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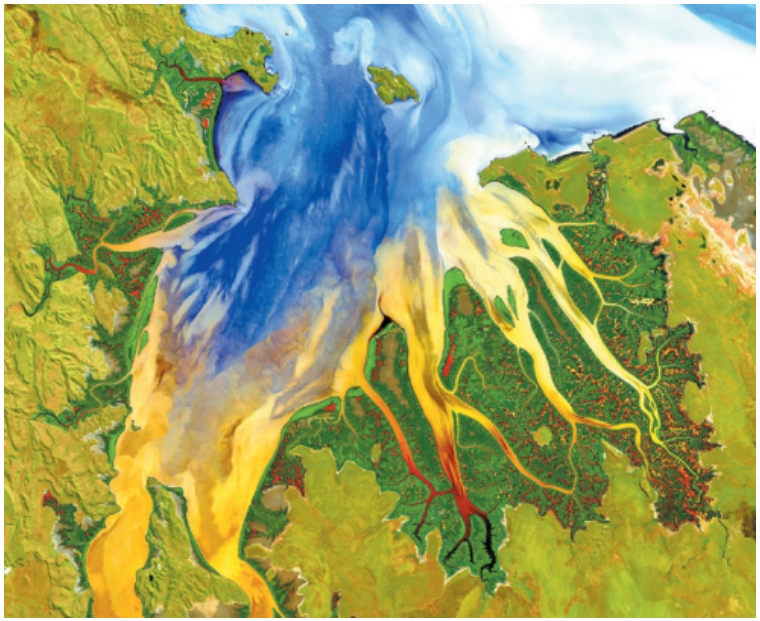
REMOTE SENSING OF ESSENTIAL BIODIVERSITY VARIABLES

SKIDMORE A.K., MUCHER S., PETTORELLI ,N., WANG T. WEGMANN M.,

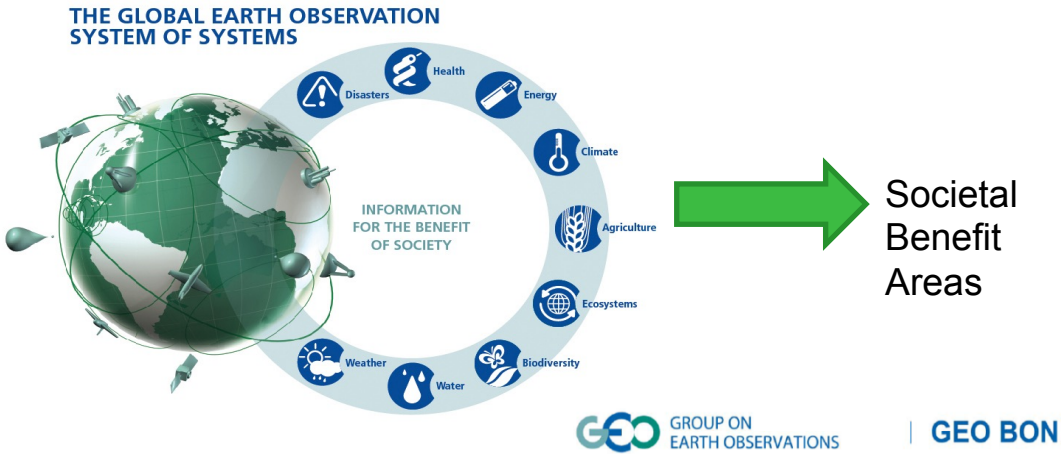
GLOBAL BIODIVERSITY LOSS

- Global biodiversity loss is intensifying
- What progress is there towards the Aichi targets 2011-2020 set by CBD?
  - Target 5 – half global deforestation rates by 2020
  - Target 15 – restoring 15% of degraded ecosystems
- National biodiversity monitoring programmes differ widely
  - Data are inconsistent
  - Few data openly shared



WHAT ARE ESSENTIAL BIODIVERSITY VARIABLES (EBV)?

