Opportunities to Develop an Interagency Spatial Hierarchy for ESD Applications

Presentation Outline

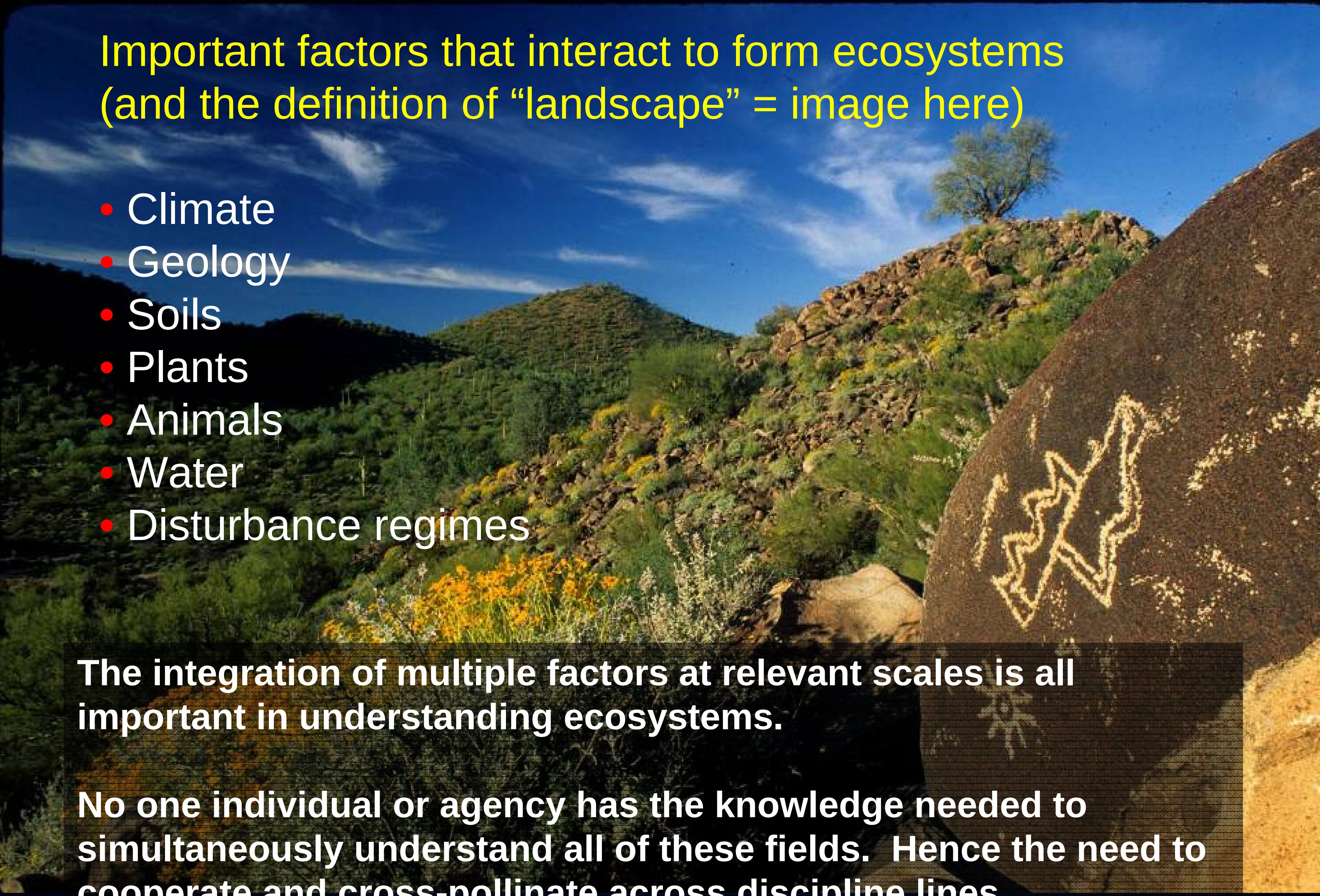
Brief history of ecological classification and mapping

What is a spatial hierarchy – concepts and examples

Simple comparison of different national systems

Opportunities to formalize and map upper levels of the ESD hierarchy while revising and fully cross-walking systems

Example of cross-scale interactions and need for multi-scaled analysis and monitoring



Important factors that interact to form ecosystems (and the definition of “landscape” = image here)

- Climate
- Geology
- Soils
- Plants
- Animals
- Water
- Disturbance regimes

The integration of multiple factors at relevant scales is all important in understanding ecosystems.

No one individual or agency has the knowledge needed to simultaneously understand all of these fields. Hence the need to cooperate and cross-pollinate across discipline lines.

Brief Background of Ecosystem Classification
Vegetative Component

The earliest scientific classification of vegetation is generally credited to Alexander von Humbolt (1807) who systematically classified vegetation types based on plant physiognomy.

Other early influential plant ecologists (Show 1822, Kerner 1895, Giesbach 1872, Drude 1890, Warming 1895 and Schimper 1903) also largely described vegetation based on similarities in physiognomy.

In Finland, Cajander (1909) identified forest types based on combinations of tree species and ground-flora communities.

Brief Background of Ecosystem Classification
Soil Component

In 1892, a new concept of soil was published by V.V. Dokuchaev in Russia (Glinka 1927, Vilenskii 1957).

Soils were conceived to be independent natural bodies resulting from interactions of climate, vegetation, parent materials, relief, and time.

In 1893, E.W. Hilgard extended this concept to soil science in the United States, emphasizing relationships between soils and climate.

Brief Background of Ecosystem Classification

The concepts underlying multifactor ecosystem classification began to emerge as early as 1789, when Alexander von Humboldt wrote that, "All natural bodies are interrelated. Find a certain type of soil and a certain type of plant and you will find a certain type of rock."

In the century following Alexander von Humboldt's observations, Gutrovich (1894) developed a system in Russia that classified different kinds of forests based on species composition and landscape topography.

Brief Background of Ecosystem Classification

During the 1920's, a study of site relationships was conducted in West Germany, eventually leading to the classification and inventory of the state of Baden-Wurttemburg.

The German system employed a regional hierarchy based upon climatic and physiographic influences, and a local hierarchy based upon topography, soil and ground-flora.

Multi-factor systems developed variously in different areas of the United States.

The Forest Service adopted these concepts and combined several systems when it developed the National Hierarchy of Ecological Units in 1993.

Spatial Hierarchy Concepts

Conditions and processes occurring across larger areas affect and often override those of smaller ecosystems, and the properties of smaller ecosystems emerge in the context of larger systems.

For example, a wetland embedded within a fire-prone landscape functions differently than one embedded within a fire-resistant landscape.

Moreover, environmental gradients affecting ecological patterns and processes change at different spatial scales, forming a natural spatial hierarchy.

Spatial Hierarchy

At continental and regional scales, ecosystem patterns correspond with climatic regions, which change mainly due to latitudinal, orographic, and maritime influences.

Within climatic regions, landforms modify macroclimate, and affect the movement of organisms, the flow and orientation of watersheds, and the frequency and spatial pattern of disturbance by fire and wind.

Within climatic - geomorphic regions, water, plants, animals, soils, and topography interact to form ecosystems at more local scales

Spatial Hierarchy

The challenge of ecosystem classification and mapping is to:

- Distinguish natural associations of ecological factors at relevant spatial scales

- Define ecological types or ESD's, and map ecological land units that reflect these different levels of organization

- Interpret the properties and dynamics of these systems for management.

NRCS-BLM-FS Ecological Site Description Handbook
Ecological Mapping Systems

Hierarchical Planning and Analysis Levels	National Hierarchical Framework of Ecological Units[1]	NRCS Soil Geography Hierarchy[3]
Continental and Region (Ecoregion)	Domain, Division, and Province (1:5,000,000-1:30,000,000)	Land Resource Region (LRR) (1:7,500,000), Climate zones
Subregion	Section (1:3,500,000) and Subsection (1:250,000)	Major Land Resource Area (MLRA) (1:3,500,000) Land Resource Unit (LRU)/Common Resource Area (CRA) (1:1,000,000) General Soil Map (1:250,000)
Landscape (watershed—5th unit of Hydrologic Unit Code)	Landtype Association (1:60,000)	Soil-geomorphic systems
Land Unit (subwatershed—6th unit of Hydrologic Unit Code), grazing allotment, farm/ranch)	Landtype (1:24,000)	Detailed Soil Map (1:24,000)
	Landtype Phase (1:12,000)	Soil Series (1:12,000)
Individual Sites	Sampling plot	Soil Pedon

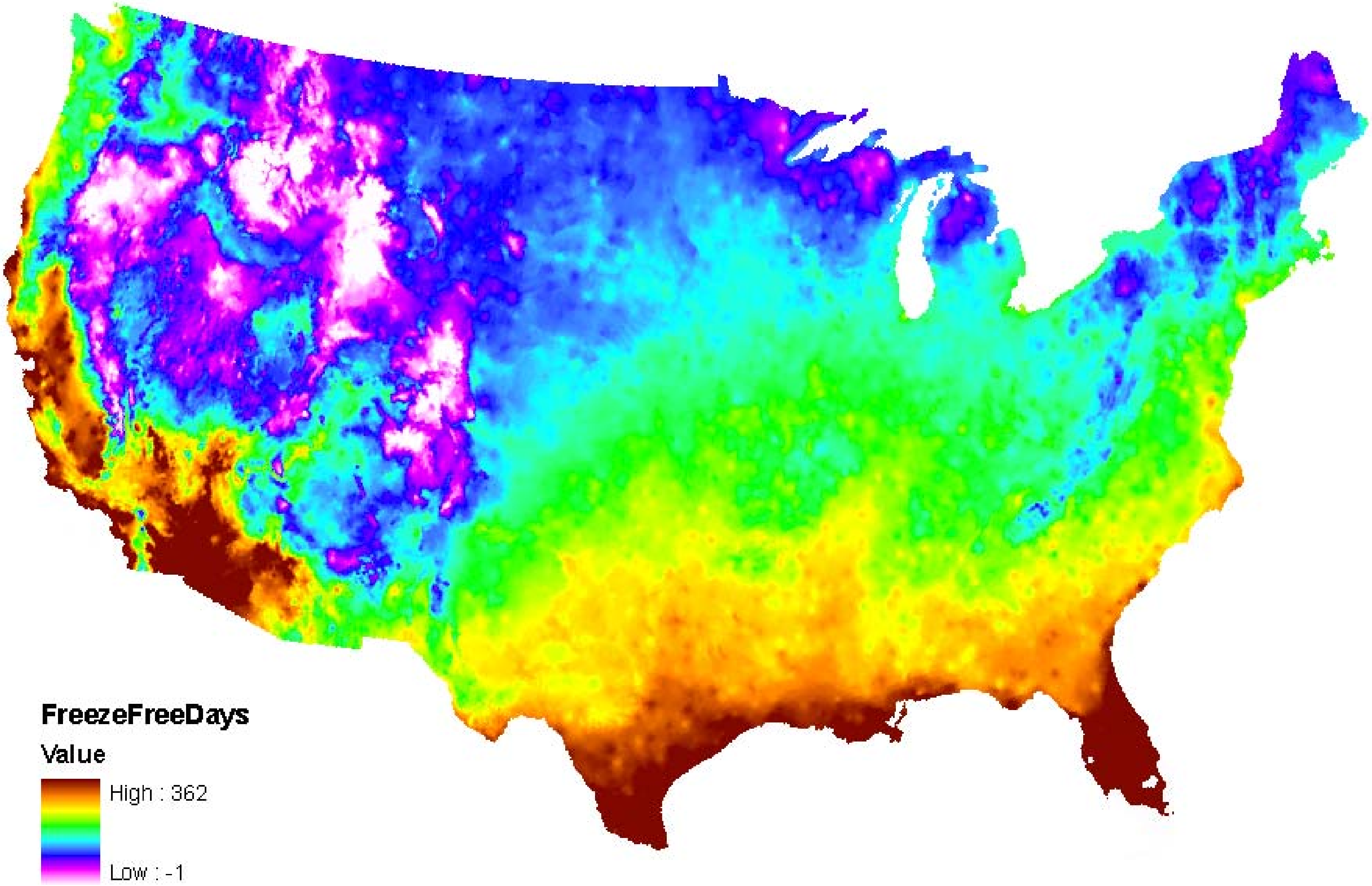
From: **Draft Interagency Ecological Site Handbook**

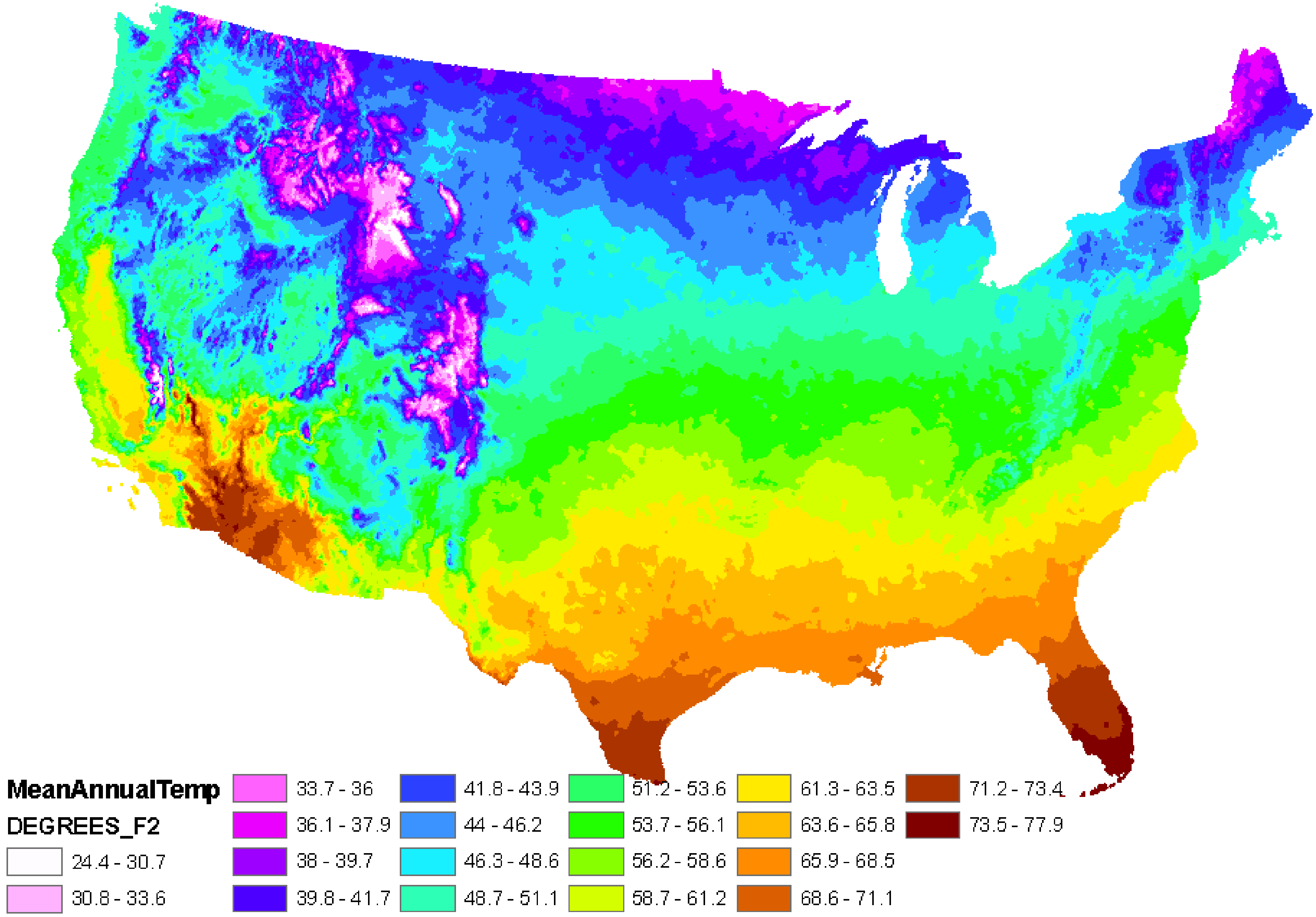
Overview of climatic gradients

Data Source

PRISM data (Parameter-elevation Regressions on Independent Slopes Model), developed by the Spatial Climate Analysis Service at Oregon State University.

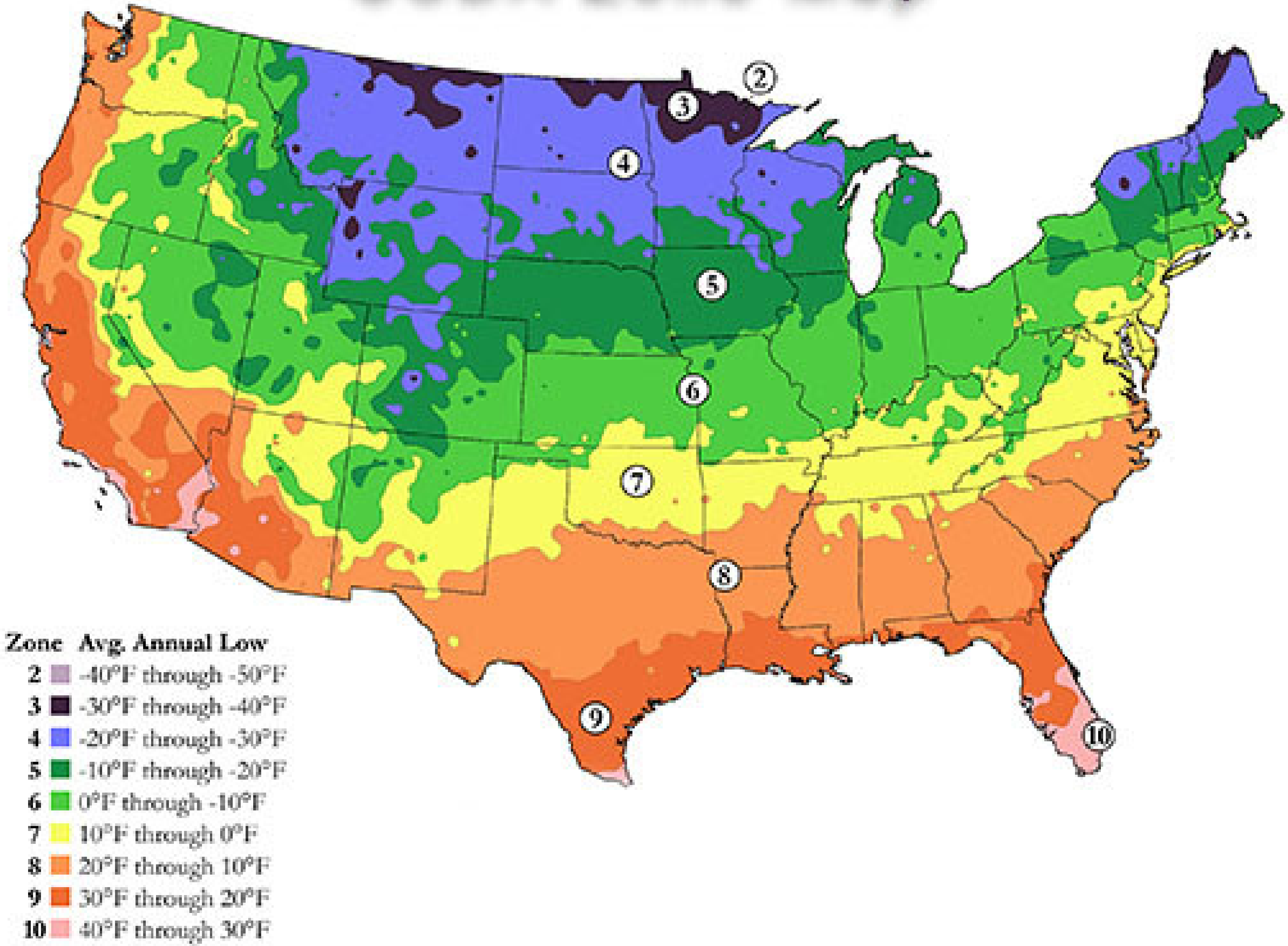
Based on a 30 year period (1961-1990), and a 16 year period (1991-2007) for estimating recent shifts in climatic regimes.

