Mapping carbon biomass in New Guinea

Sassan Saatchi, N.L. Harris, S. Brown, M. Lefsky, ETA Michard, W. Salas, BR Zutta, W. Buermann, S.L. Lewis, S. Hagen, S. Petrova, L. White, M. Silman, and A. Morel. 2011, Benchmark map of forest carbon stocks in tropical regions across three continents. PNAS 108: 9899-9904.

This map shows total carbon stored in biomass in New Guinea, a heavily forested island just north of Australia. (NASA map by Robert Simmon, using data from Saatchi et al., 2011.) Working with 14 colleagues from 10 institutions around the world (including Michael Lefsky), Sassan Saatchi set about compiling and analyzing measurements from four space-based instruments—the GLAS lidar on ICESat, MODIS, the QuikSCAT scatterometer, and the Shuttle Radar Topography Mission—and from 4,079 ground-based forest plots. The team mapped more than three million measurements of tree heights and correlated them to measurements of trees from the ground. They calculated the amount of carbon stored above ground and in the roots. And they extrapolated their results over forest areas where there is less ground sampling but some known characteristics.

The result, released in May 2011, was a benchmark map of biomass carbon stocks covering 2.5 billion hectares (9.65 million square miles) of forest in 75 countries on three continents. Though previous efforts have mapped tropical forests on regional or local scales, the new map is "the first effort to quantify the distribution of forest carbon systematically over the entire tropical region," Saatchi says.

Lecture 9   February 7
Land Cover Classification &Mapping   Chapter 11, 7

Systematic land cover mapping
missions
Global: growth form mapping
 (AVHRR, MODIS, SPOT Vegetation)

Regional land cover, cover type
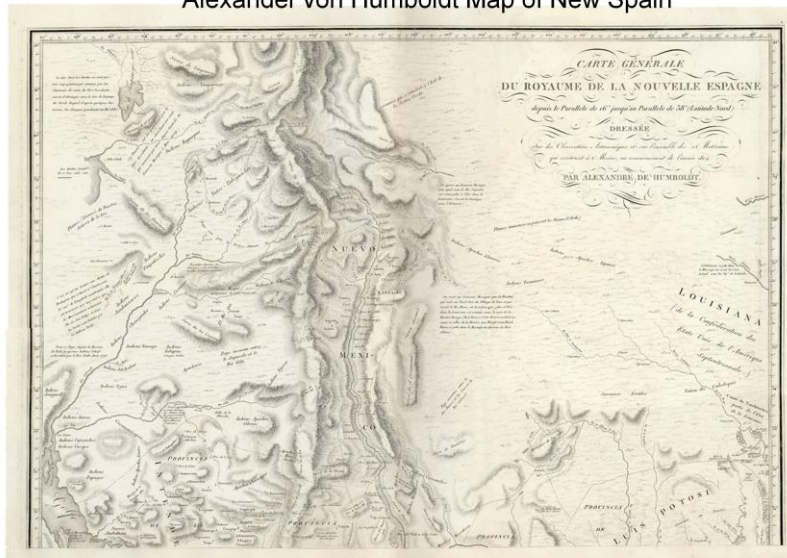(Landsat, SPOT, IRS)

Local land cover: spatial patterns and
scales (plant, patch, stand)
(IKONOS, Worldview-2, airborne)

Fragmentation, corridors

Regional systematic land cover mapping missions

Alexander von Humboldt Map of New Spain

Kingdom of New Spain by Alexander von Humboldt 1803, Published in 1812

Humboldt's "Map of the Kingdom of New Spain" was a remarkable cartographic achievement. According to Carl Wheat, as quoted in his *Mapping the Transmississippi West,* Humboldt's map "was undoubtedly the most important and most accurate published map that had yet appeared." Important enough that Humboldt's great map of New Spain found its way into the hands of Zebulon Pike prior to his 1806 expedition to the Great Plains and Rocky Mountains. Humboldt would later complain bitterly to Thomas Jefferson when he saw his work reproduced, at least to a degree, in Pike's maps of 1810.

Of particular interest was Humboldt's recognition that the "Stoney Mountains" of the north as noted by Mackenzie was a continuation of the Cordilleras of New Spain. What are now referred to as the Rocky Mountains begin to show themselves as the very backbone of the continent, with their imposing east-to-west width drawn with much more accuracy and detail than found on earlier maps. Humboldt also advanced the science of cartography by drawing his mountains with the hachure technique of shading as opposed to the less satisfactory method of showing mountains in profile. While admitting that the hachure system "forces the drawer to say more than he knows, more than it is even possible to know of the geological constitution of a vast extent of territory," Humboldt felt the newer system outweighed this disadvantage. This technique was soon adopted universally, not to be replaced until the contour method of displaying mountains became popular many years in the future.

Global systematic land cover mapping missions have a long history

Sekai Chizu, 1874
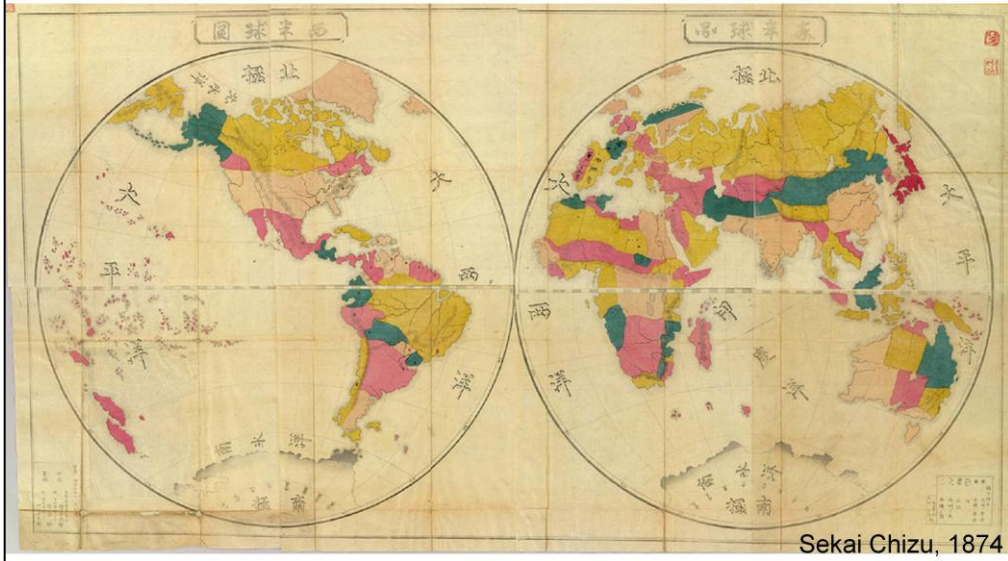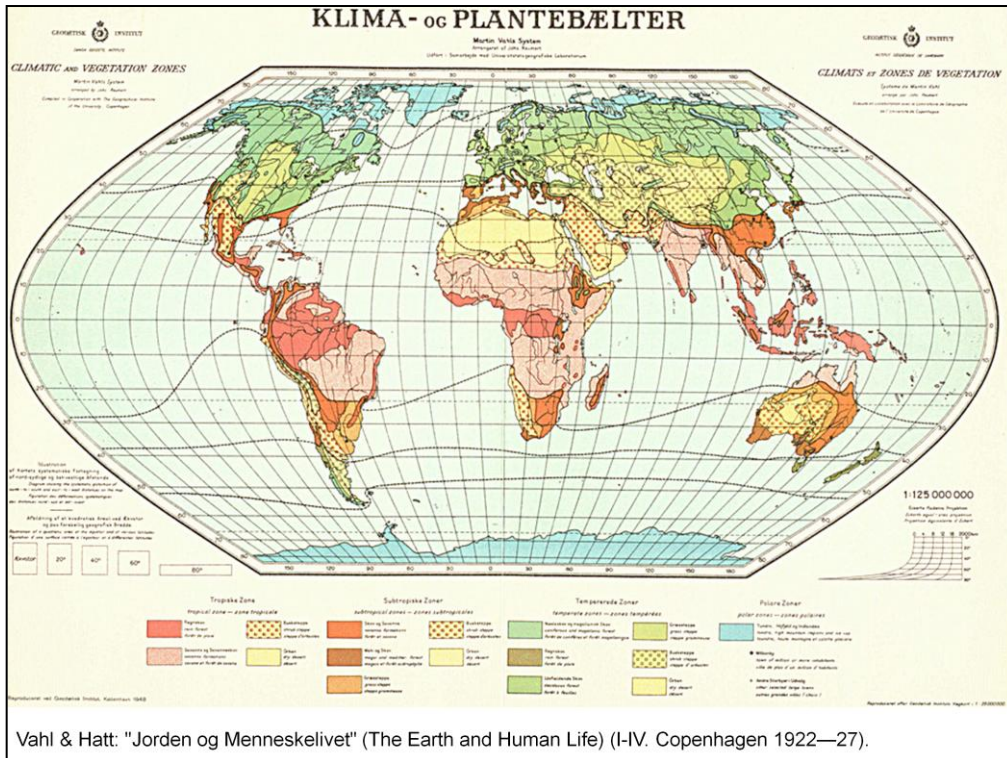
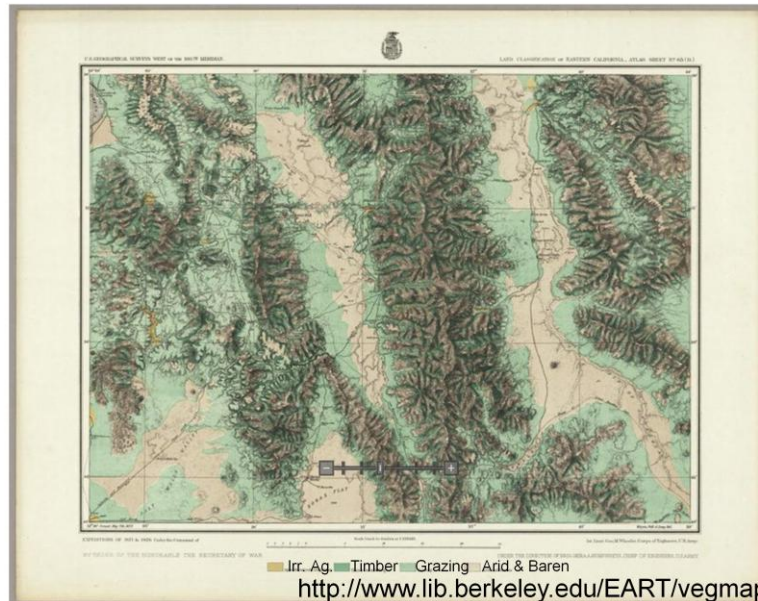Vahl & Hatt: "Jorden og Menneskelivet" (The Earth and Human Life) (I-IV. Copenhagen 1922—27).

