The power of biodiversity informatics
Or
How satellite imagery is transforming conservation science

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Who am I?

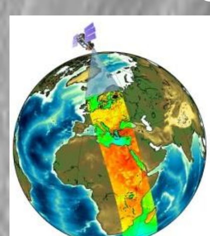
Biodiversity Research & Conservation Applications

Assess and predict the impact of global environmental change on biodiversity; use this to inform conservation

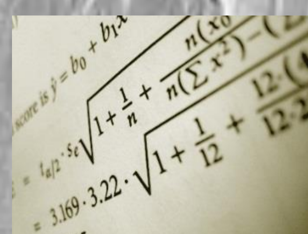
My methods

Statistics

Remote Sensing



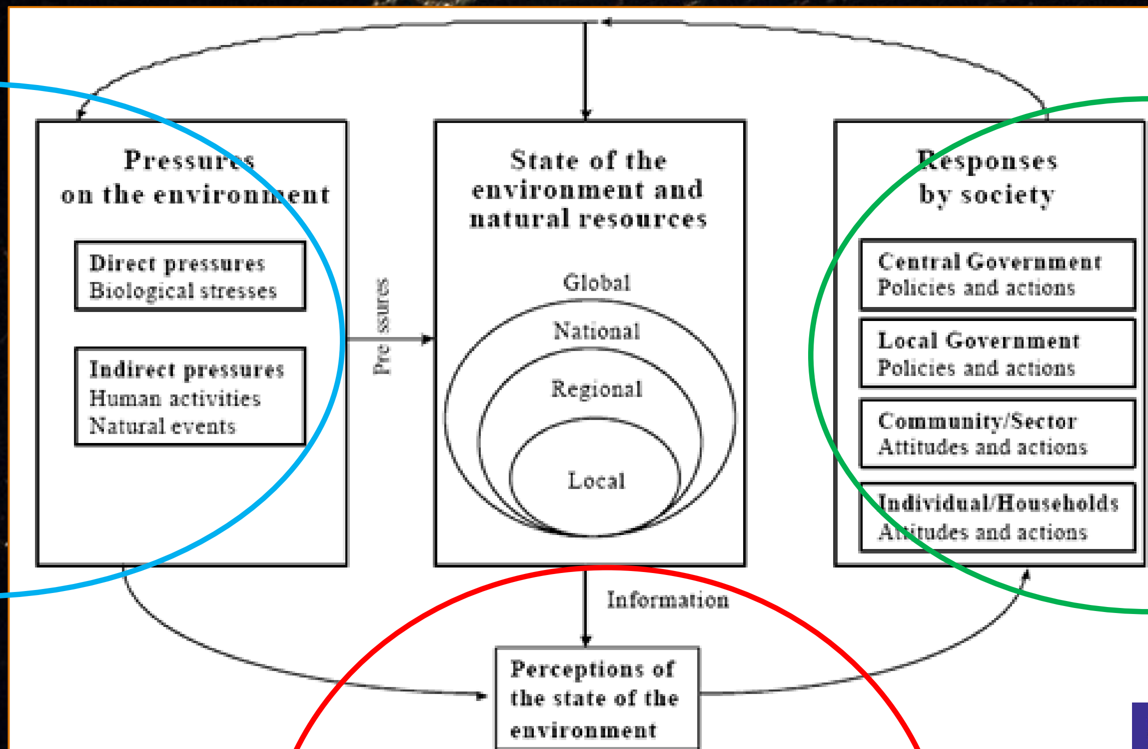
Simulations



Biological models

My research framework:
a typical research framework for conservation science

Climate change
Land conversion
Invasives
Overexploitation

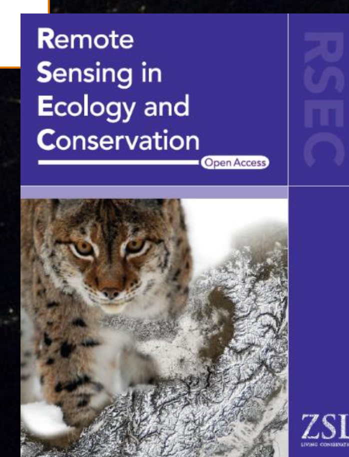


Protected areas
Land development planning
Vaccinations

Structural attributes

Functional attributes

Compositional attributes



Why satellites?

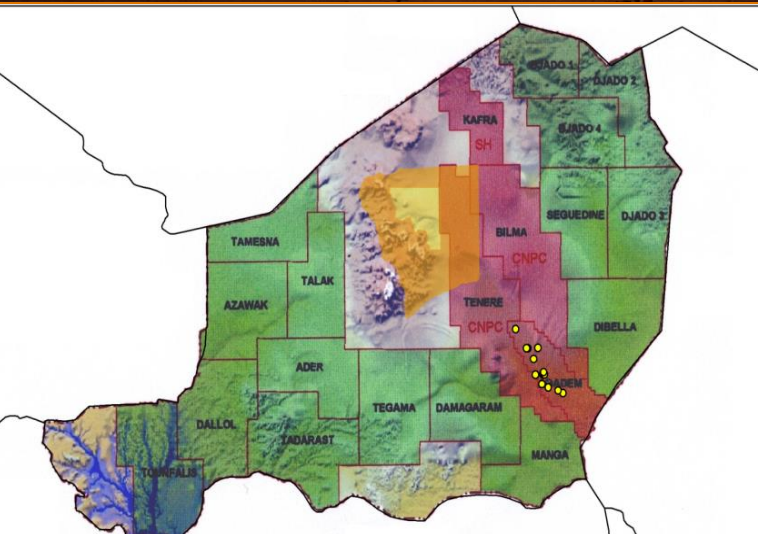
Strength of Remote sensing methods :

