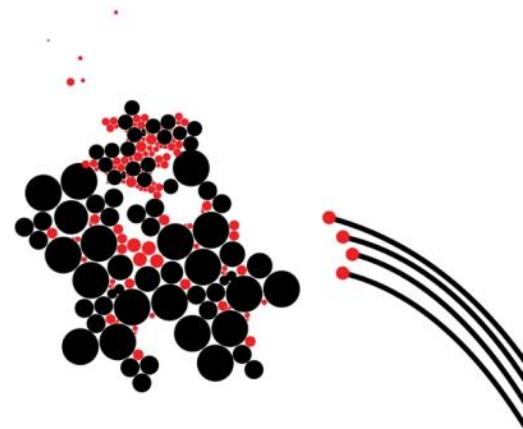


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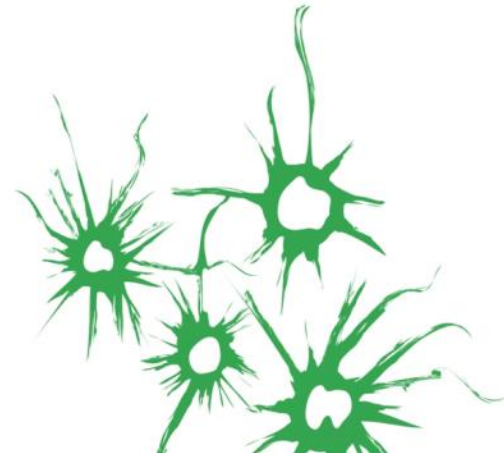
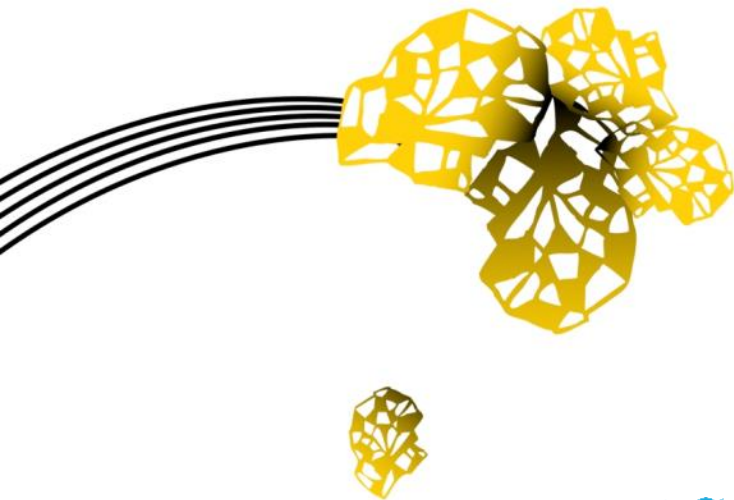
**IT'S ABOUT TIME:
ADVANCING SPATIAL ANALYSES OF ECOSYSTEM SERVICES FOR
INTEGRATED LANDSCAPE MANAGEMENT**

PROF LOUISE (WIETEKE) WILLEMEN

SPATIAL DYNAMICS OF ECOSYSTEM SERVICES

FACULTY GEO-INFORMATION SCIENCE AND EARTH OBSERVATION

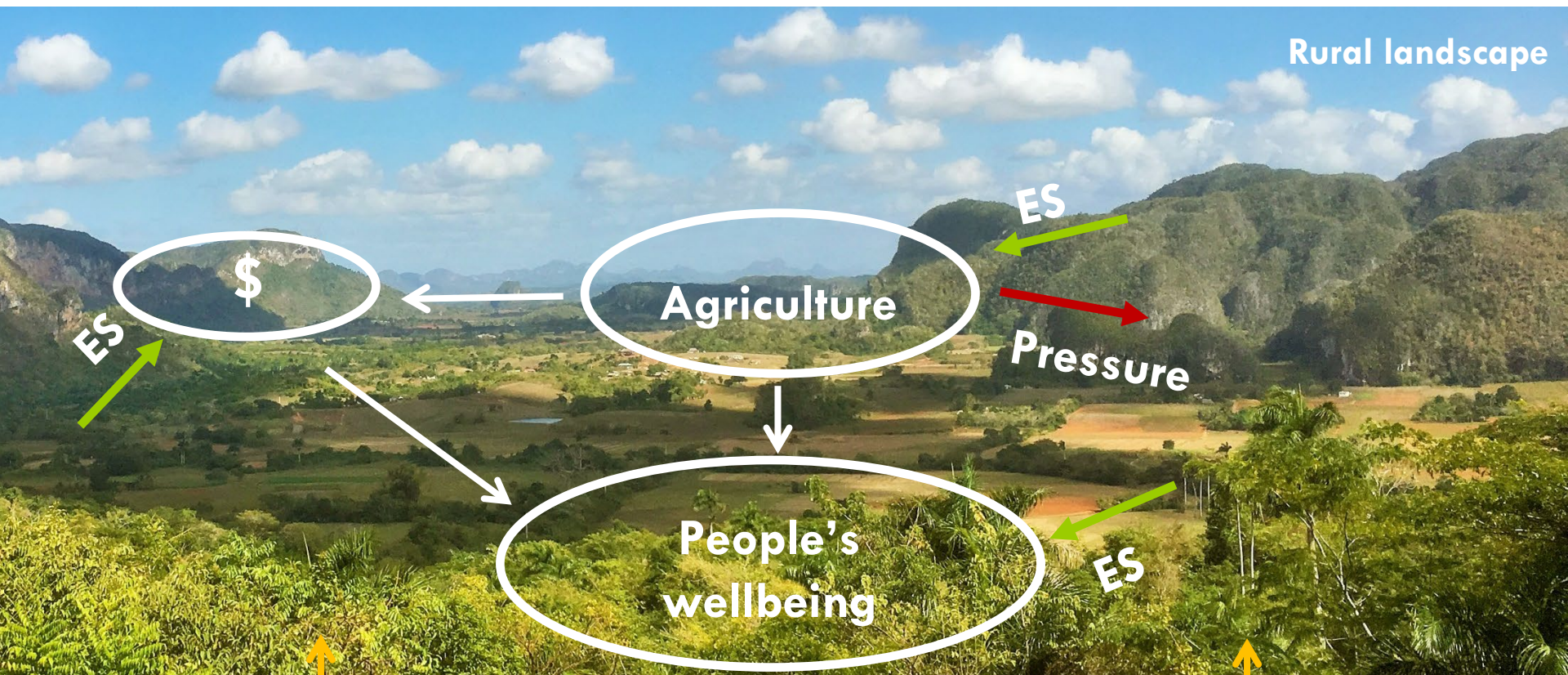
UNIVERSITY OF TWENTE, NETHERLANDS



 @wietekewillemen

CHANGING LANDSCAPES

- People and nature: continuous interaction
- Landscape approaches: influence interaction
- Ecosystem services (ES): linking people's wellbeing to nature



**Integrated management decisions
(restoration, low-impact farming, markets)**

MAPS FOR...

