CONTINENTAL SCALE VALIDATION OF ECOSYSTEM SERVICE MODELS

Simon Willcock, Danny A.P. Hooftman, Ioannis N. Athanasiadis, Kenneth J. Bagstad, Stefano Balbi, Ryan Blanchard, Terence P. Dawson, Patrick J. O'Farrell, Maike Hamann, Thomas Hickler, Malcolm D. Hudson, Mats Lindeskog, Javier Martínez-López, Alessia Marzo, Mark Mulligan, Carlo Prato, Belinda Reyers, Saverio Sciandrello, Kate Schreckenberg, Charlie Shackleton, Giovanni Signorello, Nadia Sitas, Ferdinando Villa, Brian Voigt, Sophie M. Watts, Felix Eigenbrod & James M. Bullock.

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Introduction

- Including ES in decision-making is critical

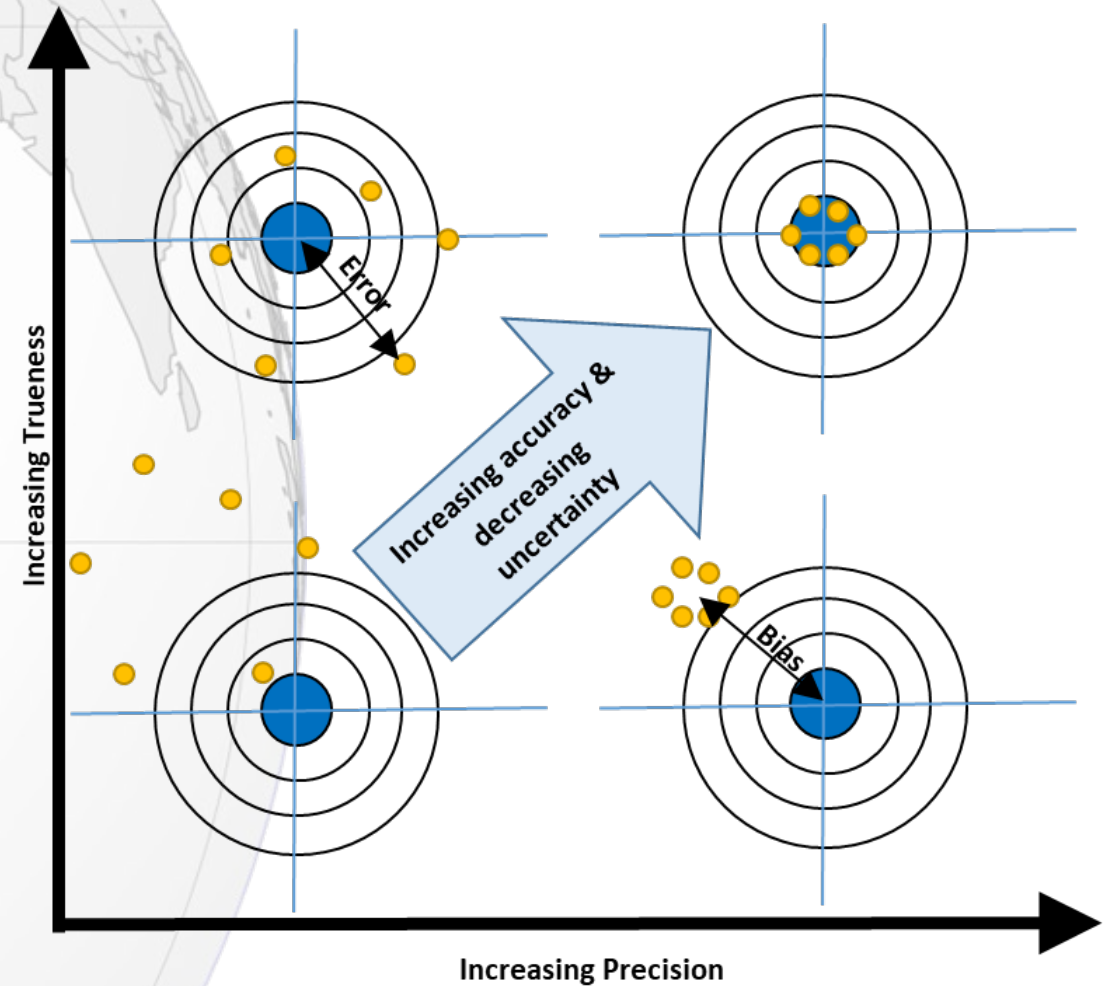| Stakeholders (n = 60)	Technical experts (n = 17)
92% are using ES approach	100% require scenarios
Only 27% have sufficient data	88% would use ranked information
>80% require information across different time points	ES models should be at least 90% accurate
	1–10 km^2 models are sufficient

