Carbon in the Forest Biomass of Russia

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Context

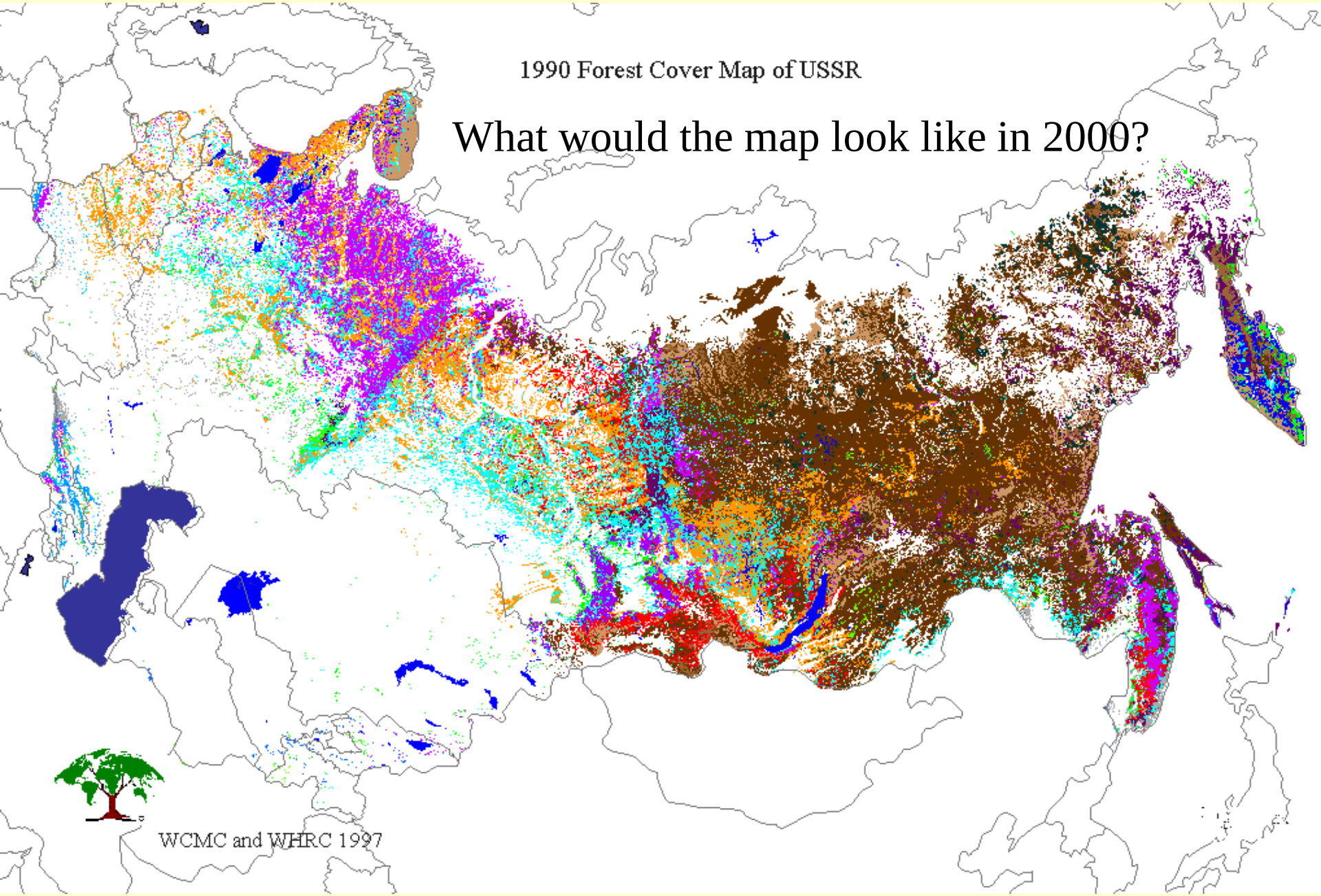
Context

1. What is the C balance of the northern mid-latitudes?
2. What are the mechanisms responsible for the current (and future) C balance?
   a. Are forests growing faster? (physiology)
   b. Are more forests in a regrowth phase?
      (age structure – past disturbances - **LCLUC**)

Questions:

How much carbon is in the biomass of Russian forests?

How has that amount changed in the last decade(s)?w

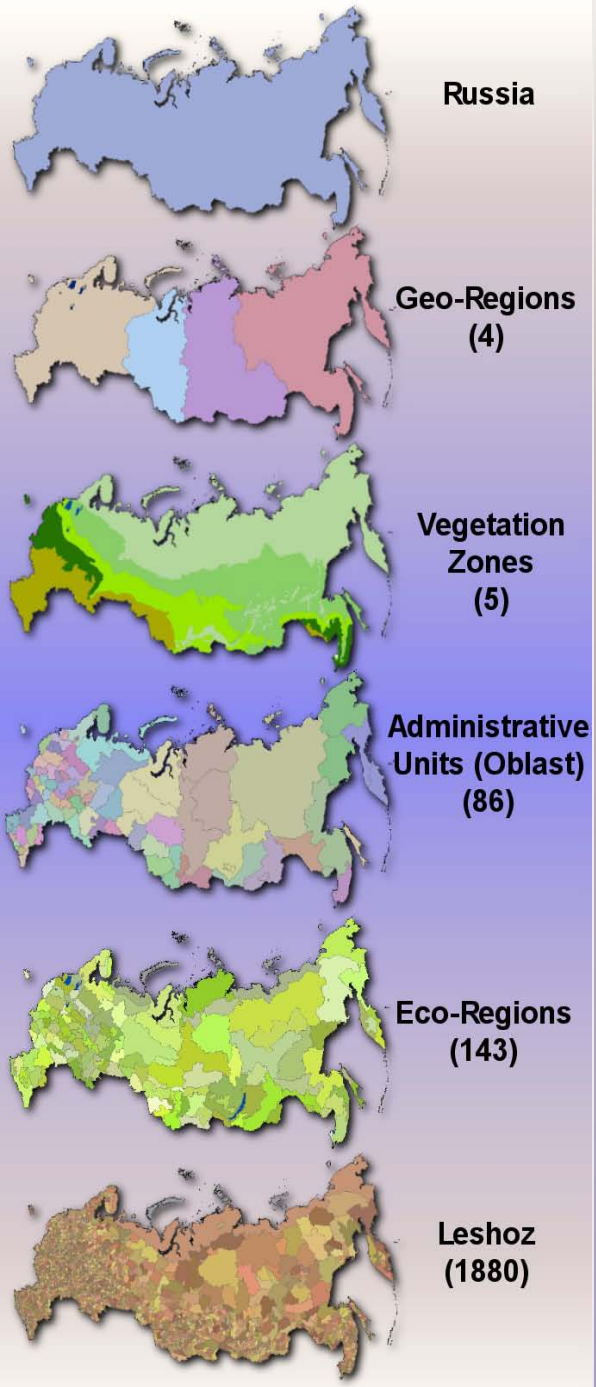

1990 Forest Cover Map of USSR
What would the map look like in 2000?
WCMC and WHRC 1997

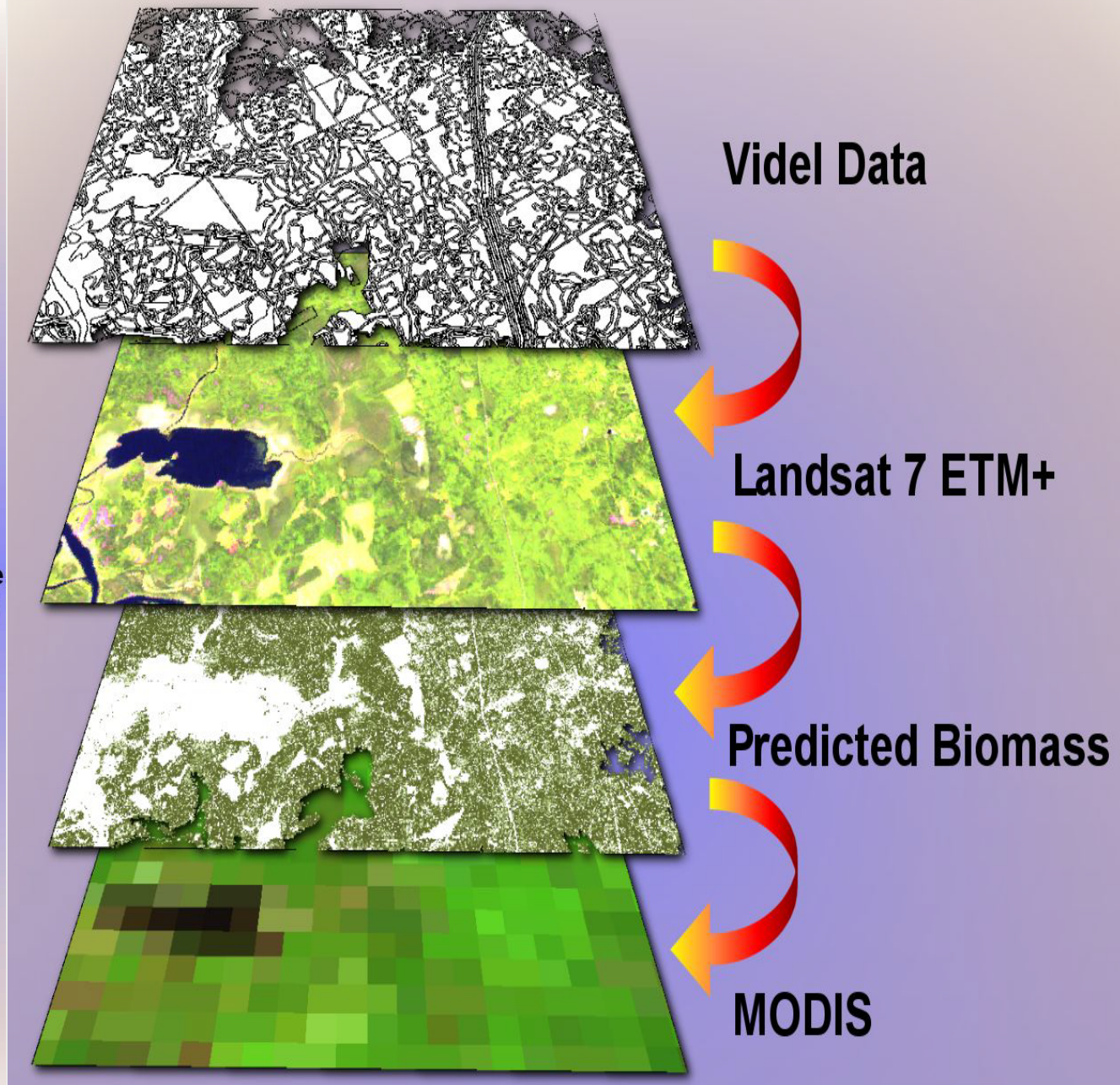
Approach

Approach

- Russian **forest inventory data** for training Landsat ETM$^+$

  (growing stock -> C/ha)
- **Landsat** ETM$^+$ for training MODIS
- **MODIS** for scaling to all Russia


