Biodiversity Monitoring: Remote Sensing and AI

‘Look closely at nature. Every species is a masterpiece, exquisitely adapted to the particular environment in which it has survived. Who are we to destroy or even diminish biodiversity?’
– E.O. Wilson

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Pictures by: Aleka Skvarc, Palle Knudson, Marcos Paulo Prado, Anne Nygard, unsplash.com

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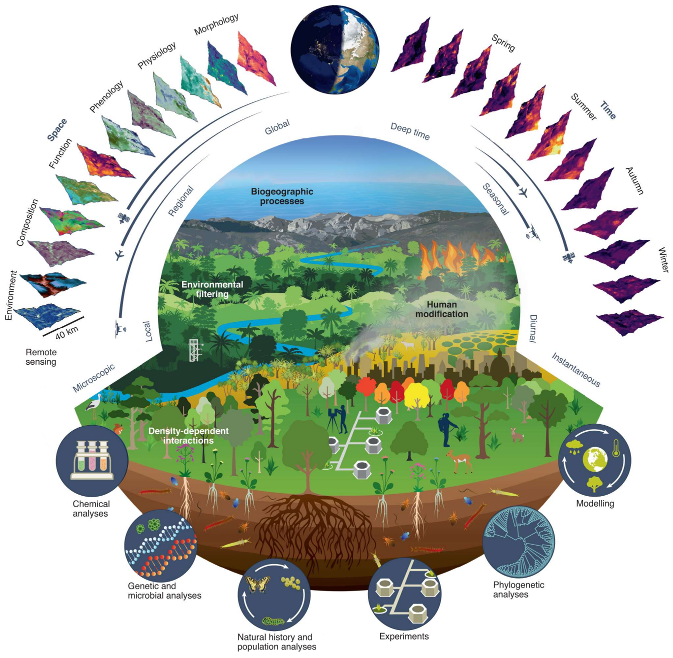
The promise of Remote Sensing for biodiversity studies

- Many biodiversity – relevant metrics can be retrieved from remotely sensed data.
- Current and emerging next-generation satellite remote sensing can create helpful data for:
  - Continuous detection of changes in biodiversity
  - Local to Global Analysis
- Data from unmanned aerial vehicle offer additional opportunities.
- Gap filling in space and time – spatial temporal coverage of in situ observations
- However, many aspects of biodiversity are not directly quantified by reflected or emitted photons.



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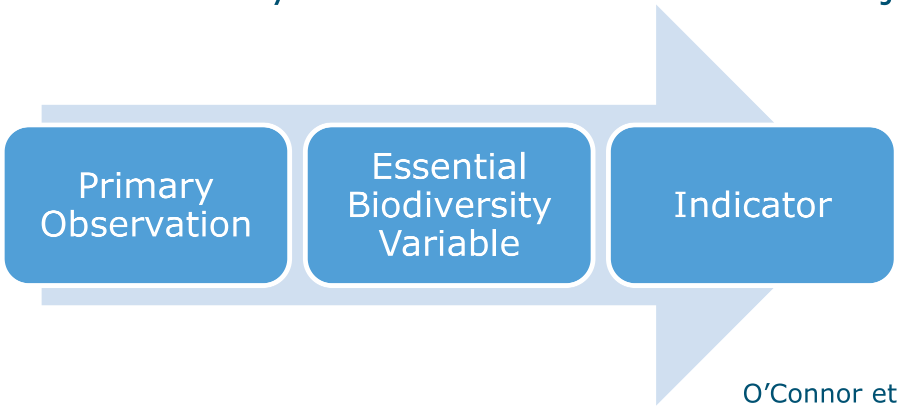
Cavender – Bares et al. , 2022. Nature Ecology & Evolution

Essential Biodiversity Variables

- "a minimum set of essential measurements to capture major dimensions of biodiversity change, complementary to one another and to environmental change observations initiatives" – Pereira et al. 2013
- Essential Biodiversity Variables – inspired by Essential Climate Variables
- EBV: Theoretical space between primary biodiversity observations and indicators.
- Indicator: information has been interpreted → a measure or metric, based on verifiable data that conveys information about more than just itself.



