanation of each data source.

AzGF: Data were collected by the Arizona Department of Game and Fish along riparian corridors (example code AZCO096) from 1993 to 2000.

Babbitt: Identifies a sample taken from an existing database of vegetation relevés obtained by the U.S. Geological Survey on the Babbitt Ranches in northern Arizona in 1997 and 1998. An example plot code is: B.

Field_CPRS: Data collected by the U.S. Geological Survey SWReGAP field crew from 2001 to 2003. Plot code structure is:
AZ<month/day><year><teamcode><idnum><sequence letter, if appl>. An example plot code is: AZ070902KM010.

Field_NMSU: Samples collected by the New Mexico Cooperative Fish and Wildlife Research Unit SWReGAP field crew. They were collected from 2001 to 2003. An example plot code is: NM070300BM06.

NM: Samples collected by the New Mexico Cooperative Fish and Wildlife Research Unit SWReGAP field crew. These data have the same source as NM above. They were collected from 2001 to 2003. An example plot code is: AZ063001BM15.

NoAZGAP: Data collected by the U.S. Geological Survey Colorado Plateau Research Station in 1997 for accuracy assessment of the first generation Arizona Gap Analysis land cover map. An example plot code is: 20997.

SoAZGAP: Identifies data from an existing database collected for accuracy assessment of the first generation Arizona Gap Analysis land cover map. Data were collected by the U.S. Geological Survey Sonoran Desert Research Station in 1997. An example plot code is: AZ080397TU02.

SUCR: Data with the identifier SUCR were collected by the U.S. Geological Survey Colorado Plateau Research Station in 1999 as part of a vegetation mapping project at Sunset Crater National Monument. An example plot code is SUCR012 or SC-025.

Terra_CPRS: These plots are from interpretation of aerial photography available on the TerraServer web site, <http://terraserver.microsoft.com/>. The U.S. Geological Survey SWReGAP team did the interpretation. An example plot code is: AZ2DQT119.

TES: Data from U.S. Forest Service (USFS) Terrestrial Ecosystem Survey plot data collected in 1994 in the Coconino National Forest. Site locations were determined by the U.S. Geological Survey SWReGAP team using plot locations inscribed on aerial photography as provided by the USFS. An example plot code is: 559.784-23(P1).

Waca: Data with the identifier Waca were collected by the U.S. Geological Survey Colorado Plateau Research Station in 1999 and 2000 as part of a vegetation mapping project at Walnut Canyon National Monument. An example plot code is: WC-006.

b) Summary of samples:

4470 samples were available to model this mapping area. A polygon coverage containing all samples is located at: AZ\ARCHIVE\AZ4\TRAIN_DATA.

Code	Ecological System	#
D04	INVASIVE SW RIPARIAN WOODLAND AND SHRUBLAND	7
S002	ROCKY MOUNTAIN ALPINE BEDROCK AND SCREE	4
S006	ROCKY MOUNTAIN CLIFF AND CANYON COMPLEX	32
S010	COLORADO PLATEAU MIXED BEDROCK CANYON AND TABLELAND	48
S020	NORTH AMERICAN WARM DESERT WASH	31
S023	ROCKY MOUNTAIN ASPEN FOREST AND WOODLAND	197
S025	ROCKY MOUNTAIN SUBALPINE-MONTANE LIMBER-BRISTLECONE PINE WOODLAND	5
S028	ROCKY MOUNTAINS SUBALPINE DRY-MESIC SPRUCE-FIR FOREST AND WOODLAND	61
S032	ROCKY MOUNTAINS MONTANE DRY-MESIC MIXED CONIFER FOREST AND WOODLAND	232
S035	MADREAN PINE-OAK FOREST AND WOODLAND	346
S036	ROCKY MOUNTAINS PONDEROSA PINE WOODLAND	1119
S039	COLORADO PLATEAU PINYON-JUNIPER WOODLAND	268
S046	ROCKY MOUNTAINS GAMBEL OAK - MIXED MONTANE SHRUBLAND	42
S051	MADREAN ENCINAL	16
S057	MOGOLLON CHAPARRAL	390
S058	MESQUITE UPLAND SCRUB	297
S062	CHIHUAHUAN MIXED DESERT AND THORN SCRUB	19
S063	SONORAN PALO VERDE-MIXED CACTI DESERT SCRUB	92
S062	CHIHUAHUAN MIXED DESERT AND THORN SCRUB	18
S069	SONORA-MOJAVE CREOSOTEBUSH-WHITE BURSAGE DESERT SCRUB	16
S075	INTER-MOUNTAIN BASINS JUNIPER SAVANNA	10
S077	CHIHUAHUAN PIEDMONT SEMI-DESERT GRASSLAND	144
S079	INTER-MOUNTAIN BASINS SEMI-DESERT SHRUB STEPPE	86
S085	SOUTHERN ROCKY MOUNTAINS MONTANE GRASSLAND	127
S090	INTER-MOUNTAIN BASINS SEMI-DESERT GRASSLAND	52
S093	ROCKY MOUNTAINS LOWER MONTANE RIPARIAN WOODLAND AND SHRUBLAND COMPLEX	39
S094	NORTH AMERICAN WARM DESERT LOWER MONTANE RIPARIAN WOODLAND AND SHRUBLAND	85
S097	NORTH AMERICAN WARM DESERT RIPARIAN WOODLAND AND SHRUBLAND	26
S098	NORTH AMERICAN WARM DESERT RIPARIAN MESQUITE BOSQUE	16
S112	MADREAN PINYON-JUNIPER WOODLAND	478

S115	MADREAN JUNIPER SAVANNA	53
S129	SONORAN MID-ELEVATION DESERT SCRUB	71
	**TOTAL	4470

c) Preparing Sample Data for Classification Tree (CT) Modeling:

The point sample data were prepared for decision tree modeling input by the following steps:

1. Create UTM point coverage of all point data with attributes (ArcInfo commands generate, dbaseinfo, additem, tables, joinitem. Note that additional fields are idnum, to accomplish the join, and N4RPTS, which is the number of random points that will be extracted from each sample polygon and is initially set to 20)
2. Project UTM points to Albers
3. Flag points that are within 30 meters of a road and increase their buffer value if they are smaller than 90m (this step is to ensure enough sample points once the roads are erased):
 - a. Identity az_pt1 az_tran_b30m az_pt2
 - b. Tables
 - c. Sel az_pt2.pat
 - d. Resel inside = 100
 - e. Resel buffer < 90 (smaller)
 - f. Resel buffer > 15 (not riparian)
 - g. Calc buffer = 90 (to get enough to sample once roads are erased)
 - h. Calc num4rpts = 40 (define more samples near roads as some will be erased to eliminate pixels on the roads)
4. Buffer the field points according to the field notes as modified by step 3. Use ArcView extension BufferThemeBuilder, choose attribute 'buffer' as the distance field.
5. Find overlapping polygons and eliminate (either re-label, if appropriate, or delete)
6. Merge all neighboring data (adjacent mapzones and states).
7. Merge with data points identified from imagery. For example, class S010 was digitized as polygons but included in the decision tree modeling by: buffering polygons by 100m (to avoid mixed pixels at edges) and assigning the number of random points to be extracted for these polygons to 5 (N4RPTS). These polygons were added after they were 'erased' by the buffered polygons of field data, so that field data took precedence.
8. Recode the character field containing the Ecosystem Code (ES_code) to a number (ES2NUM) using ArcView extension Recode.
9. Create 80% training and 20% validation polygon sets from the sample polygons. Use ArcView with featureselect extension, select 20 percent for validation set, recorded in field 'ESWH20'.
10. Create random points within each sample polygon. Use ArcView extension Random Point Generator v. 1.27, specify N4RPTS as the field with the number of points desired, convert shapefile to coverage az_rpts_all in ArcInfo.