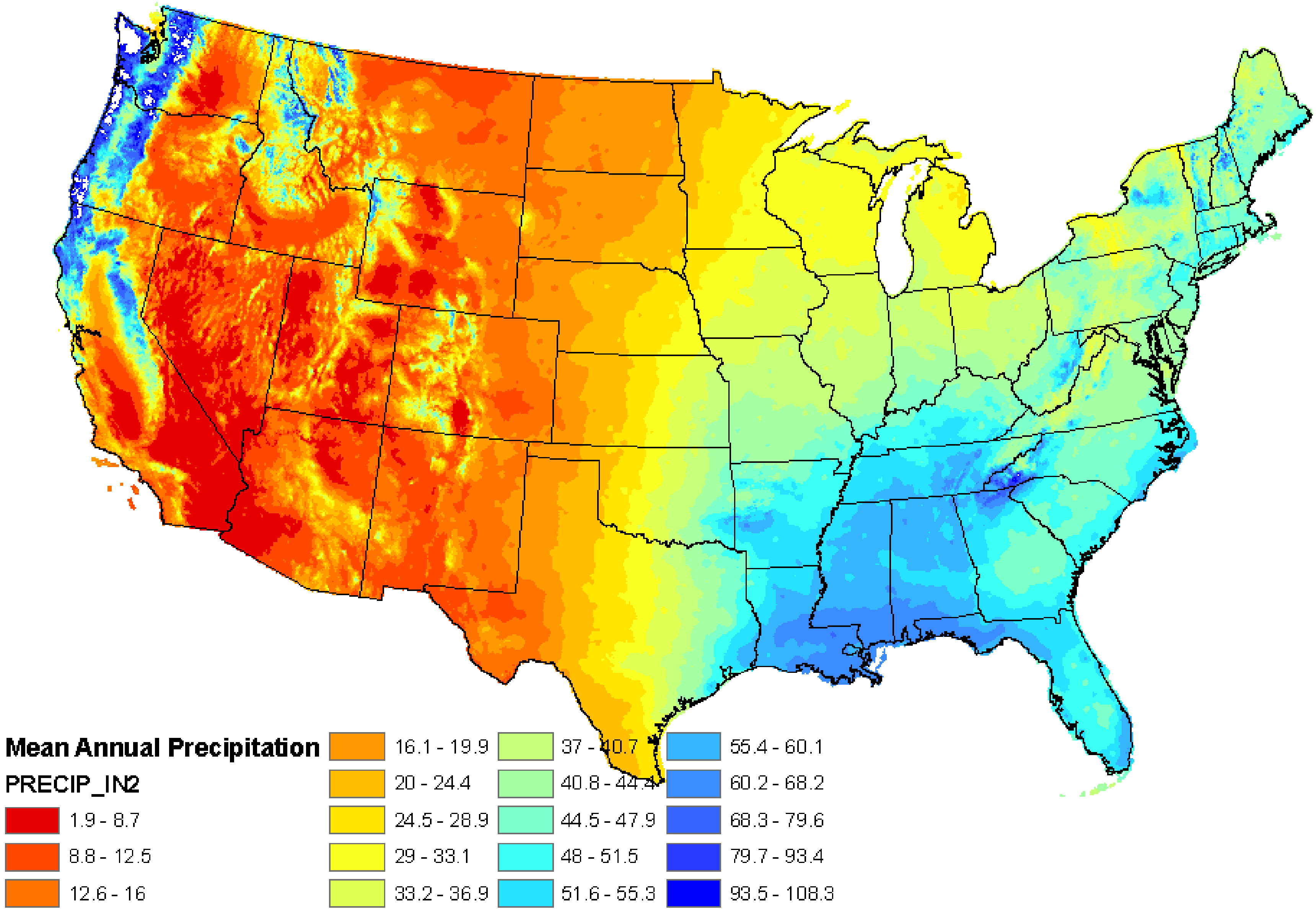

FreezeFreeDays
Value
High : 362
Low : -1



MeanAnnualTemp
DEGREES_F2
24.4 - 30.7
30.8 - 33.6
33.7 - 36
36.1 - 37.9
38 - 39.7
39.8 - 41.7
41.8 - 43.9
44 - 46.2
46.3 - 48.6
48.7 - 51.1
51.2 - 53.6
53.7 - 56.1
56.2 - 58.6
58.7 - 61.2
61.3 - 63.5
63.6 - 65.8
65.9 - 68.5
68.6 - 71.1
71.2 - 73.4
73.5 - 77.9

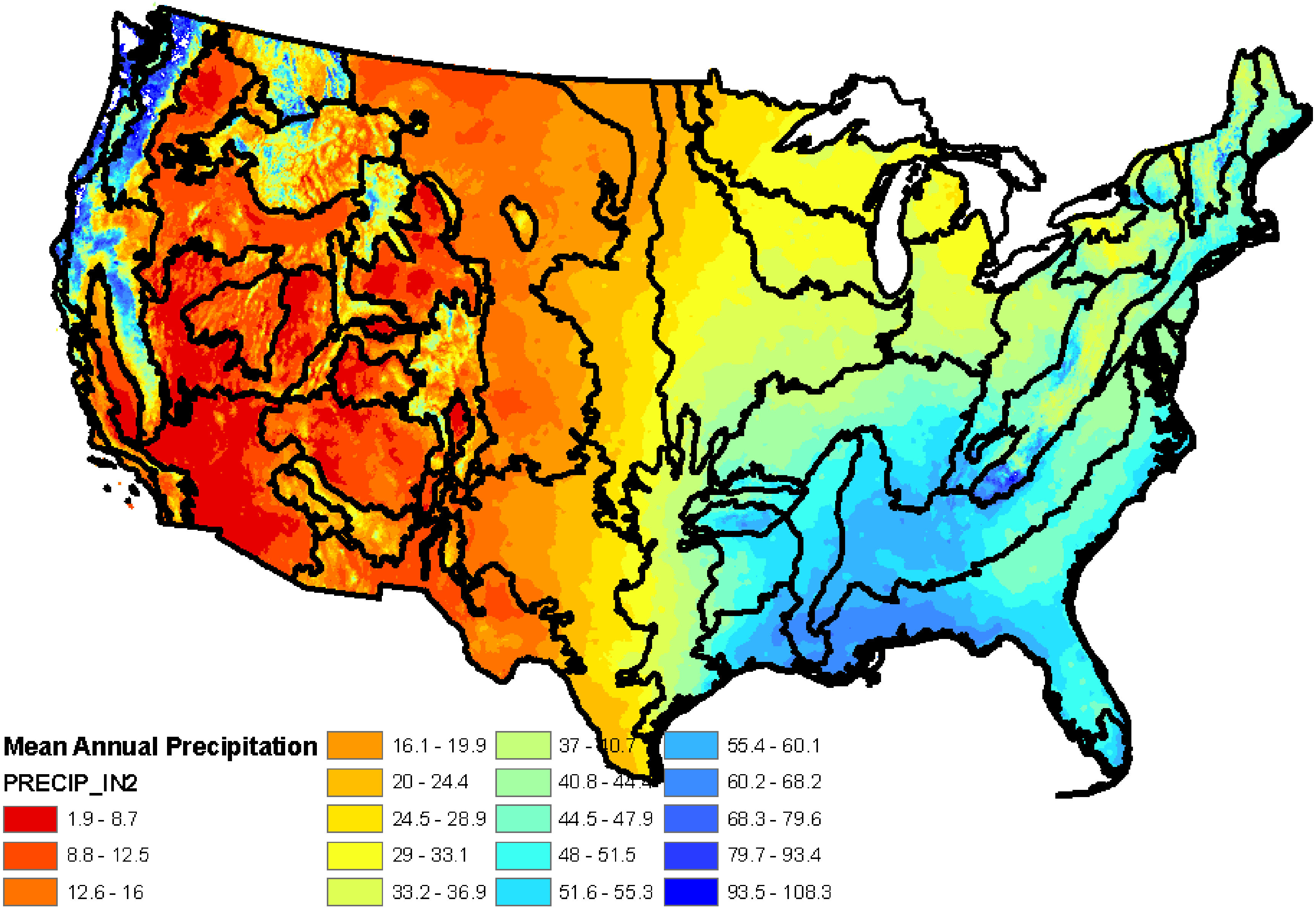
USDA Zone Map

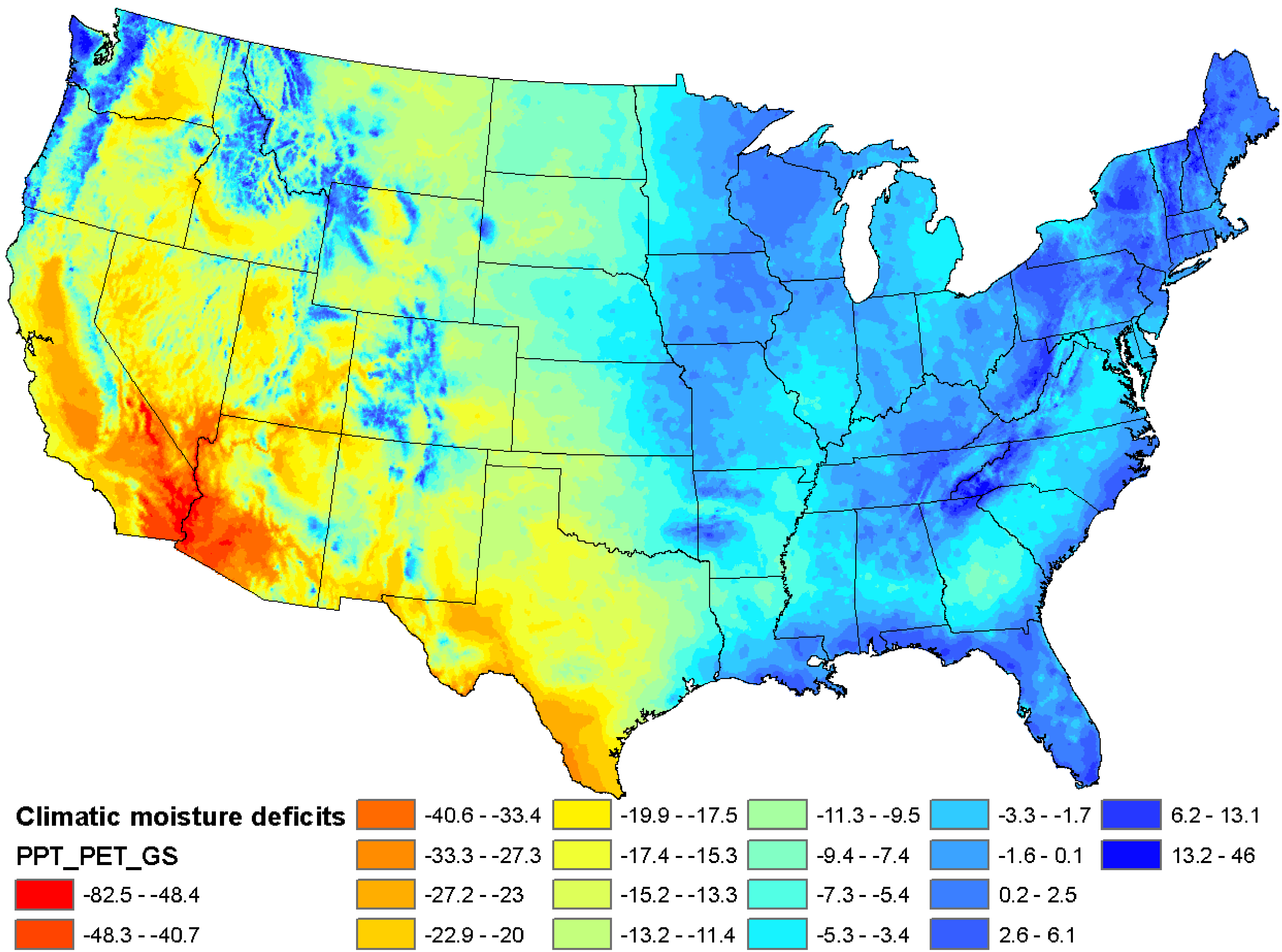




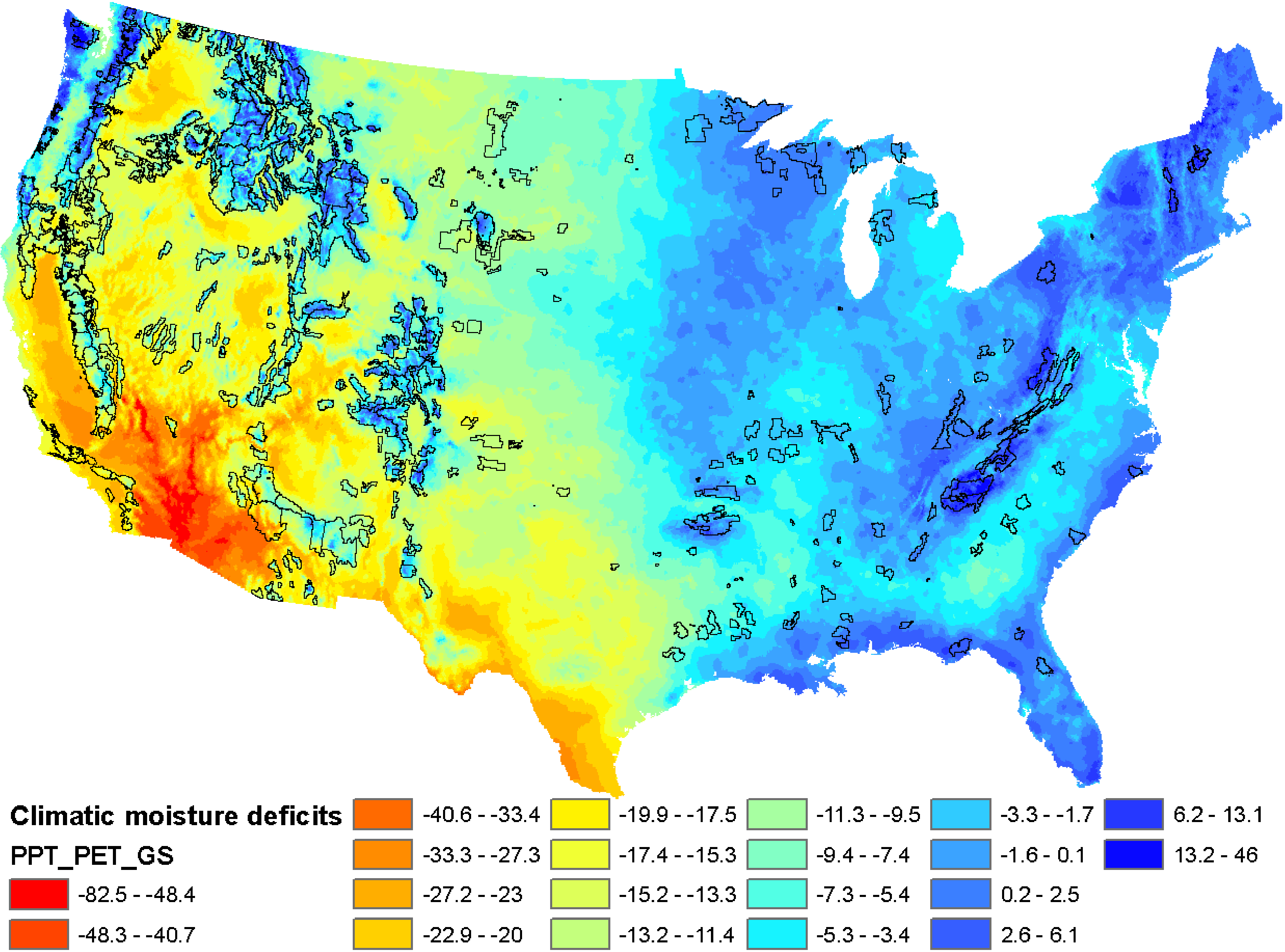
Mean Annual Precipitation
PRECIP_IN2
1.9 - 8.7
8.8 - 12.5
12.6 - 16
16.1 - 19.9
20 - 24.4
24.5 - 28.9
29 - 33.1
33.2 - 36.9
37 - 40.7
40.8 - 44.4
44.5 - 47.9
48 - 51.5
51.6 - 55.3
55.4 - 60.1
60.2 - 68.2
68.3 - 79.6
79.7 - 93.4
93.5 - 108.3