Willcock, et al. *Ecosystem Services* 18 (2016): 110-117.
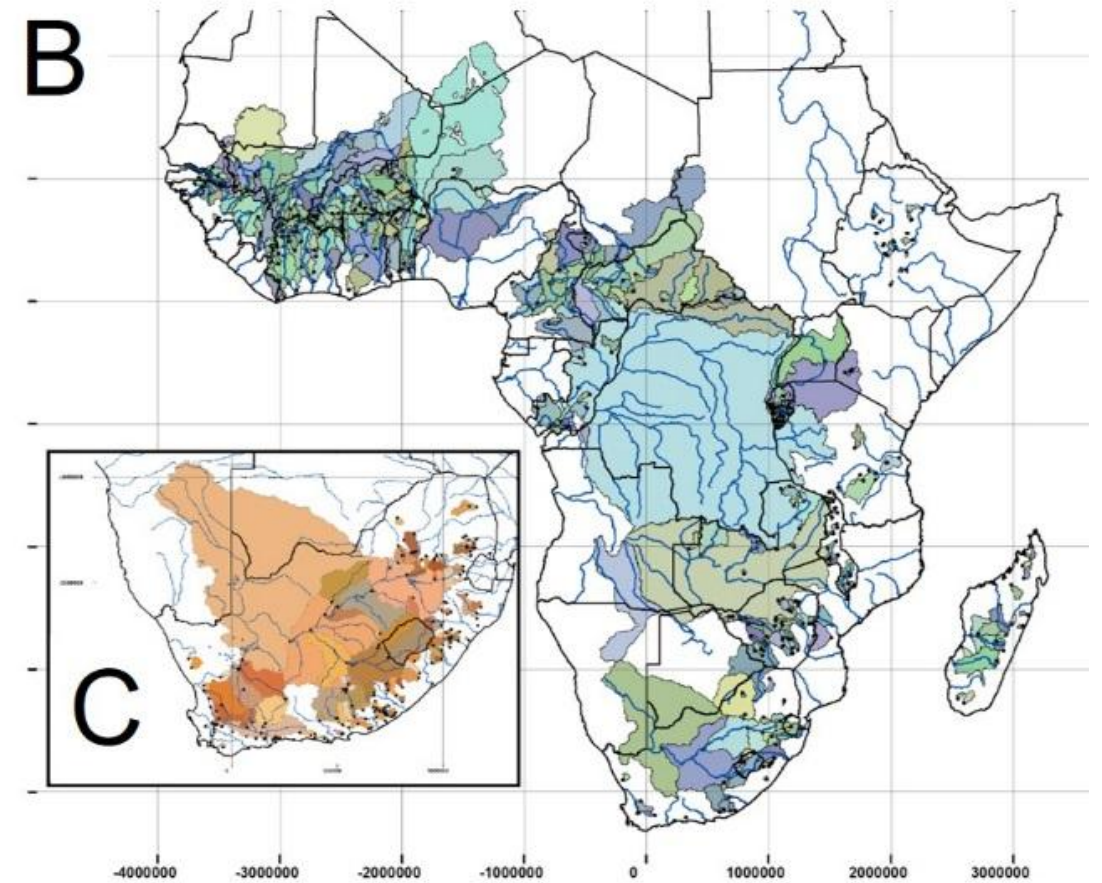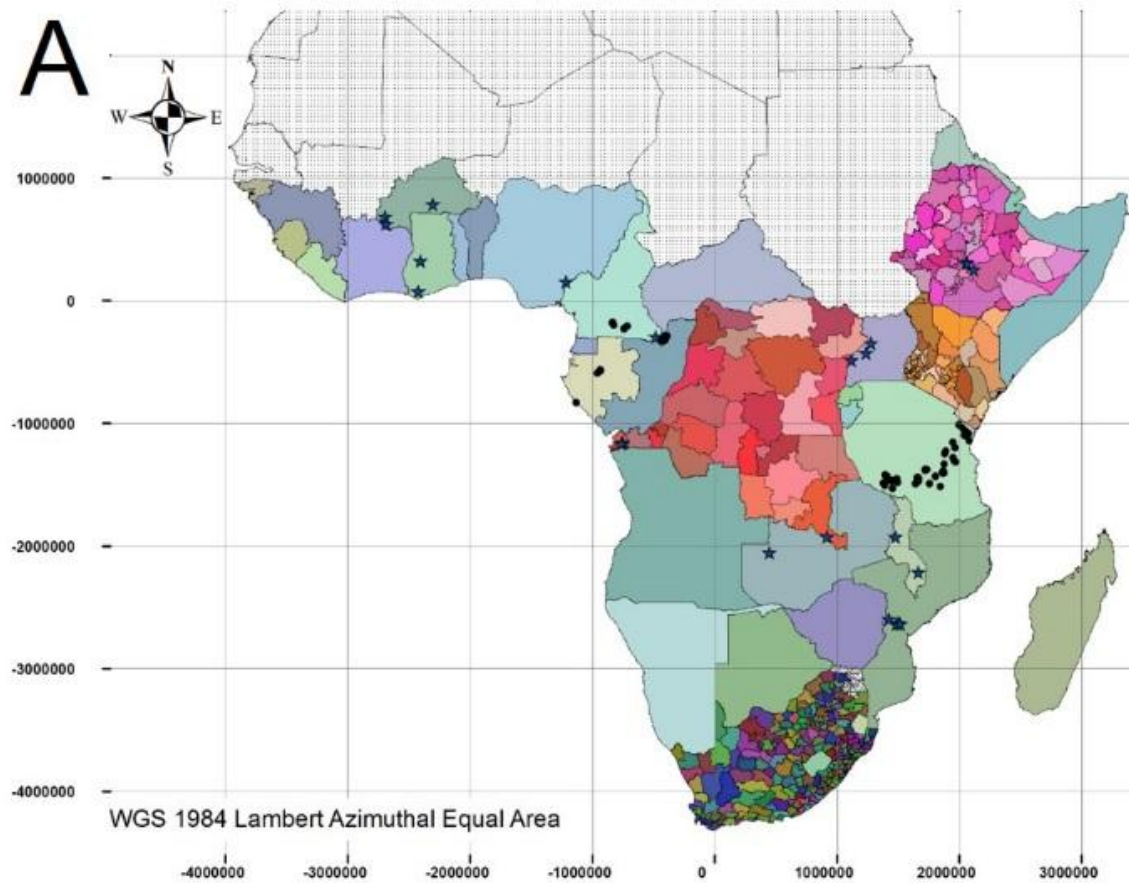
Can ES models fill this gap?

