

Inventory & Monitoring Division

National Park Service



Standard Operating Procedure 2.11.9

Processing Land Cover Source Data to Derive Landscape Dynamics Metrics: Anderson Level 1 and 2 Classification, and Natural vs. Converted Land Use

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Summary

Obtaining and processing land cover data (NLCD, CCAP) for use in calculating Landscape Dynamics summary statistics for generic land cover, and natural versus converted land cover.

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Overview

This SOP describes processing steps for Land Cover data in preparation for use in calculating Landscape Dynamics land cover summary statistics for generic land cover (LAC), and natural versus converted land cover (LNC). Sources are the National Land Cover Dataset (NLCD), and the Coastal Change Assessment Program (CCAP). Each land cover source covers a specific extent of area managed and of interest to the National Park Service Inventory and Monitoring Division (NPS IMD).

- National Land Cover Dataset (NLCD) data covers the Continental US and Alaska and is 30m resolution (dates vary by geography). The data is produced approximately every five years through the Multi-Resolution Land Characteristics Consortium (MRLC), part of the USGS and DOI.
- Coastal Change Analysis Program (C-CAP) data covers U.S. island states and territories, and ranges from 2.4m to 30m resolution depending on the geographic region and date of data acquisition. The data is produced approximately every five years through NOAA's Office of Coastal Management (dates vary by geography).

It is assumed users of this SOP have prior knowledge of data paths, file locations, and repositories referenced in this SOP.

Processing Requirements

- Internet connection
- ArcGIS Desktop, Spatial Analyst extension enabled
- Knowledge and understanding of ArcGIS concepts including raster data, reclassification tables and reclassification of raster data, projections, metadata
- Disc space and RAM available to process very large raster files locally
- Write access to X: drive
- Data Store permissions and access

Pre-Processing

Obtain Source Data from respective source. Near next anticipated release date, begin routinely checking for new data.

Download data

CONUS, Alaska (NLCD): <https://www.mrlc.gov/finddata.php>

- National Land Cover Database YYYY; for each year of interest → NLCD YYYY Land Cover

- Each release of NLCD includes rereleased versions of previous years, and supersedes all previously released data. Be sure to download all newly released data for all years, as available. Note Alaska data is processed separately from CONUS and may be available at a later date.

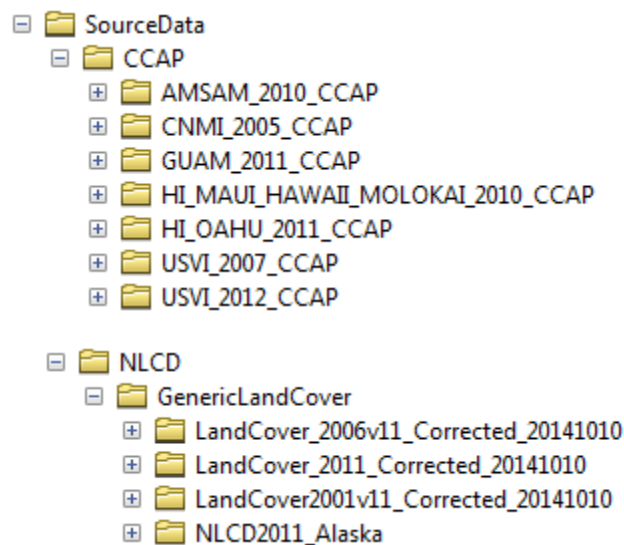
All Pacific Islands, U.S. Virgin Islands, and Puerto Rico (CCAP): <https://coast.noaa.gov/ccapftp/#/>

- Select geographic area of interest, download High Resolution land cover for year of interest

Once downloaded, source data should be unzipped/extracted, copied to:

X:\ProjectData\LandscapeDynamics\Landcover\SourceData\<Source Type>\....

Examples:



NLCD Update schedule

The NLCD outputs are routinely captured every five years.

CCAP Update schedule

CCAP data is captured approximately every five years (varies by geographical extent).