Mean Annual Precipitation and FS Provinces





Climatic moisture deficits
PPT_PET_GS
-82.5 - -48.4
-48.3 - -40.7
-40.6 - -33.4
-33.3 - -27.3
-27.2 - -23
-22.9 - -20
-19.9 - -17.5
-17.4 - -15.3
-15.2 - -13.3
-13.2 - -11.4
-11.3 - -9.5
-9.4 - -7.4
-7.3 - -5.4
-5.3 - -3.4
-3.3 - -1.7
-1.6 - 0.1
0.2 - 2.5
2.6 - 6.1
6.2 - 13.1
13.2 - 46


Climatic moisture deficits
PPT_PET_GS
-82.5 - -48.4
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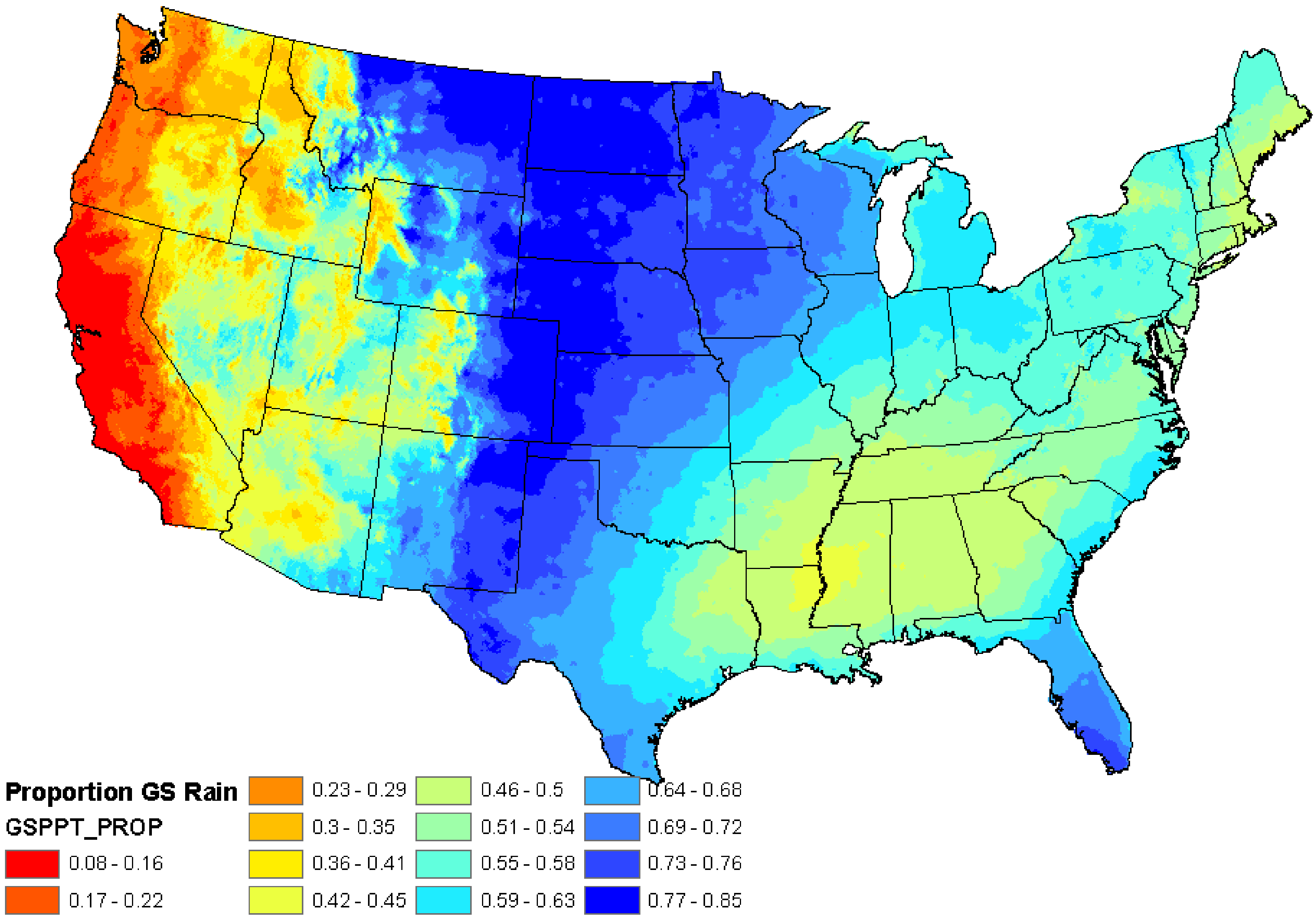
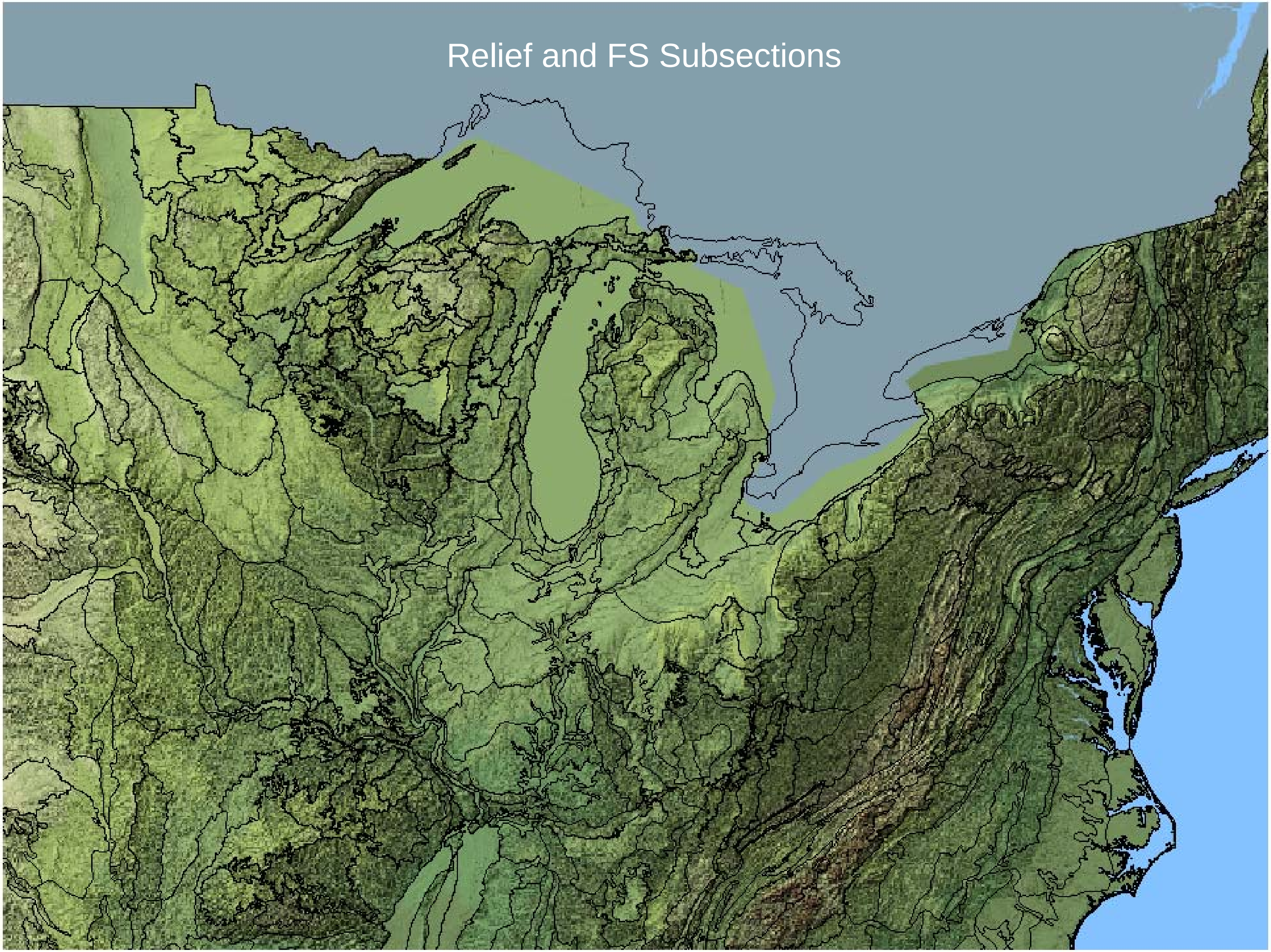
-40.6 - -33.4
-33.3 - -27.3
-27.2 - -23
-22.9 - -20
-19.9 - -17.5
-17.4 - -15.3
-15.2 - -13.3
-13.2 - -11.4
-11.3 - -9.5
-9.4 - -7.4
-7.3 - -5.4
-5.3 - -3.4
-3.3 - -1.7
-1.6 - 0.1
0.2 - 2.5
2.6 - 6.1
6.2 - 13.1
13.2 - 46


Proportion GS Rain
GSPPT_PROP
0.08 - 0.16
0.17 - 0.22
0.23 - 0.29
0.3 - 0.35
0.36 - 0.41
0.42 - 0.45
0.46 - 0.5
0.51 - 0.54
0.55 - 0.58
0.59 - 0.63
0.64 - 0.68
0.69 - 0.72
0.73 - 0.76
0.77 - 0.85

Physiography, bedrock geology, surficial geology

Need for expert interpretation in developing and interpreting Mid-level tiers of a spatial hierarchy

Relief and FS Subsections



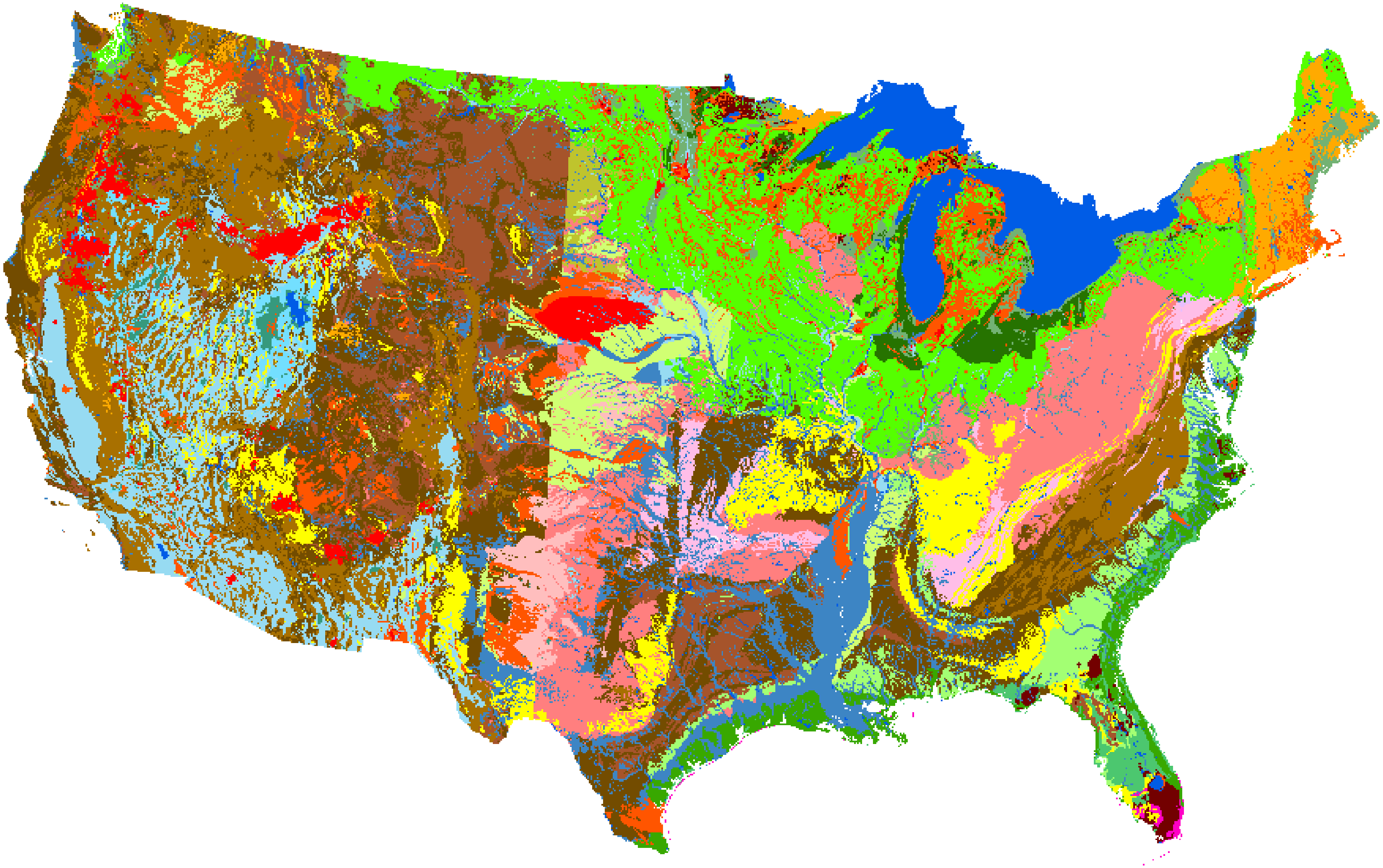
Surficial

<all other values>

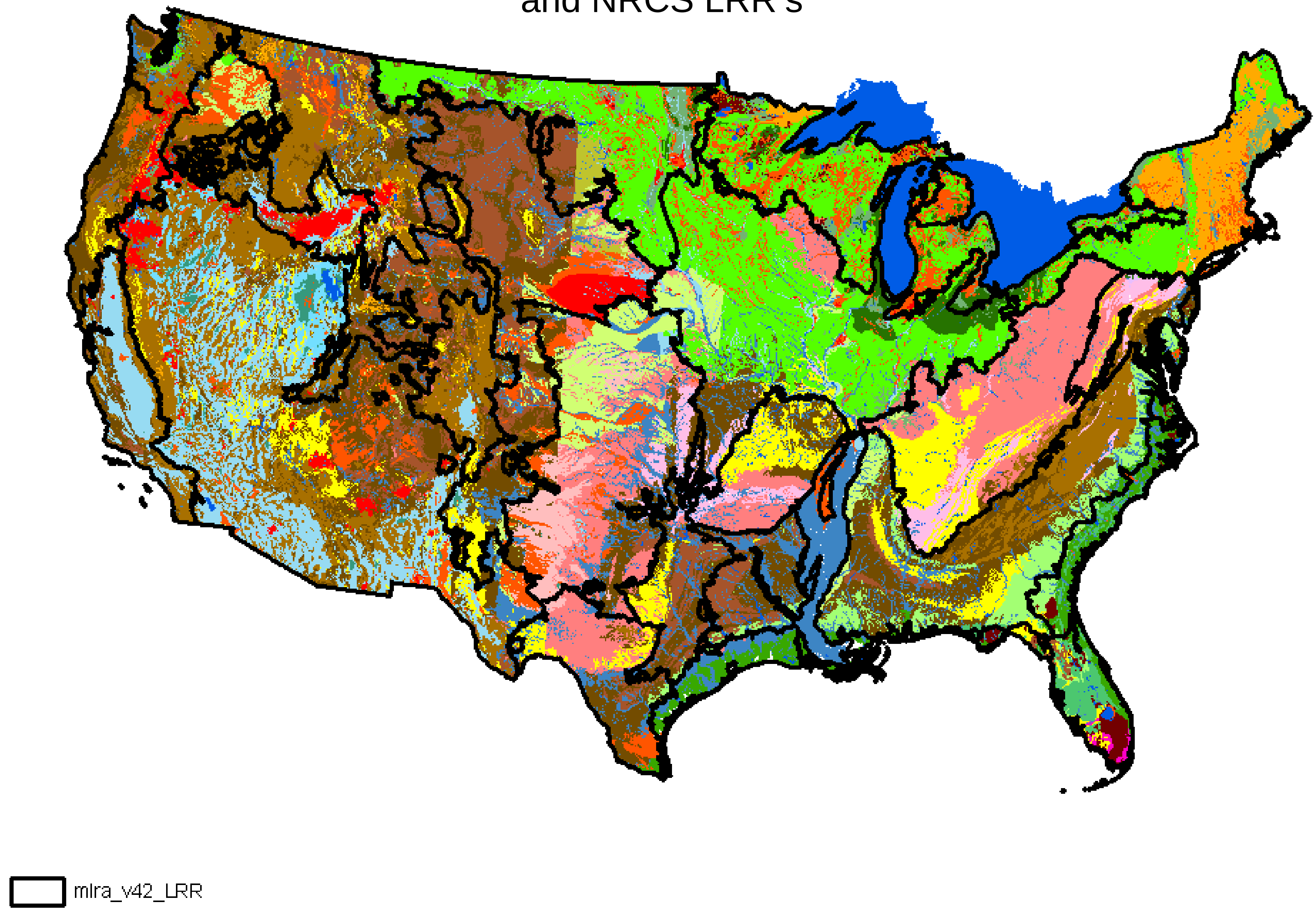
UNIT_NAME

- Alluvial sediments, thick
- Alluvial sediments, thin
- Basaltic and andesitic volcanic rocks
- Calcareous biological sediments
- Coastal zone sediments, mostly fine-grained
- Coastal zone sediments, mostly medium-grained
- Colluvial and alluvial sediments
- Colluvial sediments and loess
- Colluvial sediments and residual material
- Colluvial sediments, discontinuous
- Colluvial sediments, thin
- Eolian sediments on southern High Plains
- Eolian sediments, mostly dune sand, thick
- Eolian sediments, mostly dune sand, thin
- Eolian sediments, mostly loess, thick
- Eolian sediments, mostly loess, thin
- Glacial till sediments, mostly clayey, discontinuous
- Glacial till sediments, mostly clayey, thick
- Glacial till sediments, mostly clayey, thin
- Glacial till sediments, mostly sandy, discontinuous
- Glacial till sediments, mostly sandy, thin
- Glacial till sediments, mostly silty, discontinuous
- Glacial till sediments, mostly silty, thick
- Glacial till sediments, mostly silty, thin
- Glaciofluvial ice-contact sediments, mostly sand and gravel, discontinuous
- Glaciofluvial ice-contact sediments, mostly sand and gravel, thick
- Glaciofluvial ice-contact sediments, mostly sand and gravel, thin
- Lacustrine sediments
- Organic-rich muck and peat, thick
- Organic-rich muck and peat, thin
- Playa sediments
- Proglacial sediments, mostly coarse-grained, discontinuous
- Proglacial sediments, mostly coarse-grained, thick
- Proglacial sediments, mostly coarse-grained, thin
- Proglacial sediments, mostly fine grained, discontinuous
- Proglacial sediments, mostly fine grained, thick
- Proglacial sediments, mostly fine grained, thin
- Residual materials developed in alluvial sediments
- Residual materials developed in bedrock, discontinuous
- Residual materials developed in bedrock, thin
- Residual materials developed in bedrock, with alluvial sediments, discontinuous
- Residual materials developed in bedrock, with alluvial sediments, thin
- Residual materials developed in carbonate rocks, discontinuous
- Residual materials developed in carbonate rocks, thin
- Residual materials developed in fine-grained sedimentary rocks
- Residual materials developed in igneous and metamorphic rocks
- Residual materials developed in sedimentary rocks, discontinuous
- Residual materials developed in sedimentary rocks, thin
- Rhyolitic volcanic rocks
- Water

