Earth Observations to Value Ecosystem Services: A Series of Workshops

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INSTITUTE ON THE ENVIRONMENT
UNIVERSITY OF MINNESOTA
Driven to Discover℠

Stanford WOODS INSTITUTE for the ENVIRONMENT

THE UNIVERSITY OF VERMONT GUND INSTITUTE FOR ENVIRONMENT

natural capital PROJECT

NASA


KOMATSU

Ecosystem Services: the benefits nature provides to human well-being

InVEST

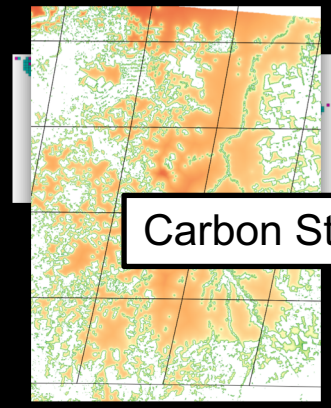
integrated valuation of ecosystem services and tradeoffs

GLOBIO

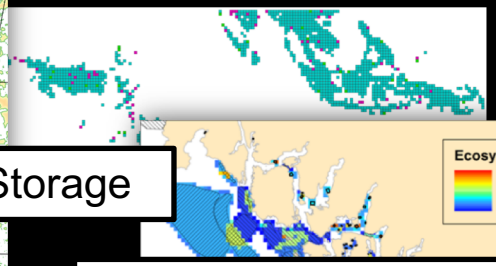
WaterWorld

LUCI

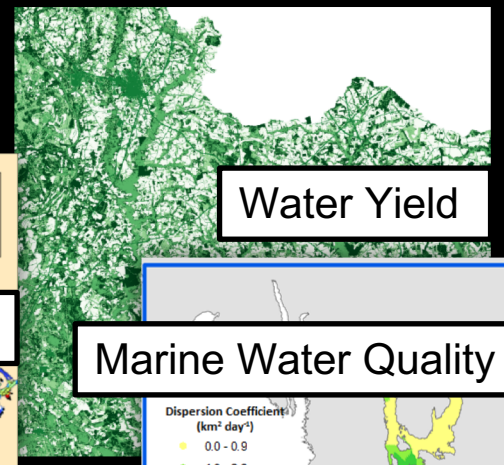
LAND UTILISATION & CAPABILITY INDICATOR



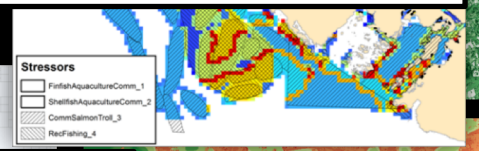
Carbon Storage

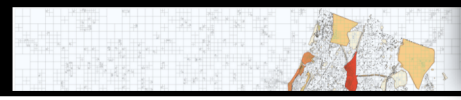


Habitat Risk Assessment

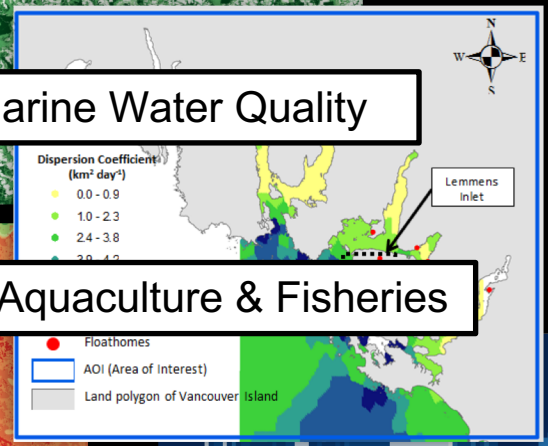


Water Yield



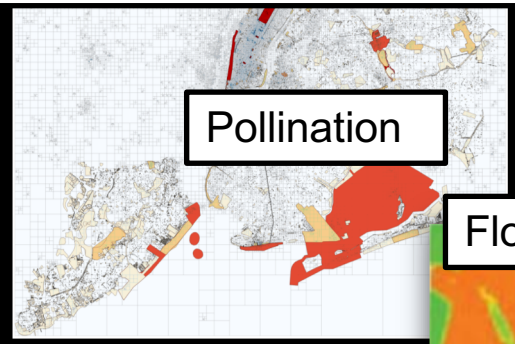


Visitation: Recreation & Tourism

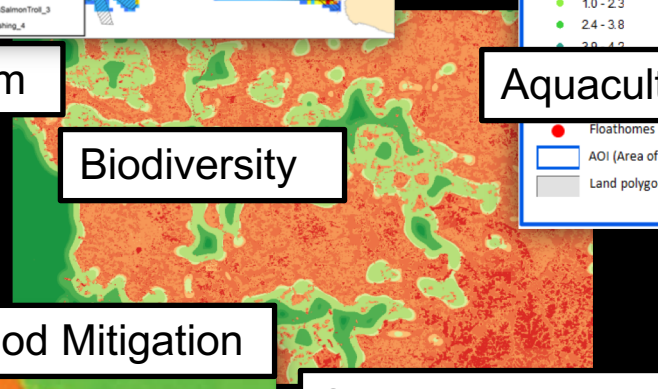


Marine Water Quality

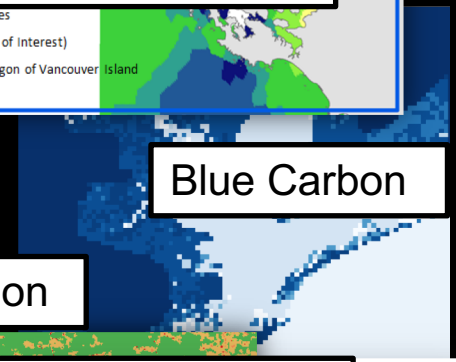
Aquaculture & Fisheries



Pollination



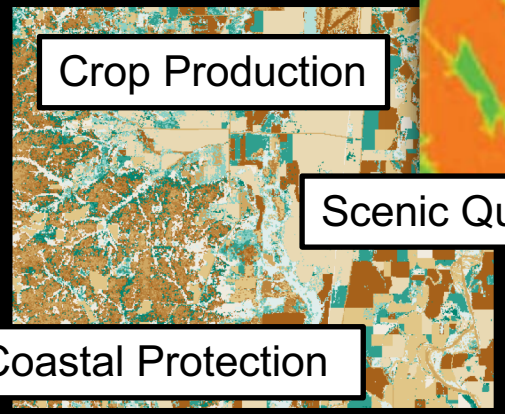
Biodiversity



Blue Carbon

Flood Mitigation

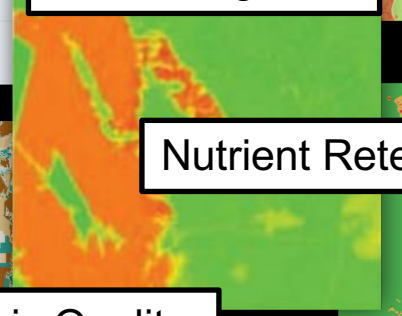
Sediment Retention



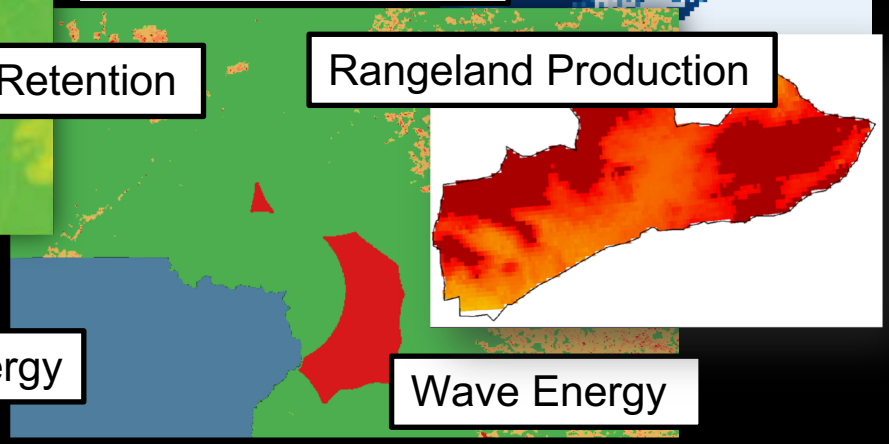
Crop Production

Scenic Quality

Coastal Protection



Nutrient Retention

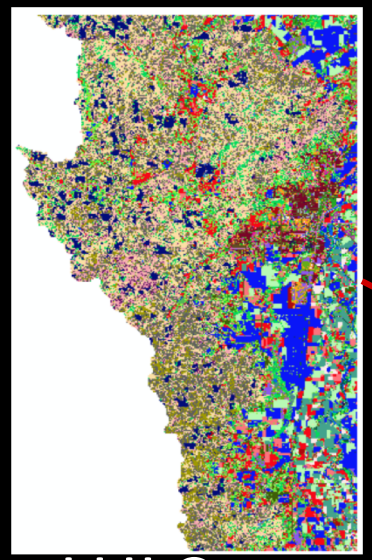


Rangeland Production

Wind Energy

Wave Energy

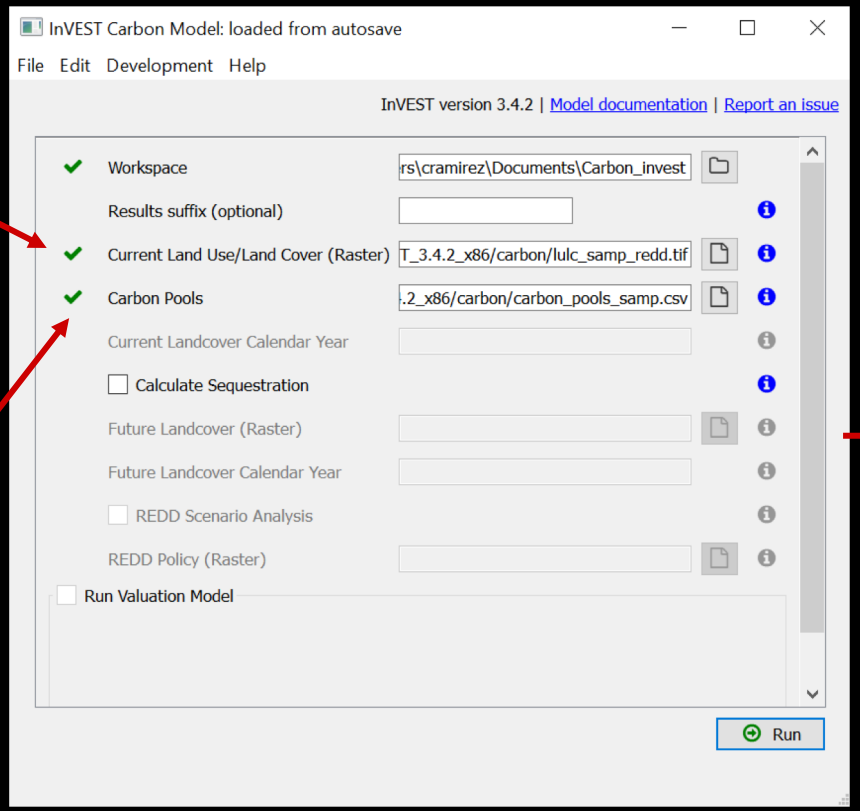
Example: ES - Climate mitigation
Carbon storage model