- EBVs are a set of variables for describing and monitoring biodiversity
- EBVs variables track:
  - trends in species traits and populations
  - changes in ecosystem function and structure
- Ecologists have relied on field surveys that are laborious, cover relatively small extent, and short temporal periods to track biodiversity changes.
- Developed by GEO BON



http://geobon.org/

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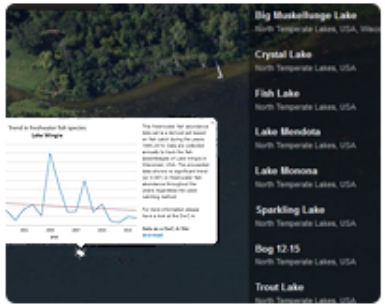
GEO BON - The Group On Earth Observations Biodiversity Observation Network

Learn more about GEO BON and the three ways to get involved with GEO BON.

Read more

News

First approach for trends in freshwater fish



May 6, 2015

GEO BON is excited to announce a first approach for trends in freshwater fish species, which is located at the address: http://data.geobon.org. The trend shows the study of the North Temperate Lakes Long Term Ecological Research (LTER)...

IUCN Red List of Ecosystems workshop

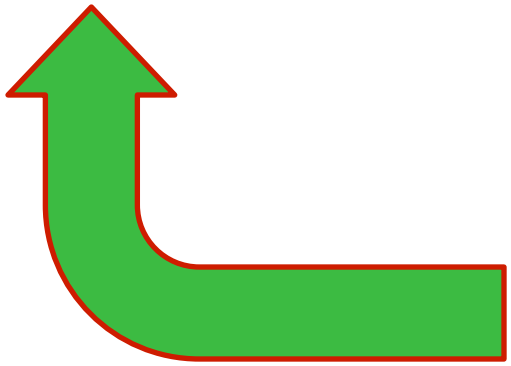
April 28, 2015

The IUCN Red List of Ecosystems paves the path for a regularly updated monitoring system on global ecosystem distribution and status, an activity in the core of GEO BON's interest. Hosted by the Tropical Agricultural Research and Higher Education Center,

GLOBAL CLIMATE OBSERVING SYSTEM ESSENTIAL CLIMATE VARIABLES (ECV)

