A New National MODIS-Derived Phenology Data Set Every 16 Days, 2002 through 2006

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A new national MODIS-derived phenology data set has been developed from MODIS MOD13 16-day composite NDVI, a "greenness" index. National maps are available every 16 days for 2002 through 2006 at 231m resolution. The algorithm uses a pixel-by-pixel specific temporal trend analysis; spatial neighborhood is ignored. A two-step process was employed: initial temporal smoothing and outlier/noise removal, followed by curve-fitting using Savitsky-Golay and estimation of seven descriptive curve parameters.

An idealized seasonal NDVI curve is fit through smoothed NDVI data for each MODIS cell independently. Seven parameters are harvested that describe important parts of the NDVI profile. For each parameter, two national maps are created at 231 m resolution—one is the NDVI value at that point, and one is the day-of-year position within the season when it was attained. We are mapping both the NDVI value and the timing.

Can sum each 16-day integral of area under the seasonal NDVI curve with each MODIS 16-day composite period, creating a Cumulative NDVI curve — a monotonically increasing Cumulative NDVI function reset to zero each year. Can watch the pattern of Cumulative NDVI accumulate each year.
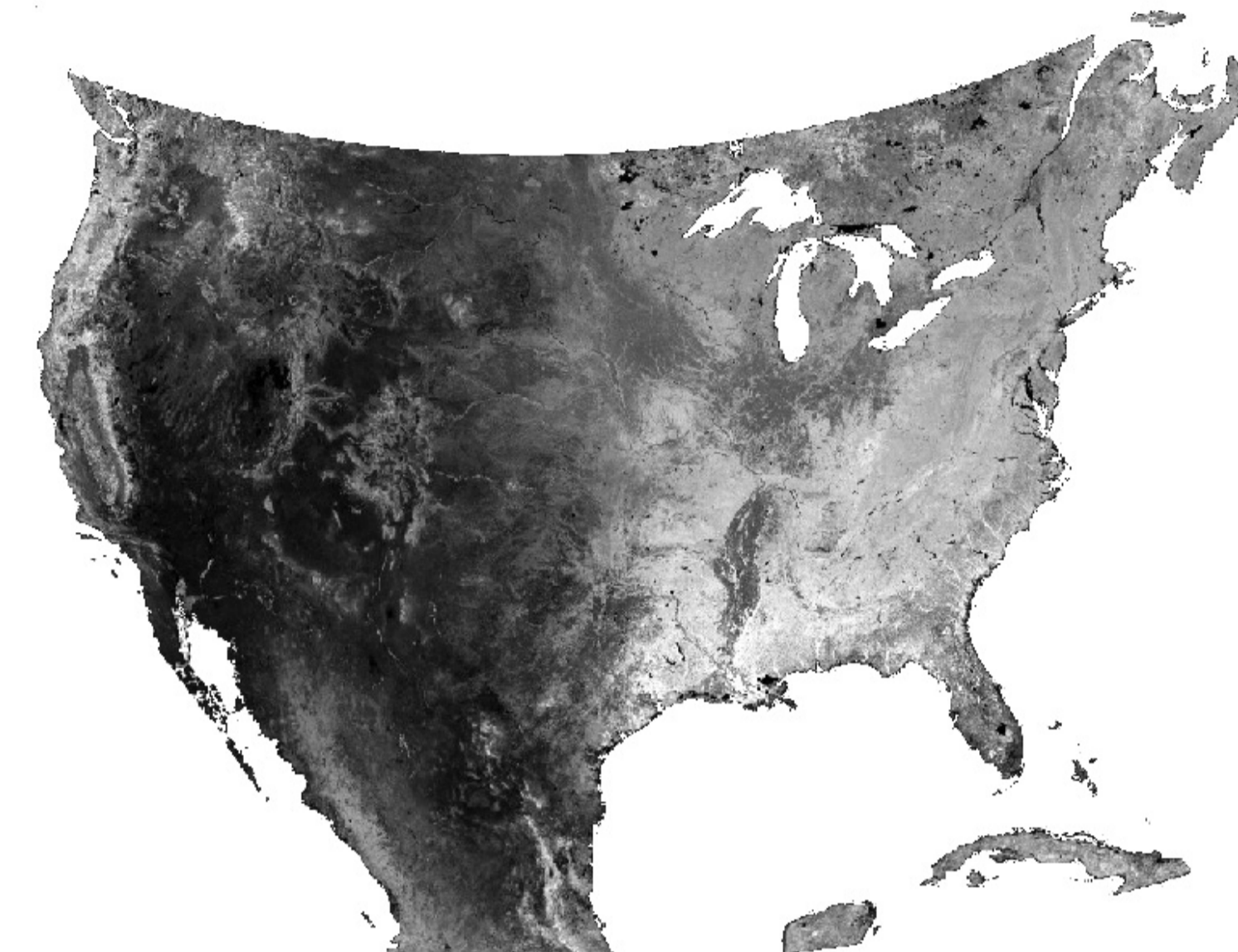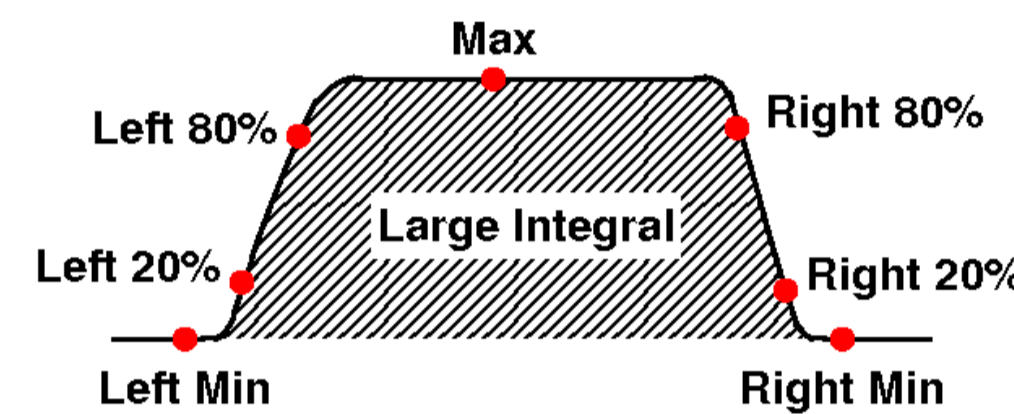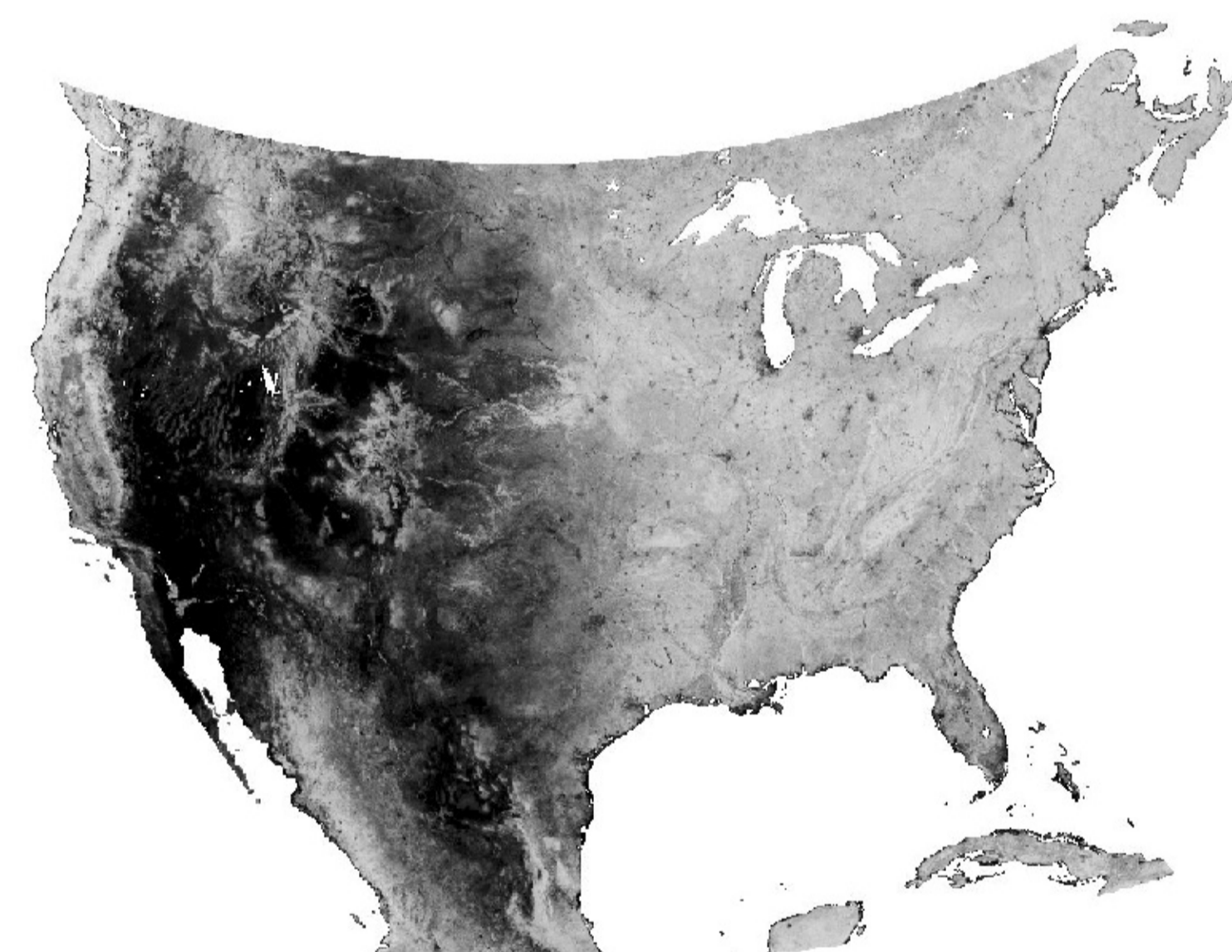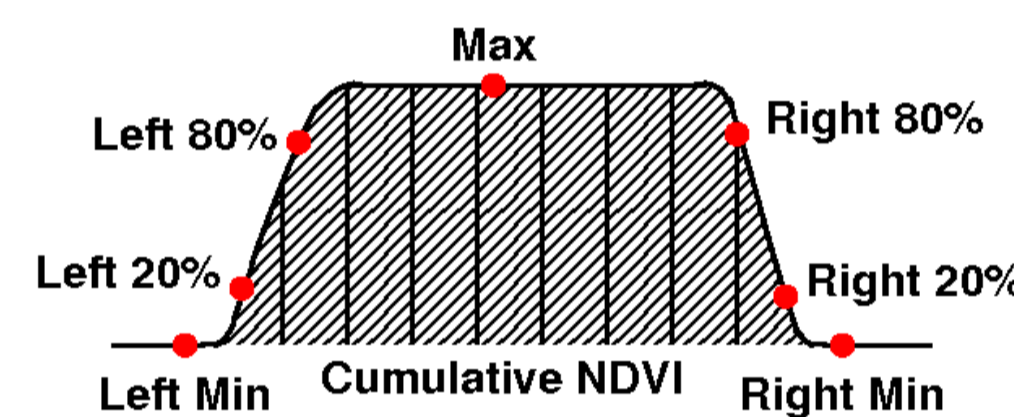
Figure 1: 2006 NDVI Large Integral Map - The area under the seasonal NDVI curve -- Dark areas are low seasonal NDVI integral, light areas are high seasonal NDVI integral

Figure 2: 2006 Maximum NDVI Value Map - Peak NDVI value -- Dark areas are low seasonal max NDVI value, light areas are high seasonal max NDVI value
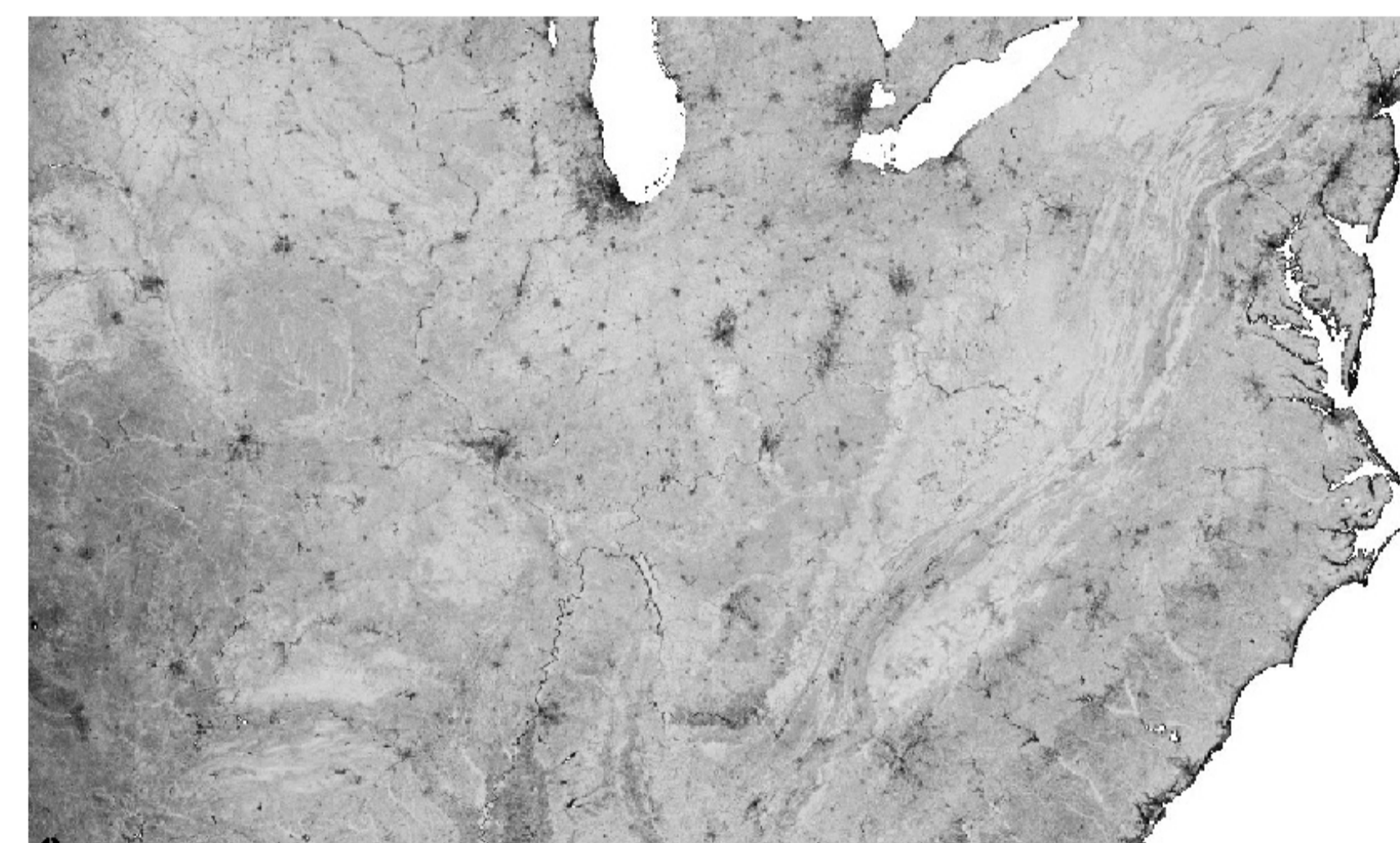