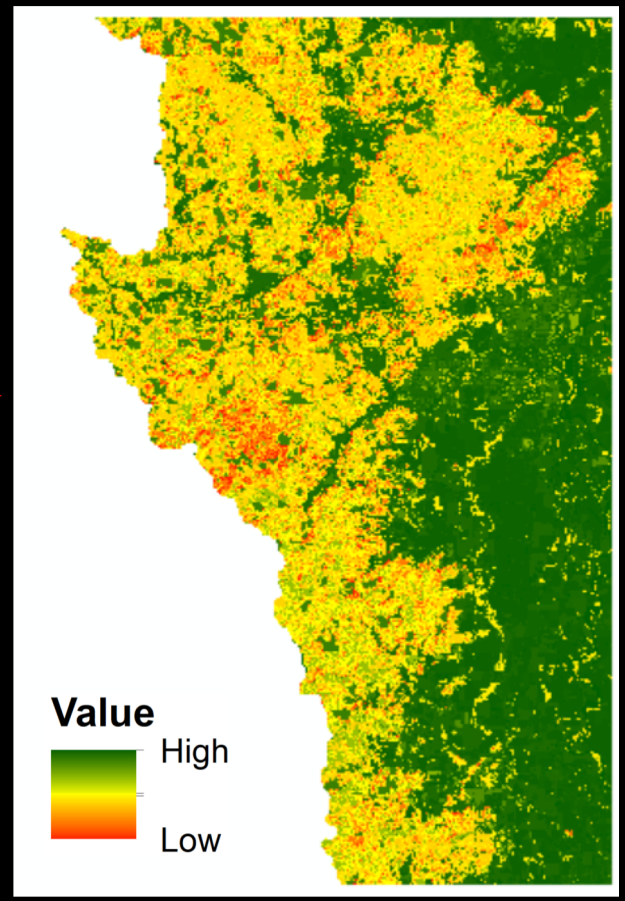


LULC

C Averages ex-situ

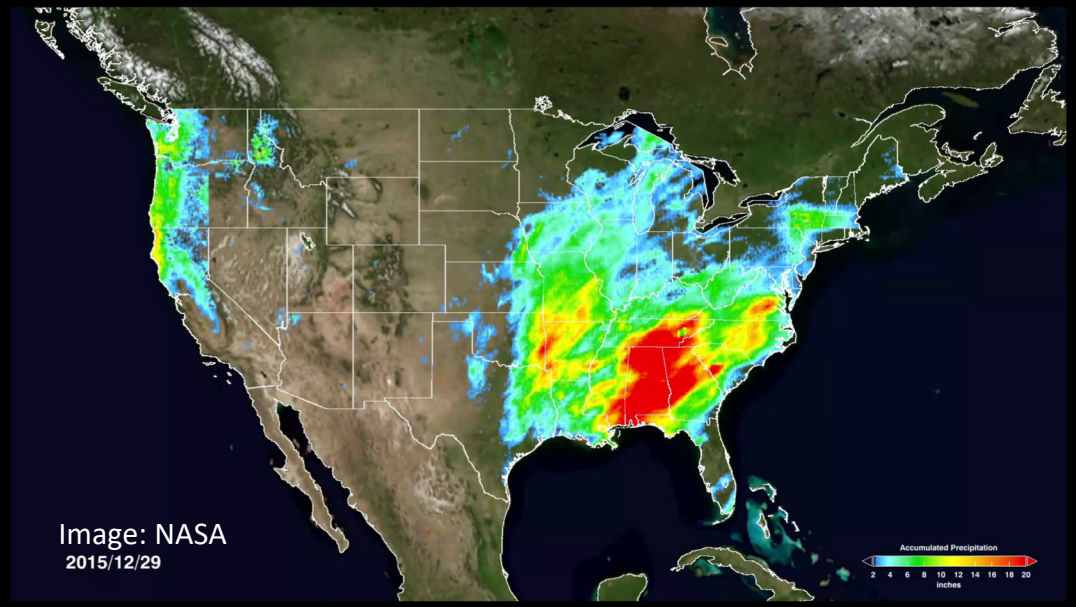
A	B	C	D	E	F	G	H
C_above	C_below	C_soil	C_dead	lucode	LULC_Name		
15	10	60	1	1	ResidentialÃ¡ 0-4 DU/ac		
5	3	20	0	2	Residential 4-9 DU/acÃ¡		
2	1	5	0	3	ResidentialÃ¡ 9-16 DU/ac		
0	0	0	0	4	ResidentialÃ¡ >16 DU/ac		
10	20	10	5	5	Vacant		
0	0	0	0	6	Commercial		
0	0	0	0	7	Comm/Industrial		
0	0	0	0	8	Industrial		
0	0	0	0	9	Industrial & Comm.		
0	0	0	0	10	Residential & Comm.		
0	0	10	0	11	Urban non-vegetated unknown		
0	0	50	0	16	Rural structures		
0	0	25	0	18	Railroad		
0	0	50	0	19	Primary roadsÃ¡		
0	0	25	0	20	Secondary roads		
0	0	35	0	21	Light duty roads		
0	0	0	0	24	Rural non-vegetated unknown		
0	0	0	0	29	Main channel non-vegetatedÃ¡		
0	0	0	0	32	Stream orders 5-7		
0	0	0	0	33	Permanent lentic water		
100	5	65	50	39	Topographic Shadow		