GCOS
GLOBAL CLIMATE OBSERVING SYSTEM

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

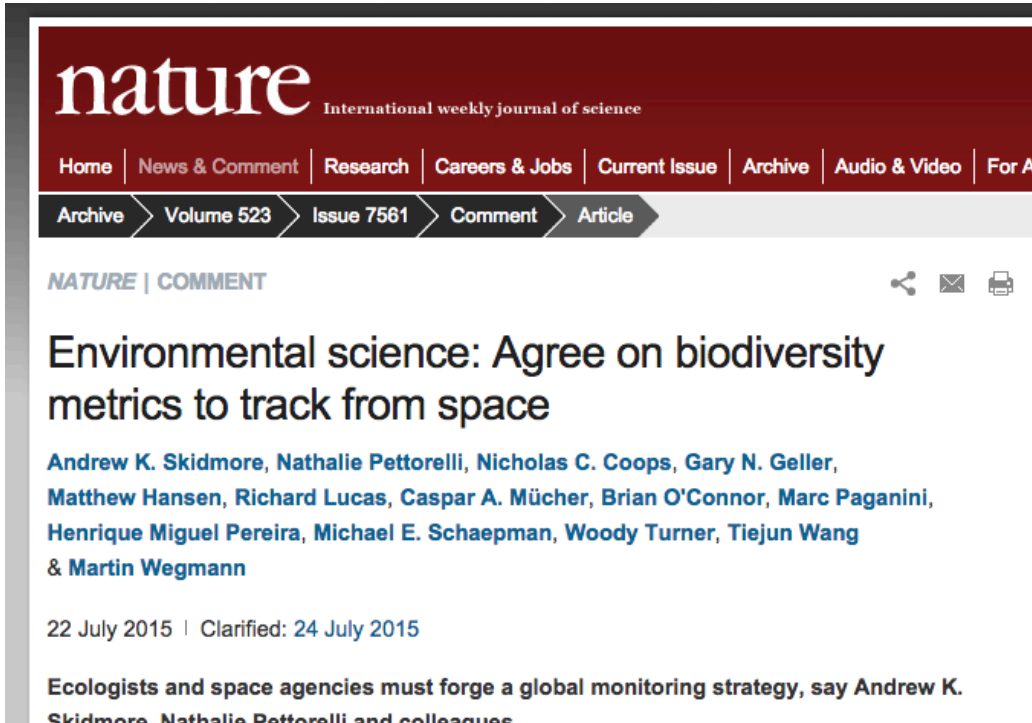


Domain	GCOS Essential Climate Variables
Atmospheric (over land, sea and ice)	**Surface:**[1] Air temperature, Wind speed and direction, Water vapour, Pressure, Precipitation, Surface radiation budget. **Upper-air:**[2] Temperature, Wind speed and direction, Water vapour, Cloud properties, Earth radiation 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

AGREE BIODIVERSITY METRICS TO TRACK FROM SPACE

- Satellite remote sensing crucial for long term wide area coverage
- RS reveals where to reverse loss of biological diversity – repeatible, consistent, borderless, scale independent
- Biodiversity metrics: such as vegetation productivity or structure
- How to translate these metrics into biodiversity monitoring?



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NATURE | COMMENT

Environmental science: Agree on biodiversity metrics to track from space

Andrew K. Skidmore, Nathalie Pettorelli, Nicholas C. Coops, Gary N. Geller, Matthew Hansen, Richard Lucas, Caspar A. Mücher, Brian O'Connor, Marc Paganini, Henrique Miguel Pereira, Michael E. Schaepman, Woody Turner, Tiejun Wang & Martin Wegmann

22 July 2015 | Clarified: 24 July 2015

Ecologists and space agencies must forge a global monitoring strategy, say Andrew K. Skidmore, Nathalie Pettorelli and colleagues

DEFINITIVE SET OF BIODIVERSITY VARIABLES TO TRACK FROM SPACE

- Conservation and space agencies must agree on a definitive set of biodiversity variables
- Need to decide on methods to derive variables and the set of satellites needed to continuously observe them
- From a GEO BON sponsored workshop, we propose 10 variables →

TRACKING BIODIVERSITY

Ten variables

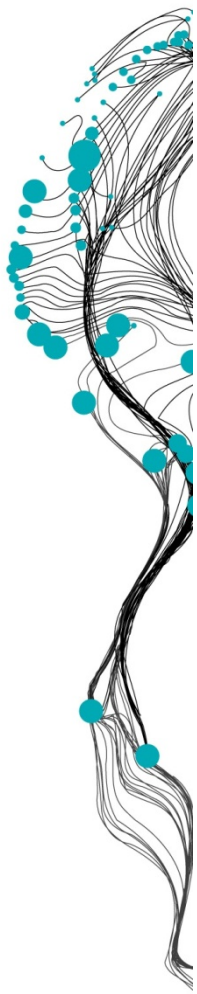
Proposed variables for satellite monitoring of progress towards the Aichi Biodiversity Targets.

Species populations
- Species occurrence

Species traits
- Plant traits (such as specific leaf area and leaf nitrogen content)

Ecosystem structure
- Ecosystem distribution
- Fragmentation and hetrogeneity
- Land cover
- Vegetation height

Ecosystem function
- Fire occurrence
- Vegetation phenology (variability)
- Primary productivity and leaf area index
- Inundation