Russia
Geo-Regions
(4)
Vegetation
Zones
(5)
Administrative
Units (Oblast)
(86)
Eco-Regions
(143)
Leshoz
(1880)


Videl Data
Landsat 7 ETM+
Predicted Biomass
MODIS

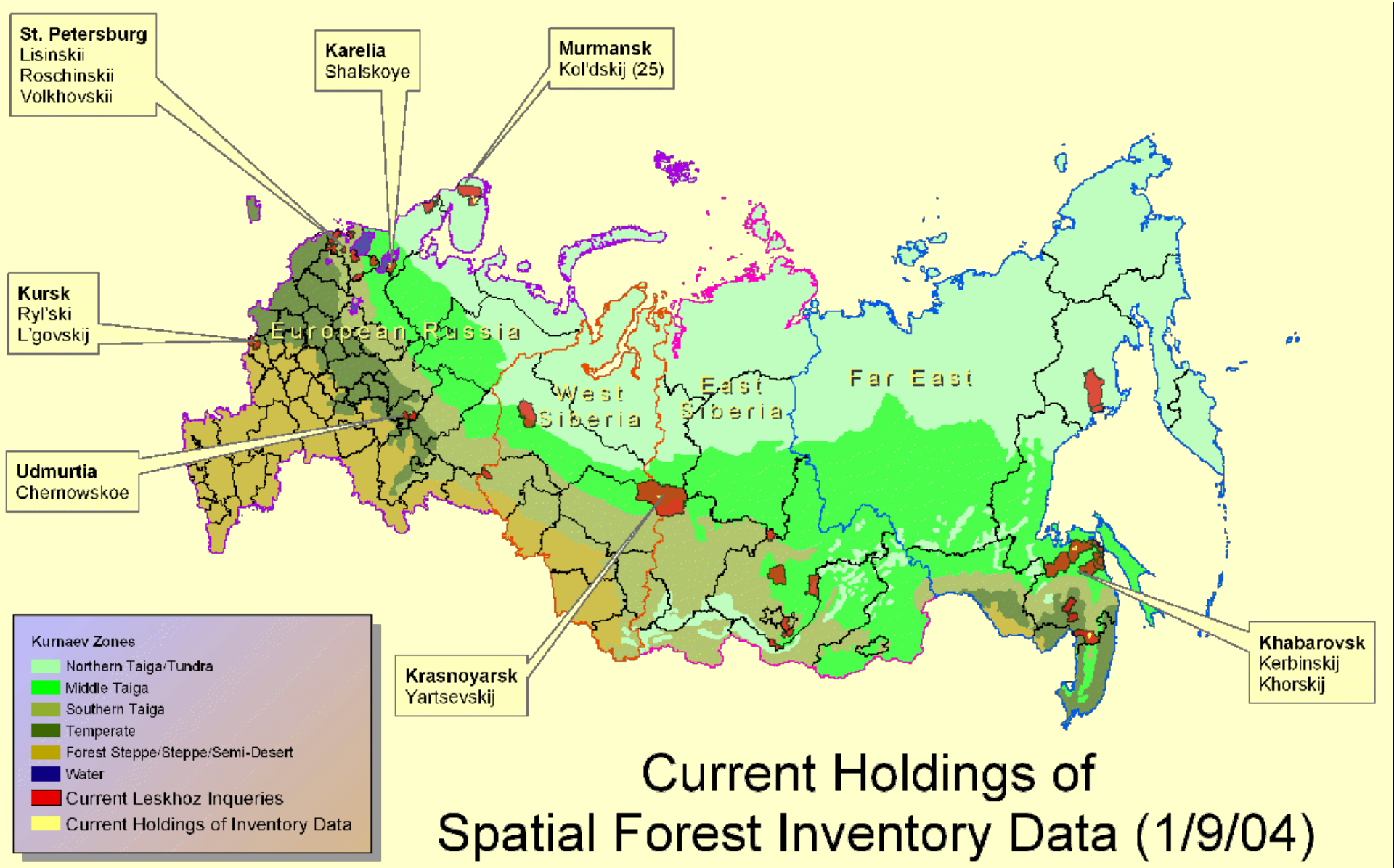
Stratify Russian forests into ~15 ecoregions by…

Geo-regions (4):

European Russia, Western Siberia, Eastern Siberia, Far East

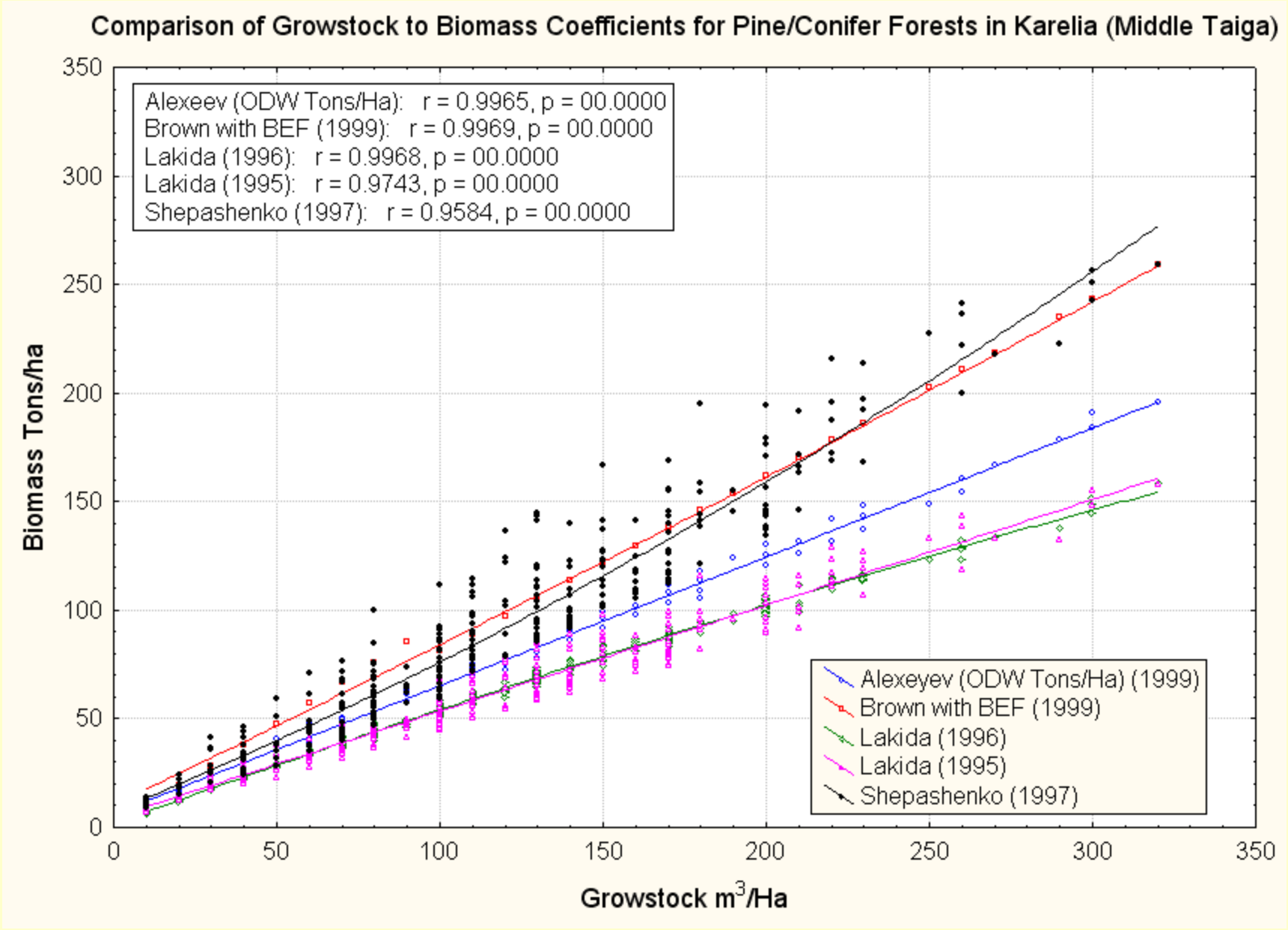
Vegetation zones (5):

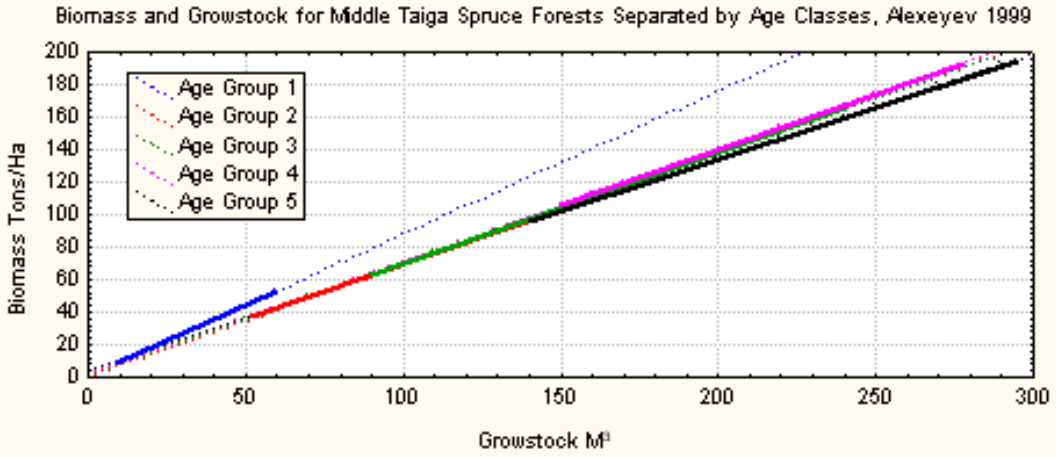
Northern, central, southern taiga, temperate forest, forest steppe