Assessments



Implementation



Planning



USEFUL MAP



- User-relevant
- Robust
- Transparent

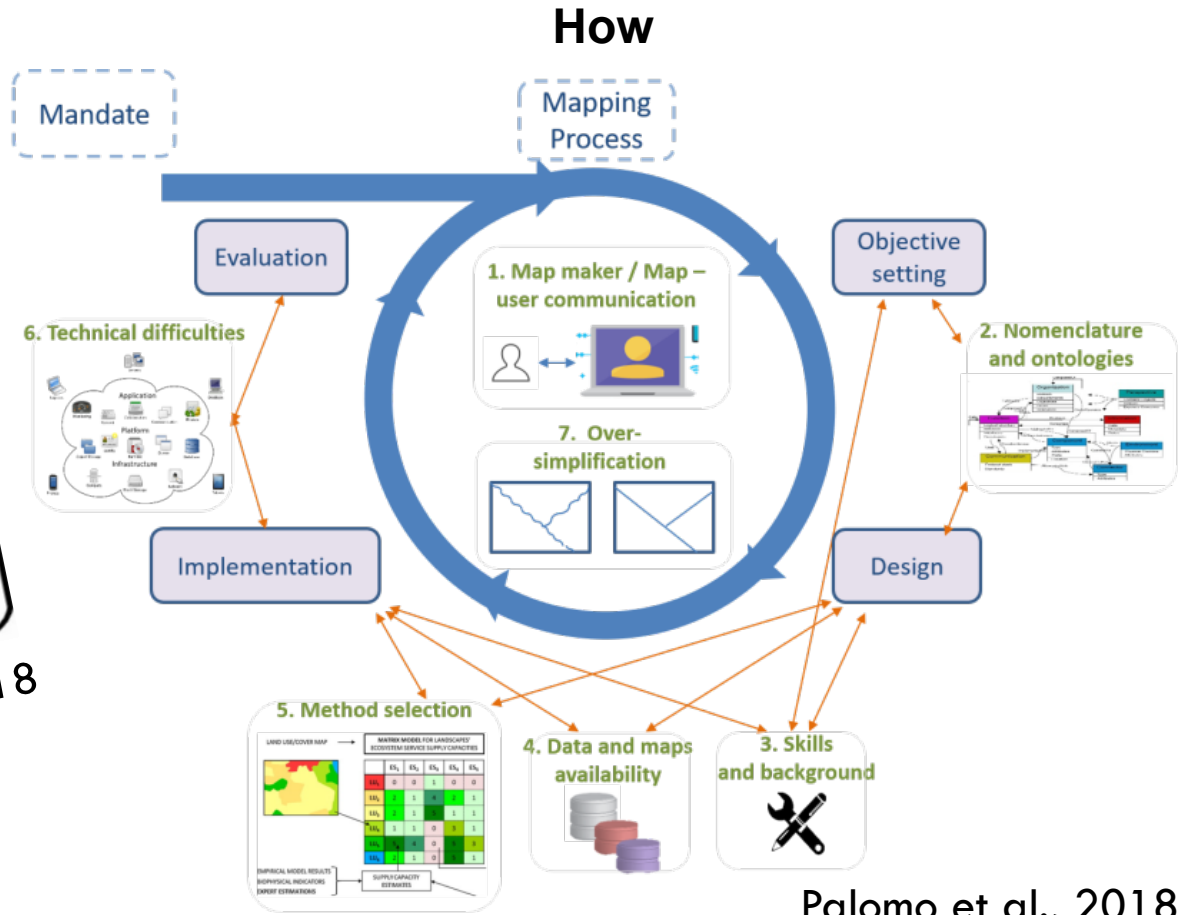
What

	Yes	No
The indicators' scientific validity and implementation in reliable decision-making contexts have been backed up by data or documented evidence.	<input type="checkbox"/>	<input type="checkbox"/>
The value of the indicator will change if the issue of concern to decision makers changes.	<input type="checkbox"/>	<input type="checkbox"/>
The indicators have been assessed and co-selected by relevant scientists, experts and decision makers in a transparent review process.	<input type="checkbox"/>	<input type="checkbox"/>
The needs and perspectives of decision makers and relevant stakeholders have been incorporated in defining the purpose, context and type of outputs of the indicators.	<input type="checkbox"/>	<input type="checkbox"/>
The indicators allow for tracking progress towards achieving relevant policy goals or local visions.	<input type="checkbox"/>	<input type="checkbox"/>
The understandability of the ES indicator has been tested with relevant actors, ensuring communicability and potential awareness raising.	<input type="checkbox"/>	<input type="checkbox"/>
The required data and information are available for assessing the indicator at an appropriate temporal and spatial scale and from recognized sources.	<input type="checkbox"/>	<input type="checkbox"/>
The required process of indicator quantification is affordable and feasible for the responsible institution, and it includes sufficiently frequent monitoring.	<input type="checkbox"/>	<input type="checkbox"/>
There is an implementation plan, including sufficient time and resources allocated, to develop the indicator, to evaluate it during its use, and to adapt the indicator when required.	<input type="checkbox"/>	<input type="checkbox"/>