O'Connor et al. 2020, Ecological Informatics

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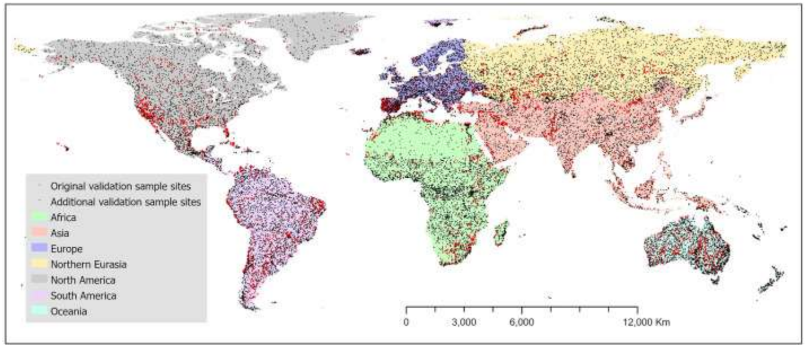
Global Standards as to how biodiversity should be monitored
Lay foundation for a global biodiversity observing system

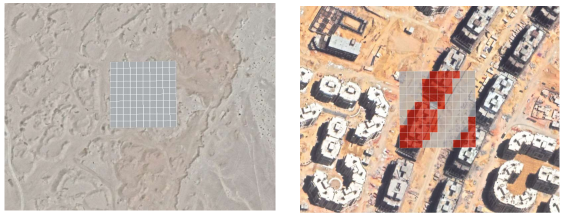
GEO BON: Group on Earth Observations Biodiversity Observation Network

- Mission: Improve the acquisition, coordination and delivery of biodiversity observations and related services to users including decision makers and the scientific community.
- 21 candidate Essential Biodiversity Variables have been defined:
  - Capture critical scale and dimensions of biodiversity
  - Biological
  - Sensitive to change
  - **Ecosystem agnostic**
  - Technically feasible
  - Measured or Modelled
  - **(Ideally) Integration between RS and in-situ observations.**

Accuracy and Validation?

Example: Global Land Cover and Change Monitoring
Assessing land cover and change products





Close to New Cairo city Egypt

In –house validation dataset for global scale land cover/change monitoring

- 30 000 sample locations
- R&D change monitoring
- Uncertainty assessment (design and model based)