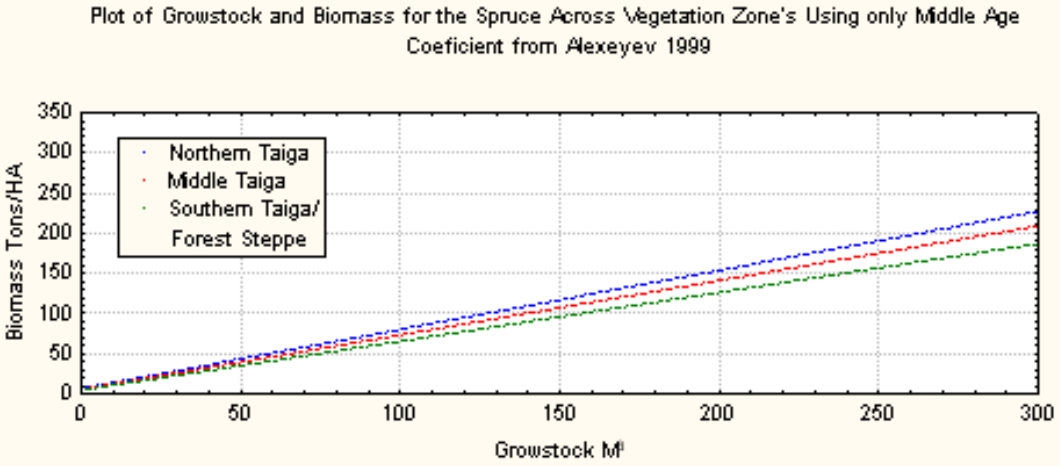


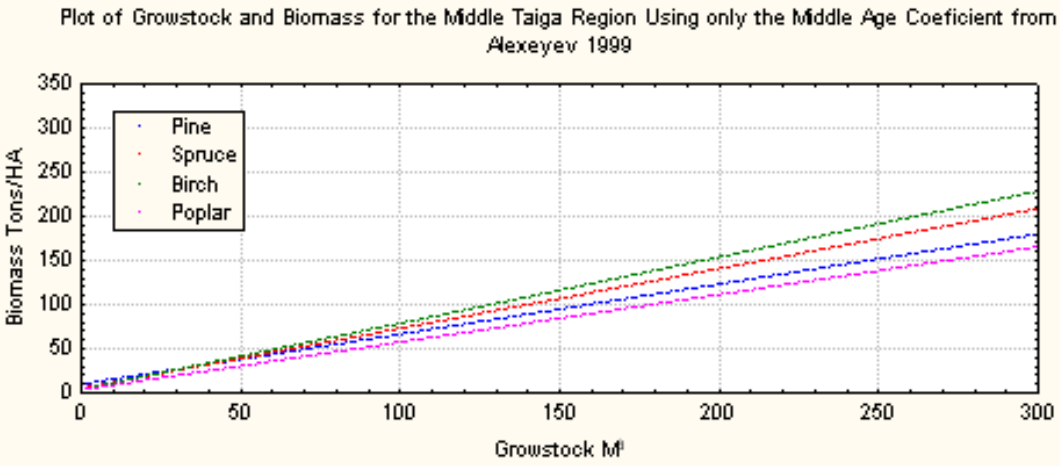
Current Holdings of Spatial Forest Inventory Data (1/9/04)

Forest Inventory Data


Comparison of Growstock to Biomass Coefficients for Pine/Conifer Forests in Karelia (Middle Taiga)
Alexeev (ODW Tons/Ha): r = 0.9965, p = 00.0000
Brown with BEF (1999): r = 0.9969, p = 00.0000
Lakida (1996): r = 0.9968, p = 00.0000
Lakida (1995): r = 0.9743, p = 00.0000
Shepashenko (1997): r = 0.9584, p = 00.0000
Biomass Tons/ha
Growstock m3/Ha
0
50
100
150
200
250
300
350
Alexeyev (ODW Tons/Ha) (1999)
Brown with BEF (1999)
Lakida (1996)
Lakida (1995)
Shepashenko (1997)







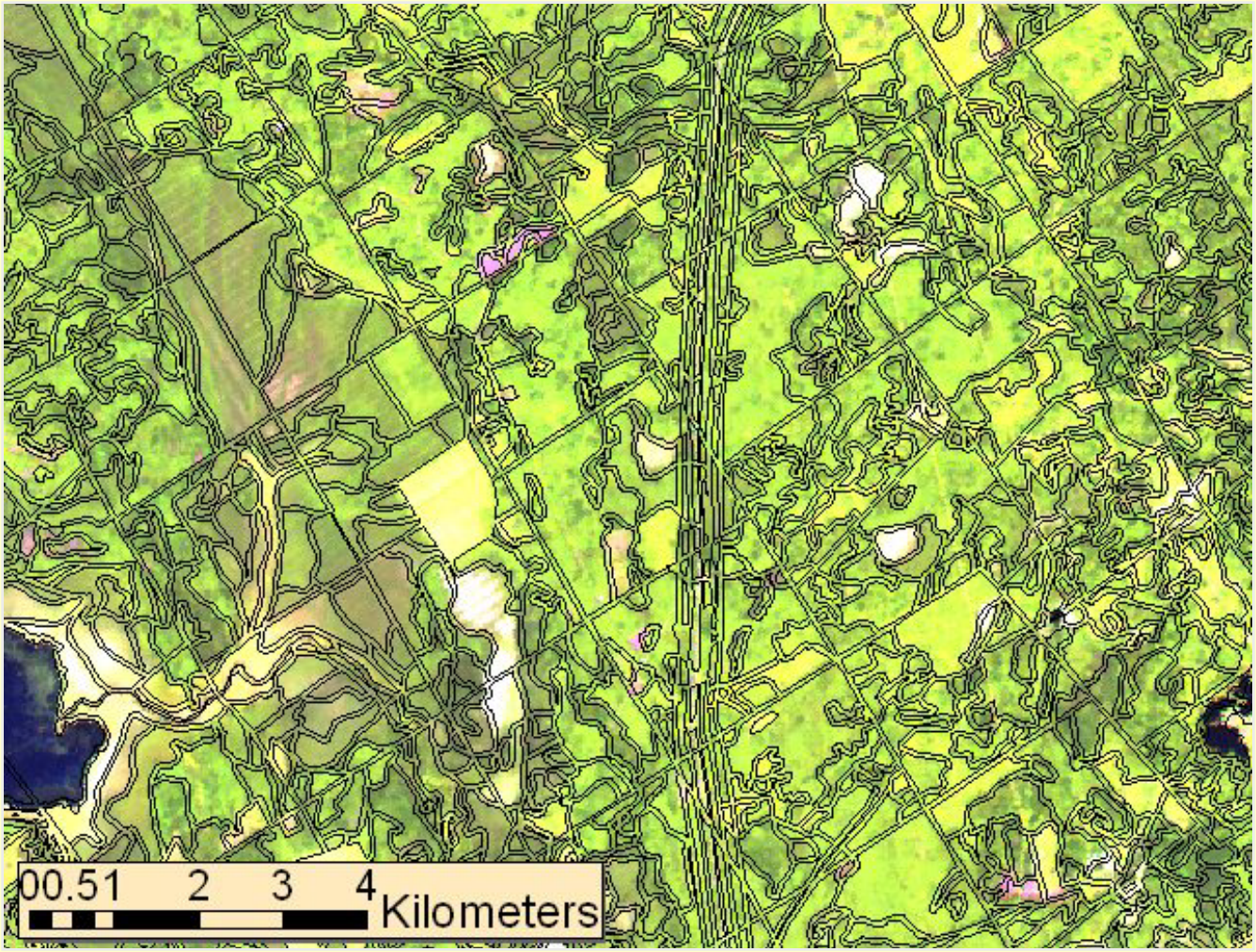
Total Biomass predicted from growing stocks

…by age

…by eco-region

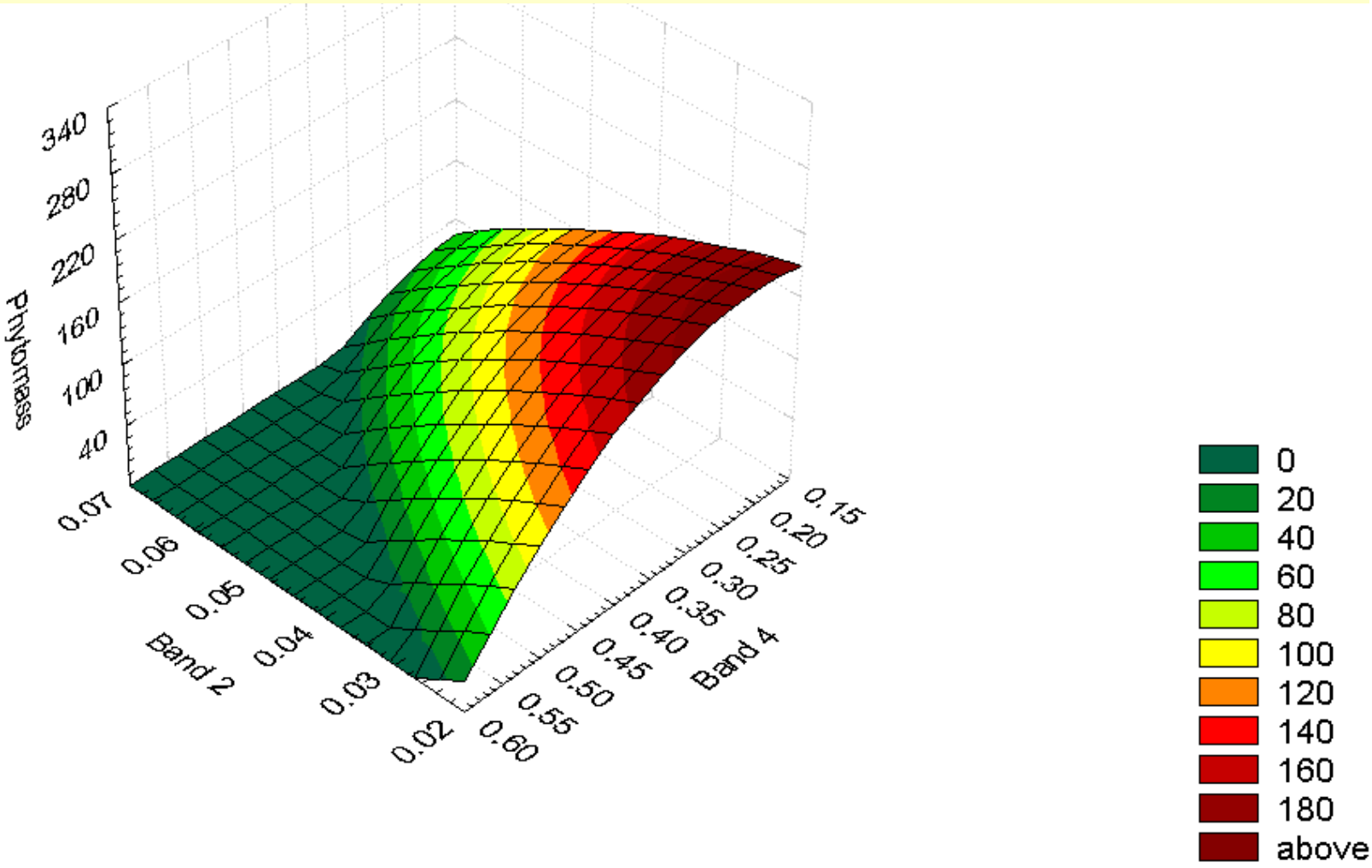
…by species (group)