Figure 3: 2006 Maximum NDVI Value Zoom - Cities, lakes, and rivers show as dark low seasonal max NDVI values
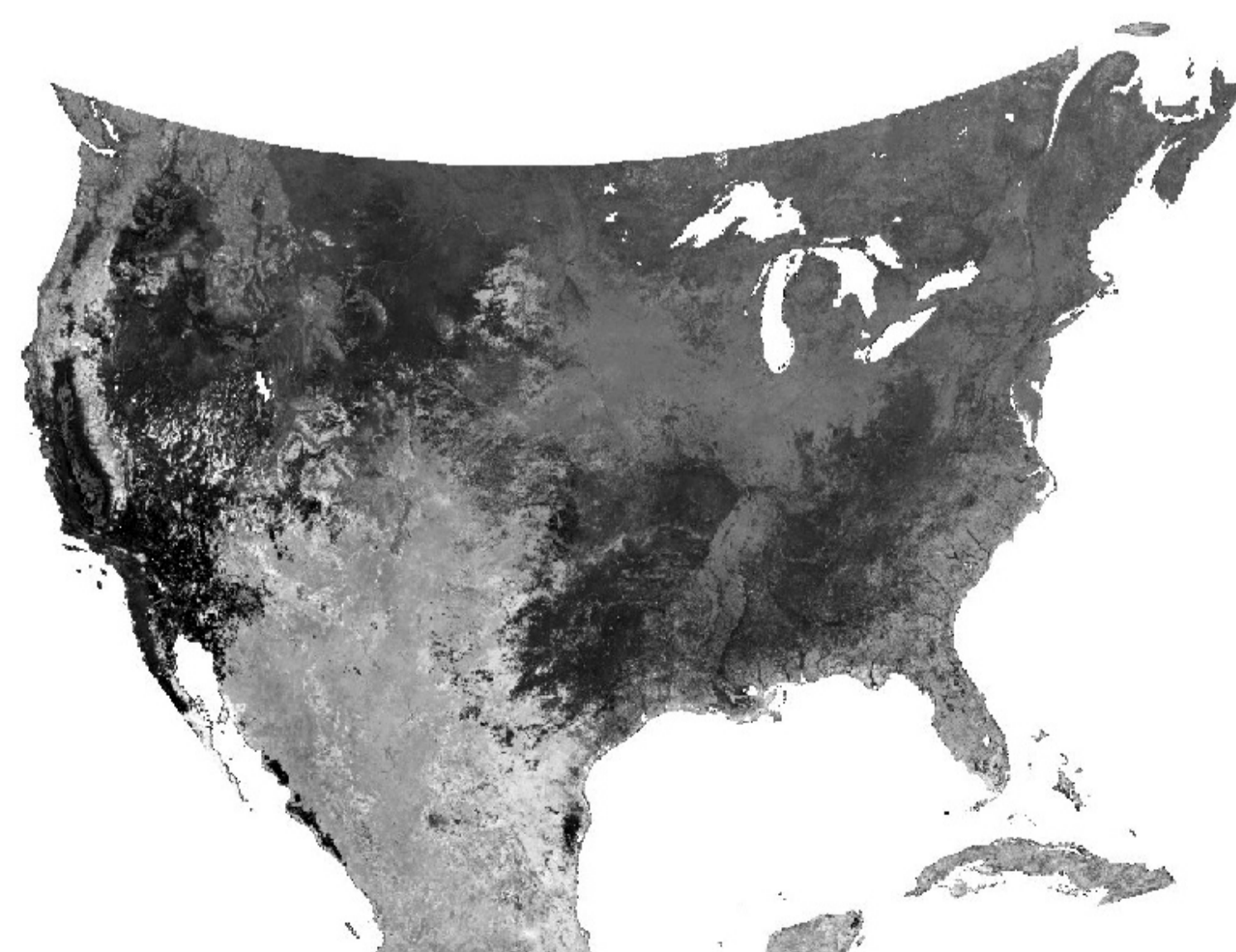
Figure 4: Timing of Peak NDVI value -- Day-of-year position when max NDVI is attained -- Dark areas are earlier dates, light areas are later dates for max
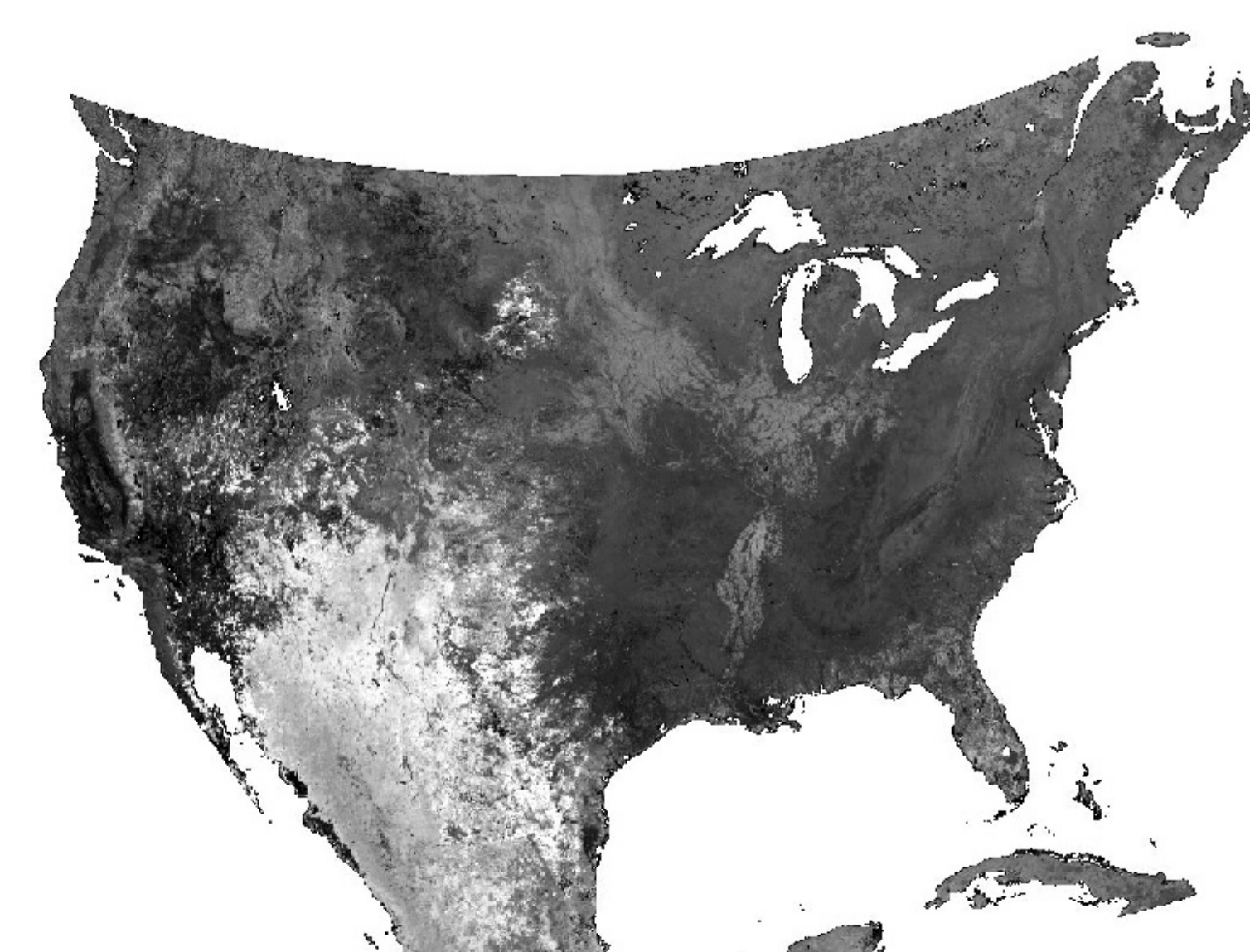
Figure 5: 2006 Left 20% NDVI Position Map - Timing of Leaf-out -- Day-of-year position when 20% max NDVI is attained -- Dark areas are earlier
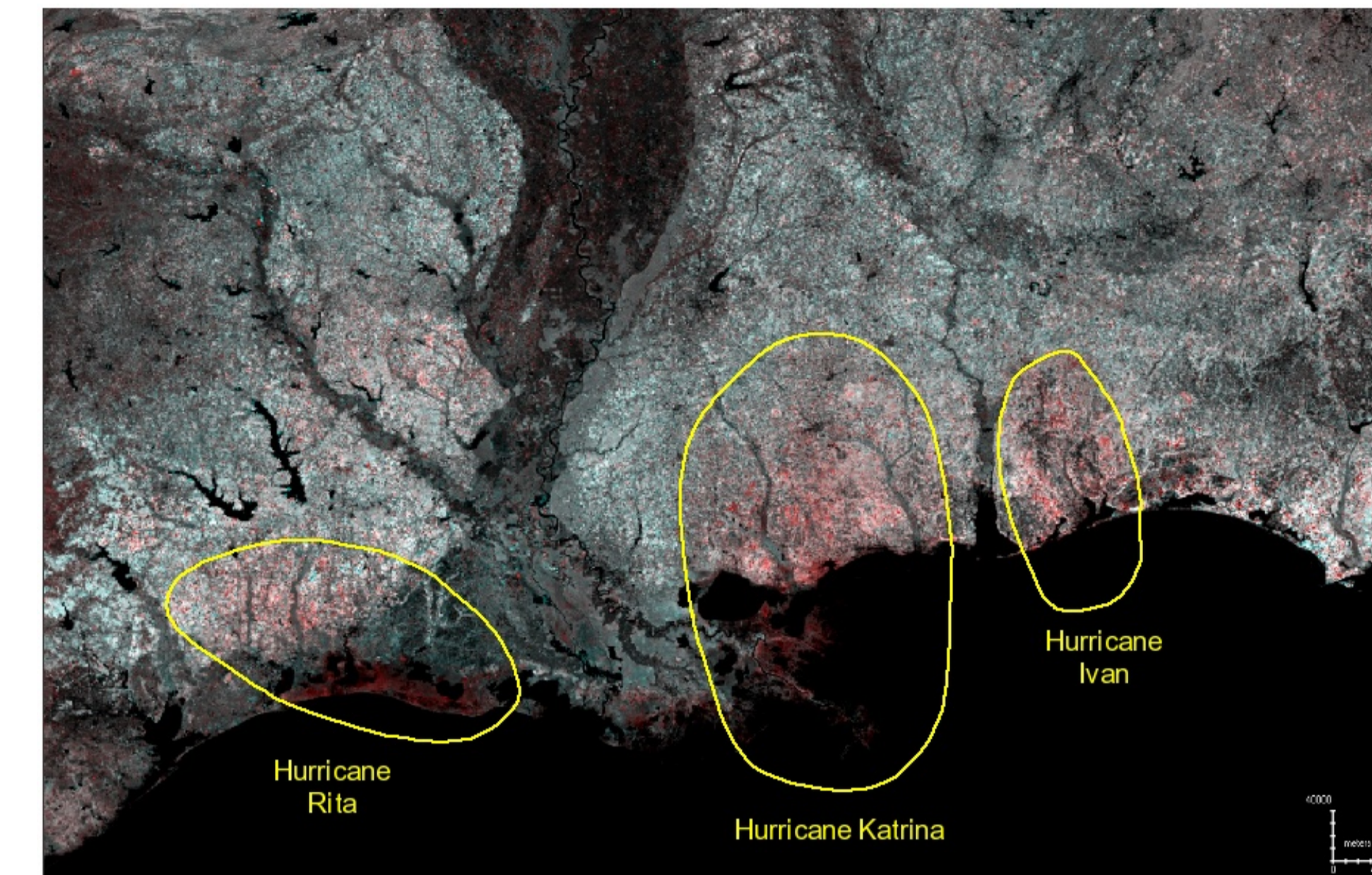
Figure 6: Effects of Three Hurricanes. Red—2004 Left 20% NDVI, Green & Blue—2006 Left 20% NDVI.

