A New Map of Global Ecological Land Units

Roger Sayre, Ph.D.
Senior Scientist for Ecosystems
U.S. Geological Survey
rsayre@usgs.gov

Dawn Wright, Ph.D.
Chief Scientist
dwright@esri.com

Charlie Frye, M.A.
Chief Cartographer

Randy Vaughan, Ph.D.
Content Engineering Lead

Peter Aniello, M.E.
Content Engineering Team

Sean Breyer
ArcGIS Content Lead
Esri

Ecological Society of America Centennial Meeting, August 13, 2015, Baltimore, MD
The work to produce the map and data was commissioned by the Group on Earth Observations, a consortium of almost 100 nations collaborating to build the Global Earth Observation System of Systems (GEOSS). The global ecosystem mapping task, as defined here, is a key program within the GEO Biodiversity Observation Network (GEO BON) and the GEO Ecosystems Initiative (GEO ECO). And I would like to just read the task description for you.

The goal is to provide a web enabled framework of data, tools and workflows that will be used to create and publish authoritative physiographic and ecological land classifications of the earth's surface at several scales. Scientists, managers, and planners will be able to use the framework to update and evolve classifications as new data becomes available. The tools and maps will be publicly available to support the wise use of the planet's natural resources and the preservation of environmental resilience.
So why do we need a global ecosystem map anyway? Such a map, and more importantly, the data, will provide scientific support for planning and management, and enable understanding of impacts to ecosystems from climate change and other disturbances. The map and data should also prove useful as an ecologically meaningful spatial accounting framework for assessments of the economic and social values of ecosystem goods and services.

- Should aid in REPEATABLE landscape mgmt - a platform for geo-accounting (instead of reducing so much by national boundaries, we are using real ecological units)

A standard repeatable accounting framework

A global view of environmental diversity

Ecosystems defined by humans for humans as opposed to ecosystem HEALTH, a healthy ecosystem vs a service that the ecosystem provides - the next level to resilient ecosystems rather than ecosystem services
Research goal in future? what are the indicators that if merged together in a better way would provide better services; one can still be SICK and provide services
Example – indicators may be relative to the status of the fish stock but not indicators as to how the ecosystem is working.

Specific needs include:
• Assessments of Economic and Social Value of Ecosystem Goods and Services
• Biodiversity Conservation Planning
• Analysis of Climate Change Impacts to Ecosystems (and other impacts e.g. fire, invasive species, land use, etc.)
• Resource Management
• Research
At the outset, this is an ecological LAND classification that focuses on the physical system in which Water, Energy, and Matter cycle through the elements of ecosystem structure, which in turn give rise to ecological processes and biotic distribution.

Energy = sunlight and temperature
Matter = substrate, nutrients, biomass

**Bioclimte, Landform, and Lithology = Drivers of Ecological Character (physical setting)**
**Land Cover = Response to the Physical Setting**
Ecological Land Classification … not Ecological Classification

Biomes

Ecoregions

Ecosystems

Natural Communities

Species

Genes
Data Sources
(in order of ecological importance)

- Global Environmental Stratification (GEnS), U. of Edinburgh
- USGS GMTED 2010
- Global Lithological Map (GLiM), Hamburg U.
- GlobCover 2009, European Space Agency

3,923 ELUs Mapped
Data Served as ArcGIS Online Content

- Landscape Ecologists
- Public
- Resource Managers
- Geodesign Planners

ArcGIS Online

- Workflows
- Data
- Tools

esriurl.com/landscape

rmgsc.cr.usgs.gov/outgoing/ecosystems/Global
48,872 unique combinations aggregated to 3923 ELUs. In 2015 106,959 unique combos thanks to the updated land forms and land cover, 2010 epoch, Global Land Cover, v. 1.4

**Bioclimates, Landform, and Lithology = Drivers of Ecological Character (physical setting)**

**Land Cover = Response to the Physical Setting**

**Bioclimates - Global Environmental Stratification (GEnS), U. of Edinburgh**

- 50 year avg of temp/precip from met stations throughout world

**30 arc sec raster, down-sampled to 250 meter raster**

**Landforms – USGS - 250 meter raster, derived from GMTED2010**

**Surficial Lithology - Global Lithological Map (GLIM), Hamburg University, Vector Polygons converted to 250 meter raster**

**Land Cover - GlobCover, 2009, European Space Agency - MARIS satellite, 300 m rez resampled to 250 m**

- Working on version 2 with updated land cover, 2010 epoch, Global Land Cover, v. 1.4
- Only layer that we had an option: GlobCover 2009, GlobalLand30 or MDA’s NaturalVue
- GlobCover 2009 offered a richer, more flexible classification, which is compatible with USGS NLCD
- NaturalVue was too old.
- Both had significant quality issues relative to broad audience acceptance

Today, there are more options. Globeland30 continues to be improved. MDA has produced BaseVue

How did we make the map? Well, we define ecosystems as distinct physical environments and their associated vegetation, so we map ecosystems by first mapping, and then combining in a GIS, global bioclimates, global landforms, global geology, and global land cover.

