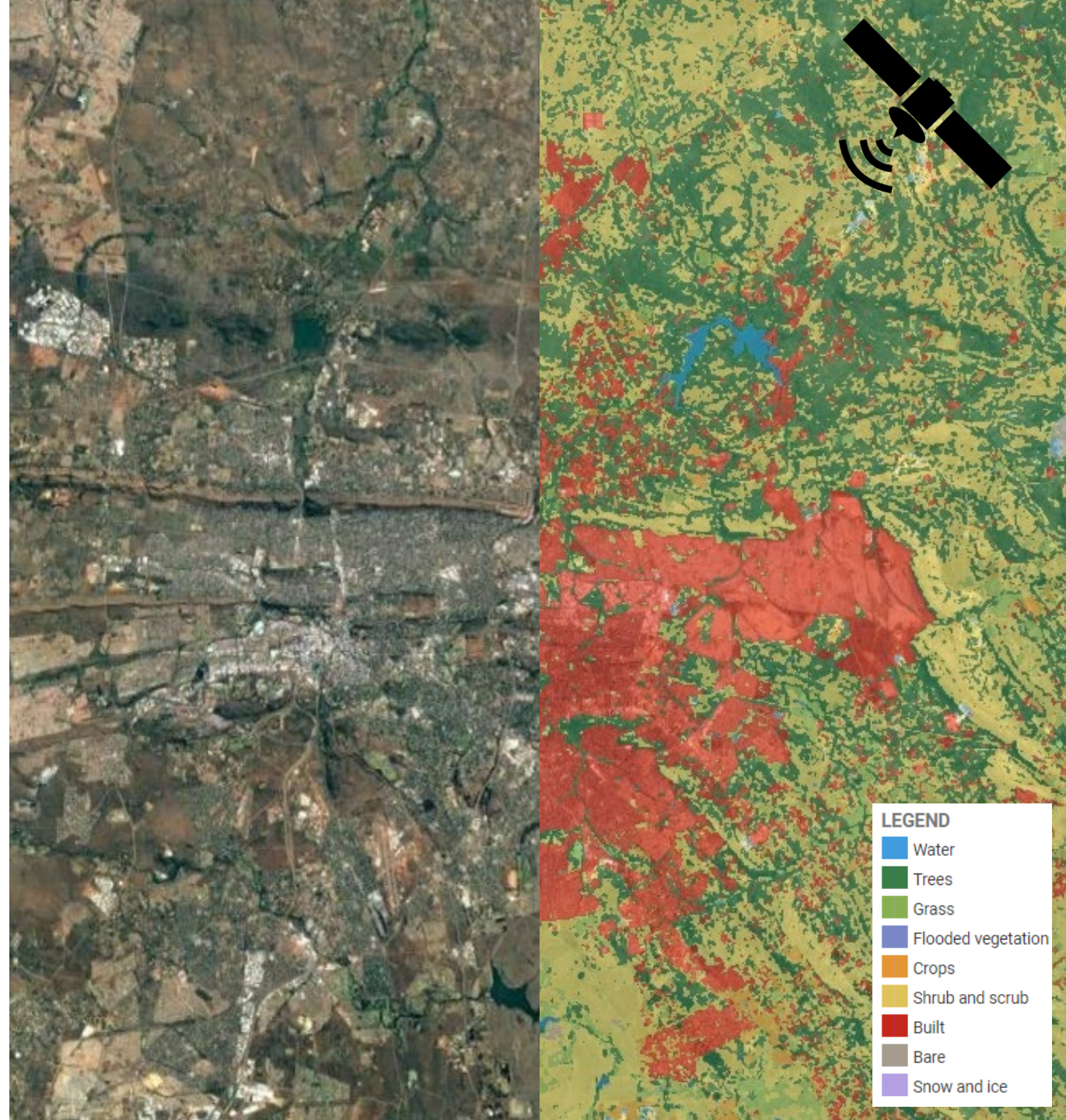


Quantifying and reporting uncertainty in biophysical ecosystem service accounts for local policy and planning: the case of satellite-based ecosystem extent maps