Figure 7: Phenological Parameters Ecoregions, shown in Random Colors. 25 National Phenological Ecoregions based on the parameters taken from the NDVI profile over a 5-year period from 2002-2006. These "national phenoregions" exhibit strong latitudinal constraints.
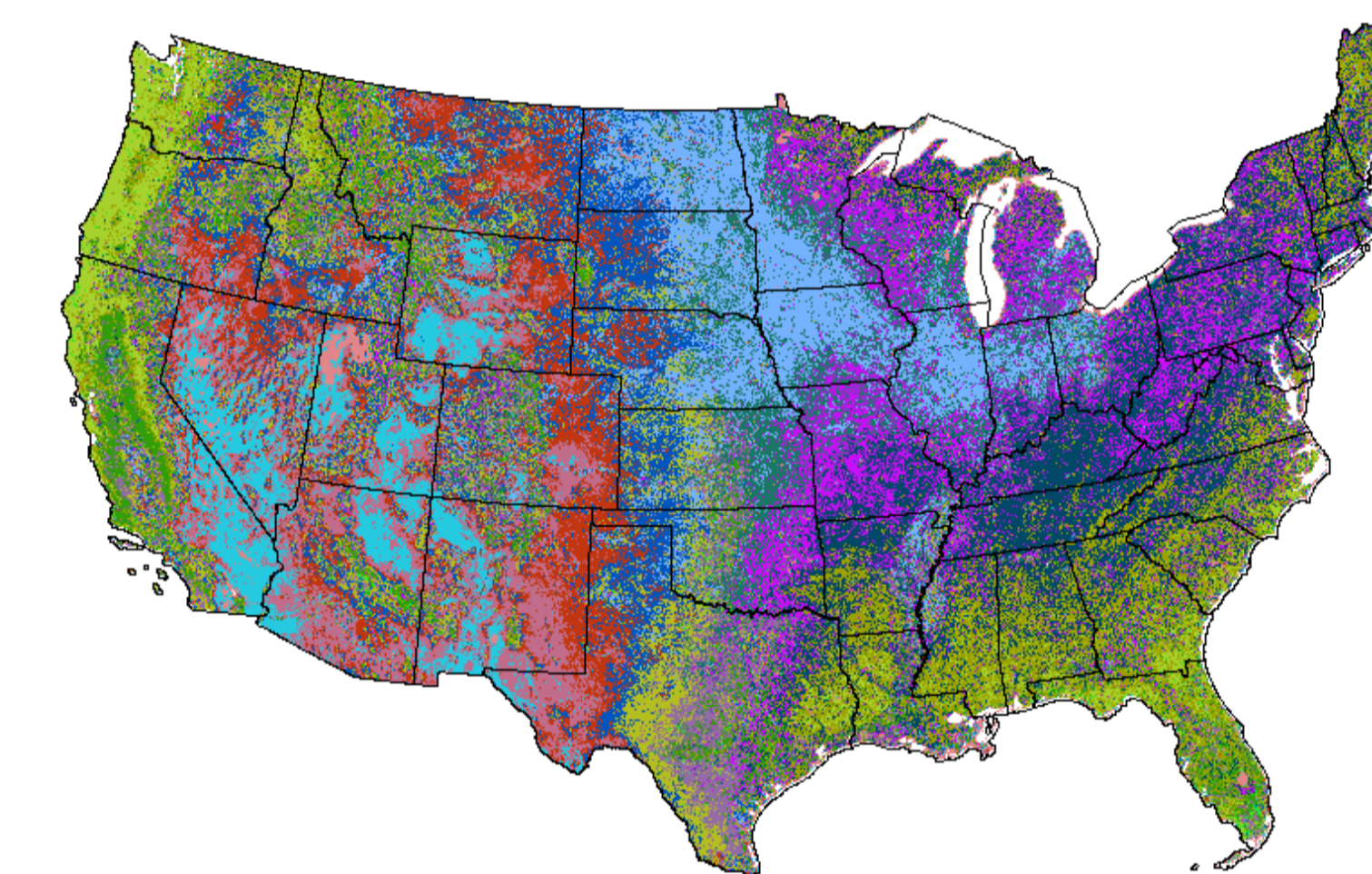
Figure 8. 15 National Phenological Ecoregions based on Cumulative NDVI over a 5-year period from 2002-2006, shown in Random Colors. Evergreens, regardless of species, are in the same phenological group in the PNW, the southeast, and Maine. Agriculture has a unique Cumulative Phenology, as do arid regions of the Desert Southwest. Lakes all have the same "phenology".
