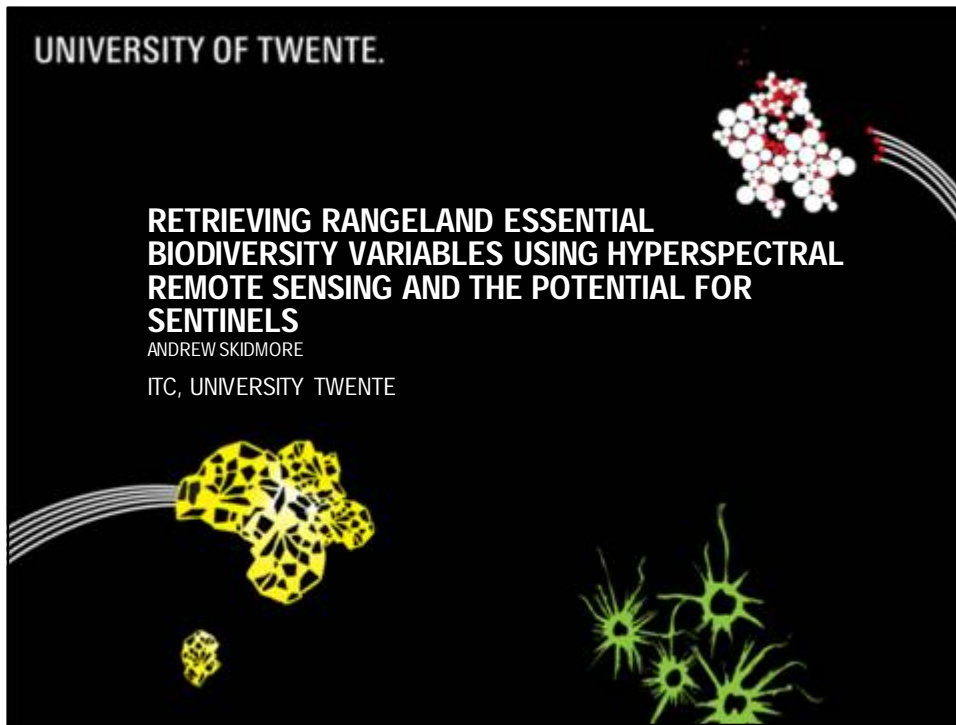


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RETRIEVING RANGELAND ESSENTIAL
BIODIVERSITY VARIABLES USING HYPERSPECTRAL
REMOTE SENSING AND THE POTENTIAL FOR
SENTINELS

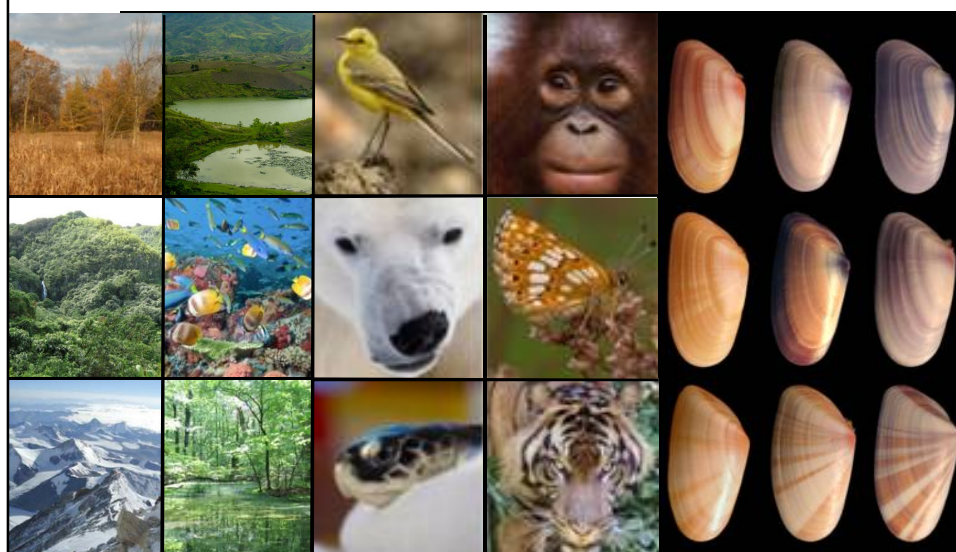
ANDREW SKIDMORE
ITC, UNIVERSITY TWENTE



Introduction (RS-)EBVs Environmental Synthesis Continuous RSEBV GBOS Conclusions

INTRODUCTION

BIODIVERSITY: THE VARIETY OF LIFE



Introduction (RS-)EBVs Environmental Synthesis Continuous RSEBV GBOS Conclusions

INTRODUCTION

WHY BIODIVERSITY MATTERS: THE EXAMPLE OF ECOSYSTEM SERVICES

Pollination
Proportion of the most productive crops, including most fruits and oilseeds, which are animal-pollinated ³²