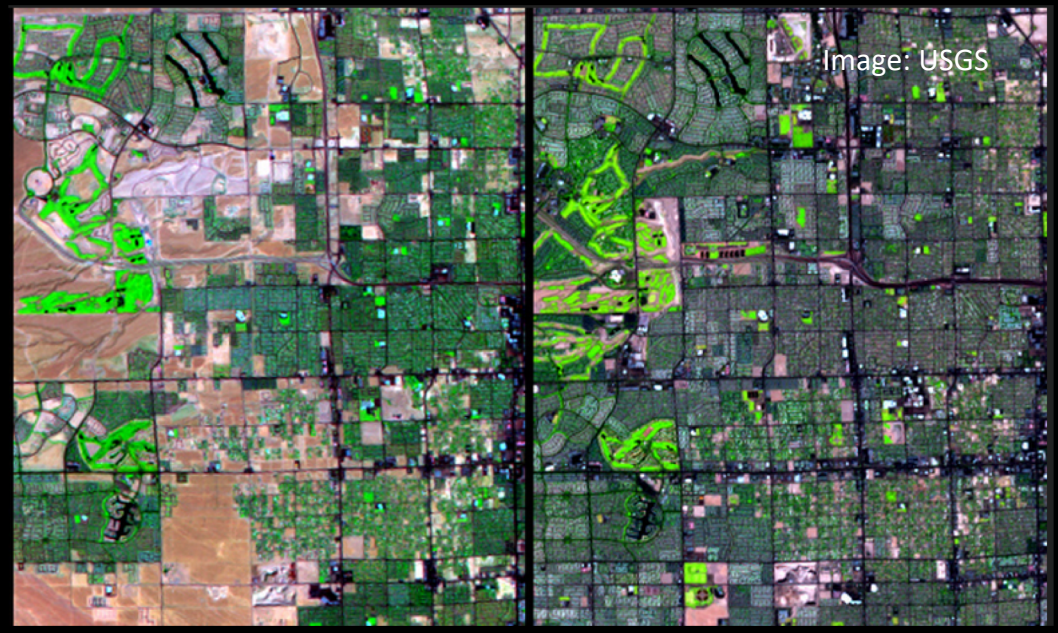


Biomass

- EO could DRIVE ES models



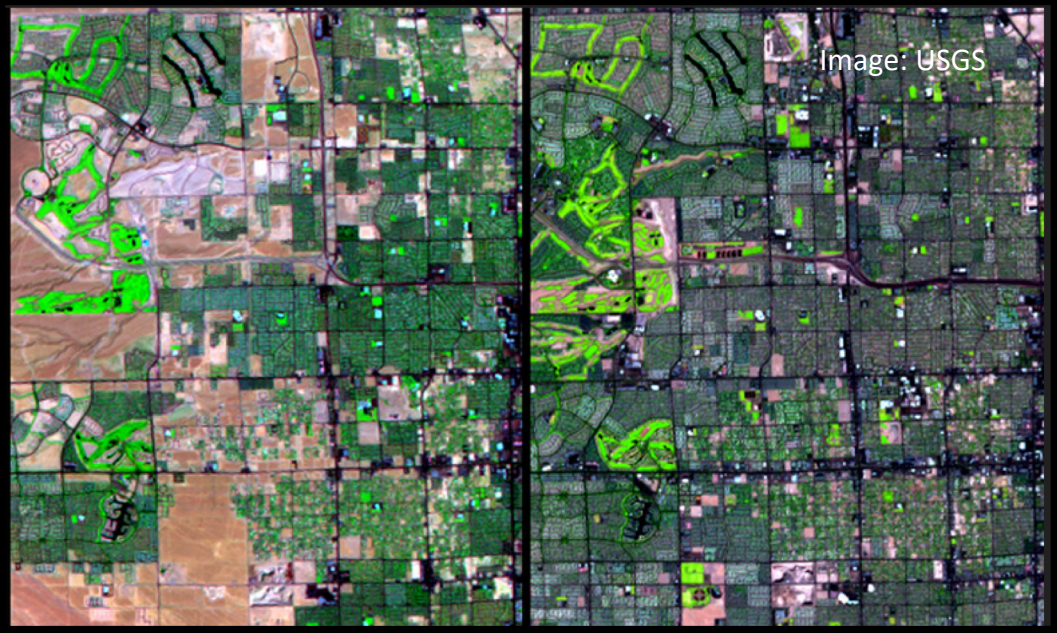
Parameterize or drive models



Determine or predict the provision of ES

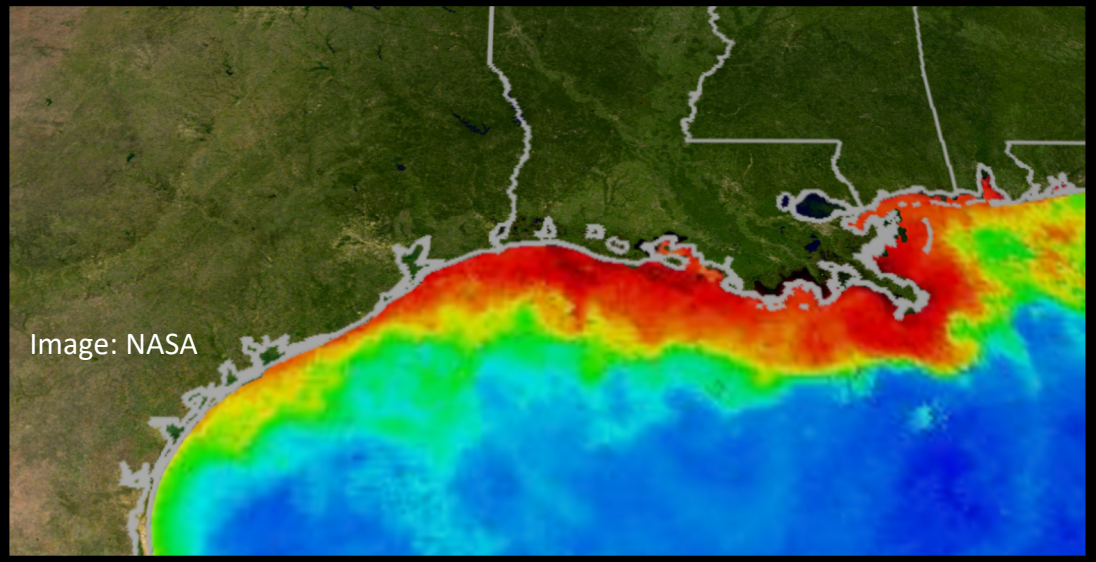
- EO could DRIVE ES models

Parameterize or drive models

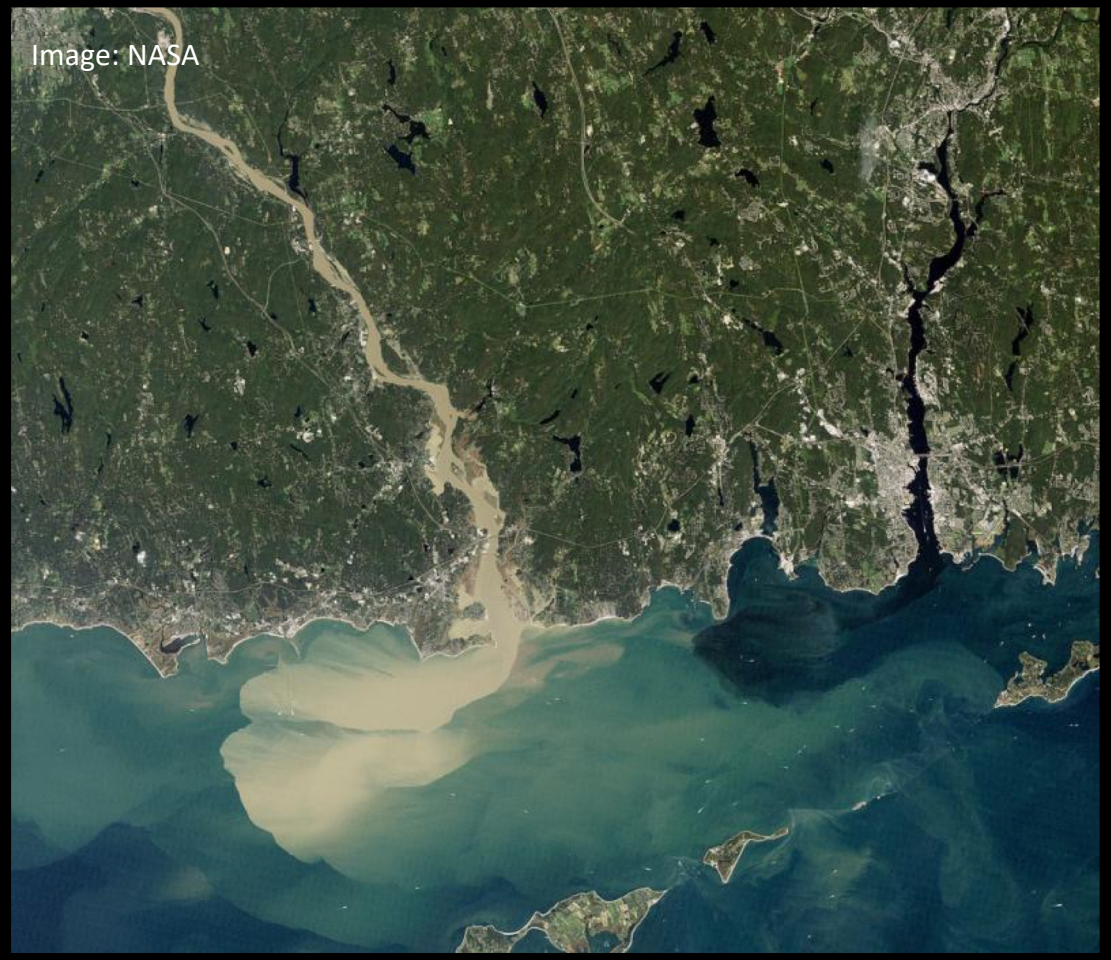


Determine the demand for ES services

- EO could CREATE ES models



Observable indicators of ES production or demand



Calibration or accuracy assessments

ELSEVIER

Ecological Modelling 129 (2000) 169–186

ECOLOGICAL MODELLING

www.elsevier.com/locate/ecolmodel

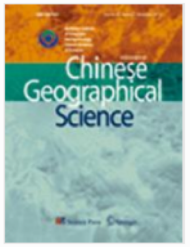
Perspectives on combining ecological process models and remotely sensed data

S.E. Plummer *

Opinion

Priorities to Advance Monitoring of Ecosystem Services Using Earth Observation

Anna F. Cord [1], Kate A. Brauman [2], Rebecca Chaplin-Kramer [3], Andreas Huth [4, 5, 6], Guy Ziv [7], Ralf Seppelt [1, 5, 8]



Chinese Geographical Science

December 2010, Volume 20, Issue 6, pp 522–535 | Cite as

Remote sensing of ecosystem services: An opportunity for spatially explicit assessment

Potential contributions of remote sensing to ecosystem service assessments

Margaret E. Andrew
Murdoch University, Australia
Michael A. Wulder
Canadian Forest Service (Pacific Forestry Centre), Canada
Trisalyn A. Nelson
University of Victoria, Canada

Satellite remote sensing of ecosystem functions: opportunities, challenges and way forward

Nathalie Pettorelli, Henrike Schulte to Bühne, Ayesha Tulloch, Grégoire Dubois, Cate Macinnis-Ng, Ana M. Queirós, David A. Keith, Martin Wegmann, Franziska Schrodt, ... See all authors

First published: 10 August 2017 | https://doi.org/10.1002/rse2.59 | Cited by:5

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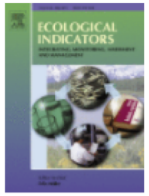
Ecological Indicators