Training Landsat data with Inventory Data

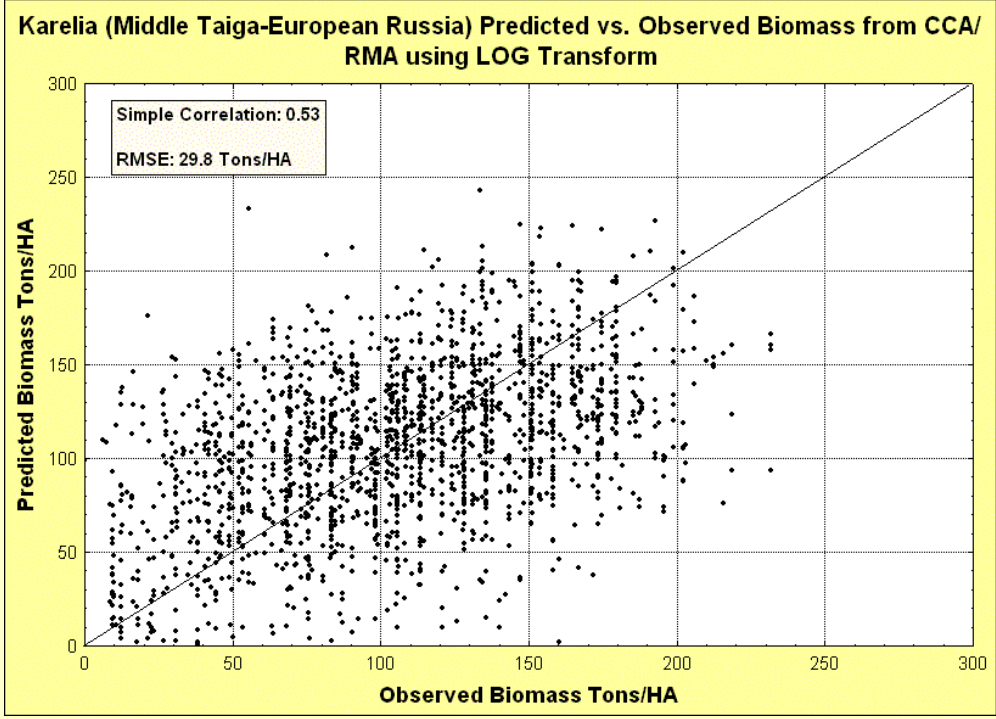


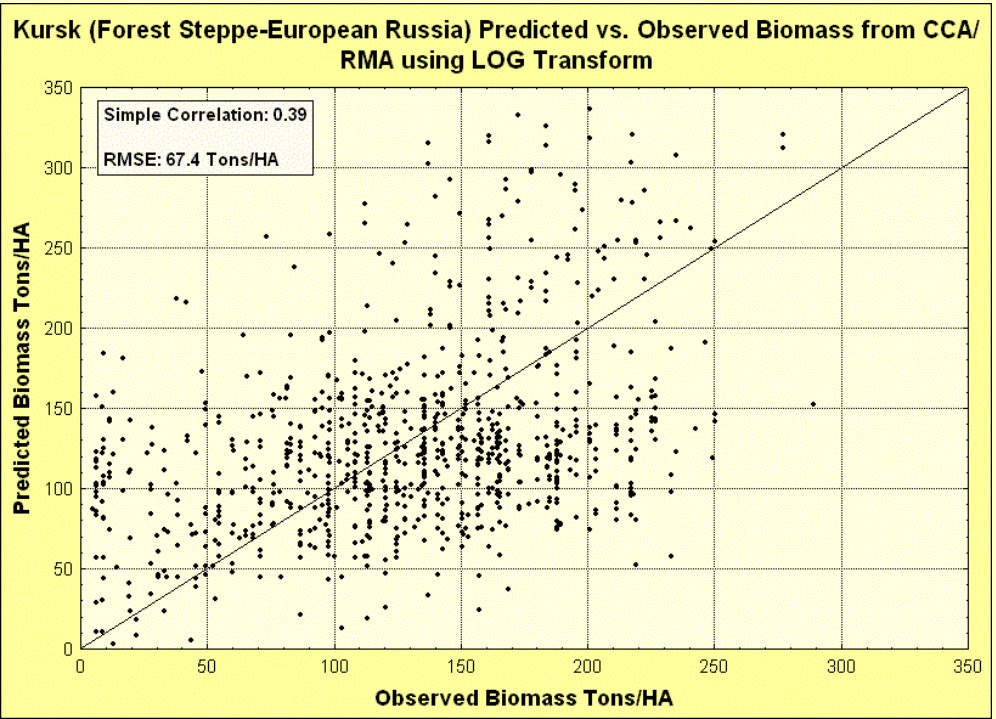
Videl (inventory polygon) data overlaid with Landsat ETM+ data

In theory…


Phytomass
340
280
220
160
100
40
Band 2
0.07
0.06
0.05
0.04
0.03
0.02
Band 4
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
0.55
0.60
0
20
40
60
80
100
120
140
160
180
above

In fact…





Observed & predicted biomass for individual videls (polygons)

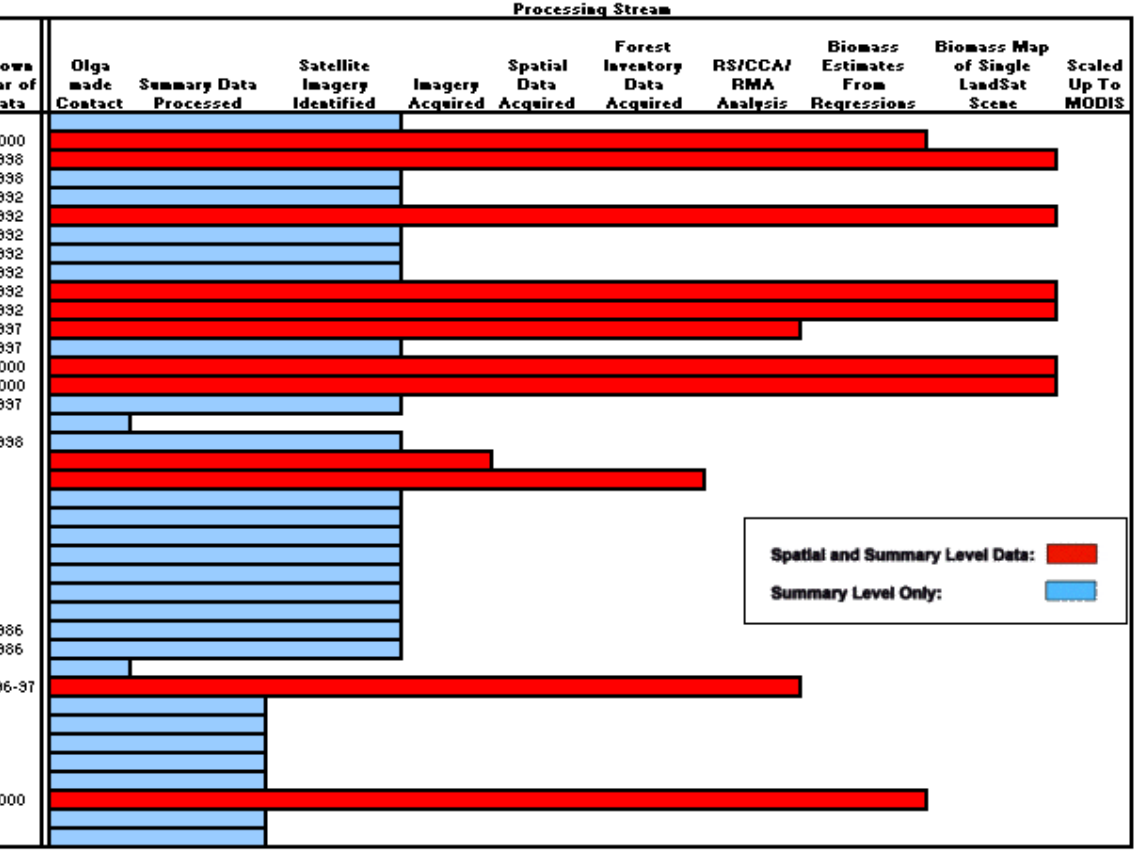
Inventories acquired, processed, …

Data Acquisition and Processing Schematic 1/9/2004
NASA Grant Number NAG5-11286

Changes in Terrestrial Carbon Storage in Russia as a Result of Recent Disturbances and Land-Use Change

Data Location and Information | **Processing Stream**

Geogr. Region	Ecoregion #	Kurnaev Vegetation Zone	Admin. Region	Leskhoz	Known Year of Data
European Russia	1	N. Taiga	Murmansk	Kol'dskij (25)	
European Russia	1	N. Taiga	Murmansk	Murmanskij	2000
European Russia	2	M. Taiga	Karelia	Pudozhskij	1998
European Russia	2	N. Taiga	Karelia	Pyaozerskij	1998
European Russia	3	S. Taiga	St. Petersburg	Kingisseppskii	1992
European Russia	3	S. Taiga	St. Petersburg	Lisinskii	1992
European Russia	3	S. Taiga	St. Petersburg	Luzhskii	1992
European Russia	3	S. Taiga	St. Petersburg	Podborovskii	1992
European Russia	3	M. Taiga	St. Petersburg	Podporozhskii	1992
European Russia	3	S. Taiga	St. Petersburg	Roschinskii	1992
European Russia	3	S. Taiga	St. Petersburg	Volkhovskii	1992
European Russia	4	Temperate Forest	Udmurtia	Wotkinsk	1997
European Russia	4	Temperate Forest	Udmurtia	Balesinskij	1997
European Russia	5	Forest-steppe and Steppe	Kursk	Ryl'ski	2000
European Russia	5	Forest-steppe and Steppe	Kursk	L'govskij	2000
West Siberia	6	N. Taiga	Khanty-Mansi	Krasnoleninskij	1997
West Siberia	7	M. Taiga	Khanty-Mansi		
West Siberia	8	S. Taiga	Tjumenskaja obl.	Tjumenskij	1998
West Siberia	9	Forest-steppe and Steppe	Novosibirsk	Ordynskiy	
East Siberia	10	M. Taiga	Krasnoyarsk	Yartsevskij	
East Sib.	11	M. Taiga	Irkutsk obl.	Ul'kanskij	
East Sib.	11	M. Taiga	Irkutsk obl.	Shestakovskij	
East Sib.	11	M. Taiga	Irkutsk obl.	Ilimskij	
East Sib.	12	S. Taiga	Irkutsk obl.	Angarskij	
East Sib.	12	S. Taiga	Irkutsk obl.	Goloustovskij	
East Sib.	12	S. Taiga	Irkutsk obl.	Sludyanskij	
East Sib.	12	S. Taiga	Irkutsk obl.	Ust'-ordynskij	
Far East	13	N. Taiga	Magadan	Magadanskij	1986
Far East	13	N. Taiga	Magadan	Palatskij	1986
Far East	13	N. Taiga	Magadan		
Far East	14	M. Taiga	Khabarovsk (N)	Kerbinskij	1996-97
Far East	14	M. Taiga	Khabarovsk (N)	Lasarevskij	
Far East	14	M. Taiga	Khabarovsk (N)	Bystrinskij	
Far East	14	M. Taiga	Khabarovsk (N)	De-Kastrinskij	
Far East	14	M. Taiga	Khabarovsk (N)	Kisinskij	
Far East	14	M. Taiga	Khabarovsk (N)	Tahtinskij	
Far East	15	S. Taiga/ Temperate	Khabarovsk (S)	Khorskij	2000
Far East	15	Temperate	Khabarovsk (S)	Litovskij	
Far East	15	Temperate	Khabarovsk (S)	Bolonskij	



Another test (coarser resolution)….