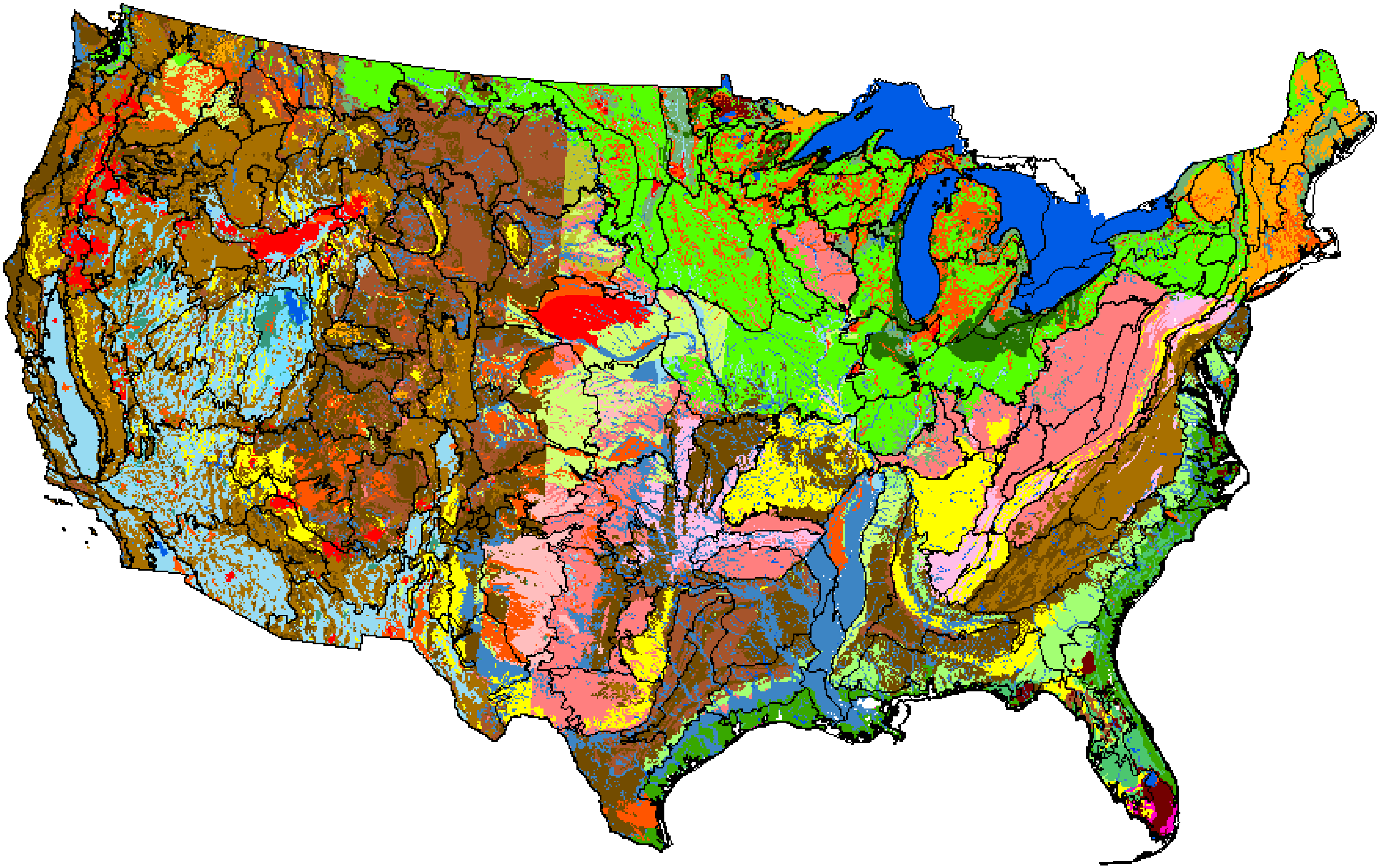
USGS Lithology 2010 (new data)



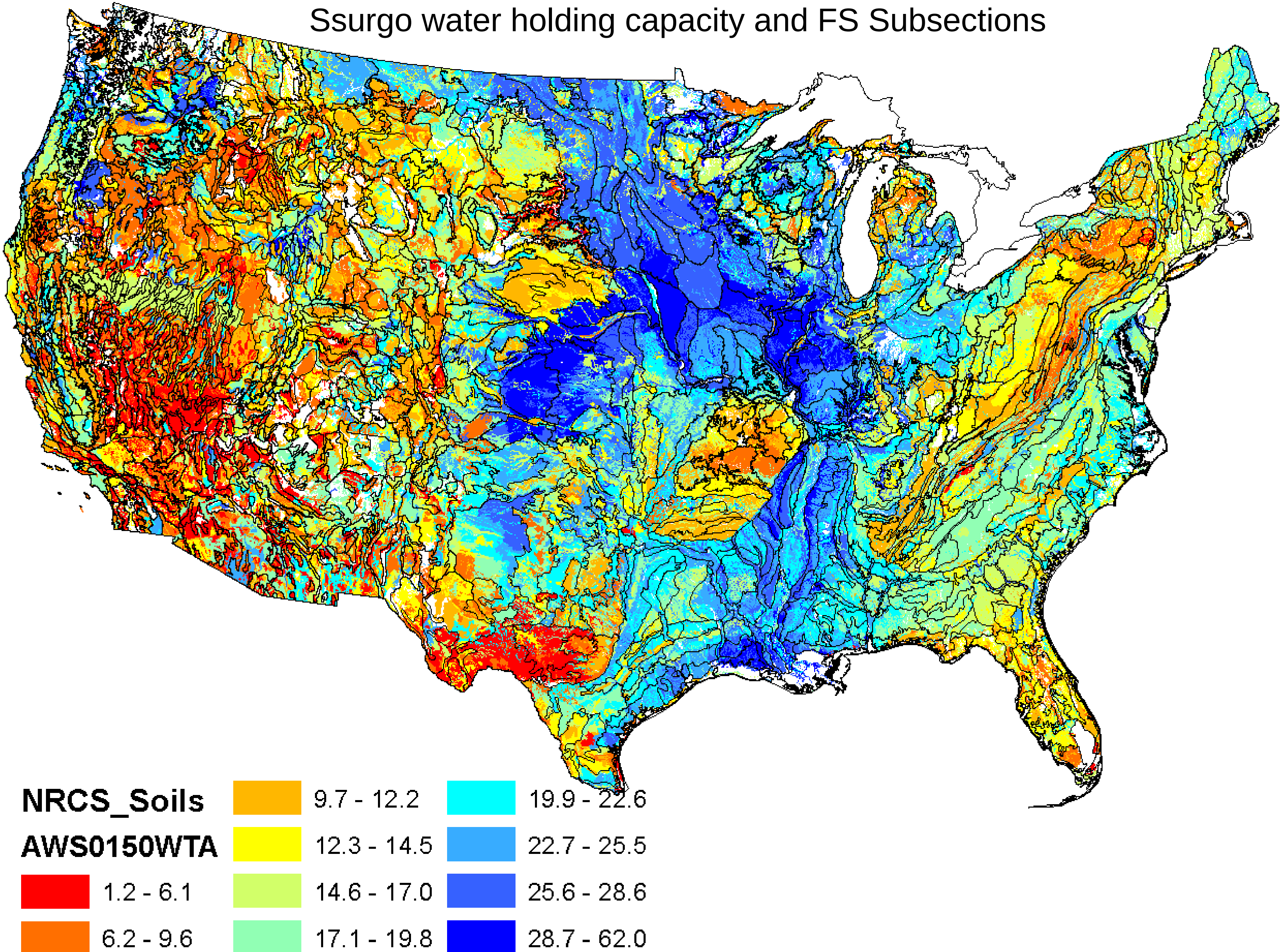
USGS Lithology and NRCS LRR's

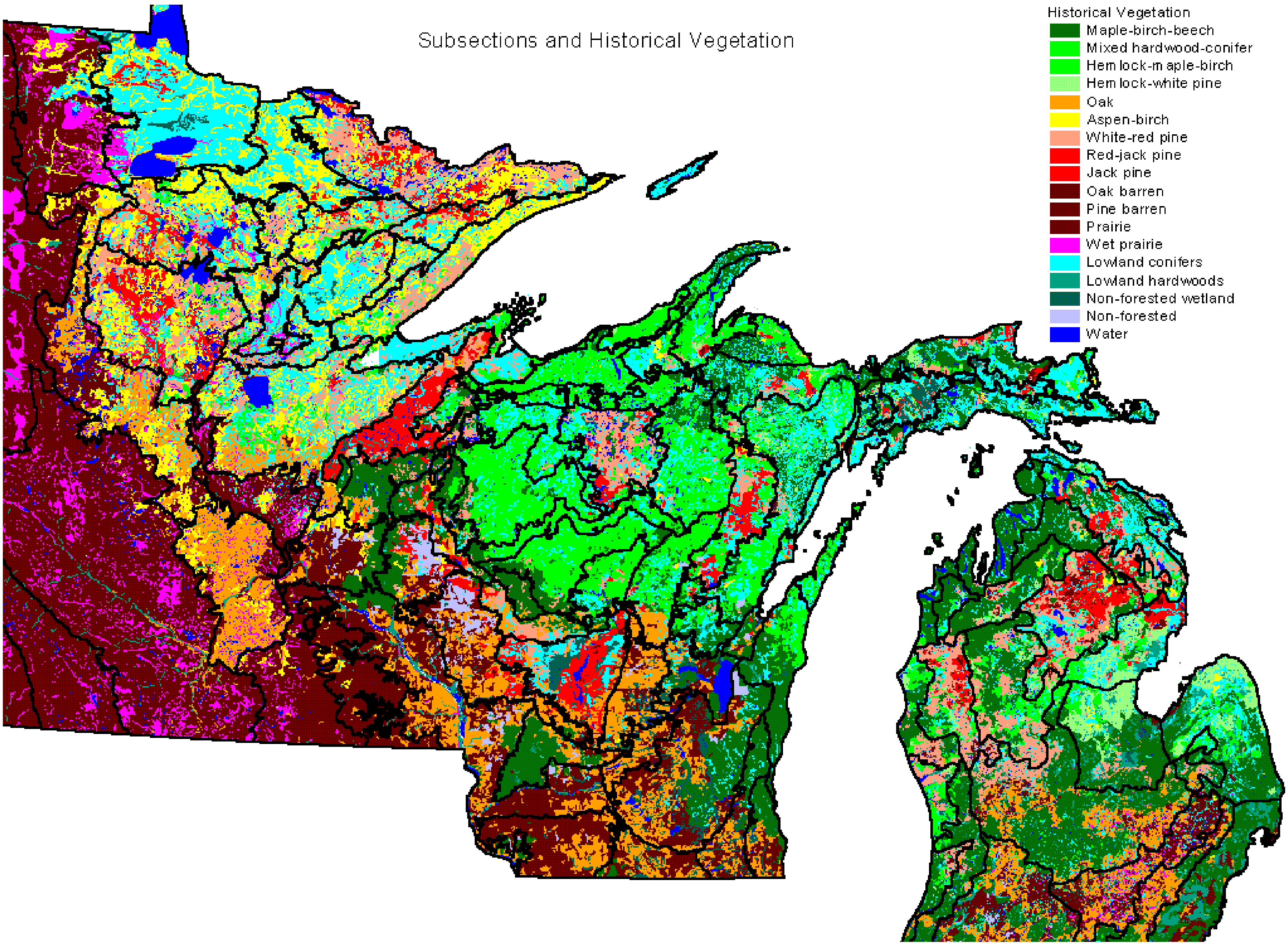


USGS Lithology and FS Sections

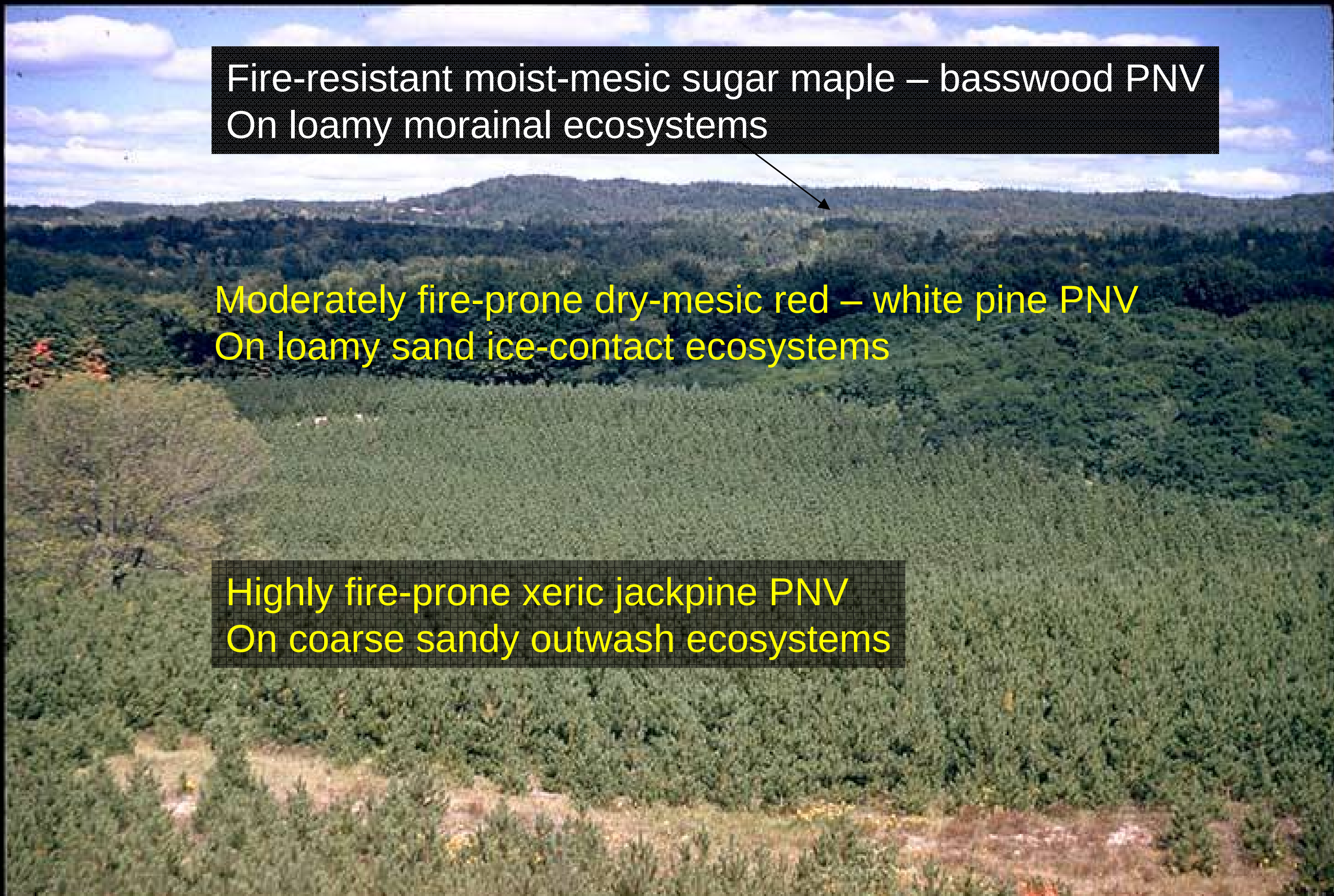


Ssurgo water holding capacity and FS Subsections




Subsections and Historical Vegetation
Historical Vegetation
Maple-birch-beech
Mixed hardwood-conifer
Hemlock-maple-birch
Hemlock-white pine
Oak
Aspen-birch
White-red pine
Red-jack pine
Jack pine
Oak barren
Pine barren
Prairie
Wet prairie
Lowland conifers
Lowland hardwoods
Non-forested wetland
Non-forested
Water

Three distinct, mappable landscape ecosystems (LTA's) with different fire regimes, habitat quality, etc.