Introduction

- Many ES models are not validated against primary data

- We need to understand:
  - Trueness
  - Precision
  - Accuracy/certainty

Increasing Trueness

Error

Increasing accuracy & decreasing uncertainty

Bias

Increasing Precision

Willcock, et al. (in prep)

Model Validation
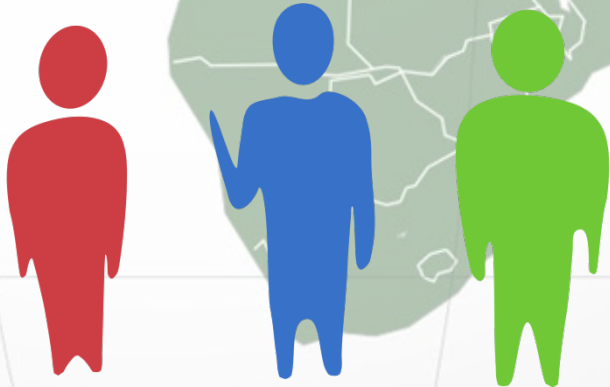

Willcock, et al. (in prep)

ES validation comparisons

- All models considered give **potential supply**. But 'true' (**realised**) values may be more dependent on **demand** for ES than potential supply of ES

- Tested this as follows:

 1) ES models (**potential ES**) vs validation data (**realised ES**)

ES validation comparisons

- All models considered give **potential supply**. But 'true' (**realised**) values may be more dependent on **demand** for ES than potential supply of ES