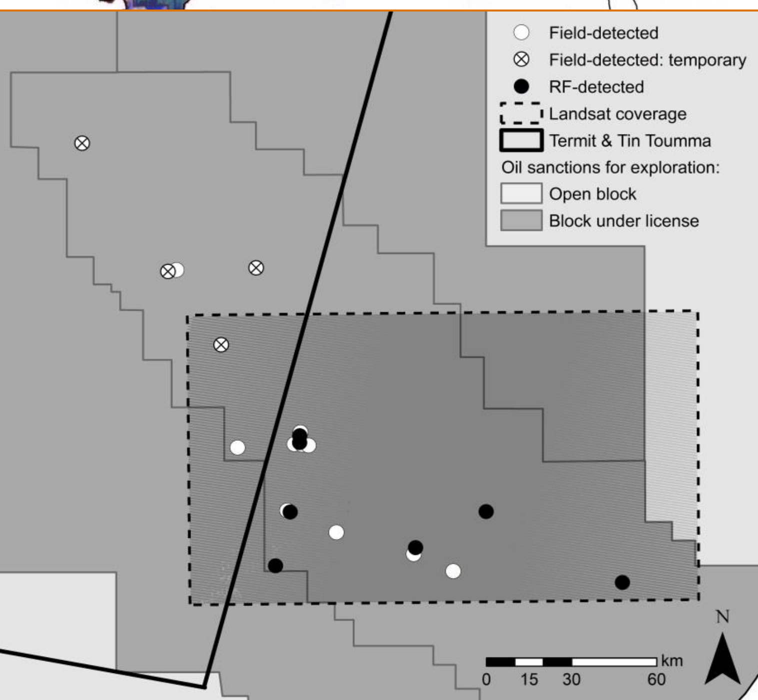
(1) World coverage; relatively cheap / less costly than field monitoring at such spatial scale
(2) Reproducible, sustainable methodologies
(3) Standardized and transparent information
(4) Information can be linked to species ecology at multiple spatio-temporal scales → relevant to behavioral ecology, population dynamics and macroecology

Pressures

Oil exploration activities

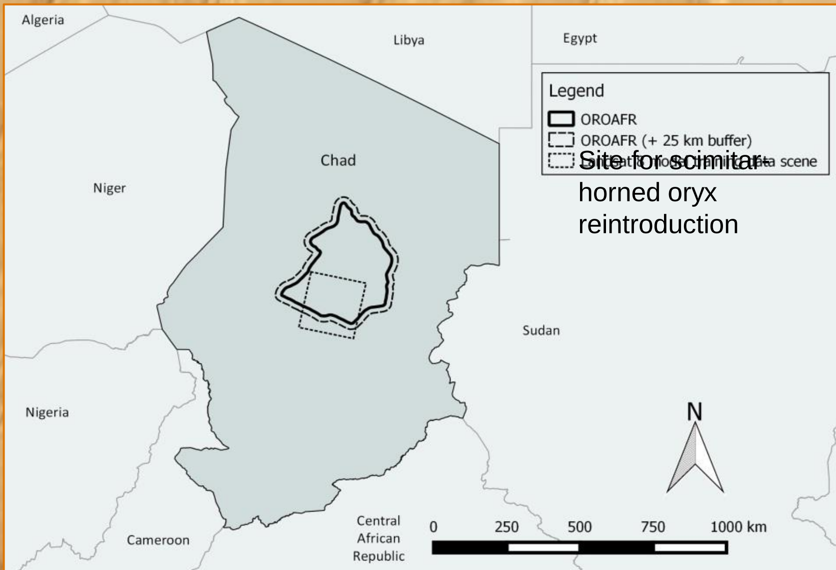
→ No spatial information available yet multiple reports of degradation/poaching associated with these developments – used Landsat





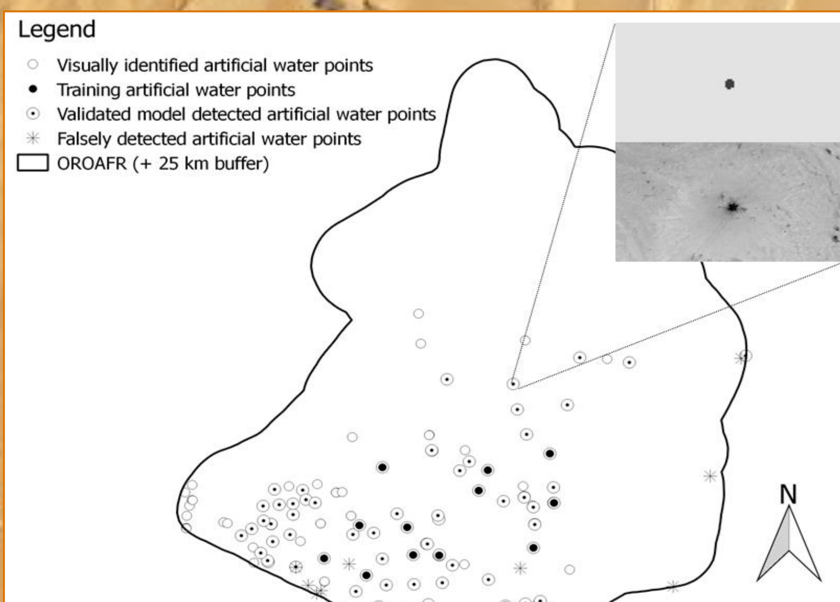
Duncan et al. 2014

Artificial water points



Site for scimitar-horned oryx reintroduction

→ Uncontrolled expansion, no information
→ Landsat combined with VHR data & Random Forest
→ 126 different points in the reserve, 24% omission rate, accuracy of 92%