Hierarchical Mapping Systems

USDA NRCS LRR’s, MLRA’s, Statsgo, Ssurgo

USDA FS National Hierarchy of Ecological Units

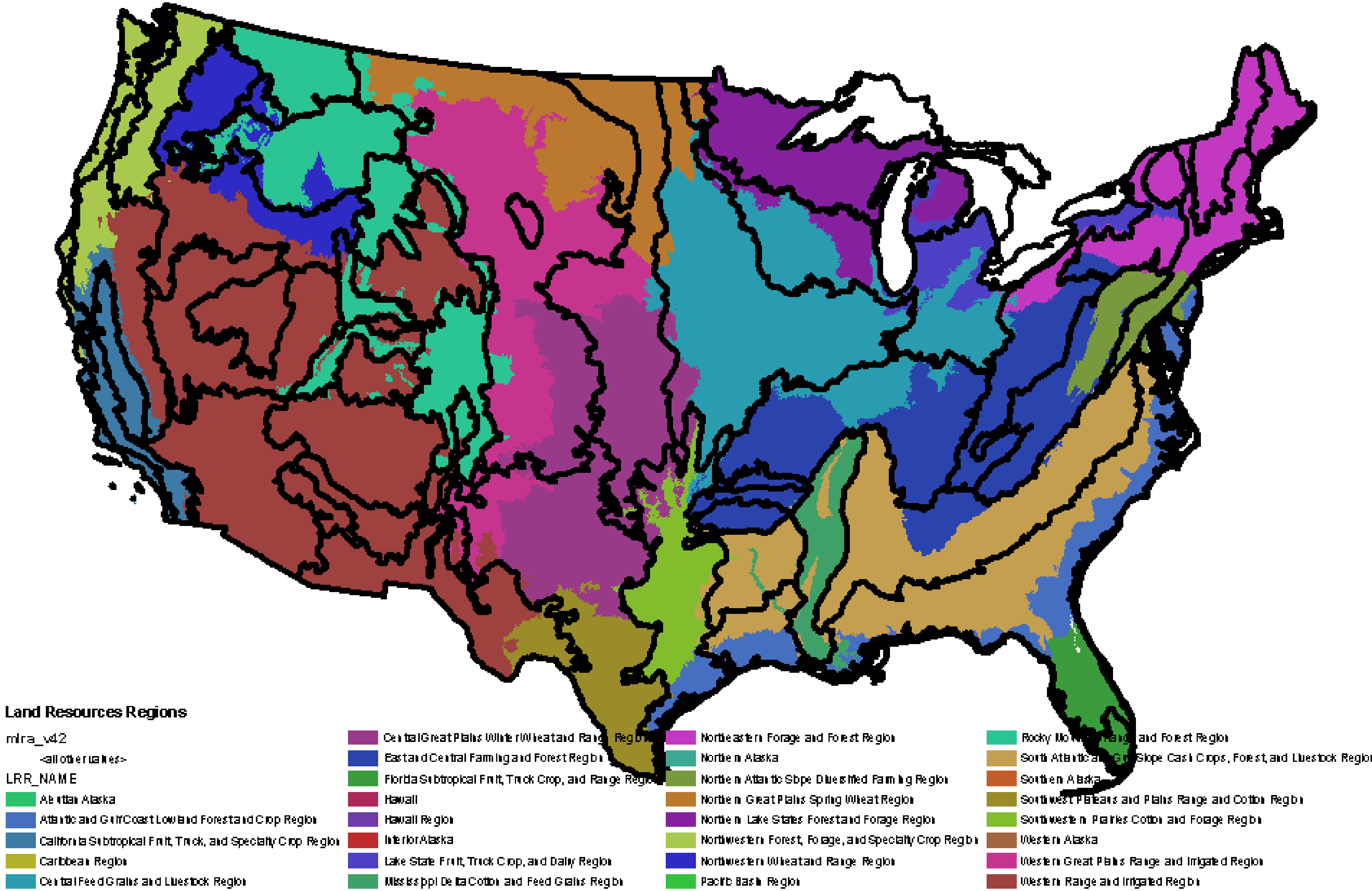
EPA Ecoregions

NatureServe

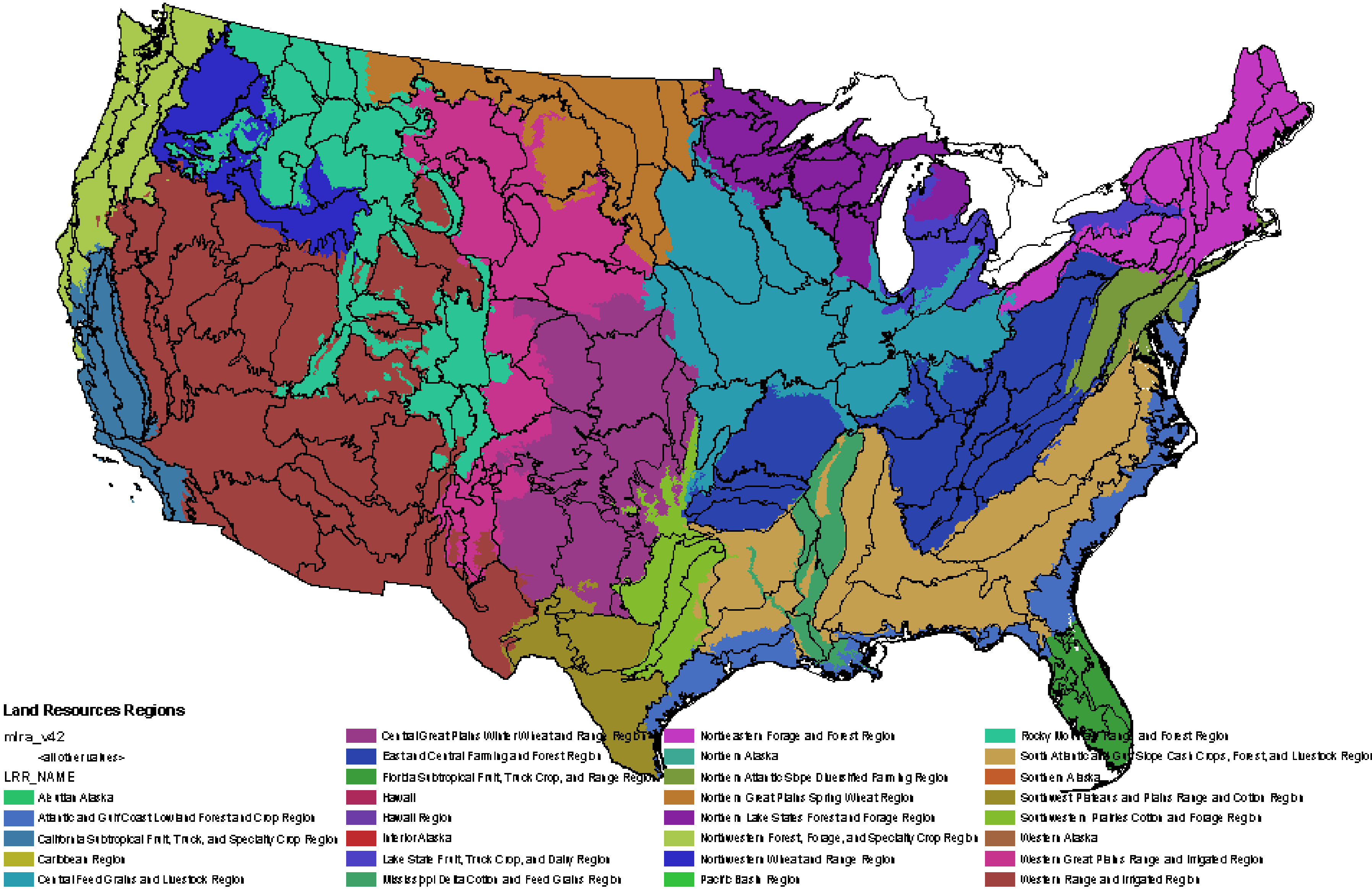
USGS

NRCS Land Resource Regions

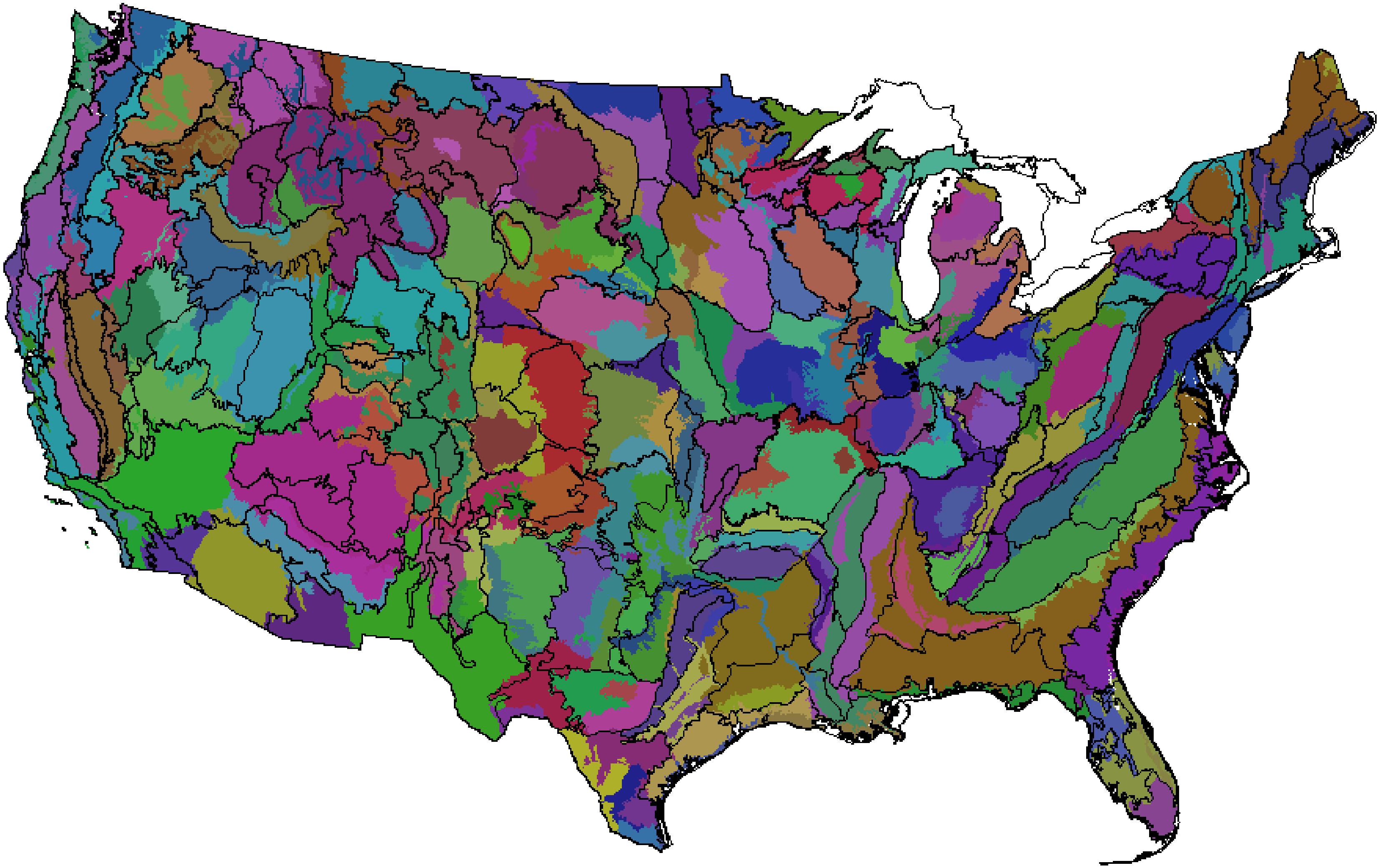
NRCS LRR's and FS Provinces



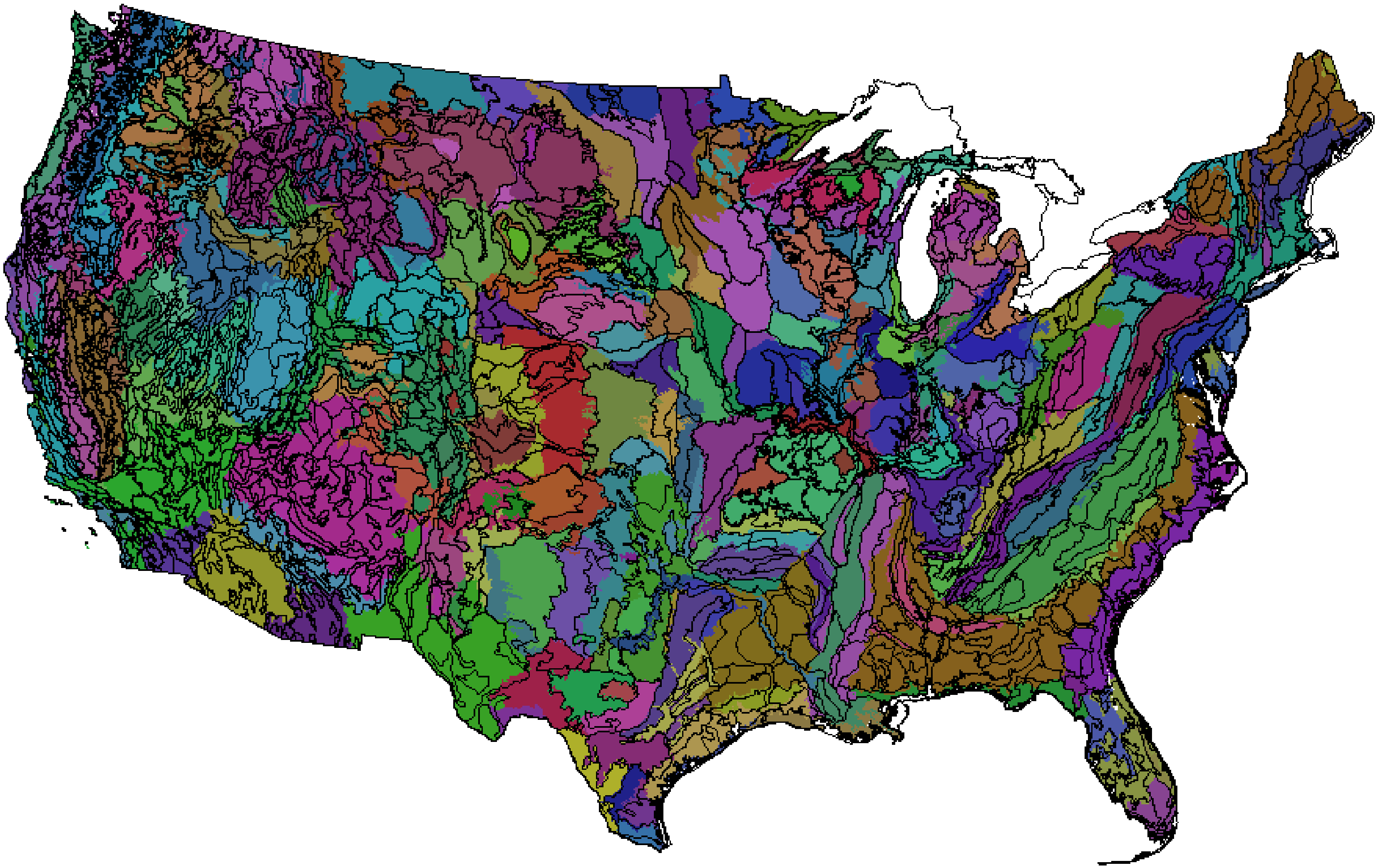
NRCS LRR's and FS Sections



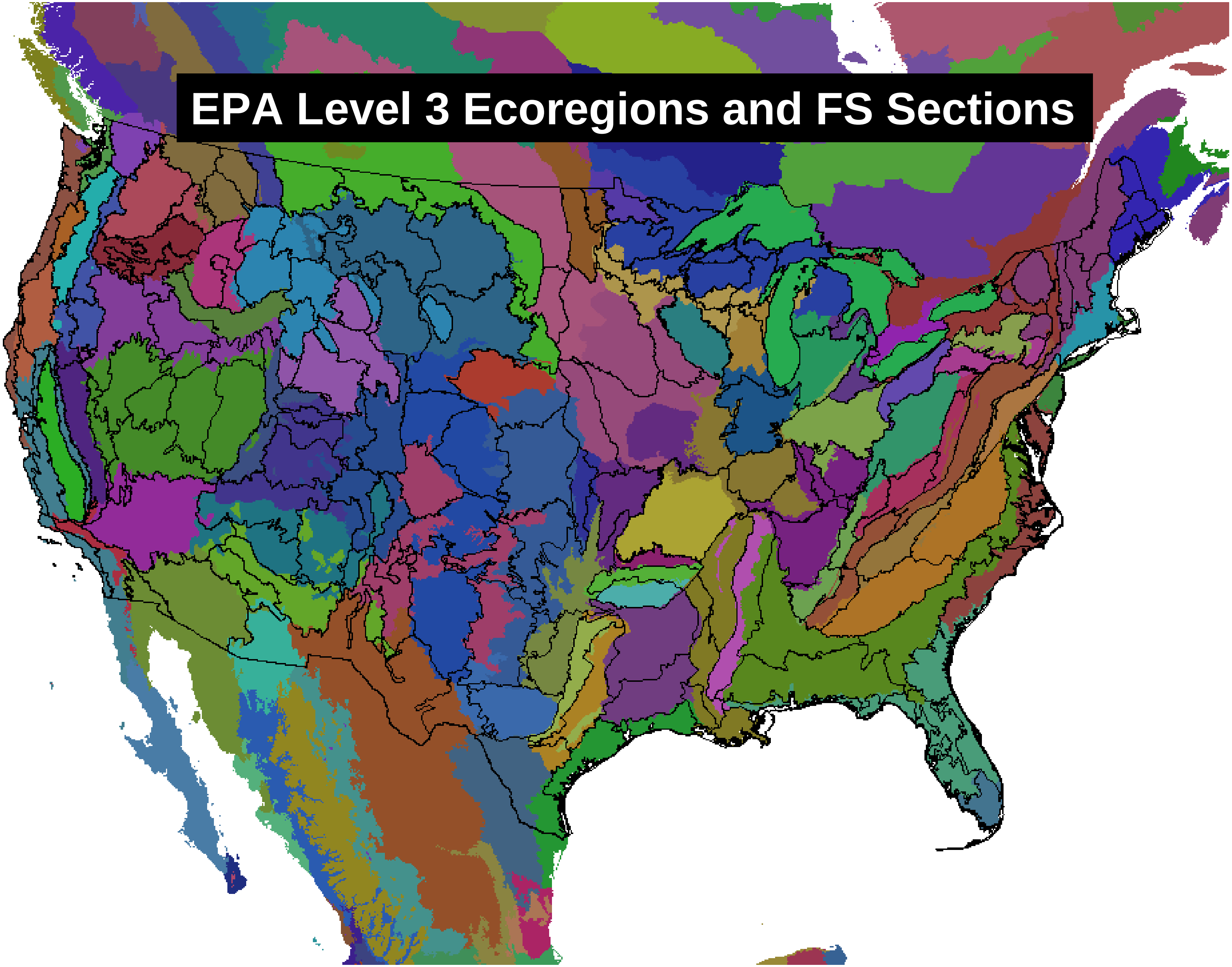
NRCS MLRA's and FS Sections



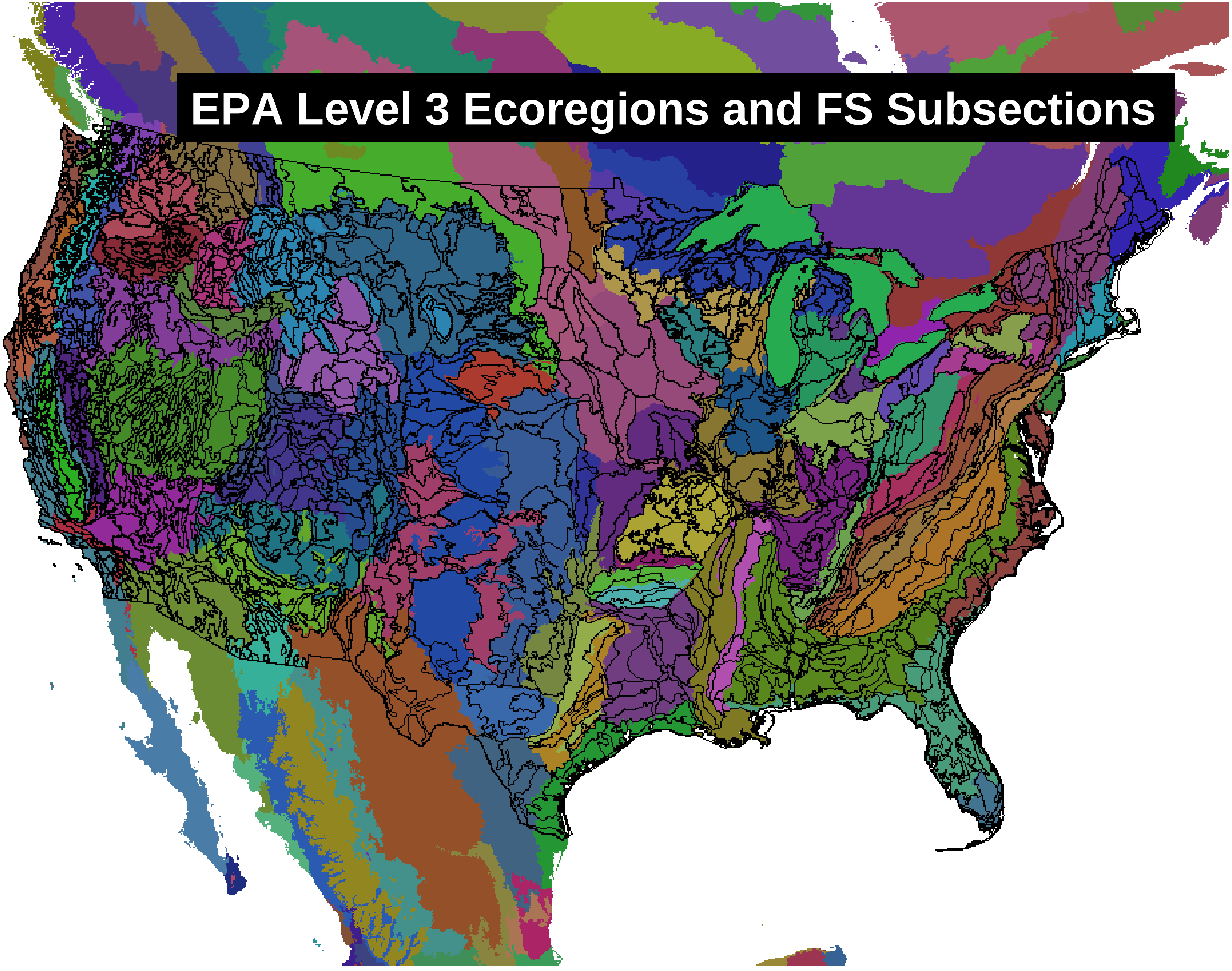
NRCS MLRA's and FS Subsections



EPA Level 3 Ecoregions and FS Sections



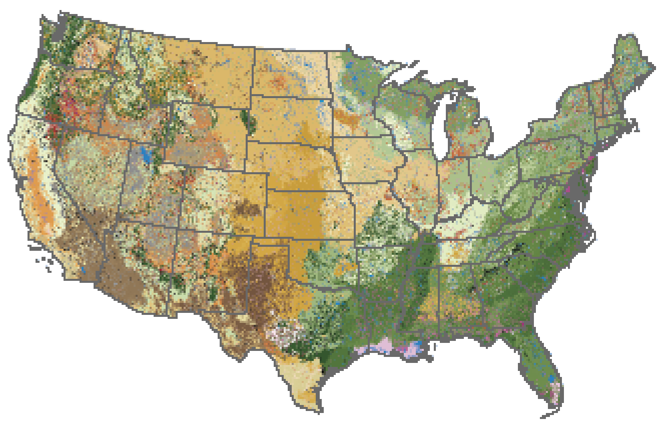
EPA Level 3 Ecoregions and FS Subsections



USGS

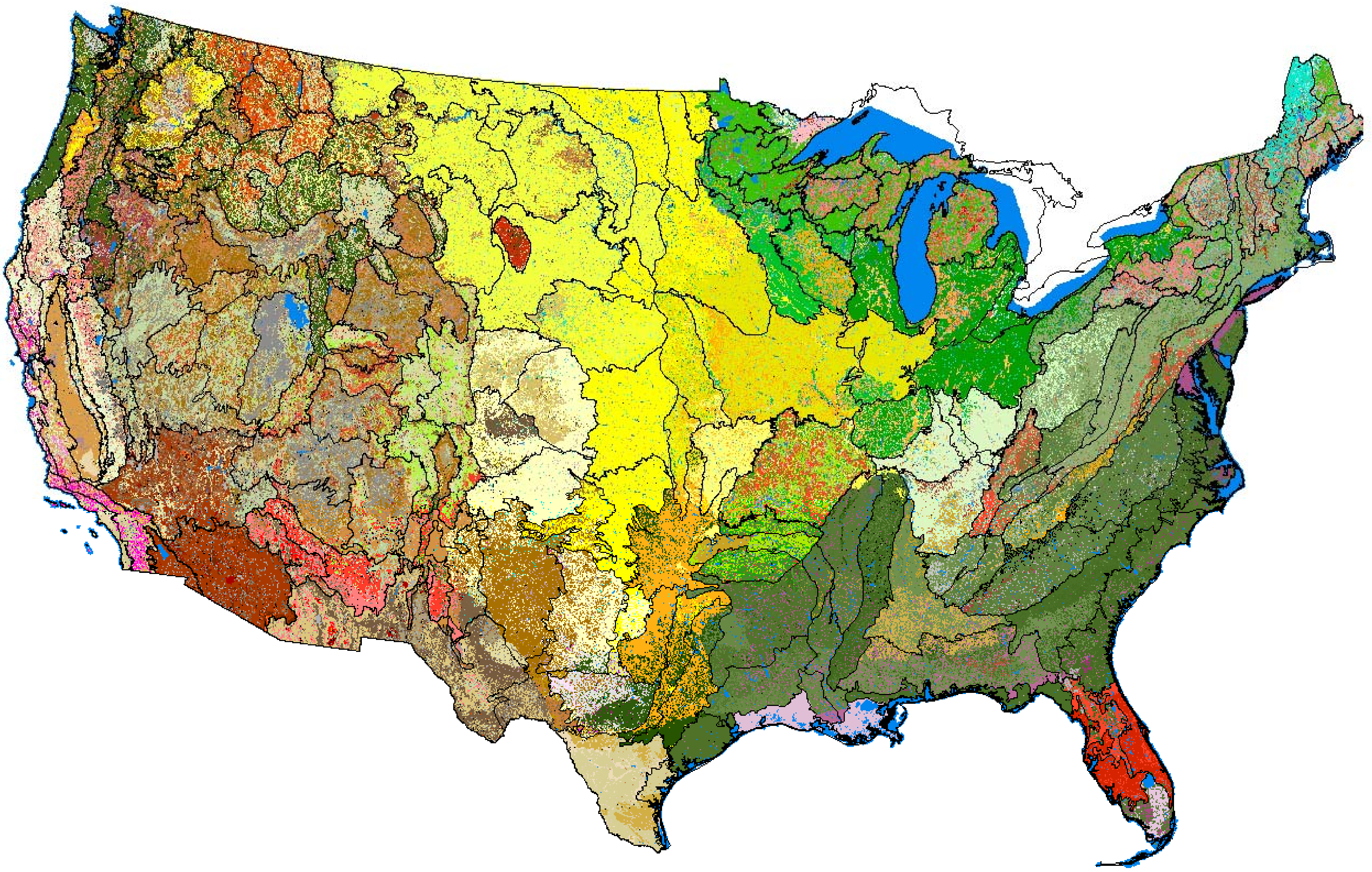
science for a changing world

A New Map of Standardized Terrestrial Ecosystems of the Conterminous United States



Professional Paper 1768