van Oudenhoven et al., 2018



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Palomo et al., 2018

HOW
LONG
IS NOW



DIE TO * JES

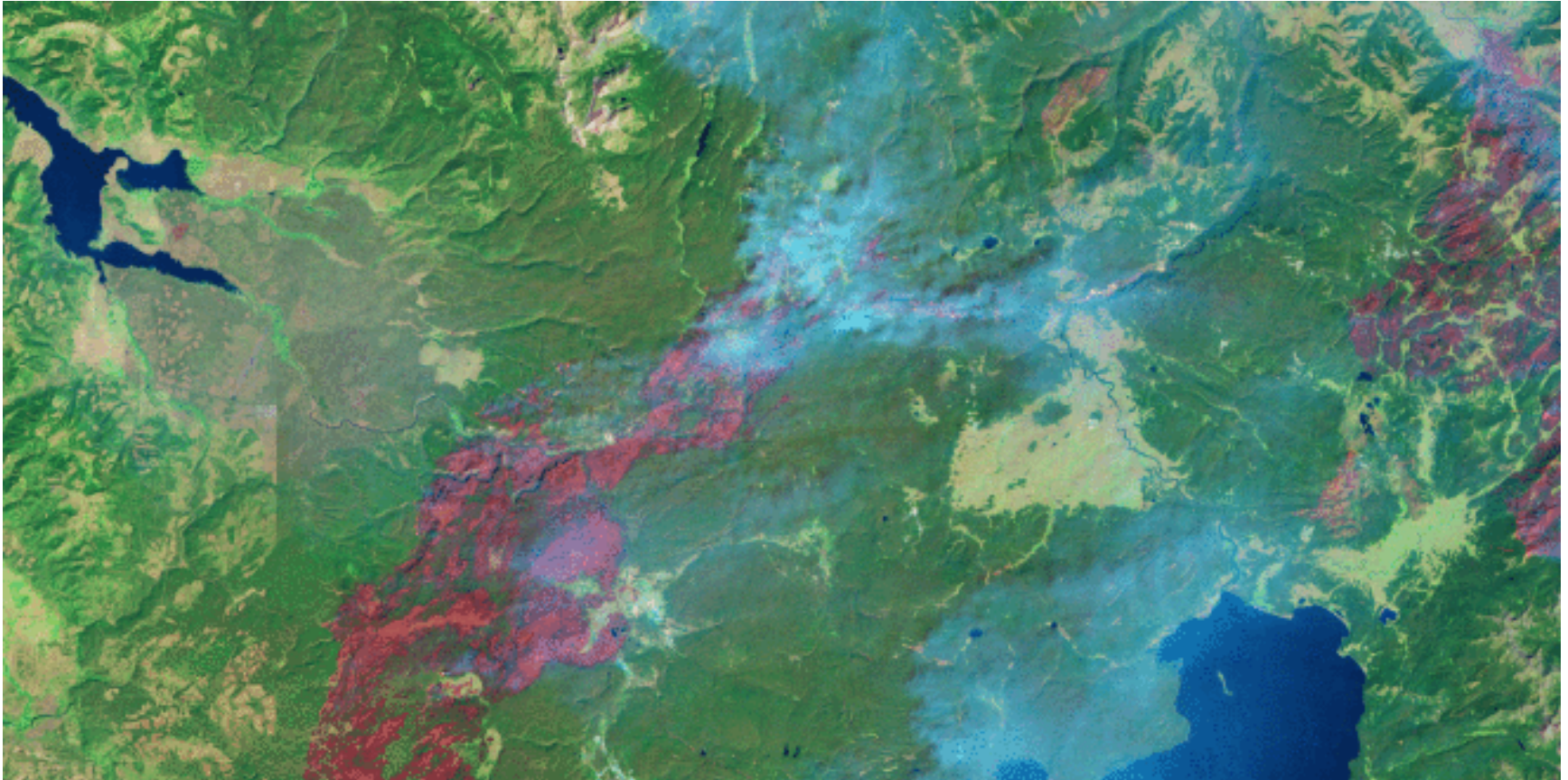


TODAY: TIME & TIMING



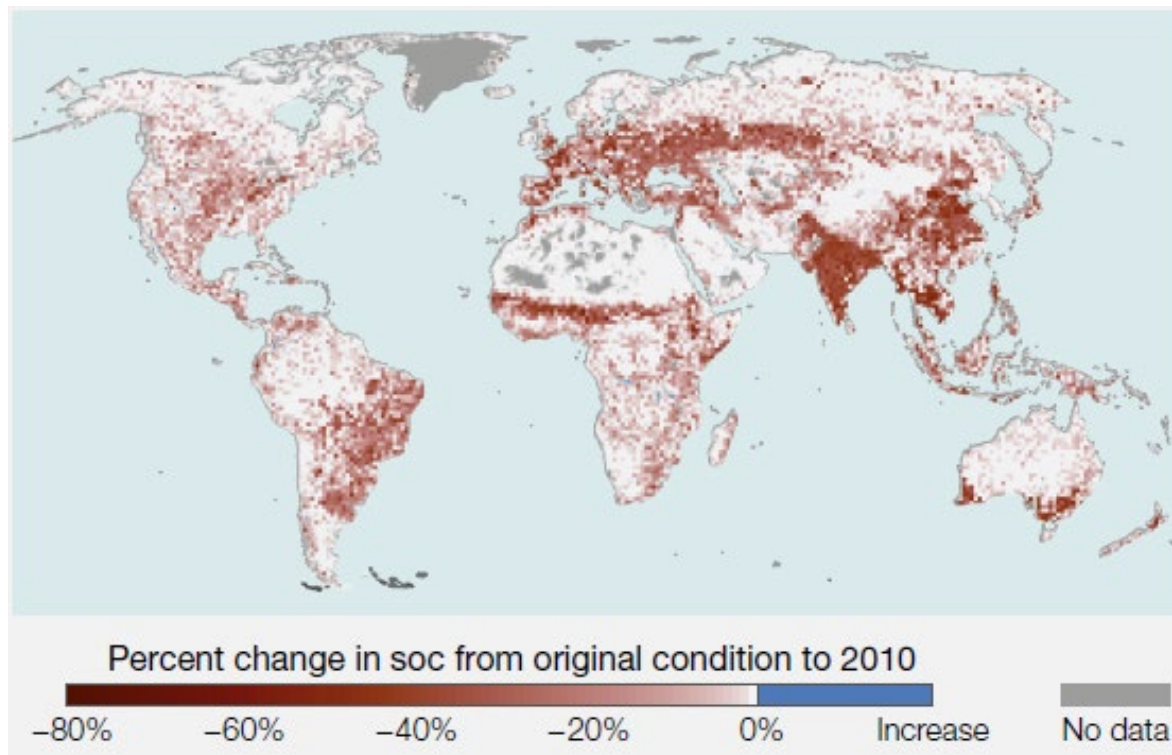
WHEN TIME MATTERS...