70%

Estimated cost to US producers in 2007 due to collapse of bee colonies

\$15 billion ³³

Water retention & flood control
Cost of flooding linked to deforestation which destroyed c.25 million hectares of crops in Bangladesh, China, India and Vietnam in 1998

\$23 billion ³¹

Pest & disease control
Annual losses caused by mismanaged or accidental species introductions as agricultural pests in the US, UK, Australia, South Africa, India and Brazil

\$100 billion ³⁰

Soil quality & retention
Amount of cropland abandoned due to soil erosion in the past 40 years

1.5 billion hectares ³⁴

Economic cost of soil erosion in Europe

€53 per hectare per year ³⁵

Genetic variability
Commercial interest in genetic banking is indicative of its value to producers. Continued loss of biodiversity will necessitate increased expenditure on seed banking or genetic variability will be lost. Crop samples currently maintained by 1,500 gene banks around the world

6 million ³⁶

Source: Biodiversity & risk, World Economic Forum

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GAPS IN BIODIVERSITY MONITORING AND SUSTAINABLE RANGELANDS

- The Living Planet Database Index (WWF) holds time-series data for over 16,000 populations for 3500+ species
- Temporal gaps in biodiversity
- Taxonomic gaps in biodiversity

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http://www.zsl.org/science/research-projects/lpi_1162_AR.html

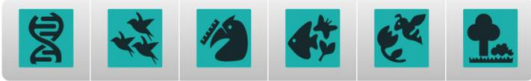
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WHAT ARE ESSENTIAL BIODIVERSITY VARIABLES (EBVs)

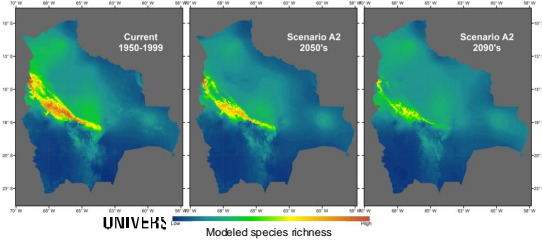
Characteristics of the EBVs:

- Quantifiable
- Repeatable
- Feasible
- Ecosystem agnostic

Cover all dimensions of biodiversity

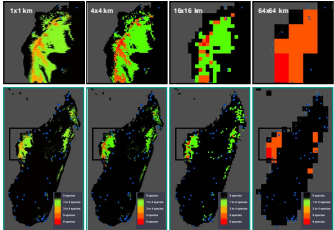


Ability to detect change



UNIVERSITY OF TWENTE Modulated species richness

Allow aggregation and disaggregation




Slide from Miguel Fernandez (GEO BON)

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WHAT ARE REMOTE SENSING EBVs?

- Long term, wide area coverage
- Repeatable, consistent, scale independent
- Definition → algorithm consistency in a product
- Biodiversity metrics → monitoring



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RS-EBVs SLOWLY EMERGE...

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 heterogeneity
 - Land cover
 - Vegetation height
- Ecosystem function**
 - Fire occurrence
 - Vegetation phenology (variability)
 - Primary productivity and leaf area index
 - Inundation

EBV Class	Candidate RS-EBV	Potential support for Aichi targets
Species populations	Species distribution*	4,5,7,9,10,11,12,14,15
Species populations	Species abundance*	5,7,9,12,14,15
Species traits	Phenology (e.g., leaf-on and leaf-off dates; peak season)	5,9,11,12,14,15
Species traits	Plant traits (e.g., specific leaf area, leaf nitrogen content)	7,9,12,14
Community composition	Taxonomic diversity	8, 10, 12, 14
Community composition	Functional diversity	5,7,10,12,14,15
Ecosystem function	Productivity (e.g., NPP, LAI, FAPAR)	5,7,10,12,14,15
Ecosystem function	Disturbance regime (e.g., fire and inundation)	7,9,10,12,14,15
Ecosystem structure	Habitat structure (e.g., height, crown cover and biomass)	5,7,9,14,15
Ecosystem structure	Ecosystem extent and fragmentation	5,11,12,14,15
Ecosystem structure	Composition by land cover	5,7,10,12,14,15