Spatial Reference

Respective source data for the varying geographies should be in the following spatial reference:

- North America (U.S., Canada, Mexico) = USA Contiguous Albers Equal Area Conic USGS (NAD83) (WKID: 102039)
- CONUS = USA Contiguous Albers Equal Area Conic USGS (NAD83) (WKID: 102039)
- Puerto Rico and USVI = USA Contiguous Albers Equal Area Conic USGS (NAD83) (WKID: 102039)
- Alaska = Alaska Albers Equal Area Conic (NAD83) (WKID: 3338)

- Hawaii = UTM Zone 5N NAD83 (WKID: 26905)
- American Samoa = NAD_1983_HARN_UTM_Zone_2S (WKID: 2195)
 - If necessary, when re-projecting use Transformation =
WGS_1984_(ITRF00)_To_NAD_1983 + NAD_1983_HARN_To_WGS_1984_2
- Guam = WGS_1984_UTM_Zone_55N (WKID: 32655)
 - If necessary, when re-projecting use Transformation =
WGS_1984_(ITRF00)_To_NAD_1983
- Saipan (Commonwealth N Mariana Islands) = WGS_1984_UTM_Zone_55N (WKID: 32655)
 - If necessary, when re-projecting use Transformation =
WGS_1984_(ITRF00)_To_NAD_1983

Processing

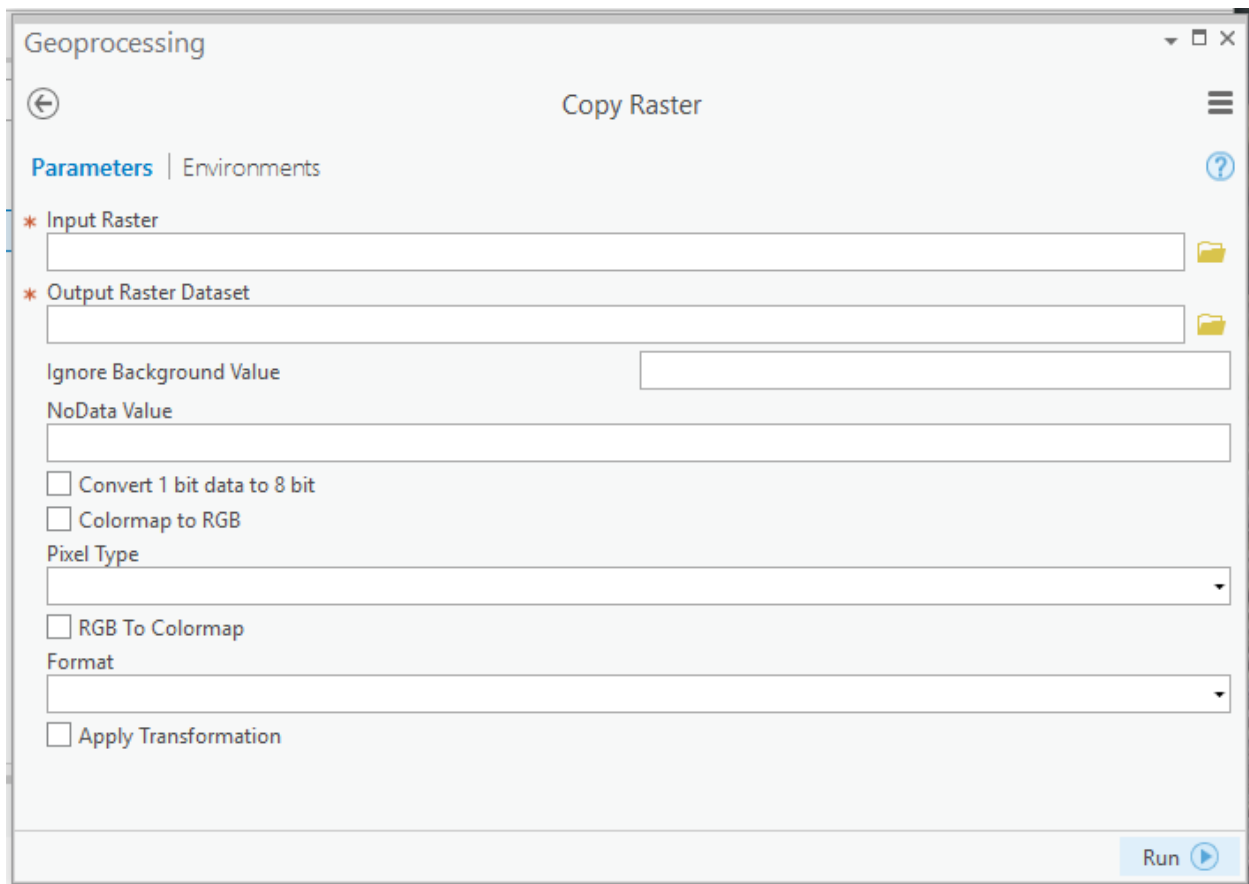
Do not process original source data. Make a copy of the data to be processed on a local drive before continuing.