1. Characterize the principle ecological land components of the terrestrial surface of the earth in a micro-scale, bottom-up, hierarchical classification process.

2. Subdivide the land surface of the earth into macro-scale physiographic (geomorphological) areas in a top-down, hierarchical regionalization process.

3. Combine the physiographic regionalization process with the ecological classification process to develop a hierarchical, ecophysiographic segmentation of the planet.
- The map is important but so too are the underlying data for unlocking the full potential.
- So we are releasing these data in our geospatial content mgmt system called ArcGIS Online, also known as the Facebook of geography and maps – see esriurl.com/landscape
  (In the spirit of “New ecosystems data for everybody”)
- We seek to be interoperable with EcolInforma with our focus on land surface and at a global scale, as well as with climate.data.gov, ecosystems.data.gov, etc. All playing well together thanks to the power of web services.
  Archival data on an ftp site ok but results in wasted time for everyone who must: download & preprocess, just to find out whether they need the data.
  Fails to reach the vast majority of potential users
- As an alternative we offer ready-to-Use GIS Content as services - Consistently curated raster properties

We want users to drive the improvement of underlying data inputs and create the analysis models.

We want users to augment with additional data sources
And of course users will define the value of the ecological process

- New thematic maps can be derived FROM these data.
- Again, this should aid in REPEATABLE landscape mgmt - a platform for geo-accounting (instead of reducing so much by national boundaries we are using real ecological units)
Explore a Tapestry of World Ecosystems

The United States Geological Survey has published a new global ecosystems map of unprecedented detail.

The map was produced by a team led by Roger Sayre, Ph.D., Senior Scientist for Ecosystems at the USGS Land Change Science Program. It is a mosaic of almost 4,000 unique ecological areas called Ecological Land Units (ELUs) based on four factors that are key in determining the makeup of ecosystems. Three of these—bioclimate, landforms,
Jay Jensen of the White House CEQ underscored the importance of telling stories at ACES 2014. Here we present a STORY MAP. This is one of the initial “value added” applications that we have developed to help people more fully understand the project— see esriurl.com/elu
For policy-makers in the audience this should aid in seeing how this project directly helps you to implement recommendations in the PCAST report on Sustaining Environmental Capital
Within the pages of this story you may also notice that although ecosystems services can be delivered, the system can still be quite sick. Therefore ecosystem HEALTH is an important factor. Hence an additional point to think on as you explore the story map: ecosystem services derived by humans for humans vs. ecosystem health
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This Story Map Journal has two main features, an ecosystems browser and an ecosystem tour.

In the ecosystem browser, opposite, point and click at any location on the map and the name of that ecosystem appears in a pop-up box. In general, tans are deserts, yellows and light greens are savannas, darker greens are forests, mountainous regions have texture, reddish is warm and bluish is cold. The browser includes pan and zoom functions.

The ecosystem tour starts on the next page of this map journal. It features places on Earth where the diversity of Ecological Facets (EFs), the building blocks of ELUs, is highly concentrated in an area. The world is divided up into 3.5 billion cells, each one 250 meters on a side, and each of these cells represents one of 47,500 types of EFs. The areas described in the following pages are all locations with relatively high numbers of EFs. While these are areas of high ecological landscape diversity, they are not necessarily areas of high biodiversity. Many EFs have naturally low species diversity, or have been heavily modified by human activity. The areas in the ecosystem tour below include many interesting and beautiful locations that are widely scattered across our hugely diverse planet.

Click on the map at left to see the Ecological Land Unit at that location. Pan and zoom for detail. Scroll down to take a tour of areas with high ecological landscape diversity.

Sweetwater Mountains  CALIFORNIA, UNITED STATES

- Click on underlined titles below to view thematic maps.
Sweetwater Mountains, California, United States

- Bioclimatic Type: Cold Moist
- Landform: Low Mountains
- Rock Type: Basic Plutonics
- Land Cover: Closed Needleleaf Evergreen Forest

This small area of Mack Canyon in the Sweetwater Mountains, California, ranges in climate from very cold wet to cold semi-dry. Mean annual precipitation in the Sweetwater Mountains ranges widely, from 10 to 30 inches. Geology is also diverse in the Sweetwater Mountains, it largely consists of a pluton surrounded by igneous flow from the Little Walker Caldera. Vascular plants are in transition between the Sierra Nevada and Great Basin floras, numbering more than 1,100 taxa. The Mack Canyon area is 30% evergreen forest, which may consist of Curleaf mountain-mahogany, Jeffrey pine, Limber pine, Pinyon and Juniper. The remainder of the area are made up by mosaics of different quantity combinations of forest, shrubland, broadleaved forest, and herbaceous vegetation.