Regional systematic land cover mapping missions

Land Classification of Eastern California, 1877

Irr. Ag. Timber Grazing Arid & Baren

http://www.lib.berkeley.edu/EART/vegmaps3.html

Wheeler, G.M. 65D. Land Classification Of Eastern California. 1877. Land Classes in Full Color. National Atlas.

Climate Based Land Cover Maps

LEGEND

Tropical Wet — Humid Subtrop.
Tropical Dry — Cool Summer
Semiarid — Subarctic
Arid — Tundra
Mediterranean — Highlands
Marine W Coast — Ice

www.theodora.com/maps
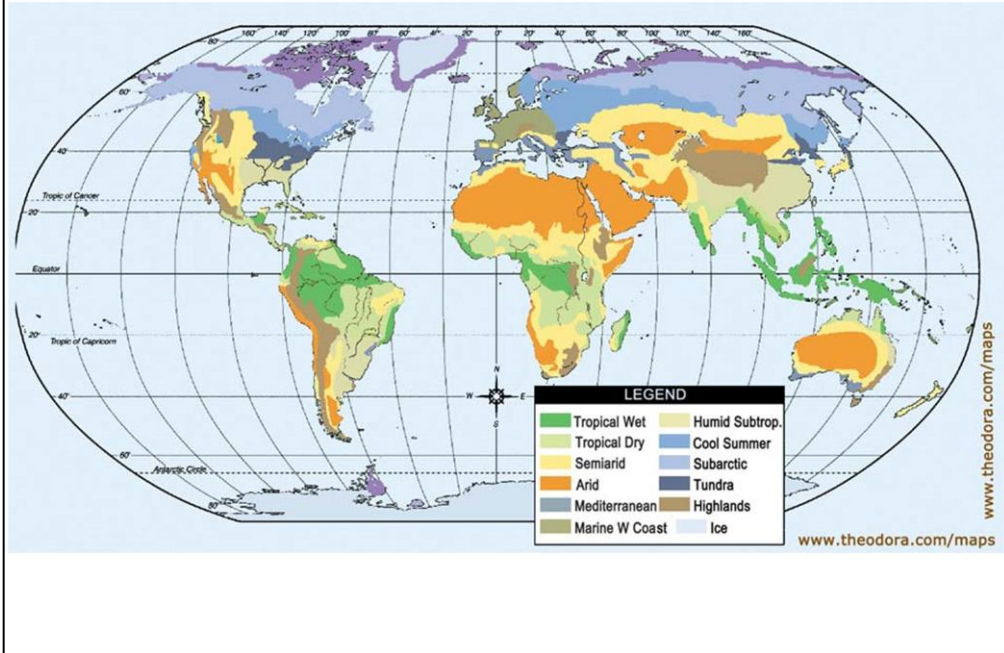
Climate Based Terrestrial Biome Map

TERRESTRIAL BIOMES

Legend:
- Tropical rainforest
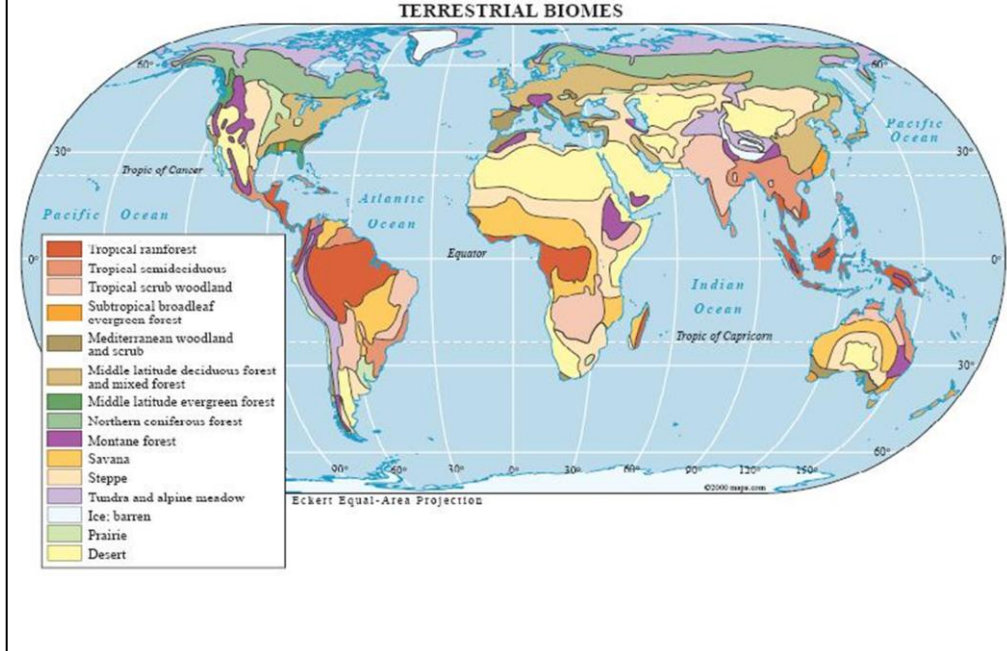- Tropical semideciduous
- Tropical scrub woodland
- Subtropical broadleaf evergreen forest
- Mediterranean woodland and scrub
- Middle latitude deciduous forest and mixed forest
- Middle latitude evergreen forest
- Northern coniferous forest
- Montane forest
- Savana
- Steppe
- Tundra and alpine meadow
- Ice; barren
- Prairie
- Desert

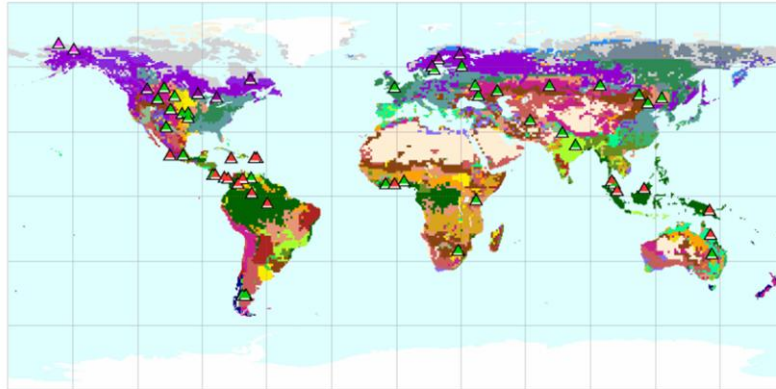Eckert Equal-Area Projection

Recent Land Cover Maps Based on Ground Data
Satellite-based Maps Started to be produced in 1990s

Matthews Vegetation Types - NPP

Tundra ▲   Boreal Forest ▲   Grassland ▲   Tropical Forest ▲

Mathews 1983 used map to compare to flux tower data

Matthews E. 1983. Global Vegetation and Land Use: New High-Resolution Data Bases for Climate Studies.
Journal of Applied Meteorology, 22: 474-487

Recent Land Cover Maps Based on Ground data
Olson et al. 1983 also used to compare to flux tower data

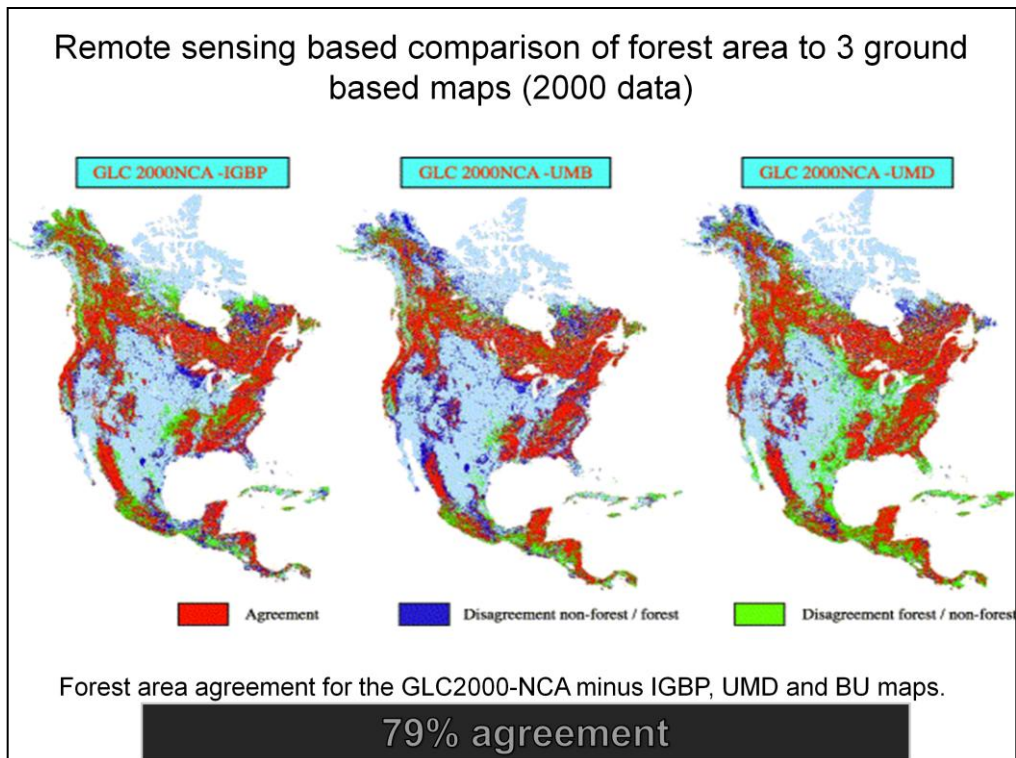Olson World Ecosystem Complexes - NPP

Tundra ▲   Boreal Forest ▲   Grassland ▲   Tropical Forest ▲
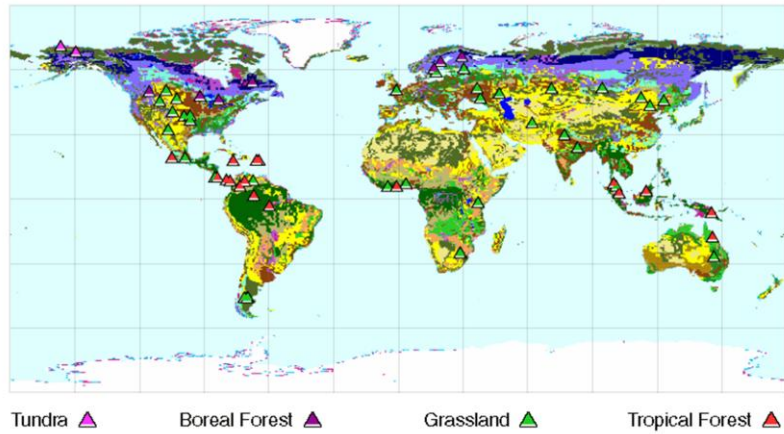
Olson, J.S., and Watts, J.A., 1982. Major World Ecosystem Complex map, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Comparison of 3 Global Land Based Land Cover Maps
(Mathews 1983, Olsen et al. 1983, and Wilson and Henderson-Sellers 1985)

