UNIVERSITY OF TWENTE.

ESSENTIAL BIODIVERSITY VARIABLES (EBV) AND PLANT FUNCTIONAL TRAITS FROM EARTH OBSERVATION AND IMAGE SPECTROSCOPY

ANDREW K. SKIDMORE

ITC, UNIVERSITY OF TWENTE.

ITC FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION

GLOBAL CLIMATE OBSERVING SYSTEM ESSENTIAL CLIMATE VARIABLES (ECV)

GOSIC Global Observing Systems Information Center

- 50+ GCOS Essential Climate Variables (ECVs) (2010)
  - Land cover, fAPAR, LAI, biomass, (fire) disturbance, soil moisture, soil carbon

Domain	GCOS Essential Climate Variables
Atmospheric (over land, sea and ice)	**Surface:**[1] Air temperature, Wind speed and direction, Water vapour, Pressure, Precipitation, Surface radiation budget. **Upper-air:**[2] Temperature, Wind speed and direction, Water vapour, Cloud properties, Earth radiation budget (including solar irradiance). **Composition:** Carbon dioxide, Methane, and other long-lived greenhouse gases[3], Ozone and Aerosol, supported by their precursors[4].
Oceanic	**Surface:**[5] Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Surface current, Ocean colour, Carbon dioxide partial pressure, Ocean acidity, Phytoplankton. **Sub-surface:** Temperature, Salinity, Current, Nutrients, Carbon dioxide partial pressure, Ocean acidity, Oxygen, Tracers.
Terrestrial	River discharge, Water use, Groundwater, Lakes, Snow cover, Glaciers and ice caps, Ice sheets, Permafrost, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (FAPAR), Leaf area index (LAI), Above-ground biomass, Soil carbon, Fire disturbance, Soil moisture.

http://gosic.org/ios/MATRICES/ECV/ECV-matrix.htm

GEOSS: A DISTRIBUTED 'SYSTEM OF SYSTEMS'

- Improve coordination of observation systems
- Link all platforms: in-situ, aircraft, satellite, buoys, etc
- Exchange data and information
- Improve decision-makers' abilities

Societal Benefit Areas

GROUP ON EARTH OBSERVATIONS | GEO BON

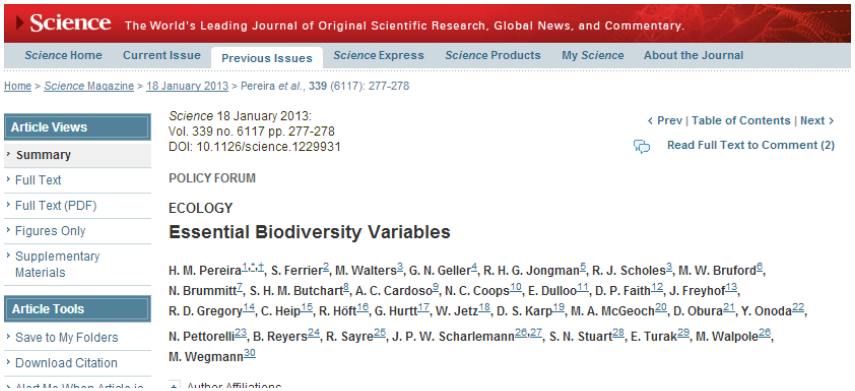
UNIVERSITY OF TWENTE.

http://www.earthobservations.org/index.shtml

ESSENTIAL BIODIVERSITY VARIABLES

PROPOSED BY GEOBON AND ACCEPTED BY CBD FRAMEWORK – BASED ON PRESSURES-STATE-RESPONSE-IMPACT FRAMEWORK

- Characteristics of EBV's
  - Ability to detect change
  - Quantifiable
  - Repeatable
  - Transferable
  - Biological
- Biodiversity dimensions
  - Genetic diversity
  - Species distributions
  - Ecosystems (functioning &services)



Web: http://www.earthobservations.org/geobon_docs_20120227.shtml
http://www.earthobservations.org/geobon_ebv.shtml

(CANDIDATE) ESSENTIAL BIODIVERSITY VARIABLES

WHICH MAY BE PARTLY OF FULLY MEASURED WITH IS OR EO

- Species occurrence
- Population abundance
- Population structure
- Number and frequency of varieties/breeds
- Phenology
- Movement patterns
- Life history and demography
- Physiological characteristics
- Ancillary attributes
- Structural type
- Disturbance regime

- Ecosystem extent (type)
- Cover (biomass, LAI, height)
- Ecosystem distribution
- Carbon sequestration (balance and storage)
- Photosynthetic activity (GPP = fAPAR = LUE)
- Respiration (NPP)
- Allocation of biomass (functional type)
- Leaf Nitrogen content
- Leaf phosphorus limitation
- Secondary products