- Tested this as follows:

  2) Human population density (**demand**) vs validation data (**realised ES**)

ES validation comparisons

- All models considered give **potential supply**. But 'true' (**realised**) values may be more dependent on **demand** for ES than potential supply of ES

- Tested this as follows:

    3) **Potential ES model** X **Demand** vs validation data (**realised ES**)
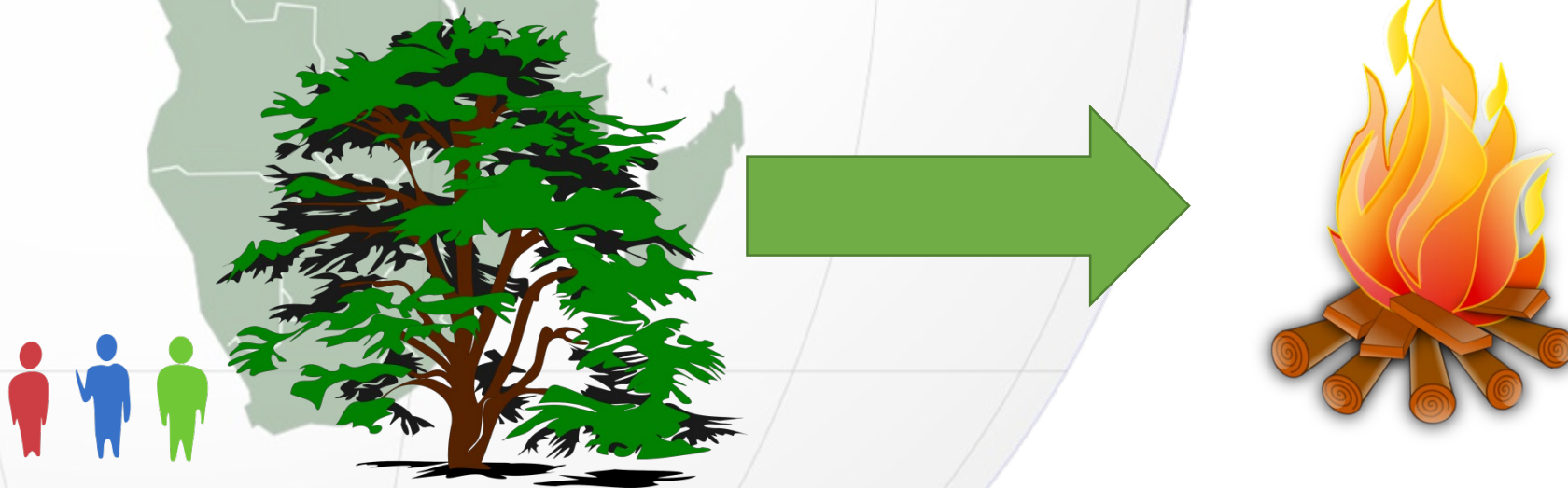
ES model validation

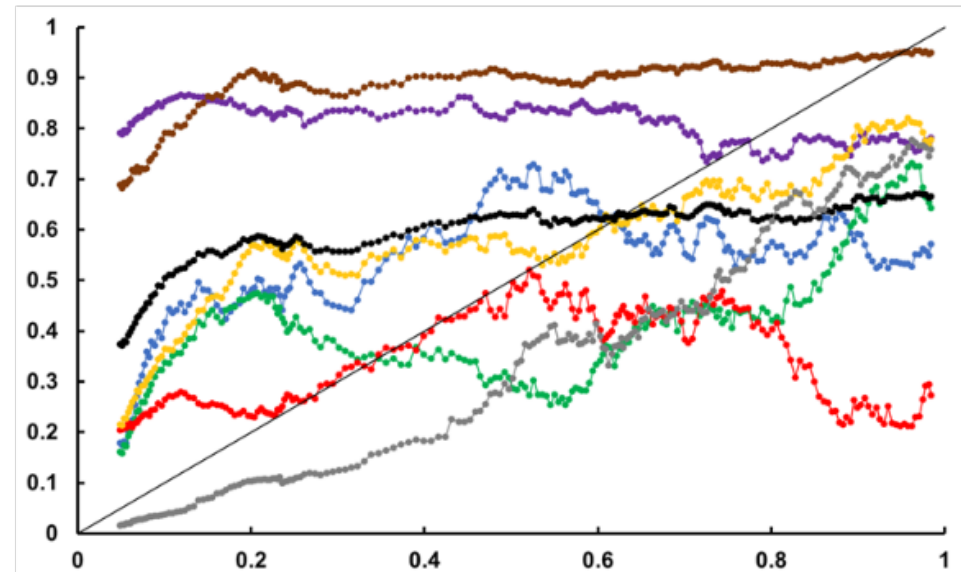| Service	Validator	Median Rho	Maximum Rho
Carbon	Biophysical	0.58	0.85
Charcoal	Use	0.19	0.51
Firewood	Use	0.32	0.79
Grazing	Use	0.38	0.84
Water	Biophysical	0.57	0.78

