

## SWReGAP Land Cover Mapping Methods Documentation

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**Functional Unit or Mapping Zone: UT5**

**Organization: RSGIS Laboratory, Utah State University**

**Person Preparing Document: John Lowry/Jessica Kirby/Lisa Langs**

**Date of Preparation: 01 November, 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:

$$\rho_{BandN} = \frac{\pi ((L_{BandN} * Gain_{BandN} + Bias_{BandN}) - (H_{BandN} * Gain_{BandN} + Bias_{BandN})) * D^2}{E_{BandN} * (\cos((90 - \theta) * \pi / 180))}$$

Where,

•<sub>BandN</sub> = Reflectance for Band N

L<sub>bandN</sub> = Digital Number for Band N

H<sub>bandN</sub> = Digital Number representing Dark Object for Band N

D = Normalized Earth-Sun Distance

$E_{\text{bandN}}$  = 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 (yr-Julian date)	Spring Overlay Order	Summer Overlay Order	Fall Overlay Order
40/31	2000-99	1999-192	1999-288	1	1	1
40/32	2000-99	2000-195	1999-272	2	2	2
39/31	2000-92	2000-172	1999-297	3	3	3

Six band ETM mosaics for each season can be found at:

/ut/archive/UT5/mosaics/

**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 /ut/archive/UT5/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: /ut/archive/UT5/img\_files/.

All imagery derived predictor layers can be found at:

/ut/archive/UT5/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. DEMs were converted from floating point grids to integer grids and mosaicked for the region, then clipped to the mapping area.

Aspect: A nine class aspect 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 (values ranging from 0-28) index grid (Manis et. al 2001).

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

/ut/archive/UT5/img\_files/

## **2) Samples:**

### **a) Sample collection methods:**

The majority of samples were collected on the ground as polygons delineated over imagery in the field by USU field crews, but others come from other 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 method and/or source for each sample can be distinguished by the SITEID field in the polygon coverage:

NV050702JK01 or UT071801ES01: Identifies a sample taken by USU RSGIS lab SWReGAP field crew. Indicates it was the second site taken in Nevada on May 7, 2002 by Jessica Kirby.

UT5doq060404\_1: Indicates sites obtained from interpretation of black and white Digital Orthophoto Quads available for the state of Utah from AGRC (date of DOQs is either 1993 or 1997). DOQ interpretation by RSGIS lab personnel.

### **b) Summary of samples:**

2,379 samples were available to model this mapping area of which 2,358 samples were used in the final model. Qualifiers for a discarded sample site was sample quality, Ecological System (ES) mapability and sample abundance. Sample quality can be defined as the likelihood that the sample has a correct geospatial location and that the site sample characteristics correspond with site species data. ES mapability can be defined as the sites likelihood to map accurately given the map model conditions. Landuse types, in comparison to landcover types, typically are seen as sites that were discarded for ES mapability problems (example: Recently Burned, Recently Mined or Quarried and Developed areas). Sample abundance can be defined as all Ecological System cover types with roughly less than 20 samples sites collected in the field. Polygon coverage containing all samples is located at: [ut/archive/UT5/train data/](http://ut/archive/UT5/train data/).

VALUE	CODE	Description Ecological System (Name)	Number Of Samples
0	S000	IGNORED	28
9	S009	INTER-MOUNTAIN BASINS CLIFF AND CANYON COMPLEX	27
23	S023	ROCKY MOUNTAIN ASPEN FOREST AND WOODLAND	26
28	S028	ROCKY MOUNTAINS SUBALPINE DRY-MESIC SPRUCE-FIR FOREST AND WOODLAND	21
40	S040	GREAT BASIN PINYON-JUNIPER WOODLAND	86
50	S050	INTER-MOUNTAIN BASINS MOUNTAIN MAHOGANY WOODLAND AND SHRUBLAND	10
54	S054	INTER-MOUNTAIN BASINS BIG SAGEBRUSH SHRUBLAND	291
55	S055	GREAT BASIN XERIC MIXED SAGEBRUSH SHRUBLAND	124
65	S065	INTER-MOUNTAIN BASINS MIXED SALT DESERT SCRUB	28
71	S071	INTER-MOUNTAIN BASINS MONTANE SAGEBRUSH STEPPE	109
78	S078	INTER-MOUNTAIN BASINS BIG SAGEBRUSH STEPPE	44
90	S090	INTER-MOUNTAIN BASINS SEMI-DESERT GRASSLAND	37
96	S096	INTER-MOUNTAIN BASINS GREASEWOOD FLAT COMPLEX	19
118	S118	GREAT BASIN FOOTHILL AND LOWER MONTANE RIPARIAN WOODLAND AND SHRUBLAND	28
<b>Total number of samples</b>			<b>878</b>