Volume 52, May 2015, Pages 430-443

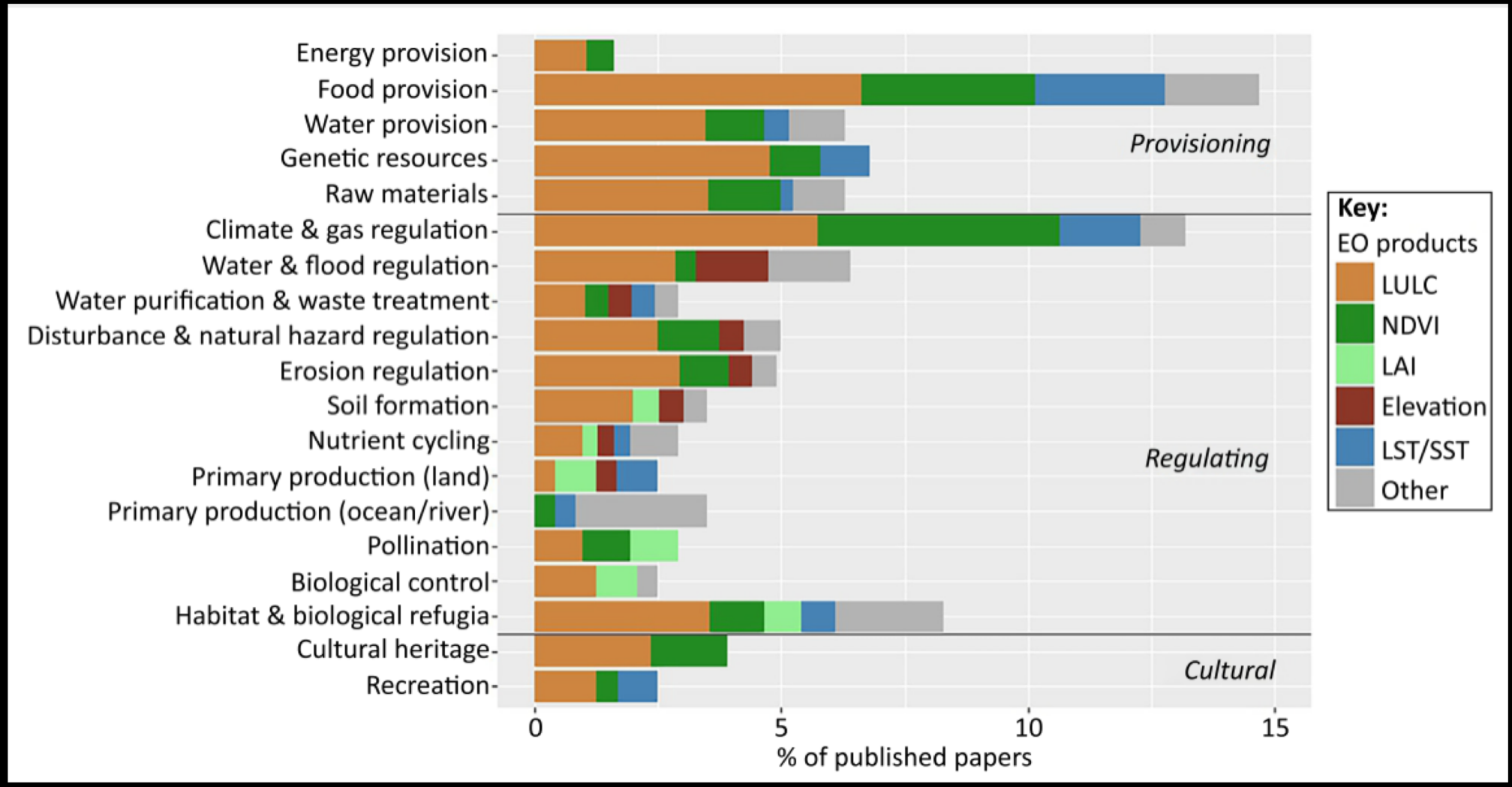


Review

Remote sensing of ecosystem services: A systematic review

Caio C. de Araujo Barbosa [a], Peter M. Atkinson [a], John A. Dearing [b]

Few EO products are the most popular



Cord et al. 2017 (based on de Araujo Barbosa 2015)

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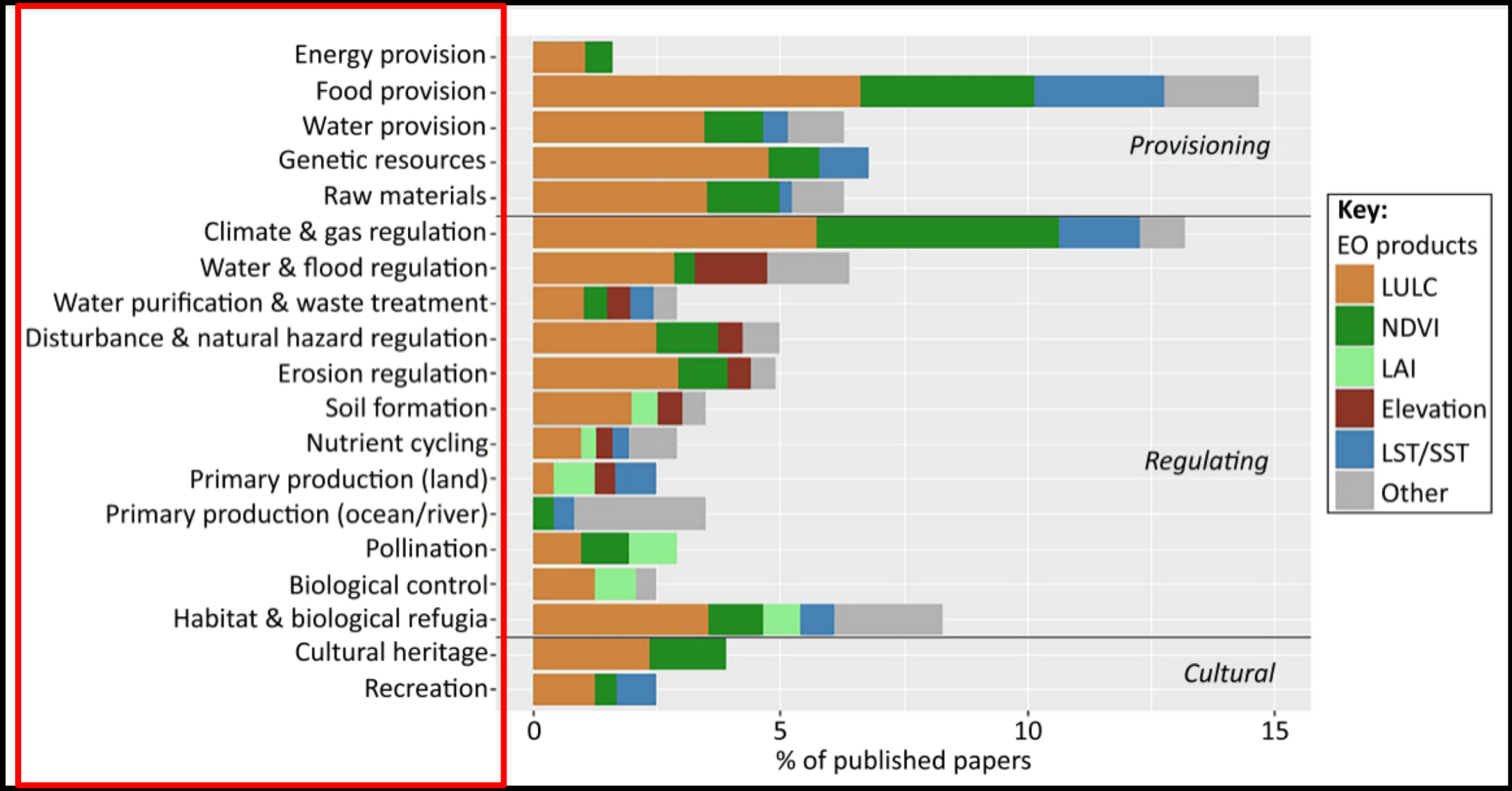

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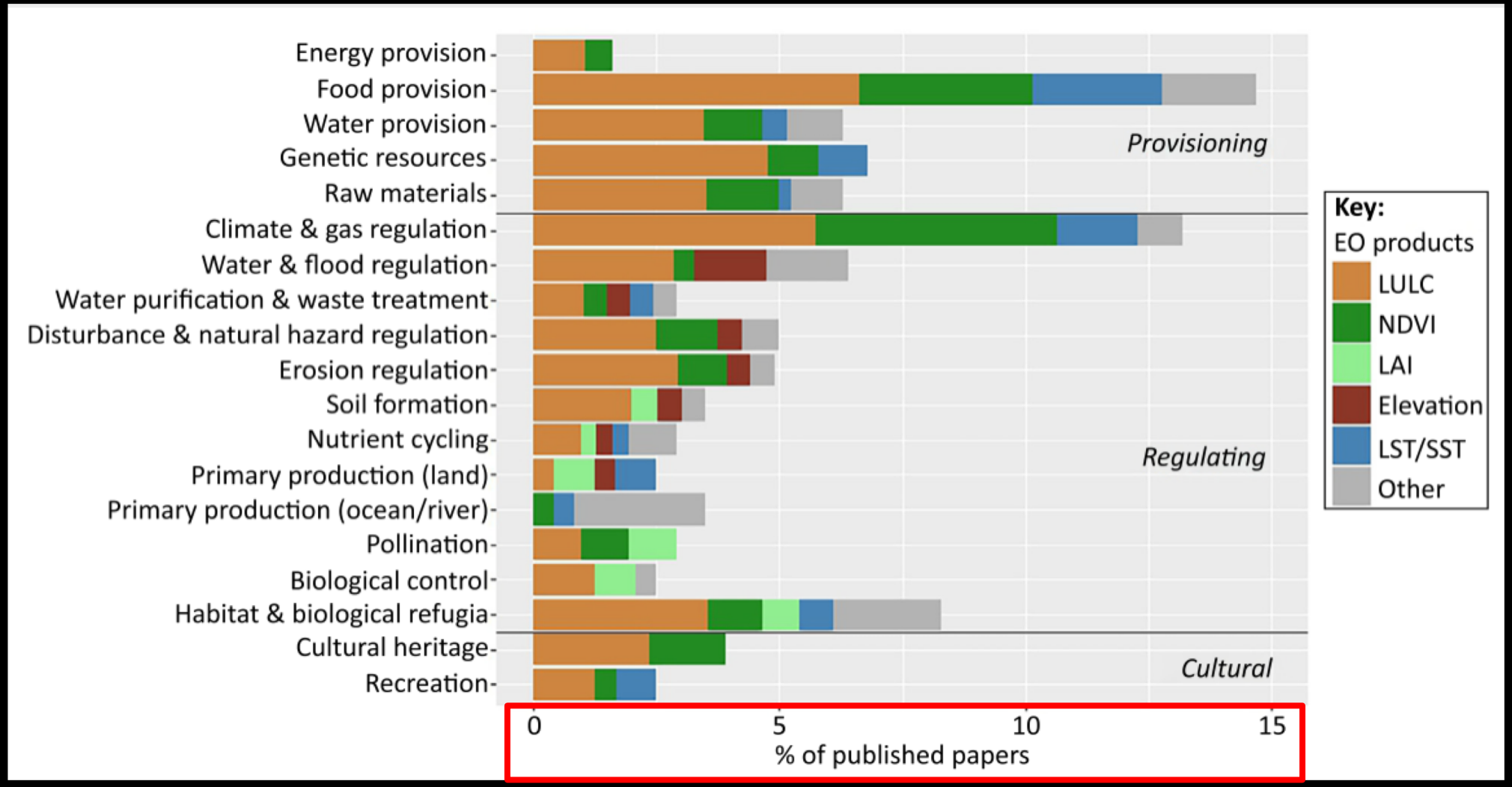