Processing Summary

Each source raster (IMG format) is copied to .tif (GeoTIFF) format using Copy Raster. A classification lookup table is exported from the source (Anderson Level 2) raster. If not present, Red, Green, and Blue decimal value colormap fields and a text-format CLASSNAME field are added to each GeoTIFF using Join Field.

Step 1: Copy Raster

1. Extract IMG file from .zip download, if not already extracted.
2. In ArcGIS, use **Copy Raster** to create a .tif raster.
 - a. Environments → Extent, set snap raster to Input Raster
 - b. Output Raster Dataset: new raster name, include “.tif”
 - c. Pixel Type: 8-bit Unsigned
 - d. Format: TIFF format
 - e. Leave all other fields blank



3. Run tool, and confirm bit depth of output raster is 8-bit unsigned.
4. If necessary, re-project output raster to respective required projection, as noted in Pre-Processing.
 - a. NOTE: CONUS source NLCD data might be in Albers_Conical_Equal_Area, which ESRI/ArcGIS Desktop interprets as equivalent to USA Contiguous Albers Equal Area Conic USGS. Alaska source NLCD Data might be in NAD_83_Alaska_Albers, which ESRI/ArcGIS Desktop interprets as equivalent to Alaska Albers Equal Area Conic in ArcMap. (See Appendix 3) Re-projecting will not be successful if the source data is natively in either of these spatial references, respectively.

Step 2: Create/Edit Reclassification Tables

1. In the source raster attribute table, cross check the Classname in the source data against existing reclassification tables for previous NLCD/CCAP releases to look for differences.
Existing reclassification tables for NLCD, CCAP:
X:\ProjectData\LandscapeDynamics\SourceData\Reclassification_Lookups
 - a. If Value and Classname are unchanged from a previous year reclassification table, create a copy of that reclass table and rename it to match the year for the new source data.

- b. If Value and Classname are different, create a new table for the new source data, duplicate the format of existing reclassification tables.

CREATE A LOCAL COPY OF RECLASSIFICATION GDB BEFORE EDITING ANY TABLES.

- i. NLCD requires reclassification tables for Anderson Level 1, Anderson Level 2, and Natural versus Converted. *NOTE: Alaska and CONUS share the same reclassification tables for NLCD.*
 - ii. CCAP requires reclassification tables for Anderson Level 2, and Natural versus Converted.
- c. Working locally, edit/create a table that contains FROM_VAL (from Value), TO_VAL (to Value), OUT_VAL (output Value), and CLASSNAME for all values found in the source raster attribute table (Appendix 2), (**TO/FROM/OUT_VAL should correlate to the land cover field Value from the source raster*).
 - i. Edit existing table if working with new/corrected/additional data for a land cover source with existing reclassification tables.
- d. If needed (if a new class is added to the classification), locally edit/create an additional table for the RGB (and Red, Green, Blue) values for each land cover classname (Level 1, 2 only) (Appendix 2).
 - i. For example: Level1_RasterDisplay, Level2_RasterDisplay
- e. Save reclassification and raster display tables to the appropriate Reclassification file geodatabase,
X:\ProjectData\LandscapeDynamics\SourceData\Reclassification_Lookups (follow naming convention present in the geodatabase)
- f. Repeat these steps until there is one table for Level 1 (where applicable), Level 2, and Natural Converted for each new source landcover raster.