(CANDIDATE) ESSENTIAL BIODIVERSITY VARIABLES

Which may not be measured with IS or EO

- Allelic richness
- Fst
- Phylogenic diversity
- Gene diversity
- Functional attributes (diet, breeding system, body mass)
- Co-ancestry
- Number and frequency of key traits
- Phylogenic diversity
- Turnover (beta-diversity)
- Degree of protection
- Use rate by humans
- Use benefits to humans (economic, spiritual, cultural …)
- Non-use benefits (existence, aesthetic…)

My interpretation…

(CANDIDATE) ESSENTIAL BIODIVERSITY VARIABLES

WHICH MAY BE PARTLY OF FULLY MEASURED WITH IS OR EO

- Species occurrence
- Population abundance
- Population structure
- Number and frequency of varieties/breeds
- Phenology (PhiX)
- Movement patterns
- Life history and demography
- Physiological characteristics
- Ancillary attributes
- Structural type
- Disturbance regime

- Ecosystem extent (type)
- Cover (biomass, LAI, height)
- Ecosystem distribution
- Carbon sequestration (balance and storage)
- Photosynthetic activity (GPP = fAPAR = LUE)
- Respiration (NPP)
- Allocation of biomass (functional type)
- Leaf Nitrogen content
- Leaf phosphorus limitation
- Secondary products

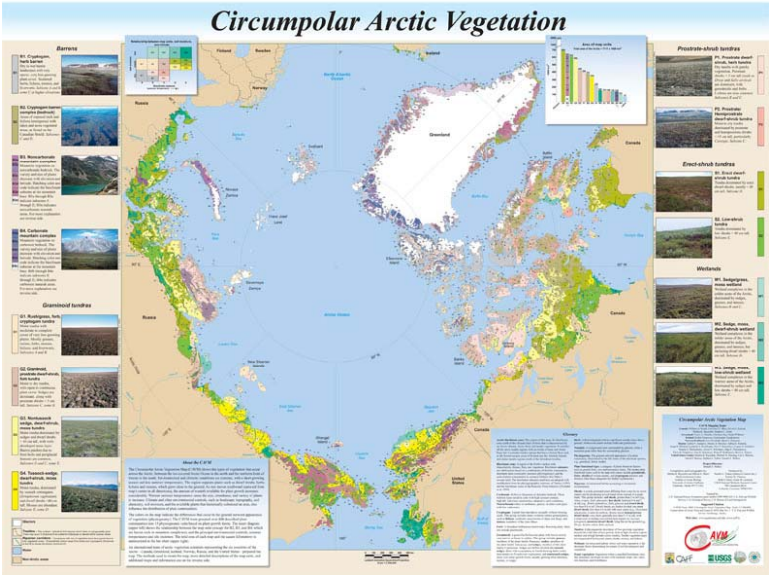
PLANT FUNCTIONAL TYPES

LAND COVER TYPE VEGETATION TYPE, PLANT FUNCTIONAL GROUPS

- PFT use structural, physiological and/or phenological features to group species into plant communities (Ustin et al. 2008)
- PFT are a mix of traits for example, **growth form**, **plant height** and/or **species** groups:

Circumpolar Arctic Vegetation

- ✓ B — barrens
- ✓ G — graminoid-dominated tundras
- ✓ P — prostrate-shrub-dominated tundras
- ✓ S — erect-shrub-dominated tundras
- ✓ W — wetlands