Owen et al. 2015

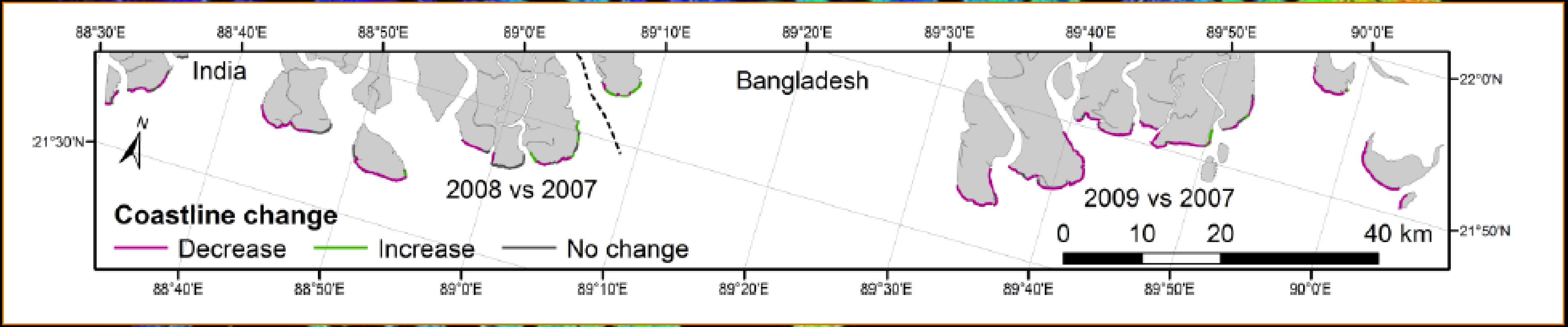
State

Biodiversity monitoring so far

	Compositional	Structural	Functional
Gene level	*Genes*	*Genetic structure*	*Genetic processes*
Species level	*Species, populations*	*Population structure*	*Demographic processes*
Ecosystem level	*Communities*	*Ecosystem structure*	*Ecosystem processes, functions*

Sea rise and coastal retreat

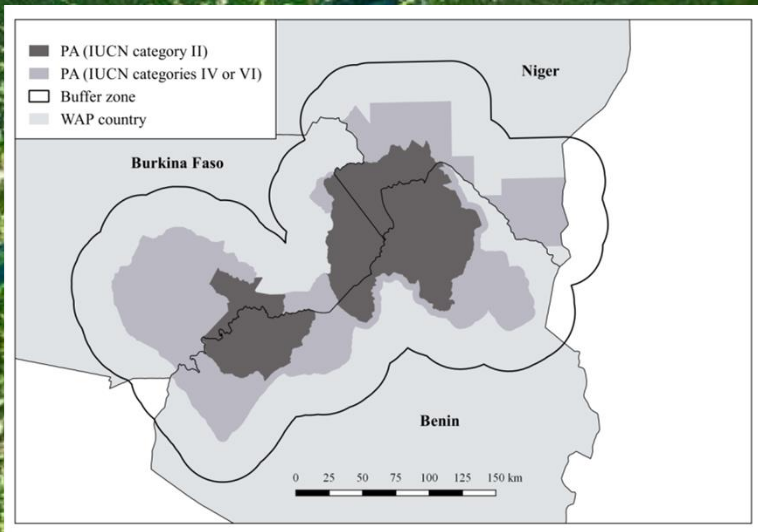
100m recession on average over 2 years (2007 to 2009); up to 170m max