Step 3: Reclassify Raster

1. Begin with Level 2 and run the **Reclass by Table** tool using new reclass table. This removes all 'NoData' cells and creates a clean raster table.
 - a. Make sure "Change missing values to NoData" is checked.
 - b. Make sure to set Snap Raster in the environments settings (to match input raster)
2. Run **Join Field** tool.
 - a. Input table: raster

- b. Input Join Field: Value
 - c. Join Table: Raster Display table (respective Reclassification gdb in this directory: X:\ProjectData\LandscapeDynamics\SourceData\Reclassification_Lookups\)
 - d. Output Join Field: Value
 - e. Join Fields: CLASSNAME, R, G, B, Red, Green, and Blue fields (RGB whole numbers, and Red, Green, Blue decimal values)
3. Repeat **Reclass by Table** and **Join Field** for Level 1 (where applicable), and Natural Converted (LNC). The Input raster for reclassification of Level 1 and LNC is the Level 2 raster just created.

Island Geographies

1. **Copy Raster, Create Reclassification Tables, and Reclassify Raster** as described above to create an individual landcover raster (Level 2, LNC only) for each island extent, as data becomes available to do so from CCAP.
2. **Mosaic to New Raster** to combine all individual island rasters into a single raster, by extent.
 - a. If necessary, multiple mosaics should be done, both by matching data year, and by matching geographical extent (Figure 3).

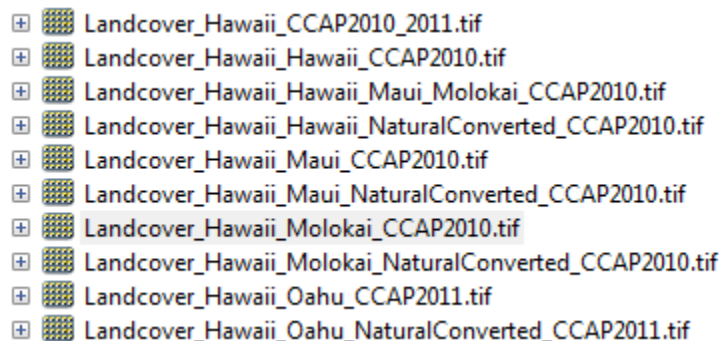


Figure 3. Example of raster outputs for Hawaii CCAP.

Step 4: Import Metadata

This section requires ArcCatalog.

For all land cover rasters (LAC1, LAC2, LNC), import the Metadata .xml that accompanied the source download.

1. **If using ArcGIS versions 10.4.1 or 10.5; else, go to #2:**
 - a. In a text editor (Notepad++), open the source metadata .xml and ‘Find and Replace’ “Landsat” with “Lsat”.
 - i. SAVE .xml.

Note: There is a known bug in these versions of ArcGIS that corrupts metadata files if the word “Landsat” is present in the text. ESRI is aware of the issue.

2. If not using version 10.4.1 or 10.5, or, if you have completed step 1:

- a. In ArcCatalog, Use Conversion → **Metadata Importer** tool
 - i. Source Metadata is .xml from source download
 - ii. Target Metadata is new raster (GeoTIFF).
 - iii. If there is more than one year of data, make sure the Source Metadata and the Target Metadata are for the SAME YEAR.
- b. When prompted, say yes to upgrade Metadata and then Click “OK” on tool that pops up
- c. In ArcCatalog, Edit metadata (Description), adding these elements:
 - i. Summary: Source for landscape dynamics analyses.
 - ii. Description: Landscape dynamics source for NPS Inventory and Monitoring national protocol.
 - iii. Use Limitations:

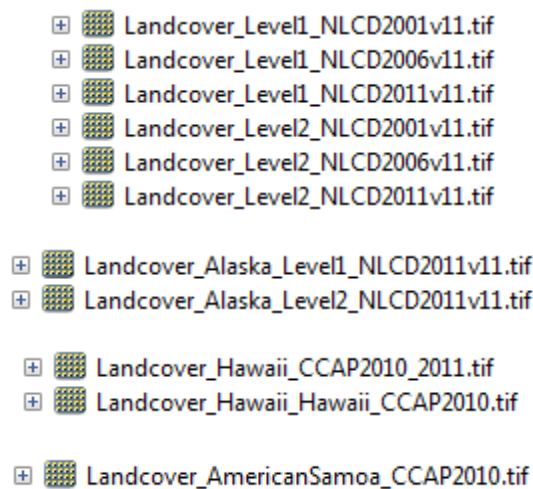
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Post-Processing

Step 1: Move Processed Source Data

1. Move final, processed land cover rasters to the respective folder on X:\ProjectData\LandscapeDynamics\Landcover\Products\Seamless, and if needed, rename the rasters being moved following the naming conventions present.
 - a. Be sure to append ‘vYY’ to each new raster to denote the fact the data was re-processed and re-released from NLCD to reflect updates and changes to their methods.