Willcock, et al. (in prep)

1 km gridcell — **10 km gridcell**

Potential ES (biophysical supply): Normalised comparator value of log$_{10}$ LSUs per hectare grazing area
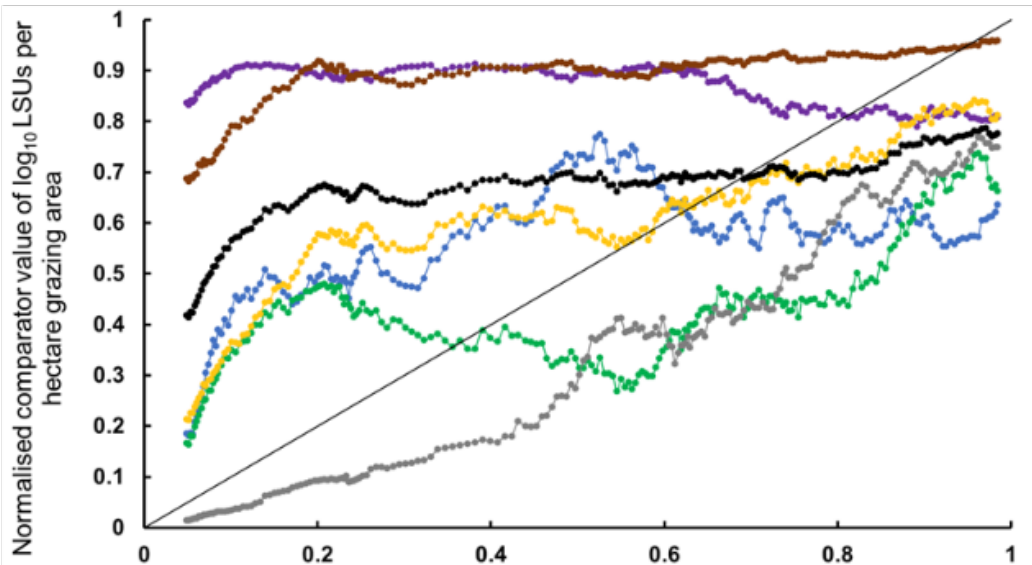
Realised ES (use), with added beneficiary layer: Normalised comparator value of log$_{10}$ LSUs per person per hectare grazing area