Hüsamlar, Turkey

- Bioclimatic Type: Hot Wet
- Landform: Hills
- Rock Type: Siliciclastic Sedimentary Rock
- Land Cover: Mosaic Cropland/vegetation

Return to Ecological Land Unit map.
Value-Added Apps

Explore the Ecological Tapestry of the World

To start:
Clicking on the map will display information about ecological structure based on a framework of foundational data at 250-meter resolution using an objective data-driven classification. Use this map to understand global ecological patterns and processes for wise planning and use of natural resources.

Learn more

esriurl.com/ecotapestry
To start:

Clicking on the map will display information about ecological structure based on a framework of foundational data at 250-meter resolution using an objective data driven classification. Use this map to understand global ecological patterns and processes for wise planning and use of natural resources.

Learn more
Explore the Ecological Tapestry of the World
Explore the Ecological Tapestry of the World

- Bioclimates + Warm Wet
- Landforms + Flat Plains
- Rock Type + Metamorphics
- Land Cover + Closed (>40%) needleleaf evergreen forest (>5m)

Ecological Name: Warm Wet / Flat Plains / Metamorphics / Closed (>40%) needleleaf evergreen forest (>5m)

“This app shows how climate change is affecting the world around you.” – *Time*

https://shar.es/1tJj9K
“This app shows how climate change is affecting the world around you.” – *Time*
See the Map & Apps in the Exhibit Hall
Enter Hall, Immediate Left, Go to End Corner
URLs

**AGOL Data**: esriurl.com/landscape
**Raw Data**: rmgsc.cr.usgs.gov/outgoing/ecosystems/Global/
**Story Map app**: esriurl.com/elu
**EcoTapestry app**: esriurl.com/ecotapestry
**Field Notes-Earth app**: iTunes or Google Play
**Anchor pub**: www.aag.org/global_ecosystems
**White paper**: esriurl.com/eluwhite

Dawn Wright, dwright@esri.com
Analyzing ecological land units to improve understanding of landscape composition

Charlie Frye,
Esri, Redlands, California
Overview

Topics

• Introduce concepts
  - Image Services
  - Analysis extent
  - Avoiding data loss from unnecessary transformations

• Make Image Server Layer tool

• Ecological Characterization of Polygons
  - Example output
  - Future Work
Using Image Services in Analysis Workflows
Stored in the Cloud, used exactly like data on your hard drive

- Imagery in the **Living Atlas**
  on ArcGIS.com
  - Available with your ArcGIS License
  - 100s of Ready-to-Use Layers
- Analysis Workflow varies slightly from Visualization (default) Workflow
  - Define Layer to use Server-Side Processing
  - Geoprocessing Environment Settings Define Context
Analyze Image Server Layers in ArcMap

Demo
Find the Imagery Layer to use

Step 1

Map Contents

World Ecophysiographic Facets 2015

Create an ArcGIS Server Connection

Step 2

http://landscape7.arcgis.com/arcgis
Create Image Server Layer to Use in Workflow

Step 3

A

B

C
Automate With Python Demo
Initial Example Characterizations

- **Sequoia National Forest** - 28% of this area is cool and moist, and 16% is cold and wet, 12% is cool and wet, 20% is cool and semi dry, 16% is warm and semi-dry. 94% of the region is high mountains. 83% of the lithology is comprised of acid plutonics, while 11% is metamorphics. 77% of the land cover is covered by broadleaved and needle-leaved trees, 13% is grassland.

- **Sequoia National Park** - 33% of this area is very cold and wet, and 28% is cold and wet, 10% is cool and wet. 100% of the landforms are high mountains. 89% of the lithology is comprised of acid plutonics. 56% of the land cover is covered by broadleaved and needle-leaved trees, and 38% is shrubland.

- **Adirondack National Park** - 49% of this area is cold and very wet, and 44% is cold and wet. 42% of the land is scattered low mountains, while 15% is high hills, 21% is low mountains. 79% of the lithology is comprised of metamorphics, 10% is unconsolidated sediment. 61% of the land cover is covered by trees, broadleaved, deciduous, closed (>40%), 13% is broadleaved and needle-leaved trees.

