Using ecosystem water and carbon fluxes as integrated measures of reclamation success

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Problem statement

1. Lack of certainty on how to measure and demonstrate successful reclamation
2. Most current approaches rely on measurement of many variables

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A proposed (partial) solution

Use of measures of ecosystem fluxes of water and carbon to understand *integrated* ecosystem performance

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"Trait-based" reclamation assessment

An analogy is human-health assessment

We can look at a number of individual parameters:

- Glucose
- Cholesterol
- LDL
- HDL
- Triglycerides
- Fibrinogen
- Hemoglobin A1C
- DHEA
- Homocysteine
- C-Reactive protein

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Function-based reclamation assessment

e.g., eddy covariance

Or we can assess the ability of an individual to do work:

- This ability relies on the adequacy of a number of supporting functions

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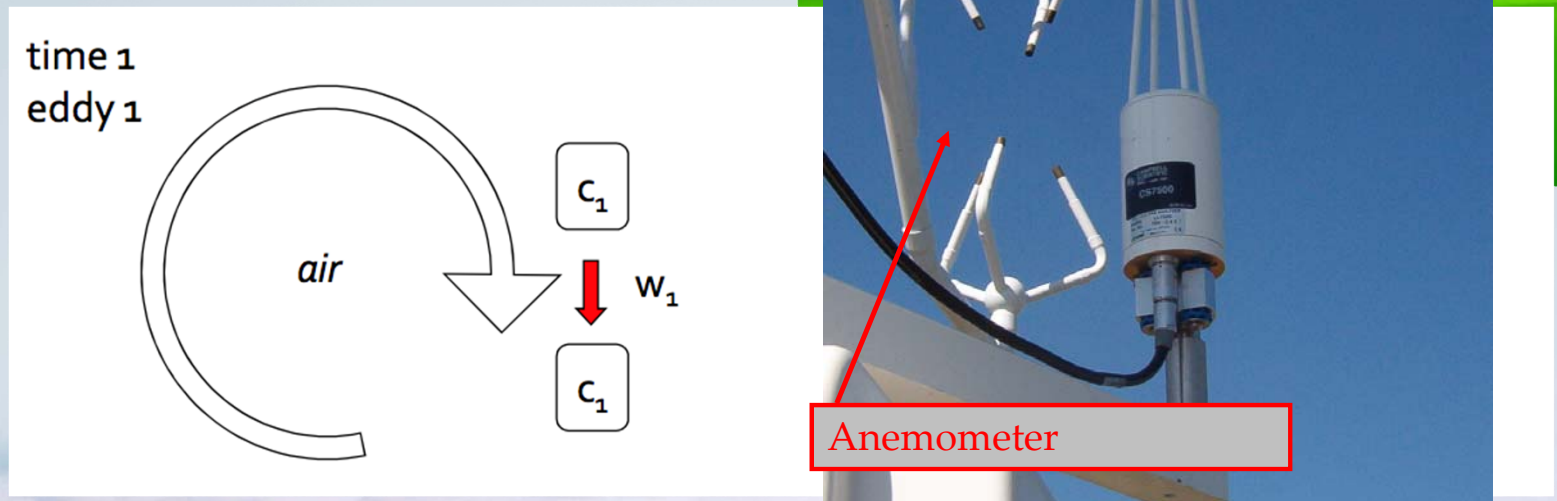
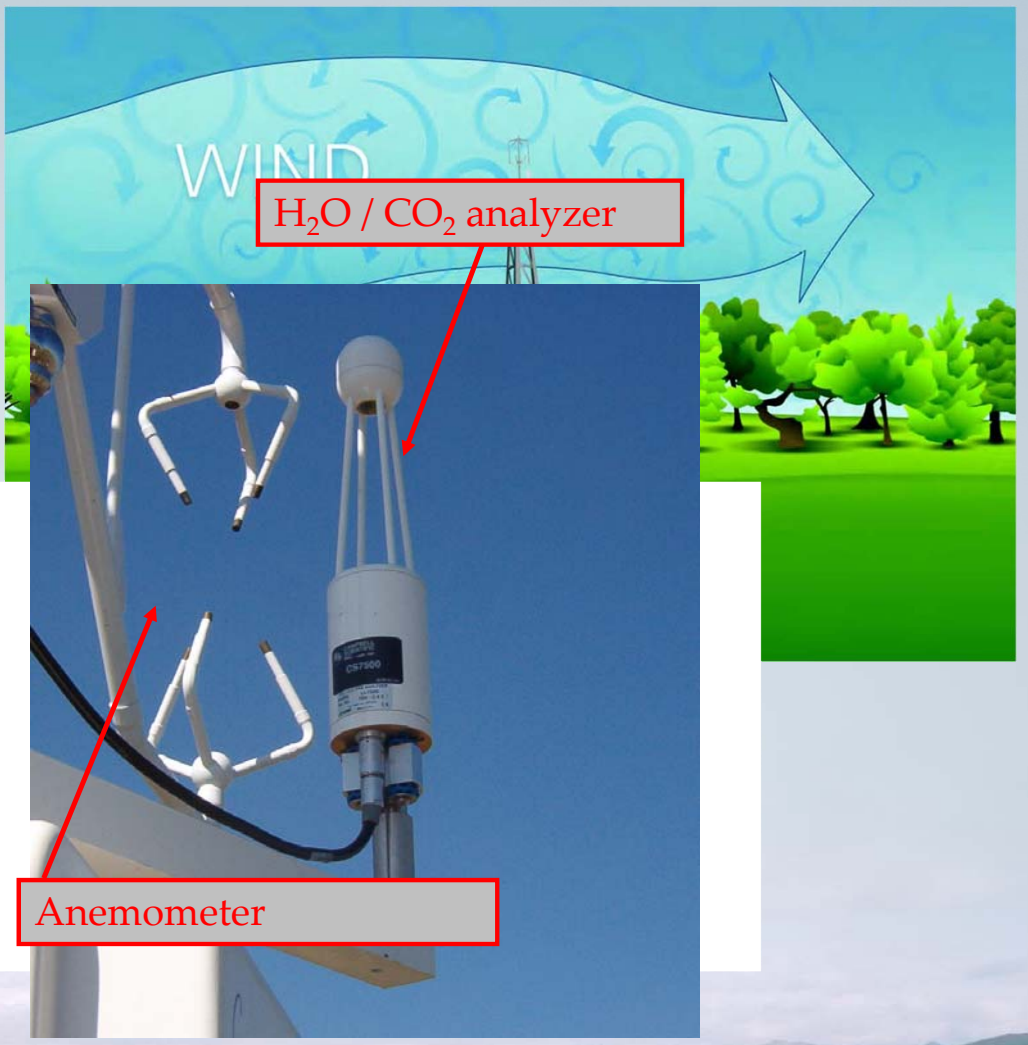
Eddy Covariance