**3) Cover types:**

**a) Classification Tree modeled cover types:**

The following cover types were modeled using the See5 Classification Tree:

VALUE	CODE	Description Ecological System (Name)	Number Of Samples
9	S009	INTER-MOUNTAIN BASINS CLIFF AND CANYON COMPLEX	27
23	S023	ROCKY MOUNTAIN ASPEN FOREST AND WOODLAND	26
28	S028	ROCKY MOUNTAINS SUBALPINE DRY-MESIC SPRUCE-FIR FOREST AND WOODLAND	21
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71	S071	INTER-MOUNTAIN BASINS MONTANE SAGEBRUSH STEPPE	109
78	S078	INTER-MOUNTAIN BASINS BIG SAGEBRUSH STEPPE	44
90	S090	INTER-MOUNTAIN BASINS SEMI-DESERT GRASSLAND	37
96	S096	INTER-MOUNTAIN BASINS GREASEWOOD FLAT COMPLEX	19
118	S118	GREAT BASIN FOOTHILL AND LOWER MONTANE RIPARIAN WOODLAND AND SHRUBLAND	28
<b>Total number of samples</b>			<b>850</b>

**b) Non CT modeled cover types:**

Screen digitized over ETM imagery at a scale between 1:24,000 and 1:100,000; Updated existing **Land Use | Water Related Use** GIS coverage (screen digitizing over ETM imagery). Source of GIS coverage: Utah Department of Natural Resources, Division of Water Resources, collection period: 1985-2001. FGDC metadata for **Land Use | Water Related Use** coverage is found at: /ut/archive/UT5/non model/

VALUE	SCODE	Description Ecological System (Name)
118	S118	Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland
211	N11	Open Water
221	N21	Developed, Open Space - Low Intensity
222	N22	Developed, Medium - High Intensity
281	N81	Agriculture, Pasture Hay
282	N82	Agriculture, Cultivated Crops
302	D02	Recently Burned
303	D03	Recently Mined or Quarried

Modeled with a post-classification model (see section 5c for details):

VALUE	SCODE	Description Ecological System (Name)
30	S030	Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland
34	S034	Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland

**4) Summary of predictor layers used:**

**a) Multi band predictors:**

UT5\_fall\_2000.img (ETM bands 1-5 & 7 for fall 2000)  
 UT5\_spr\_2000.img (ETM bands 1-5 & 7 for spring 2000)  
 UT5\_sum\_2000.img (ETM bands 1-5 & 7 for summer 2000)

All multi-band predictors can be found at:  
/ut/archive/UT5/mosaics/

**b) Single band predictors:**

asp_9cls.img	Categorical 9 class aspect
elev.img	Continuous (integer) elevation
fabrt.img	Fall brightness band
fagr.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 (from DEM)

All single-band predictors can be found at:  
/ut/archive/UT5/img\_files/

**5) Modeling Methods:**

**a) See5 Classification Tree modeling:**

Sampling: Pseudo-replication within each sample polygon was conducted in order to increase the number of samples used by the classification algorithm. While this use of non-independent data is not ideal for classification tree modeling, it has been found to improve classification accuracies, particularly when there are limited amounts of training data. 20 random points were placed within each polygons using an Arcview Avenue script. The points were converted to pixels while ensuring that the resulting pixels (the new grid) aligned with the raster predictor layers. The resulting sub-sampled pixels would often be less than 20 per sample polygon, if random points fell within the same pixel. This new grid was converted to an Imagine IMG file (e.g.m4all20ppp.img) and is available at: UT/ARCHIVE/UT2/TRAIN\_DATA/

Withholding Validation 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: ut/archive/UT5/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:**

Introduction: This post-classification model was designed to be used as a tool to assist in differentiating between ecological systems that have similar characteristics. Similar characteristics can be defined as one or all of the following: Shared physiognomic structure, shared species composition and/or shared ecological process.

The .gmd file used for this post-classification model is:

/archive/UT5/post\_model/swgap\_UT5.gmd

#### **Step 1: Discriminating Mesic Conifer from Non-Mesic Conifer Forests Types**

The National Vegetation Classification Standard (NVCS) legend used for the Southwest Regional Gap Analysis Project divided Rocky Mountain conifer forest types into two distinct moisture classes; Mesic Forest types and Dry-Mesic Forest types (Comer et. al 2003). Early indications revealed that these types would be difficult to accurately discriminate using standard CT modeling methods due to site composition and spectral similarities. As a result, these types have been post modeled using their Ecological System conceptual description as a basis for modeling.

#### **Step 1A: Discriminating Between Rocky Mountain Montane Dry-Mesic and Rocky Mountain Montane Mesic Conifer Types**

Model methods: The original CT output modeled *S032 Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland* as the only montane conifer type. This post model was designed to discriminate between *S032* and, its moister ecologic counterpart, *S034 Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland*. The logic and parameters for the model were as follows:

This post-classification model was designed to extract *S034 Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland* from the standard CT modeled conifer system, *S032 Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland*.