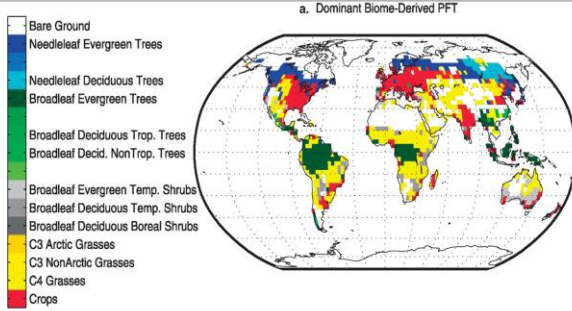| For land Agreement | Red | (26%) | ALL |
| | Yellow | (46%) | 2 of 3 |
| | Black | (28%) | none |

DeFries, R., Field, C., Fung, A., Justice, C., Los, S., Matson, P., Matthews, M., Mooney, H., Potter, C., Prentice, K., Sellers, P., Townshend, J., Tucker, C., Ustin, S., Vitousek, P. 1995. Mapping the land surface for global atmosphere-biopshere models: toward continuous distributions of vegetation's functional properties. Journal of Geophysical Research-Atmospheres 100:20, 867-882.

Remote sensing based comparison of forest area to 3 ground based maps (2000 data)

GLC 2000NCA -IGBP   GLC 2000NCA -UMB   GLC 2000NCA -UMD

Agreement   Disagreement non-forest / forest   Disagreement forest / non-forest

Forest area agreement for the GLC2000-NCA minus IGBP, UMD and BU maps.

79% agreement

GLC2000-NCA - The GLC 2000-NCA land cover map is provided as a regional product with 28 land cover classes based on modified Federal Geographic Data Committee/Vegetation Classification Standard (FGDC NVCS) classification system, and as part of a global product with 22 land cover classes based on Land Cover Classification System (LCCS) of the Food and Agriculture Organisation.

The map was compared on both areal and per-pixel bases over North and Central America to the International Geosphere–Biosphere Programme (IGBP) global land cover classification, the University of Maryland global land cover classification (UMd) and the Moderate Resolution Imaging spectroradiometer (MODIS) Global land cover classification produced by Boston University (BU). There was good agreement (79%) on the spatial distribution and areal extent of forest between GLC 2000-NCA and the other maps, however, GLC 2000- NCA provides additional information on the spatial distribution of forest types. The GLC 2000-NCA map was produced at the continental level incorporating specific needs of the region

Plant Functional Types

a. Dominant Biome-Derived PFT

Legend:
- Bare Ground
- Needleleaf Evergreen Trees
- Needleleaf Deciduous Trees
- Broadleaf Evergreen Trees
- Broadleaf Deciduous Trop. Trees
- Broadleaf Decid. NonTrop. Trees
- Broadleaf Evergreen Temp. Shrubs
- Broadleaf Deciduous Temp. Shrubs
- Broadleaf Deciduous Boreal Shrubs
- C3 Arctic Grasses
- C3 NonArctic Grasses
- C4 Grasses
- Crops

Existing Global Land Cover Maps are Based on Biome Distribution from Climate Relationships (not actual vegetation type distribution)

**Coarse Spatial Resolution**

b. Dominant Satellite-Derived PFT

Legend:
- Bare Ground
- Needleleaf Evergreen Temp. Trees
- Needleleaf Evergreen Boreal Trees
- Needleleaf Deciduous Trees
- Broadleaf Evergreen Trop. Trees
- Broadleaf Evergreen Temp. Trees
- Broadleaf Deciduous Trop. Trees
- Broadleaf Deciduous Temp. Trees
- Broadleaf Deciduous Boreal Trees
- Broadleaf Evergreen Temp. Shrubs
- Broadleaf Deciduous Temp. Shrubs
- Broadleaf Deciduous Boreal Shrubs
- C3 Arctic Grasses
- C3 NonArctic Grasses
- C4 Grasses
- Crops

Satellite Based Plant Functional Type Maps are **higher Spatial Resolution** and Derived from Actual Measurements

From: Bonan, GB, Levis S, Sitch S, Vertenstein M, Olson KW (2003). Global Change Biology 9: 1543-1556, Figure b from: Ramankutty N. and Foley JA. (1999). Global Biogeochemical Cycles 13: 997-1027.

Maps today are based on remote sensing of **actual** land cover types (not just climate potential), often in combination with other database information
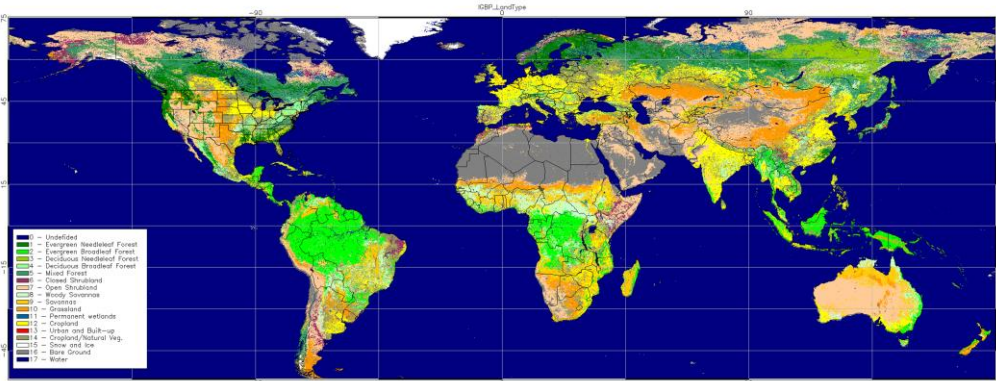
IGBP Vegetation Map Classes, USGS **"Global Land Cover Characteristics Data Base (GLCC World)"** at a 30 arc second resolution using 17 clutter categories.

http://www.pathloss.com/pwiki/index.php?title=Global_Land_Cover_Characteristics_Data_Base_(GLCC_World)

**Global Systematic Land Cover Mapping
(AVHRR, MODIS, SPOT-VEGETATION)**

- How do we go about mapping landcover?
  - define classes
  - determine the extent and resolution
    - Extent
      - continental, regional, local
    - Resolution
      - spatial (minimum mapping unit)
      - temporal (multidate needed to classify?)
      - spectral (class spectral features)

Global Systematic Land Cover Mapping (AVHRR, MODIS, SPOT-VEGETATION)

Define Classes

What does the map represent?
Biomes? Ecoregions? Ecosystems? Plant functional types? Land cover? Physiognomic classes? Vegetation map? Species maps? Urban areas? Mining?

Map limit is defined by your scientific questions

The actual landscape units to be mapped
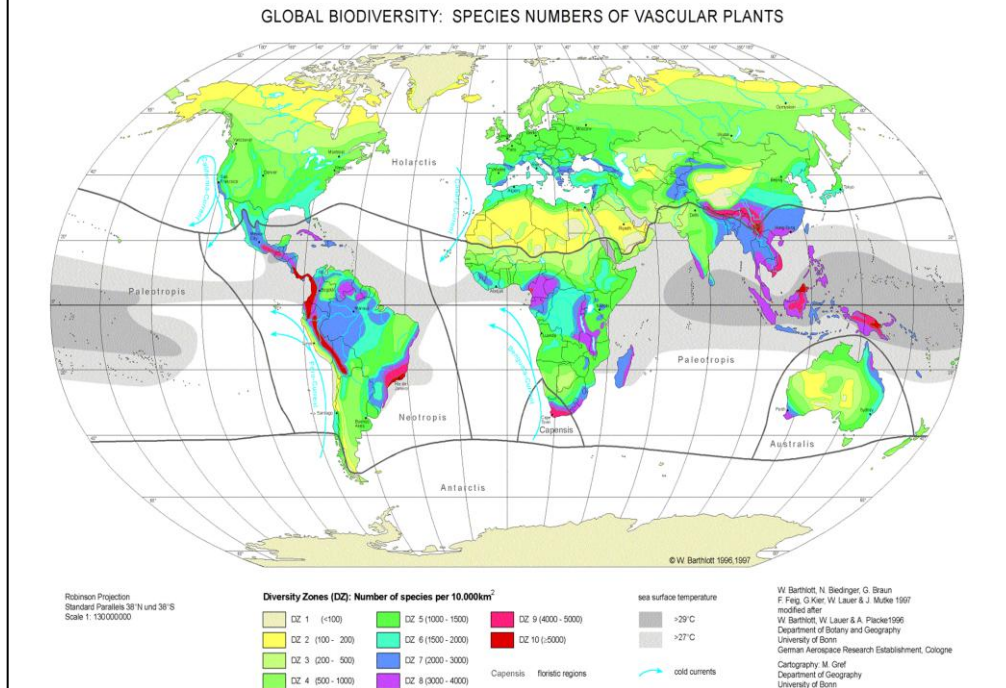
Classified 9-Class Map of Land Cover

**Global Systematic Land Cover Mapping
(AVHRR, MODIS, SPOT-VEGETATION)**

How to define Class composition?

What information to use in your creating your map?

Soil? Geographic locations? Growth form (physiognomic type)? Vegetation type? Species clusters? Climate? Productivity?

Vegetation Classification is Often Just a Starting Point

GLOBAL BIODIVERSITY: SPECIES NUMBERS OF VASCULAR PLANTS

Diversity Zones (DZ): Number of species per 10.000km^2

DZ 1 (<100)	DZ 5 (1000 - 1500)	DZ 9 (4000 - 5000)
DZ 2 (100 - 200)	DZ 6 (1500 - 2000)	DZ 10 (>5000)
DZ 3 (200 - 500)	DZ 7 (2000 - 3000)	
DZ 4 (500 - 1000)	DZ 8 (3000 - 4000)	Capensis floristic regions

sea surface temperature: >29°C, >27°C — cold currents

Robinson Projection
Standard Parallels 38°N und 38°S
Scale 1: 130000000

© W. Barthlott 1996, 1997

W. Barthlott, N. Biedinger, G. Braun
F. Feig, G.Kier, W. Lauer & J. Mutke 1997
modified after
W. Barthlott, W. Lauer & A. Placke 1996
Department of Botany and Geography
University of Bonn
German Aerospace Research Establishment, Cologne

Cartography: M. Gref
Department of Geography
University of Bonn

A world map of the potential species diversity of terrestrial vascular plants based on the evaluation of approximately 1400 records from literature is presented. The evaluation of data from approximately 1400 floras, floristic studies, biogeographical essays and vegetation studies, regional to continental in scope, provides the mainstay for our map. The species numbers of the areas covered (predominantly political units) is calculated for a standard area of 10 000 sq. km. by a benchmark formula. Ten diversity zones in categories within the spectrum of less than 100 species and more than 5000 species per 10 000 sq. km. have been considered and mapped by ten colour indicators. Because political, and not natural, units constituted the data utilized, zonation boundaries of those areas with equal taxa density (isotaxas) are inferred on the basis of climatic and other data.