11. Delete random points within 45m of roads. (In ArcInfo, identify the random points with the 45m road buffer coverage; in ArcEdit, delete points with INSIDE = 100).
12. Attached sample polygon attributes to the random points using Identity in ArcInfo and the azx_polys_all coverage.
13. In ArcInfo, copy the sample polygon set (azx_polys_all) twice to create azx_polys_trn and azx_polys_val. In ArcEdit, delete the polygons with ESWH20 = 1 in azx_polys_trn and delete the polygons with ESWH20 = 0 in azx_polys_val.
14. In ArcInfo, copy the sample point set (azx_rpts_all) twice to create azx_rpts_trn and azx_rpts_val. In ArcEdit, delete the polygons with ESWH20 = 1 in azx_rpts_trn and delete the polygons with ESWH20 = 0 in azx_rpts_val.
15. Convert the three random point coverages (azx_rpts_all, azx_rpts_trn and azx_rpts_val) to grids using the ES2NUM field as the grid value. Use ArcView with Spatial analysis tool, specify extent and grid cells to match the ETM+ imagery.
16. Import the grids azx_rpts_all and azx_rpts_trn into ERDAS Imagine as *.img files for Cart modeling.

3) Cover types:

a) Classification Tree modeled cover types:

COD E	DESCRIPTION
D04	INVASIVE SW RIPARIAN WOODLAND AND SHRUBLAND
S002	ROCKY MOUNTAIN ALPINE BEDROCK AND SCREE
S006	ROCKY MOUNTAIN CLIFF AND CANYON COMPLEX
S010	COLORADO PLATEAU MIXED BEDROCK CANYON AND TABLELAND
S020	NORTH AMERICAN WARM DESERT WASH
S023	ROCKY MOUNTAIN ASPEN FOREST AND WOODLAND
S025	ROCKY MOUNTAIN SUBALPINE-MONTANE LIMBER-BRISTLECONE PINE WOODLAND
S028	ROCKY MOUNTAINS SUBALPINE DRY-MESIC SPRUCE-FIR FOREST AND WOODLAND
S032	ROCKY MOUNTAINS MONTANE DRY-MESIC MIXED CONIFER FOREST AND WOODLAND
S035	MADREAN PINE-OAK FOREST AND WOODLAND
S036	ROCKY MOUNTAINS PONDEROSA PINE WOODLAND
S039	COLORADO PLATEAU PINYON-JUNIPER WOODLAND
S046	ROCKY MOUNTAINS GAMBEL OAK - MIXED MONTANE SHRUBLAND
S051	MADREAN ENCINAL
S057	MOGOLLON CHAPARRAL
S058	MESQUITE UPLAND SCRUB
S062	CHIHUAHUAN MIXED DESERT AND THORN SCRUB

S063	SONORAN PALO VERDE-MIXED CACTI DESERT SCRUB
S062	CHIHUAHUAN MIXED DESERT AND THORN SCRUB
S069	SONORA-MOJAVE CREOSOTEBUSH-WHITE BURSAGE DESERT SCRUB
S075	INTER-MOUNTAIN BASINS JUNIPER SAVANNA
S077	CHIHUAHUAN PIEDMONT SEMI-DESERT GRASSLAND
S079	INTER-MOUNTAIN BASINS SEMI-DESERT SHRUB STEPPE
S085	SOUTHERN ROCKY MOUNTAINS MONTANE GRASSLAND
S090	INTER-MOUNTAIN BASINS SEMI-DESERT GRASSLAND
S093	ROCKY MOUNTAINS LOWER MONTANE RIPARIAN WOODLAND AND SHRUBLAND COMPLEX
S094	NORTH AMERICAN WARM DESERT LOWER MONTANE RIPARIAN WOODLAND AND SHRUBLAND
S097	NORTH AMERICAN WARM DESERT RIPARIAN WOODLAND AND SHRUBLAND
S098	NORTH AMERICAN WARM DESERT RIPARIAN MESQUITE BOSQUE
S112	MADREAN PINYON-JUNIPER WOODLAND
S115	MADREAN JUNIPER SAVANNA
S129	SONORAN MID-ELEVATION DESERT SCRUB

b) Non CT modeled cover types:

The following types were included as non-modeled cover types:

Code	Ecological System Name
S002	ROCKY MOUNTAIN ALPINE BEDROCK AND SCREE
S012	INTER-MOUNTAIN BASINS ACTIVE AND STABILIZED DUNES
S013	INTER-MOUNTAIN BASINS VOLCANIC ROCK AND CINDERLAND
S015	INTER-MOUNTAIN BASINS PLAYA
N11	OPEN WATER
N21	DEVELOPED, LOW INTENSITY
N22	DEVELOPED, MED-HIGH INTENSITY
N82	AGRICULTURE, CULTIVATED CROPS
D02	RECENTLY BURNED
D03	RECENTLY MINED OR QUARRIED

S002: ROCKY MOUNTAIN ALPINE BEDROCK AND SCREE

The alpine class was extracted from the ETM+ imagery using an unsupervised classification procedure. The initial unsupervised classification used an input image stack consisting of the raw bands of the fall image. The 6 band image stack was classified into 20 clusters within an AOI using Erdas Imagine's unsupervised classification module. Alpine was identified by visually inspecting the images for uniform barren areas at the peak of the San Francisco Mountains. The classified alpine image was recoded to a binary image, clumped (allowing 4 neighbors), and eliminated (removing clusters less

than 5 pixels in size), to produce an alpine image that retains features of 1 acre MMU. For the AOI, see \AOI\alpine_aoi folder in the ARCHIVE.

S012: INTER-MOUNTAIN BASINS ACTIVE AND STABILIZED DUNES

The active and stabilized dunes class was extracted from the ETM+ imagery using an unsupervised classification procedure. The initial unsupervised classification used an input image stack consisting of the raw bands of the fall image. The AOI was selected for identifying dunes based on field knowledge and DeLorme atlas mapping. The 6 band image stack was classified into 20 clusters using Erdas Imagine's unsupervised classification module. Dunes were identified by visually inspecting the images for bright areas known to contain dunes. The classified dunes image was recoded to a binary image and then filtered, applying a 5x5 majority filter three times, to reduce speckle and produce an image of contiguous dune fields. For AOIs, see \AOI\dune_aoi folder in the ARCHIVE.

S013: INTER-MOUNTAIN BASINS VOLCANIC ROCK AND CINDERLAND

The volcanic rock and cinder land class was extracted from the ETM+ imagery using an unsupervised classification procedure. The unsupervised classification used an input image stack consisting of the 6 non-thermal raw bands of the summer image. Several distinct AOIs were selected for identifying volcanics based on field knowledge and inspection of the imagery. Volcanics were identified by visually inspecting the images for dark areas known to contain volcanics, commonly with distinctive crater or flow textures. Areas thought to contain volcanics based on inspection of the imagery were confirmed by referring to the Roadside Geology of Arizona (Chronic 1983) and/or the Delorme Atlas. The 6 band image stack was classified into 20 or 30 clusters using ERDAS Imagine's unsupervised classification module. The classified volcanics image was recoded to a binary image, clumped (allowing 4 neighbors), and eliminated (removing clusters less than 5 pixels in size), to produce a volcanics image that retains only features of 1 acre MMU. For AOIs, see AZ\ARCHIVE\AOI\LAVA_AOI folder in the ARCHIVE.