- Compare larger forest inventory unit (lesnichestvo) with Landsat-derived estimates of ...
  - Forest area
  - Average C/ha

Scaling up with MODIS

Approach

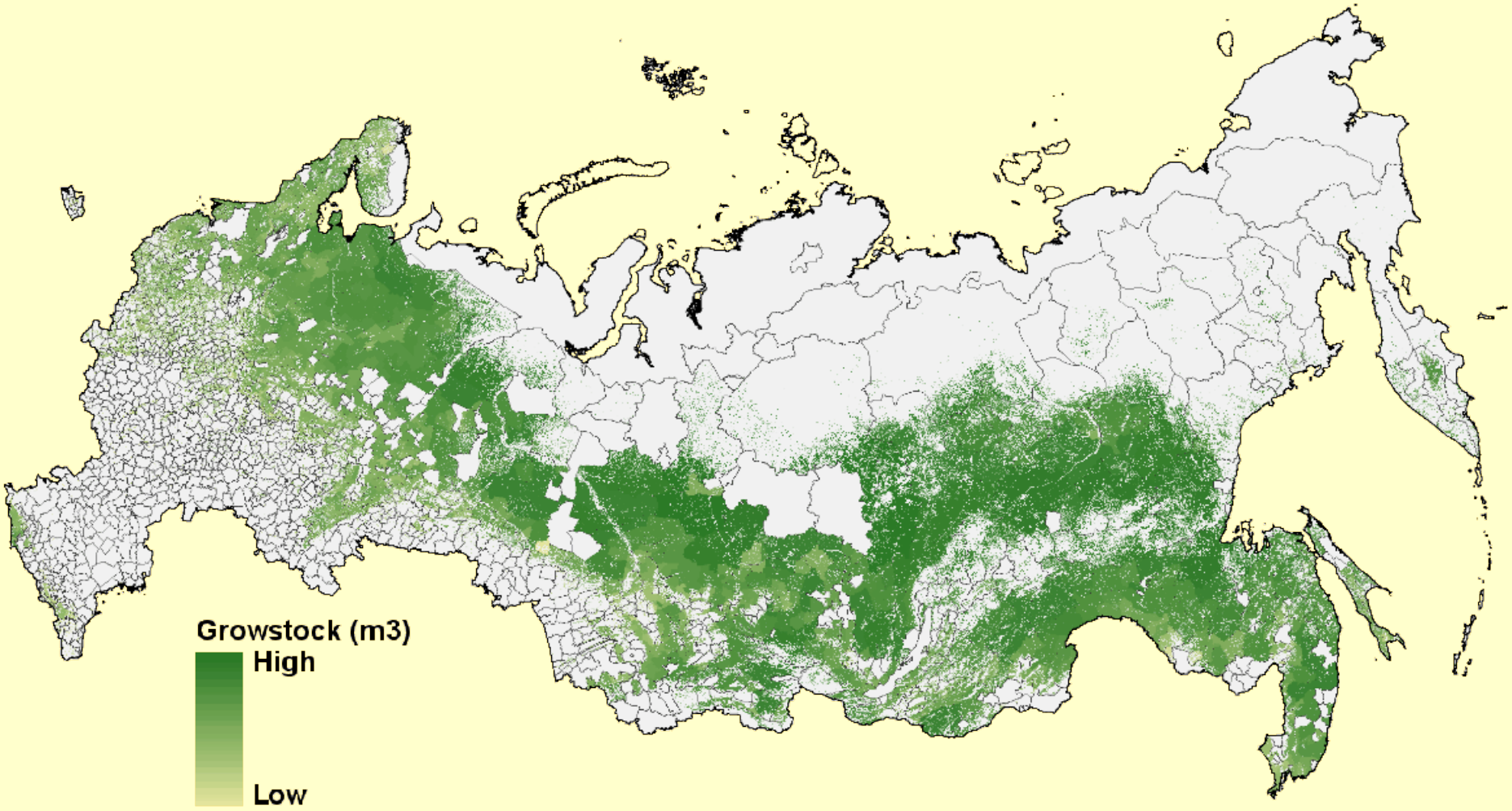
- Russian forest inventories for training Landsat ETM+
- Landsat ETM+ for training MODIS
- MODIS for scaling to entire Federation

But wait…

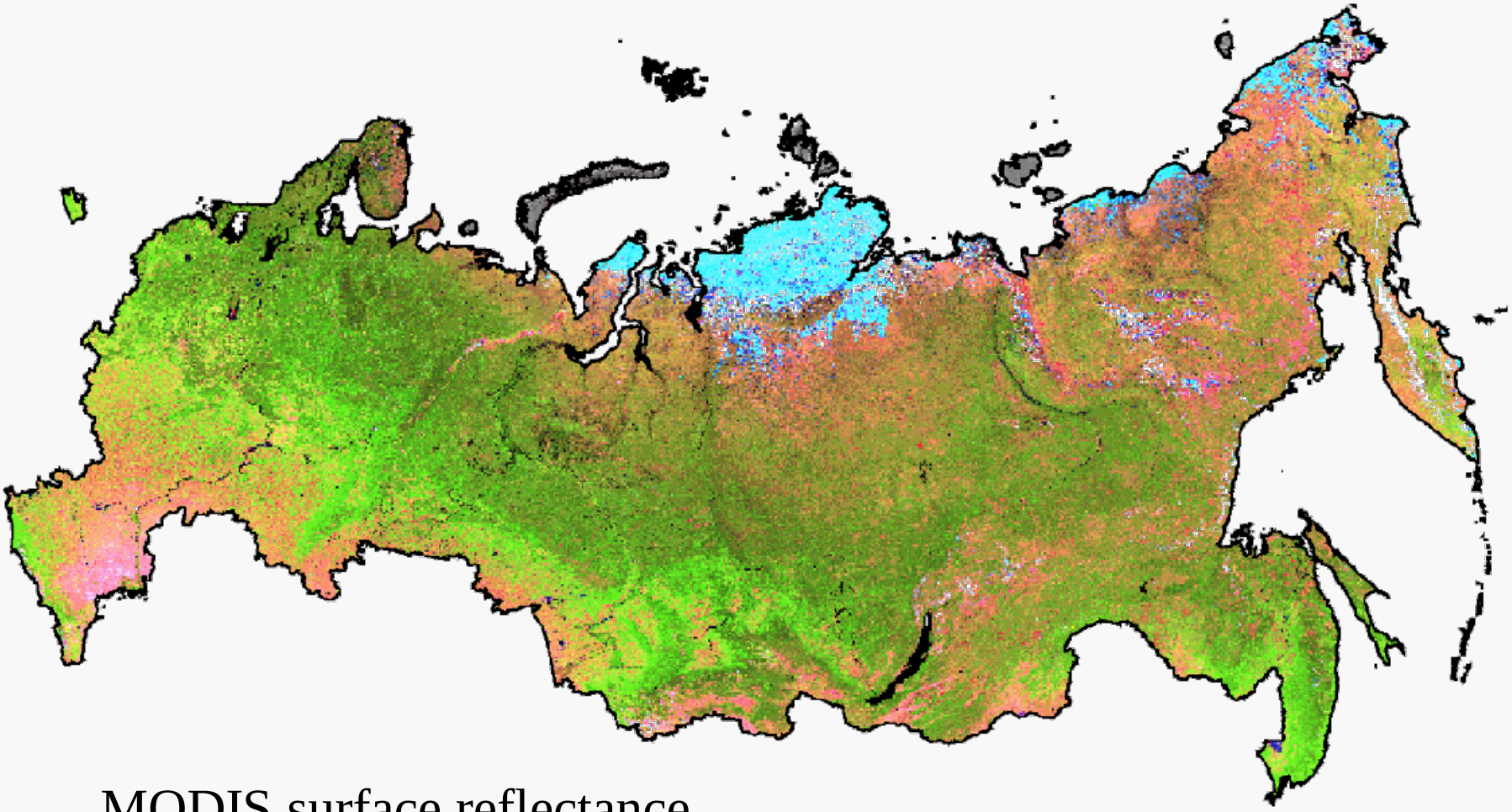
An Alternative Approach

- At a more aggregated (coarser) scale (leskhoz), MODIS may be a reasonable predictor of biomass C (??)

Leskhoz boundaries



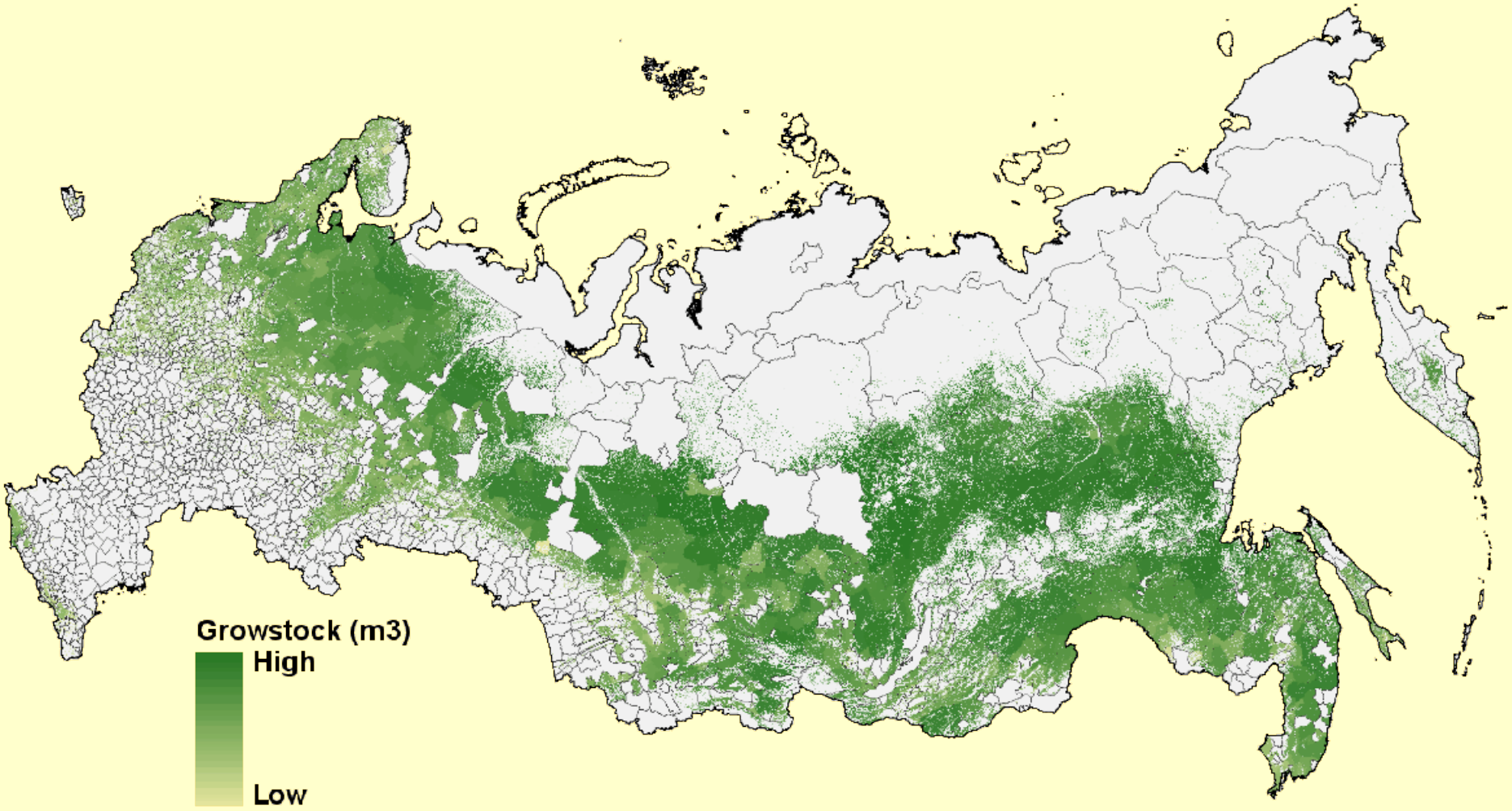
~1880 Leskhozes in the Russian Federation