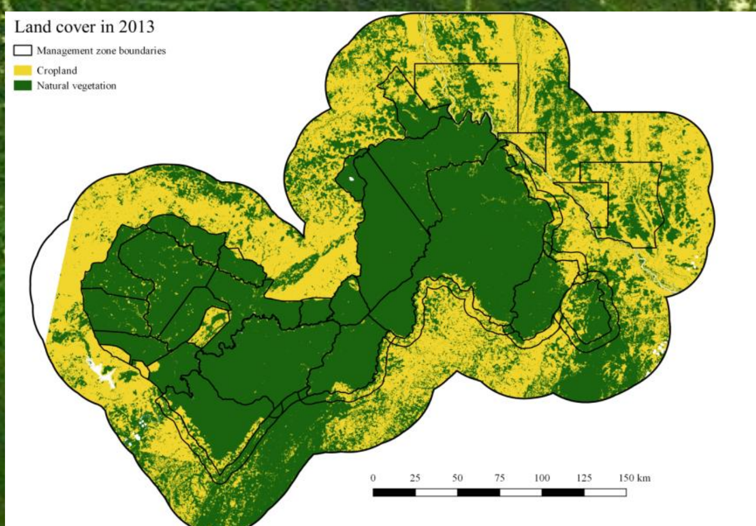


Bangladesh
India

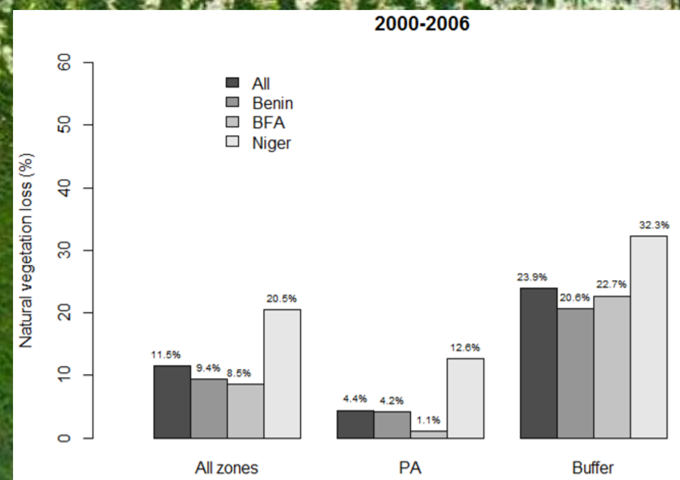
Cornforth et al. 2013

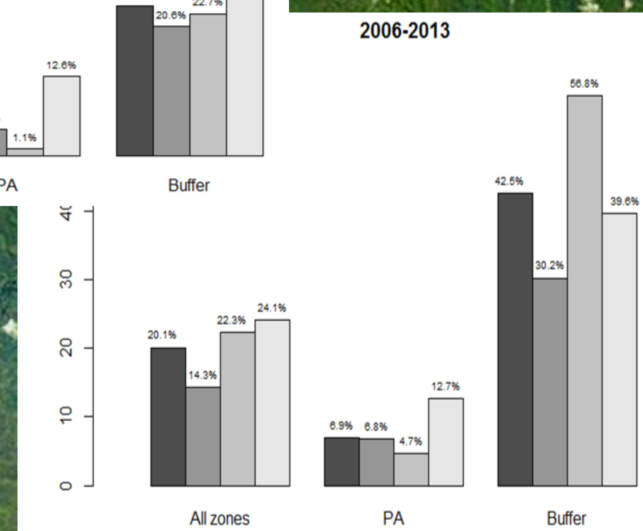
Natural vegetation loss & fragmentation





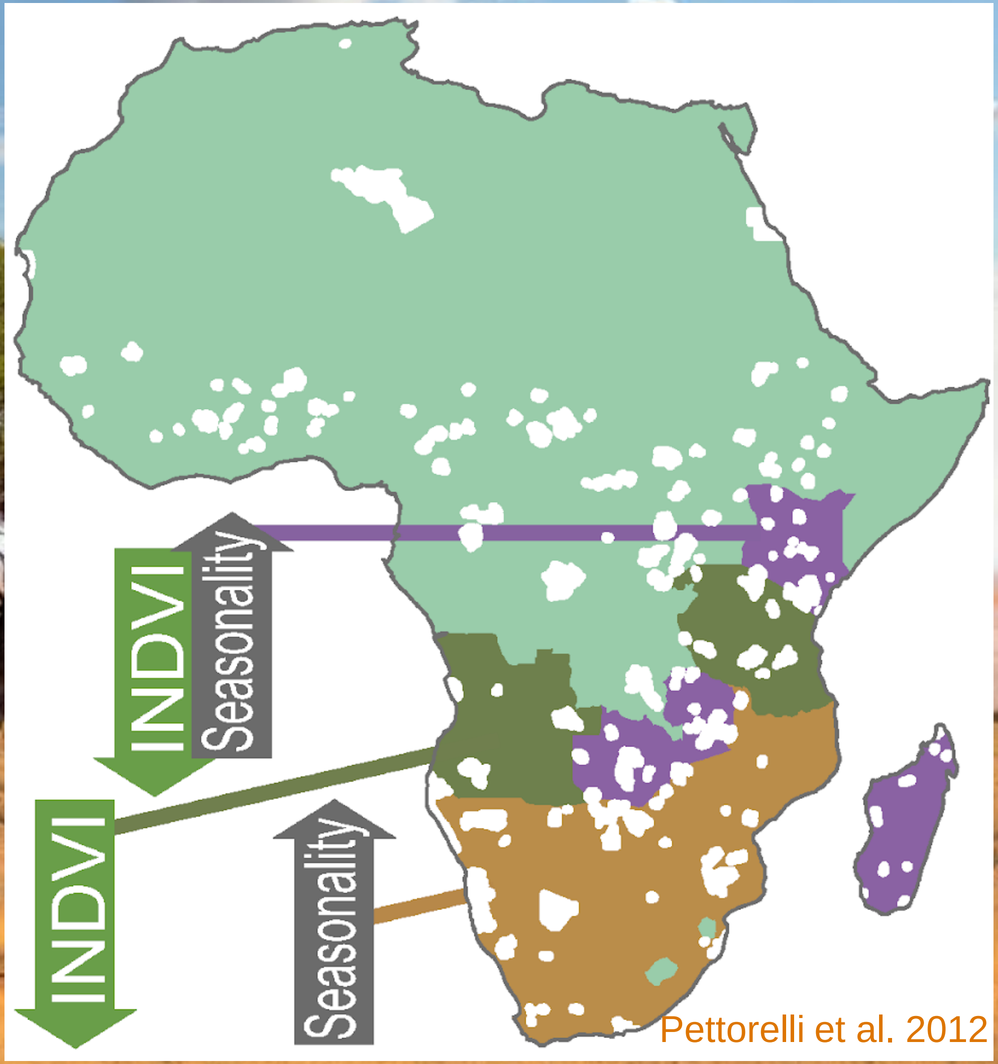
→ Biodiversity hotspot
→ Uncontrolled cropland expansion, no information on transboundary PA effectiveness