MISMATCH IN THE DEFINITION OF REMOTE SENSING AND ECOLOGICAL UNITS

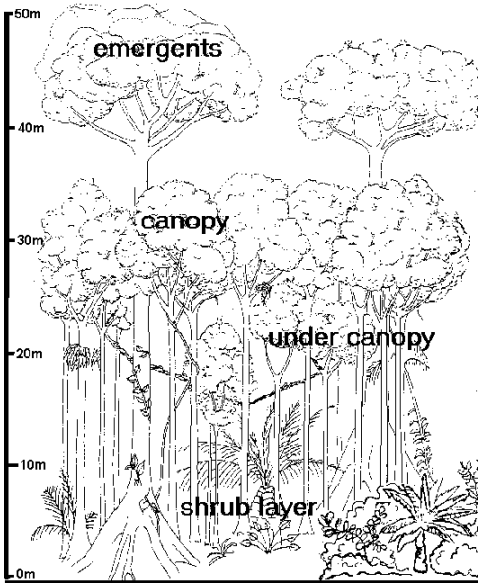
- Challenges :
  - Access to RS data
  - Continuity of observations
  - Temporal and spatial limitations of RS data
  - Communication between RS and ecology communities
- Ecologists definitions change for biodiversity
  - Forest (1990) = ecosystems with minimum 10% crown cover of trees or bamboo associated with wild flora
  - Forest (2005) = trees with a minimum height of 5 m (reference to bamboo and wild flora is dropped)
  - Shifts perception of where forests are, and where they used to be.

DEFINING WHAT IS A '<u>FOREST</u>'

Forest (*plantation*)	TYPE	Forest (*pristine tropical*)
Species = 1		Species = hundreds
LAI = 0-10		LAI = 7-9
Phenology = <u>change</u> denotes 'healthy' and no degradation		Phenology = <u>no</u> change denotes 'healthy' and no degradation
Extent > 0.5 ha		Extent > 1,000,000 ha

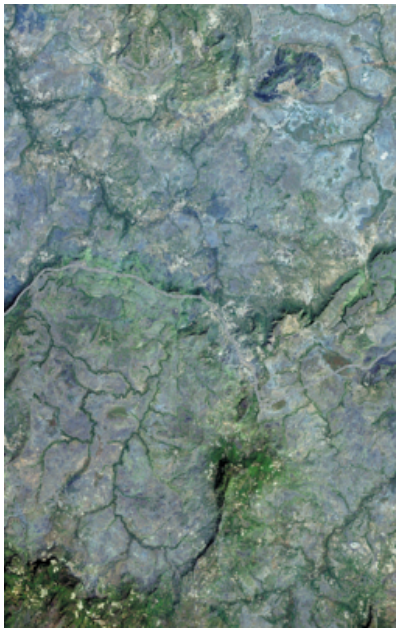
RS EBV

RS EBV



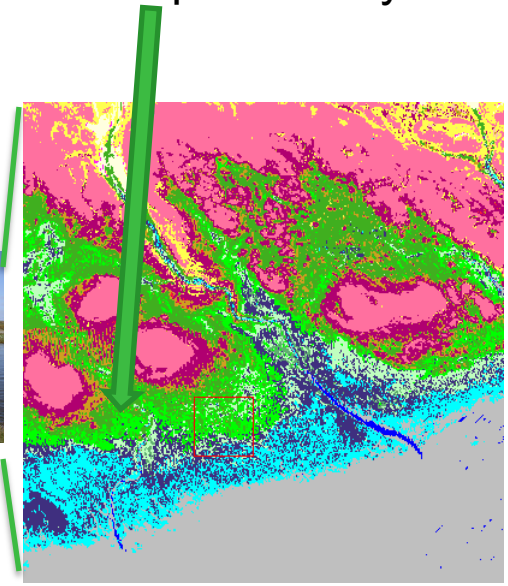
PROGRESS IN SATELLITES

- Landsat
  - Global acquisition and free
  - NASA Sustainable Land Imaging programme ensures data continuation for 25 years
- Sentinel series S-2
  - 5 day revisit
  - Free data until 2028
  - Refined red edge
- NASA Global Ecosystem Dynamics Investigation Lidar
- German Aerospace Centre
  - High resolution and hyperspectral EnMap