MODIS surface reflectance

(MOD43B4) (BRDF product)

Leskhoz boundaries



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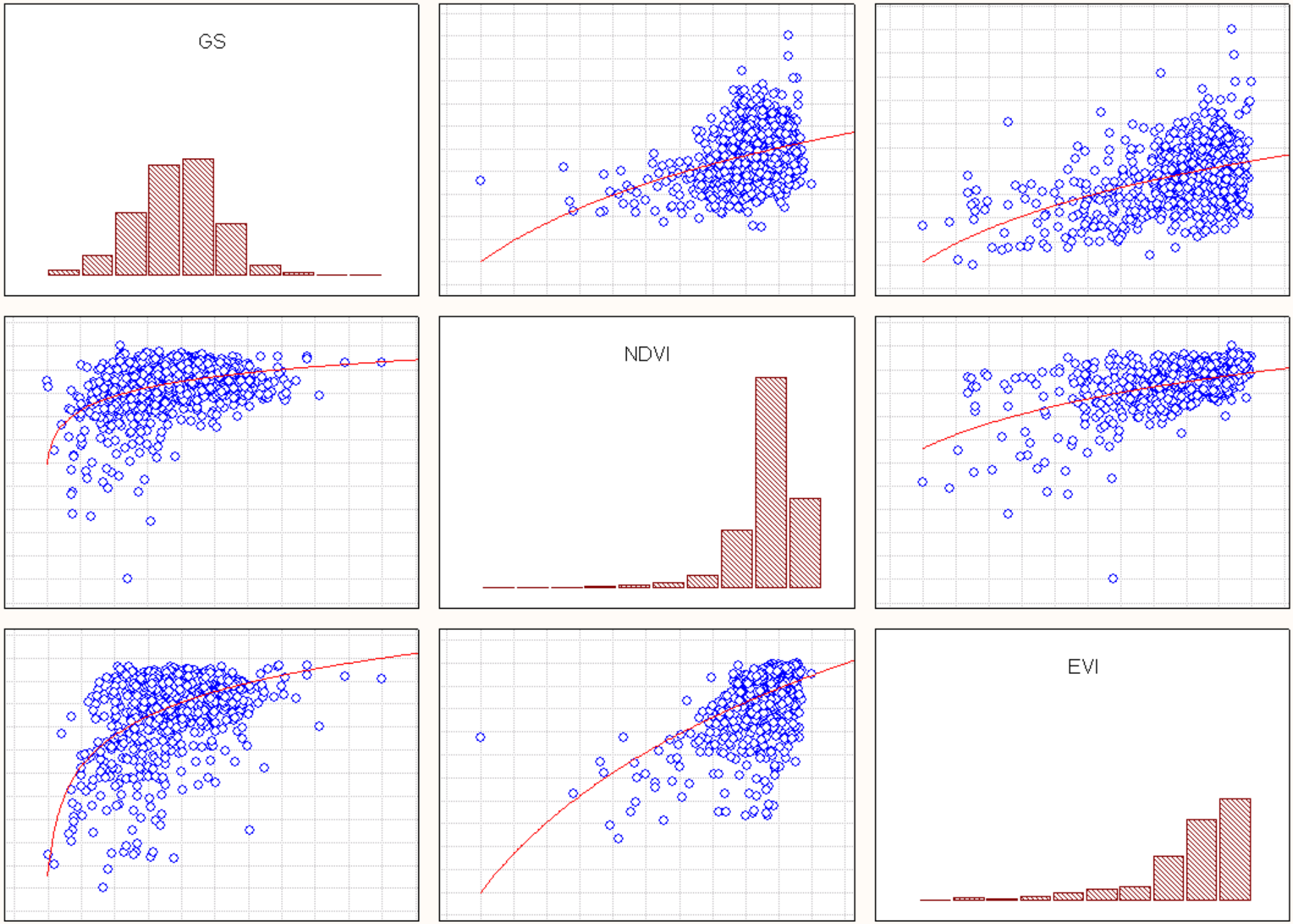
GS
NDVI
EVI

Thank you


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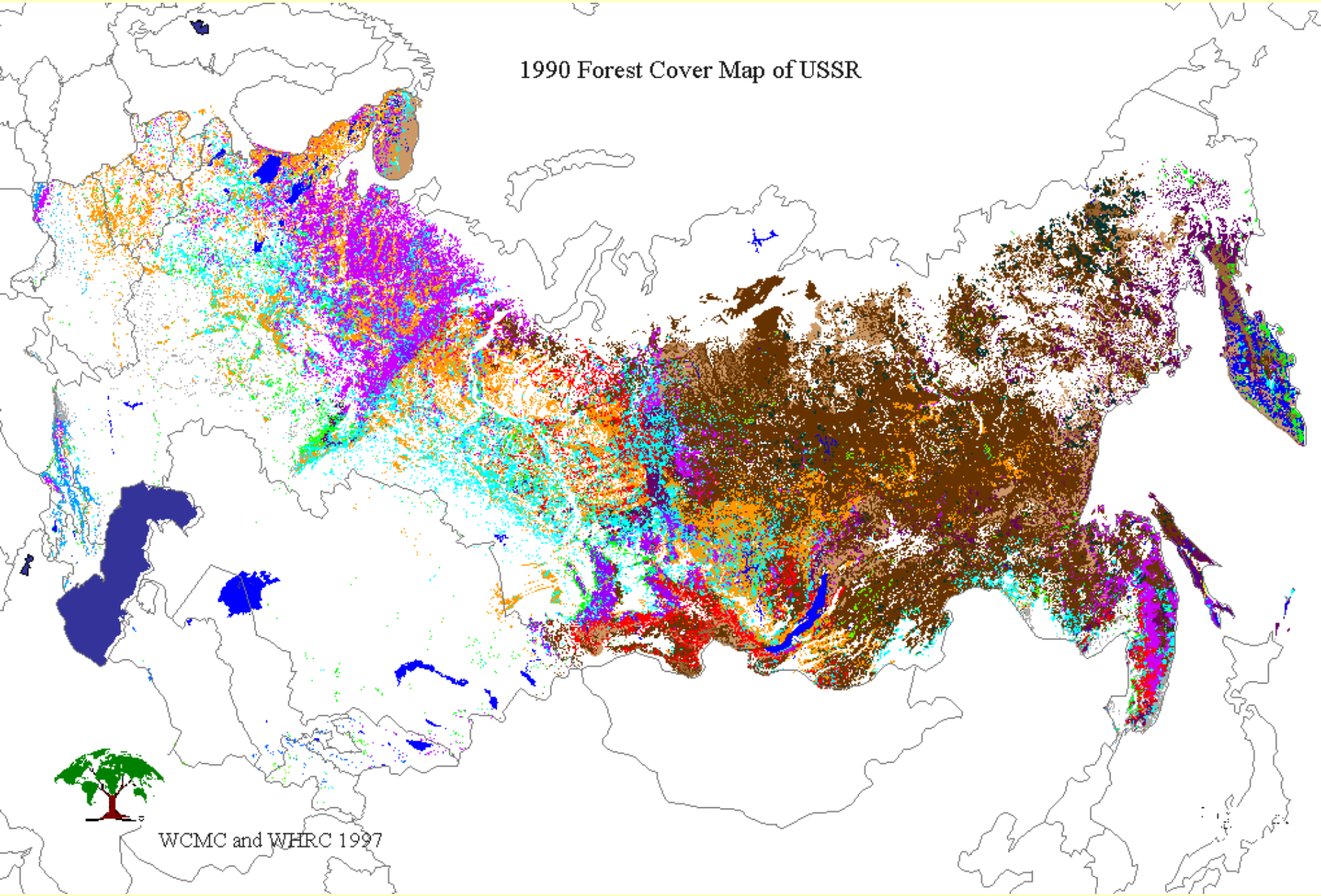
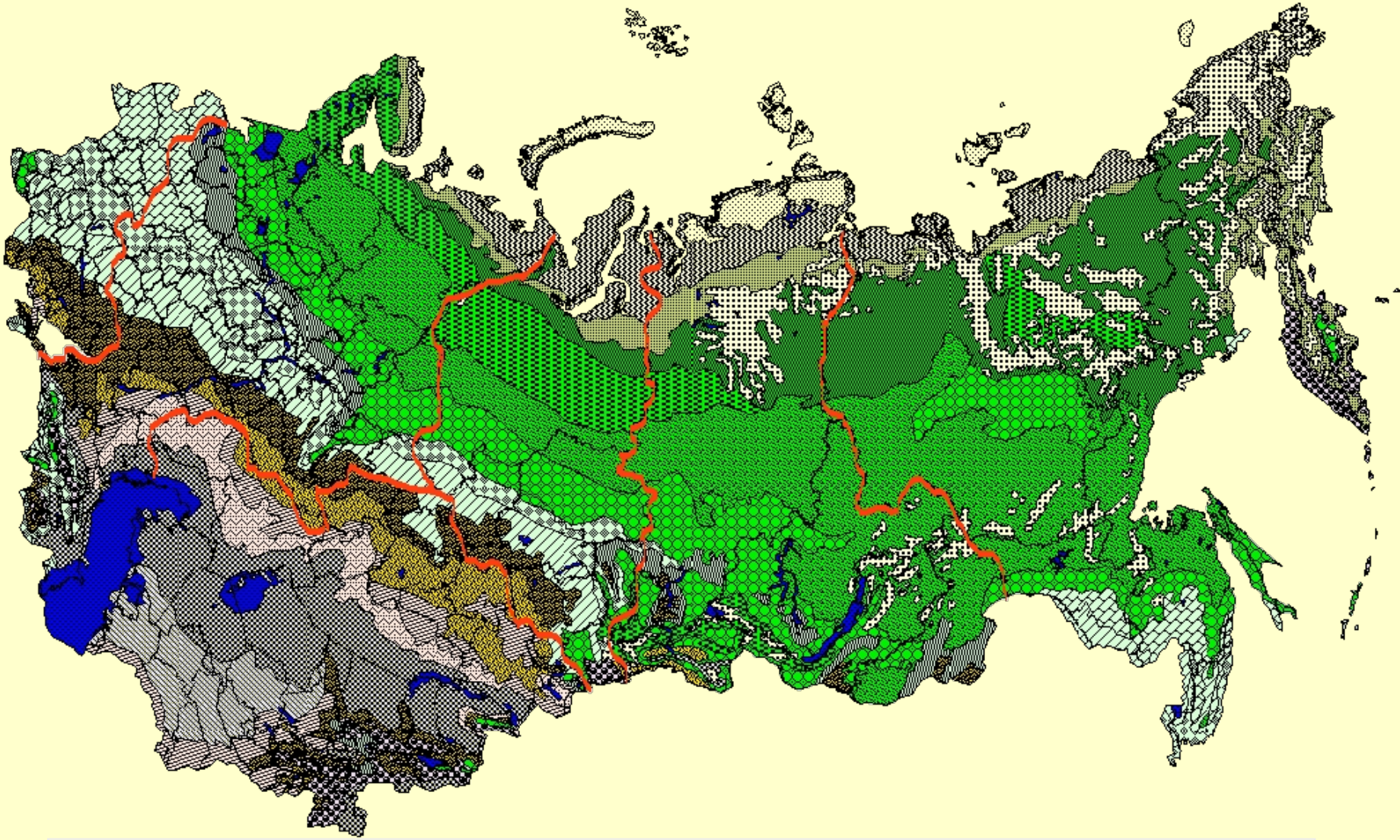