Naming conventions (example):



Step 2: Publish Services

See Environmental Settings Data Services SOP (SOP 4.1.2; Nelson and Kinseth 2018), and use the following information as a guide when creating and publishing the services; see Publishing, Publish Map, Feature, or Image Services to ArcGIS Server or NPS ArcGIS Online, “Landscape Dynamics” section for guidance.

Landcover Seamless

Publish Map Services for all NLCD and CCAP Level 2 data only. Publish Image Services for CONUS NLCD Level 2 only. Publish all services to ArcGIS Server.

When complete, check REST endpoint for update of any new, published services.

<http://irmaservices.nps.gov/arcgis/rest/services/LandscapeDynamics>

See Landscape Dynamics Viewer Maintenance SOP (SOP 2.11.18; Kinseth 2018) to add the new data to the viewer.

Step 3: Publish to Data Store

See Publishing to Data Store SOP (SOP 4.1.1; Kinseth and Nelson 2018), and use the following information (Table 1) as a guide when uploading Landcover Source and Seamless data to Data Store.

1. From Environmental Settings Program, <https://irma.nps.gov/DataStore/Reference/Profile/2244060>, go to Landcover Project.
2. Compress all raster GeoTIFFs into a .zip folder, by respective geography/year.

Landcover_<Measure>_<GEOGRAPHY>_<Source><Year>.zip

Measure = LAC1 (NLCD only), LAC2, LNC

GEOGRAPHY = CONUS, Alaska, Hawaii, Guam, AmericanSamoa, Saipan, USVI

Source = NLCD, CCAP

Year = YYYY(vYY if NLCD)

NOTE: State of Hawaii CCAP has multiple rasters/years associated with it (by island), include ALL rasters (by measure) and note all years in the file name (i.e. 2010_2011).

Table 1. Required upload parameters for holdings: Landcover Landscape Dynamics Source and Seamless Data - Land Cover Level 2; Landcover Landscape Dynamics Seamless Data - Land Cover Level 1, and Landcover Landscape Dynamics Seamless Data - Land Cover Level Natural Converted.

Parameter	Value
Notes (Version/Clone)	"New release of source data" if adding new data; or, "Corrected source data" if NLCD data is reprocessed because of an error discovered after its initial release.
Date of Issue/Publication	Reference Level; Date of upload
Description, Notes, Purpose	Reference Level; Make necessary edits to text in the reference for these two fields. Update years of data, reasons for new reference, etc, as needed.
Permissions	Reference/Holding Level; Public, all
Description	Holding Level; "<Source> Land Cover <Measure>, <Geography> <YYYY>(<vYY> for NLCD only) (GeoTIFF)", where <Measure> is "Level 1", "Level 2", or "Natural Converted"

3. Add external, source data links (update url's as needed).
 - a. MRLC (<https://www.mrlc.gov/finddata.php>)
 - b. CCAP (<https://coast.noaa.gov/ccapftp/#/>)

Literature Cited

- Kineth, M. 2018. Maintenance and management of the landscape dynamics data viewer for use as part of the IMD Environmental Settings Protocol. Inventory & Monitoring Division Standard Operating Procedure NPS/IMD/SOP—2.11.18. National Park Service, Fort Collins, Colorado.
- Kineth, M. and L. Nelson. 2018. Publishing to Data Store. Inventory & Monitoring Division Standard Operating Procedure NPS/IMD/SOP—4.1.1. National Park Service, Fort Collins, Colorado.
- Nelson, L. and M. Kineth. 2018. Creating and maintaining data services for the IMD Environmental Settings Monitoring Protocol. Inventory & Monitoring Division Standard Operating Procedure NPS/IMD/SOP—4.1.2. National Park Service, Fort Collins, Colorado.