10 RS-EBVs proposed in RS-EBV paper by Skidmore et al 2015

List of candidate RS-EBVs submitted to CBD

Continuous variables
Environmental Synthesis variables

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ENVIRONMENTAL SYNTHESIS VARIABLE

SPECIES ABUNDANCE IN A TROPICAL AGRICULTURAL LANDSCAPE

- CAO: airborne hyperspectral @ 5m
- Trees identified by LIDAR ht
- Tree species classified by support vector machine (SVM)

2 meter hyperspectral image

Species prediction map

Landscape species abundance

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[Open Access Article](#)

Tree Species Abundance Predictions in a Tropical Agricultural Landscape with a Supervised Classification Model and Imbalanced Data

by Sarah J. Graves, Gregory P. Asner, Roberta E. Martin, Christopher B. Anderson, Matthew S. Colgan, Lella Kalantari and Stephanie A. Bohman

Remote Sens. 2016, 8(2), 161; doi:10.3390/rs8020161

Received: 2 December 2015 / Revised: 3 February 2016 / Accepted: 14 February 2016 / Published: 19 February 2016

Cited by 5 | Viewed by 810 | PDF Full-text (5505 KB) | HTML Full-text | XML Full-text | Supplementary Files

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ENVIRONMENTAL SYNTHESIS VARIABLE

SPECIES ABUNDANCE IN A DUTCH SALT MARSH

- CASI + LIDAR

SAM result

Expert result

Combined result

Legend:

- Unclassified
- 1 Spartina
- 2 Salicornia
- 3 Suaeda
- 4 Puccinellia
- 5 Limonium
- 6 Halimione
- 7 Glaux
- 8 Juncus g
- 9 Festuca
- 10 Juncus m
- 11 Elymus
- 12 Pot Agr Lot
- 13 Sagina
- 14 Carex
- 15 Agrostis
- 16 Scir Phrag
- Dune
- 0 bare sand
- water

Remote Sensing of Environment
Volume 85, Issue 1, 25 April 2003, Pages 92-108

Spectral discrimination of vegetation types in a coastal wetland
K.R. Schmitz, A.K. Skidmore

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ENVIRONMENTAL SYNTHESIS VARIABLE

COMMUNITY COMPOSITION IN KNP

FIG. 3. (a) Results of the three-dimensional NMF decomposition of community composition, displayed as an RGB image; (b) map of the 10 most abundant community types, with colors corresponding to the change vector from the NMF map; (c) proportional abundance of the 10 most abundant species classes—the “factor” share. C₁ acutatum (C₁), C₂ divinus (C₂), C₃ divinus (C₃), C₄ divinus (C₄), C₅ divinus (C₅), C₆ divinus (C₆), C₇ divinus (C₇), C₈ divinus (C₈), C₉ divinus (C₉), C₁₀ divinus (C₁₀).

EBV Class	Candidate RS-EBV	Potential support for Aichi targets
Species populations	Species distribution*	4, 5, 7, 9, 10, 11, 12, 14, 15
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Species traits	Phenology (e.g., leaf-on and leaf-off dates; peak season)	5, 9, 11, 12, 14, 15
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Community composition	Productivity (e.g., NPP, LA FAPAR)	5, 7, 10, 12, 14, 15
Ecosystem function	Disturbance regime (e.g., fire and inundation)	7, 9, 10, 12, 14, 15
Ecosystem structure	Habitat structure (e.g., height, crown cover and density)	5, 7, 9, 14, 15
Ecosystem structure	Ecosystem extent and fragmentation	5, 11, 12, 14, 15
Ecosystem structure	composition by Ecosystem functional type & land cover	5, 7, 10, 12, 14, 15

ECOLOGICAL APPLICATIONS
Landscape-scale variation in plant community composition of an African savanna from airborne species mapping