1990 Forest Cover Map of USSR
WCMC and WHRC 1997

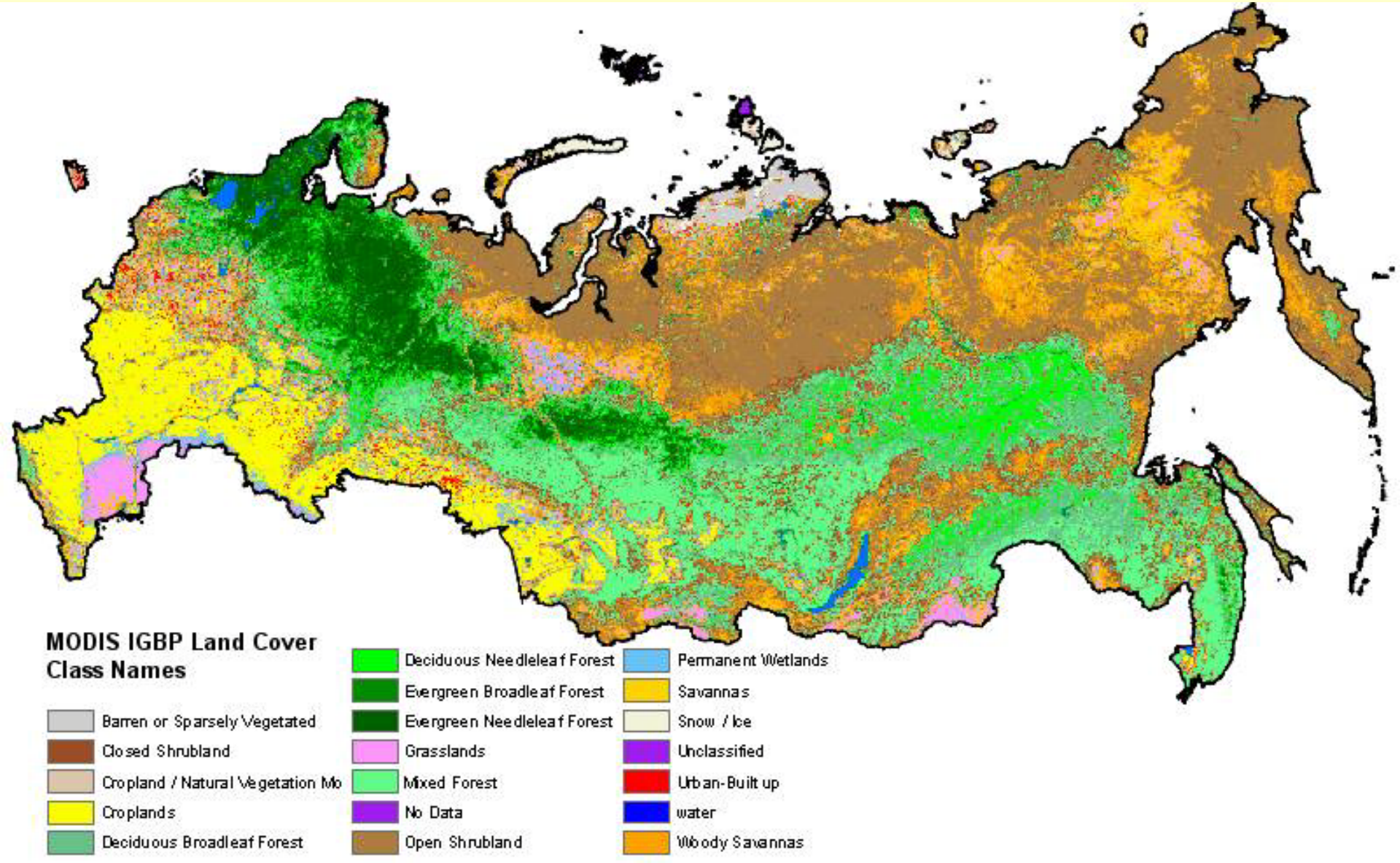
Geo-Ecoregion stratification for sampling

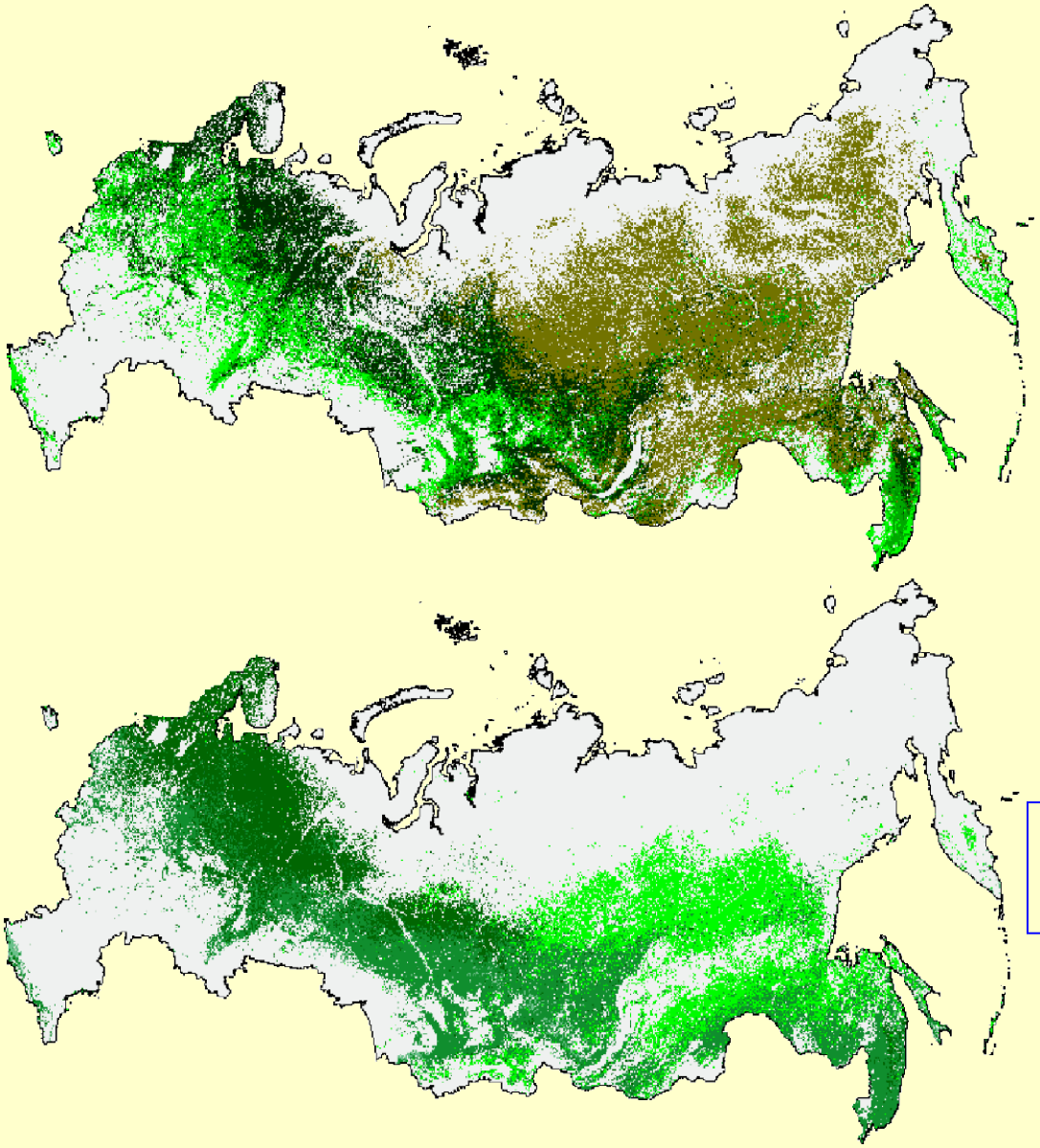


Highly generalized vegetation zones of the FSU based on the work of [illegible] zones - green. The mixed forest (light green). The brown zone - forest steppe, which grades south into steppe.

The four regions of Russia to be studied are colored and are (l to r), European-Urals, West Siberia, Central Siberia, and Eastern Russia.


GLC 2000 Class Names
Bare soil and rock
Barren tundra
Bogs and marshes
Broadleaf deciduous shrubs
Broadleaf/Needle-leaf Forest
Burns of year 2000
Cropland - Grassland complexes
Croplands
Deciduous Broadleaf Forest
Deciduous Needle-leaf Forest
Evergreen Needle-leaf Forest
Forest - Cropland complexes
Forest - Natural Vegetation comp
Humid grasslands
Mixed Forest
Needle-leaf evergreen shrubs
Needle-leaf/Broadleaf Forest
Palsa bogs
Permanent snow/ice
Prostrate shrub tundra
Recent burns
Riparian vegetation
Salt-march
Sedge tundra
Shrub tundra
Steppe
Urban
Water bodies


MODIS IGBP Land Cover
Class Names
Barren or Sparsely Vegetated
Closed Shrubland
Cropland / Natural Vegetation Mo
Croplands
Deciduous Broadleaf Forest
Deciduous Needleleaf Forest
Evergreen Broadleaf Forest
Evergreen Needleleaf Forest
Grasslands
Mixed Forest
No Data
Open Shrubland
Permanent Wetlands
Savannas
Snow / Ice
Unclassified
Urban-Built up
water
Woody Savannas

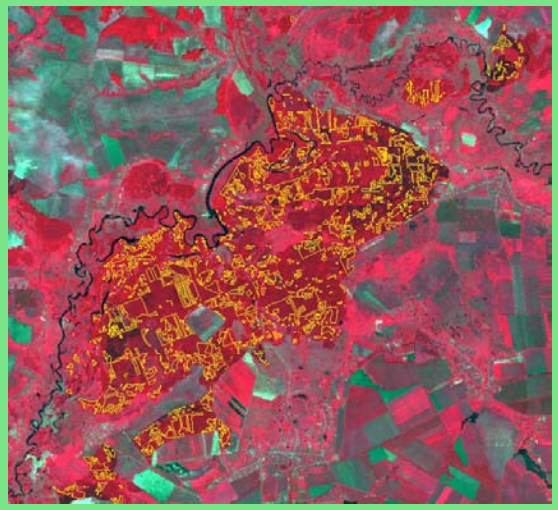


GLC 2000 Forest Cover for Russia (8.3 million Km^2)

MODIS IGBP Forest Cover for Russia (6.5 million Km^2)

Spatial Analysis for the Development of a Russian Biomass Map

Iterative Iso-clustering of Digital Data:
ERDAS: Unsupervised Classification of Atmospherically corrected DN's into forest and non-forest land cover classes Non-forest includes all agriculture, urban etc.