Zander Venter

David N Barton

29th London Group Meeting

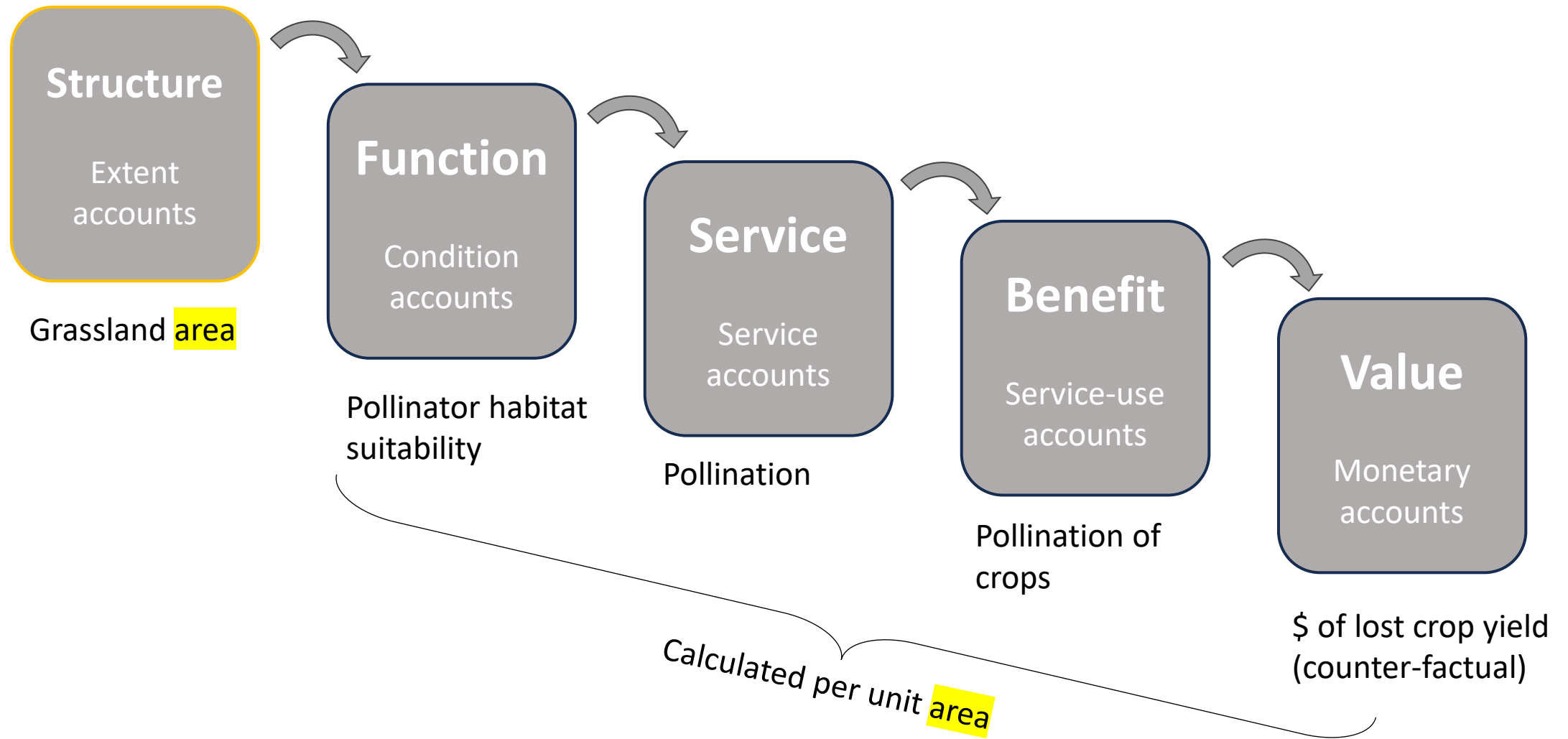




Ecosystem accounting has inherent uncertainty

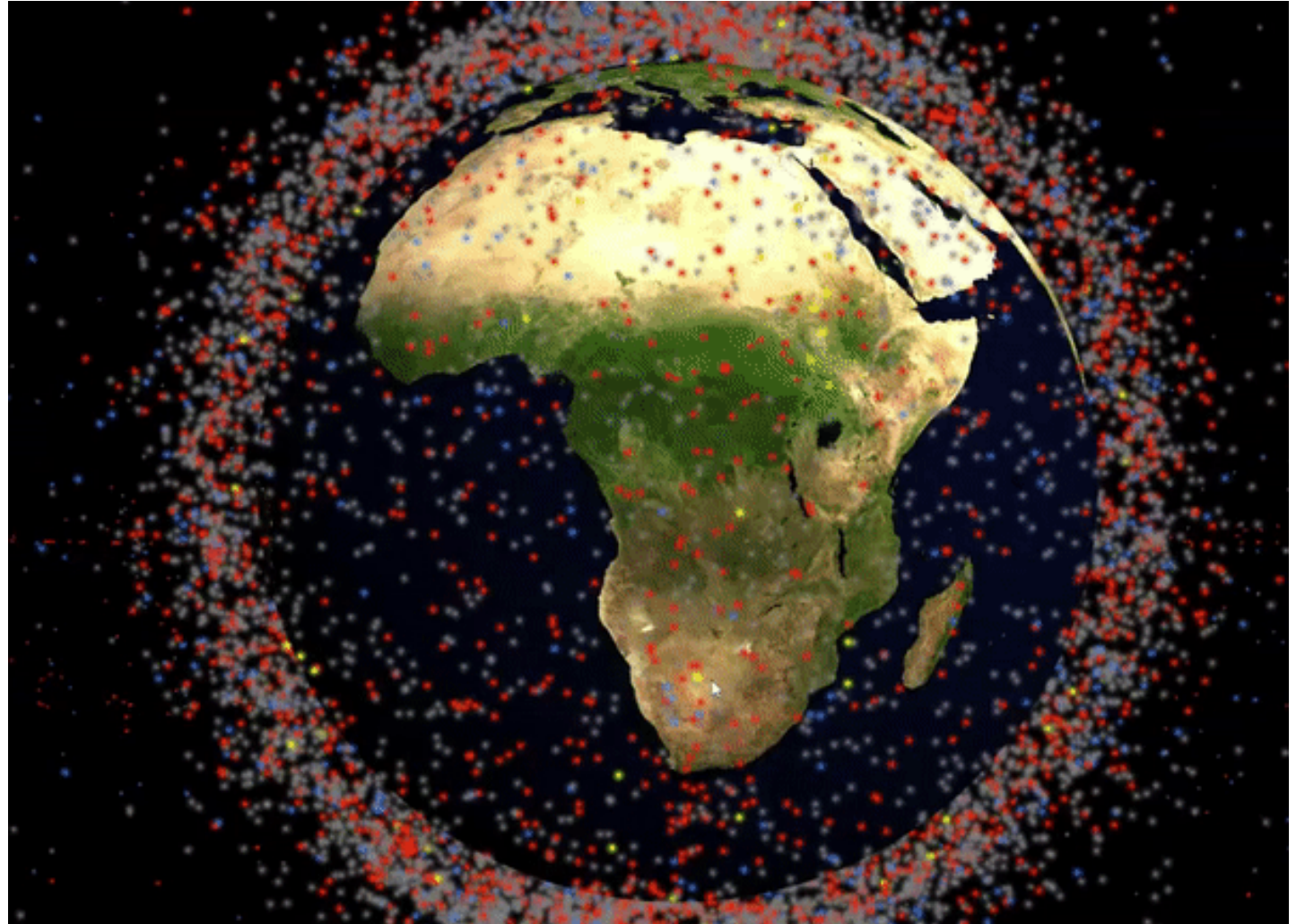
- SNA and economic accounts - transactions of exactly known value. (low uncertainty)
- Ecosystem accounting depends on modelling ecosystem states and processes. (high uncertainty)
- While demography and macroeconomics have a long record of developing methods for integrating uncertain data into accounting frameworks, current proposals for implementing SEEA-EA seem to ignore uncertainty.
- Quantifying uncertainty is necessary to inform robust decision making and policy implementation.

Ecosystem extent is where it all begins



Proliferation of satellite-based earth observation

- >7700 satellites currently orbiting Earth
- 26% of these are for earth observation
- Companies like Planet take a high resolution picture of the earth every day



Satellites are useful for detecting changes over time – a prerequisite for ecosystem accounting