- **Trends** in ecosystem services
- **Impact** of area management



Land degradation & Restoration

A ~~percentage~~ loss of productivity, ecosystem services and biodiversity



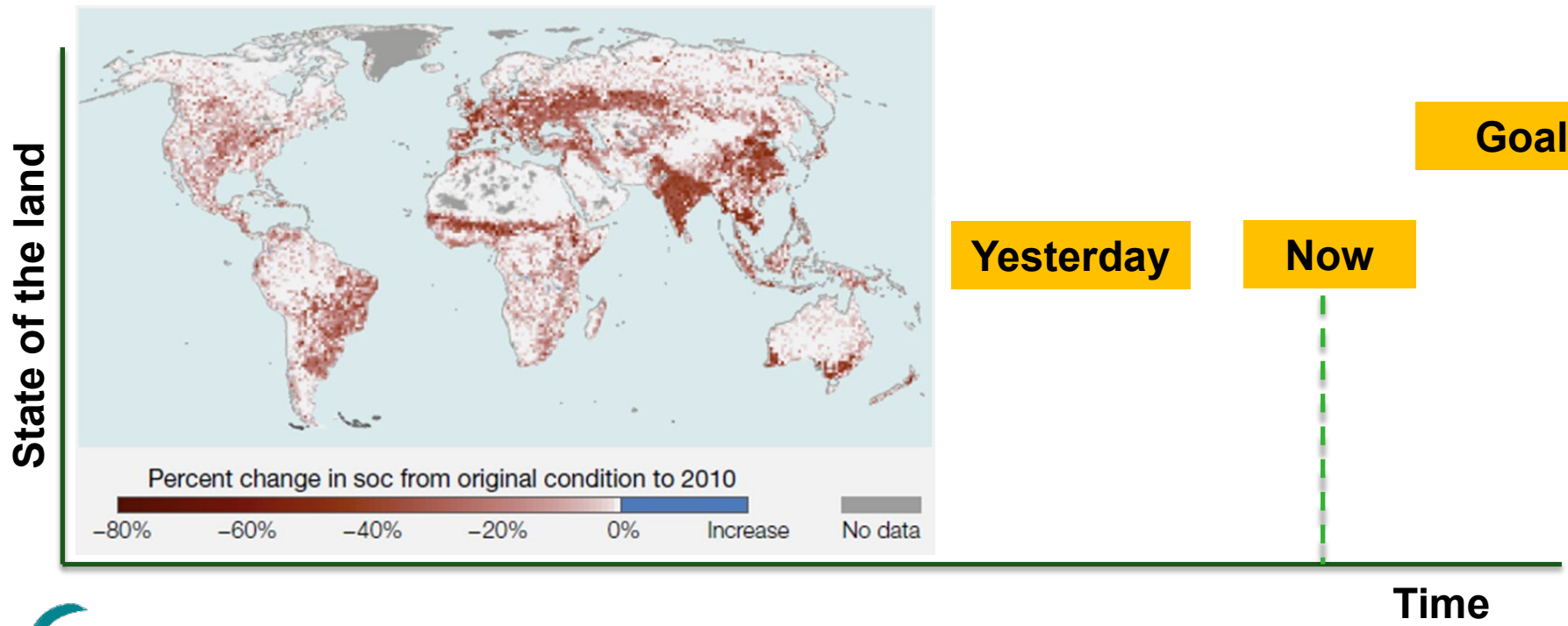
Source: IPBES, 2018

CAPTURE CHANGE

Loss of ecosystem services compared to?

Restore to?

Influence on perception,
policy and actions



➤ Information over time is key; make action-relevant comparisons

CAPTURING TIME

Observations to
keep track



CAPTURING TIME IN THE FIELD

People

Fact sheets and participatory mapping



Tech

Citizen science; cameras measures & counts



Small sensors

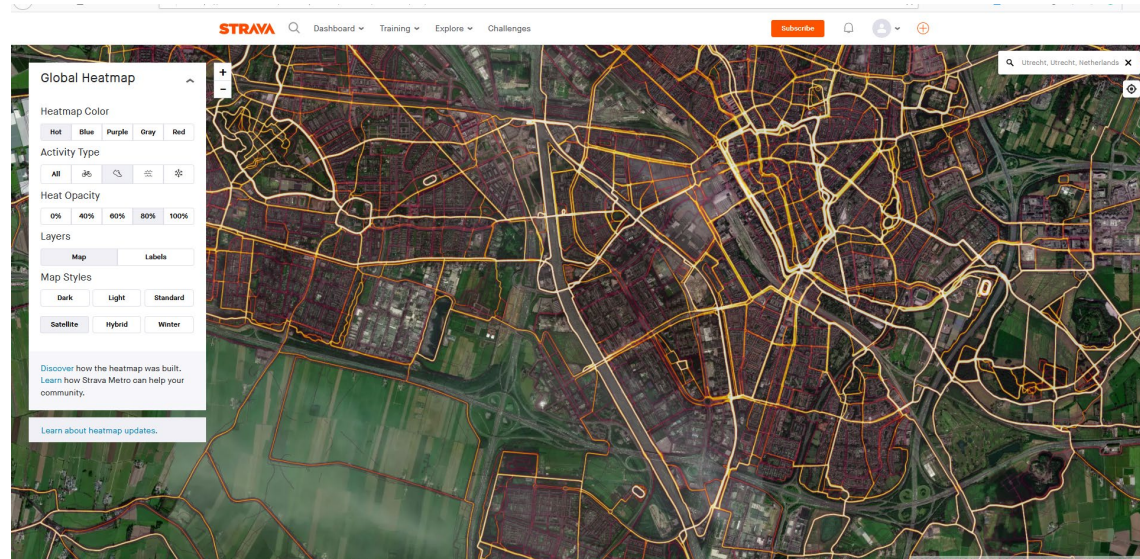
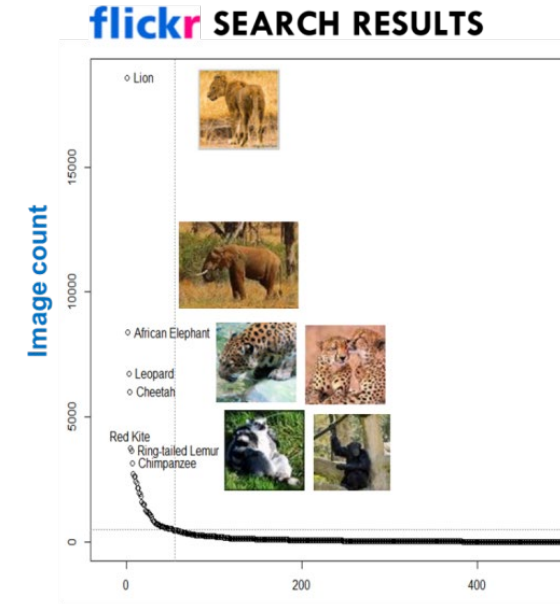
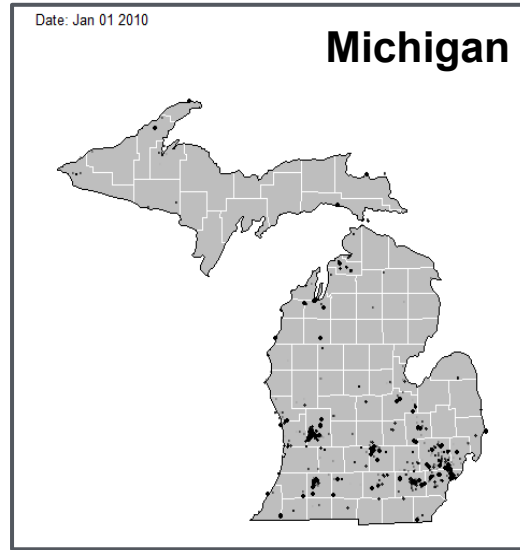