In the context of the elaboration of the map, it became clear that certain terminological and methodological issues need to be clarified. Based on the existing literature, a terminology for the classification of plants according to the mode and time of their first occurrence in the study area, and for the respective diversities, is introduced. It is particularly important to distinguish between the autodiversity, i.e. the diversity of indigenous plants (autophytes), and the allodiversity, i.e. the diversity of plants introduced by man (allophytes). In addition, for other purposes it is more important to distinguish between the eudiversity, i.e. the diversity of autophytes and plants introduced with the former continuous migration of man (archaeophytes), and the neodiversity, i.e. the diversity of plants dispersed by man over large distances, usually resulting in distribution gaps (neophytes). Neodiversity is increased tremendously by neoterodiversity, i.e. the diversity of plants dispersed in the context of motorised mass transportation since the end of the last century (neoterophytes, "invaders").

This world map diverges in significant details from hitherto acknowledged concepts of the distribution of diversity (e.g. the Cameroon-Gabon Centre is identified as a diversity maximum for Africa for the first time). We recognize six global species maxima: 1. Chocó-Costa Rica Centre, 2. Tropical Eastern Andes Centre, 3. Atlantic Brazil Centre , 4. Eastern Himalaya-Yunnan Centre, 5. Northern Borneo Centre, 6. New Guinea Centre.

The results are elucidated by explanatory comments and critical discussion. Inevitably, a number of terminological issues must be clarified (e.g. isotaxas - isoporia, diversity maxima, diversity centres, criteria governing the quality of diversity, landscape diversity - geodiversity - ecodiversity, etc.). As is to be expected, the biodiversity of an area does not depend solely on its history (climatic and floristic history, palaeogeography and evolutionary availability of genetic diversity) or its position (degree of isolation and zonobiom), but also on the whole variety of its abiotic parameters (geodiversity). In this context, a connection becomes apparent between tropical diversity maxima and oceanic surface temperatures of more than 27°C. With reference to and in the context of the well documented interdependent ecosystem of primary producers (vascular plants) with consumers and decomposers, we suppose that the map reflects quite accurately the global distribution of terrestrial biodiversity in its entirety.
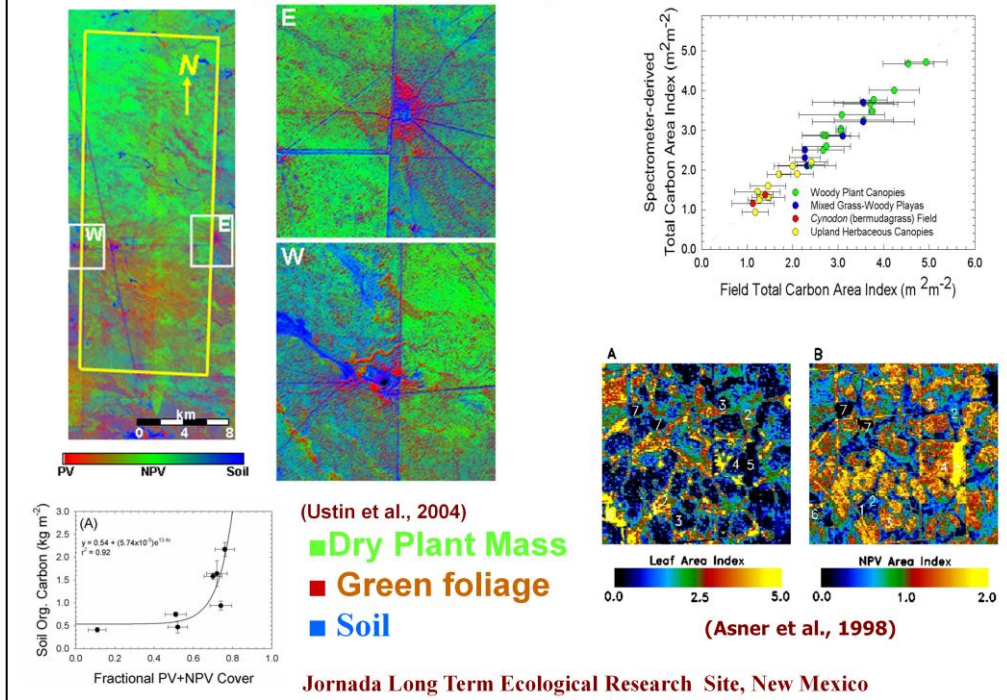
Examples of trait-based biogeography for macroorganisms. (A) Covariation in leaf traits [leaf life span (LL) and leaf mass per area (LMA)] as a function of climate [mean annual rainfall (MAR)]. Data plotted for species sampled worldwide [modified from (10)]. (B) Variation in community-aggregated plant traits over successional time. Data sampled from vineyards in France after abandonment [modified from (15)]. (C) Variation in community-aggregated wood density with latitude. Data plotted for mean wood density of all species in 1° grid cells [modified from (14)]. **Microbial Biogeography: From Taxonomy to Traits**

Jessica L. Green,

Brendan J. M. Bohannan and

Rachel J. Whitaker, *Science* Magazine > 23 May 2008 > Green et al., *320 (5879): 1039-1043*

Land Use/change: Changes in Proportion of Cover Classes

(Ustin et al., 2004)

Dry Plant Mass
Green foliage
Soil

(Asner et al., 1998)

Jornada Long Term Ecological Research Site, New Mexico
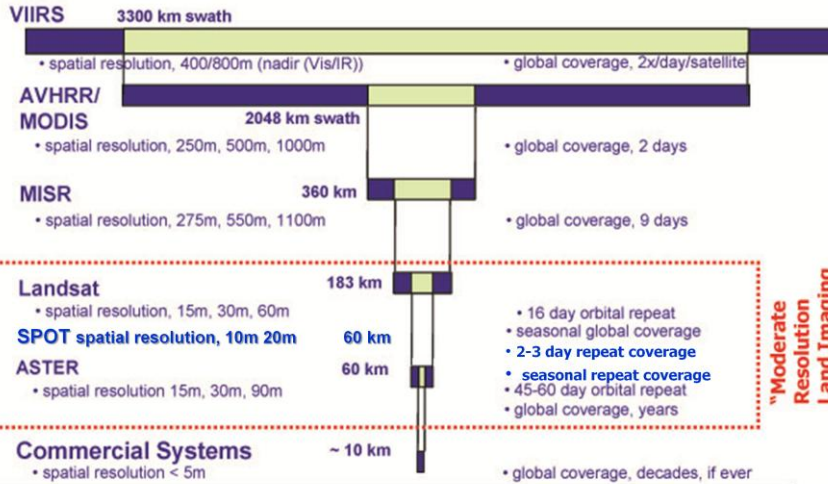
PV = photosynthetic vegetation

NPV = non-photosynthetic vegetation (all the non-green parts of plants and dead plant material)

Global Systematic Land Cover Mapping
(AVHRR, MODIS, SPOT-VEGETATION)

- determine the extent and resolution
    - Extent = continental
    - Resolution
        - spatial
        - temporal
        - spectral

TOOLS FOR OBSERVING THE LAND
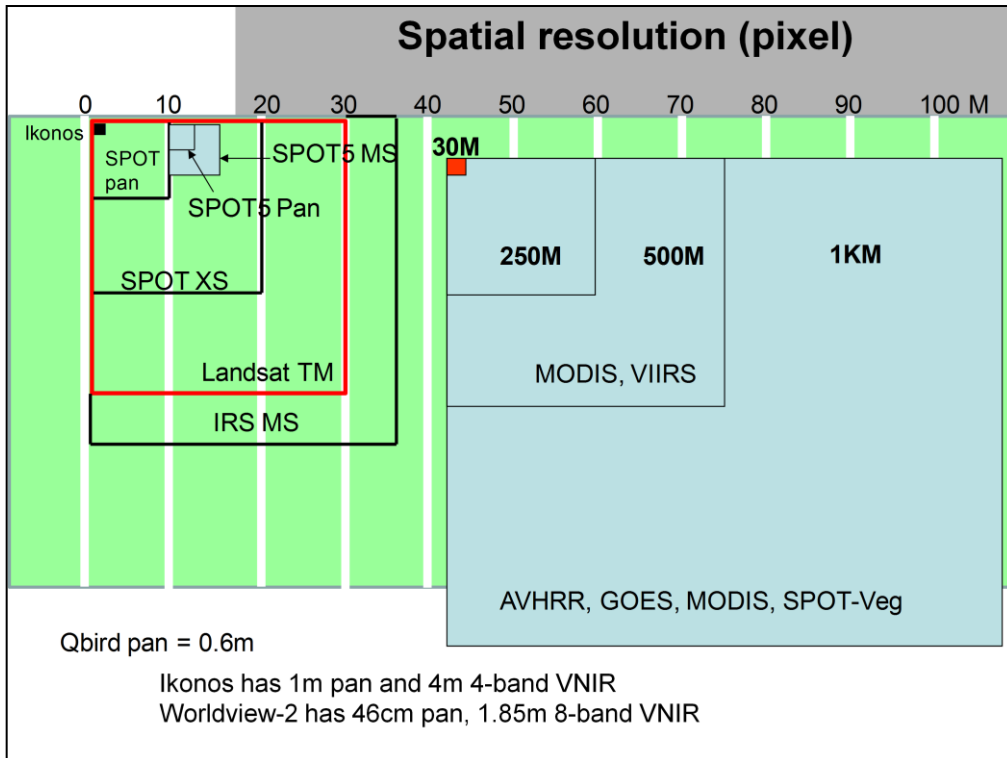Resolution and coverage for different needs....