S015: INTER-MOUNTAIN BASINS PLAYA

This class was captured in two ways: screen digitizing over the ETM+ imagery and unsupervised classification of the ETM+ imagery within local AOIs. Some playas were identified on the fall ETM+ imagery and screen digitized over ETM+ imagery at a scale of 1:24,000 or larger. Other playas were identified on the imagery as distinct, closed, highly reflective patches in topographic lows and verified in the DeLorme Atlas. AOIs were created around these features and an unsupervised classification of the 6 raw bands of the fall image was performed. The classification specified 20 clusters, which were labeled as a binary playa image based on inspection of the image. For AOIs, see \AOI\playa_aoi folder in the ARCHIVE.

N11: OPEN WATER

The majority of the open water class was extracted from the ETM+ imagery using a nested unsupervised classification procedure. The initial unsupervised classification used an input image stack consisting of the following 13 images:

- 12 pca bands resulting from a PCA analysis of the 12 band stack of the fall image and the summer image. This pca was calculated to enhance the seasonal differences between the two dates.
- Slope image, derived from the 30 meter DEM.

The 13 image stack was classified into 40 clusters using ERDAS Imagine's unsupervised classification module. Water was identified by visually inspecting the images for open water visible in either season. Several of the original 40 clusters were isolated and re-classified into 20 clusters. The classified water image was recoded to a binary image, clumped (allowing 8 neighbors), and eliminated (removing clusters less than 5 pixels in size), to produce a water image that retains only water bodies of 1 acre MMU. The image was converted to a grid and the grid was converted to a polygon coverage.

The polygons extracted from the imagery were then given to a field mapper, who labeled or deleted polygons by comparing them to information in the DeLorme Atlas (1993) and ancillary data sources. Areas where the image classification incorrectly identified pixels as water (e.g., areas of shadow) were captured via screen digitizing as a polygon coverage that was used to erase the water coverage. Additional areas of open water visible in either the fall or summer image (but missed by the nested unsupervised classification) were screen digitized over ETM+ imagery at a scale of 1:24,000 or larger using ArcMap.

N21: DEVELOPED, LOW INTENSITY

N22: DEVELOPED, MED-HIGH INTENSITY

The urban areas were identified on ETM+ imagery and screen digitized at a scale of 1:50,000 or larger (1:24,000) using ArcMAP. Urban areas were recognized by their distinctive rectilinear patterns of intersecting road networks and variable patterns of spectral brightness, including extremely bright visible reflectance associated with roofing materials and concrete. Fall, spring and summer images were variously used. When the image pattern was questionable, urban areas were verified by referring to ancillary data, including the DeLorme Atlas (1993) and the ALRIS urban area coverage (based on census tract data). The shapefile created using the fall image was then overlain on the spring and summer images and additional urban areas visible on these images were captured. Two classes of urban areas were recognized: N21 (open space - low intensity developed) and N22 (medium - high intensity developed). These were differentiated on the basis of the density of 'green space' included, i.e. yards, parks, golf courses, etc.

N82: AGRICULTURE, CULTIVATED CROPS

The agricultural areas were identified on ETM+ imagery and screen digitized at a scale of 1:50,000 or larger (1:24,000) using ArcMAP. Typically, agricultural fields were easily recognized by their rectangular geometries and distinctive patterns of uniform spectral

brightness, including extremely bright near-infrared reflectances found in at least one of the seasonal images. Fall, spring and summer images were variously used. When the image pattern was questionable, agricultural areas were verified by referring to ancillary data, including the DeLorme Atlas (1993).

D02: RECENTLY BURNED

Recently burned areas were identified on ETM+ imagery as dark patches, typically angular, commonly bordered by roads. These were captured by: defining an AOI around each burn identified in each season, performing an unsupervised classification within the AOI specifying 20 clusters, and recoding the clusters corresponding to the burned area. For AOIs, see AZ\ARCHIVE\AZ4\AOI\FIRE_AOI folder in the ARCHIVE.

D03: RECENTLY MINED OR QUARRIED

Recently mined areas were identified on the fall ETM+ imagery and screen digitized over ETM+ imagery at a scale of 1:24,000 or larger. The image was overlaid with locations of surface mining activities extracted from the USGS Minerals point coverage found at: <http://mrddata.usgs.gov/>. Areas of apparent disturbance (anomalous reflectance on the image) that were collocated with known surface mining activity were identified and digitized as land cover type D01. A few larger mined areas were digitized with the Urban Areas and extracted from that shapefile to include in this coverage.

The following cover types were modeled with a post-classification model (see section 5c for details):

Code	Ecological System Name
S030	ROCKY MOUNTAINS SUBALPINE MESIC SPRUCE-FIR FOREST AND WOODLAND
S034	ROCKY MOUNTAINS MONTANE MESIC MIXED CONIFER FOREST AND WOODLAND

4) Summary of predictor layers used:

a) Multi band predictors:

Multi band predictors:

- AZ3_fa.img (ETM bands 1-5 & 7 for fall)
- AZ3_sp.img (ETM bands 1-5 & 7 for spring)
- AZ3_su.img (ETM bands 1-5 & 7 for summer)

All multi-band predictors can be found at: AZ\ARCHIVE\AZ4\IMG_FILES

b) Single band predictors:

- aspect_9cls_az4.img Categorical 9 class aspect
- elev.img Continuous (integer) elevation

fabrt.img	Fall brightness band
fagrn.img	Fall greenness band
spbrt.img	Spring brightness band
spgrn.img	Spring greenness band
subrt.img	Summer brightness band
sugrn.img	Summer greenness band
landf.img	Categorical 10 class landform (modeled from DEM)

All multi-band predictors can be found at: AZ\ARCHIVE\AZ4\IMG_FILES

5) Modeling Methods:

AZ4 was modeled using special methods referred to as “LifeZone Mapping”. It was recognized early in the mapping process that the AZ4 functional unit contained a rather large ecotone area. This ecotone, or transition zone, represents the joining of two distinctly different ecological areas. In this area, several hundred meters of elevation separates the Mogollon Rim, otherwise referred to as the Apache Highlands and the northern most extent of the Sonoran Desert. Species composition, presence and distribution can be quite different within these two areas. Further, regional NVCS ecological system regional names change within this mapping unit. All of the above factors, when combined, output a messy and ecoregional confused land cover output. This confusion can be credited for the development of the LifeZone mapping strategy.

A LifeZone Arc Info Coverage base map was created by stratifying an elevation grid to identify three classes within the ecotone (see AZ\ARCHIVE\TRAIN-DATA\LIFEZONE_MASK). The three stratified classes follow:

Elev_m = 2000; all cells with elevation > 2000 meters: definitely on the rim

Elev_m = 1900; all cells with elevation > 1900, <= 2000 meters: probably on the rim

Elev_m = 1800; all cells with elevation > 1800, <= 1900 meters: maybe on the rim, especially as you head NW

This three class base map was then converted into two masking images for use the final CT Classifier modeling process. The mask image maps can be found at AZ\ARCHIVE\TRAIN_DATA\LIFEZONE_MASK. The mask images were created based on the Elev_m = 1900 elevation break.