CAPTURING TIME THROUGH THE WEB

People

Social media:
preference & behaviour

Tech



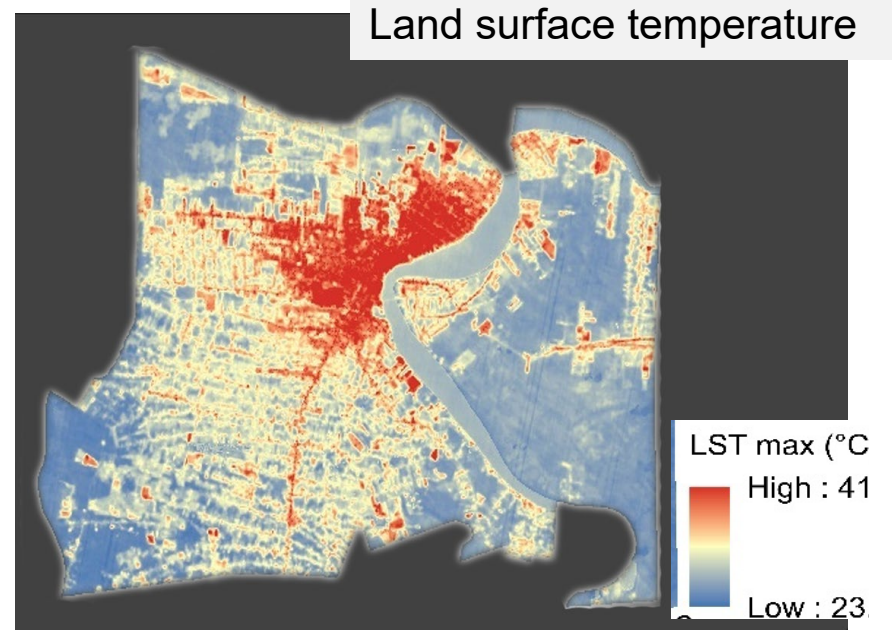
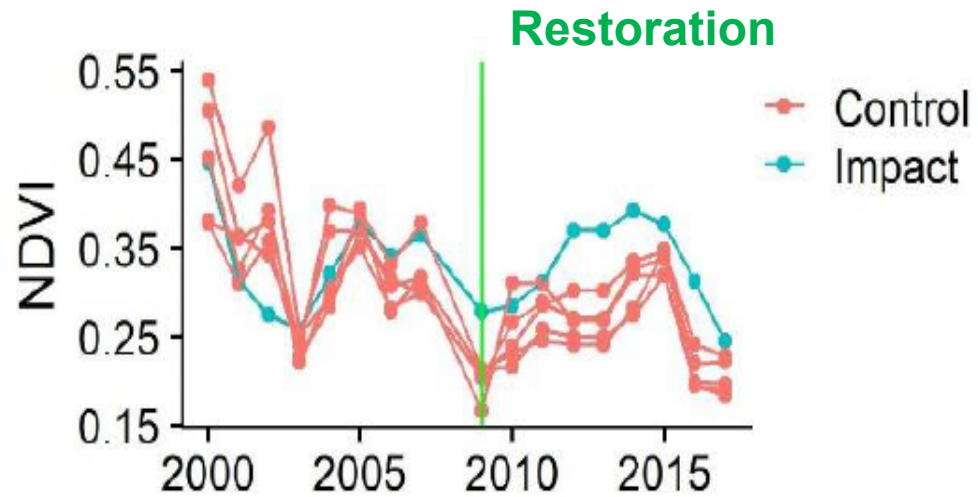
Sources: Van Berkel et al., Willemsen et al. 2015; www.strava.com/heatmap

CAPTURING TIME FROM SPACE

People

Tech

Remote sensing



Sources: Muchando. 2019; Romijn 2020

CAPTURING TIME: ECOSYSTEM SERVICE MONITORING

People-driven

Engaging
Holistic
Feasible?

Account for bias/error

Tech-driven

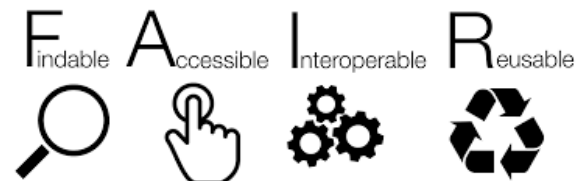
Objective
Precise
Skills?

Change or error?

t2



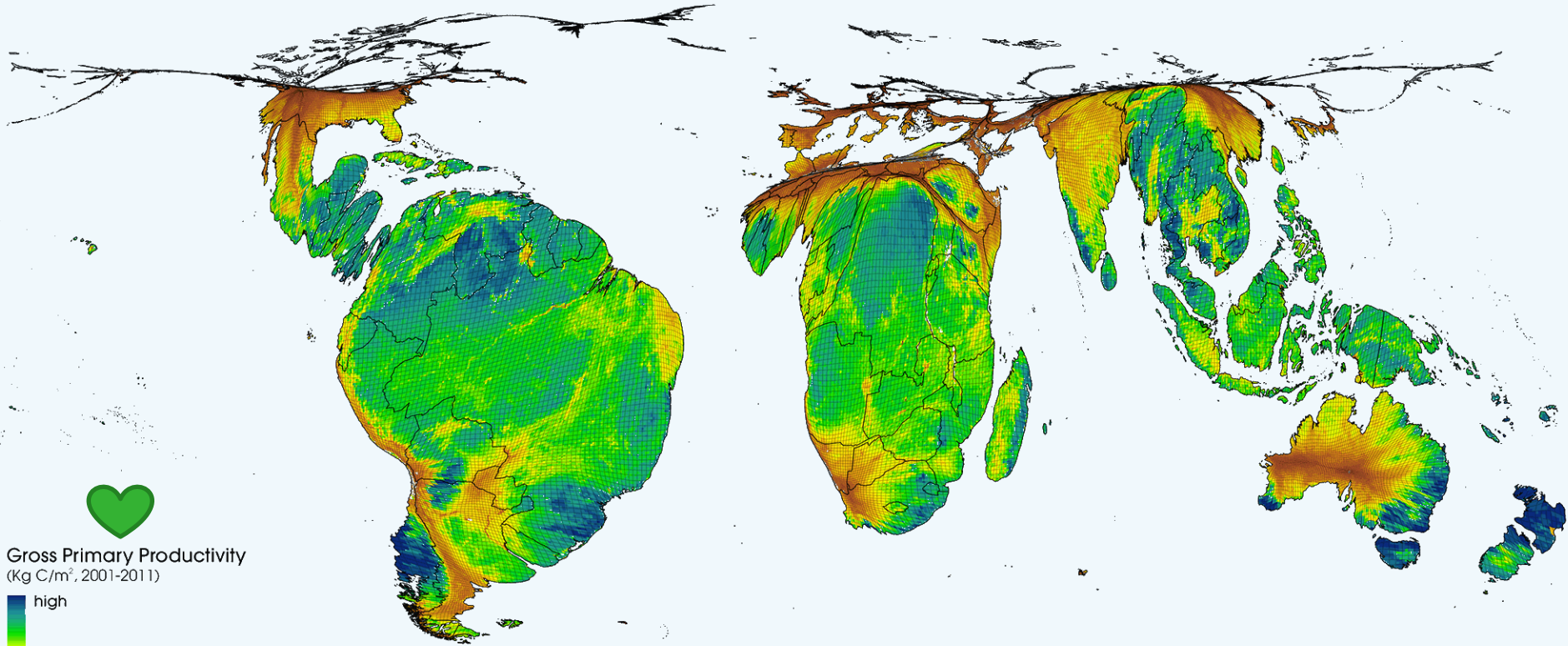
t1



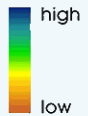
➤ FAIR spatial data allowing for comparison over time

TIMING

January



Gross Primary Productivity
(Kg C/m², 2001-2011)



Data source: MODIS GPP/NPP Project (MOD17)