Normalised validation value of log$_{10}$ # persons with lifestock per hectare

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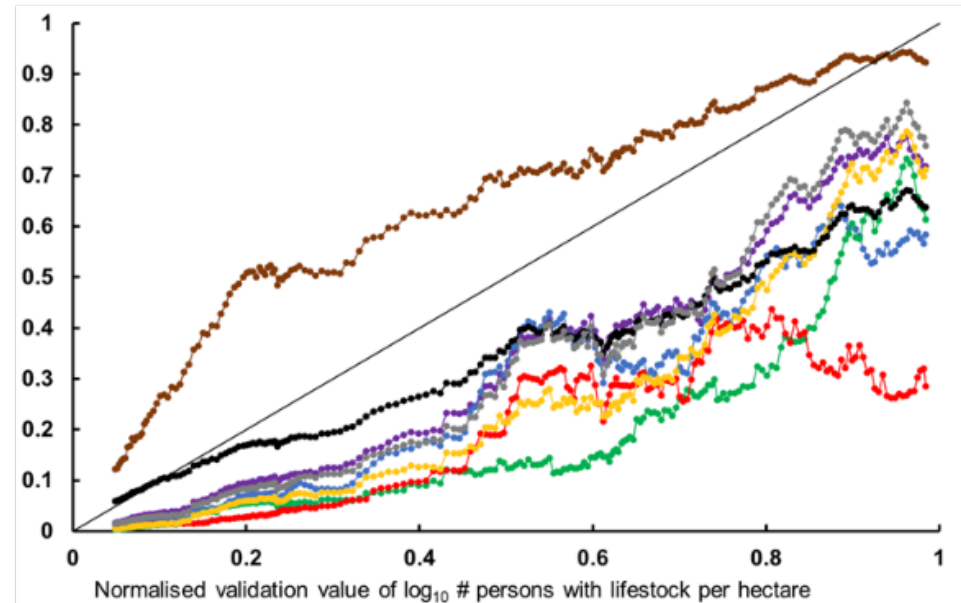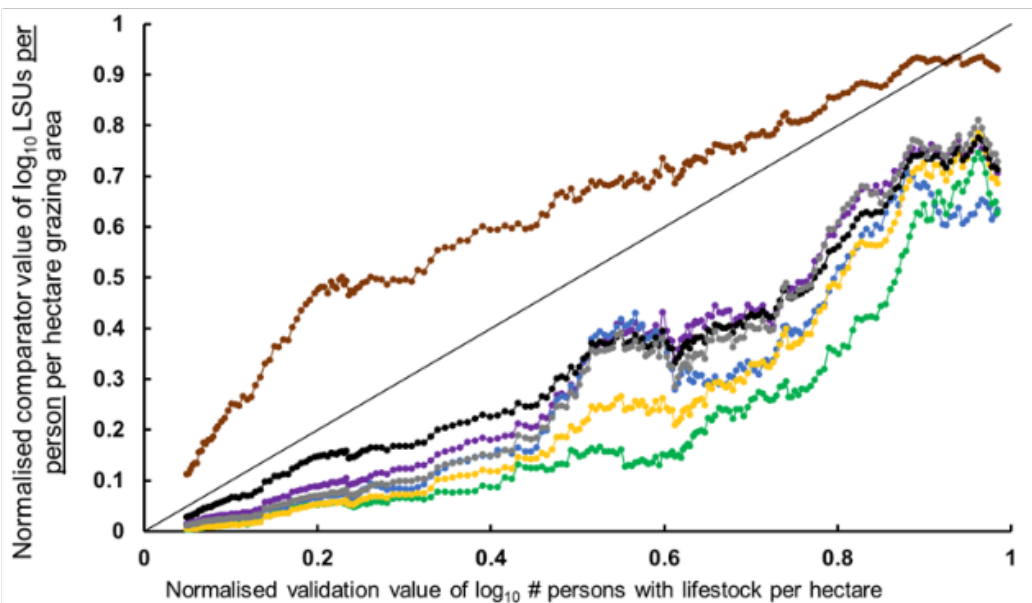
Legend:
- Complexity: 38
- Complexity: 34
- Complexity: 4
- Complexity: 36
- Complexity: 4
- Complexity: 2
- Ensemble model
- Population size

Model Complexity

- 7 out of 12 comparisons (58%) show no effect of model complexity on accuracy

- 5 (42%) show positive effects

- No cases of a negative effect

Model Ensembles

- 4 out of 12 comparisons (33%) show higher accuracy of model ensembles

- Ensemble variation was correlated with accuracy for potential ES models

- But, in 7 out of 8 comparison, realised ES show no correlation

Willcock, et al. (in prep)

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Machine-learning

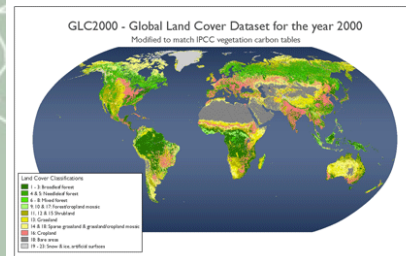| Model	Model Criteria	Recall for the upper quartile of firewood use (%)
ML Complexity: 14	50%	64.3
	75%	90.9
Complexity: 2	1 km	75.0
	10 km	73.2
Complexity: 4	1 km	75.0
	10 km	76.8
Complexity: 4	1 km	60.7
	10 km	60.7
Complexity: 36	55.6 km	76.8
Complexity: 31	5 km	53.6