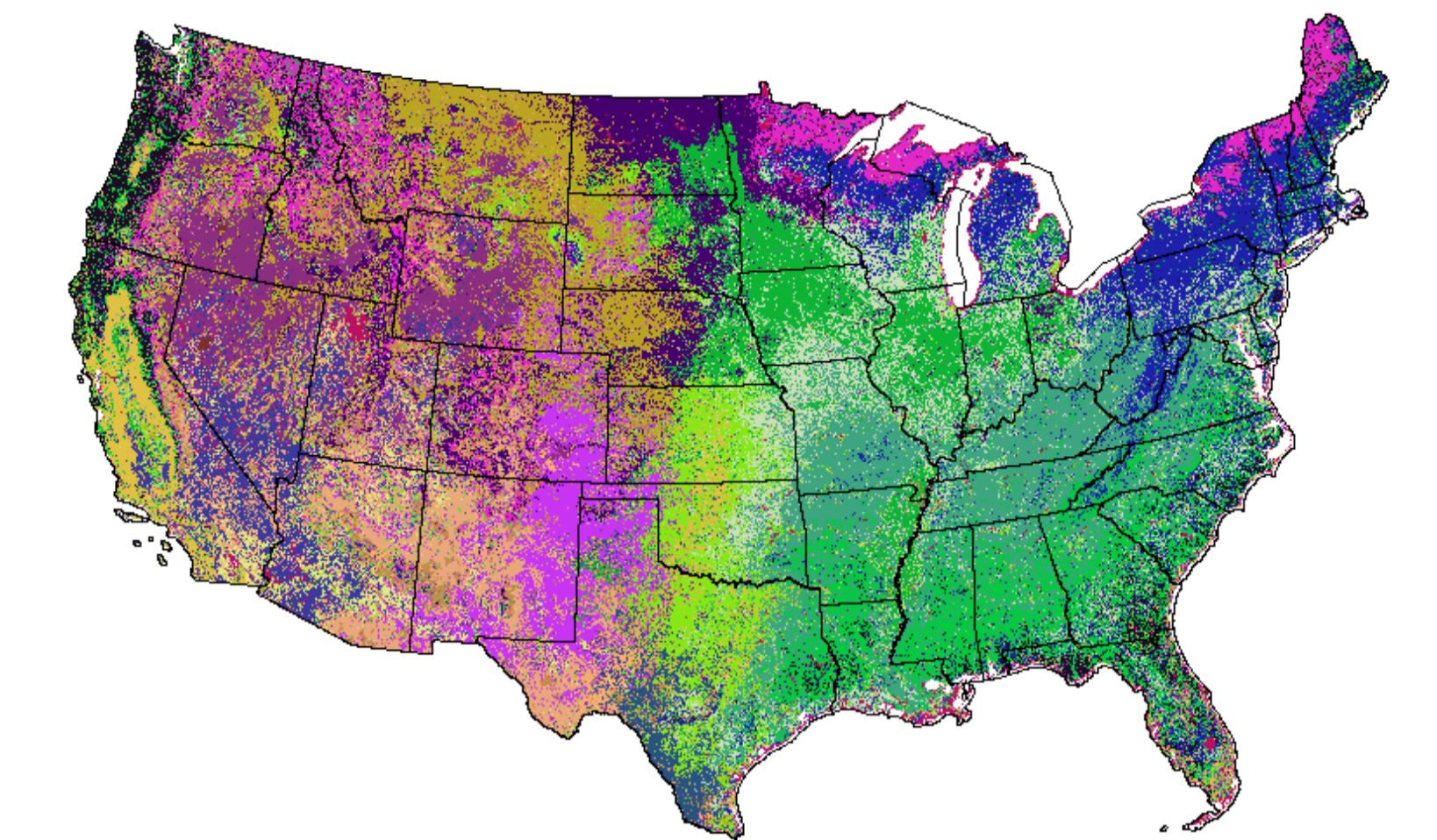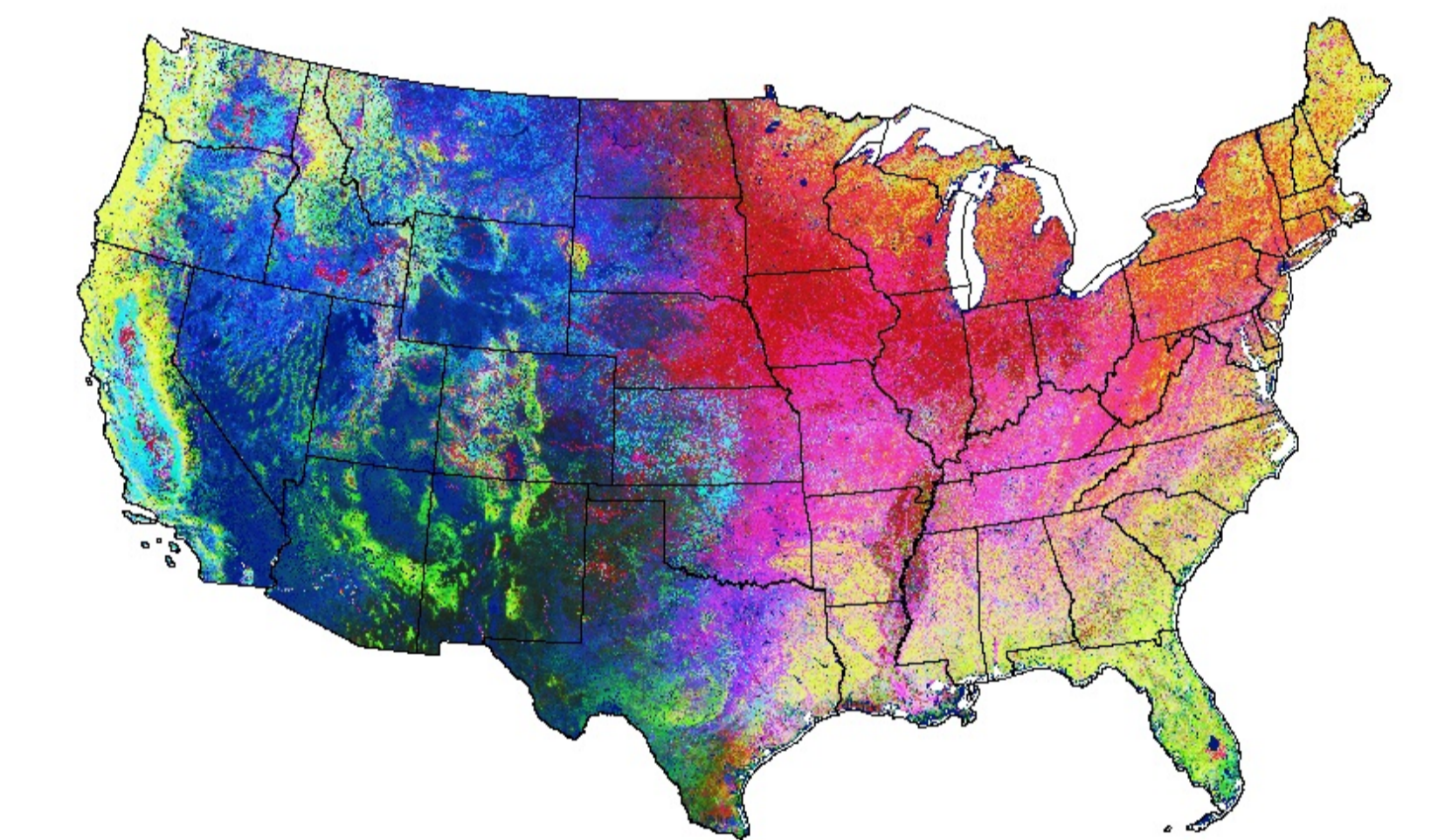
Figure 9. National Phenological Ecoregions based on Cumulative NDVI, shown in Similarity Colors. Red is a surrogate for annual gross primary productivity, highlighting agriculture and Eastern Deciduous forest. Green is winter greenness, which highlights evergreen vegetation. Yellow = Red + Green, which highlights highly productive evergreen forests in