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Nandika Tsendbazar

Beyond coarse resolution passive Remote Sensing

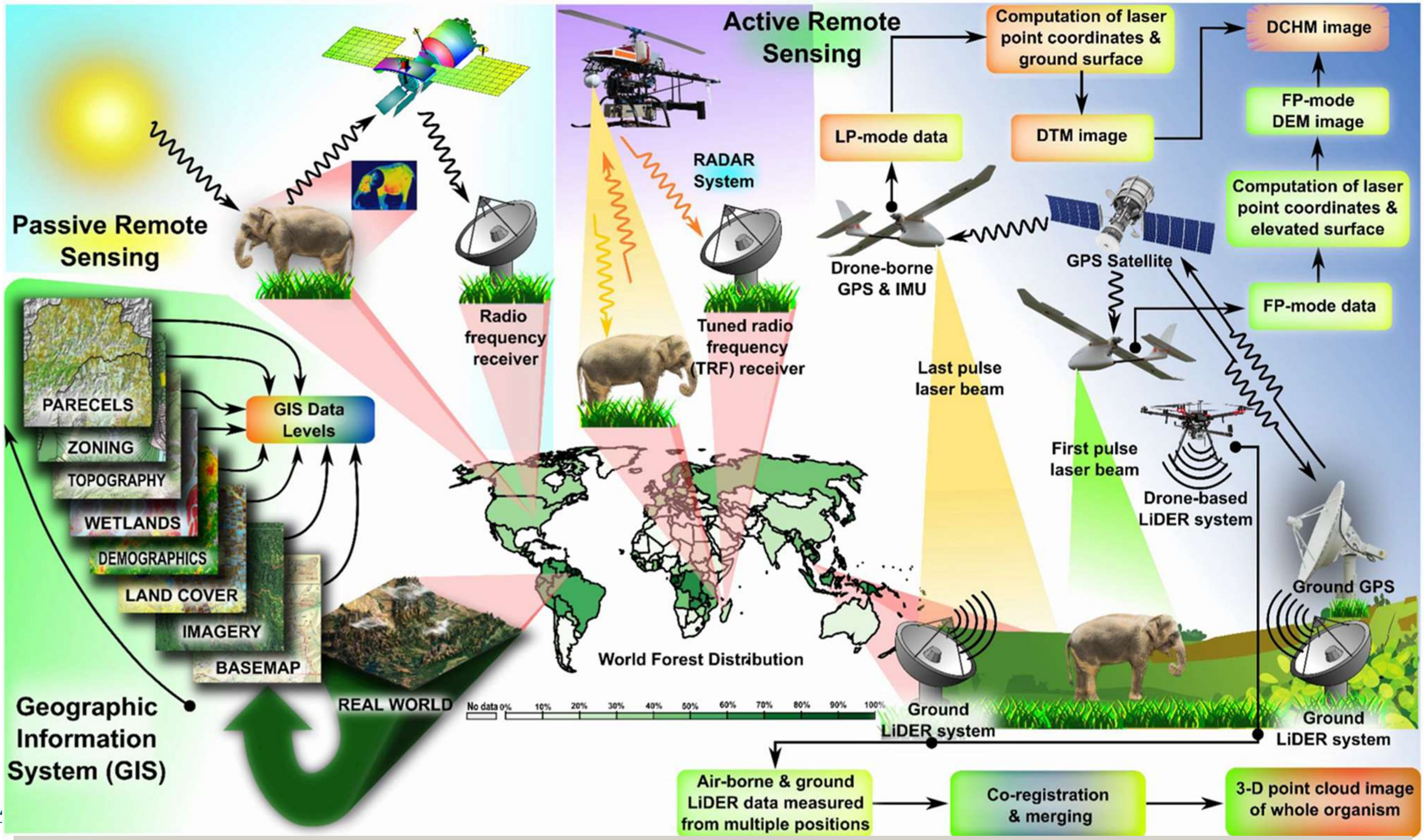


Figure 1 from Kerry et al. 2022. Environmental Science and Pollution Research, 29, 80179-80221

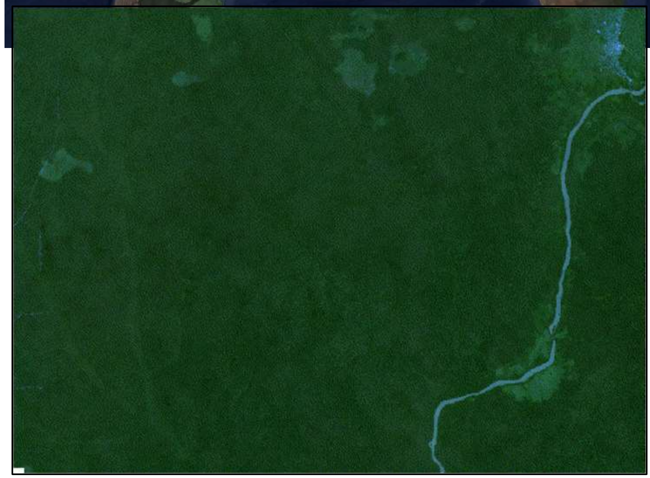
Radar Remote Sensing of Forest Dynamics

- RADD forest disturbance alerts using cloud-penetrating Sentinel-1 radar

Johannes Reiche
(Assoc. Prof)

Reiche et al., 2021 ERL
(http://radd-alert.wur.nl)

Selective tree logging
(Central African Republic)