Airport construction 1990-2022



Forestry activity 1990-2022

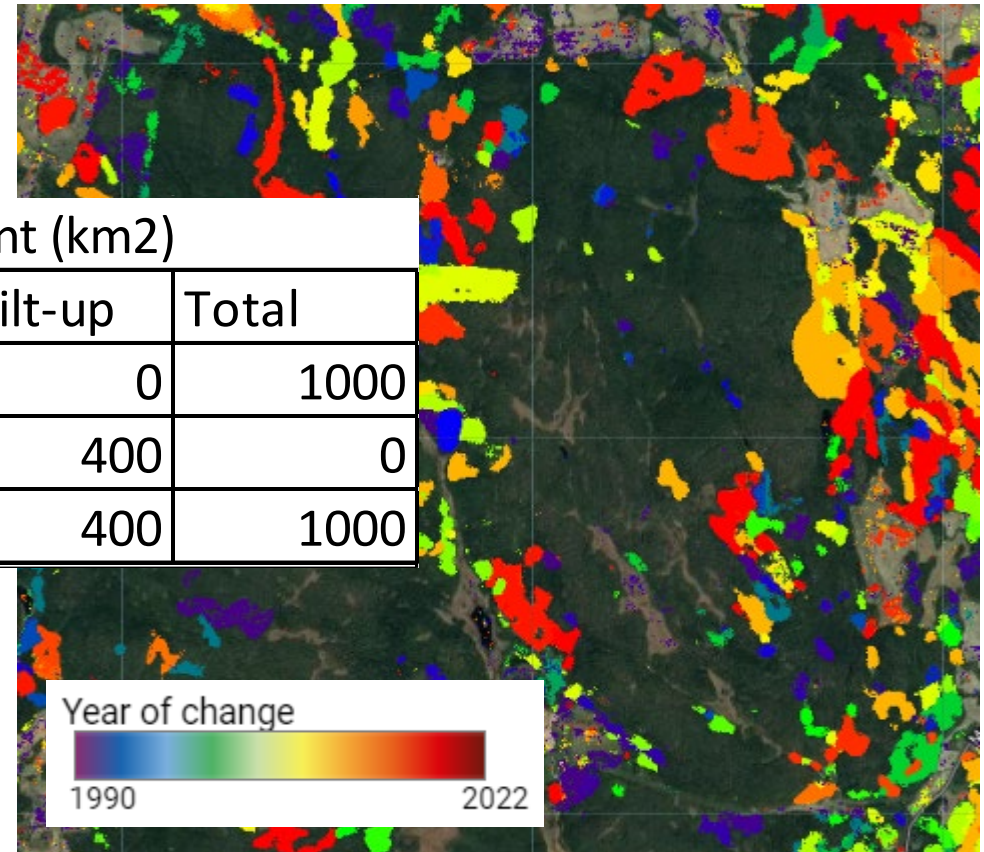


Satellites are useful for detecting changes over time – a prerequisite for ecosystem accounting