U.S. Department of the Interior
U.S. Geological Survey



“A New Map of Standardized Terrestrial Ecosystems of the Conterminous United States”
(USGS -NatureServe 2009) and Section Boundaries

“A New Map of Standardized Terrestrial Ecosystems of the Conterminous United States”
(USGS -NatureServe 2009) and Subsection Boundaries

USGS Lithology and FS Subsections

The boundaries of different mapping systems delineating broader-scale ecological regions are converging, most likely due to improved technology.

The principal differences are interpretations of scale relationships.

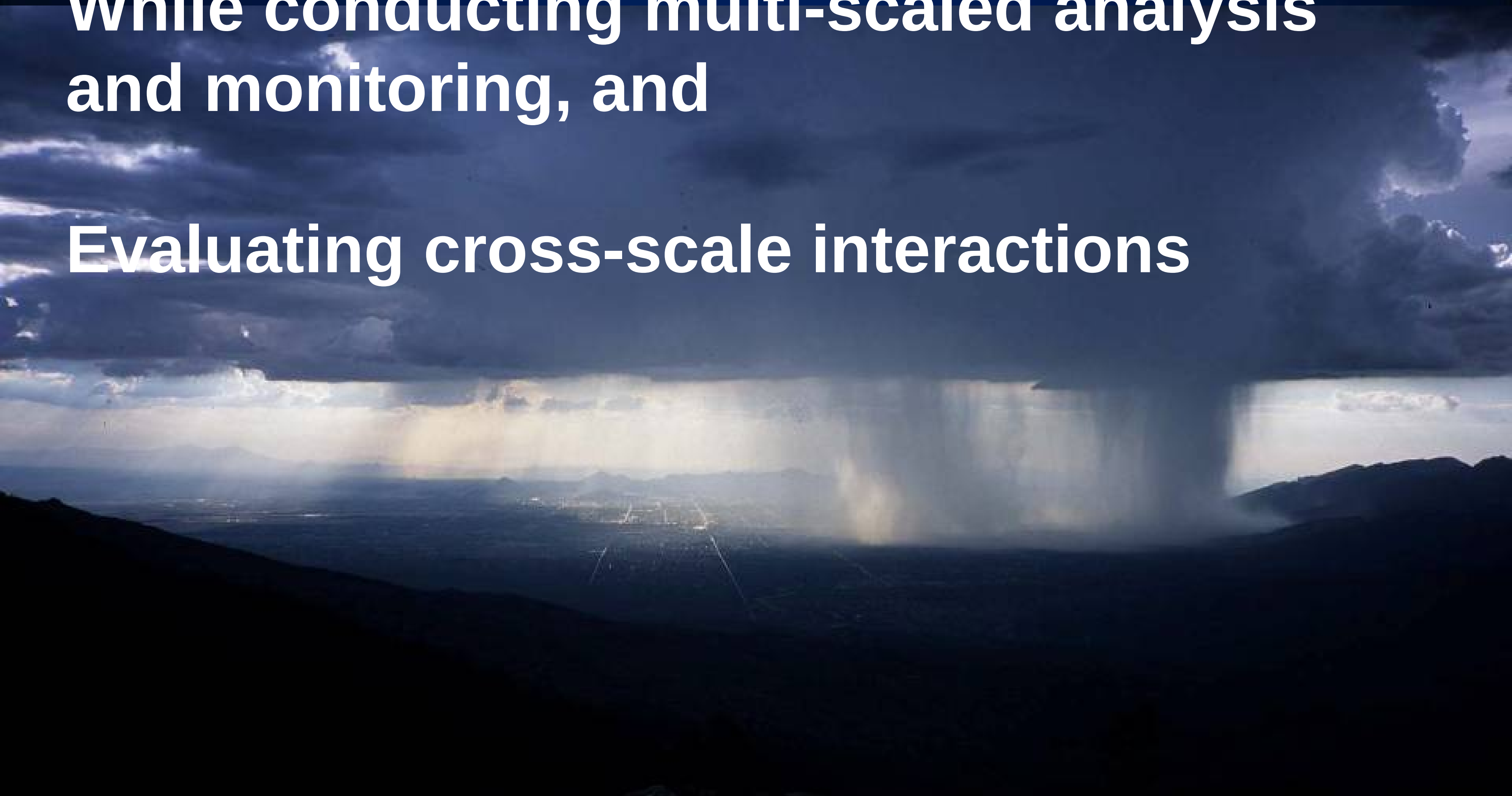
The opportunity to develop an interagency hierarchy for use in ESD applications, while revising respective agency complementary systems, has never been more possible.

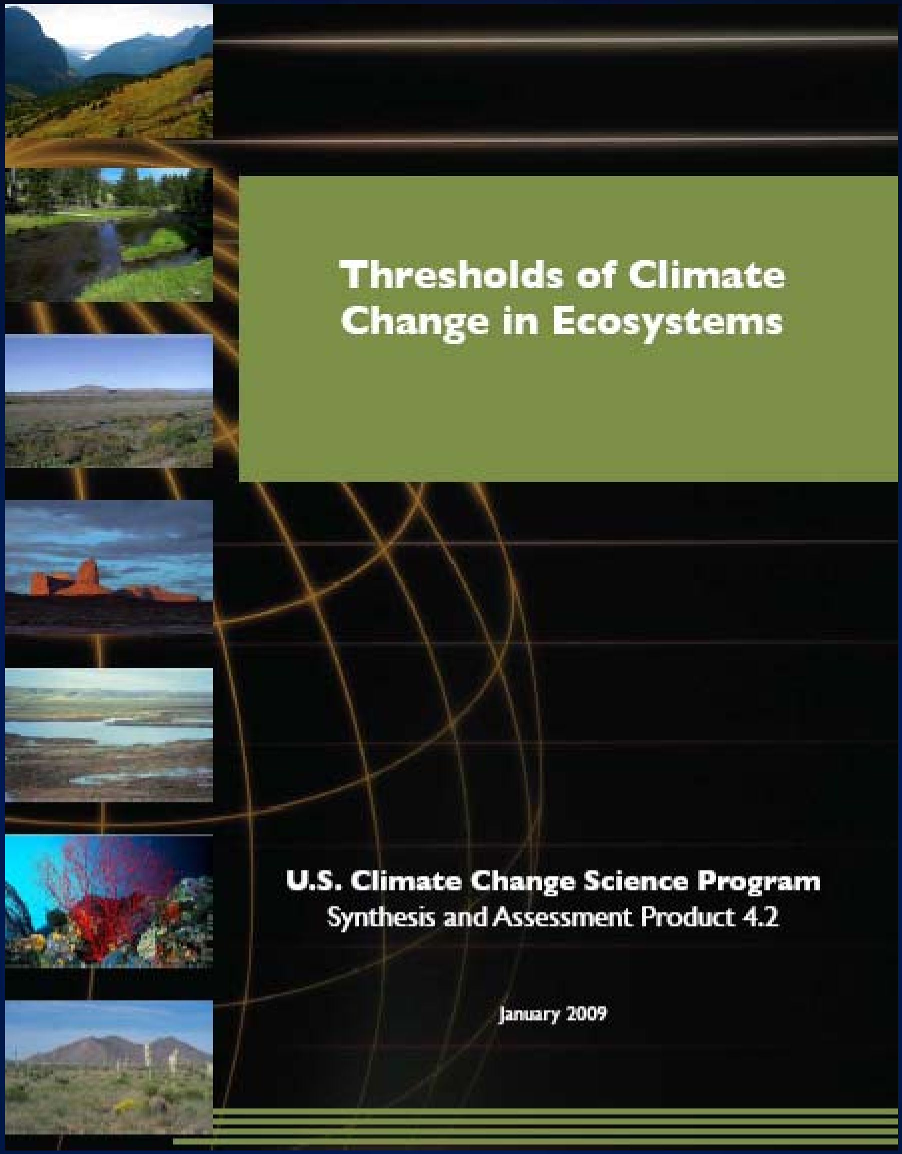
The barriers are not scientific, they are institutional.