NatureServe's NVCS concept describes S032 montane mesic 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." (Comer et. al 2003)

Using the output of step 1, a conditional statement was created to extract *S034 Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland*. The conditional statement was created by using the aspect and landform characteristics described above. Affected pixels were then recoded to represent montane mesic mixed conifer system S034.

The details of the conditional statement follow:

```
EITHER 30 IF (($n2_landf == 2 OR $n2_landf == 5 OR
$n2_landf==6 OR $n2_landf == 9) AND ($n3_asp_9cls== 1 OR
$n3_asp_9cls == 2 OR $n3_asp_9cls == 0) AND ($n1_m4all1_rec
== 28)) OR $n1_m4all1_rec OTHERWISE
```

Where:

30	<i>S030 Mountain Subalpine Mesic Spruce-Fir Forest and Woodland</i>
28	<i>S028 Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland</i>
landf	10 class landform 2= toe slopes, bottoms, and swales 5= very moist steep slopes 6= moderately moist steep slopes 9= cool aspect scarps, cliffs, canyons
asp_9cls	Nine class aspect image 1=North facing slope 2=Northeast facing slope 0=slope less than 3 degrees
m4all1_rec	UT5 standard CT output image. Recoded to standard integer code.

**c) Generalizing to MMU and map completion:**

Once the CT model and the post-classification steps were employed, the map was generalized using the Clump tool in ERDAS Imagine 8.6. The parameter of 4 connected neighbors (or "rook's move") was used in the clumping process. Isolated pixels that fell under the specified 1-acre minimum mapping unit (MMU) were removed using the Eliminate tool.

Following the Clump & Eliminate step, the non-CT modeled classes were then "burned in" to the final map using the Overlay function. The final map can be found at: /ut/archive/UT5/final\_map/.

## **6) Validation:**

**a) CT model validation:** 20% of sample polygons were randomly selected and withheld from CT modeling using the featuresselect.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: /ut/archive/UT5/validation/.

**b) 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 **the final map product**, which can be found at /ut/archive/UT5/final\_map/.

**c) 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.

### **N11 OPEN WATER:**

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

### **N21 DEVELOPED, OPEN SPACE-LOW INTENSITY:**

Not quantitatively assessed. Qualitative assessment indicates that most low density developed areas contemporary with the date of the imagery are included. Some confusion may occur with the N22 DEVELOPED, MEDIUM-HIGH INTENSITY class.

### **N22 DEVELOPED, MEDIUM-HIGH INTENSITY:**

Not quantitatively assessed. Qualitative assessment indicates that most low density developed areas contemporary with the date of the imagery are included. Some confusion may occur with the N21 DEVELOPED, OPEN SPACE-LOW INTENSITY class.

### **N81 PASTURE/HAY:**

Not quantitatively assessed. Qualitative assessment indicates that most pasture/hay agricultural areas contemporary with the date of the imagery are included. This class included alfalfa and other non-irrigated agricultural types, which may be confused with N82 CULTIVATED CROPS.

### **N82 CULTIVATED CROPS:**

Not quantitatively assessed. Qualitative assessment indicates that most cultivated agricultural areas contemporary with the date of the imagery are included. This class may be confused with N81 PASTURE/HAY, where crops were harvested prior to the date of the imagery or where crops were out of rotation for the season producing spectral signatures similar to that of N81.

### **D02 RECENTLY BURNED:**

Not quantitatively assessed. Qualitative assessment indicates that most recently burned areas contemporary with the date of the imagery are included. This class may be confused with areas that have had fires in the past, but where the site has become somewhat revegetated since the time of the burn.

D03 RECENTLY MINED OR QUARIED:

Not quantitatively assessed. Qualitative assessment indicates that most recently mined or quarried areas contemporary with the date of the imagery are included. Some confusion may occur with the N21 DEVELOPED, OPEN SPACE-LOW INTENSITY class.

S009 INTER-MOUNTAIN BASINS CLIFF AND CANYON:

Quantitatively assessed, validation 83% (producers) and 83% (users) based on 6 independent validation samples. S009 mapped very well.

S023 ROCKY MOUNTAIN ASPEN FOREST AND WOODLAND: Quantitatively assessed, validation 67% (producers) and 100% (users) based on 6 independent validation samples. Confusion is primarily with S071 INTER-MOUNTAIN BASINS MONTANE SAGEBRUSH STEPPE (2 of 6 samples). Where training data was available S023 mapped very well.

S028 ROCKY MOUNTAIN SUBALPINE DRY-MESIC SPRUCE-FIR FOREST AND WOODLAND: Quantitatively assessed, validation 100% (producers) and 100% (users) based on 5 independent validation samples. S028 mapped extremely well.