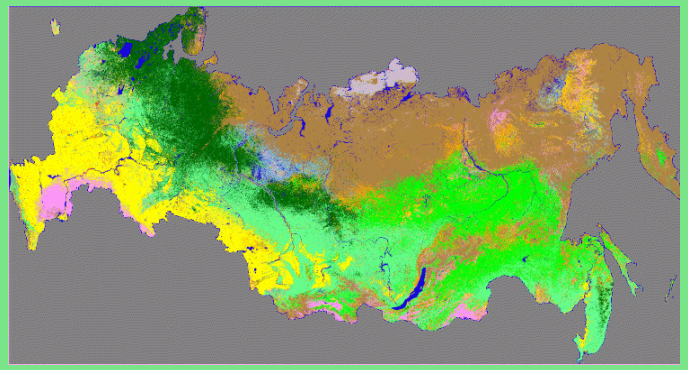


The recoding of the digital data is based off of the percent composition data given within the Forest Inventory.

Recoding the raw DN's into a forest sub-type classification:

-Pine
-Spruce
-Mixed Conifer
-Deciduous
-Mixed Forest

Training plot derived from this classified data coded 1-5 for each forest type



Supervised Classification: (Maximum likelihood Classification)

Derive classified images that are specific to the forest types:

- Pine
- Spruce
- Mixed Conifer
- Deciduous
- Mixed Forest

Have in hand separate spatial datasets. These datasets are used to separate the image into batches of data that reflect each forest type.

Bands Selection and Statistical Analysis Done By Species For the Development of A Russian Biomass Map

Split Forest Inventory Data set into a Testing and a Training Dataset:
Model 1
Model 2

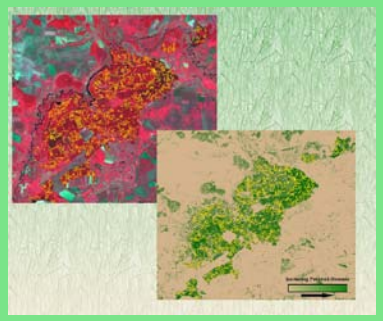
Analysis of Raw DN's
Perform Transformation on all bands
- Square Root
- Square
- Log
- Inverse Log

To determine if non-linear relationships exist and can be corrected for using various techniques.

Create Correlation Plots for all bands and all transformations against Vegetation data: (Biomass).
The correlation plots between raw DNs and biomass are used to determine if non-linear relationships exist, and then the transformations are created and re-plotted to see if they correct for the non-linearity.

R-Square:
Develop a ranking mechanism to tell which combination of bands/transformations produces the strongest correlations with the Biomass Values

Rule: (Due to Co-linearity between Bands)
Use two bands from the visible spectrum
Bands 1 or 2, and 3
Use two bands from the infrared spectrum
Bands 4, and 5 or 7



Canonical Correlation Analysis:
Evaluate the four bands and the inventory biomass values using a CCA technique.

CCA INDEX Derivation:
The index is created by summing the Input bands/transformations, that have been Standardized about the mean and multiplied By the canonical coefficient for that band

Derive Canonical Index of landsat values:

RMA Technique:
Slope = (sign of correlation +/-) Sdy / SDx
x = LANDSAT (CCA Index)
y = BIOMASS (Inventory)
Intercept = mean Y - slope * meanX
Pred = slope (LANDSAT) + intercept
RMSE = square root (average (residual squared)))

Reduce Major Axis Regression: (RMA)
Used to perform a regression between the inventory biomass values and the summed Canonical index values

From the RMA we obtain an equation that is then multiplied against the original CCA Biomass Indices to create a biomass layer that is species specific.

Russia

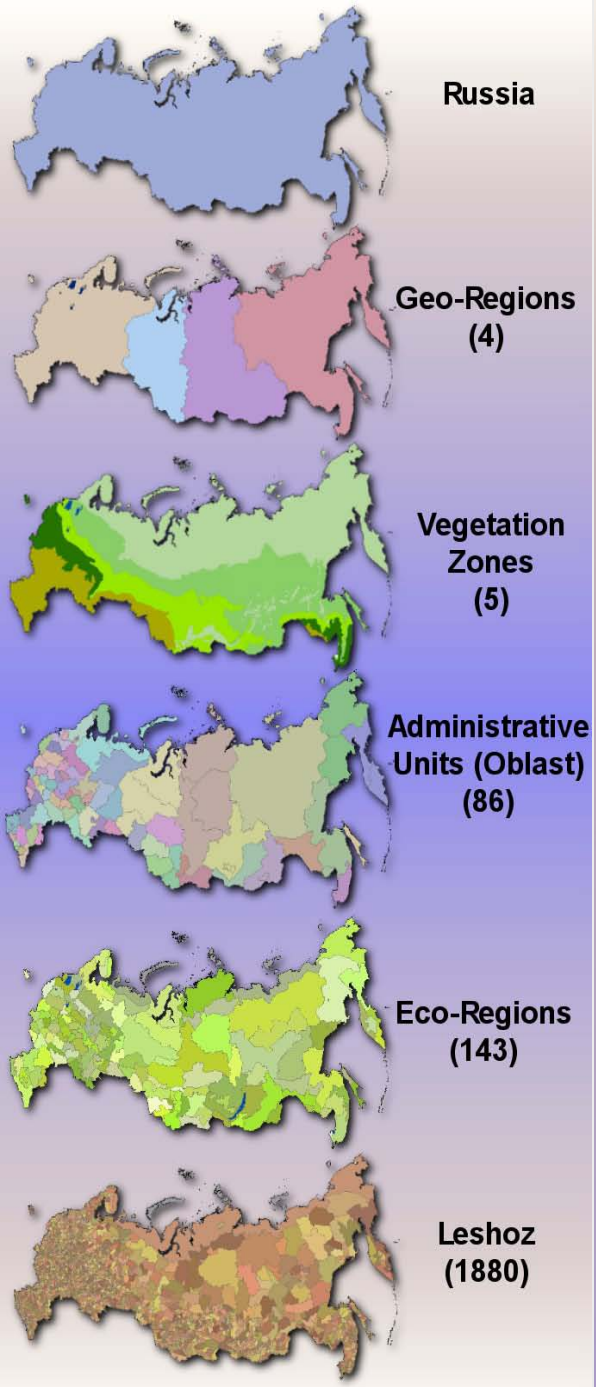
Geo-Regions
(4)

Vegetation
Zones
(5)

Administrative
Units (Oblast)
(86)

Eco-Regions
(143)

Leshoz
(1880)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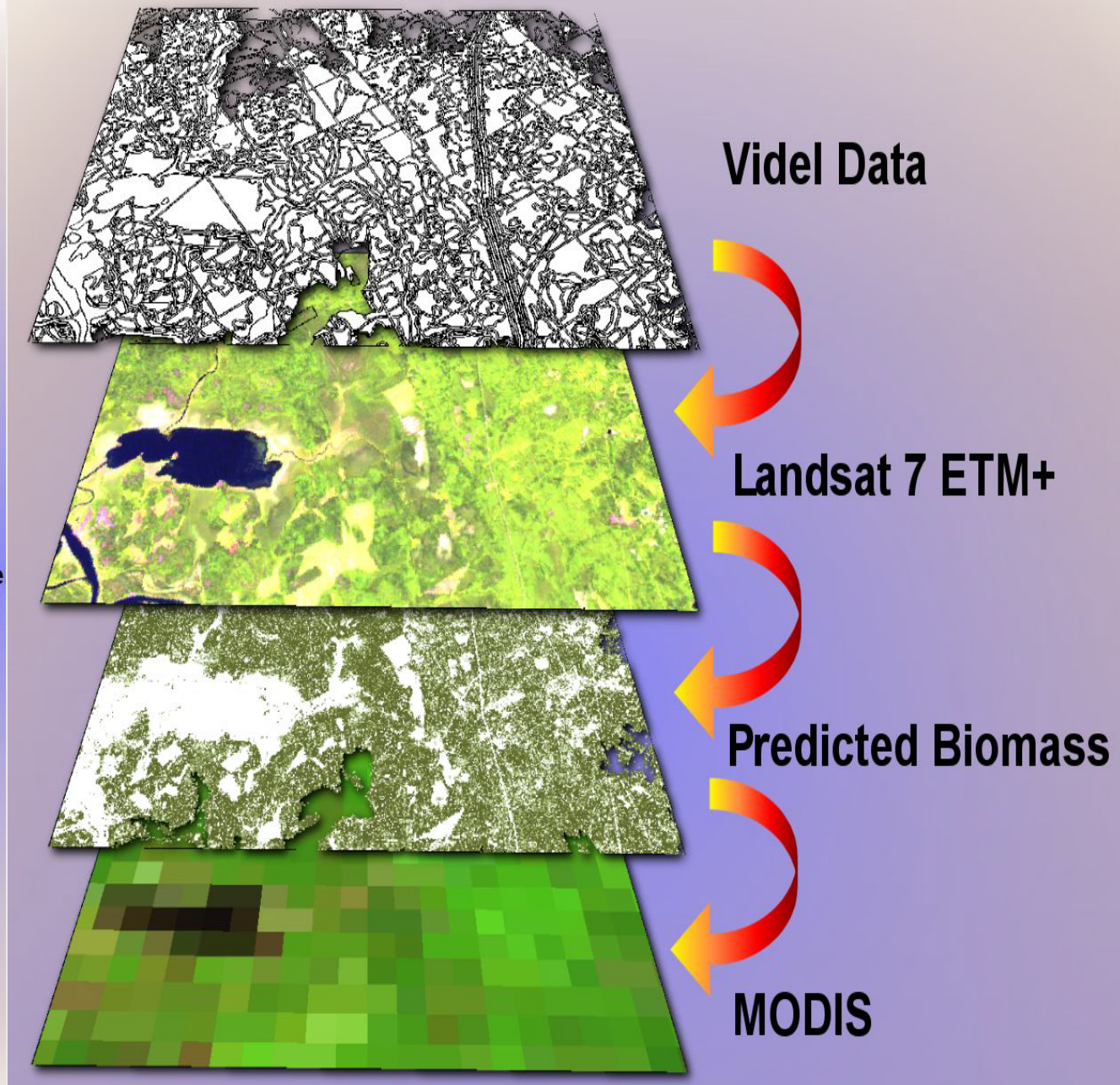
Videl Data
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