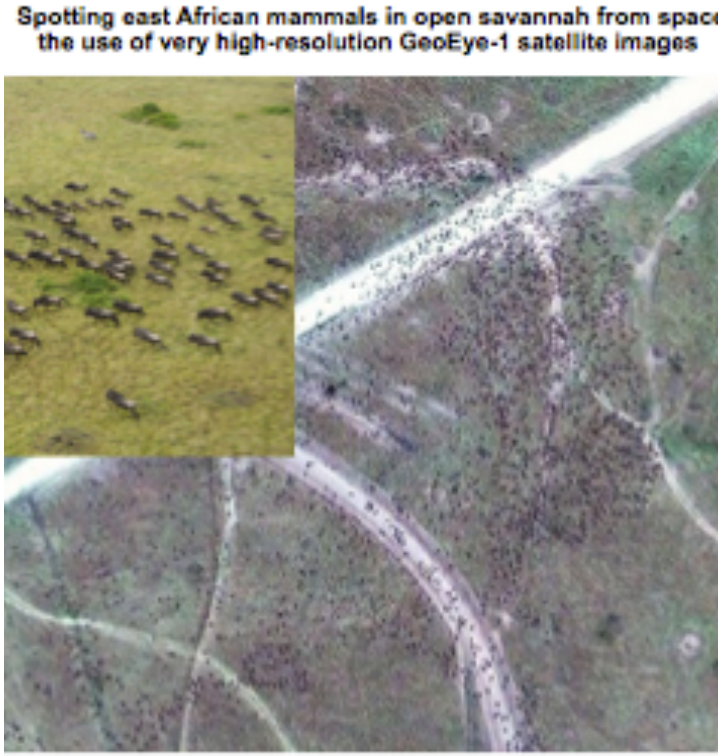


INDIVIDUAL TREE OR ANIMAL SPECIES CAN BE IMAGED FROM HIGH SPATIAL AND SPECTRAL RESOLUTION

- 27 salt marsh species could be discriminated based on their spectra using HyMap
- Possible to compare species extent and change over time
- 80% map accuracy



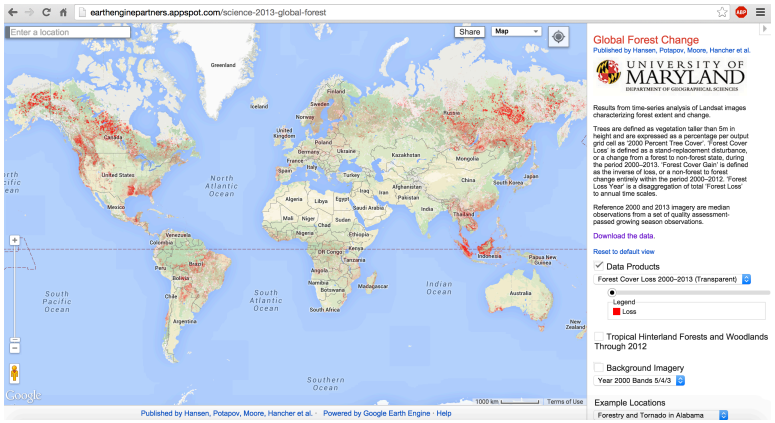
- Wildbeest be counted in African savannah with 92% accuracy
- GeoEye-1, Masai Mara NP Kenya