Global and Regional Satellites: Spatial Resolution

Regional:
Landsat
SPOT
ASTER
IRS

Global:
AVHRR
MODIS
SPOT Vegetation

Spatial resolution (pixel)

0   10   20   30   40   50   60   70   80   90   100 M

Ikonos

SPOT pan

SPOT5 MS

SPOT5 Pan

SPOT XS

Landsat TM

IRS MS

30M

250M   500M   1KM

MODIS, VIIRS

AVHRR, GOES, MODIS, SPOT-Veg

Qbird pan = 0.6m

Ikonos has 1m pan and 4m 4-band VNIR
Worldview-2 has 46cm pan, 1.85m 8-band VNIR

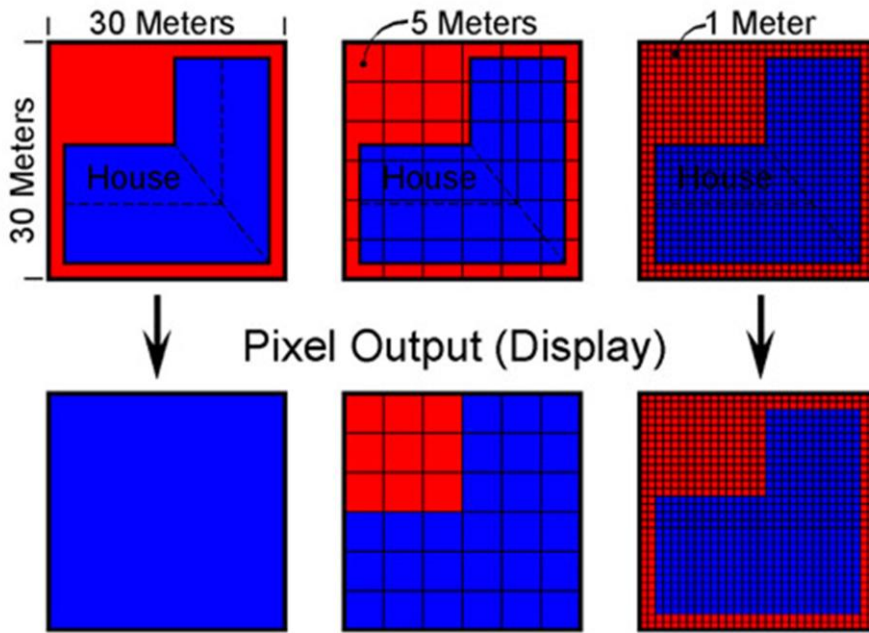Pixel Size (Resolution)

30 Meters · 5 Meters · 1 Meter

House

Pixel Output (Display)

Local land cover mapping

Green Circles—Al Khufrah Oasis, Libya
October 28, 2004

Green circles in the desert frequently indicate tracts of agriculture supported by center-pivot irrigation. The Al Khufrah Oasis in southeastern Libya (near the Egyptian border) is one of Libya's largest agricultural projects, and is an easy-to-recognize landmark for orbiting astronauts aboard the International Space Station. Because only about 2 percent of Libya's land receives enough rainfall to be cultivated, this project uses fossil water from a large underground aquifer. The Libyan government also has a plan called the Great Man Made River to pump and transport these groundwater reserves to the coast to support Libya's growing population and industrial development.

The center-pivot irrigation system pumps water under pressure into a gantry or tubular arm from a central source. Anchored by a central pivot, the gantry slowly rotates over the area to be irrigated, thereby producing the circular patterns. Although the field diameters vary, these fields are approximately 0.6 mile (1 kilometer) in diameter. Darker colors indicate fields where such crops as wheat and alfalfa are grown. Lighter colors can indicate a variety of agricultural processes: fields that have been harvested recently; fields that are lying fallow; fields that have just been planted; or fields that have been taken out of production.

Astronaut photograph ISS010-E-5266 was acquired October 28, 2004 with a Kodak 760C digital camera with a 180 mm lens, and is provided by the ISS Crew Earth Observations experiment and the Image Science & Analysis Group, Johnson Space Center. The International Space Station Program supports the laboratory to help astronauts take pictures of Earth that will be of the greatest value to scientists and the public, and to make those images freely available on the Internet. Additional images taken by astronauts and cosmonauts can be viewed at the NASA/JSC Gateway to Astronaut Photography of Earth.

Global Systematic Land Cover Mapping (AVHRR, MODIS, SPOT-VEGETATION)

AVHRR

AVHRR/3 Channel Characteristics

Channel Number	Resolution at Nadir	Wavelength (um)	Typical Use
1	1.09 km	0.58 - 0.68	Daytime cloud and surface mapping
2	1.09 km	0.725 - 1.00	Land-water boundaries
3A	1.09 km	1.58 - 1.64	Snow and ice detection
3B	1.09 km	3.55 - 3.93	Night cloud mapping, sea surface temperature
4	1.09 km	10.30 - 11.30	Night cloud mapping, sea surface temperature
5	1.09 km	11.50 - 12.50	Sea surface temperature

250m pixels for red, NIR bands; 500m pixel for (3A) SWIR band

8km pixels for TIR bands
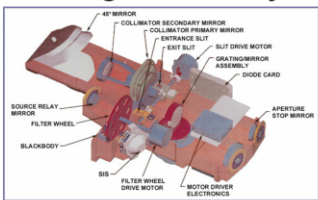
Global systematic land cover mapping

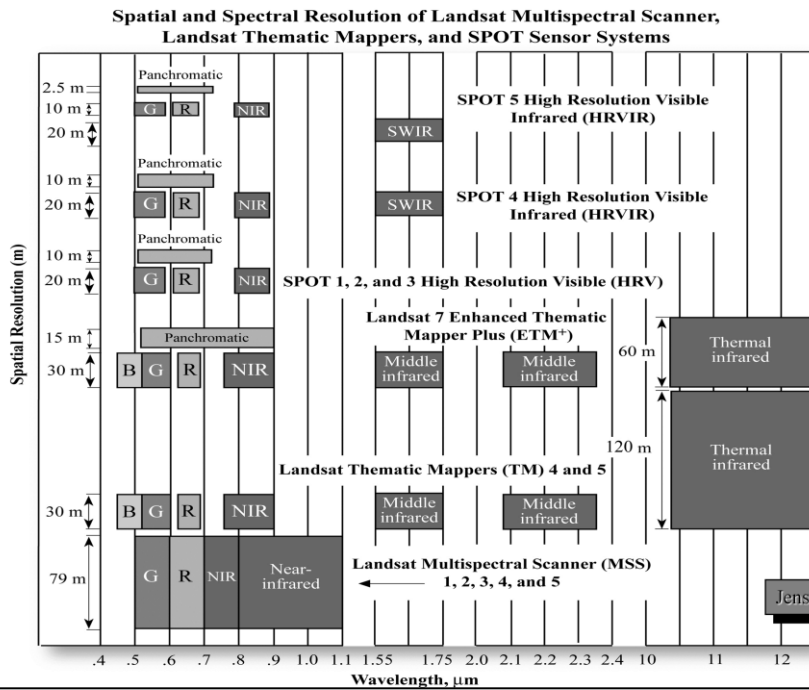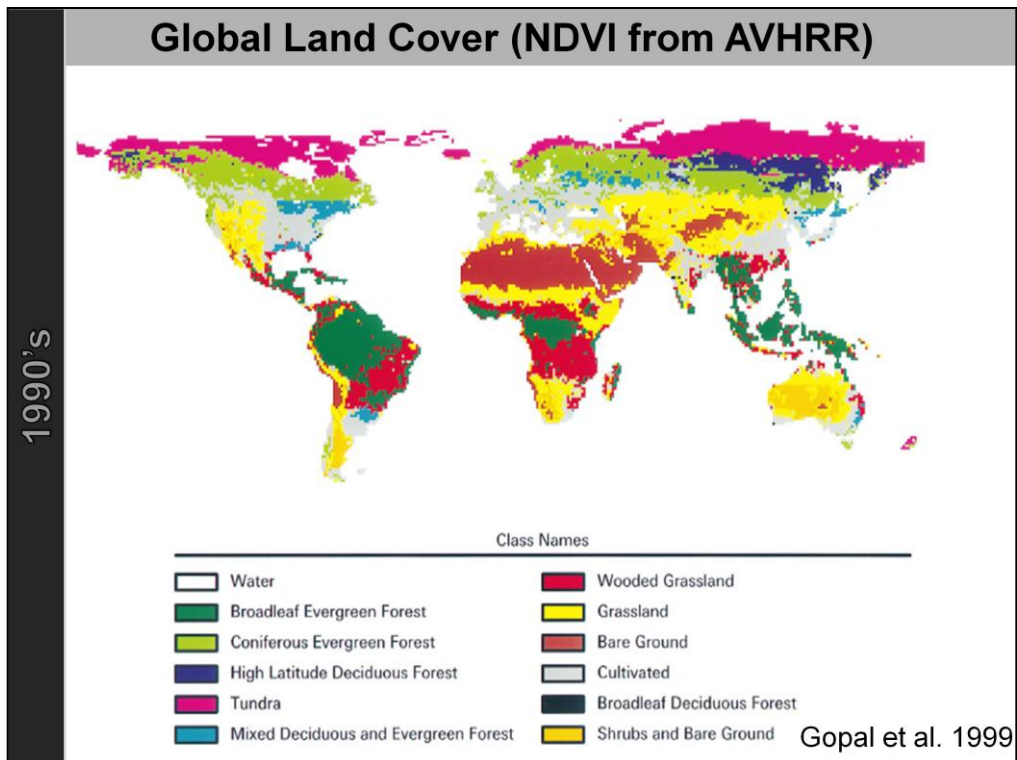| Primary Use	Band	Bandwidth (nm)
Land/Cloud/Aerosols	1	620 - 670
Boundaries	2	841 - 876
Land/Cloud/Aerosols	3	459 - 479
Properties	4	545 - 565
	5	1230 - 1250
	6	1628 - 1652
	7	
Ocean Color/		
Phytoplankton/		
Biogeochemistry	10	483 - 493
	11	526 - 536
	12	546 - 556
	13	662 - 672
	14	673 - 683
	15	743 - 753
	16	862 - 877
Atmospheric	17	890 - 920
Water Vapor	18	931 - 941
	19	915 - 965

MODIS

$$NDVI = \frac{B2 - B1}{B2 + B1}$$

http://modis.gsfc.nasa.gov/data/atbd/atbd_mod13.pdf

36 bands

Use just visible

Spectral resolution (# bands, band location, bandwidth)

Spatial and Spectral Resolution of Landsat Multispectral Scanner, Landsat Thematic Mappers, and SPOT Sensor Systems

Jensen, 2007

Global Land Cover (NDVI from AVHRR)

1990's

Class Names

☐	Water	■	Wooded Grassland
■	Broadleaf Evergreen Forest	■	Grassland
■	Coniferous Evergreen Forest	■	Bare Ground
■	High Latitude Deciduous Forest	☐	Cultivated
■	Tundra	■	Broadleaf Deciduous Forest
■	Mixed Deciduous and Evergreen Forest	■	Shrubs and Bare Ground

Gopal et al. 1999

used AVHRR NDVI maps, and a "fuzzy neural network" (a self-learning algorithm that uses indeterminant class boundaries based on statistical tests) classifier to classify global ecosystems. Note how general the classes are.