The LifeZone mask strategy examined training data collected in the field by Arizona crew overtop of the mask images. The examination looked for trends in regional occurrence. Occurrence data was analyzed to determine where training data was located in comparison to the LifeZone masks. It was determined that AZ4 functional unit had three areas that would be used for training data LifeZone categories. The categories were

Mogollon, Sonoran and Transition. Mogollon LifeZone types reside at least 80% of the time on the up elevation Mogollon Rim. Sonoran LifeZone types reside at least 80% of the time on the lower desert basins of the Sonoran Desert. The Transition LifeZone was created to account for the types that occur in the majority of the time in both zones and represents the transition between the two zones. The distributions of LifeZone classes by cover type follow:

VALUE	CODE	DESCRIPTION	LIFEZONE
2	S002	ROCKY MOUNTAIN ALPINE BEDROCK AND SCREE	Mogollon
6	S006	ROCKY MOUNTAIN CLIFF AND CANYON COMPLEX	Mogollon
10	S010	COLORADO PLATEAU MIXED BEDROCK CANYON AND TABLELAND	Transition
20	S020	NORTH AMERICAN WARM DESERT WASH	Sonoran
23	S023	ROCKY MOUNTAIN ASPEN FOREST AND WOODLAND	Mogollon
25	S025	ROCKY MOUNTAIN SUBALPINE-MONTANE LIMBER-BRISTLECONE PINE WOODLAND	Mogollon
28	S028	ROCKY MOUNTAINS SUBALPINE DRY-MESIC SPRUCE-FIR FOREST AND WOODLAND	Mogollon
30	S030	ROCKY MOUNTAINS SUBALPINE MESIC SPRUCE-FIR FOREST AND WOODLAND	Mogollon
32	S032	ROCKY MOUNTAINS MONTANE DRY-MESIC MIXED CONIFER FOREST AND WOODLAND	Mogollon
34	S034	ROCKY MOUNTAINS MONTANE MESIC MIXED CONIFER FOREST AND WOODLAND	Mogollon
35	S035	MADREAN PINE-OAK FOREST AND WOODLAND	Transition
36	S036	ROCKY MOUNTAINS PONDEROSA PINE WOODLAND	Transition
39	S039	COLORADO PLATEAU PINYON-JUNIPER WOODLAND	Mogollon
46	S046	ROCKY MOUNTAINS GAMBEL OAK - MIXED MONTANE SHRUBLAND	Mogollon
51	S051	MADREAN ENCINAL	Sonoran
57	S057	MOGOLLON CHAPARRAL	Transition
58	S058	MESQUITE UPLAND SCRUB	Sonoran
62	S062	CHIHUAHUAN MIXED DESERT AND THORN SCRUB	Sonoran
62	S062	CHIHUAHUAN MIXED DESERT AND THORN SCRUB	Sonoran
63	S063	SONORAN PALO VERDE-MIXED CACTI DESERT SCRUB	Sonoran
69	S069	SONORA-MOJAVE CREOSOTEBUSH-WHITE BURSAGE DESERT SCRUB	Sonoran
75	S075	INTER-MOUNTAIN BASINS JUNIPER SAVANNA	Mogollon

77	S077	CHIHUAHUAN PIEDMONT SEMI-DESERT GRASSLAND	Sonoran
79	S079	INTER-MOUNTAIN BASINS SEMI-DESERT SHRUB STEPPE	Mogollon
85	S085	SOUTHERN ROCKY MOUNTAINS MONTANE GRASSLAND	Mogollon
90	S090	INTER-MOUNTAIN BASINS SEMI-DESERT GRASSLAND	Mogollon
93	S093	ROCKY MOUNTAINS LOWER MONTANE RIPARIAN WOODLAND AND SHRUBLAND COMPLEX	Mogollon
94	S094	NORTH AMERICAN WARM DESERT LOWER MONTANE RIPARIAN WOODLAND AND SHRUBLAND	Sonoran
97	S097	NORTH AMERICAN WARM DESERT RIPARIAN WOODLAND AND SHRUBLAND	Sonoran
98	S098	NORTH AMERICAN WARM DESERT RIPARIAN MESQUITE BOSQUE	Sonoran
112	S112	MADREAN PINYON-JUNIPER WOODLAND	Transition
115	S115	MADREAN JUNIPER SAVANNA	Sonoran
129	S129	SONORAN MID-ELEVATION DESERT SCRUB	Sonoran
304	D04	INVASIVE SW RIPARIAN WOODLAND AND SHRUBLAND	Transition

a) See5 Classification Tree modeling:

Samples: 20% of the all sample polygons were withheld for validation. With the remaining 80%, 20 sub-samples were randomly selected for each sample polygon. This was done by first randomly generating points within each polygon and then converting the points to a raster *.img file. Pixels in the *.img (each to be considered a separate observation for the See5 classifier) were ‘drilled’ through predictor layers using the Sampling tool from CART Module for Imagine (EarthSatellite Corp. 2003), producing two important files for See5: the *.names and *.data files.

See5 Classification Tree: See5 (Release 1.8) data mining software (Rulequest 2004) was used for generating classification trees. Boosting was employed using 15 trials.

The See5 files are located: AZ\ARCHIVE\AZ4\OUTPUT\ . The following briefly describes these files (Rulequest 2004).

*.names file: Identifies the dependent variable *.img file and the predictor *.img files created from the CART Module Sampling tool. Required by See5 software.

*.data file: Contains the training cases from which See5 extracts rules. This is also produced from the CART Module Sampling tool, by ‘drilling’ the dependent variable pixels through the specified predictor images. Required by See5 Software.

*.test file: Produced from the CART Module Sampling tool, but not used by SWReGAP. This file, if populated, would contain a separate 'test' set of cases to evaluate the rules generated from See5. The SWReGAP mapping procedures did not populate this file, and it was not used.

*.names.hst file: Produced from the CART Module Sampling tool. Details the distribution of samples available within the dependent input, and those output to the *.data and *.test file. Not required by See5, but produced by CART Module Sampling tool.

*.set file: Produced from See5 software. This file contains the settings for the classification tree run. For example the third value '15' indicates the number of boosts used for boosting.

*.tree file: Produced from the See5 software. This file contains the classification tree in 'tree' format. This along with the *.data and *.names file are required by the CART Module Classifier tool to spatially apply the tree.

*.out file: Output file generated by See5 and displayed when See5 classification tree model has run. This file provides a visual representation of the classification tree that is somewhat easier to interpret than the *.tree file.

As a result of spatially applying the classification tree using the CART Module's Classifier tool, two files are created: an *.img file, which is the spatial application of the tree's rules, and the *_error.img file which is spatial depiction of confidence in the rules generated by the tree and displayed pixel by pixel.

b) Post-classification, recoding and other modeling steps:

The post-classification model described below was created to assist in differentiating between ecological system cover types that possess similar characteristics. In these cases species composition, species presents and/or ecoregional location was not enough to distinguish between the two types especially when the types share similar physiognomic and hydrologic characteristics. The following model is a tool for discriminating between these ecological system cover types.

The .gmd file used for this post-classification model is:
AZ\ARCHIVE\AZ4\POST_MODEL\swgap_az4.gmd

Step 1: Removing summer clouds from the CT output image. A post-classification model was used to remove summer clouds.