Example of the need for use of a spatial hierarchy

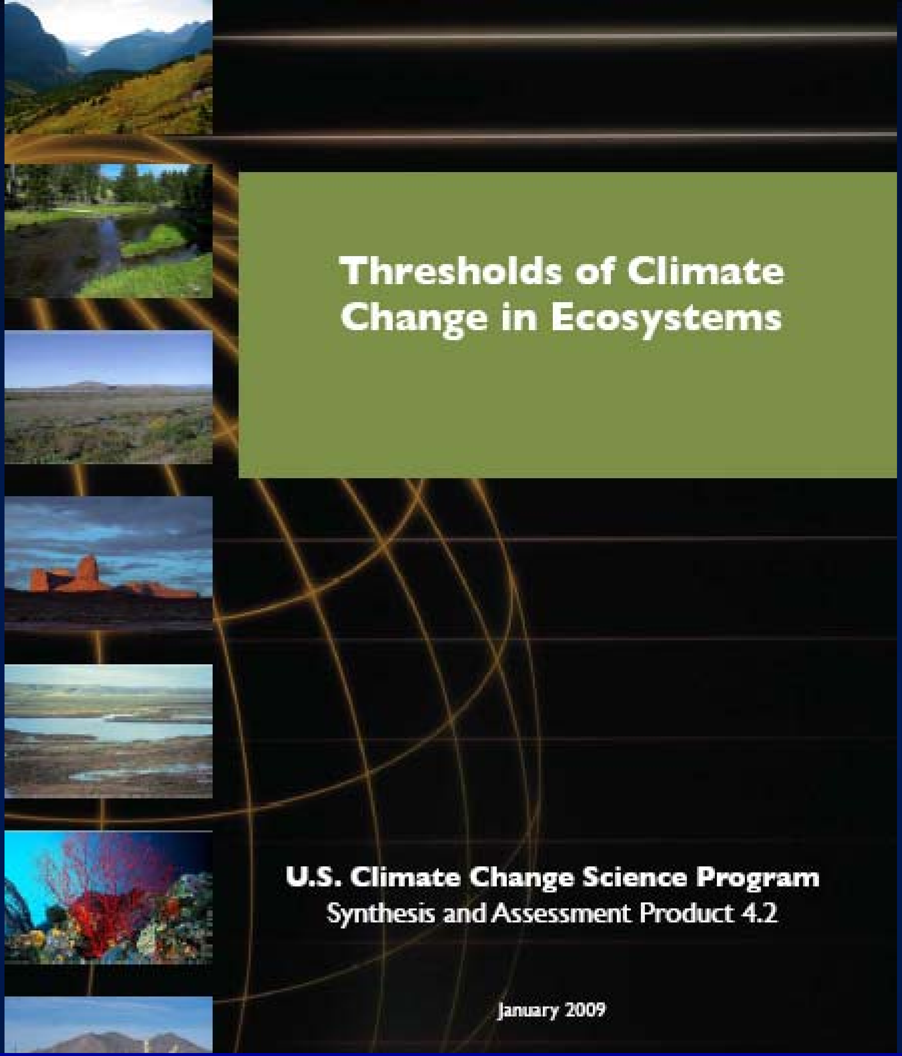
While conducting multi-scaled analysis and monitoring, and

Evaluating cross-scale interactions

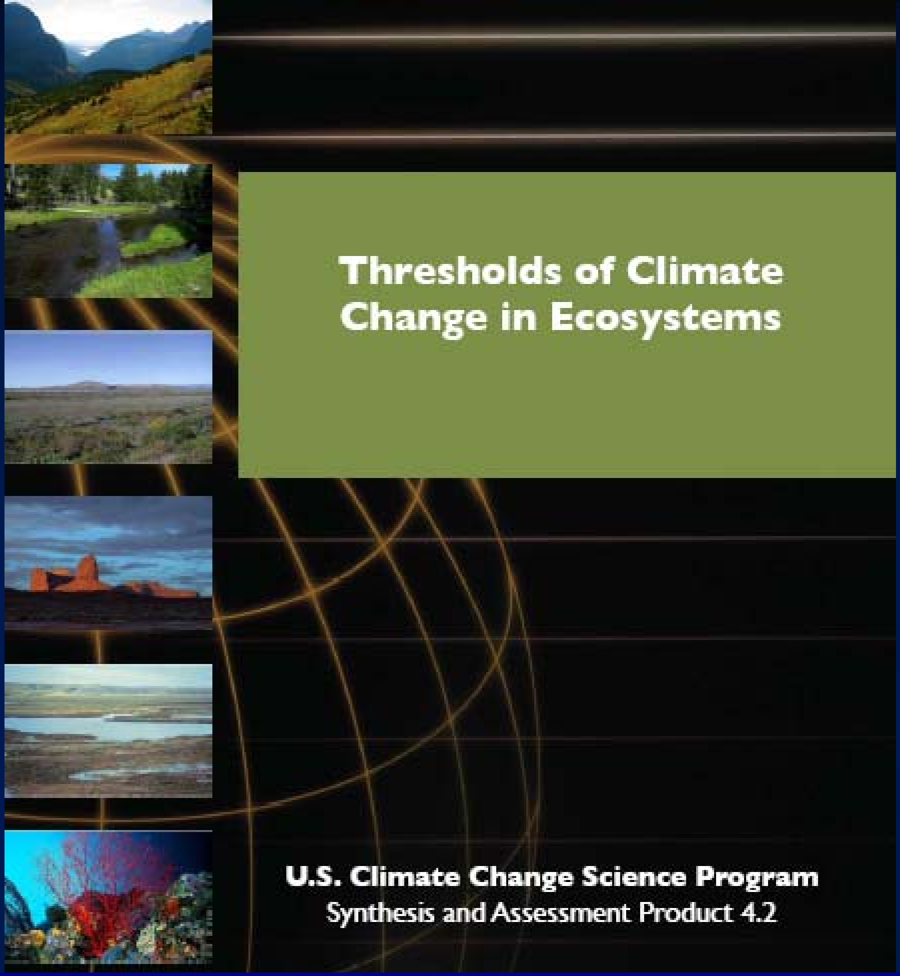




5.2.1 Role of Monitoring: “Because climate change effects are likely to interact with patterns and processes across spatial and temporal scales, it is clear the monitoring strategies must be integrated across scales.”



"First and foremost, the earth's surface must be hierarchically stratified (for example, using the MLRA's and Ecological Site Description System of the U.S. D.A. National Resources Conservation Service and U.S. Forest Service ecoregions), and conceptual or simulation models of possible impacts and feedbacks must be specified for each stratum (Herrick et al., 2006).



“The models are used to develop scenarios and to identify key properties and processes that are likely to be associated with abrupt changes.

Second, simultaneous multiple-scale monitoring should be implemented at up to three spatial scales based on these scenarios and the recognition of pattern-and-process coupling developed in the models (Bestelmeyer, 2006), which may feature cross-scale interactions (Peters et al., 2004).”

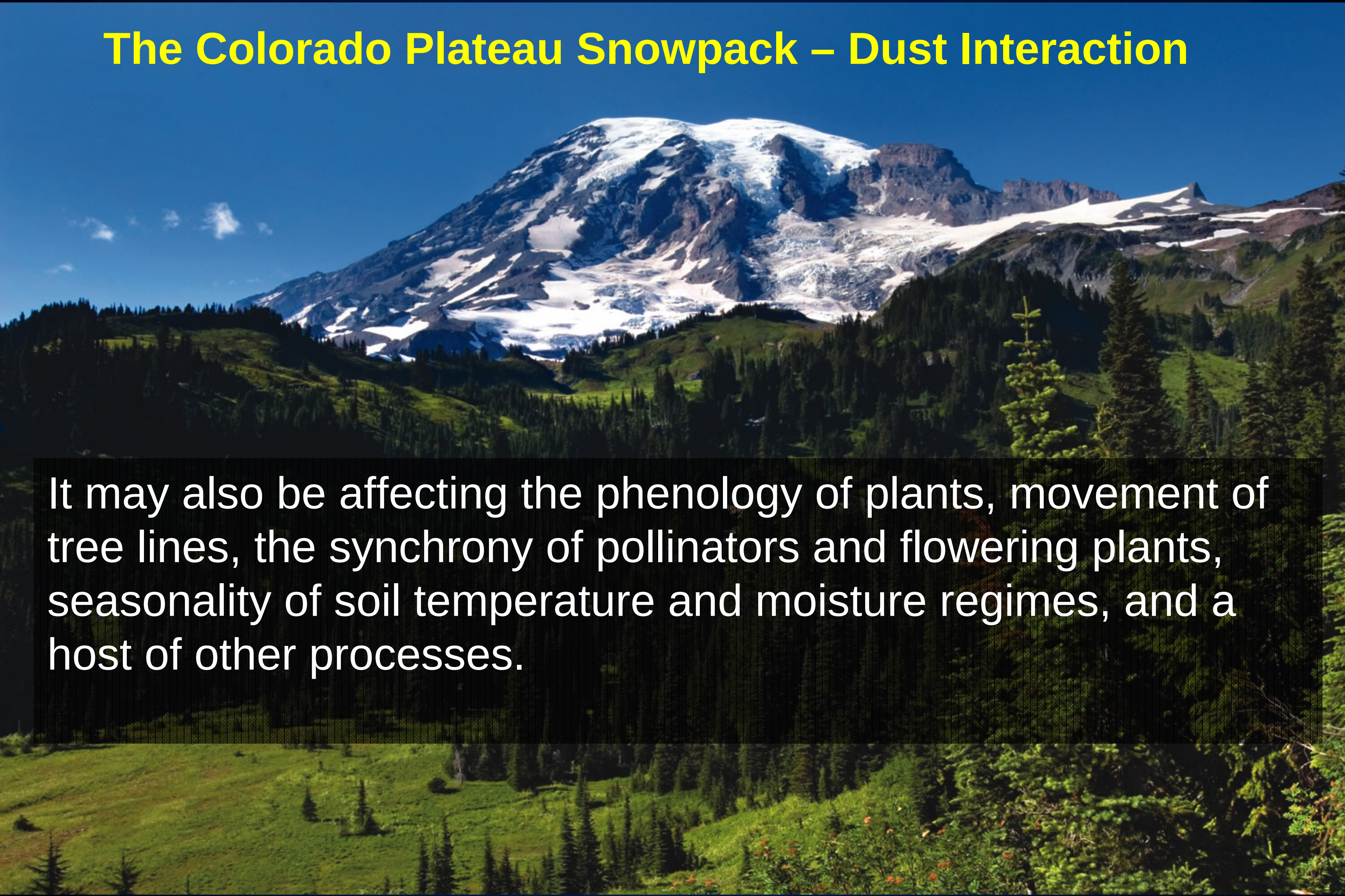
The Colorado Plateau Snowpack – Dust Interaction

Dust originating from larger surrounding shrubland and grassland dominated landscapes is being deposited within alpine zones in Colorado.

This has caused snowpacks to melt 35 – 45 days earlier than normal, affecting hydrologic function, urban water supply, and recreation (skiing).

(IPPC)

The Colorado Plateau Snowpack – Dust Interaction



It may also be affecting the phenology of plants, movement of tree lines, the synchrony of pollinators and flowering plants, seasonality of soil temperature and moisture regimes, and a host of other processes.

(IPPC)

The Colorado Plateau Snowpack – Dust Interaction

This raises several questions related to:

- Causal relationships
- Scale of observation for monitoring and detection
- Interactions which may be occurring across scales

Causal Relationships

Dust is originating from drier, lower lying areas where destablization of soil crusts, loss of vegetative cover, and high winds facilitate higher elevation deposition.

The effect of regional sources of dust vary at a landscape scale, with altered albedo in alpine areas differing from lower elevation forests areas.

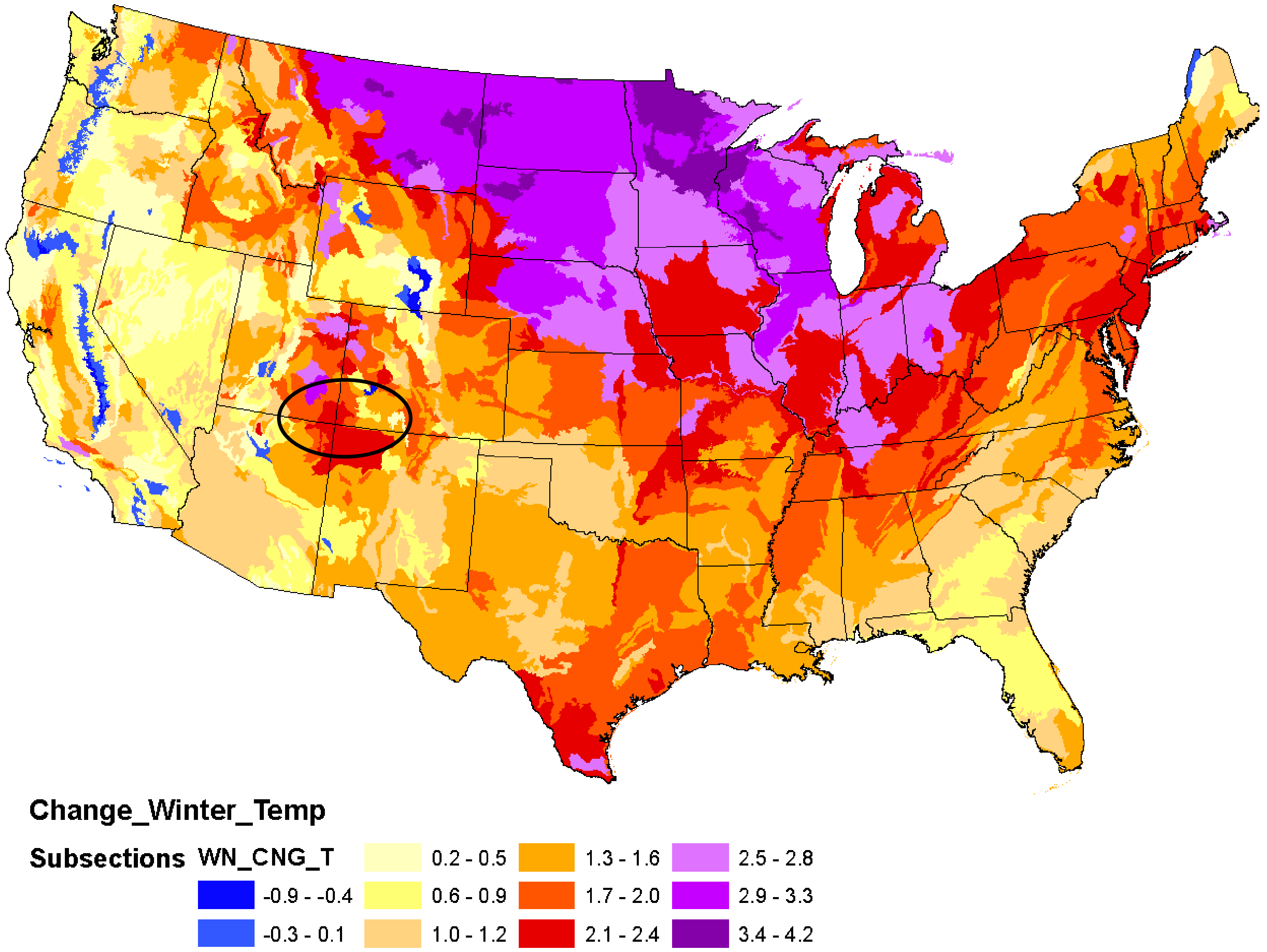
Causal Relationships

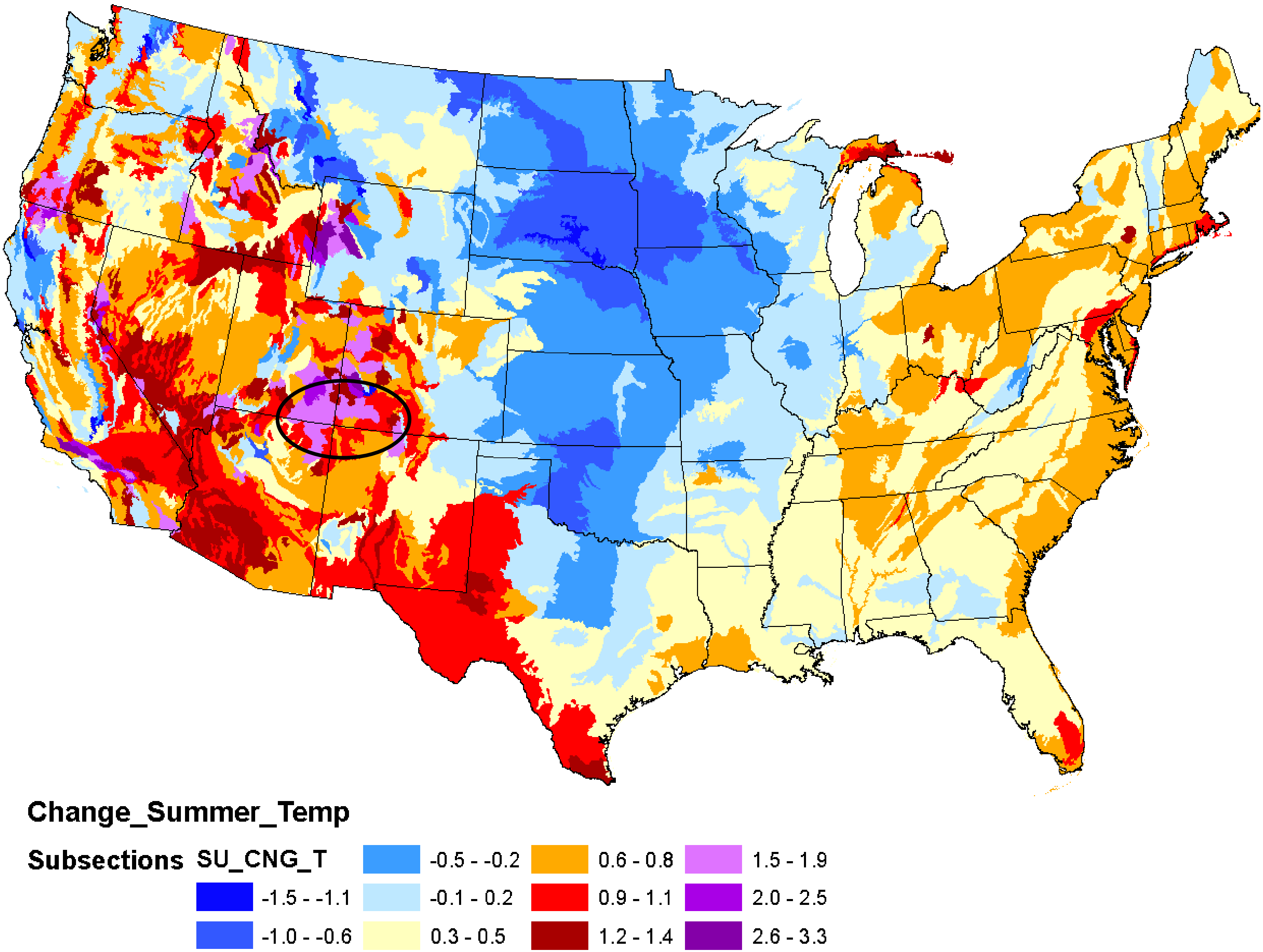
The questions are, is desertification taking place because of:

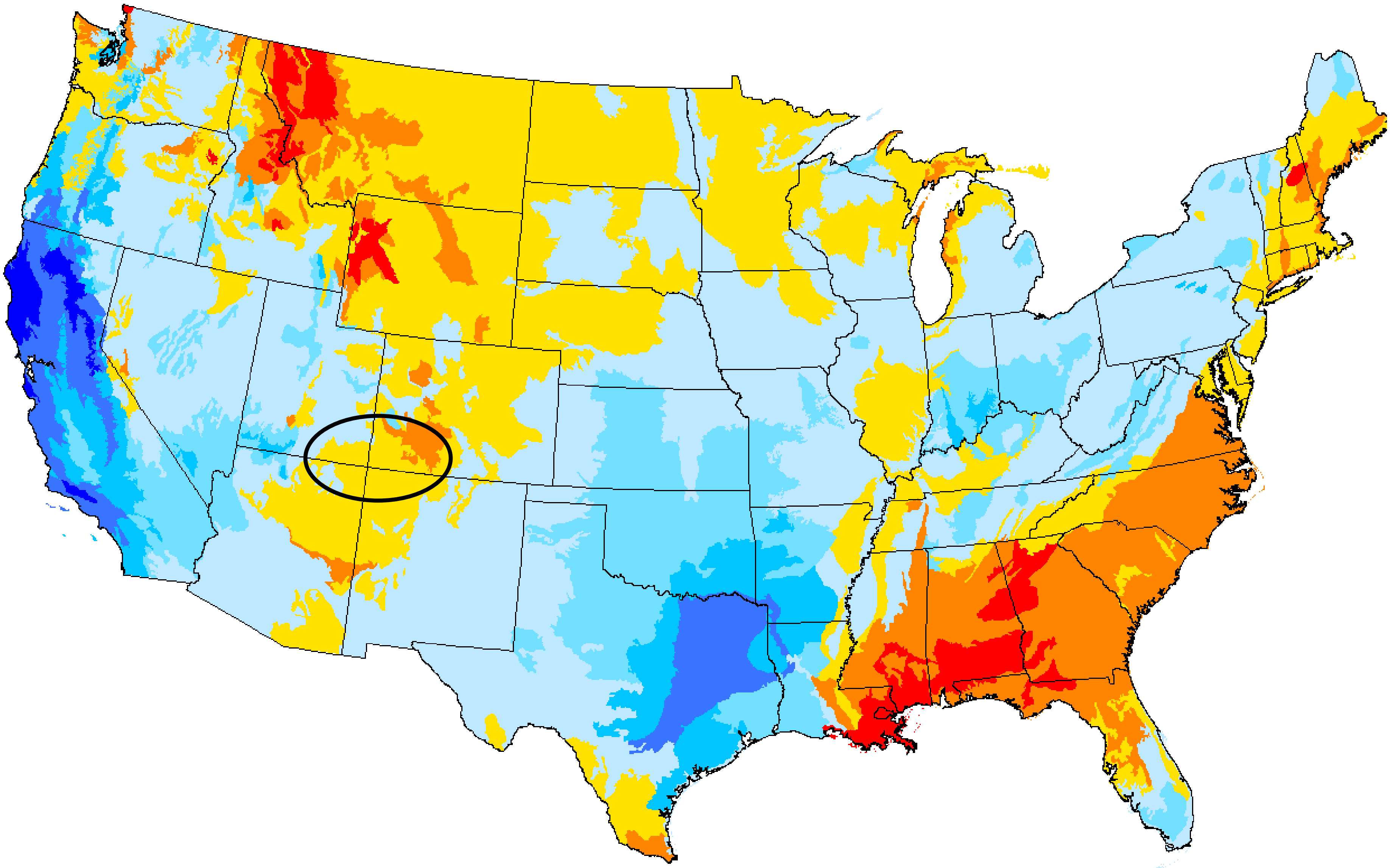
(i)recent drought or climate change?
(ii)anthropogenic forcing via land-use?
(iii)a natural range of variability phenomenon?
(iv) interactions of the above?