Temporal resolution (revisit times)

Land Cover Map Created by 3 Bands from a Time Series Composite and an Image Based Classification.

What do you think about these two images and what you can interpret from them?
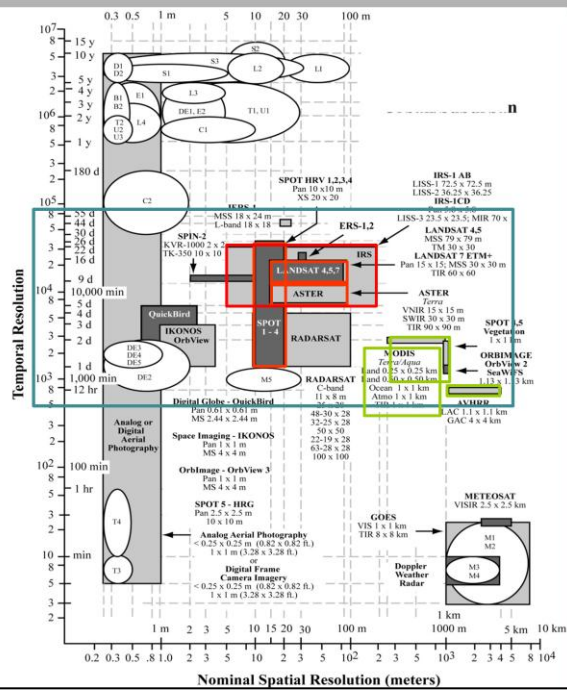
Global Systematic Land Cover Mapping

- Why do we care?

Ecoregions

US FOREST SERVICE
Research and Development

Ecoregions are large areas of similar climate where ecosystems recur in predictable patterns. We provide resources and education on the origins of these patterns and their relevance to sustainable design and planning.

Who's Using Ecoregions

Many federal agencies and private organizations use a system of land classification based on the ecoregion concept. Some of these include USDA Forest Service, U.S Geological Survey, U.S. Fish and Wildlife Service, The Nature Conservancy, and The Sierra Club. Projects include biodiversity analysis, landscape and regional level forest planning, and the study of mechanisms of forest disease.

- USDA UV-B Monitoring and Research Program
- The Committee on Earth Observing Satellites
- Sierra Club Critical Ecoregions Program
- NEARCTICA - The Natural World of North America
- National Geographic and World Wildlife Fund
- Applications of Bailey's Ecoregions to Military Lands
- Ecoregional Planning – The Nature Conservancy
- Wild Ones - Guidelines for Selecting Native Plants

http://www.fs.fed.us/rm/ecoregions/

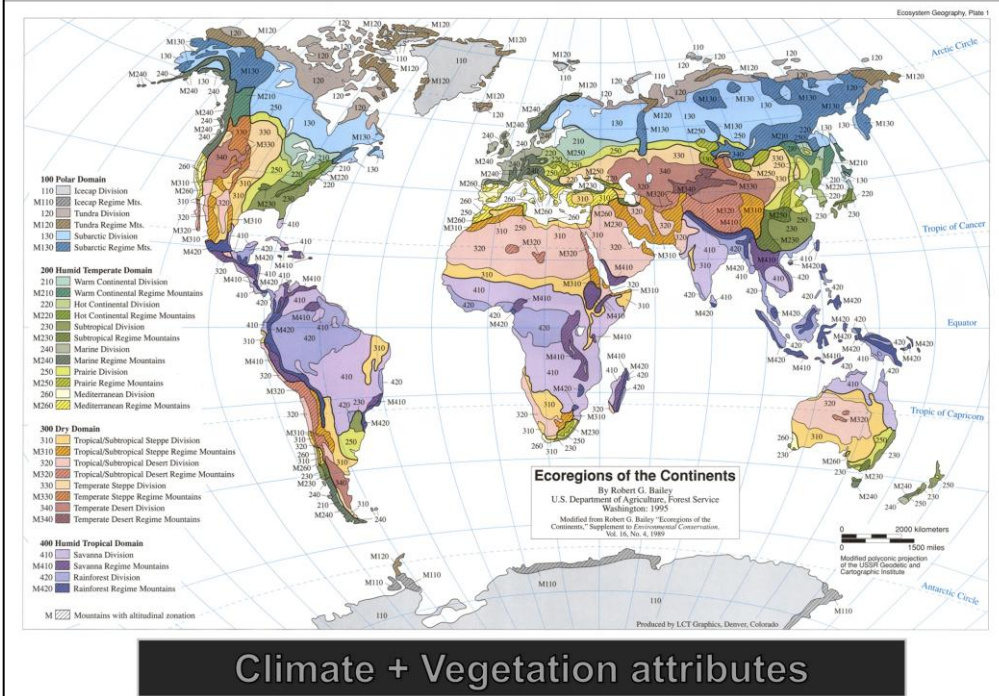The Nature Conservancy
Protecting nature. Preserving life.

Ecoregional Assessments (ERAs) provide a vision for conservation success for ecosystems, natural communities and species representative of an ecoregion, and establish priorities for resource allocation.
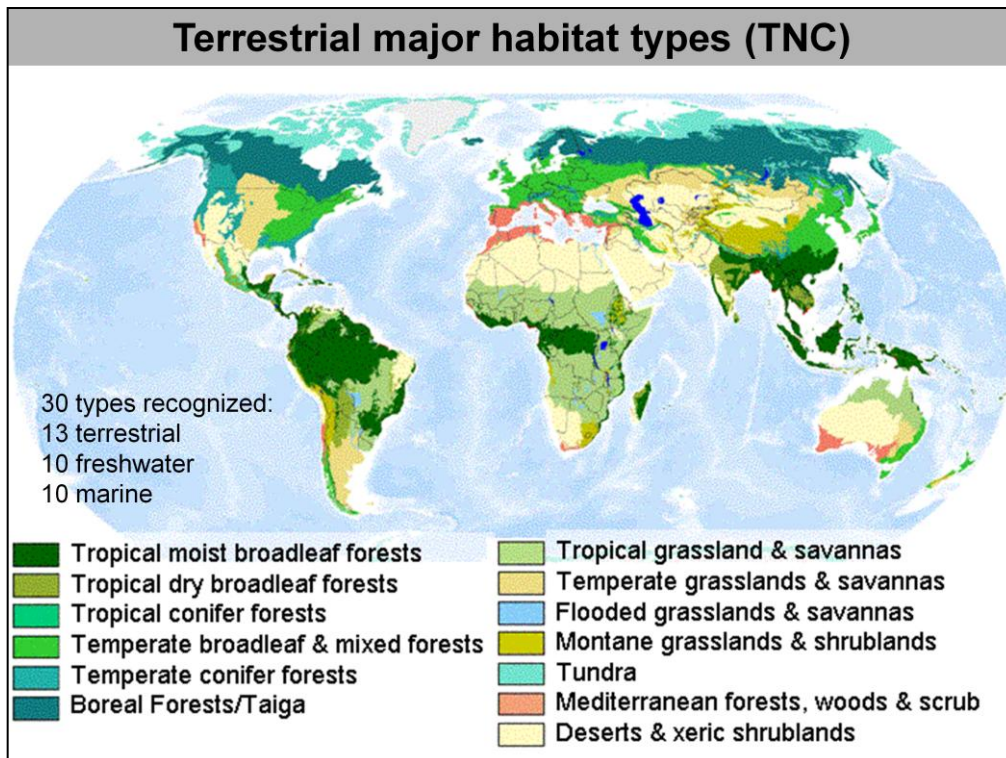
Ecoregions

WWF

Biodiversity ignores national and other political boundaries, so a more relevant conservation planning unit is required - WWF addresses this need with ecoregions.

Global Ecoregions (Bailey 1995, USFS)

Climate + Vegetation attributes

Terrestrial major habitat types (TNC)

30 types recognized:
13 terrestrial
10 freshwater
10 marine

- Tropical moist broadleaf forests
- Tropical dry broadleaf forests
- Tropical conifer forests
- Temperate broadleaf & mixed forests
- Temperate conifer forests
- Boreal Forests/Taiga
- Tropical grassland & savannas
- Temperate grasslands & savannas
- Flooded grasslands & savannas
- Montane grasslands & shrublands
- Tundra
- Mediterranean forests, woods & scrub
- Deserts & xeric shrublands

The Nature Conservancy. "Major Habitat Types" are groupings of ecoregions; they share similar environmental conditions, habitat structure, natural communities and patterns of biological complexity. Globally there are about 30 major habitat types: 13 terrestrial, about 10 freshwater and about 10 marine. The marine and freshwater major habitat types are in the process of being refined. To do this, our scientists are working with their counterparts at the World Wildlife Fund, World Resources Institute and other organizations to ensure scientific credibility and buy-in so that all our organizations can adopt consistent definitions and perspectives on the global-scale organization of biodiversity. We adopted outright the World Wildlife Fund's 13 terrestrial major habitat types, which are widely accepted by the scientific community. The major habitat type (also know as biome) framework was published some time ago by World Wildlife Fund scientists.