Yang et al., PLoS ONE

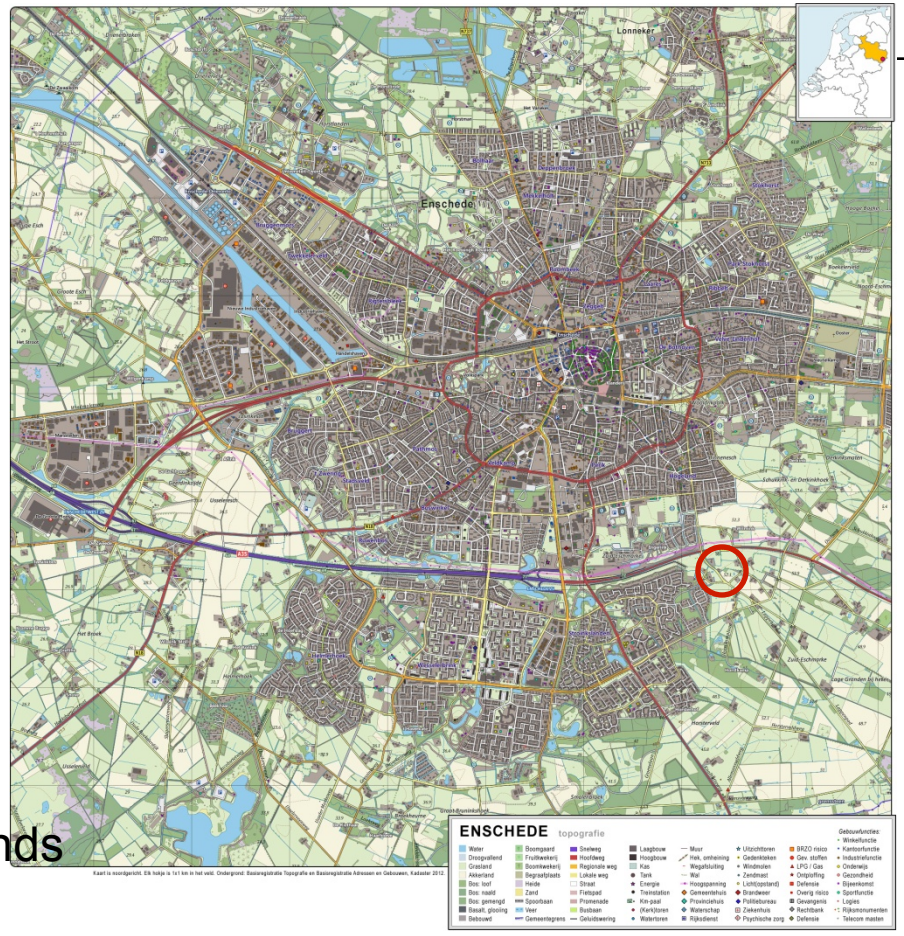
PROGRESS IN PRODUCTS

- Global forest change 2001-2013 by University Maryland, Google, USGS and NASA



- Joined up thinking required between
  - Biodiversity *in situ* data providers
  - Space agencies
  - Product engineers
  - Researchers
  - Policy makers
- …in order to align technical specifications of sensors and product algorithms

FOREST AROUND ENSCHEDE



Netherlands

Dutch topographic map 1:25000

Aerodata International 10 cm air photo + Hansen Forest 2000 Landsat 7

JRC Forest Map 2006 23m (FMAP2006)

IRS-P6 LISS-III

http://upload.wikimedia.org/wikipedia/commons/f/fe/Enschede-topografie.jpg
http://www.earthzine.org/2012/07/25/pan-european-forest-maps-derived-from-optical-satellite-ir
http://forest.jrc.ec.europa.eu/download/data/google-earth-overlays/
http://earthenginepartners.appspot.com/science-2013-global-forest

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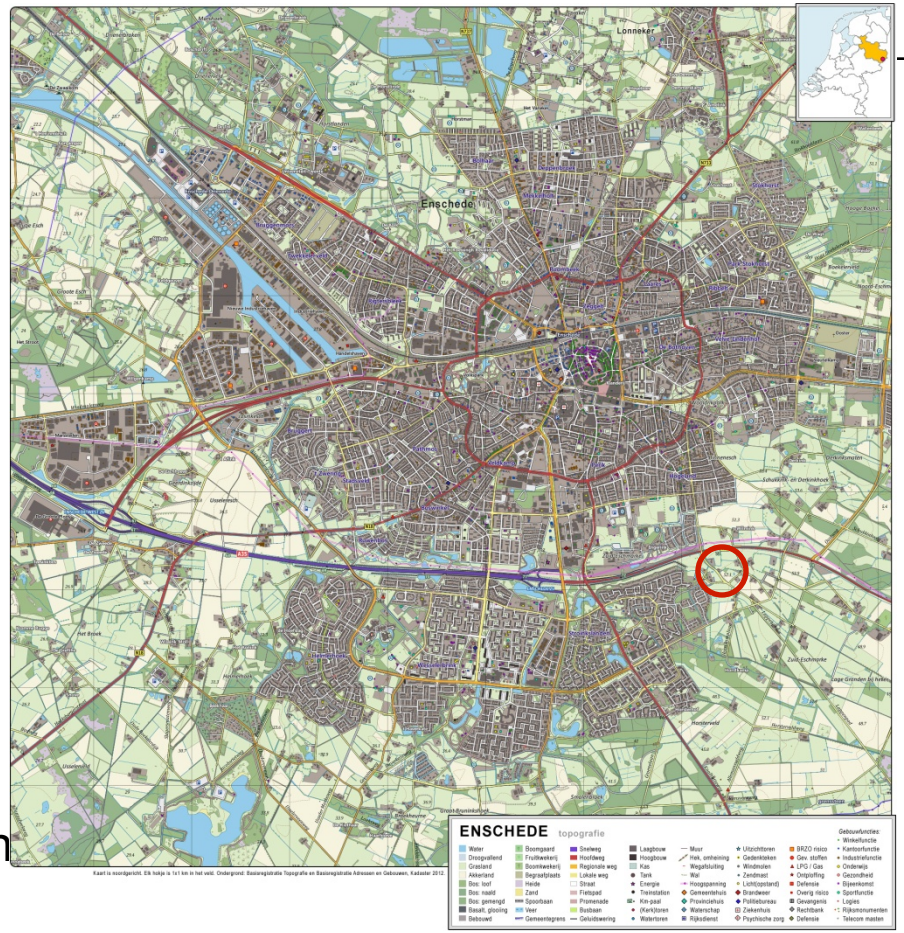
FOREST AROUND ENSCHEDE