S030 ROCKY MOUNTAIN SUBALPINE MESIC SPRUCE-FIR FOREST AND WOODLAND: Not quantitatively assessed. This cover type was attained using a post processing modeler. Please reference methods section entitled *Post-classification and recoding, Step 1a*, for a detailed explanation. Post-classification mapped S030 very well.

S040 GREAT BASIN PINYON-JUNIPER WOODLAND: Quantitatively assessed, validation 94% (producers) and 94% (users) based on 18 independent validation samples. S040 mapped very well.

S042 INTER-MOUNTAIN WEST ASPEN-MIXED CONIFER FOREST AND WOODLAND COMPLEX: Quantitatively assessed, validation 57% (producers) and 100% (users) based on 7 independent validation samples. Confusion is distributed among S023 ROCKY MOUNTAIN ASPEN FOREST AND WOODLAND (1 of 7 samples), S032 ROCKY MOUNTAIN MONTANE DRY-MESIC MIXED CONIFER FOREST AND WOODLAND (1 of 7 samples), and S028 ROCKY MOUNTAINS SUBALPINE DRY-MESIC SPRUCE-FIR FOREST AND WOODLAND (1 of 7 samples). Confusion can be explained by similarities in species composition among these three cover types. Where training data was available S042 mapped very well.

S050 INTER-MOUNTAIN BASINS MOUNTAIN MAHOGONY WOODLAND AND SHRUBLAND: Quantitatively assessed, validation 50% (producers) and 100% (users) based on 2 independent validation samples. S050 mapped well considering the limited sample data available.

S054 INTER-MOUNTAIN BASINS BIG SAGEBRUSH SHRUBLAND: Quantitatively assessed, validation 92% (producers) and 67% (users) based on 59 independent validation samples. Confusion is primarily with S055 GREAT BASINS XERIC MIXED SAGEBRUSH SHRUBLAND (2 of 59 samples). Confusion can be partially explained by the physiognomic similarities and similar composition of species among the two systems. Otherwise, S054 is mapping very well.

S055 GREAT BASINS XERIC MIXED SAGEBRUSH SHRUBLAND:

Quantitatively assessed, validation 32% (producers) and 57% (users) based on 25 independent validation samples. Confusion is

primarily with S054 INTER-MOUNTAIN BASINS BIG SAGEBRUSH SHRUBLAND (12 of 25 samples). These two systems are commonly found adjacent to one another and share codominating species. Where training data was available S055 mapped very well.

S065 INTER-MOUNTAIN BASINS MIXED SALT DESERT SCRUB:

Quantitatively assessed, validation 33% (producers) and 67% (users) based on 6 independent validation samples. Confusion is primarily with S054 INTER-MOUNTAIN BASINS BIG SAGEBRUSH SHRUBLAND (2 of 6 samples). It is unclear why this system is mapping poorly. Where training data was available S065 mapped very well.

S071 INTER-MOUNTAIN BASINS MONTANE SAGEBRUSH STEPPE:

Quantitatively assessed, validation 82% (producers) and 60% (users) based on 22 independent validation samples. Confusion is predominantly with S054 INTER-MOUNTAIN BASINS BIG SAGEBRUSH SHRUBLAND (2 of 22 samples) and S055 GREAT BASINS XERIC MIXED SAGEBRUSH SHRUBLAND (2 of 22 samples). Confusion can be partially explained by presence of similar species and physiognomic structure among the three cover types.

S078 INTER-MOUNTAIN BASINS BIG SAGEBRUSH STEPPE: Quantitatively assessed, validation 30% (producers) and 0% (users) based on 9 independent validation samples. Confusion is primarily with S054 INTER-MOUNTAIN BASINS BIG SAGEBRUSH SHRUBLAND (6 of 9 samples). Confusion can be explained by the species composition of S078 and S054. Where training data was available S078 mapped very well.

S090 INTER-MOUNTAIN BASINS SEMI-DESERT GRASSLAND: Quantitatively assessed, validation 38% (producers) and 75% (users) based on 8 independent validation samples. Confusion is primarily with S054 INTER-MOUNTAIN BASINS BIG SAGEBRUSH SHRUBLAND (3 of 8 samples). It is unclear why this system is mapping poorly.. Where training data was available S090 mapped very well.

S096 INTER-MOUNTAIN BASINS GREASEWOOD FLAT: Quantitatively assessed, validation 25% (producers) and 50% (users) based on 4 independent validation samples. It is unclear why this system is mapping poorly. Where training data was available S096 mapped very well.

S118 GREAT BASIN FOOTHILL AND LOWER MONTANE RIPARIAN WOODLAND AND SHRUBLAND: Quantitatively assessed, validation 100% (producers) and 100% (users) based on 6 independent validation samples. S118 mapped very well.

**7) Citations:**

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