Global Agricultural Land

Percentage Cultivated

N. Ramankutty and Foley.
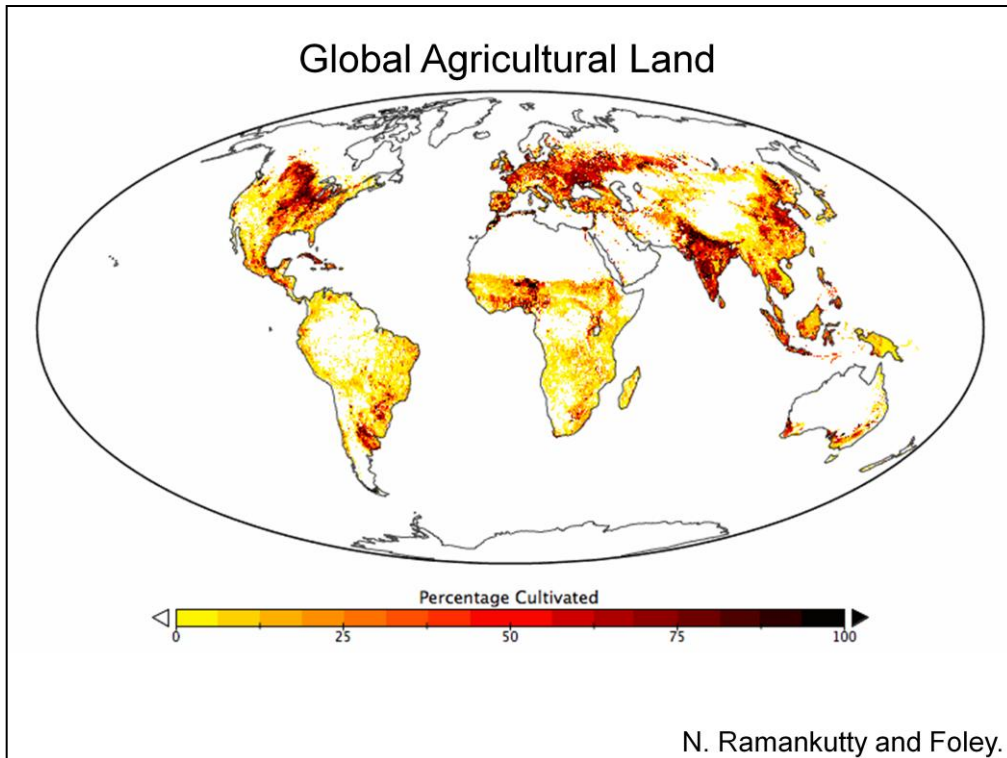
By using the data fusion method, the study was able to characterize the world's cultivated lands in a continuous fashion, depicting the percentage of each pixel that is in croplands.

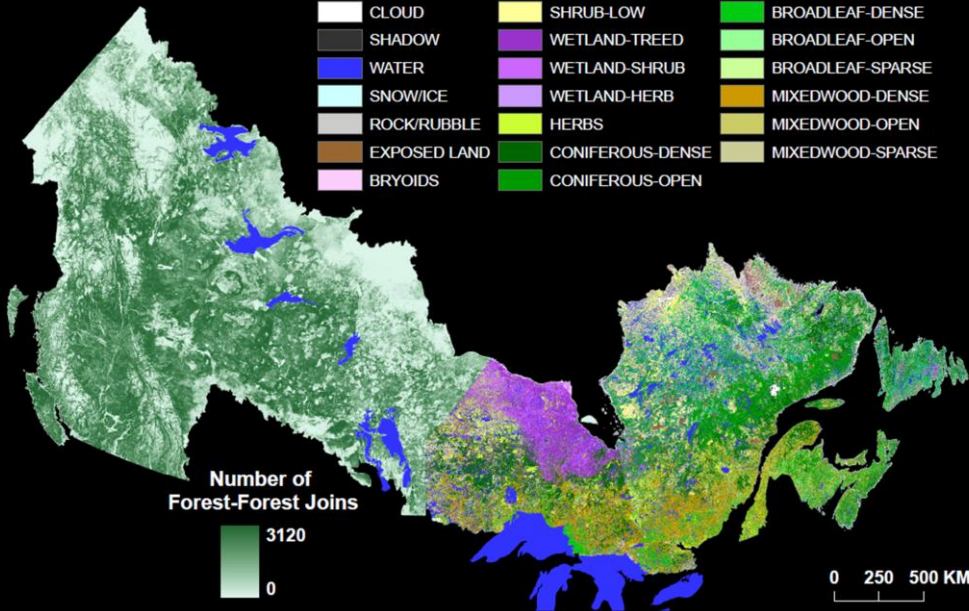UNEP Global Distribution of Forests
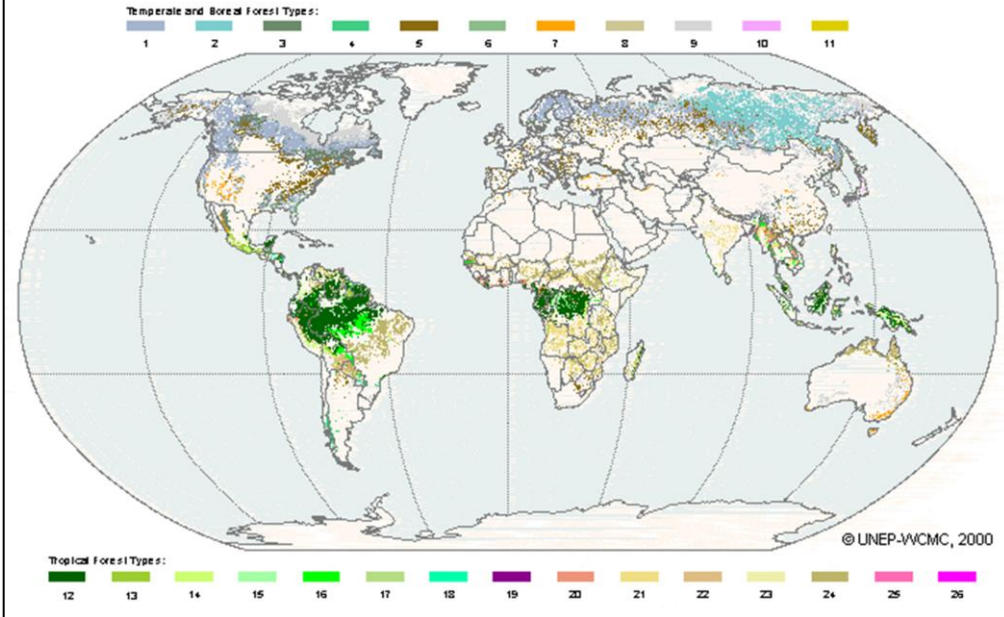
Regional land cover mapping

- determine the extent and resolution
  - Extent = regional
  - Resolution
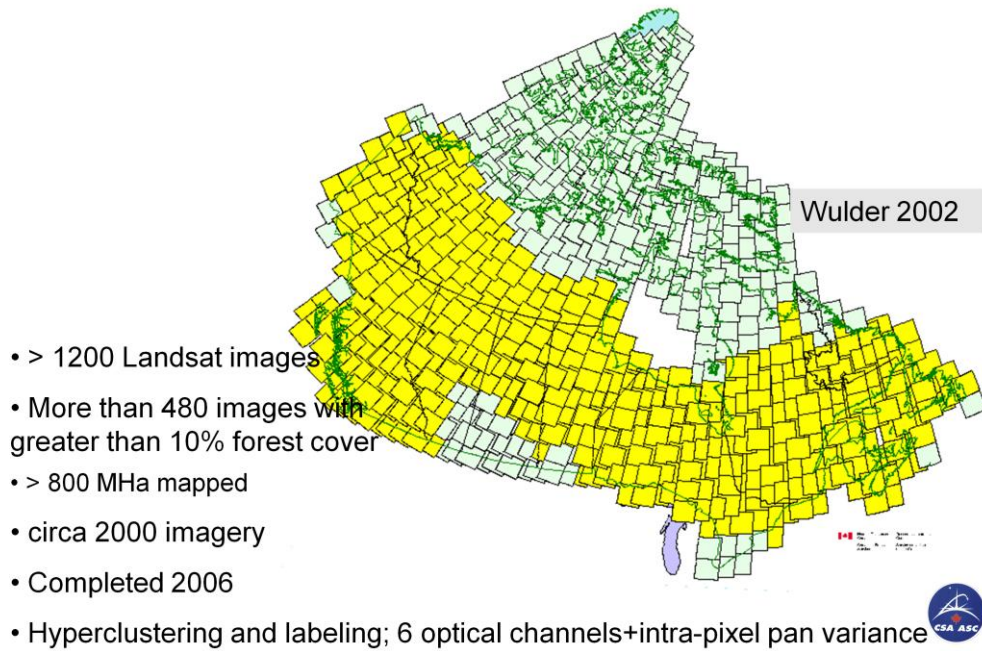   - spatial
    - temporal
    - spectral

THE FORESTED AREA OF CANADA

EOSD Land Cover Classes

NO DATA · CLOUD · SHADOW · WATER · SNOW/ICE · ROCK/RUBBLE · EXPOSED LAND · BRYOIDS · SHRUB-TALL · SHRUB-LOW · WETLAND-TREED · WETLAND-SHRUB · WETLAND-HERB · HERBS · CONIFEROUS-DENSE · CONIFEROUS-OPEN · CONIFEROUS-SPARSE · BROADLEAF-DENSE · BROADLEAF-OPEN · BROADLEAF-SPARSE · MIXEDWOOD-DENSE · MIXEDWOOD-OPEN · MIXEDWOOD-SPARSE

Number of Forest-Forest Joins

3120

0

0 250 500 KM

WRS with > 10% forest cover

Wulder 2002

- > 1200 Landsat images
- More than 480 images with greater than 10% forest cover
- > 800 MHa mapped
- circa 2000 imagery
- Completed 2006
- Hyperclustering and labeling; 6 optical channels+intra-pixel pan variance

Proportion of patches in the analysis unit that are forested

0 - 10	50 - 60
10 - 20	60 - 70
20 - 30	70 - 80
30 - 40	80 - 90
40 - 50	90 - 100

Canada

0   250   500   1,000   1,500 Kilometers

43

Wulder, M.A., J.C. White, M. Cranny, R.J. Hall, J.E. Luther, A. Beaudoin, D.G. Goodenough, and J.A. Dechka, 2008. Monitoring Canada's forests. Part 1: Completion of the EOSD land cover project. Canadian Journal of Remote Sensing. Vol. 34, No. 6, pp. 549-562.