Schulte to Buhne et al. 2017

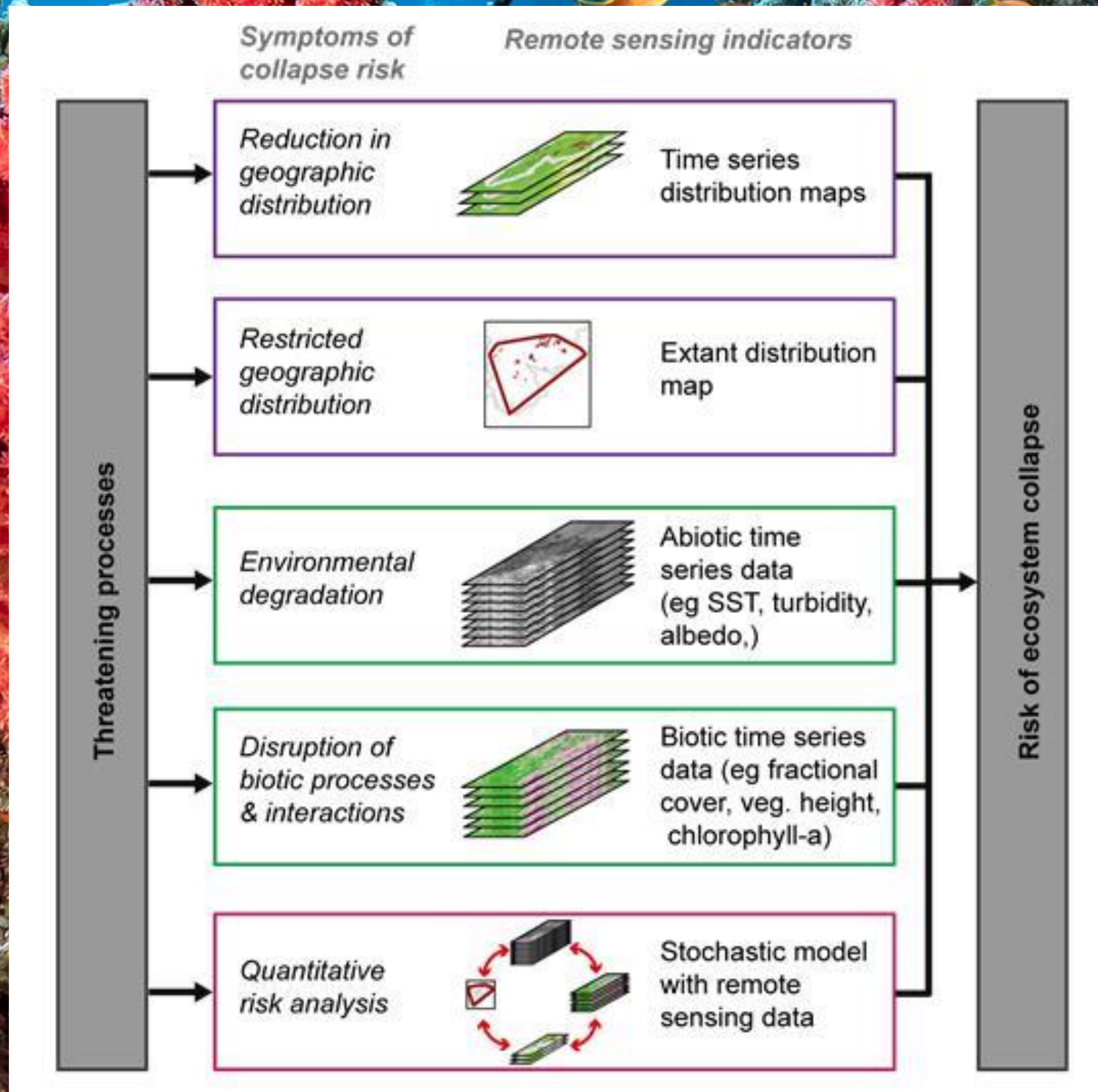
Changes in primary productivity as an example of what can be done