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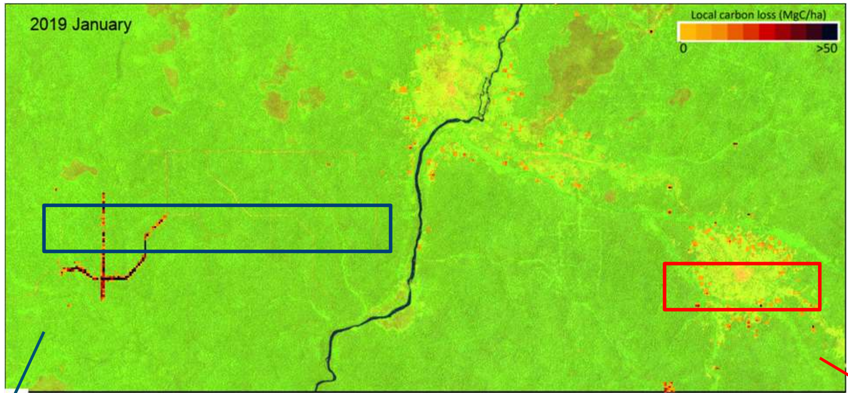
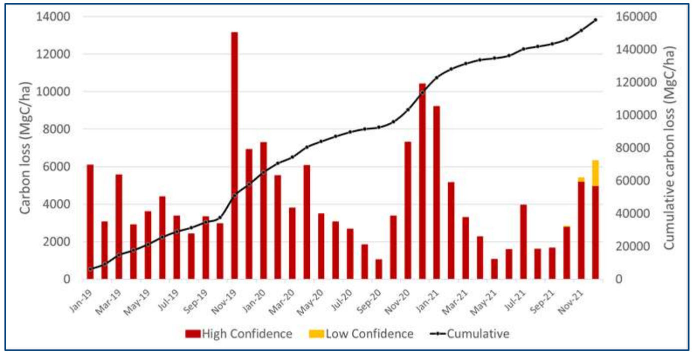
http://radar-rs.wur.nl

Beyond I: Rapid Carbon Loss Monitoring



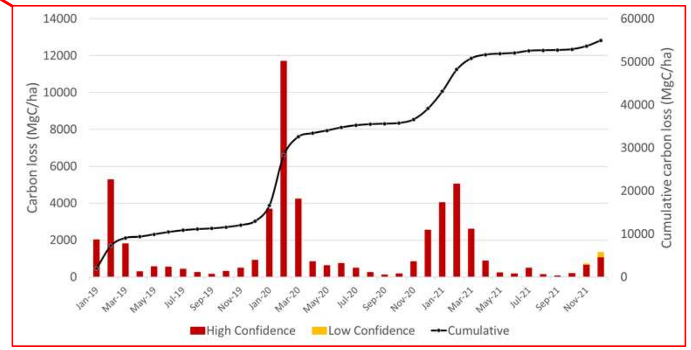


Selective logging

Johannes Reiche

(Assoc. Prof)

Smallholder agriculture

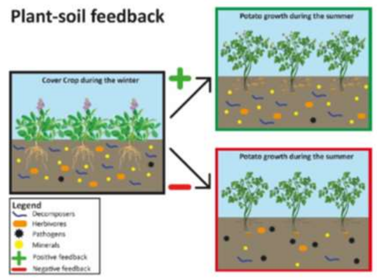


O. Csillik et al., 2022 (Nature CEE)

Plant-soil feedback: cover crops effects on plant traits

Can UAV hyperspectral data characterise plant traits sufficiently well to be used instead of field measurements?

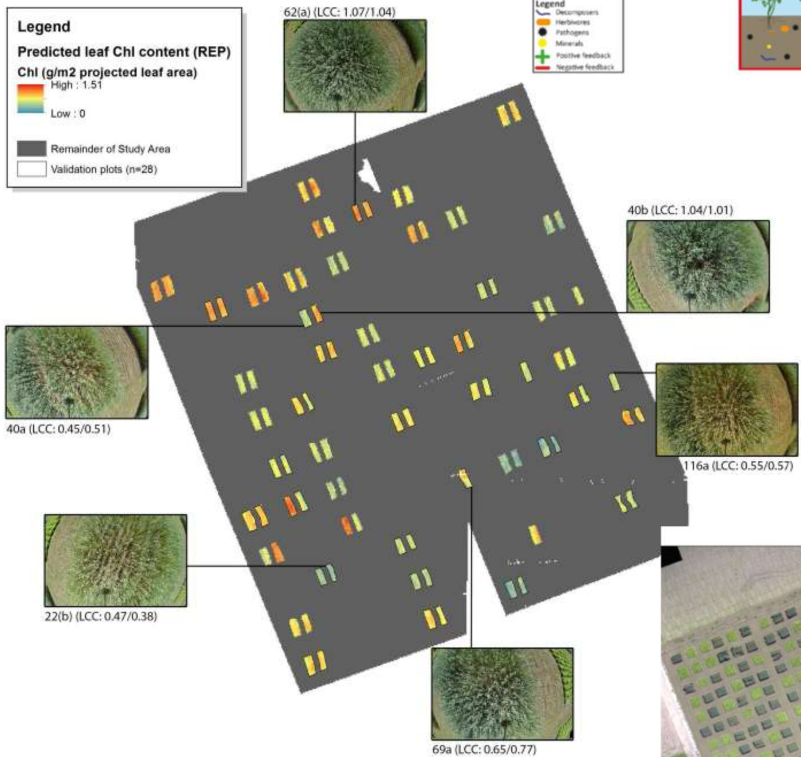
Lammert Kooistra
(Personal Professor)