The presence of clouds required using TM images from different seasons to remove the effected areas and "burn in" the correct cover type. Clouds were captured by visually

inspecting three seasons of TM imagery (spring, summer and fall). Summer was identified as the imagery that contained the problem areas. Clouds were captured using an area of interest (.aoi). A cloud binary mask image file was generated by subsetting to the identified areas of interest (see *AZ\ARCHIVE\AZ4\POST_MODEL\POST_MODEL_IMAGES\ cld_mask_sum.img*). The training data was then modeled using standard CT modeling methods while excluding the seasonal imagery that contained clouds. In this case the summer season was withheld. The output is located at *AZ\ARCHIVE\AZ4\POST_MODEL\POST_MODEL_IMAGES\ az4all_m7j2_m_nosum.img*

A condition statement was then created to extract the cloud influenced vegetation pixels from the original CT output model (see *AZ\ARCHIVE\AZ4\POST_MODEL\POST_MODEL_IMAGES\ az4all_m7j2_rec.img*) containing all season and replaced them with non-cloud influenced pixels (see *AZ\ARCHIVE\AZ4\POST_MODEL\POST_MODEL_IMAGES\ az4all_m7j2_m_nospr_rec.img*).

The conditional statement is:

```
EITHER $n44_az4all_m7j2_nosum_rec IF ($n52_cld_mask_sum== 1) OR  
$n43_az4all_m7j2_rec OTHERWISE
```

Where:

\$n44_az4all_m7j2_nosum_rec	AZ4 CT output image containing no spring brightness, spring greenness or spring raw TM imagery as independent variables. Recoded to standard integer code.
\$n52_cld_mask_sum	Binary cloud mask image 1 = clouds 0 = all other areas
\$n43_az4all_m7j2_rec	AZ4 standard CT output image. Recoded to standard integer code.

Step 2: Discriminating Mesic Conifer from Non-Mesic Conifer Forests Types.

The Southwest Regional GAP-National Vegetation Classification Standard (NVCS) legend has divided Rocky Mountain montane and subalpine forest types into two distinct classes; mesic forest types and dry-mesic forest types (Comer et. al 2003). It was determined early in the modeling process that these types are difficult to discriminate using standard CT modeling methods alone due to composition similarities. As a result, it was decided that these types would be post modeled based strictly on conceptual meaning rather than spectral and ancillary differences. The logic and parameters for the model follows:

A post-classification model was used to discriminate *S032 ROCKY MOUNTAINS MONTANE DRY-MESIC MIXED CONIFER FOREST AND WOODLAND* and *S034 ROCKY MOUNTAINS MONTANE MESIC MIXED CONIFER FOREST AND WOODLAND*. This post-classification model was designed to extract *S034 ROCKY MOUNTAINS MONTANE MESIC MIXED CONIFER FOREST AND WOODLAND* from the standard CT modeled *S032 ROCKY MOUNTAINS MONTANE DRY-MESIC MIXED CONIFER FOREST AND WOODLAND* ecological system cover type. NatureServe NVCS describes this system as “occurring predominantly in cool ravines and on north-facing slopes. Elevations range from 1200 to 3300 m. Occurrences of this system are found on cooler and more mesic sites than the Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland. Such sites include lower and middle slopes of ravines, along stream terraces, moist, concave topographic positions and north and east-facing slopes which burn somewhat infrequently.”

Model methods: A conditional statement was created to extract *S034 ROCKY MOUNTAINS MONTANE MESIC MIXED CONIFER FOREST AND WOODLAND* using the above aspect and landform characteristics in order to identify this montane mesic mixed conifer system.

The conditional statement is:

EITHER 34 IF ((\$n3_landf==2 OR \$n3_landf==5 OR \$n3_landf==6 OR \$n3_landf==9) AND (\$n4_asp_az3_9cls==1 OR \$n4_asp_az3_9cls==2 OR \$n4_asp_az3_9cls==0) AND (\$n2_az3_allwr_mod2_rec==32)) OR \$n2_az3_allwr_mod2_rec OTHERWISE

Where:

34 *S034 ROCKY MOUNTAINS MONTANE MESIC MIXED CONIFER FOREST AND WOODLAND*

32 *S032 ROCKY MOUNTAINS MONTANE DRY-MESIC MIXED CONIFER FOREST AND WOODLAND*

\$n3_landf 10 class landform grid
 2= toe slopes, bottoms, and swales
 5= very moist steep slopes
 6= moderately moist steep slopes
 9= cool aspect scarps, cliffs, canyons

\$n4_aspaz2 Nine class aspect image
 1=North facing slope
 2=Northeast facing slope
 0=slope less than 3 degrees

\$n2_az3_allwr_mod2_rec

AZ3 standard CT output image. Recoded to standard integer code.

c) Generalizing to MMU and map completion:

After the spatial application of the CT model to create an *.img file, and post classification steps were taken, the map was generalized using ERDAS Imagine 8.6 GIS Analysis, Clump tool using 4 connected neighbors (rooks move), and then using Eliminate with a setting of a minimum of 1 acre.

After the Clump & Eliminate step, the non CT modeled classes were ‘burned in’ to the final map using an overlay function. The final map can be found at:
\\AZ\ARCHIVE\AZ3\FINAL_MAP\.

After CT model validation, a final map was generated using the methods described in section 5a this time using 100% of the sample data. Similarly to the steps involved with the 80% CT model, post-classification modeling, inclusion of the non-modeled cover types, and generalization to the MMU were completed to create **az3_final.img**, which can be found at \\AZ\ARCHIVE\AZ3\FINAL_MAP.

6) Validation:

a) CT model validation: 20% of sample polygons were randomly selected and withheld from CT modeling using the featureselect.avx as reference data. The CT model was run as described in section 5a using the remaining 80% of the samples. The 20% withheld samples were used to assess the predictive capability of the CT modeled map using the 80% training data. The CT-modeled classes were assessed using kappa.avx, which works by intersecting the validation sample polygons through the CT modeled land cover map, and considers the site correctly mapped when the majority of pixels within the sample polygon agree with the sample label. Output from kappa.avx consists of a *.txt, *.dbf and *.shp file. The *.txt file presents the kappa statistic, the *.dbf file is an error matrix indicating errors of commission and omission and the *.shp file indicates for each reference sample site whether the sample location was considered correctly mapped, or incorrectly mapped and what it was mapped as. These files can be found at:
\\AZ\ARCHIVE\AZ3\VALIDATION\.

b) Discussion of mapped cover types:

The following narrative provides qualitative assessments by the mapping team for each cover type mapped in this mapping area. It is intended to elaborate on the quantitative results of the CT model validation from the perspective of those most familiar with the map and the mapping process and is hoped to be of value to potential map users. User's accuracy indicates how well the model predicts a withheld sample point; producer's accuracy indicates how well a withheld sample was predicted by the model. When

quantitatively evaluated, the error tendency can be described as confusion between types indicated by the producer's accuracy and the tendency of the mapped types to actually represent some other type as indicated by the user's error. Accuracy of 65% of above indicates good model performance. It is important to note that this is not a complete accuracy assessment of map performance, but is rather a preliminary measure of map performance. Also, the total number of withheld samples may differ from the total number of samples reported in 2b above. Overlapping training sites create duplicate ID fields and replicates site information; these training sites were ignored in the validation totals.

D02: RECENTLY BURNED. Not quantitatively assessed. Qualitative assessment indicates that many recently burned areas contemporary with the date of the imagery are included. Recently burned areas were identified on ETM+ imagery as dark patches, typically angular, commonly bordered by roads. Burned areas, however, can be confused with recently logged and regenerating areas or shadows. Since the date of the imagery some substantial fires have occurred. The perimeters of these recent fires may be obtained through Geomac (geomac.usgs.gov) at <ftp://ftp.geomac.gov/outgoing>.