C. A. Hurlbert, M. S. Colgan, J. B. Fiebert, S. R. Lewis, B. E. Martin, G. P. Asner

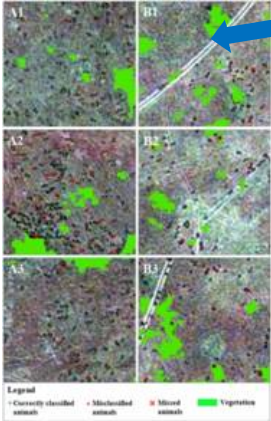
- CAO hyperspectral and lidar
- >500 000 tree and shrub crowns for 11 veg types
- 144-km² landscape
- Stacked support vector machines

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ENVIRONMENTAL SYNTHESIS VARIABLE

KENYAN RANGELAND

- Very high resolution instruments directly observe large or gregarious animals



Yang Z, et al (2014) Spotting East African Mammals in Open Savannahs from Space. PLoS ONE 9(12)

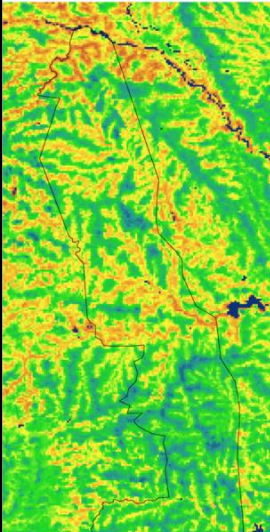
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ENVIRONMENTAL SYNTHESIS VARIABLE

SPECIES ABUNDANCE



Predicted bat richness for Kruger NP

High : 53
Low : 0

EBV Class	Candidate RS-EBV	Potential support for Aichi targets
Species populations	Species distribution*	4,5,7,9,10,11,12,14,15
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- WorldClim 1.4 ppt & temperature
- Ruggedness indices SRTM30
- Freshwater proximity
- HydroSHEDS & SRTM Water Body Data
- MODIS Vegetation Continuous Fields
- SPOT VEGETATION red & NIR

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FUNCTIONAL RICHNESS

Functional richness

Modelled in-situ functional richness

Functional richness of pixel based remotely sensed variables

FD modelled in-situ vs FD of RS pixels

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Functional richness of the saltmarsh is very low but increases at vegetation transition zones. These 'fronts' or transition zones are well highlighted by the moving window.

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ENVIRONMENTAL SYNTHESIS VARIABLE LAND COVER

Land cover legend

- Cropland, wetland
- Cropland irrigated / paddy/Roading
- Mosaic: cropland / vegetation
- Mosaic: vegetation / cropland
- Tree broadleaved evergreen
- Tree broadleaved deciduous
- Tree needleleaved evergreen
- Tree needleleaved deciduous
- Tree mixed leaf type
- Mosaic: tree, shrub / HC
- Mosaic: HC / tree, shrub
- Shrubland
- Grassland
- Lichens and mosses
- Sparse vegetation
- Tree flooded, fresh water
- Tree flooded, saline water
- Shrub or herbaceous flooded
- Urban areas
- Bare areas
- Water bodies
- Permanent snow and ice
- No data

A consistent set of global Land Cover products at 300m

3 consistent global LC maps for epochs 2000, 2005 and 2010

A new generation of satellite-derived global land cover products

7-day composites time series of MODIS Resolution over the whole archive (2000-2012)

CCI LC processing

1998-2002
2003-2007
2008-2012

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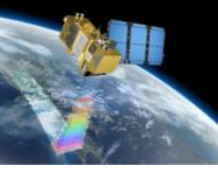
GENERATING CONTINUOUS RSEBVS

PROGRESS IN SATELLITES AND IMAGE PROCESSING TECHNIQUES

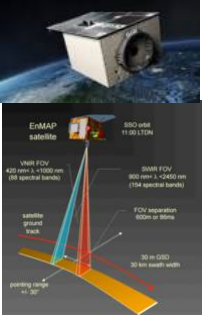
Landsat – systematic and global acquisition for next 25 years



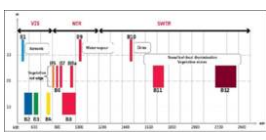
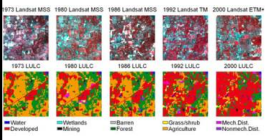
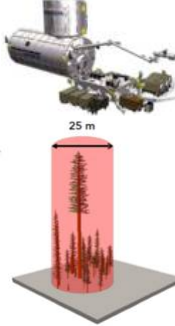
Sentinel-2 – systematic global acquisition including the red edge to 2028



EnMAP- Environmental mapping and analysis program



GEDI – Global Ecosystems Dynamics Investigation LiDAR



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