Benefits:

✓Information on spatial distribution of plant traits

✓Temporal flexibility: diurnal observations



Hyperspectral Mapping
System (HYMSY)
450-950 nm
30 bands

Machine learning Model (PLS)

van der Meij de Deyn, et al. (2017)

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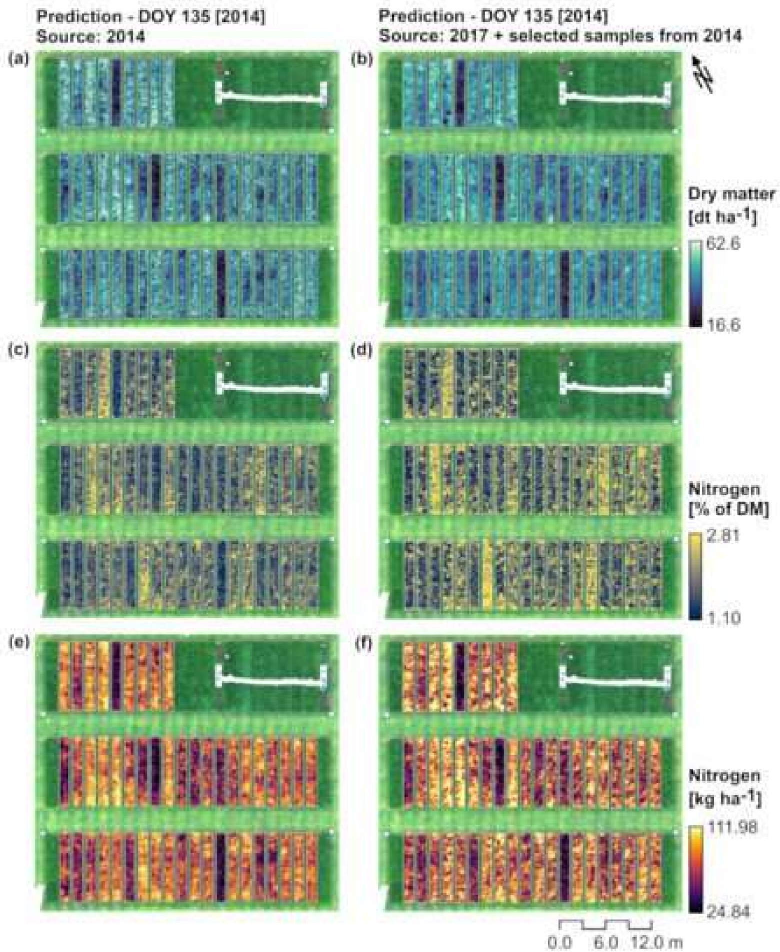
Pixel-wise prediction of grassland traits



UAVs as a potential validation platform for satellite-based IS products:

- ✓ Comprehensive ground reference
- ✓ Insight into spatial variability
- ✓ Temporal flexibility: diurnal observations

Source: Franceschini et al., 2022

RS Outlook – Still much to do

- Build trust within the global biodiversity community (Cavender – Bares, 2022):
    - RS needs to be better integrated with ground-based observations
    - Large scale validation is difficult but important
- Better integration of RS data at different spatial and temporal resolutions (e.g., framework for UAV implementation) + different spectral bands (e.g., RADAR).
- RS biodiversity data need to be openly and equitably available to regions including those with less current capacity (Cavender – Bares, 2022)

Promise of AI for Biodiversity

- AI has already proven its value in many different biodiversity studies
- Large scale cloud-based initiatives, e.g., Google Earth Engine, Microsoft's AI for Earth (Planetary Computer).
- But!
    - Literature is still disjointed and few recognized, well-validated, transferable methods.
    - Human-centered AI → AI must be for the greater interest of the people, not the other way around (UNESCO).
    - AI models are powerful but also consume high amounts of energy. Evaluate necessity, not a solution for everything.