EOSD LEGEND

- NO DATA
- CLOUD
- SHADOW
- WATER
- SNOW/ICE
- ROCK/RUBBLE
- EXPOSED LAND
- BRYOIDS
- SHRUB
- WETLAND
- HERB
- CONIFEROUS
- BROADLEAF
- MIXEDWOOD

Taiga Cordillera

Taiga Plains

Boreal Cordillera

Taiga Shield

Boreal Plains

Hudson Plains

Taiga Shield

Montane Cordillera

Pacific Maritime

Atlantic Maritime

Boreal Shield

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CANADA'S FORESTS

Legend	
↓ FOREST PATCHES ↓ NATURAL DRIVERS ↓ HUMAN DRIVERS	
↓ FOREST PATCHES ↓ NATURAL DRIVERS ↑ HUMAN DRIVERS — ROADS	
↑ FOREST PATCHES ↓ NATURAL DRIVERS ↑ HUMAN DRIVERS — ROADS & URBANIZATION	
↑ FOREST PATCHES ↑ NATURAL DRIVERS ↓ HUMAN DRIVERS — TOPOGRAPHY	
↑ FOREST PATCHES ↑ NATURAL DRIVERS ↓ HUMAN DRIVERS — LAKES & WETLANDS	
↑ FOREST PATCHES ↑ NATURAL DRIVERS ↓ HUMAN DRIVERS — TOPOGRAPHY	

4 Taiga Plains
5 Taiga Shield
6 Boreal Shield
7 Atlantic Maritime
9 Boreal Plains
11 Taiga Cordillera
12 Boreal Cordillera
13 Pacific Maritime
14 Montane Cordillera
15 Hudson Plains

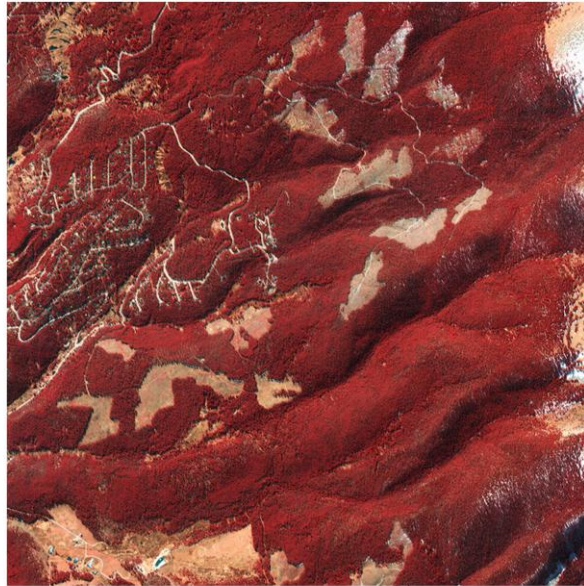0   250   500   750 KM

Local land cover mapping

- determine the extent and resolution
  - Extent = regional
  - Resolution
    - spatial
    - temporal
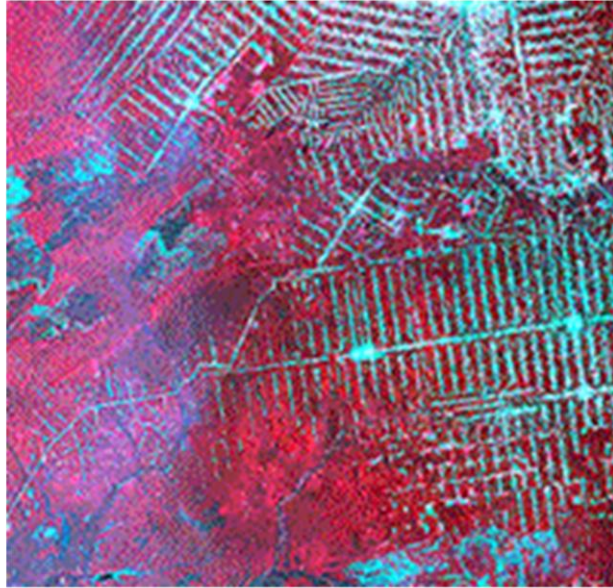   - spectral

Local land cover mapping

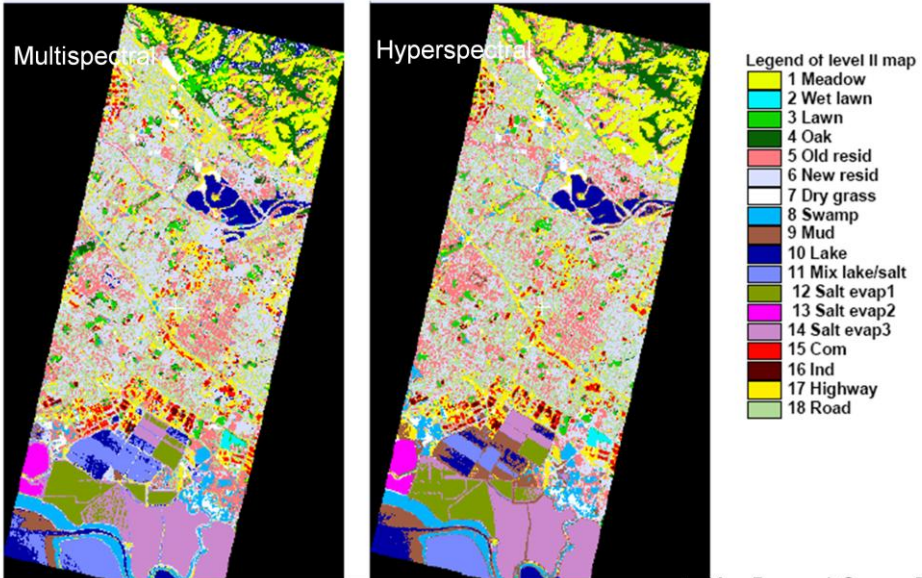Quickbird View of Copper Mountain Ski Resort, Colorado

0.5 km   N

QuickBird

Local land cover mapping

Logging in the Tropics Observed from Weather Satellites

Local land cover mapping

Multispectral Hyperspectral

Legend of level II map
1 Meadow
2 Wet lawn
3 Lawn
4 Oak
5 Old resid
6 New resid
7 Dry grass
8 Swamp
9 Mud
10 Lake
11 Mix lake/salt
12 Salt evap1
13 Salt evap2
14 Salt evap3
15 Com
16 Ind
17 Highway
18 Road

Effect of sensor data

Xu, B., and Gong, P.
2002

MESMA: vegetation mapping of the Santa Barbara Front Range

Dar Roberts UCSB

Adenostoma fasciculatum
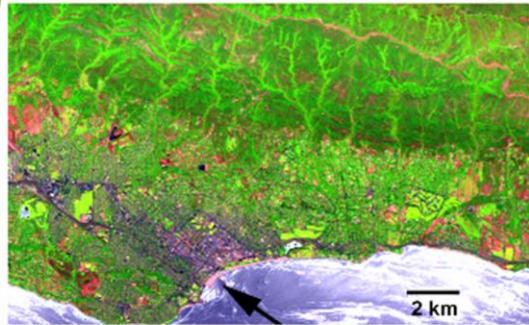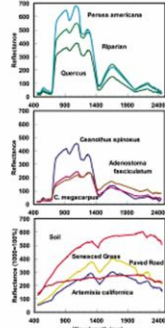
Ceanothus megacarpus

Arctostaphylos spp.

Quercus agrifolia

Accuracy: 90%

Grass
Soil

Plant species

chamise, ■ sagebrush, ■ manzanita, ■ mustard, ■ bigpod ceanothus, ■ redheart ceanothus, ■ grass, ■ coast live oak, ■ scrub oak, ■ California bay, ■ yucca, ■ soil, ■ urban, ☐ unclassified

Plant functional type

■ Annual grass, ■ annual herb, ■ Evergreen broadleaf shrub, ■ evergreen broadleaf tree, ■ evergreen needleleaf shrub, ■ evergreen succulent, ■ soil, ■ urban, ☐ unclassified
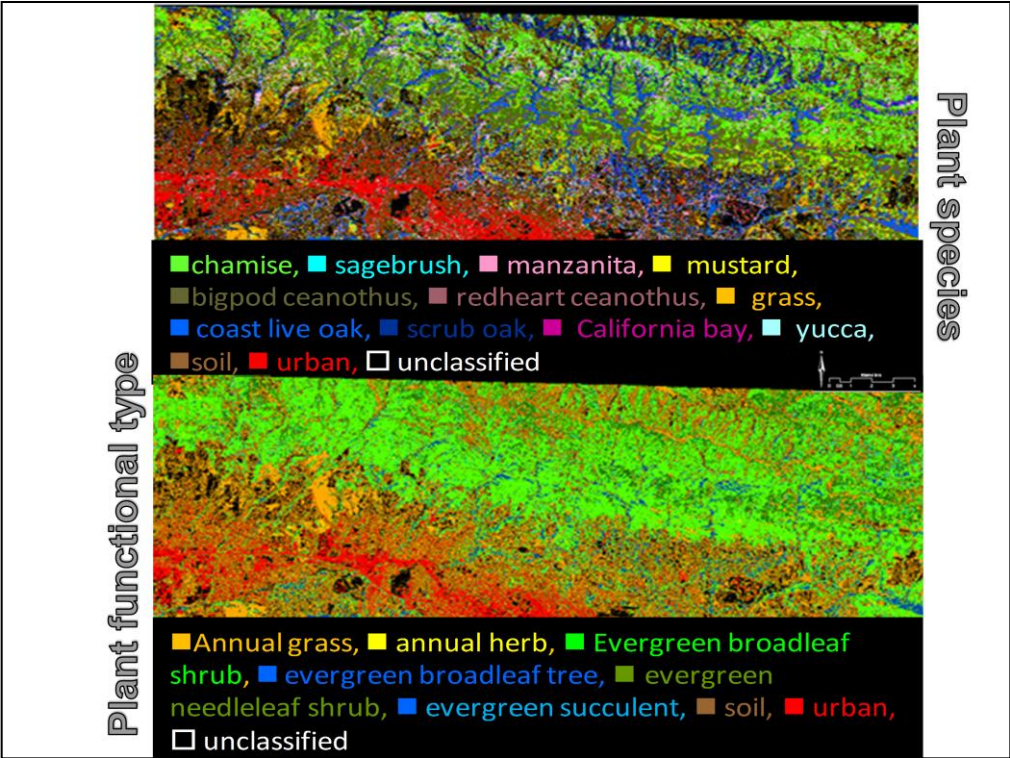
How to measure fragmentation

- The conversion of a single **patch** of habitat into smaller disconnected patches.

Yasuni National Park, Ecuador,
LANDSAT

1996

How to measure fragmentation

Metrics can be derived for each category:
  Patch: area, distance to nearest patch, edge effects, etc.
  Habitat Type: area of each habitat

From these, landscape level metrics can be derived: patch count, total patch area, etc.

How to measure fragmentation

EDGES:

➢ Boundaries may impact habitat quality.

➢ Edges are functions of both the *area* of the patch as well as the *shape*.

AREA:

➢ Patch size can be related to habitat quality

➢ Smaller patches are more likely to go extinct than larger patches

DISTANCE:

➢ May preclude migration, further threatening extinction in a single patch.

➢Corridors effectively connect two separate patches, allow migration to occur unimpeded.

What you should know from this lecture

1. Analyzing Patterns: **how landscape patterns *may have* developed (using spatial, spectral and temporal patterns)**

2. Data analysis and interpretation range from **visual evaluation** and **simple band comparison** (techniques with roots in photogrammetry)

3. Classifications from only **single date image data** (trained or unsupervised), **multiple datasets** (capturing phenological separation), or **multiple types of data** (field, various image datasets, etc.)

4. Greater differentiation of land cover with hyperspectral alone and with lidar at smallest **scales**