WORLD
MAPPER
www.worldmapper.org

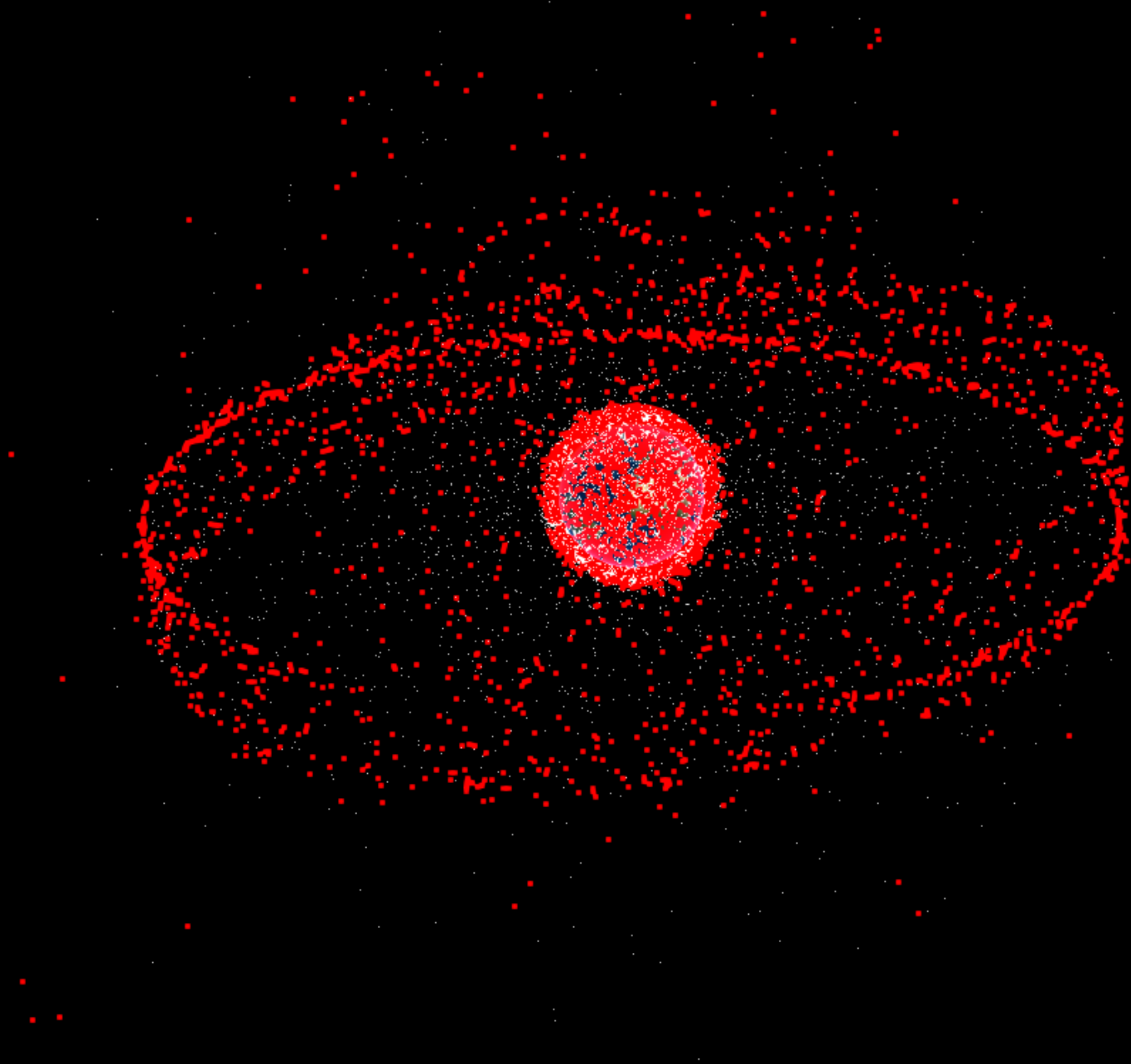


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Source: WorldMapper

CATCHING NATURE'S RHYTHM

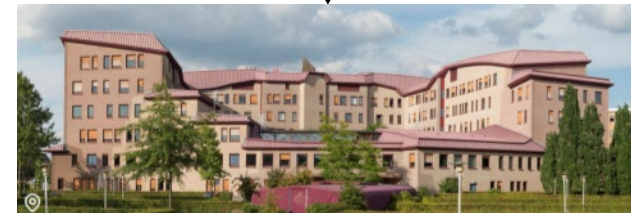
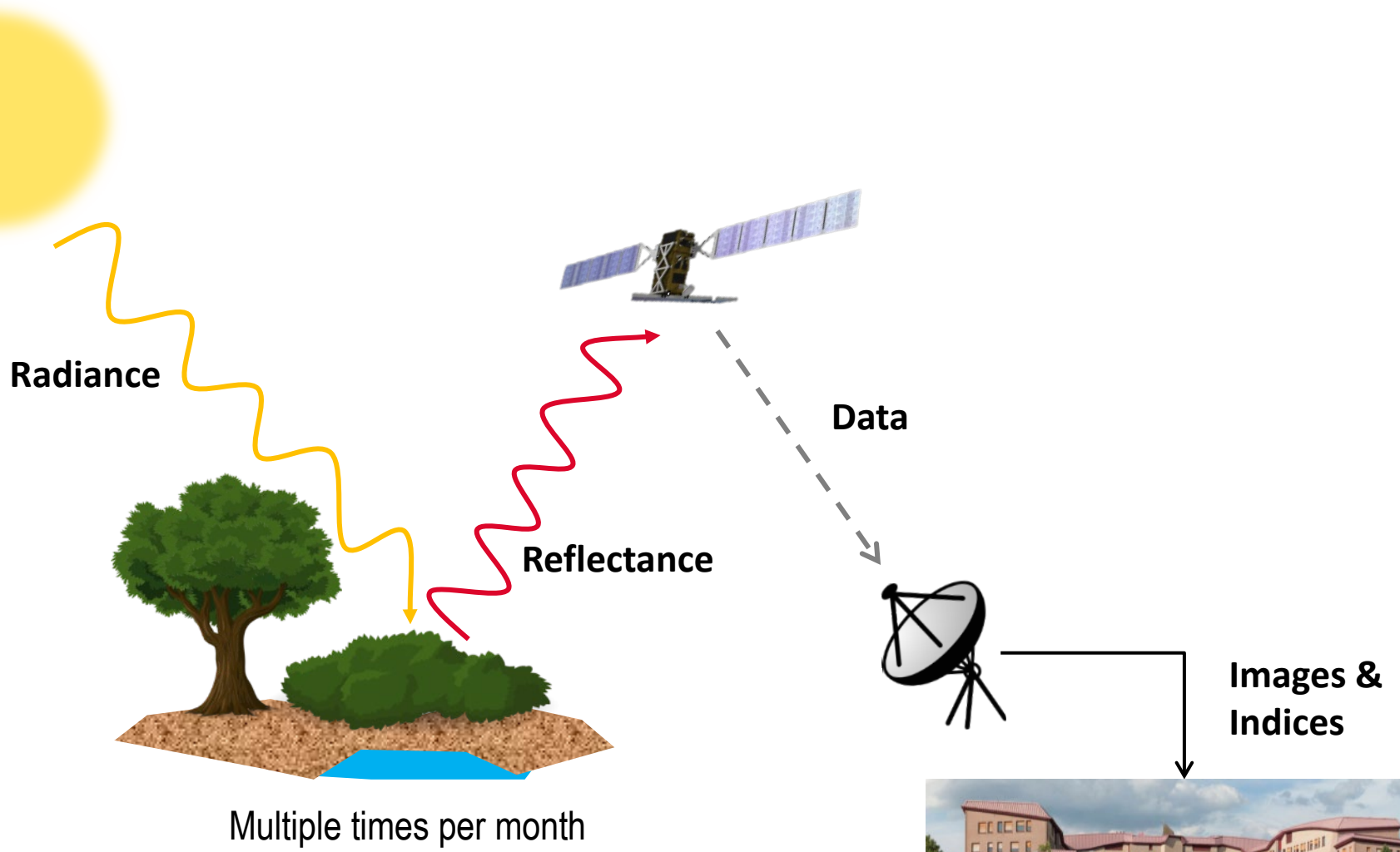