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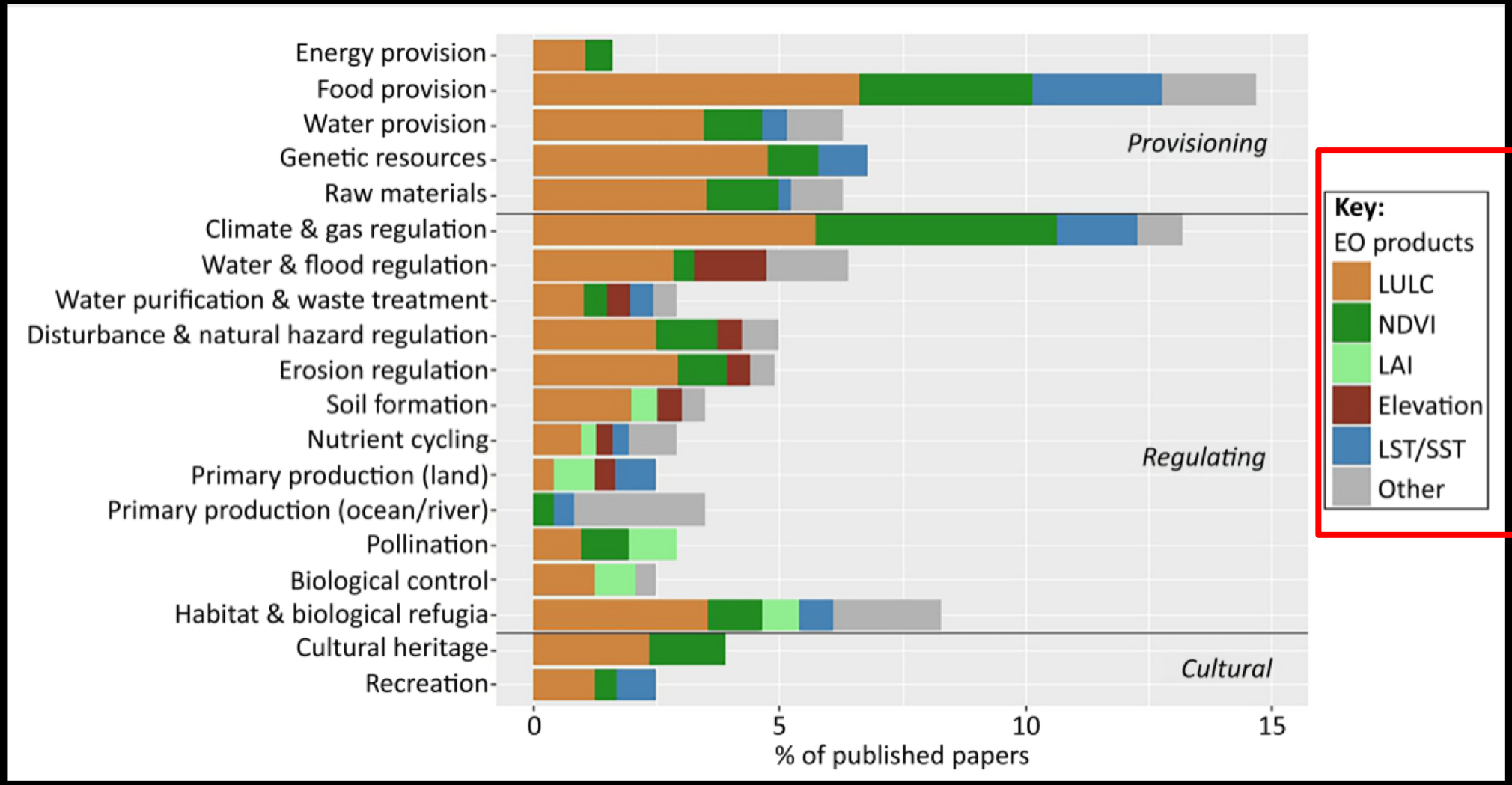

Cord et al. 2017 (based on de Araujo Barbosa 2015)

EO & ES integration is still not happening

Why?

- W1: EO and ES Model development
- 20 ES & EO scientists
- 12 institutions
- Process of ES modelling and EO integration

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- 20 ES & EO scientists
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- Process of ES modelling and EO integration

- W2: Sharing ideas and needs with practitioners
- 40 ES & EO scientist and practitioners
- 25 institutions
- Feedback from practitioners and identify solutions

Preliminary Results : 4 types of challenges

Types of challenges

1- Practical challenges

Types of challenges

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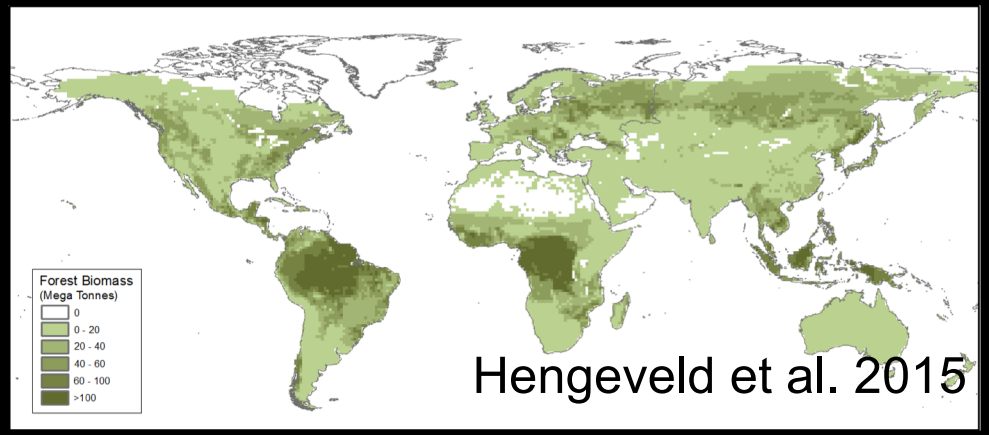

Hengeveld et al. 2015

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Types of challenges

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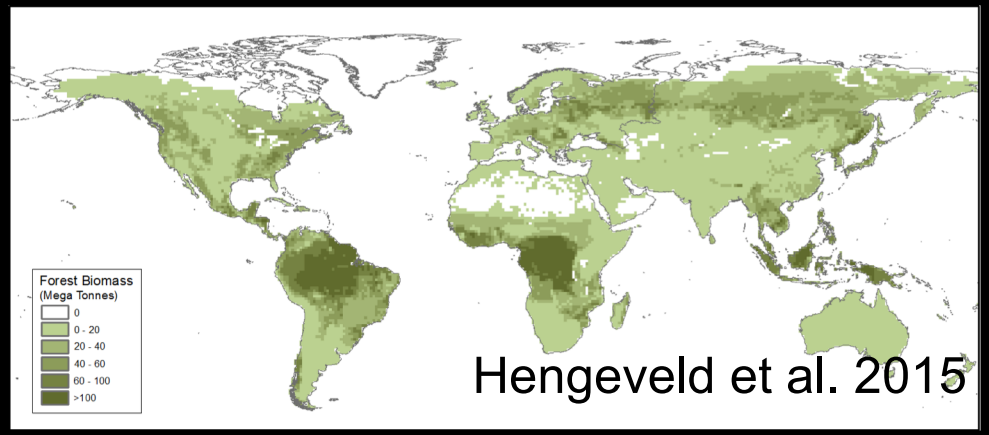

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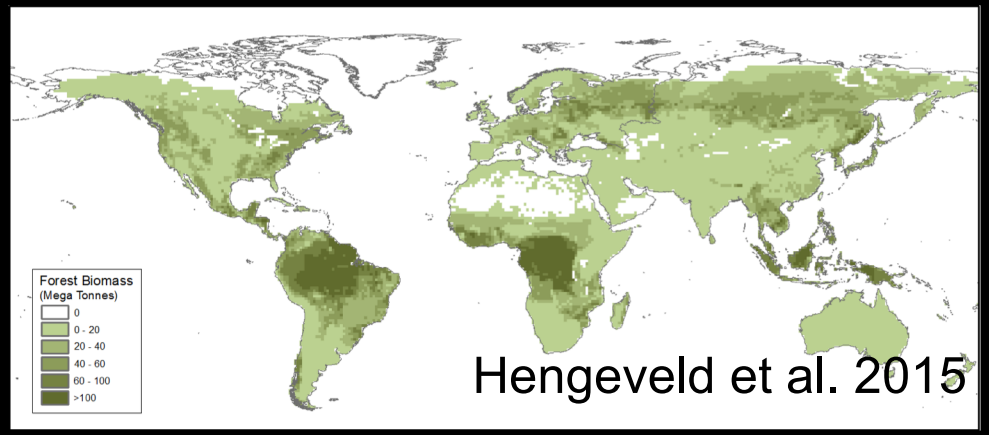