2.5 m

JRC Forest Map 2006 (FMAP2006)

IRS-P6 LISS-III

30 m

300 m

GLOBCOVER Forest class 300 m pixel with Spatial Pattern Analysis (MSPA)

JRC (GCOVER2009) MODIS

Netherlan

http://upload.wikimedia.org/wikipedia/commons/f/fe/Enschede-topografie.jpg
http://www.earthzine.org/2012/07/25/pan-european-forest-maps-derived-from-optical-s
http://forest.jrc.ec.europa.eu/download/data/google-earth-overlays/

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RANKING* OF RS EBV'S

- PRIORITY 1 user and use fully identified. 3 variable less directly linked to science and policy questions
- FEASIBILITY 1 indicates maturity of science / technology / experience needed to make the observation, 3 indicates that significant R&D effort remains or that observations on the scale needed are technically, logistically or financially difficult or impossible to make
- IMPLEMENTATION 1 you can identify who needs to take action, what action needs to be taken and how to initiate such action. 3 indicates a complete lack of relevant infrastructure
- STATUS 1 fully operational network or service is in place making observations fit for purpose. 3 indicates that no or very limited action has been taken

Continuously measured & biophysical RS-EBV

- fAPAR P-1 F-1 I-1 S-2 (EO)
- Veg height P=1 F=2 I=3 S=3

Threshold based & thematic RS-EBV

- Land cover P=1 F=1 I=1 S=2
- Fire Disturbance P=1 F=1 I=1 S=2
- Other Disturbance P=2 F=2 I=2 S=3

*based on TOPC (Terrestrial Observation Panel for Climate)

TEN PROPOSED REMOTE SENSING DERIVED BIODIVERSITY VARIABLES

TRACKING BIODIVERSITY

Ten variables

Proposed variables for satellite monitoring of progress towards the Aichi Biodiversity Targets.

Species populations
- Species occurrence ← threshold

Species traits
- Plant traits (such as specific leaf area and leaf nitrogen content) ← continuous