D03; RECENTLY MINE OR QUARRIED. Not quantitatively assessed. Qualitative assessment indicates that most recently mined or quarried areas contemporary with the date of the imagery are included.

D04: INVASIVE SOUTHWEST RIPARIAN WOODLAND AND SHRUBLAND. Quantitatively assessed, validation 100% (users) and 50% (producers) based on 2 independent validation samples. This type was confused with SO94 NORTH AMERICA WARM DESERT LOWER MONTANE RIPARIAN (1 of 2). Confusion can be explained by the similar vegetation structure and habitat of the two ecological systems. However, there are too few independent validation samples to adequately assess the modeling of D04.

N11: OPEN WATER Not quantitatively assessed. Qualitative assessment indicates that most perennial open water mapped well. Ephemeral water bodies were not a focus of the effort and may be missing.

N21: DEVELOPED, LOW INTENSITY. Not quantitatively assessed. Some of this class may have been excluded due to the difficult nature of detecting low intensity development.

N22: DEVELOPED, MED-HIGH INTENSITY. Not quantitatively assessed. Qualitative assessment indicates that most medium and high density developed areas contemporary with the date of the imagery are included.

N82: AGRICULTURE, CULTIVATED CROPS. Not quantitatively assessed. Qualitative assessment indicates that most agricultural areas contemporary with the date of the imagery are included; however, distinction between cultivated crops and pasturelands may not be consistent.

S002: ROCKY MOUNTAIN ALPINE BEDROCK AND SCREE. Not quantitatively assessed.

S006: ROCKY MOUNTAIN CLIFF AND CANYON. Quantitatively assessed, validation 100% (users) and 38% (producers) based on 8 independent validation samples. This type was confused with S028 ROCKY MOUNTAIN SUBALPINE DRY-MESIC SPRUCE-FIR FOREST (1 of 8), S036 ROCKY MOUNTAIN PONDEROSA PINE WOODLAND (2 of 8), and S085 SOUTHERN ROCKY MOUNTAIN MONTANE GRASSLAND (2 of 8). This type may occur interspersed within each of S028, S036 and S085; however, its spectral signal and the plant composition are different.

S010: COLORADO PLATEAU MIXED BEDROCK CANYON AND TABLELAND. Quantitatively assessed, validation 92% (users) and 100% (producers) based on 12 independent validation samples. This type is well modeled.

S012: INTER-MOUNTAIN BASINS ACTIVE AND STABILIZED DUNES. Not quantitatively assessed. The occurrence of this type is assumed to be a typographic error and should be labeled S102.

S013: INTER-MOUNTAIN BASINS VOLCANIC ROCK AND CINDERLAND. Not quantitatively assessed.

S015: INTER-MOUNTAIN BASINS PLAYA. Not quantitatively assessed.

S020: NORTH AMERICAN WARM DESERT WASH. Quantitatively assessed, validation 0% (users) and 0% (producers) based on 8 independent validation samples. This type was confused with SO57 MOGOLLON CHAPARRAL (2 of 8), SO63 SONORAN PALOVERDE-MIXED CACTI DESERT SCRUB (1 of 8), SO77 CHIHUAHUAN PIEDMONT SEMI-DESERT GRASSLAND (1 of 8), S112 MADREAN PINYON-JUNIPER WOODLAND (2 of 8), and S129 SONORAN MID-ELEVATION DESERT SCRUB (2 of 8). This ecological system is not well represented within this functional unit and has not been adequately modeled. Occurrences usually occur in narrow linear features.

S023: ROCKY MOUNTAIN ASPEN FOREST AND WOODLAND. Quantitatively assessed, validation 88% (users) and 86% (producers) based on 50 independent validation samples. This type was confused with SO32 ROCKY MOUNTAIN MONTANE DRY-MESIC MIXED CONIFER FOREST (2 of 8), SO36 ROCKY MOUNTAIN PONDEROSA PINE WOODLAND (3 of 8), and SO85 SOUTHERN ROCKY MOUNTAIN MONTANE GRASSLAND (2 of 8). S023 can intergrade or occur adjacent to S032, S036 or S085. It does appear to be adequately modeled.

S025: ROCKY MOUNTAIN SUBALPLINE-MONTANE LIMBER BRISTLECONE. Quantitatively assessed, validation 0% (users) and 0% (producers) based on 2 independent validation samples. This type was confused with SO28 ROCKY

MOUNTAIN SUBALPINE DRY-MESIC SPRUCE-FIR FOREST (2 of 2). These two ecological systems can occur adjacent to each other.

S028: ROCKY MOUNTAINS SUBALPINE DRY-MESIC SPRUCE-FIR FOREST AND WOODLAND. Quantitatively assessed, validation 67% (users) and 38% (producers) based on 16 independent validation samples. This type was confused with SO23 ROCKY MOUNTAIN ASPEN FOREST AND WOODLAND (2 of 16), SO32 ROCKY MOUNTAIN MONTANE DRY-MESIC MIXED CONIFER FOREST (5 of 16), SO36 ROCKY MOUNTAIN PONDEROSA PINE WOODLAND (2 of 16), and SO85 SOUTHERN ROCKY MOUNTAIN MONTANE GRASSLAND (1 of 16). S028 can intergrade with or be adjacent to each of the ecological systems with which has been confused. It is similar in structure with S032 and S036.

S030: ROCKY MOUNTAINS SUBAPLINE MESIC SPRUCE-FIR FOREST AN WOODLAND. Not quantitatively assessed. This cover type was mapped using a post processing modeler. Please reference methods section entitled *Post-classification, recoding and other modeling* section 5b for a detailed explanation

S032: ROCKY MOUNTAINS MONTANE DRY-MESIC MIXED CONIFER FOREST AND WOODLAND. Quantitatively assessed, validation 62% (users) and 31% (producers) based on 59 independent validation samples. This type was confused with SO23 ROCKY MOUNTAIN ASPEN FOREST AND WOODLAND (4 of 59), SO36 ROCKY MOUNTAIN PONDEROSA PINE WOODLAND (34 of 59), SO35 MADREAN PINE-OAK FOREST AND WOODLAND (1 of 59), SO39 COLORADO PLATEAU PINYON-JUNIPER WOODLAND (1 of 59), and SO85 SOUTHERN ROCKY MOUNTAIN MONTANE GRASSLAND (1 of 59). This ecological system is similar in structure with S036 and to a lesser extent S039. It can intergrade with S023 and S085.

S034. ROCKY MOUNTAINS MONTANE MESIC MIXED CONIFER FOREST AND WOODLAND. Not quantitatively assessed. This cover type was mapped using a post processing modeler. Please reference methods section entitled *Post-classification, recoding and other modeling* section 5b for a detailed explanation

S035: MADREAN PINE-OAK FOREST AND WOODLAND. Quantitatively assessed, validation 22% (users) and 42% (producers) based on 86 independent validation samples. This type was confused with SO36 ROCKY MOUNTAIN PONDEROSA PINE WOODLAND (15 of 86), SO57 MOGOLLON CHAPARRAL (15 of 86), SO77 CHIHUAHUAN PIEDMONT SEMI-DESERT GRASSLAND (2 of 86), and S112 MADREAN PINYON-JUNIPER WOODLAND (16 of 86). This type can intergrade with all of these ecological systems and shares floristic components with S036 and S112.