- 168 protected areas (I and II), 1982-2008 NDVI dynamics analysed

→ *results mostly supported current expectations of CC impacts*

Satellites facilitate ecosystem risk assessments

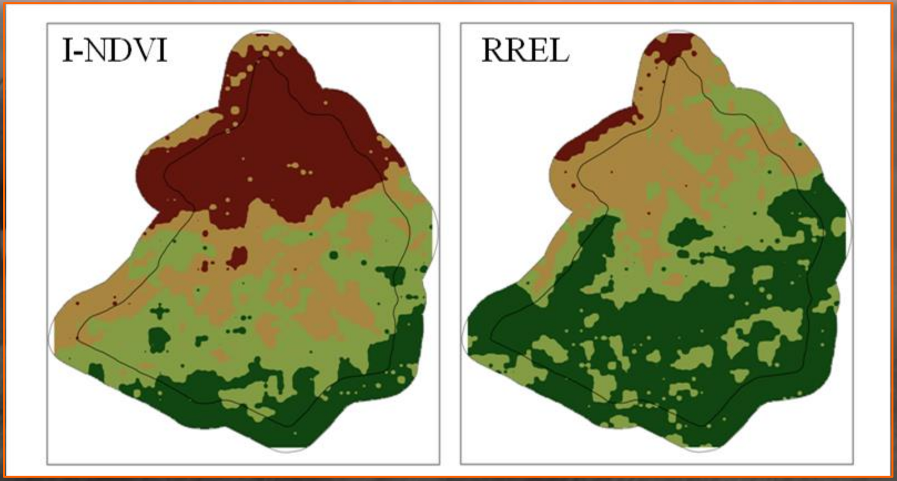


Murray et al. 2017

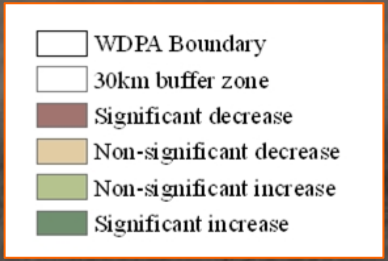

Response

Informing reintroductions

Scimitar oryx reintroduction in Chad



RREL: level of seasonality
I-NDVI: annual primary productivity



Freemantle et al. 2013

1982-2008 trends in vegetation dynamics in Ouadi Rime Ouadi Achim

Informing restoration

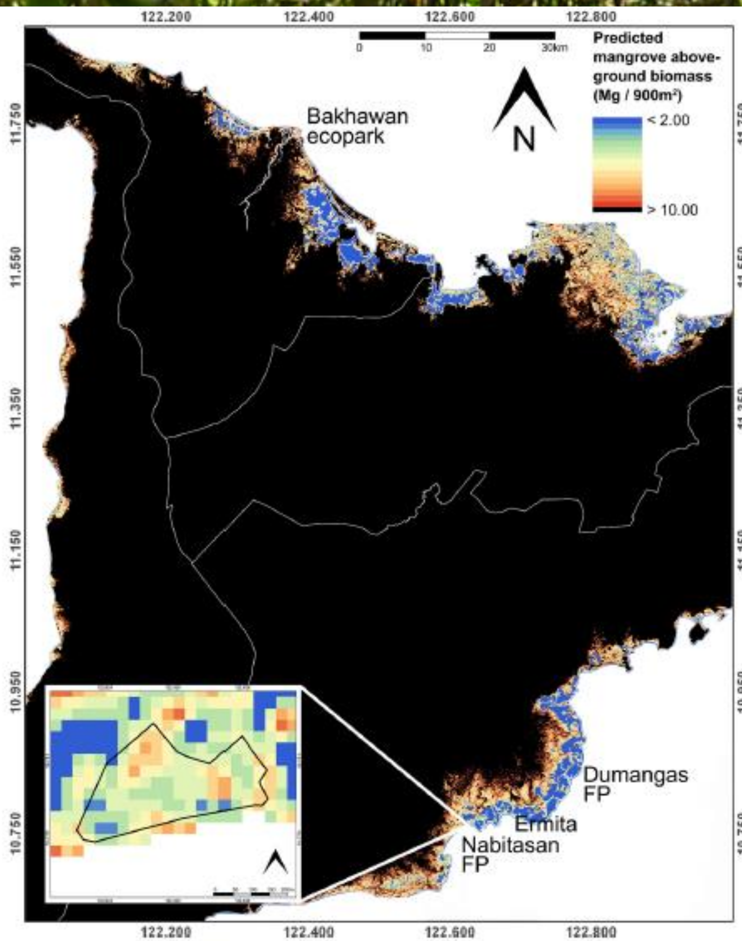


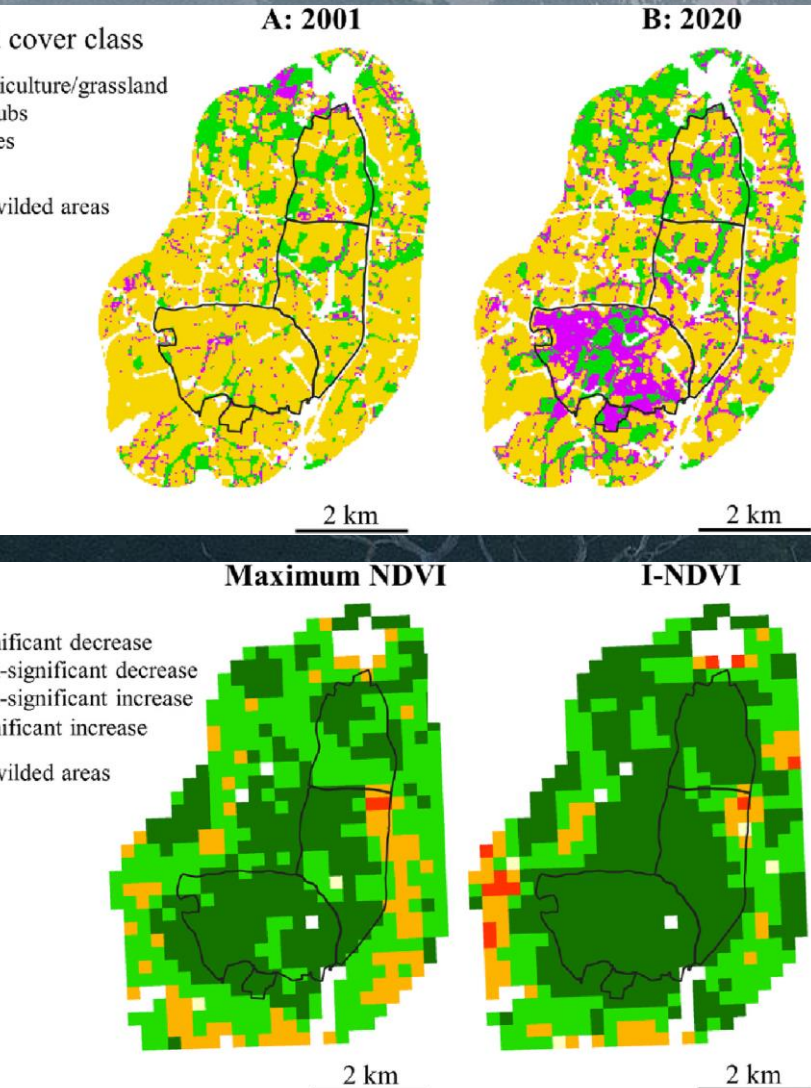
Fig. 4. Predicted aboveground mangrove biomass (Mg 900m^2) across the two SRTM DEM tiles on Panay Island. Blue pixels denote areas of low biomass, while red areas denote higher biomass areas. Dark blue pixels indicate active aquaculture pond areas, and black pixels denote areas with biomass > 10 Mg 900 m^2. N.B. This figure illustrates predictions of areas outside of the distribution of mangroves on Panay Island (e.g. beach forest and terrestrial forest and plantation areas), which were not included in the analyses of this study.

Detailed information on ecosystem structure, at large scales

Here helped unveil the potential of abandoned pond reversion to mangroves for climate change adaptation and mitigation

Duncan et al. 2016

nforming rewilding



Significant changes in land cover distribution, with a 41.4% decrease in areas with brown agriculture and grass, a roughly sixfold increase in areas covered with shrubs, and a 40.9% increase in areas with trees