5,699 of 19,243 satellites found

<http://richiearmichael.github.io/sat/index.html>

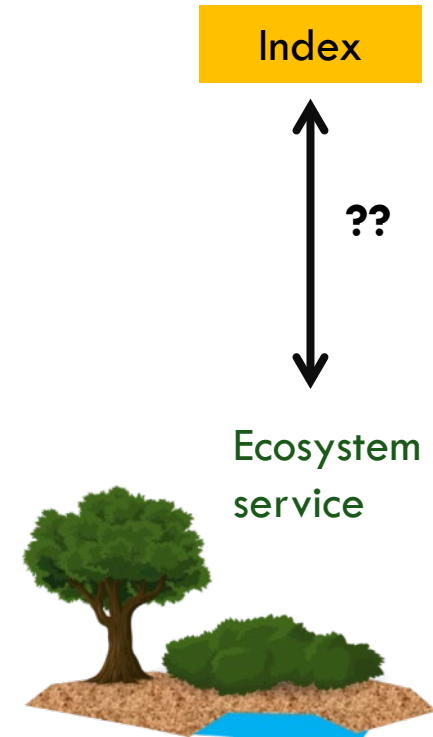
CATCHING NATURE'S RHYTHM



REMOTE SENSING INDICES FOR ECOSYSTEM SERVICES

- **NDVI 'greenness'**
- **Land cover** Most often used
- **Leaf Area Index**
- Land/sea surface temperature
- Elevation
- Water
- Suspended solids
- CDOM index (Dissolved Organic Matter)

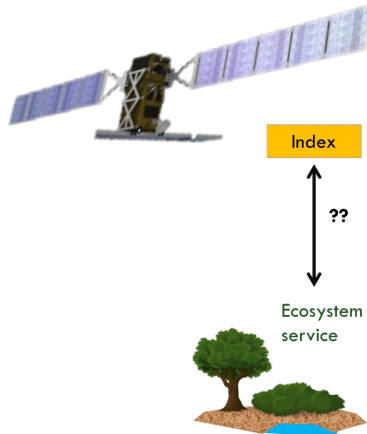
(De Araujo Barbosa 2015; Cord et al 2017; Ramirez-Reyes et al 2019)



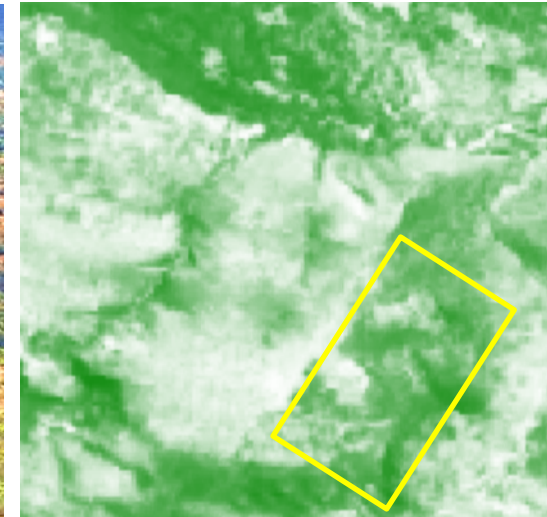
CALIBRATING ECOSYSTEM SERVICE SUPPLY



CAPTURING ECOSYSTEM SERVICES WITH REMOTE SENSING



Source: T Del Rio



Source: NDVI ESA Sentinel 2

Ecosystem services

Erosion control
Forage provision

=

Vegetation indices: NDVI, SAVI, MSAVI,

IRECI, NDVI₇₀₅, GNDVI, **NDVI₄₅**, MTCI

Water index: NDWI

Soil index: Brightness index (BI)