Appendix 1: Data Availability and Known Issues

Data availability

NLCD land cover and imperviousness is available for CONUS, Alaska, and Puerto Rico. C-CAP land cover is available for the coastal areas of the continental U.S, the US Virgin Islands and for Hawaii, Guam, American Samoa, and the Commonwealth of Northern Mariana Islands.

Additional issues

NLCD data contain different thematic classifications for CONUS vs. Alaska data. Also, C-CAP thematic content differs between Hawaii and US Virgin Island and other Pacific Islands, and each geography has a specific reclass table for each land cover metric.

NLCD-based land cover pixels for Open Water extend off shore for a distance in coastal areas. For areas of analysis in these locations, the area summary for this thematic class will be inflated somewhat and the percent area values will be skewed between classes. This may or may not affect use of these data for management and decision making purposes.

NLCD data is provided from MRLC with the spatial reference Albers_Equal_Area_Conical (NAD83 Datum). This spatial reference name is not explicitly defined within ESRI ArcGIS software. If a re-projection is attempted (to USA Contiguous Albers Equal Area Conic USGS (NAD83)), there will be no change to the source as ArcGIS interprets the two projections to be the same. See Appendix 2 for more on Spatial Reference issues.

Appendix 2: Example Reclassification Tables

Level2_2001v11_Reclass					
	OBJECTID *	FROM_VAL	TO_VAL	OUT_VAL	CLASSNAME
▶	1	11	11	11	Open Water
	2	12	12	12	Perennial Snow/Ice
	3	21	21	21	Developed, Open Space
	4	22	22	22	Developed, Low Intensity
	5	23	23	23	Developed, Medium Intensity
	6	24	24	24	Developed, High Intensity
	7	31	31	31	Barren Land
	8	41	41	41	Deciduous Forest
	9	42	42	42	Evergreen Forest
	10	43	43	43	Mixed Forest
	11	52	52	52	Shrub/Scrub
	12	71	71	71	Herbaceous
	13	81	81	81	Hay/Pasture
	14	82	82	82	Cultivated Crops
	15	90	90	90	Woody Wetlands
	16	95	95	95	Emergent Herbaceous Wetlands
	17	51	51	51	Dwarf Scrub
	18	72	72	72	Sedge/Herbaceous
	19	73	73	73	Lichens
	20	74	74	74	Moss

Figure 1. Example reclass table, Level2_2001v11_Reclass (NLCD)

Level2_RasterDisplay									
	OBJECTID *	Value	Red	Green	Blue	R	G	B	CLASSNAME
▶	1	0	0	0	0	0	0	0	Unclassified
	2	11	0.28	0.42	0.63	71	107	161	Open Water
	3	12	0.82	0.87	0.98	209	222	250	Perennial Snow/Ice
	4	21	0.87	0.79	0.79	222	201	201	Developed, Open Space
	5	22	0.85	0.58	0.51	217	148	130	Developed, Low Intensity
	6	23	0.93	0	0	237	0	0	Developed, Medium Intensity
	7	24	0.67	0	0	171	0	0	Developed, High Intensity
	8	31	0.7	0.68	0.64	178	173	163	Barren Land
	9	41	0.41	0.67	0.39	105	171	99	Deciduous Forest
	10	42	0.11	0.39	0.19	28	99	48	Evergreen Forest
	11	43	0.71	0.79	0.56	181	201	143	Mixed Forest
	12	52	0.8	0.73	0.49	204	186	125	Shrub/Scrub
	13	71	0.89	0.89	0.76	227	227	194	Herbaceous
	14	81	0.86	0.85	0.24	219	217	61	Hay/Pasture
	15	82	0.67	0.44	0.16	171	112	41	Cultivated Crops
	16	90	0.73	0.85	0.92	186	217	235	Woody Wetlands
	17	95	0.44	0.64	0.73	112	163	186	Emergent Herbaceous Wetlands
	18	51	0.65	0.55	0.19	160	140	48	Dwarf Shrub
	19	72	0.79	0.79	0.47	202	202	120	Sedge/Herbaceous
	20	73	0.72	0.84	0.02				Lichens
	21	74	0.47	0.68	0.58	120	174	148	Moss