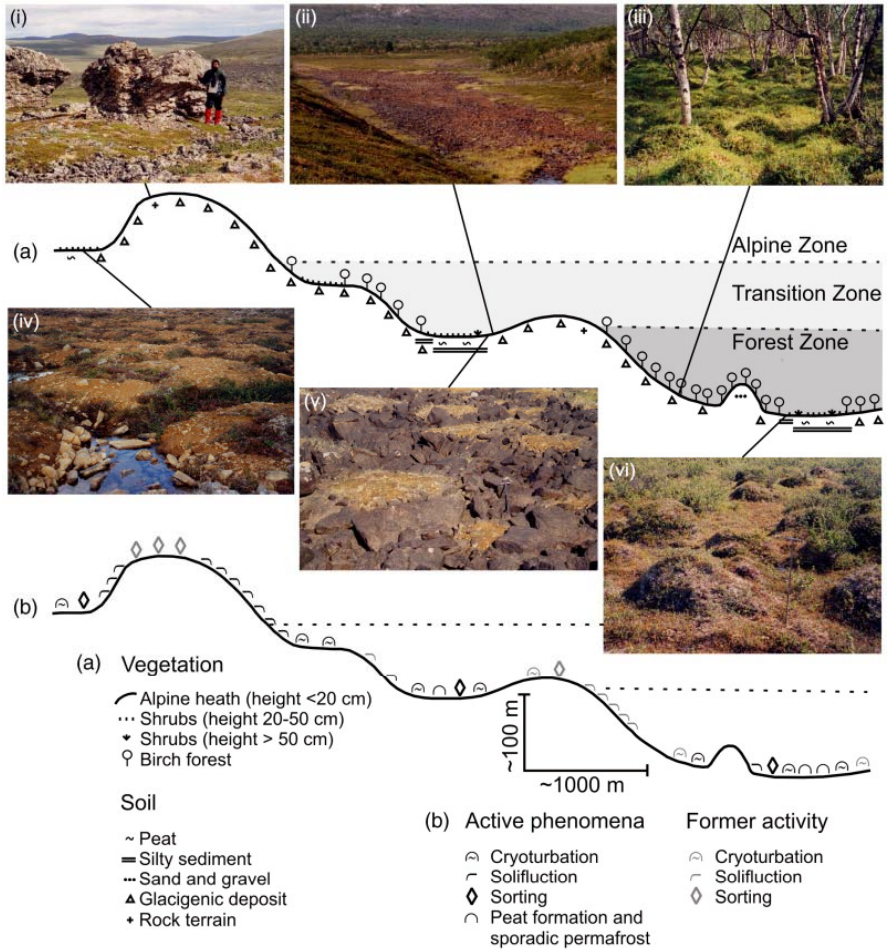


http://www.arcticatlas.org/glossary/pft/

PLANT FUNCTIONAL TYPES

ARCTIC PLANT FUNCTIONAL TYPE

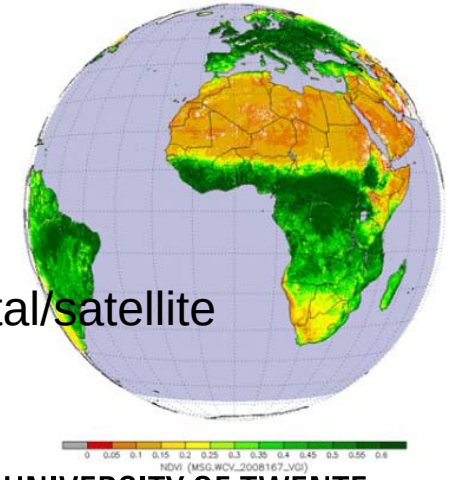
- Arctic vegetation has been characterized as discrete patches (Shaver et al., 2007).
- Do types actually exist
- Are there universal classification schemes.
- Bret-Harte et al (2008) could not predict plant functional traits (biomass, N) per PFTypes.



PLANT FUNCTIONAL TRAITS (SPECIES) FROM IMAGE SPECTROSCOPY

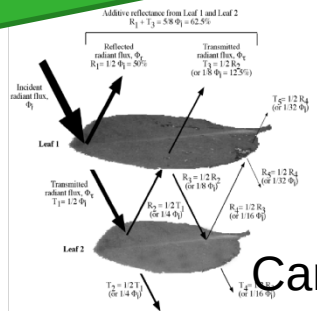
SPECIES – AIRCRAFT LEVEL – HYMAP + LIDAR - ANN

- 27 salt marsh species could be discriminated based on their spectra
- Mapped HyMAP + LIDAR using ANN
- 80% map accuracy