+

**Slope,
elevation,
access**

R²= 0.8

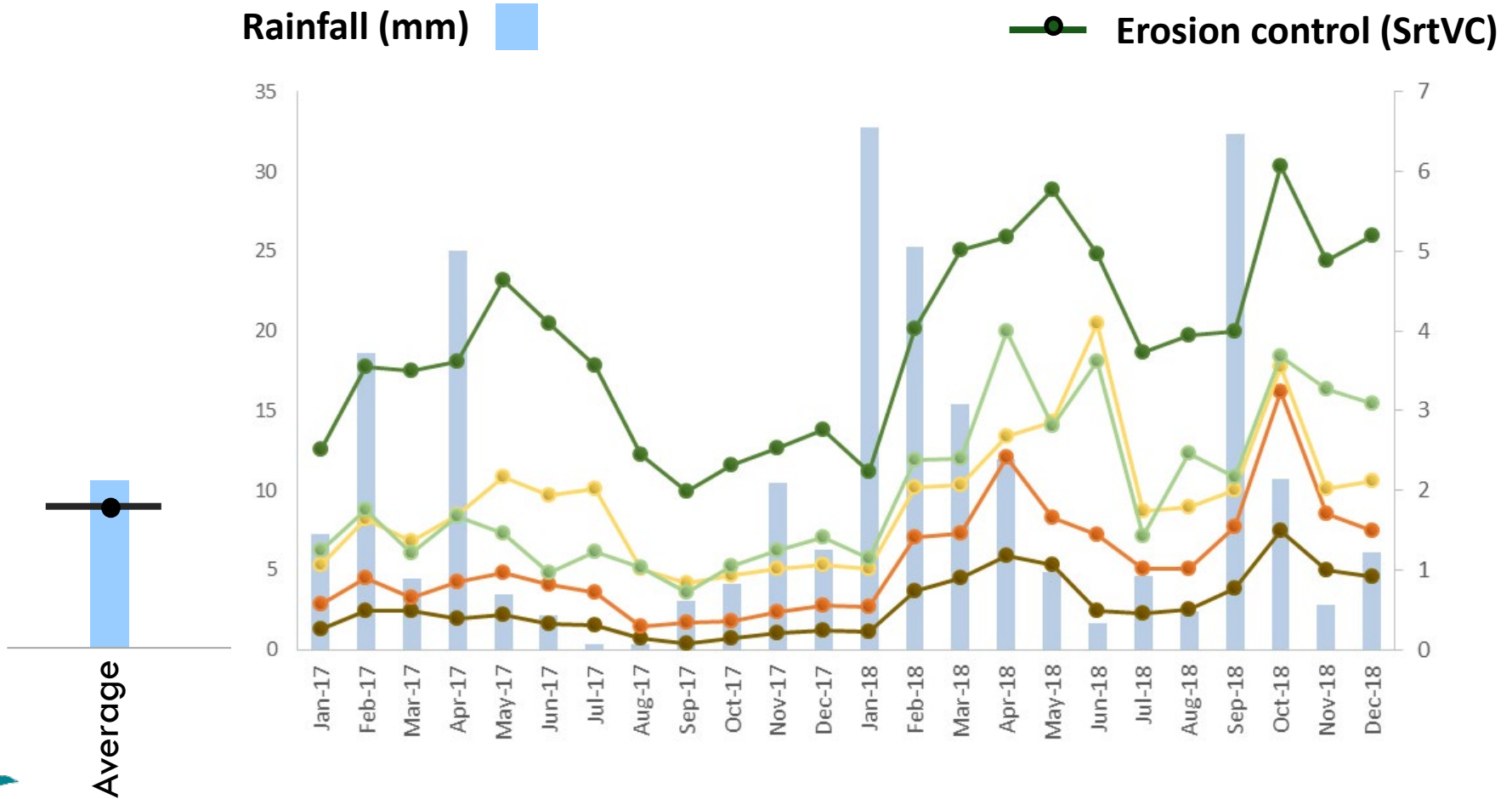
R²= 0.9

Linear regression fitting



➤ **Systematic testing of diverse RS indices**

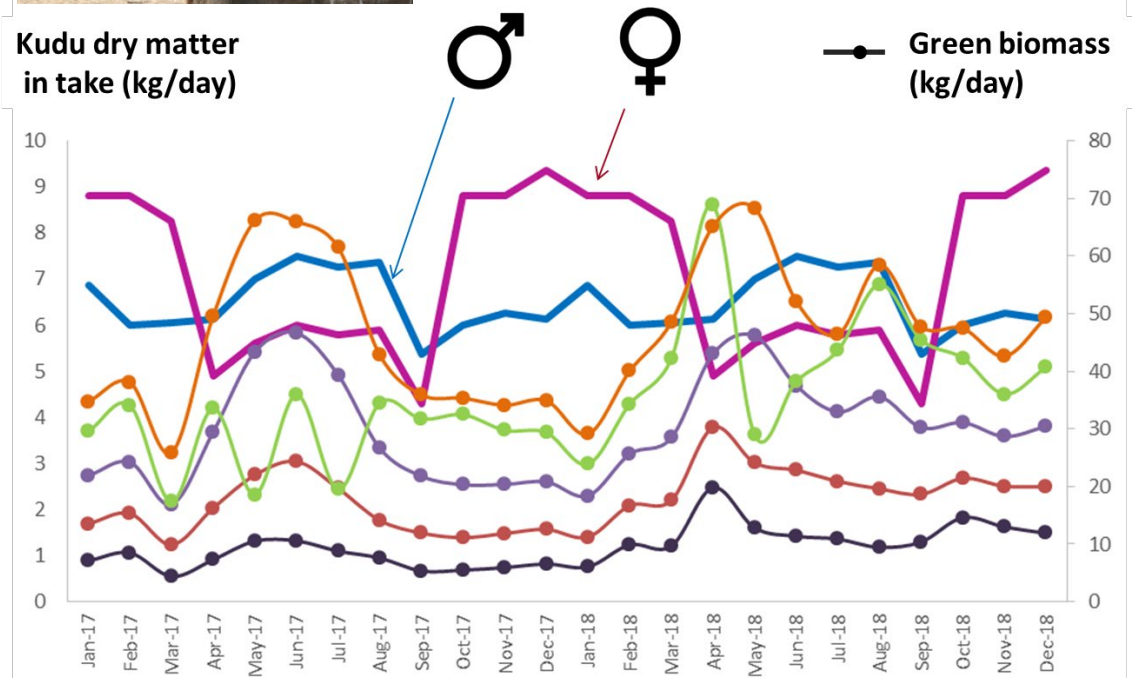
FOLLOWING THE RHYTHM?



RHYTHM AND TIMING



Account for fluctuation and alignment of nature and human demand



ADVANCING SPATIAL ANALYSES AND APPLICATION

integrated policy support aiming at strengthening sustainable management of multifunctional areas. (Willemen et al., 2028)

1) Capture relevant moments in time

2) FAIR, diverse, spatial data allowing for comparison over time

3) Systematic testing of diverse RS indices

4) Measures to manage and plan for change

Partnership: sharing, diverse angles, joining forces





Cited literature

- Willemen, L., R. Kozar, A. Desalegn, and L. Buck. 2014. Spatial Planning and Monitoring of Landscape Interventions: Maps to link People with their Landscapes. A Users' Guide. , Washington DC, USA
- Palomo, I., L. Willemen, E. Drakou, B. Burkhard, N. Crossman, C. Bellamy, K. Burkhard, C. S. Campagne, et al. 2018. Practical solutions for bottlenecks in ecosystem services mapping. *One Ecosystem* 3:e20713.
- van Oudenhoven, A. et al. 2018. Key criteria for developing ecosystem service indicators to inform decision making. *Ecological Indicators* 95:417-426.
- IPBES. 2018. Summary for policymakers of the assessment report on land degradation and restoration of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. R. Scholes, L. Montanarella, A. Brainich, ...M. Sankaran and L. Willemen (eds). IPBES Secretariat, Bonn, Germany.
- Van Berkel D. et al. Estimating the value of cultural ecosystem services for the United States.
- Willemen, L., A. J. Cottam, et al. 2015. Using Social Media to Measure the Contribution of Red List Species to the Nature-Based Tourism Potential of African Protected Areas. *PLoS ONE* 10:e0129785
- Muchando, A. 2019. Remote sensing assessment of land restoration interventions in South Africa. MSc thesis. University of Twente, Enschede.
- Romijn, T. 2020. The ecolling effect of urban green spaces in Paramaribo. MSc thesis. University of Amsterdam. Contributing to www.groenparamaribo.org
- de Araujo Barbosa, C. et al . 2015. Remote sensing of ecosystem services: A systematic review. *Ecological Indicators* 52:430-443.
- Cord, A. F., et al . 2017. Priorities to Advance Monitoring of Ecosystem Services Using Earth Observation. *Trends in Ecology & Evolution* 32:416-428.
- Ramirez-Reyes, C., et al. 2019. Reimagining the potential of Earth observations for ecosystem service assessments. *Science of The Total Environment* 665:1053-1063
- del Río-Mena, T., L. Willemen, A. Vrieling, and A. Nelson. 2020. Understanding Intra-Annual Dynamics of Ecosystem Services Using Satellite Image Time Series. *Remote Sensing* 12:710.

CAPTURING TIME: ECOSYSTEM SERVICE EVALUATION

People

Account for change



Landscape 1

Compared to where?

t2



t1



Landscape 2

Tech

➤ Pattern for comparison over time