the Pacific Northwest and the Southeast. Blue is late growing season onset, including colder, higher elevation, and arid regions.
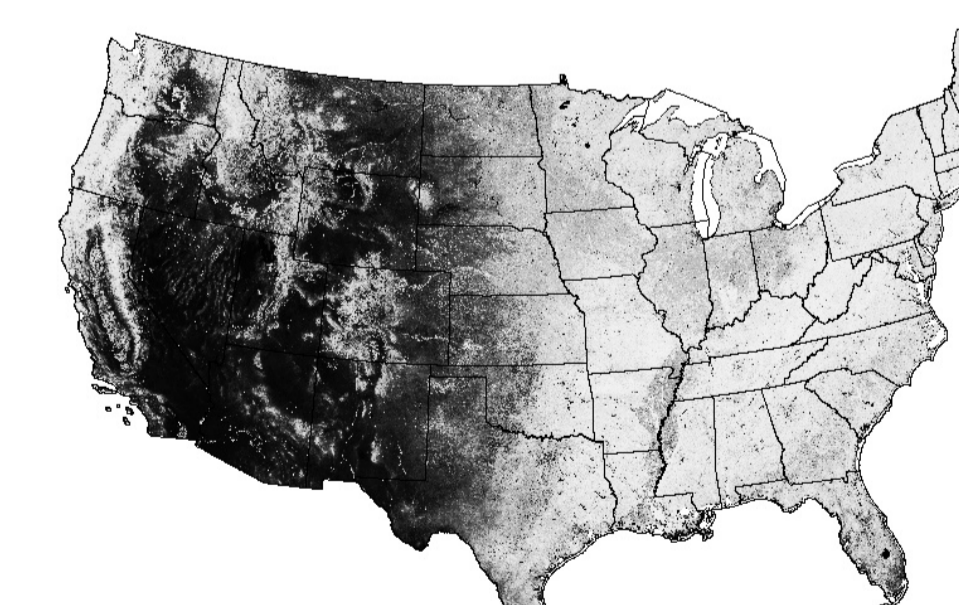
First Principal Component of Cumulative NDVI (Red)
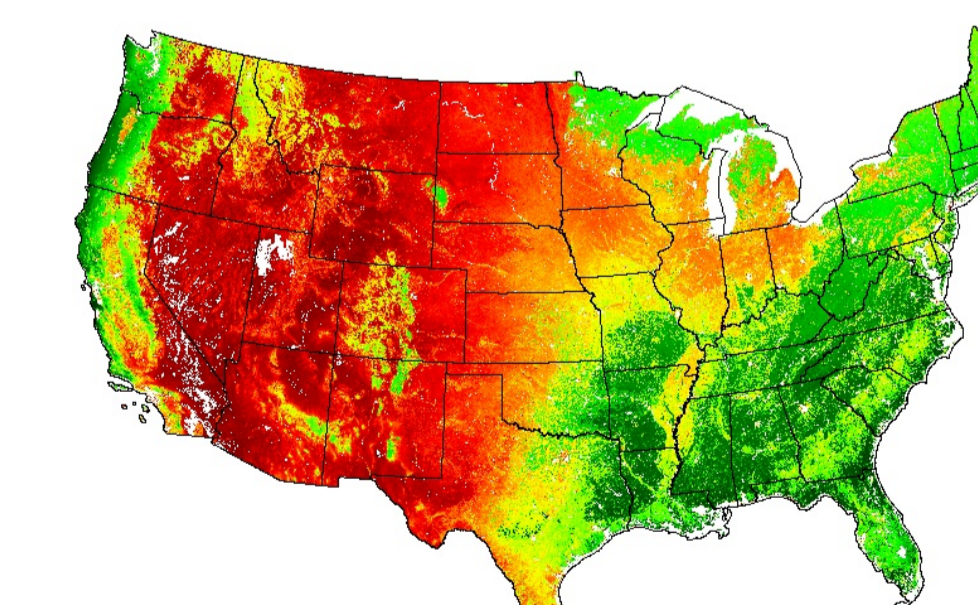
Gross Primary Production (GPP) from MODIS process-based Model
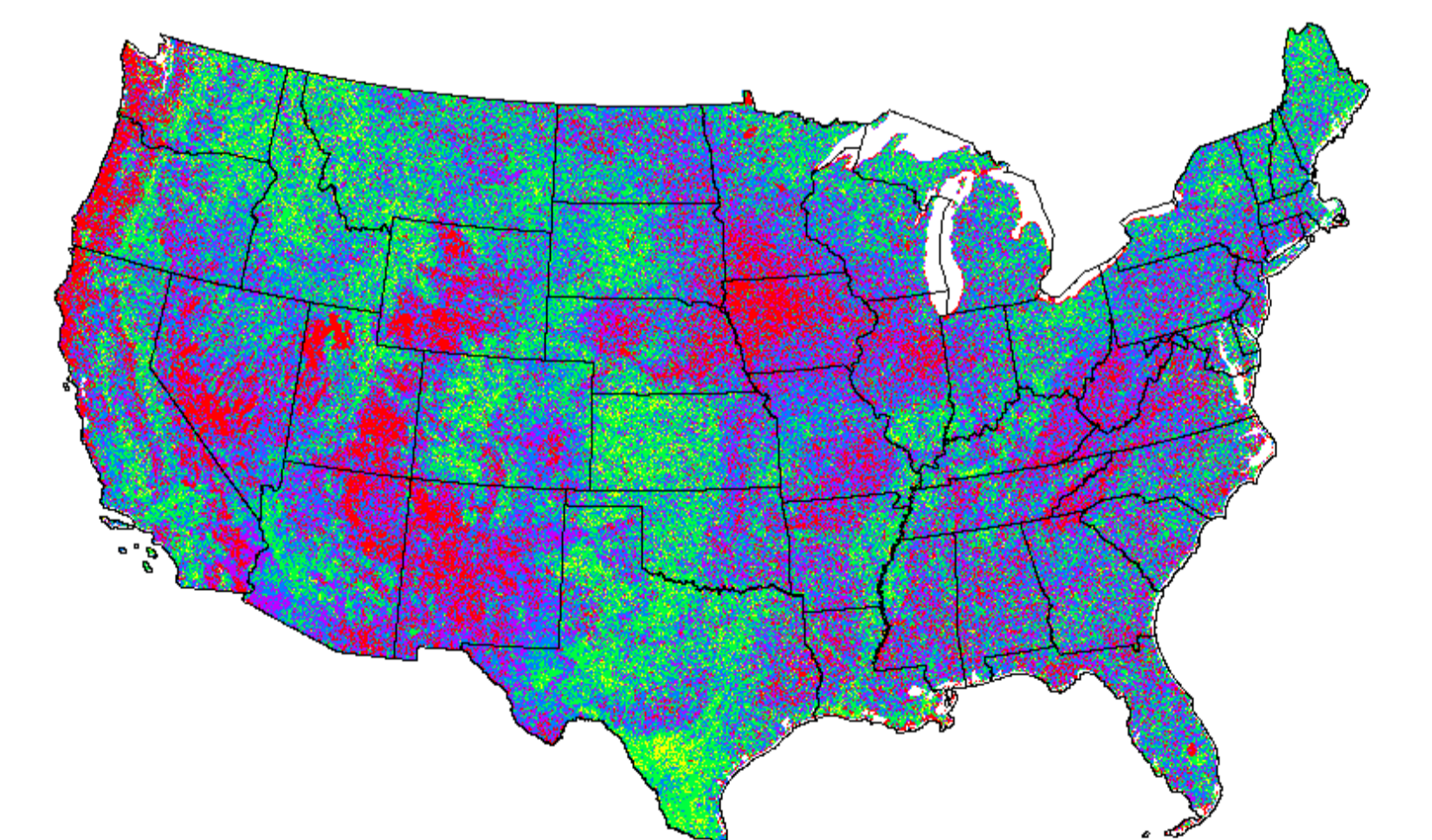
$R^2 = 0.8$ when these two maps are compared

Figure 11. Changes in Cumulative Phenology Classification 2002-2006. Red areas were classified to the same Cumulative Phenology Ecoregion (no matter which one) throughout the 2002-2006 period. Southern Appalachian forests, Iowa agriculture, Rocky Mountains, and Pacific Northwest have constant Cumulative Phenology classifications. Cumulative Phenology changes every year in south Texas and western Kansas.

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