Recent shifts in climatic regimes

Comparison of components of climatic regimes of the 1961-1990 versus 1991-2007 periods

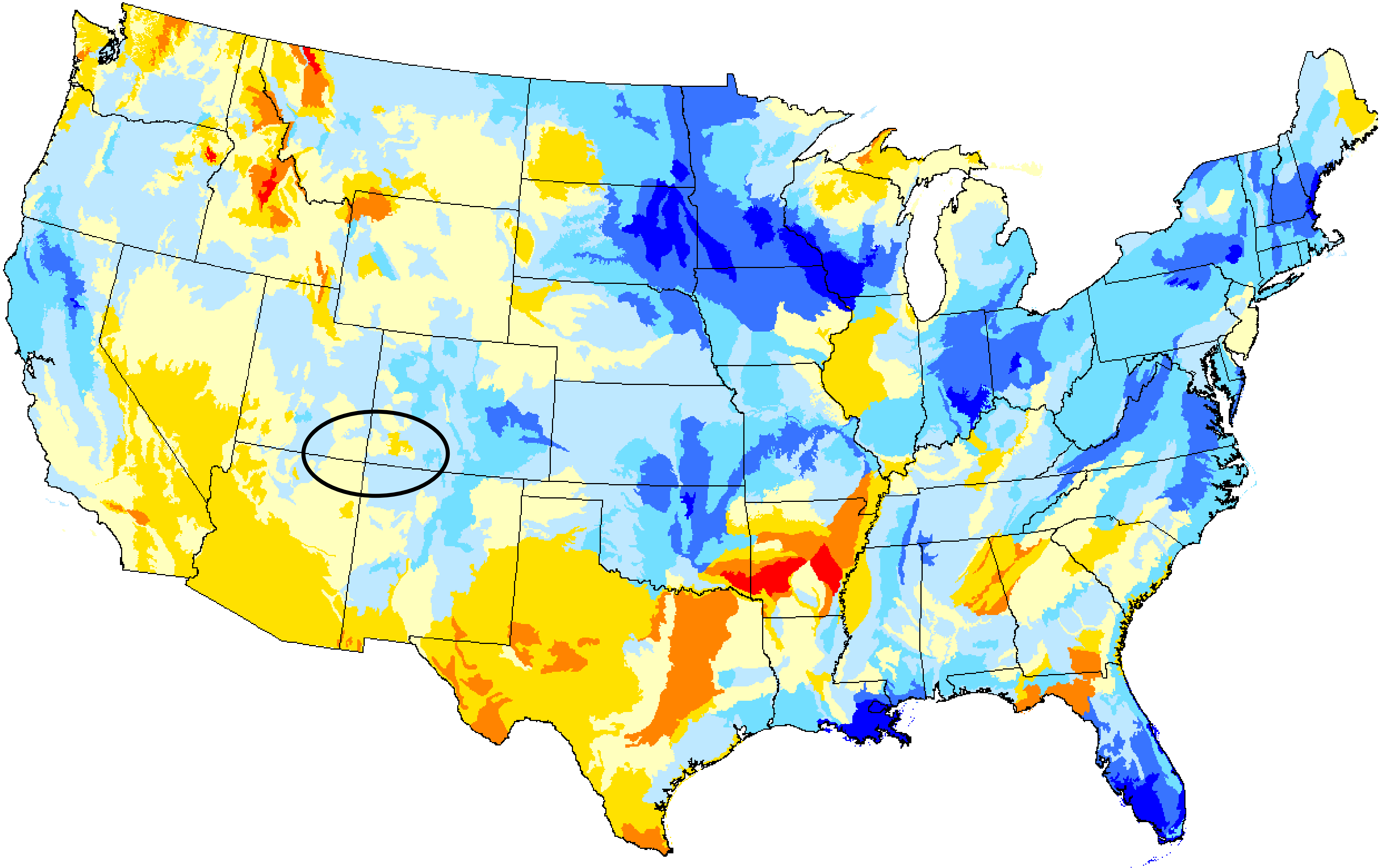

Change_Winter_Temp
Subsections WN_CNG_T
-0.9 - -0.4
-0.3 - 0.1
0.2 - 0.5
0.6 - 0.9
1.0 - 1.2
1.3 - 1.6
1.7 - 2.0
2.1 - 2.4
2.5 - 2.8
2.9 - 3.3
3.4 - 4.2


Change_Summer_Temp
Subsections
SU_CNG_T
-1.5 - -1.1
-1.0 - -0.6
-0.5 - -0.2
-0.1 - 0.2
0.3 - 0.5
0.6 - 0.8
0.9 - 1.1
1.2 - 1.4
1.5 - 1.9
2.0 - 2.5
2.6 - 3.3



Change winter precipitation

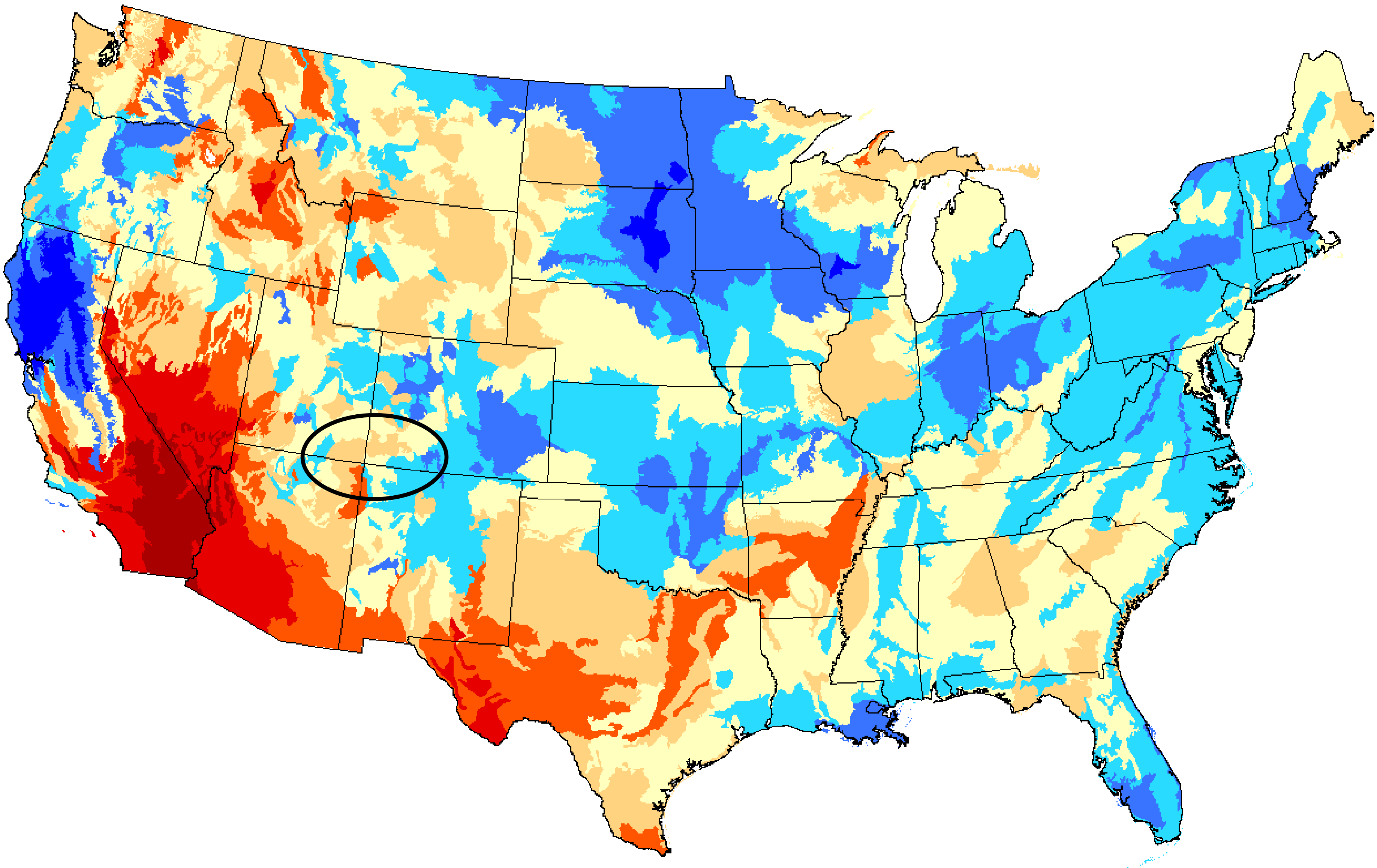
Subsections WN_CNG_P									
		-1.5 - -0.5		0.1 - 0.5		1.1 - 2.0		5.3 - 7.9	
-4.9 - -1.6		-0.4 - 0.0		0.6 - 1.0		2.1 - 5.2			



Change growing season precipitation

Subsections GS_CNG_P

-4.8 - -2.8
-2.7 - -1.3
-1.2 - -0.6
-0.5 - -0.1
0.0 - 0.5
0.6 - 1.2
1.3 - 2.1
2.2 - 4.6



Percent Change Growing Season Precipitation

Subsections GS_CG_P_PT

- -45.8 - -26.4
- -26.3 - -15.0
- -14.9 - -7.0
- -6.9 - -2.1
- -2.0 - 1.8
- 1.9 - 6.4
- 6.5 - 13.8
- 13.9 - 30.2

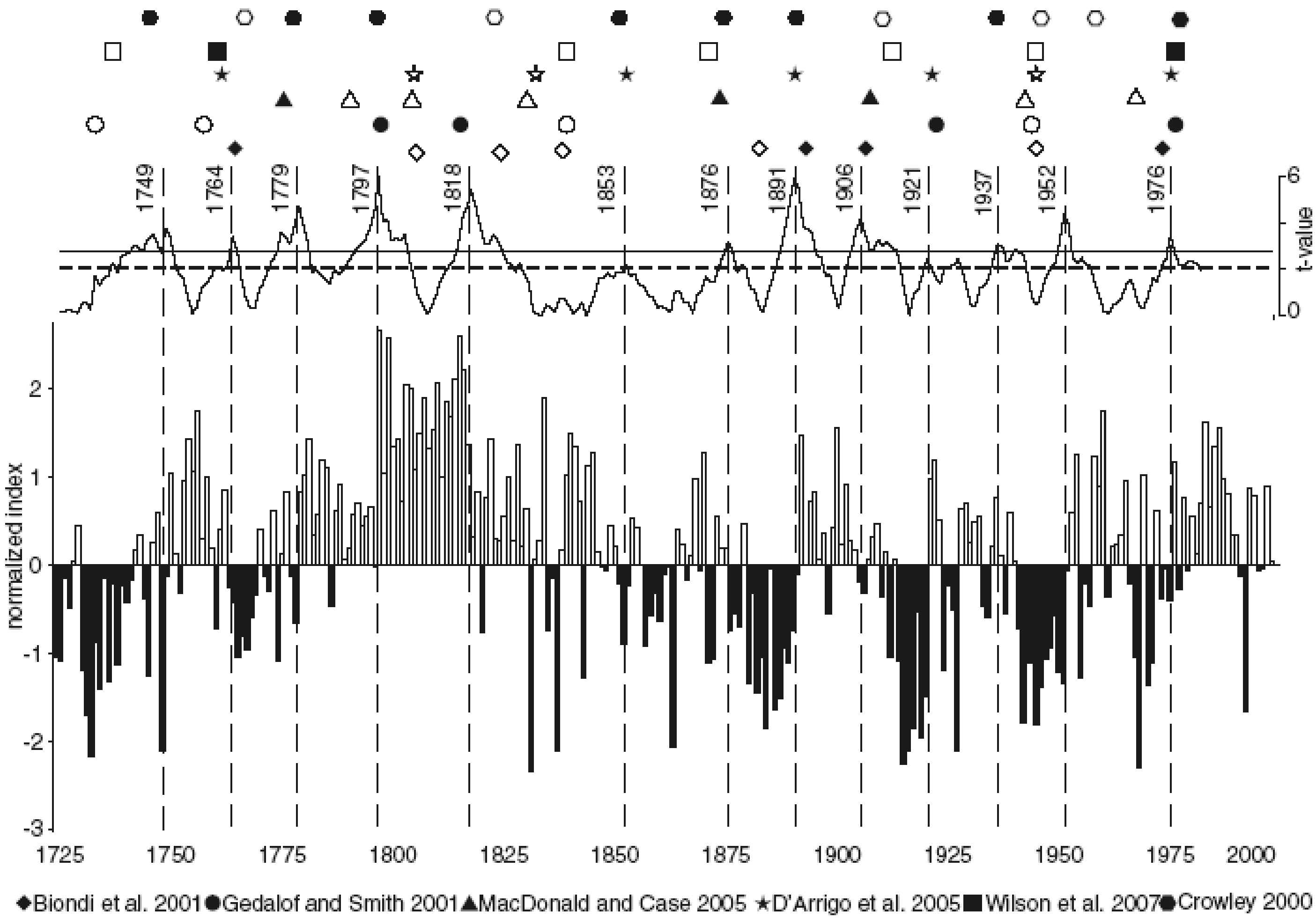
Interactions that may be occurring across scales

It is possible that climate change is the driving force

It is possible that land use is the driving force

It is possible that long-term natural variability in climate is the driving force

Fig. 5 Climatic shift years in the normalized (1725–1999) winter PNAI series, identified using a two-sample *t*-test between the first and second half of 30-year moving windows. Significance levels are indicated by *full* ($P < 0.01$) and *dashed* ($P < 0.05$) *horizontal lines*. Climatic shift years (*vertical dashed lines*) were defined as the years with highest absolute *t*-value. Years of climatic shifts identified in other proxy records of Pacific climate variability and solar activity (Crowley 2000) are also indicated. *Filled symbols* represent climatic shifts within a 3 year range from the shifts in winter PNAI



Multi-century variability in the Pacific North American circulation pattern reconstructed from tree rings. Trouet and Taylor. Clim Dyn (2010) 35:953–963.

“Positive PNA phases produce below average snow accumulation in western North America as a result of warm temperatures and decreased precipitation.”

Interactions that may be occurring across scales

It is also possible that implementation of best management practices has been effective in reducing effects of grazing, recreation, or other anthropogenic impacts.

And that the rate of desertification due to climate change or a positive Pacific North American circulation pattern has been slowed through these practices.

Interactions that may be occurring across scales

However, monitoring meso-scale trends in land use in the absence of macro-scale monitoring might lead to conclusions that BMP’s are ineffective, that opportunity costs of limiting resource use are being incurred, and BMP’s should be adjusted accordingly.

Interactions that may be occurring across scales

Similarly, assessing landscape level conditions and processes, and implementing adaptation strategies at the landscape scale may not be effective without implementing adaptation strategies at the meso-scale.

Scale of observation for monitoring and detection

Macro-scale – monitoring climate change

Meso-scale – monitoring land use, BMP’s

Landscape scale – monitoring snow, dust, vegetation within Alpine zones

Local scale – monitoring response of various species, hydrology, other phenomena of interest

Cross-scale interactions

The bottom line is broader scale stressors may override finer-scale conditions and actions that are effective at reducing adverse cumulative effects.

And finer-scale processes (destabilized soil crusts, coalescence of open patches) may propagate upward through the system to alter broader scale patterns (dust production, snowpack melt).

Multi-scaled Monitoring

Designing inventory and monitoring programs that employ concepts of hierarchical structures is therefore needed for assessing climate change as well as other stressors.

We have that opportunity via the interagency ESD effort.

Cooperation among disciplines, agencies, and research and management - a key need for ESD development and use

In cases, communication and cooperation is difficult to achieve, or even breaks down.

Successful partnerships, applying common sense and research results, and producing high quality classifications, maps, and interpretation systems should be our goal. We need to be in this race together, and be willing to tie.