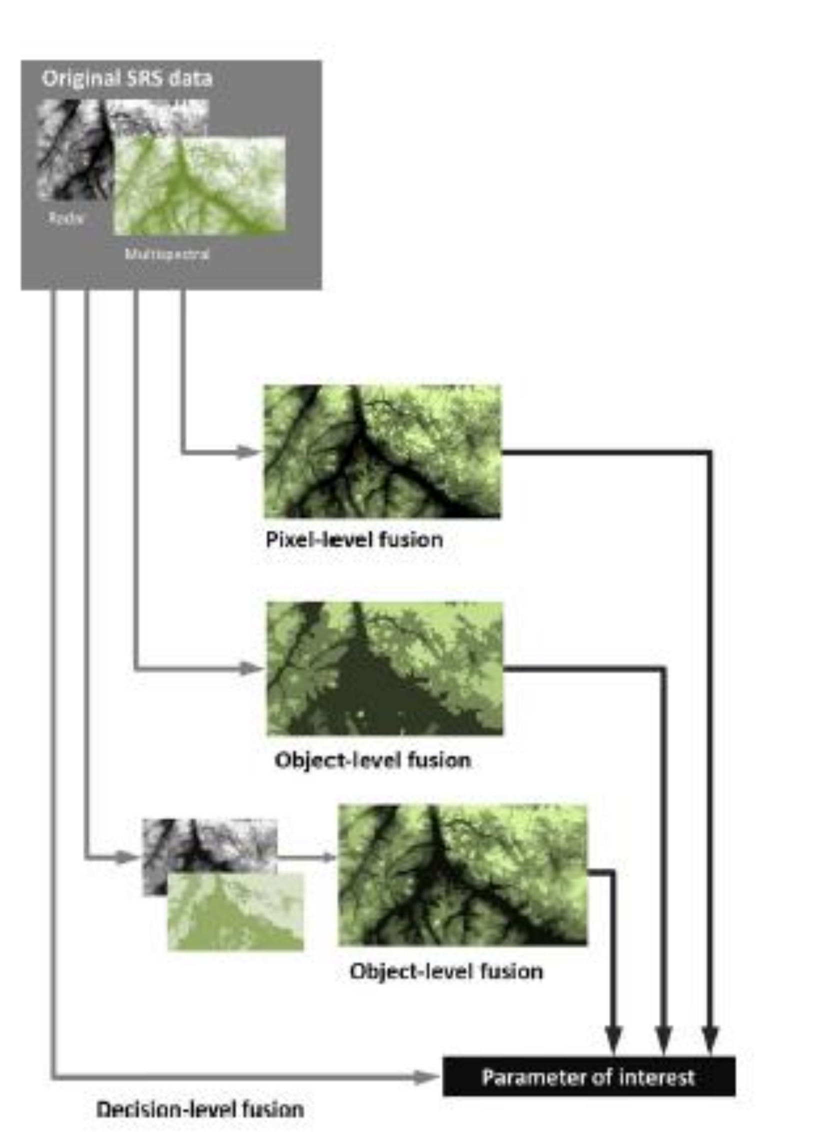
Changes in land cover & primary productivity are particularly pronounced in the part of the estate that began its rewilding journey with a period of large herbivore absence

Schulte to Buhne et al. 2022

Many more applications

- Climate change and disturbance dynamics (e.g., fire, floods, blooms)
- Interactions between climate change and other threats (eg invasive species, land use change) – impacts on biodiversity
- Species detection, behaviour, population dynamics, macroecology
- Climate change and ecosystem collapse risks

Many more algorithms & approaches



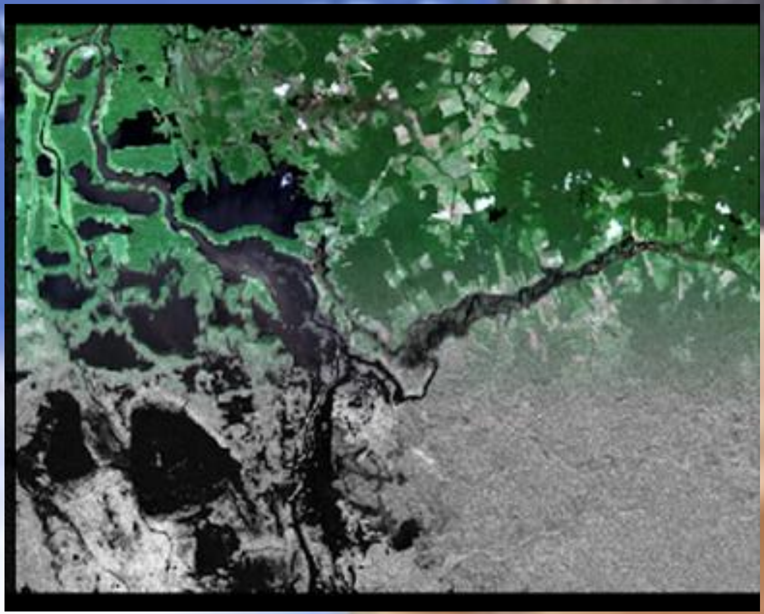
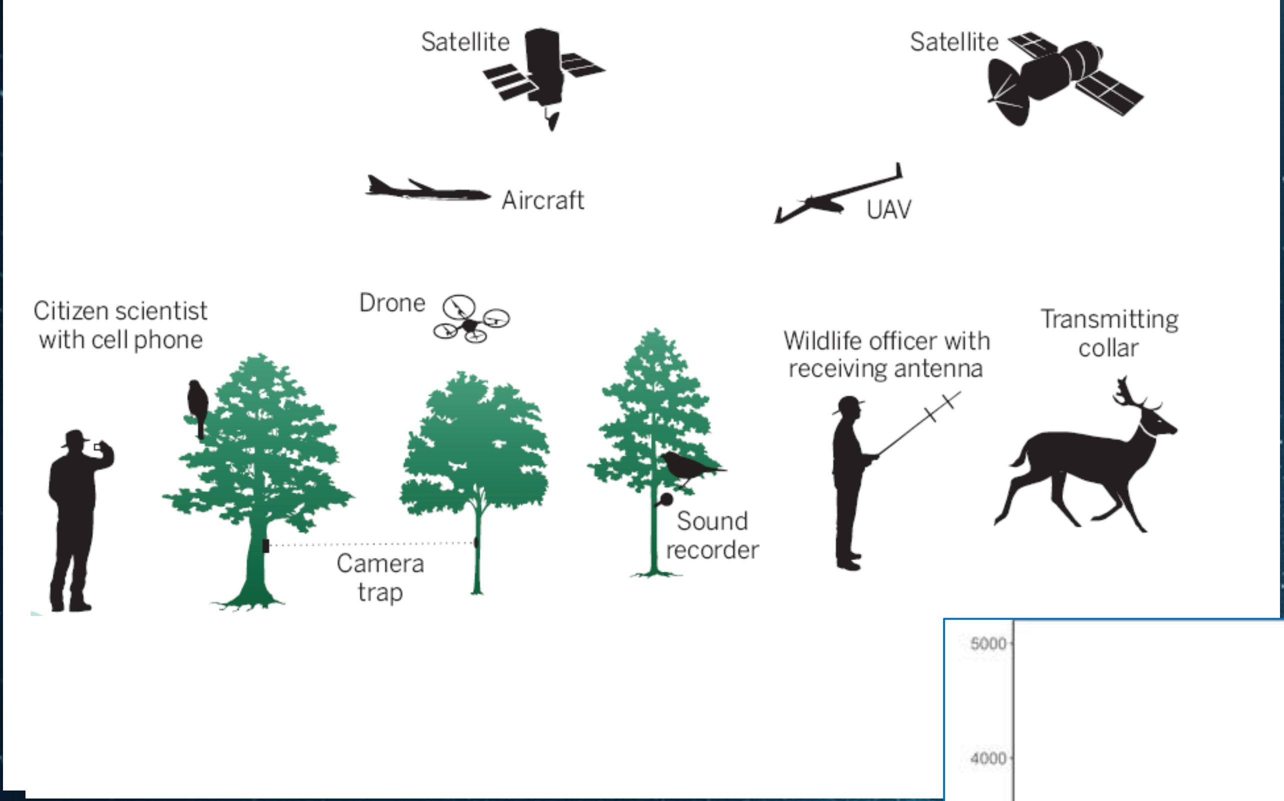
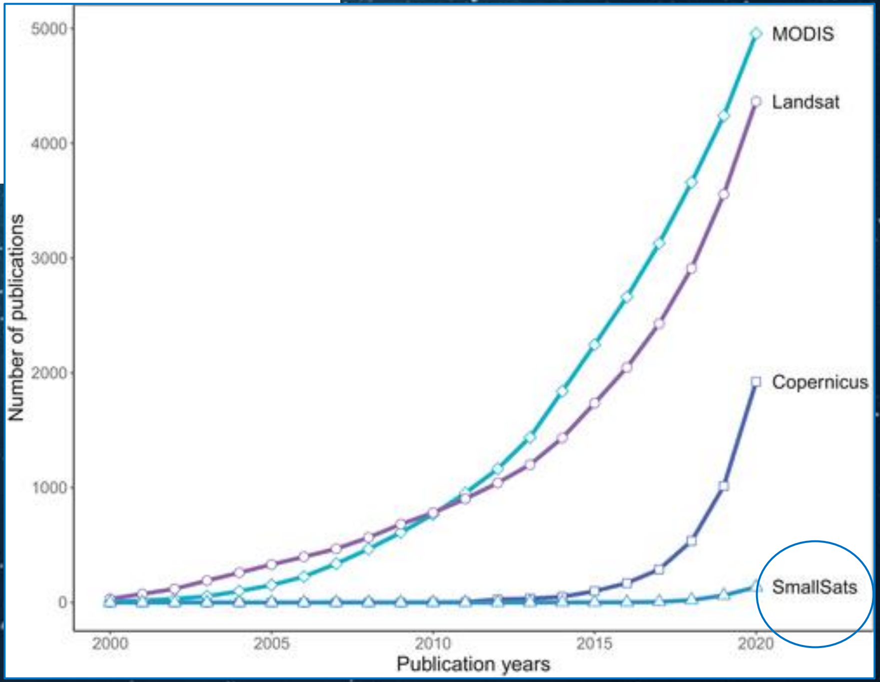