Airport construction 1990-2022



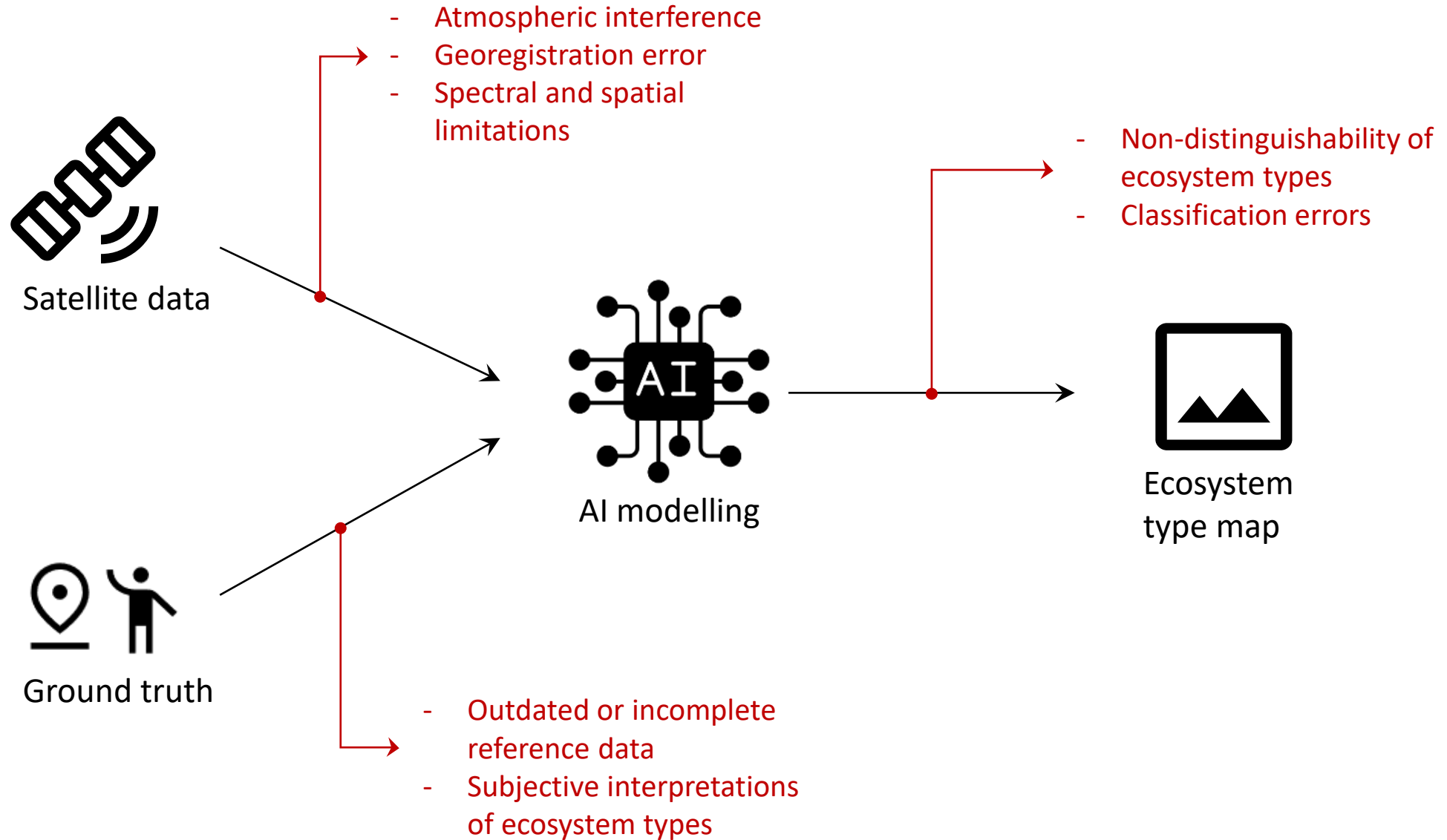
Forestry activity 1990-2022



Ecosystem extent account (km²)

	Forest	Built-up	Total
Opening	1000	0	1000
Change	-400	400	0
Closing	600	400	1000

Satellite-based maps are fraught with error and uncertainty



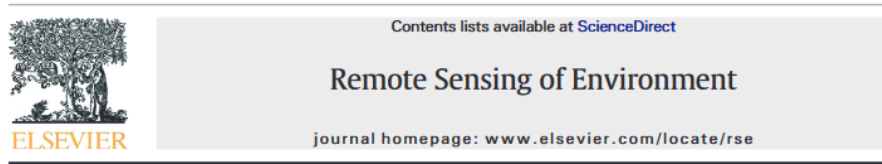
Correcting for bias and quantifying uncertainty are crucial

- Pixel-counting is the norm in ecosystem accounting
- Pixel-counting does not account for biases and uncertainties inherent in maps
- Design-based inference necessary to prevent biased estimates
 - Use orthophotos or VHR satellite imagery to collect stratified reference «ground-truth» sample
 - Use reference sample to estimate areas & 95% confidence intervals