Willcock, et al. (2018) *Ecosystem Services*
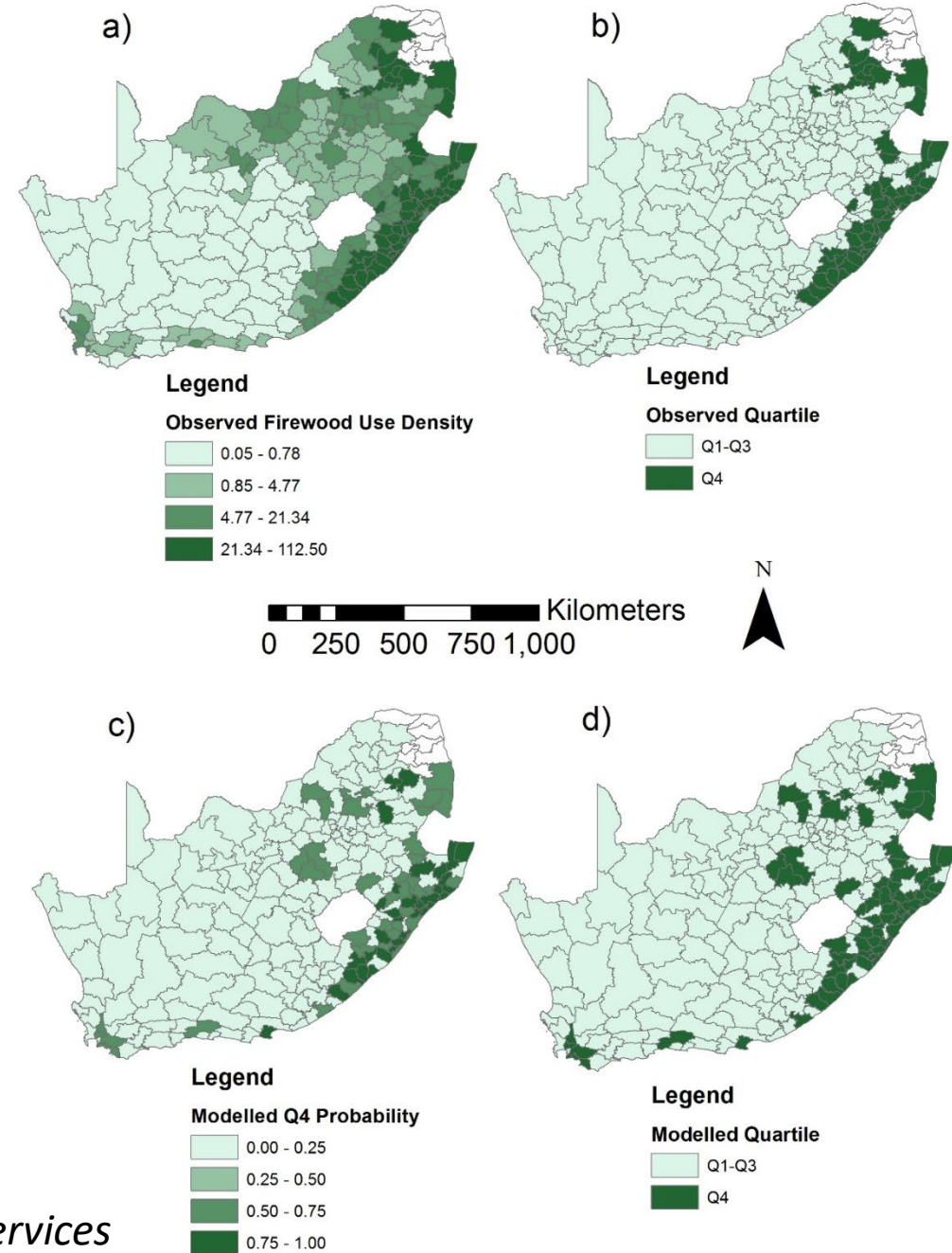
Conclusion

- ES models provide reasonable predictive power of potential ES, but are less accurate for predicting realised ES

- More complex ES models are often more accurate

- Where data is lacking, ensembles may indicate uncertainty

- The social component of realised ES models is important

- Machine-learning has a role to play when modelling ES (e.g. incorporating social-science 'big data')

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Thank you – to you, the data providers & the model developers

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