FIGURE 1 Schematic overview of multispectral-radar SRS data fusion techniques. The parameter of interest can be a categorical variable, like land cover, or a continuous variable, like species richness. In pixel-level fusion, the original pixel values of radar and multispectral imagery are combined to yield new, derived pixel values. Object-based fusion refers to (1) using radar and multispectral imagery is input into an object-based image segmentation algorithm, or (2) segmenting each type of imagery separately before combining them. Finally, decision-level fusion corresponds to the process of quantitatively combining multispectral and radar imagery to derive the parameter of interest (by e.g. combining them in a regression model, or classification algorithm)

Schulte To Buhne & Pettorelli 2018





Many more technologies and possibilities for integration

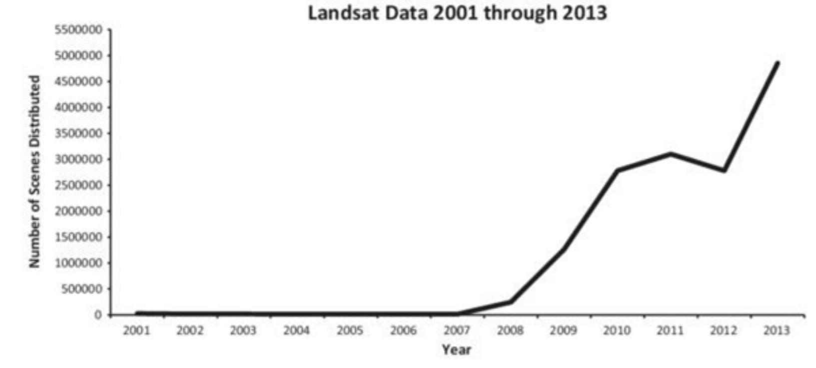
Curnick et al. 2021

Take home message(s)

- SRS provides a fantastic opportunity to monitor changes in habitat/ecosystem distribution, composition, structure and functioning in difficult/remote places
- SRS can provide a quantified measure of change which can be linked to species distribution, but also to behaviours, life history traits or abundance
- Satellite data is no replacement to classical ground-based data; complementary – best results when both types of data are integrated

Take home message(s)

- We are only starting to capitalise on this opportunity (new sensors, new products, new algorithms) – things are changing fast
- Importance of data accessibility – free data is key
- Increased importance of technology in conservation – increased role of interdisciplinary training
- Earth Observation community and wildlife management in need of more collaboration to ensure that pertinent tools are developed and that money is not wasted



Thank you!

More information

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