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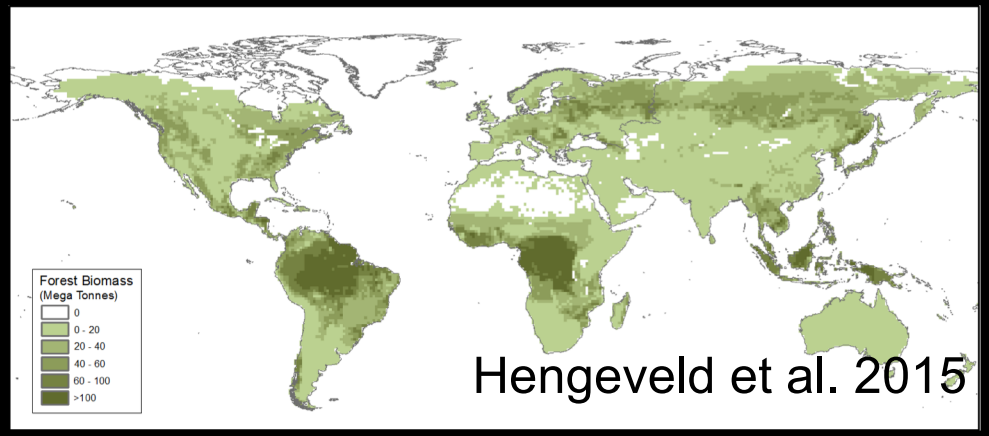

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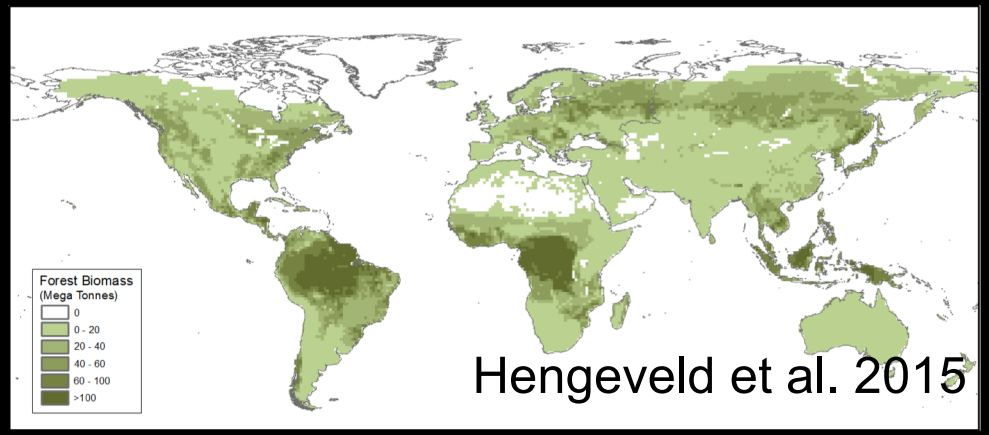

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- ES modelers don't know how to **ingest ES** into their models. **EO data is big** and complicated and **hard to compute**
- People don't understand **how to interpret EO** products

Types of challenges

2- Data and model adjustments

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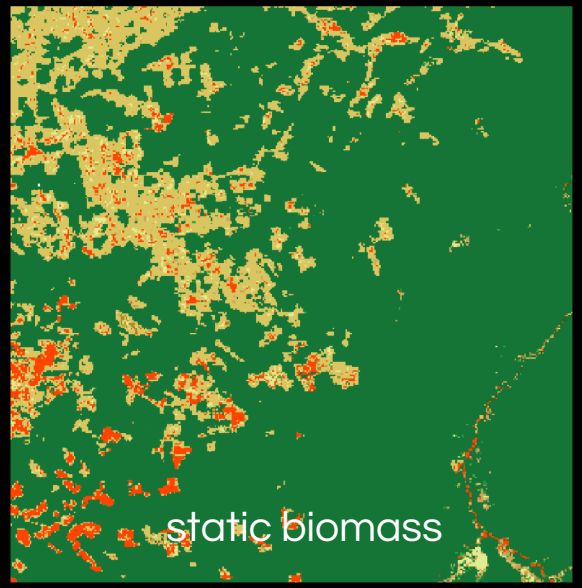
- EO tells us what IS, ES models compare what is to what could be (**need to be responsive to scenarios**)



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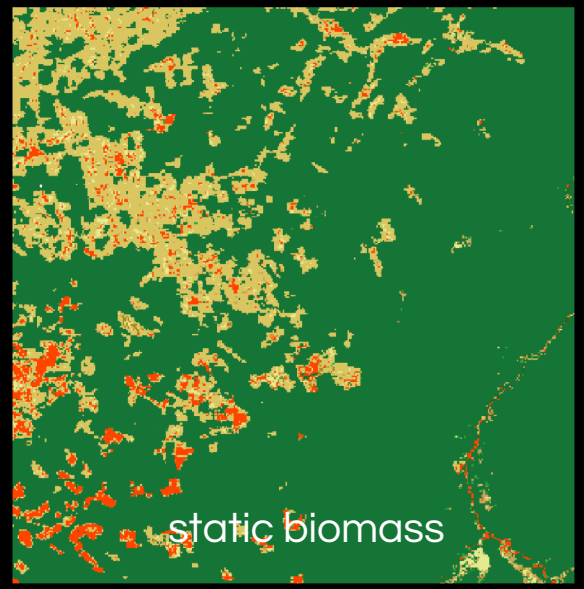

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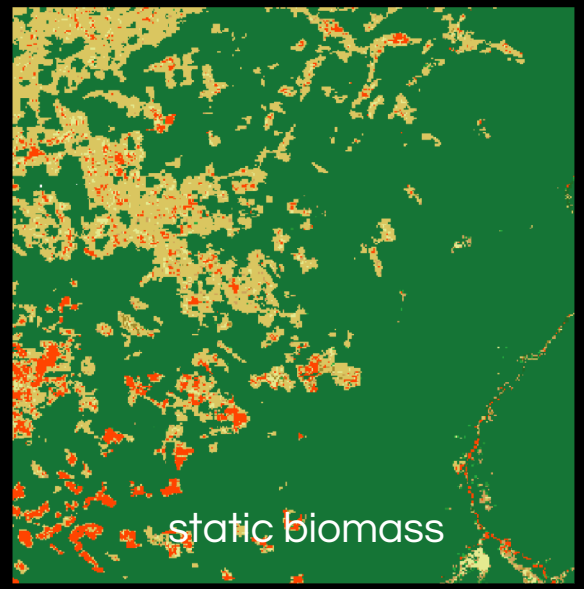

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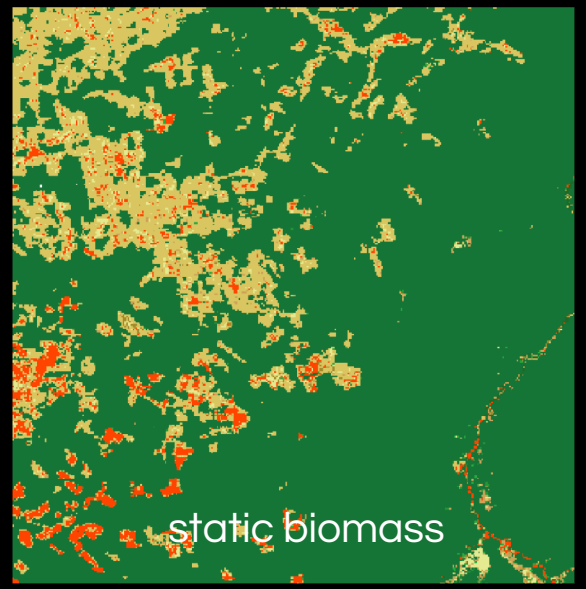
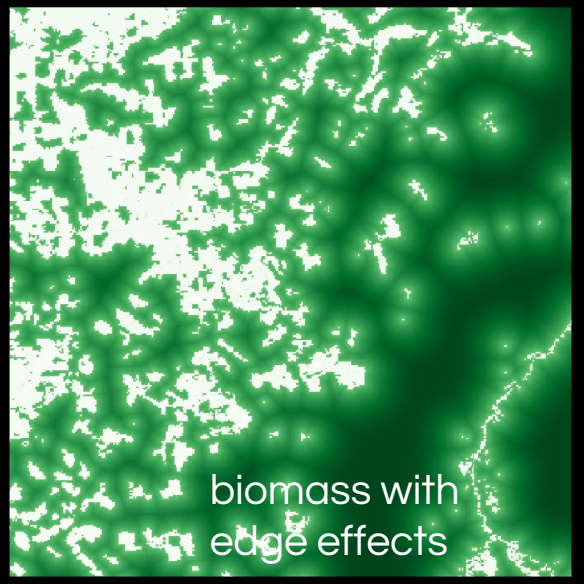
- EO tells us what's on the landscape but not **how people are choosing and using** ES benefits
- Most ES models **use categorical LULC data**; ES processes depend on ecosystem condition, not just type





Chaplin-Kramer 2018

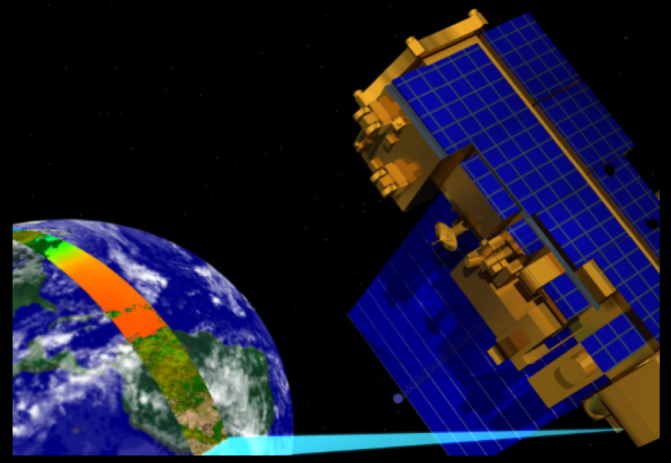
Types of challenges

3- New models

Types of challenges

3- New models

- Now we use LULC and production functions to model ES; could use existing or potential EO products to **directly measure ES supply or demand**