S036: ROCKY MOUNTAINS PONDEROSA PINE WOODLAND. Quantitatively assessed, validation 71% (users) and 90% (producers) based on 280 independent validation samples. This type was confused with SO32 ROCKY MOUNTAIN MONTANE DRY-MESIC MIXED CONIFER FOREST (3 of 280), SO35 MADREAN

PINE-OAK FOREST AND WOODLAND (11 of 280), SO39 COLORADO PLATEAU PINYON-JUNIPER WOODLAND (5 of 280), SO57 MOGOLLON CHAPARRAL (1 of 280), SO63 SONORAN PALOVERDE-MIXED CACTI DESERT SCRUB (1 of 280), and S112 MADREAN PINYON-JUNIPER WOODLAND (6 of 280). Regardless this type has been well modeled.

S039: COLORADO PLATEAU PINYON-JUNIPER WOODLAND. Quantitatively assessed, validation 64% (users) and 53% (producers) based on 68 independent validation samples. This type was confused with SO35 MADREAN PINE-OAK FOREST AND WOODLAND (4 of 68), SO36 ROCKY MOUNTAINS PONDEROSA PINE WOODLAND (14 of 68), SO85 SOUTHERN ROCKY MOUNTAIN MONTANE GRASSLAND (1 of 68), and S112 MADREAN PINYON-JUNIPER WOODLAND (8 of 68). S039 can intergrade with each of these ecological systems. Structurally it is similar to S112.

S046: ROCKY MOUNTAINS GAMBEL OAK-MIXED MONTANE SHRUBLAND. Quantitatively assessed, validation 0% (users) and 0% (producers) based on 11 independent validation samples. This type was confused with SO35 MADREAN PINE-OAK FOREST AND WOODLAND (1 of 11), SO36 ROCKY MOUNTAINS PONDEROSA PINE WOODLAND (8 of 11), SO57 MOGOLLON CHAPARRAL (1 of 11), and SO58 CHIHUAHUAN MESQUITE UPLAND SCRUB (1 of 11). This type does not model well.

S051: MADREAN ENCINAL. Quantitatively assessed, validation 100% (users) and 20% (producers) based on 5 independent validation samples. This type was confused with SO57 MOGOLLON CHAPARRAL (2 of 5) and S112 MADREAN PINYON-JUNIPER WOODLAND (2 of 5). S051 can occur adjacent to S057 and S112.

S057: MOGOLLON CHAPARRAL. Quantitatively assessed, validation 51% (users) and 54% (producers) based on 98 independent validation samples. This type was confused with SO35 MADREAN PINE-OAK FOREST AND WOODLAND (11 of 98), SO36 ROCKY MOUNTAINS PONDEROSA PINE WOODLAND (2 of 98), SO58 CHIHUAHUAN MESQUITE UPLAND SCRUB (17 of 98), SO77 CHIHUAHUAN PIEDMONT SEMI-DESERT GRASSLAND (1 of 98), SO79 INTER-MOUNTAIN BASINS SEMI-DESERT SHRUB STEPPE (1 of 98), and S112 MADREAN PINYON-JUNIPER WOODLAND (12 of 98). S057 can intergrade or occur adjacent to each of the ecological systems with which it was confused.

S058: CHIHUAHUAN MESQUITE UPLAND SCRUB. Quantitatively assessed, validation 40% (users) and 59% (producers) based on 75 independent validation samples. This type was confused with SO57 MOGOLLON CHAPARRAL (10 of 75), SO61 CHIHUAHUAN SUCCULENT DESERT SCRUB (2 of 75), SO63 SONORAN PALOVERDE-MIXED CACTI DESERT SCRUB (3 of 75), SO62 CHIHUAHUAN MIXED DESERT AND THORN SCRUB (1 of 75), SO77 CHIHUAHUAN PIEDMONT SEMI-DESERT GRASSLAND (3 of 75), SO97 NORTH AMERICAN WARM DESERT RIPARIAN WOODLAND AND SHRUBLAND (1 of 75), S112 MADREAN

PINYON-JUNIPER WOODLAND (9 of 75), and S129 SONORAN MID-ELEVATION DESERT SCRUB (2 of 75). It is being confused with ecological systems with similar lifeform that also occur in the Mogollon Rim - warm desert transition area (S057, S061, S063, S062 and S129) or with ecological systems with which it intergrades (S077 and S112). Confusion with S097 probably reflects misplacement of training data.

S061: CHIHUAHUAN SUCCULENT DESERT SCRUB. Quantitatively assessed, validation 0% (users) and 0% (producers) based on 5 independent validation samples. This type was confused with SO58 CHIHUAHUAN MESQUITE UPLAND SCRUB (2 of 5), SO77 CHIHUAHUAN PIEDMONT SEMI-DESERT GRASSLAND (1 of 5), and S112 MADREAN PINYON-JUNIPER WOODLAND (2 of 5). This ecological system is being confused with other systems in the Chihuahuan desert habitat. It is not well modeled.

S062: CHIHUAHUAN MIXED DESERT AND THORN SCRUB. Quantitatively assessed, validation 33% (users) and 20% (producers) based on 5 independent validation samples. This type was confused with SO35 MADREAN PINE-OAK FOREST AND WOODLAND (1 of 5), SO58 CHIHUAHUAN MESQUITE UPLAND SCRUB, and SO77 CHIHUAHUAN PIEDMONT SEMI-DESERT GRASSLAND (1 of 5). This ecological system is being confused with other systems in the Chihuahuan desert habitat. It is not well modeled.

S063: SONORAN PALOVERDE-MIXED CACTI DESERT SCRUB. Quantitatively assessed, validation 56% (users) and 61% (producers) based on 23 independent validation samples. This type was confused with SO58 CHIHUAHUAN MESQUITE UPLAND SCRUB (8 of 23), SO77 CHIHUAHUAN PIEDMONT SEMI-DESERT GRASSLAND (1 of 23). This ecological system is confused with other scrub systems in similar habitat and, to some extent, with S077 with which it can intergrade.

S069: SONORA-MOJAVE CREOSTOEBUSH-WHITE BURSAGE DESERT SCRUB. Quantitatively assessed, validation 0% (users) and 0% (producers) based on 4 independent validation samples. This type was confused with SO58 CHIHUAHUAN MESQUITE UPLAND SCRUB (3 of 4) and SO63 SONORAN PALOVERDE-MIXED CACTI DESERT SCRUB (1 of 4). This ecological system is being confused with two other scrub types with which it intergrades in this region. It is not well modeled.

S075: INTER-MOUNTAIN BASINS JUNIPER SAVANNA. Quantitatively assessed, validation 0% (users) and 0% (producers) based on 3 independent validation samples. This type was confused with SO36 ROCKY MOUNTAIN PONDEROSA PINE WOODLAND (1 of 3) and SO39 COLORADO PLATEAU PINYON-JUNIPER WOODLAND (2 of 3). This ecological system is being confused with two other conifer types with which it intergrades. It is not well modeled.

S077: CHIHUAHUAN PIEDMONT SEMI-DESERT GRASSLAND. Quantitatively assessed, validation 46% (users) and 50% (producers) based on 36 independent validation samples. This type was confused with SO58 CHIHUAHUAN MESQUITE UPLAND

SCRUB (4 of 36), SO61 CHIHUAHUAN SUCCULENT DESERT SCRUB (1 of 36), SO62 CHIHUAHUAN MIXED DESERT AND THORN SCRUB (1 of 36), SO75 INTER-MOUNTAIN BASINS JUNIPER SAVANNA (1 of 36), S112 MADREAN PINYON-JUNIPER WOODLAND (9 of 36), and S115 MADREAN JUNIPER SAVANNA (2 of 36). This ecological system is being confused with a number of ecological systems with which it intergrades.