Essence of method

- Vertical flux can be represented as a covariance of the vertical velocity and concentration of the entity of interest





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Collective study sites – uplands only

Reclaimed / Reference (disturbance)	Site age	Dominant tree species
Reclaimed	4	Black spruce, jack pine
Reclaimed	6	Aspen, white spruce
Reclaimed	6	Aspen, balsam poplar
Reclaimed	6, 10	Aspen, white spruce
Reclaimed	11	White spruce
Reclaimed	12	Jack pine
Reclaimed	15	Aspen
Reclaimed	20	Aspen
Reclaimed	22	Aspen, Larch
Reclaimed	25	Jack pine
Reference (harvest)	10	Aspen
Reference (harvest)	11	Aspen
Reference (fire)	73	Aspen
Reference (fire)	76	Aspen
Reference (fire)	89	Jack pine

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Mature (Pre-Harvest) Reference Site - Fresh

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Juvenile (Post-Harvest) Reference Site - Fresh

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Juvenile Reclaimed Site - Fresh

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Juvenile Reclaimed Site - Fresh

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Juvenile Reclaimed Site – Fresh

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Juvenile Reclaimed Site – Dry

Juvenile Reclaimed Site – Dry

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Juvenile Reclaimed Site – Dry

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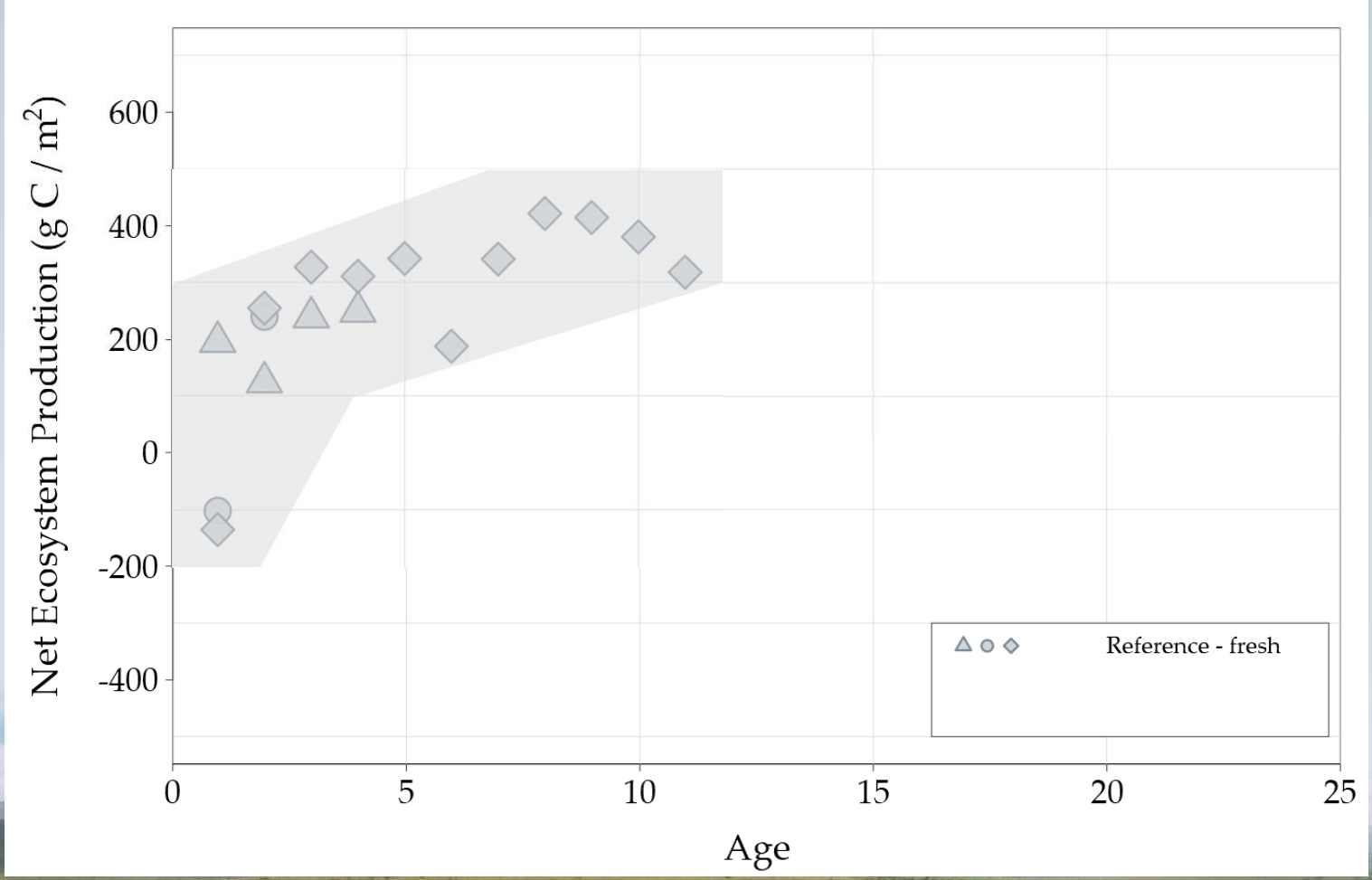
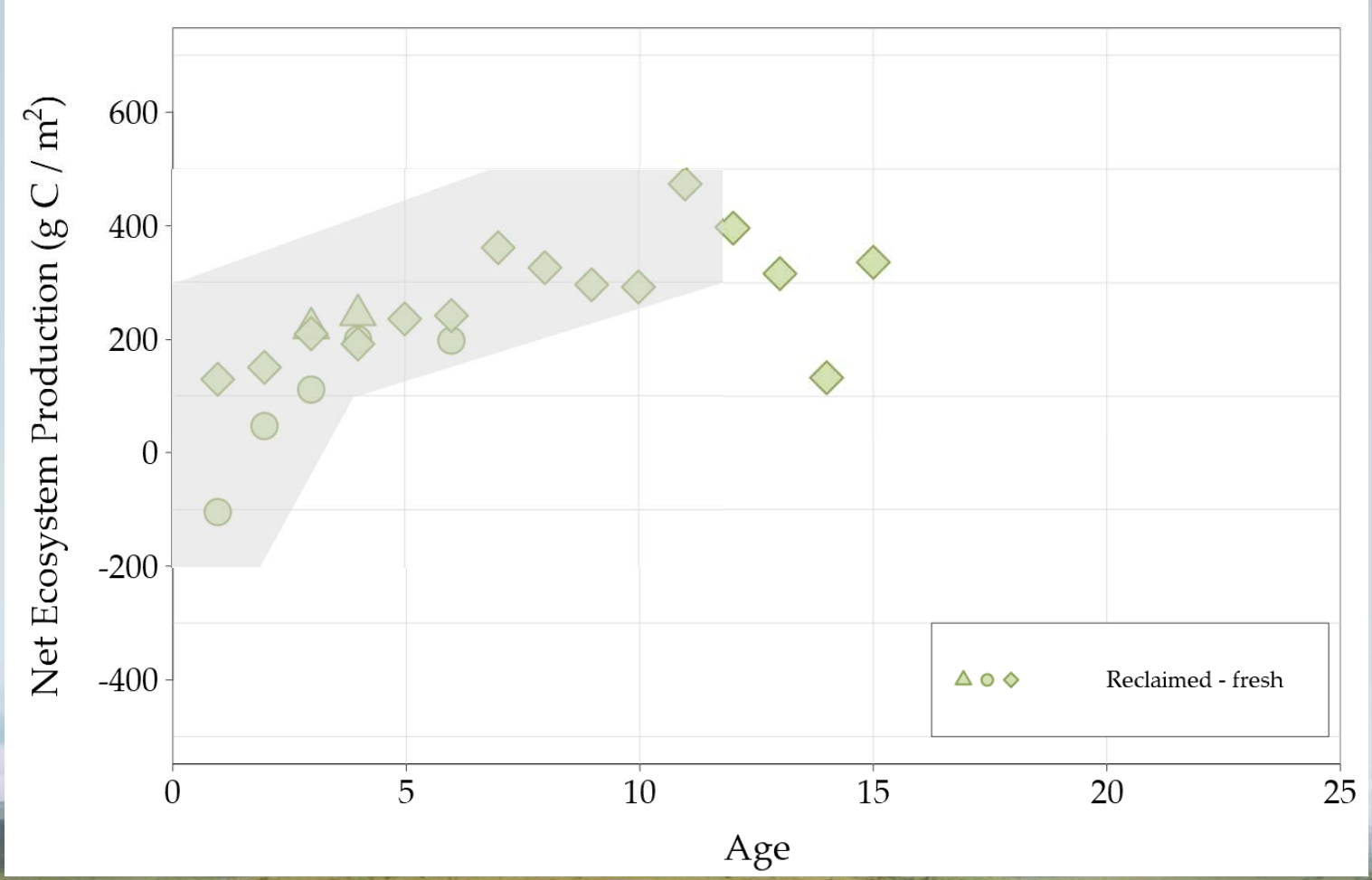
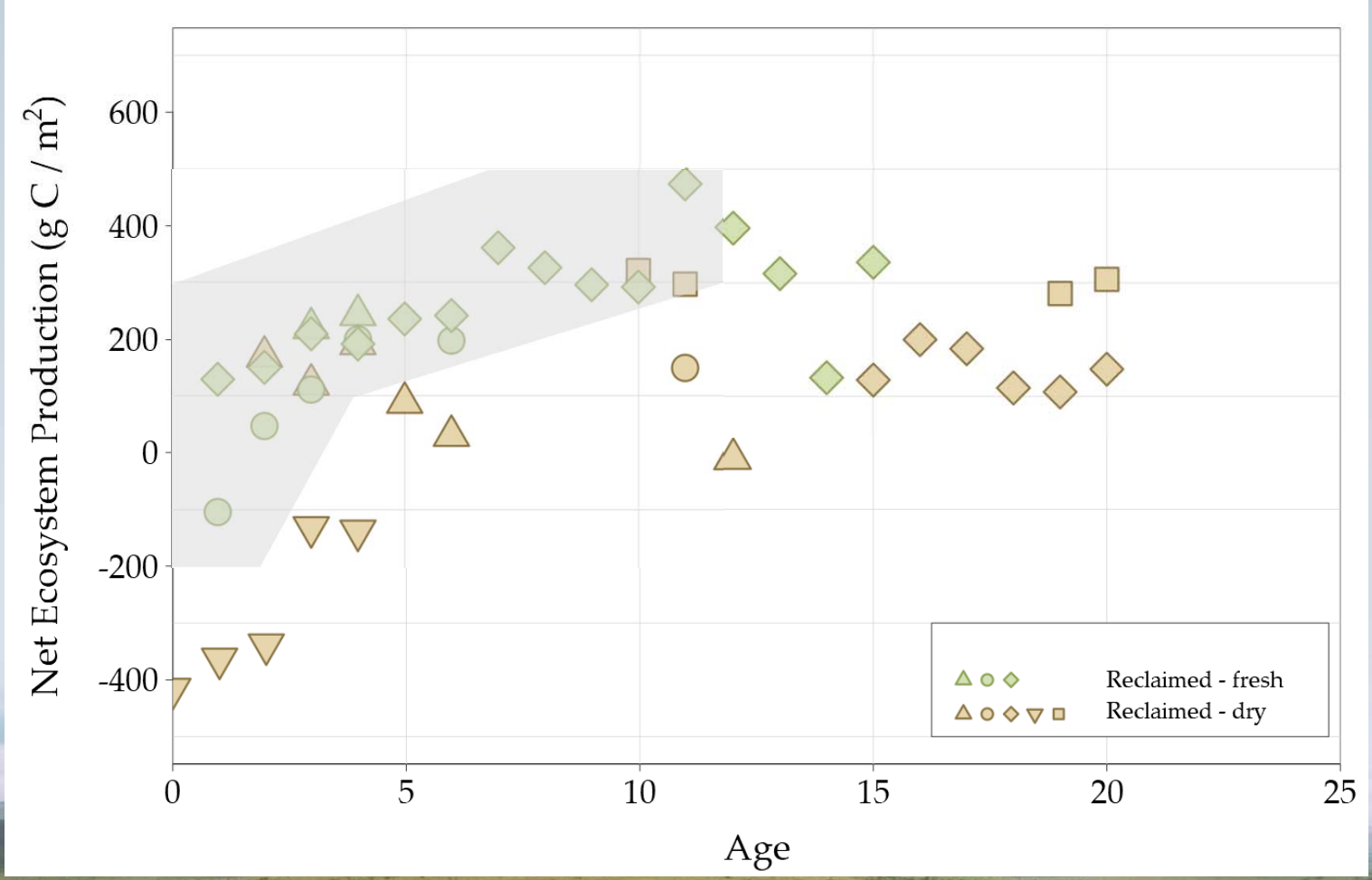
Net carbon production – reference sites only