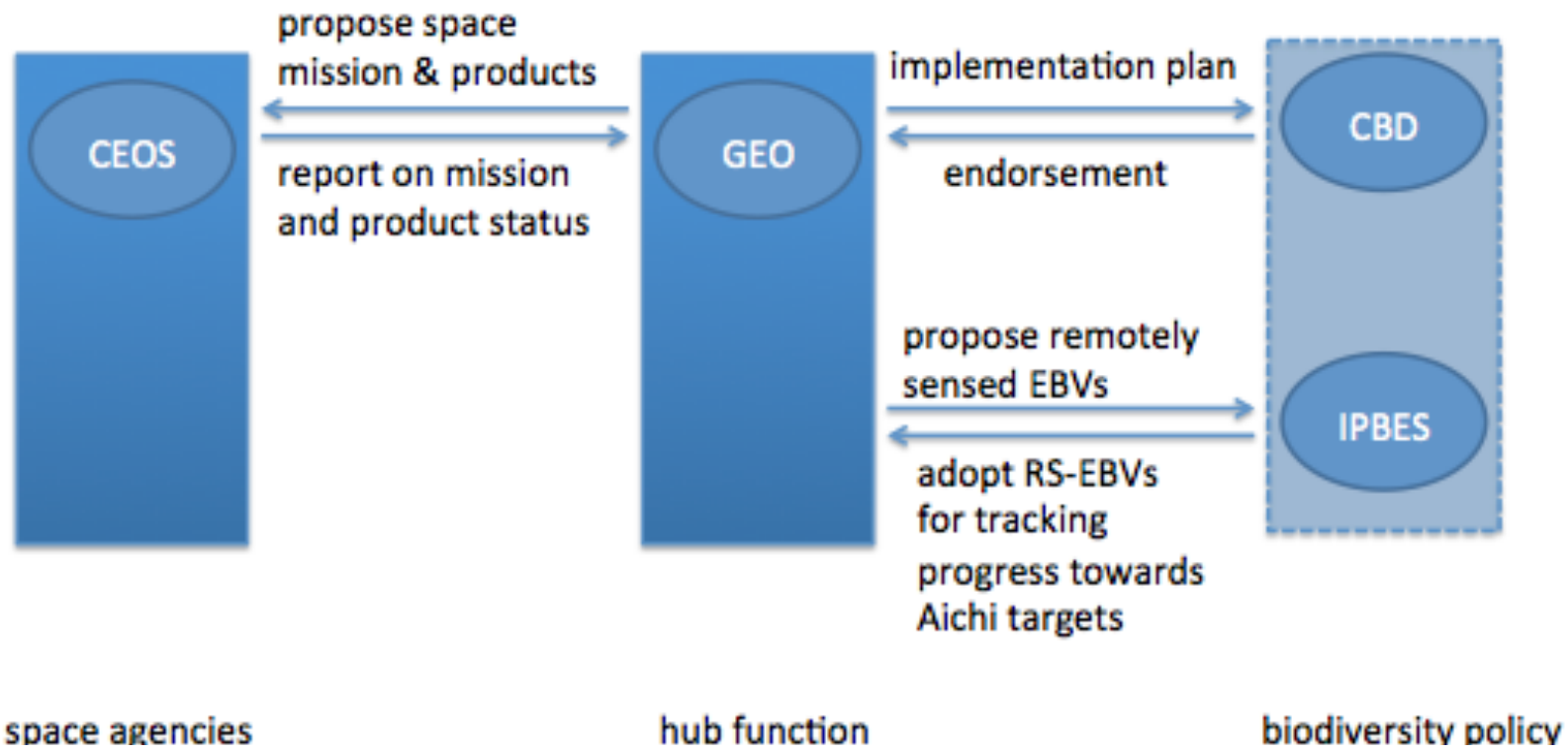
Ecosystem structure
- Ecosystem distribution ← threshold
- Fragmentation and hetrogeneity ← threshold
- Land cover ← threshold
- Vegetation height

Ecosystem function
- Fire occurrence ← threshold
- Vegetation phenology (variability)
- Primary productivity and leaf area index ← continuous
- Inundation

most complex & multifaceted	National	indicator
threshold based, categorical & of increasing complexity	Land cover categories Fragmentation Species occurrence Ecosystem distribution	essential biodiversity variable
biophysical, continuous, simple, global	height Leaf area index Phenology Specific leaf area % vegetation cover	essential variable
		In situ / Remote sensing → measurement

WHAT NEXT? A JOINED UP APPROACH….

GLOBAL MAPPING OF REMOTE SENSING BIODIVERSITY VARIABLES



CONCLUSIONS

- Remote Sensing community require a deeper understanding of ecological concepts and requirements to minimize semantic confusion
- Biodiversity community needs to recognize the potential and limitations of image processing for biodiversity monitoring
- Natural resource managers need to be trained in biodiversity and remote sensing
- Research funding agencies (EC, NSF, etc) must lend their support
- Conservation and space agencies must agree on a definitive set of biodiversity variables
- Set up structure to map trends in biodiversity variables from space