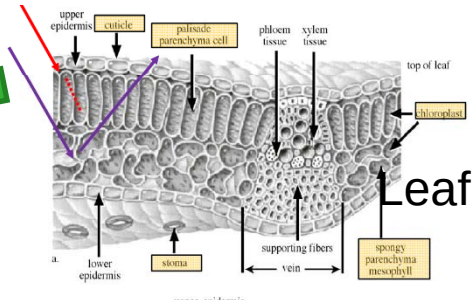


Continental/satellite

Landscape/aircraft



Canopy

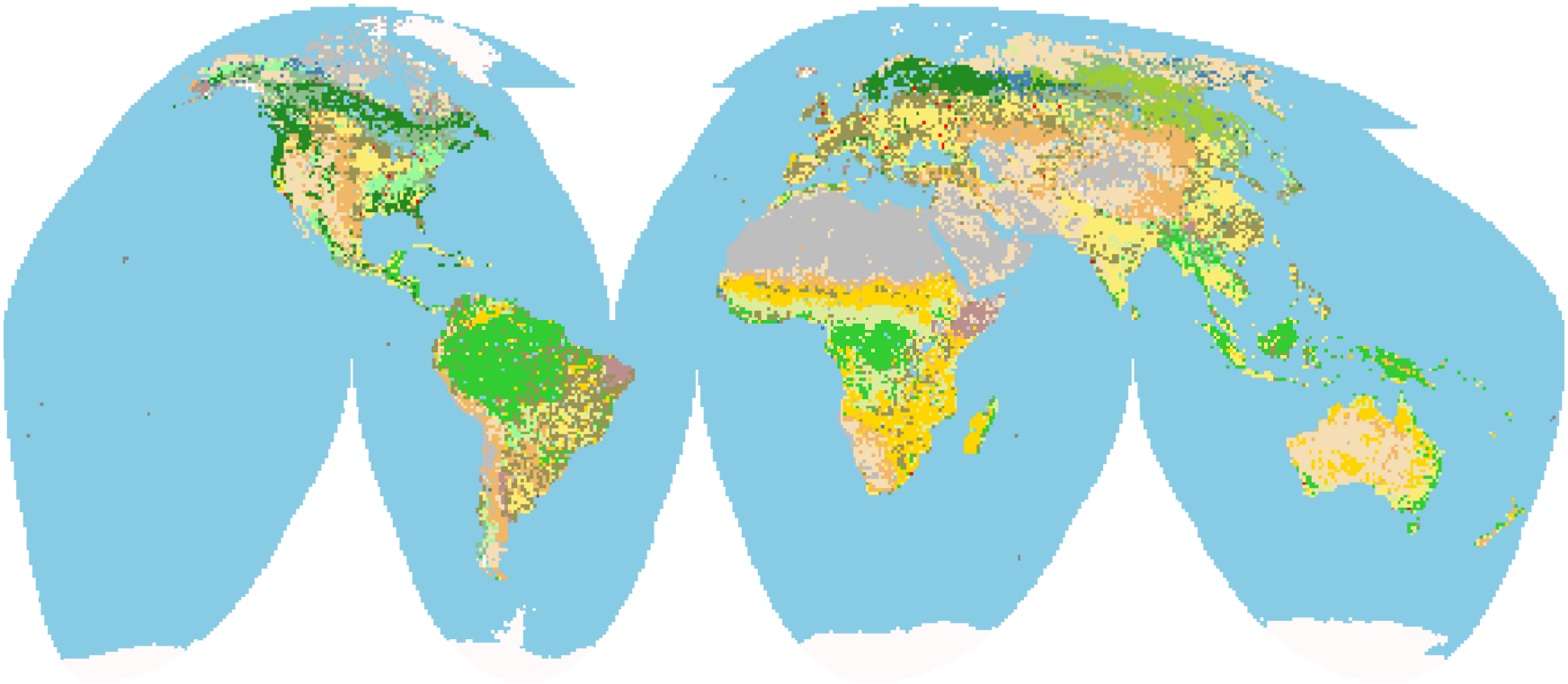


Leaf

UNIVERSITY OF TWENTE.

Schmidt and Skidmore 2002

MAPPING SPECIES (AS A TRAIT) IS NOT MAPPING PLANT FUNCTIONAL TYPE OR LAND COVER CLASS



Scaling in space as well as by theme

UNIVERSITY OF TWENTE.

(CANDIDATE) ESSENTIAL BIODIVERSITY VARIABLES

WHICH MAY BE PARTLY OF FULLY MEASURED WITH IS OR EO

- Species occurrence
- Population abundance
- Population structure
- Number and frequency of varieties/breeds
- Phenology
- Movement patterns
- Life history and demography
- Physiological characteristics
- Ancillary attributes
- Structural type
- Disturbance regime

- Ecosystem extent (type)
- Cover (LAI), height, clumping
- Ecosystem distribution
- Carbon sequestration (balance and storage)
- Photosynthetic activity (GPP = fAPAR = LUE)
- Respiration (NPP)
- Allocation of biomass (functional type)
- Leaf Nitrogen retention
- Leaf phosphorus limitation
- Secondary production

CONCLUSION

- Essential variables
  - a huge global investment
  - needed: policy & business
  - consistent (global) datasets
- EVs (EBVs, ECVs, EOVs)
  - thematic specialists
  - poorly definable

- Way forward
- Focus on physically definable EVs from EO (primary EVs)
  - LAI, species, ht, APAR, phenology, temperature…
  - Favour scale independent parameters like LAI, ht, species
- Derived EBVs through combination of primary EVs
  - Land cover, carbon sequestration, population structure, disturbance ….