Net carbon production – "Fresh" reclaimed sites



Net carbon production – "Fresh" and "Dry" reclaimed sites



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Challenges with flux measures

- Requires expertise to install, maintain, and process data
- Equipment costs and labour are not insubstantial
- These factors do not restrict its use as a research and monitoring tool, but they do restrict the number of sites that can be feasibly maintained

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Extrapolating findings to non-instrumented sites

- We have tested relationships between flux measures and a number of simpler biometrics, with leaf-area index (LAI) proving most useful to date

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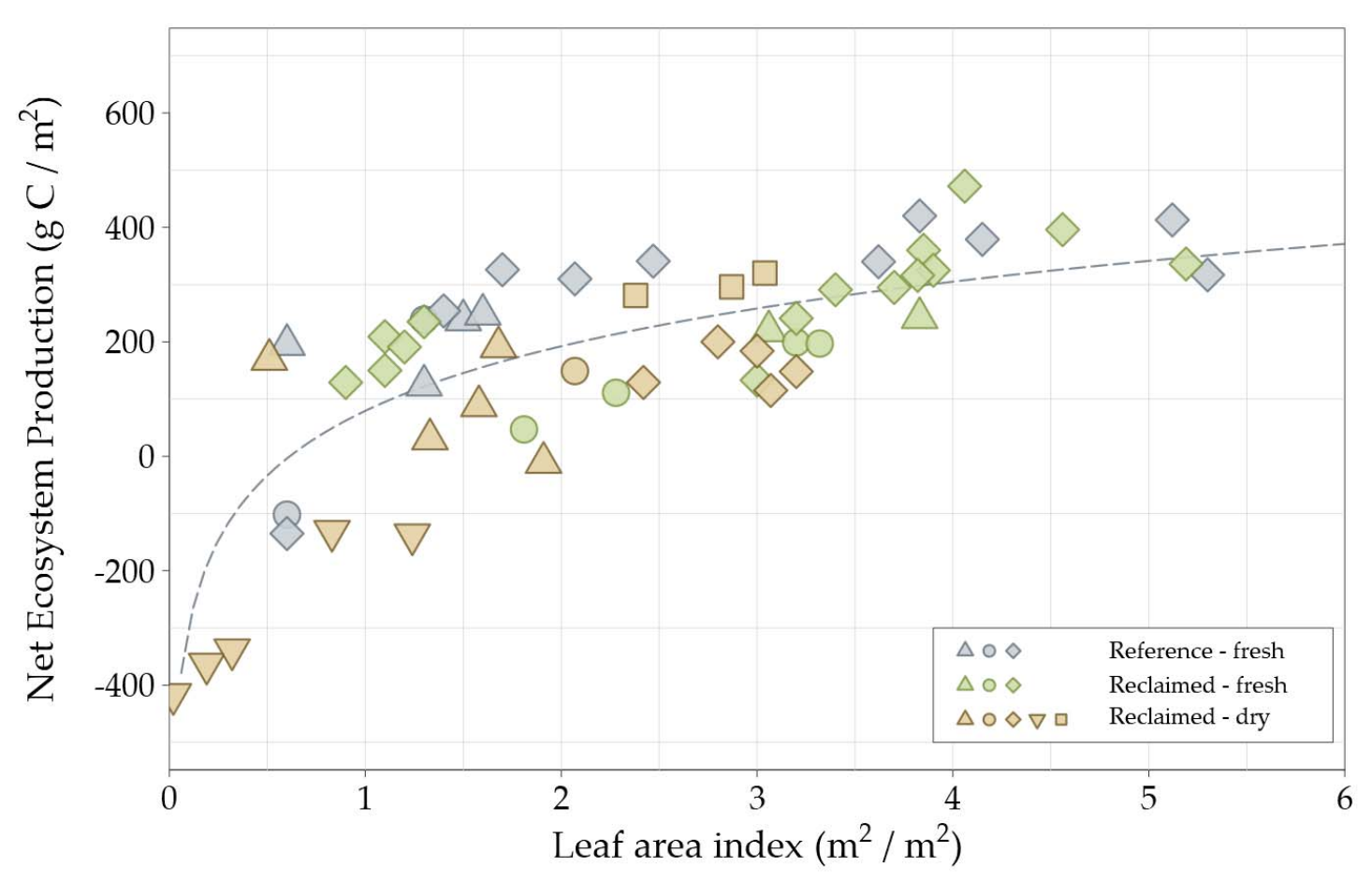
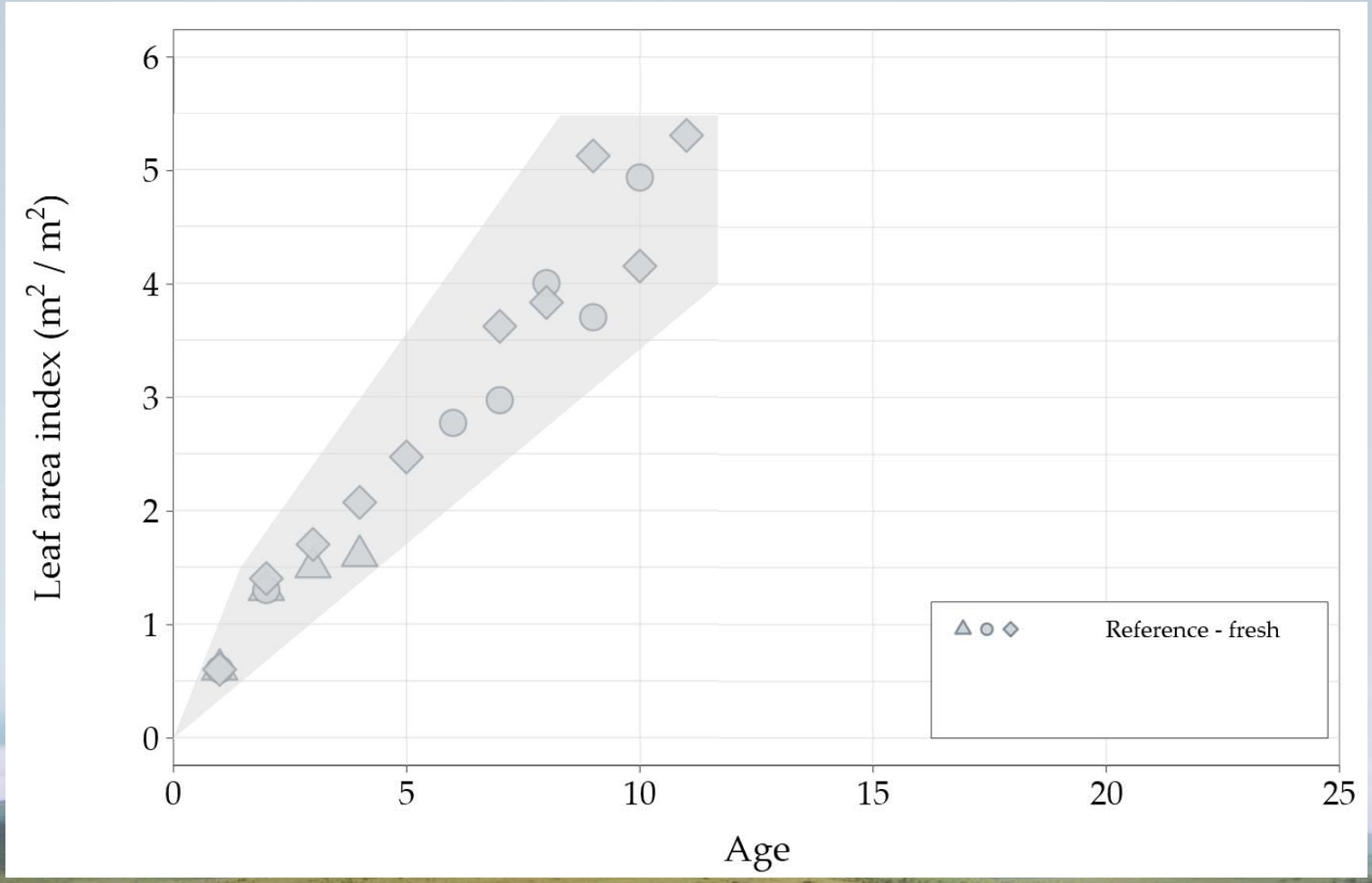
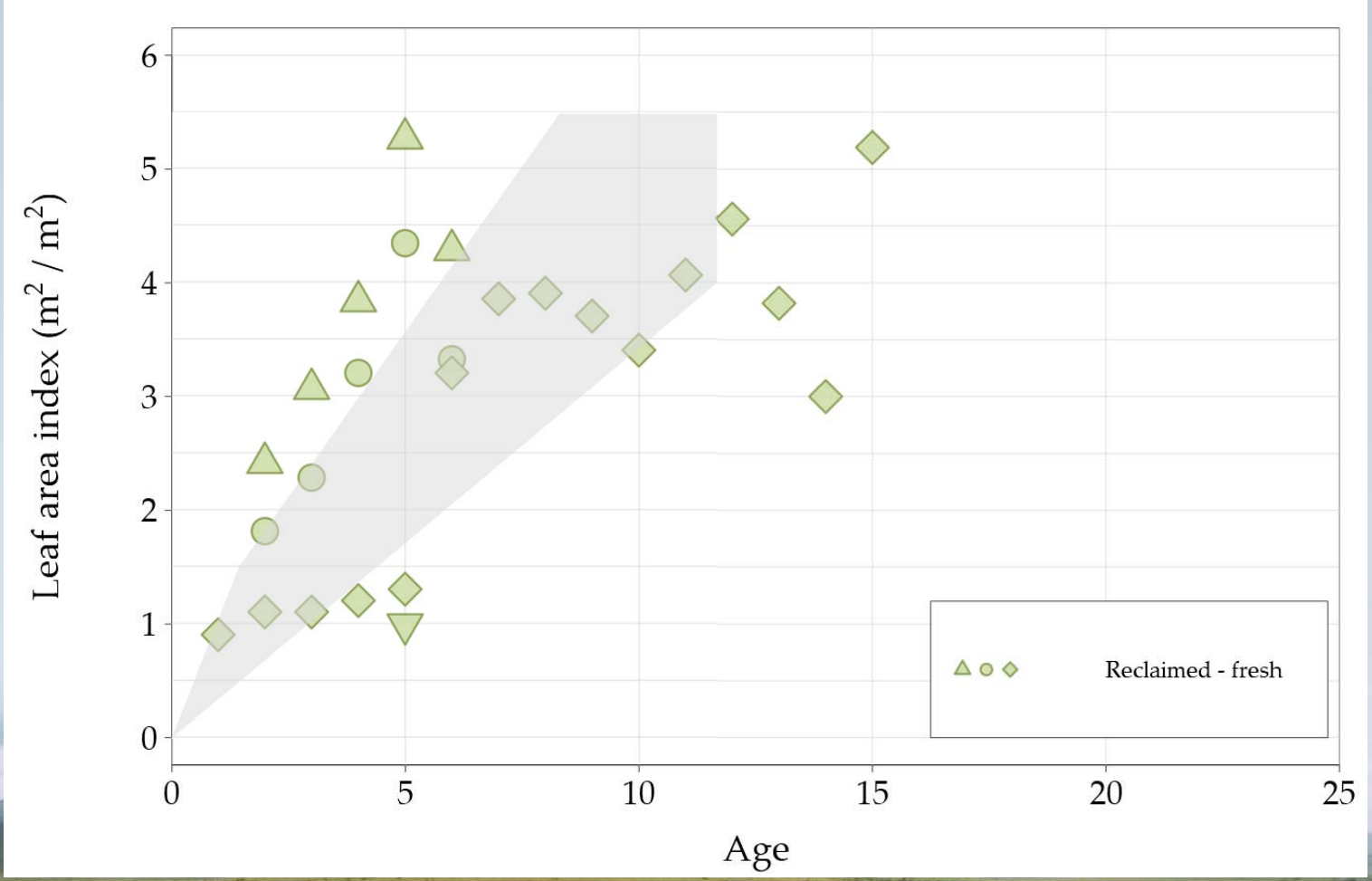
Net carbon production and LAI – reference and reclaimed sites