S079: INTER-MOUNTAIN BASINS SEMI-DESERT SHRUB STEPPE. Quantitatively assessed, validation 53% (users) and 36% (producers) based on 22 independent validation samples. This type was confused with SO36 ROCKY MOUNTAIN PONDEROSA PINE WOODLAND (2 of 22), SO39 COLORADO PLATEAU PINYON-JUNIPER WOODLAND (4 of 22), SO57 MOGOLLON CHAPARRAL (1 of 22), SO77 CHIHUAHUAN PIEDMONT SEMI-DESERT GRASSLAND (3 of 22), SO85 SOUTHERN ROCKY MOUNTAIN MONTANE GRASSLAND (1 of 22), and S112 MADREAN PINYON-JUNIPER WOODLAND (2 of 22). This type is being confused with a number of ecological systems with different structure. In some cases S079 intergrades with these types. The confusion may be caused by the high topographic variability along the Mogollon Rim.

S085: SOUTHERN ROCKY MOUNTAINS MONTANE GRASSLAND. Quantitatively assessed, validation 75% (users) and 66% (producers) based on 32 independent validation samples. This type was confused with SO32 ROCKY MOUNTAIN MONTANE DRY-MESIC MIXED CONIFER FOREST (1 of 32), SO36 ROCKY MOUNTAIN PONDEROSA PINE WOODLAND (5 of 32), SO39 COLORADO PLATEAU PINYON-JUNIPER WOODLAND (2 of 32), and SO79 INTER-MOUNTAIN BASINS SEMI-DESERT SHRUB STEPPE (3 of 32). S085 can occur adjacent to S032, S036 and S039. It has similar structure to S079. It is generally well mapped.

S090: INTER-MOUNTAIN BASINS SEMI-DESERT GRASSLAND. Quantitatively assessed, validation 100% (users) and 8% (producers) based on 13 independent validation samples. This type was confused with SO36 ROCKY MOUNTAIN PONDEROSA PINE WOODLAND (2 of 13), SO39 COLORADO PLATEAU PINYON-JUNIPER WOODLAND (2 of 13), SO57 MOGOLLON CHAPARRAL (1 of 13), SO77 CHIHUAHUAN PIEDMONT SEMI-DESERT GRASSLAND (4 OF 13), SO79 INTER-MOUNTAIN BASINS SEMI-DESERT SHRUB STEPPE (1 of 13), and S112 MADREAN PINYON-JUNIPER WOODLAND (1 of 13). This system is being somewhat confused with systems with which it intergrades or with similar structure.

S093: ROCKY MOUNTAIN LOWER MONTANE RIPARIAN WOODLAND AND SHRUBLAND. Quantitatively assessed, validation 0% (users) and 0% (producers) based on 9 independent validation samples. This type was confused with SO35 MADREAN PINE-OAK FOREST AND WOODLAND (3 OF 9), SO36 ROCKY MOUNTAIN PONDEROSA PINE WOODLAND (1 OF 9), SO58 CHIHUAHUAN MESQUITE UPLAND SCRUB (1 of 9), SO79 INTER-MOUNTAIN BASINS SEMI-DESERT SHRUB STEPPE (1 of 9), and S112 MADREAN PINYON-JUNIPER WOODLAND (3

of 9). It appears that training data was not well registered. The ecological system is generally not well modeled.

S094: NORTH AMERICAN WARM DESERT LOWER MONTANE RIPARIAN. Quantitatively assessed, validation 75% (users) and 8% (producers) based on 20 independent validation samples. This type was confused with SO35 MADREAN PINE-OAK FOREST AND WOODLAND (3 OF 20), SO36 ROCKY MOUNTAIN PONDEROSA PINE WOODLAND (4 of 20), SO57 MOGOLLON CHAPARRAL (6 of 20), SO58 CHIHUAHUAN MESQUITE UPLAND SCRUB (3 of 20), and S112 MADREAN PINYON-JUNIPER WOODLAND (1 of 20). It appears that training data was not well registered. The ecological system is generally not well modeled.

S097: NORTH AMERICAN WARM DESERT RIPARIAN WOODLAND AND SHRUBLAND. Quantitatively assessed, validation 50% (users) and 14% (producers) based on 7 independent validation samples. This type was confused with SO36 ROCKY MOUNTAIN PONDEROSA PINE WOODLAND (1 of 7), SO39 COLORADO PLATEAU PINYON-JUNIPER WOODLAND (1 of 7), SO58 CHIHUAHUAN MESQUITE UPLAND SCRUB (1 of 7), SO63 SONORAN PALOVERDE-MIXED CACTI DESERT SCRUB (2 of 7), and S129 SONORAN MID-ELEVATION DESERT SCRUB (1 of 7). It appears that training data was not well registered.

S098: NORTH AMERICAN WARM DESERT RIPARIAN MESQUITE BOSQUE. Quantitatively assessed, validation 0% (users) and 0% (producers) based on 4 independent validation samples. This type was confused with SO58 CHIHUAHUAN MESQUITE UPLAND SCRUB (3 of 4) and SO63 SONORAN PALOVERDE-MIXED CACTI DESERT SCRUB (1 of 4). It appears that training data was not well registered.

S112: MADREAN PINYON-JUNIPER WOODLAND. Quantitatively assessed, validation 51% (users) and 69% (producers) based on 120 independent validation samples. This type was confused with SO35 MADREAN PINE-OAK FOREST AND WOODLAND (10 of 120), SO36 ROCKY MOUNTAIN PONDEROSA PINE WOODLAND (4 of 120), SO39 COLORADO PLATEAU PINYON-JUNIPER WOODLAND (3 of 120), SO57 MOGOLLON CHAPARRAL (7 of 120), SO58 CHIHUAHUAN MESQUITE UPLAND SCRUB (8 of 120), SO75 INTER-MOUNTAIN BASINS JUNIPER SAVANNA (1 of 120), SO77 CHIHUAHUAN PIEDMONT SEMI-DESERT GRASSLAND (3 of 120), and S115 MADREAN JUNIPER SAVANNA (1 of 120). S112 is confused with systems with similar structure (S035, S036, S039, S075 and S115) or with which it intergrades (S057, S058 and S077).

S115: MADREAN JUNIPER SAVANNA. Quantitatively assessed, validation 0% (users) and 0% (producers) based on 14 independent validation samples. This type was confused with SO36 ROCKY MOUNTAIN PONDEROSA PINE WOODLAND (1 of 14), SO57 MOGOLLON CHAPARRAL (1 of 14), SO58 CHIHUAHUAN MESQUITE UPLAND SCRUB (6 of 14), SO77 CHIHUAHUAN PIEDMONT SEMI-DESERT GRASSLAND (1 of 14), S112 MADREAN PINYON-JUNIPER WOODLAND (5 of

14). S115 is being confused with systems with similar structure (S112) or with which it intergrades. It is not well modeled.

S129: SONORAN MID-ELEVATION DESERT SCRUB. Quantitatively assessed, validation 55% (users) and 33% (producers) based on 18 independent validation samples. This type was confused with SO57 MOGOLLON CHAPARRAL (3 of 18), SO58 CHIHUAHUAN MESQUITE UPLAND SCRUB (6 of 18), SO63 SONORAN PALOVERDE-MIXED CACTI DESERT SCRUB (2 of 18), and S112 MADREAN PINYON-JUNIPER WOODLAND (1 of 18). S129 is being generally confused with scrublands with similar structure.

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