True extent:
- 92 ha

Pixel counting:
- 150 ha

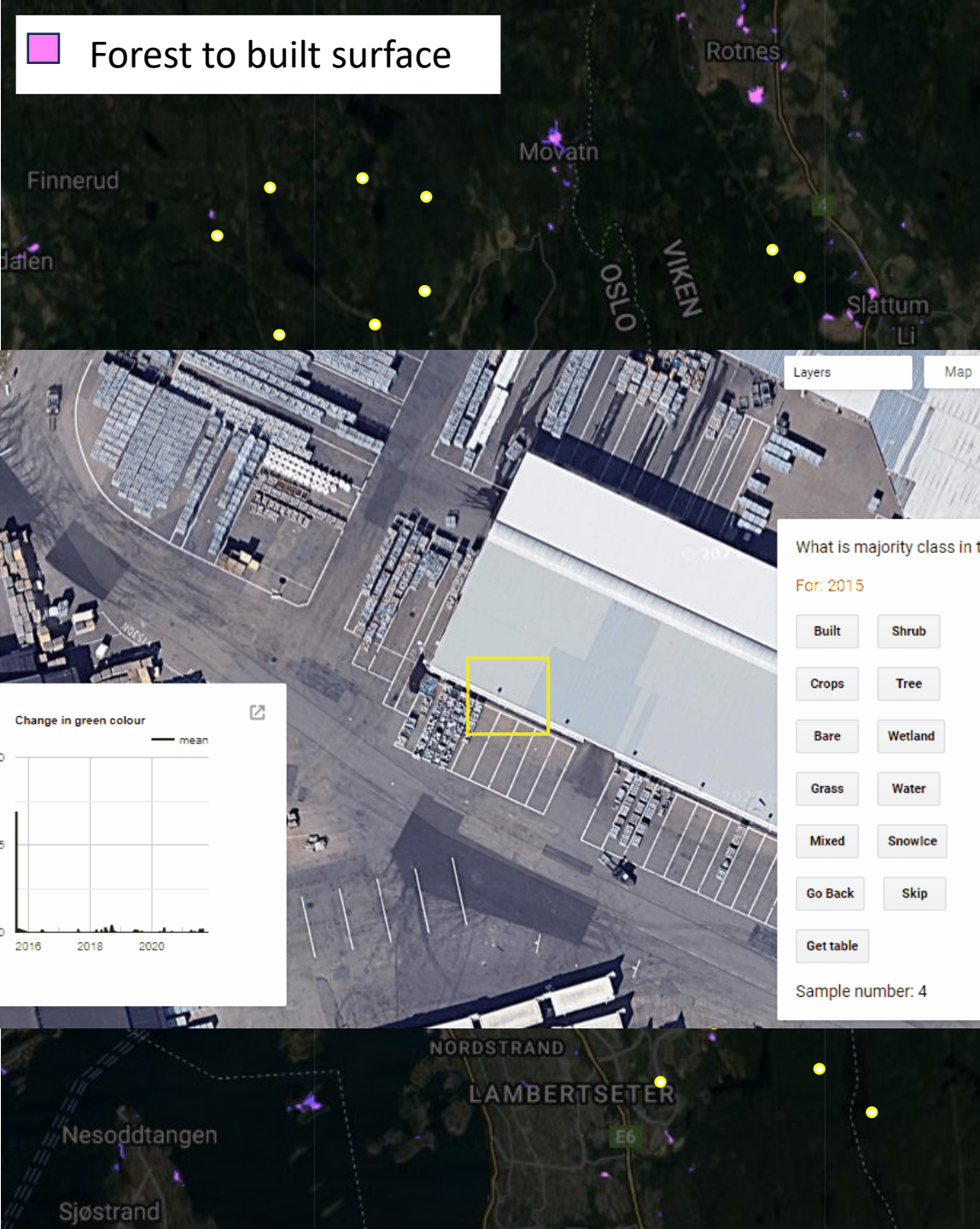
Design-based:
- 105 ± 30 ha

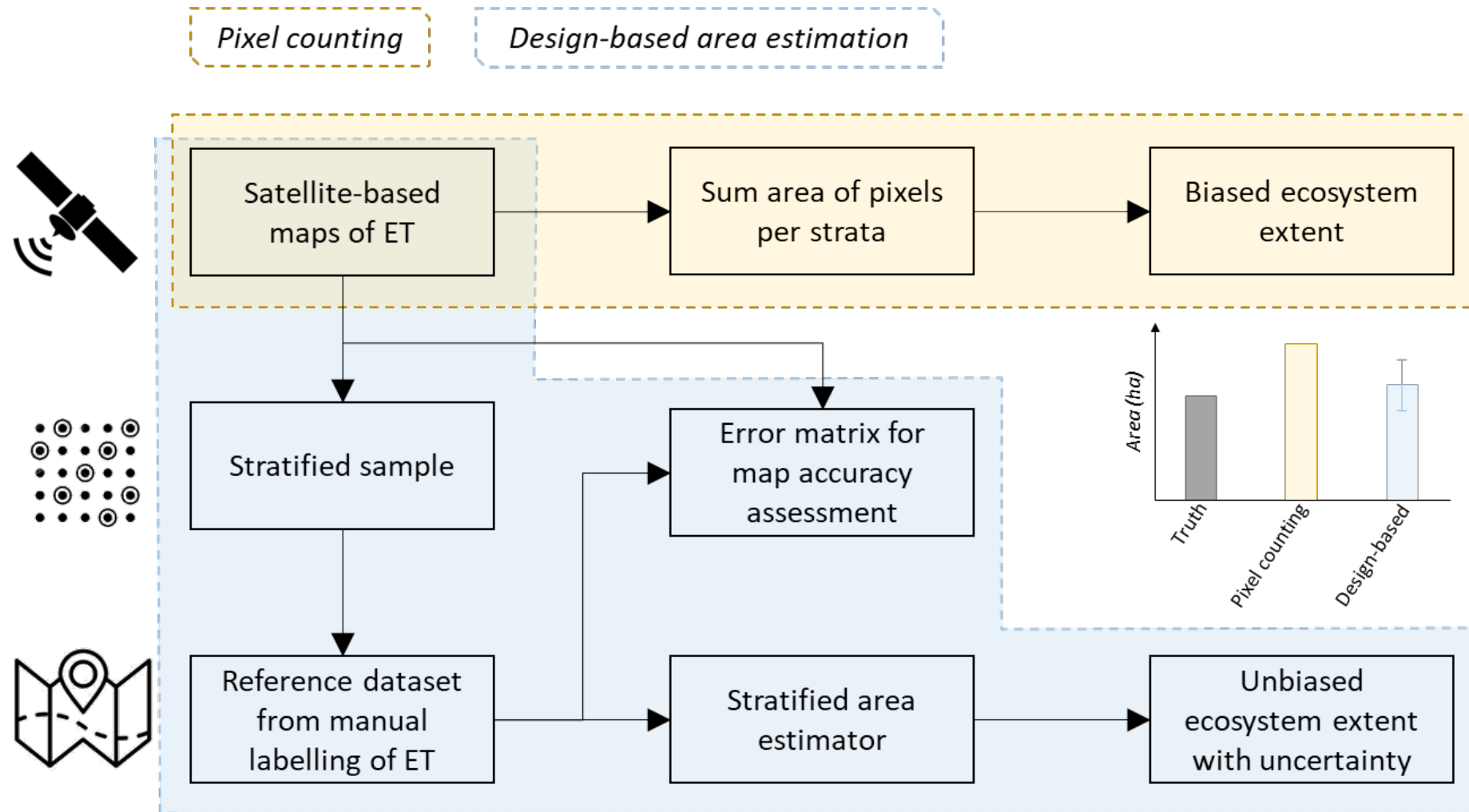


Review

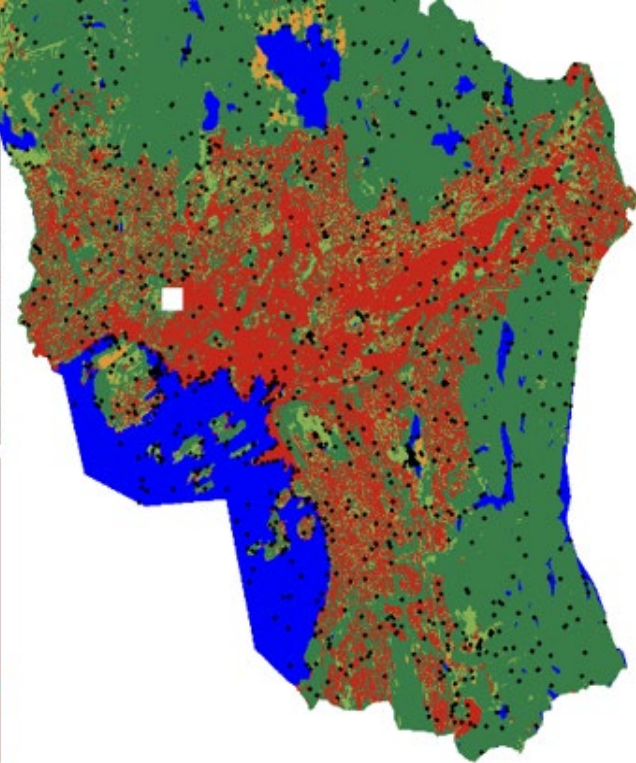
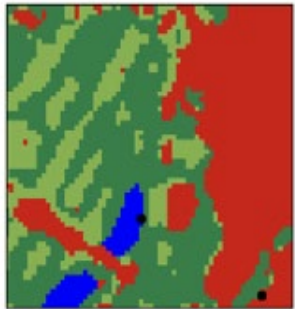
Good practices for estimating area and assessing accuracy of land change

Pontus Olofsson ^{a,*}, Giles M. Foody ^b, Martin Herold ^c, Stephen V. Stehman ^d,
Curtis E. Woodcock ^a, Michael A. Wulder ^e





Case-study in Oslo municipality 2015 and 2021



- Vegetation tall
- Vegetation short
- Water
- Bare/Built-up



PC = pixel counting
DB = design-based

Ecosystem extent account (ha)		Water		Bare		Vegetation tall		Vegetation short	
		PC	DB	PC	DB	PC	DB	PC	DB
2015 to 2018	Opening	4818*	6628 ± 565	11599*	8025 ± 640	30755*	28416 ± 954	903*	5006 ± 678
	Change	132*	-15 ± 94	868*	234 ± 166	-1137*	-281 ± 186	137	62 ± 163
	Closing	4951*	6613 ± 541	12467*	8259 ± 781	29618*	28135 ± 852	1040*	5069 ± 663
2018 to 2021	Opening	4951*	6749 ± 513	12467*	7895 ± 650	29618*	28014 ± 849	1040*	5417 ± 654
	Change	60*	-36 ± 78	-276*	-16 ± 120	165*	-34 ± 138	51	86 ± 124
	Closing	5011*	6713 ± 474	12190*	7879 ± 648	29783*	27981 ± 860	1091*	5503 ± 684

* PC areas which are significantly biased by exceeding the 95% CI of the DB estimates.