- **Yosemite National Park** - 46% of this area is cold and wet, while 31% is very cold and wet, 16% is cool and wet. 97% of the landforms are high mountains. 83% of the lithology is comprised of acid plutonics, 12% is unconsolidated sediment. 60% of the land cover is covered by broadleaved and needle-leaved trees, 33% is shrubland.
More Examples

- **Arica, Chile** - 33% of this area is warm and very dry, while 25% is very cold and semi-dry, 17% is cold and semi-dry, and 14% is cool and dry. 48% of the region is high mountains, but 24% is scattered high mountains. 32% of the lithology is comprised of unconsolidated sediment, while 12% is siliciclastic sedimentary rock, 18% is pyroclastics, and 21% is acid volcanics. 64% of the land cover is covered by bare ground, while 12% is shrubland, and 19% is sparse vegetation.

- **Birobidzhan, Siberia** - 84% of this region is cool and wet, but 15% is cold and wet. 44% of the landforms are flat or nearly flat plains, while 20% is low mountains, and 20% is scattered low mountains. 50% of the lithology is comprised of unconsolidated sediment, while 10% is mixed sedimentary rock, 17% is acid plutonics, and 12% is metamorphics. 40% of the land cover is covered by grassland, while 29% is closed to open broadleaved deciduous forest, and 12% is mixed broadleaved and needleleaved forest.

- **Graubunden, Switzerland** - 67% of this area is cold and very wet, but 26% is very cold and very wet. 99% of the region is high mountains. 33% of the lithology is comprised of carbonate sedimentary rock, while 19% is unconsolidated sediment, and 30% is metamorphics. 28% of the land cover is covered by closed to open needleleaved evergreen forest, while 12% is rainfed cropland, 23% is grassland, and 12% is bare ground.
And more…

- **Serengeti National Park** - *94% of this area is hot and moist.* 33% of the region is high hills, while 16% is low mountains, 13% is scattered low mountains, and 20% is flat or nearly flat plains. *71% of the lithology is comprised of metamorphics, but 20% is siliciclastic sedimentary rock.* 37% of the landcover is covered by rainfed cropland, while 33% is shrubland, and 20% is grassland.

- **Modoc County, California** - *95% of this area is cool and semi dry.* 18% of the region is scattered low mountains, while 15% is high hills, 14% is low mountains, 12% is high mountains, and 14% is flat or nearly flat plains. *59% of the lithology is comprised of basic volcanics, while 18% is unconsolidated sediment, and 11% is acid volcanics.* 48% of the landcover is covered by shrubland, while 28% is closed to open needleleaved evergreen forest, and 11% is grassland.

- **Sacramento County, California** - *100% of this area is warm and semi-dry.* 81% of the landforms are flat or nearly flat plains. *65% of the lithology is comprised of unconsolidated sediment, but 30% is siliciclastic sedimentary rock.* 47% of the land cover is covered by grassland, while 18% is rainfed cropland, and 28% is urban.

- **Santa Cruz County, California** - *64% of this area is warm and wet, while 12% is warm and semi-dry, and 23% is warm moist.* 48% of the region is low mountains, but 36% is scattered low mountains. *70% of the lithology is comprised of siliciclastic sedimentary rock, but 19% is unconsolidated sediment.* 69% of the land cover is covered by closed to open needleleaved evergreen forest, but 17% is grassland.

- **Alpine County, California** - *50% of this area is cold and wet, while 13% is very cold and wet, and 10% is cool and moist.* 92% of the land is high mountains. *52% of the lithology is comprised of acid plutonics, while 24% is acid volcanics, and 18% is basic volcanics.* 73% of the land cover is covered by closed to open needleleaved evergreen forest, but 17% is shrubland.

- **San Bernardino County, California** - *50% of this region is hot and dry, while 29% is warm and dry, and 15% is warm and semi-dry.* 33% of the region is scattered low mountains, while 28% is low mountains, and 13% is high mountains. *59% of the lithology is comprised of unconsolidated sediment, but 15% is acid plutonics.* 87% of the land cover is covered by shrubland.
Welcome to the R – ArcGIS Community

Combine the power of ArcGIS and R to solve your spatial problems

The R – ArcGIS Community is a community driven collection of free, open source projects making it easier and faster for R users to work with ArcGIS data, and ArcGIS users to leverage the analysis capabilities of R.

r-bridge-install
Python
Install the R ArcGIS Tools

r-bridge
C++
Bridge library to connect ArcGIS and R, including arcgis10interface R library

r-sample-tools
R
Sample tools illustrating R usage in geoprocessing scripts

BROWSE ON GITHUB

Need the R Statistical Software? Download it now.
Thank You
Contact information:

Charlie Frye
e-mail: cfrye@esri.com
Twitter: @Charlie_Frye

380 New York Street
Redlands, California 92373 USA