Figure 2. Example Colormap (raster display) table, Level2_RasterDisplay (NLCD)

Appendix 3: Spatial Reference Details

For NLCD, the 2011 version datasets use the following spatial reference:

USA_Contiguous_Albers_Equal_Area_Conic_USGS_version

In the ESRI/ArcGIS Coordinate System nomenclature, this is SRID 102039 (in ArcGIS, WKID 102039). In spatialreference.org (the global authority for spatial references), this spatial reference is [SR-ORG:7480](https://spatialreference.org/ref/esri/102039/). The projection parameters in ESRI WKT format are:

```
PROJCS["USA_Contiguous_Albers_Equal_Area_Conic_USGS_version",GEOGCS["GCS_North_American_1983",DATUM["D_North_American_1983",SPHEROID["GRS_1980",6378137.0,298.257222101]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.017453292519943295]],PROJECTION["Albers"],PARAMETER["False_Easting",0.0],PARAMETER["False_Northing",0.0],PARAMETER["Central_Meridian",-96.0],PARAMETER["Standard_Parallel_1",29.5],PARAMETER["Standard_Parallel_2",45.5],PARAMETER["Latitude_Of_Origin",23.0],UNIT["Meter",1.0]]
```

Human-readable OGC WKT format is:

```
PROJCS["USA_Contiguous_Albers_Equal_Area_Conic_USGS_version",  
  GEOGCS["GCS_North_American_1983",  
    DATUM["D_North_American_1983",  
      SPHEROID["GRS_1980",6378137.0,298.257222101]],  
    PRIMEM["Greenwich",0.0],  
    UNIT["Degree",0.0174532925199433]],  
  PROJECTION["Albers"],  
  PARAMETER["False_Easting",0.0],  
  PARAMETER["False_Northing",0.0],  
  PARAMETER["Central_Meridian",-96.0],  
  PARAMETER["Standard_Parallel_1",29.5],  
  PARAMETER["Standard_Parallel_2",45.5],  
  PARAMETER["Latitude_Of_Origin",23.0],  
  UNIT["Meter",1.0],  
  AUTHORITY["ESRI","102039"]]
```

In October of 2014, NLCD released an amended version of the land cover products which use this spatial reference:

albers_equal_area

In the ESRI/ArcGIS Coordinate System nomenclature, the name is Albers_Conical_Equal_Area which may be SRID 102003. However, the ArcGIS projected coordinate system document (<install folder>\ArcGIS\Desktop10.3\Documentation\projected_coordinate_systems.pdf) does not list a spatial reference with the Albers_Conical_Equal_Area name.

In spatial reference, the albers_equal_area spatial reference is [SR-ORG:8073](#). The parameters appear to be identical to ESRI SRID 102039. The projection parameters in ESRI WKT format are:

```
PROJCS["Albers_Conical_Equal_Area",GEOGCS["GCS_North_American_1983",DATUM["D_North_American_1983",SPHEROID["GRS_1980",6378137.0,298.257222101]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.017453292519943295]],PROJECTION["Albers"],PARAMETER["false_easting",0.0],PARAMETER["false_northing",0.0],PARAMETER["central_meridian",-96.0],PARAMETER["standard_parallel_1",29.5],PARAMETER["standard_parallel_2",45.5],PARAMETER["latitude_of_origin",23.0],UNIT["Meters",1.0]]
```

Human-readable OGC WKT format is:

```
PROJCS["Albers_Conical_Equal_Area",
  GEOGCS["GCS_North_American_1983",
    DATUM["D_North_American_1983",
      SPHEROID["GRS_1980",6378137.0,298.257222101]],
    PRIMEM["Greenwich",0.0],
    UNIT["Degree",0.0174532925199433]],
  PROJECTION["Albers"],
  PARAMETER["false_easting",0.0],
  PARAMETER["false_northing",0.0],
  PARAMETER["central_meridian",-96.0],
  PARAMETER["standard_parallel_1",29.5],
  PARAMETER["standard_parallel_2",45.5],
  PARAMETER["latitude_of_origin",23.0],
  UNIT["Meters",1.0]]
```