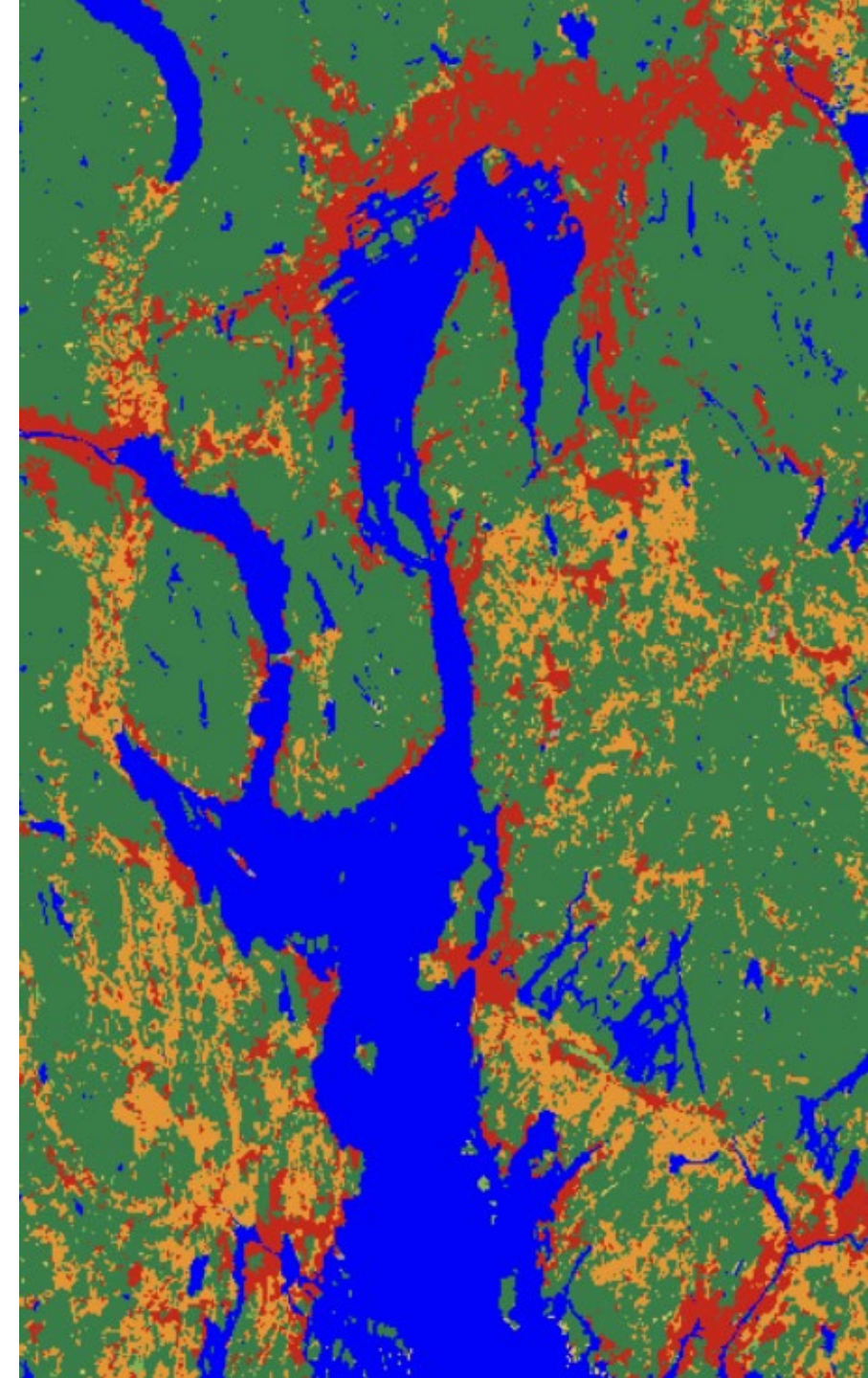
Bold: DB conversion estimates which reflect significant changes in ecosystem extent.

Key conclusions:

- Pixel counting from satellite-based land cover maps is standard practice in SEEA-EA
- Pixel counting can lead to biased area estimates – in Oslo's case an average bias of 150% difference from true value
- Design-based inference can produce unbiased area estimates with known uncertainty
- We found that simpler ecosystem typologies and longer accounting periods produced more certain extent accounts

Avenues for further research:

- The compounding effect of uncertainty in extent accounts down the ecosystem accounting cascade
- Challenge of very complex ecosystem typologies (IUCN Ecosystem Typology level 3 contains 108 classes – potential for 11664 conversion types)
- Problem of maintaining accounting identities in an uncertain world



Key recommendations:

- Pixel counting should be discouraged in SEEA-EA unless there are insufficient resources to support design-based area estimation from a photointerpretation survey.
- In cases where pixel counting takes place, this should be explicitly communicated and the potential for biased area estimates acknowledged.
- Longer accounting periods offer more precise extent change estimates and may be preferred.
- Simplified ecosystem typologies which are possible to classify reliably with remote sensing should be considered when estimating ecosystem changes with satellite-based extent maps.
- Need for SEEA-EA to develop standards for quantifying and disclosing uncertainty. An 'uncertainty audit' for ecosystem accounting could play an analogous role to that of an 'information systems audit' vis-à-vis corporate financial accounts.