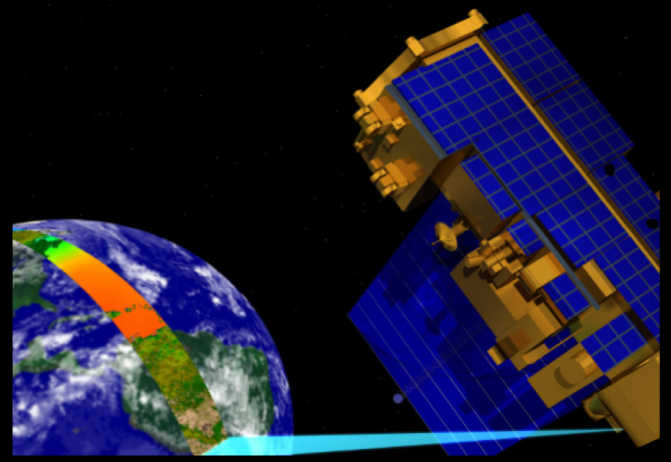
Example: ES - Climate mitigation

Carbon storage model -> Carbon Cycles

Types of challenges

3- New models

- Now we use LULC and production functions to model ES; could use existing or potential EO products to **directly measure ES supply or demand**
- Many ES models rely on LULC proxies; could measure/**create variable of interest directly**



Types of challenges

4- Testing assumptions

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Types of challenges

4- Testing assumptions

- ES models assume that when people and ES production are both present, **ES provides benefit**
- Scenario assessments assume that a management action will have an intended ecosystem consequence; EO provides an opportunity to test **how ES changes in response** over time
- ES model outputs are seldom calibrated; EO can be used for **calibration**

Summary

- 4 Distinct TYPES of challenges to EO-ES integration
  - Practical challenges
  - Data and model adjustments
  - New models
  - Testing assumptions

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- Each type of challenge must be addressed by different KINDS of solutions

- **Collaborative ES-EO networks** - need interdisciplinary groups to address challenges holistically

Next steps

- 3rd workshop
  - Use case examples of EO-ES integration
    - test framework and provide guidance
- Getting additional feedback and recommendations to NASA
- Disseminate results
  - -Peer review paper
  - -White paper

Acknowledgments

- Our workshop participants
- NASA

cramirez@umn.edu

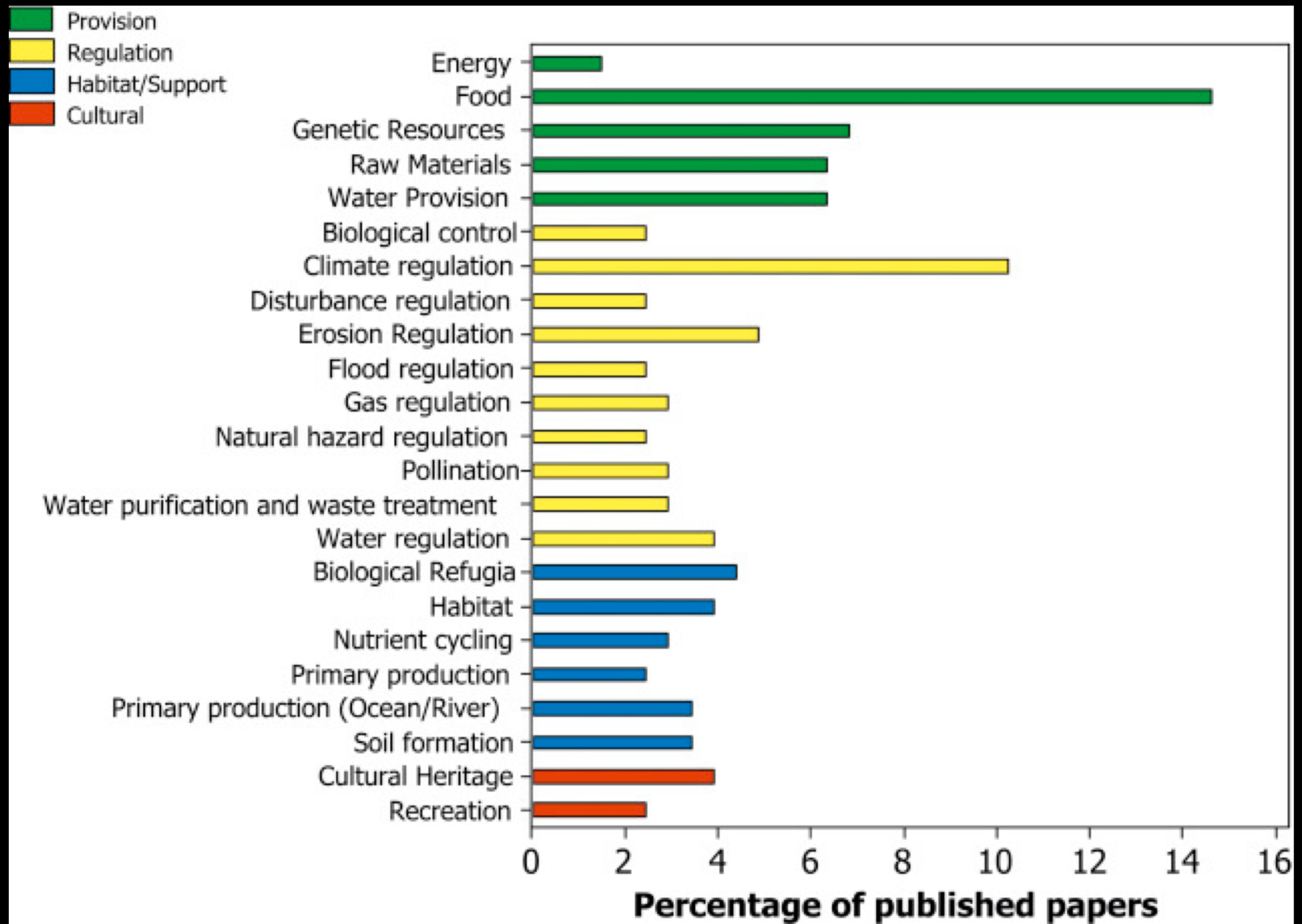
List of ES products

EO products available for different ES (Pettorelli et al., 2017)

Table 3. Non-exhaustive list of freely available, global satellite remote sensing data products that open opportunities for the dynamic monitoring of ecosystem functions.

Function	Indicator	Proxy	Satellite (sensor)	SRS data product	Examples
Gas regulation	Gas concentrations	Total ozone burden	Terra/Aqua (MODIS)	MODIS Atmospheric Profile product	Spichtinger et al. (2001) used GOME-derived nitrogen oxide concentration to map emissions from boreal forest fires.
			Nimbus-7/Meteor-3/Earth Probe	Total Ozone Mapping Spectrometer (TOMS) (1978-2006)	
			Sentinel-5P (TROPOMI)	O_3 tropospheric profile	
		Total methane burden	Aqua (AIRS)	Methane product	Ribeiro et al. (2016) used the Aqua (AIRS) Methane product to link methane concentrations over the Amazon to wetness and biomass burning.
	Emissions of gases by ecosystems	Air-sea CO_2 flux	Multiple, including POES (AVHRR), Terra/Aqua (MODIS), TRMM (CERES)	NOAA AOML Surface CO_2 Flux maps (1982–2009)	
Climate regulation	Temperature regulation	Land and sea surface temperature	Terra/Aqua (MODIS)	MODIS Land Surface Temperature and Emissivity	Jin and Dickinson (2010) used Terra (MODIS) data to derive land skin temperature and investigate its relationship with local surface albedo and vegetation, among other parameters.
			Terra/Aqua (MODIS)	MODIS Sea Surface Temperature	
			POES (AVHRR)	NOAA Coral Reef Watch Sea Surface Temperature	
			Sentinel 3 (SLSTR)	Ocean/Sea Surface Temperature Land Surface Temperature	
	Precipitation regulation	Rainfall	TRMM (PR, TMI, VIRS, CERES)	TRMM precipitation estimates (1998–2015)	
			TRMM (PR, TMI, VIRS, CERES)	CHIRPS	
			TRMM (PR, TMI, VIRS, CERES)	GPCP	

EO is mostly used to asses provision services



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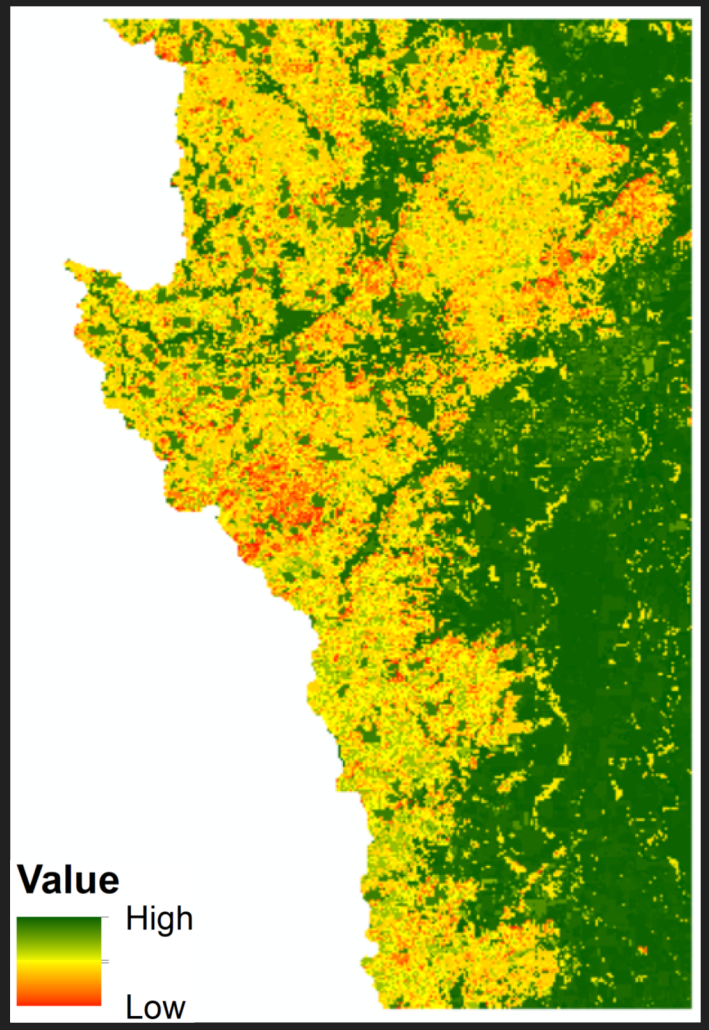
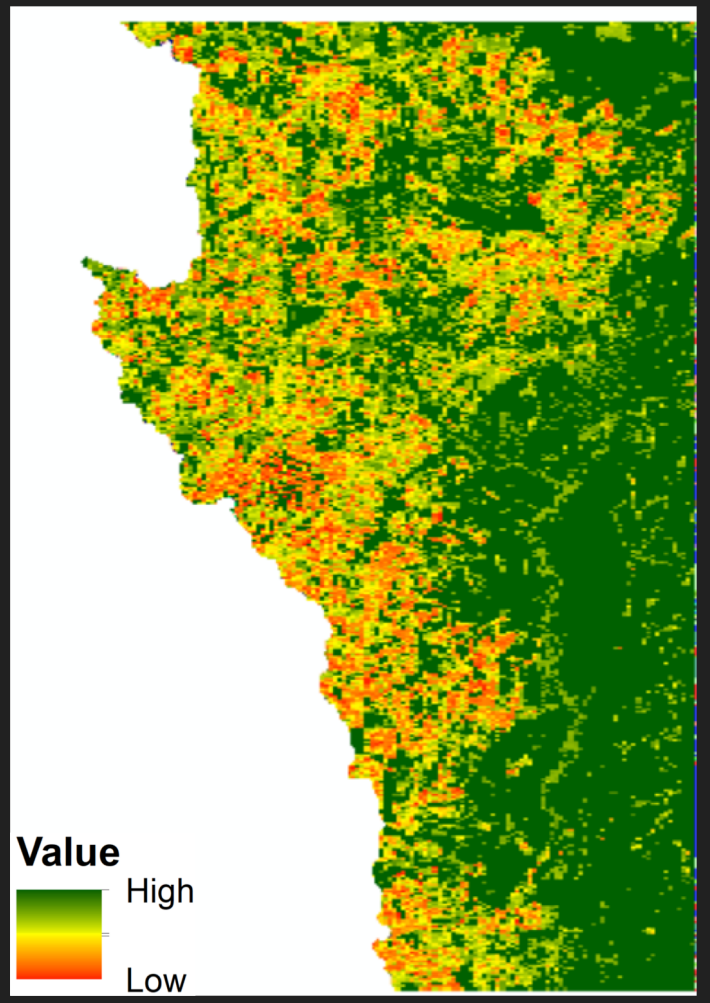
InVEST LULC-derived biomass

USGS biomass map

-Depends on LULC

-C Averages ex-situ

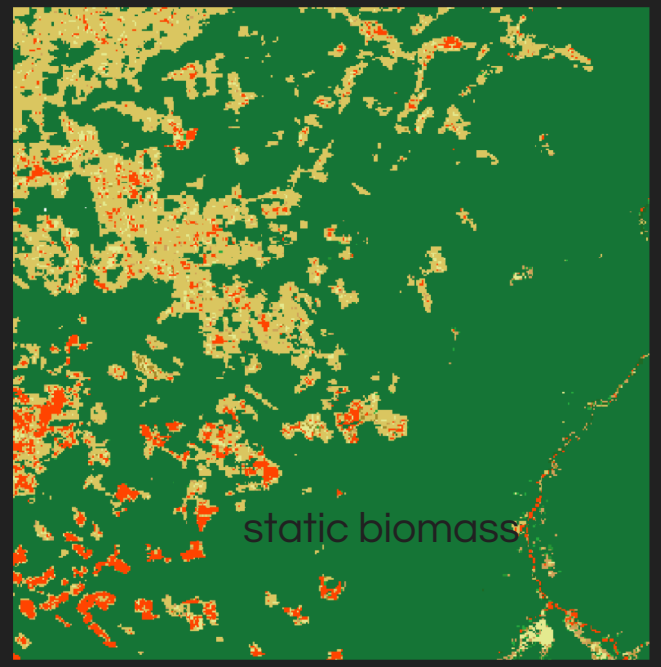


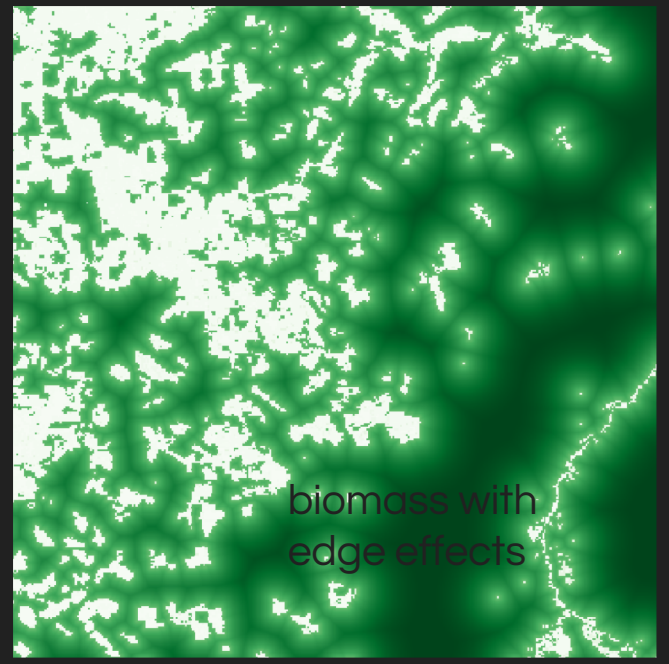


-Doesn’t depend on LULC

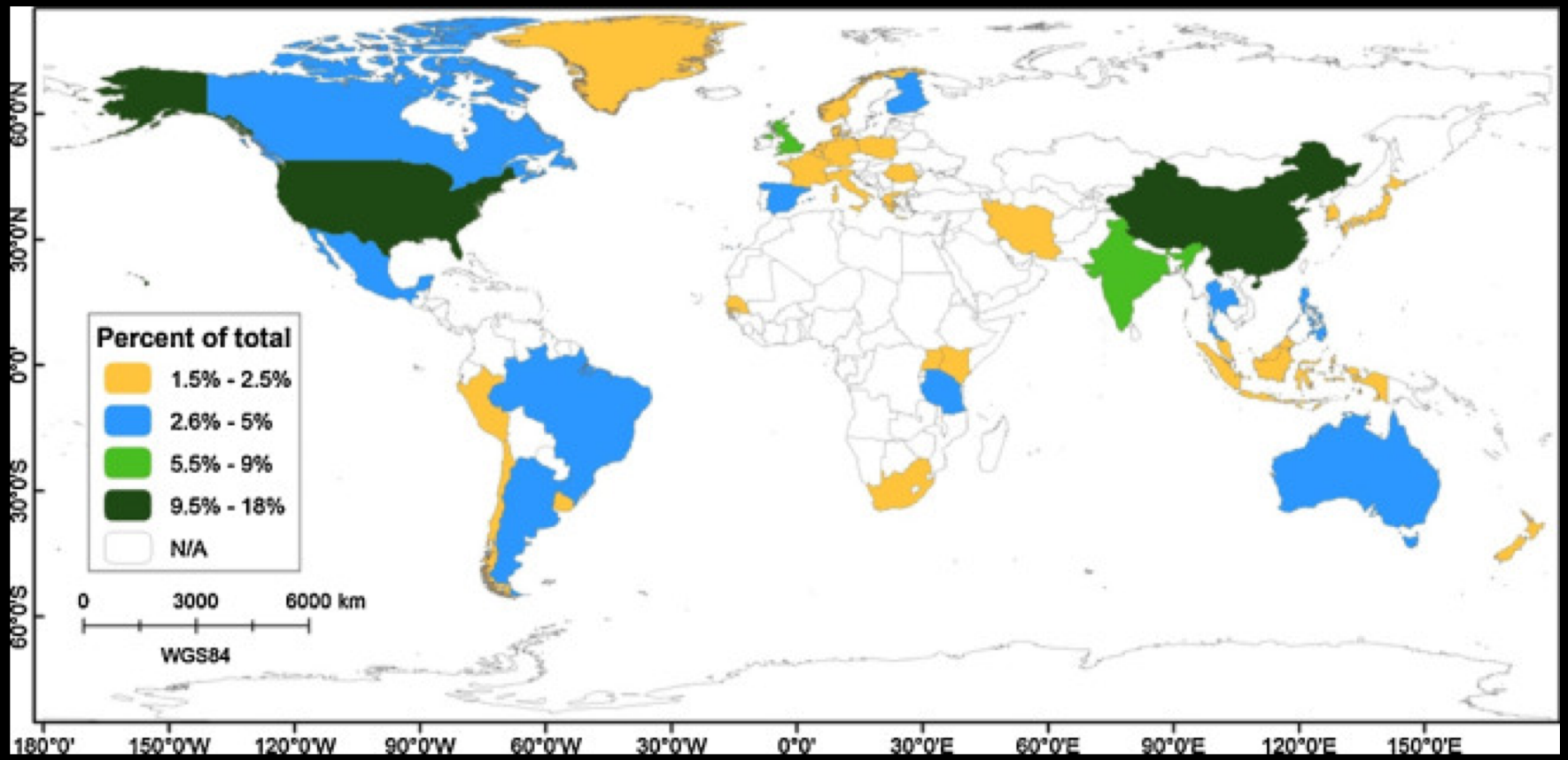
How is this used in decisions?

- Understanding impacts of forest fragmentation on remaining forest for sustainable development planning
- Sustainable supply chain commitments: no net deforestation does not mean no net carbon loss





The use of EO is limited and geographically constrained



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