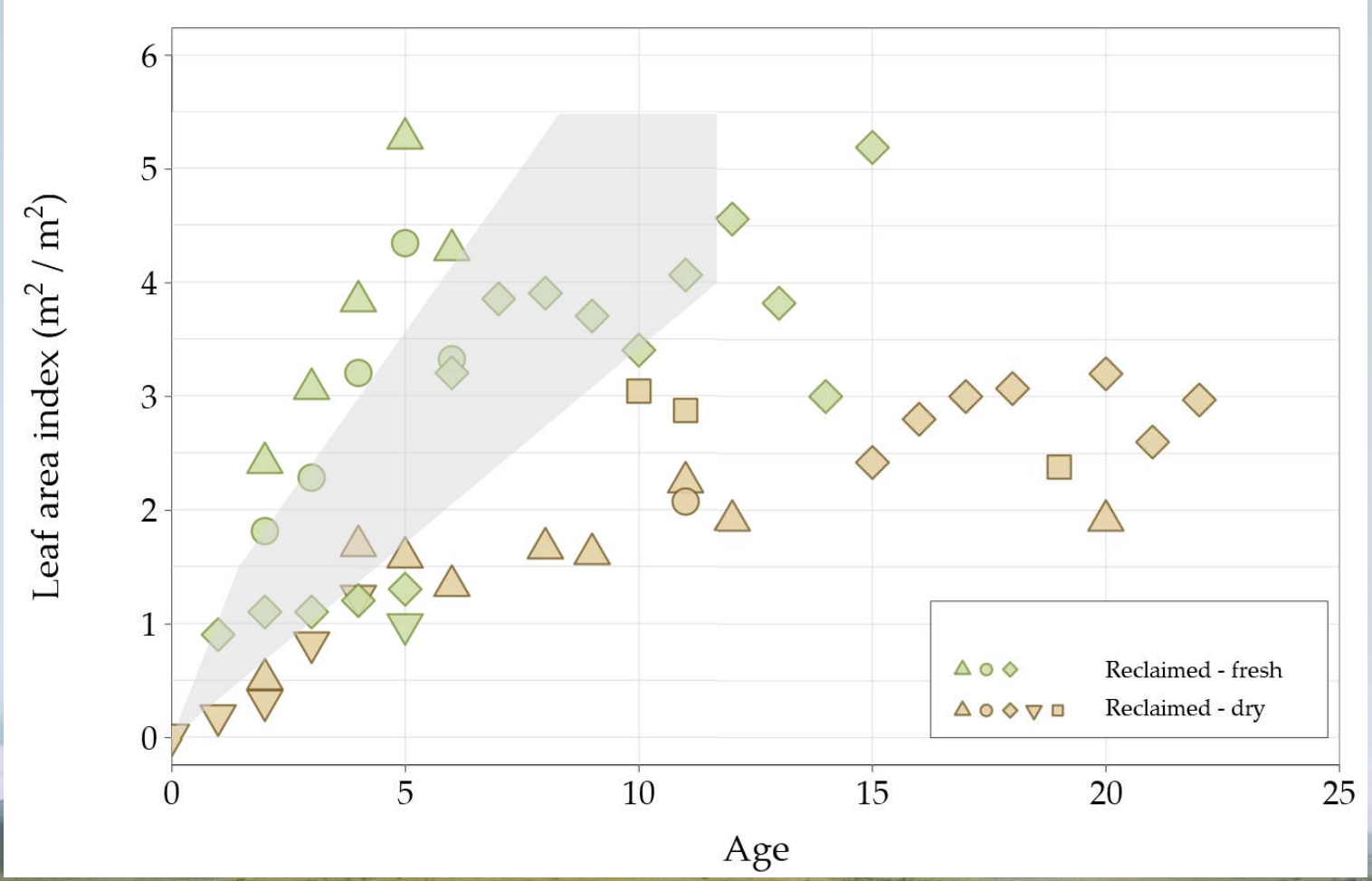
LAI-age trajectories – reference sites only



LAI-age trajectories – "Fresh" reclaimed sites



LAI-age trajectories – "Fresh" and "Dry" reclaimed sites



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Extension of the method to Yukon sites – Faro and Wolf Ck.

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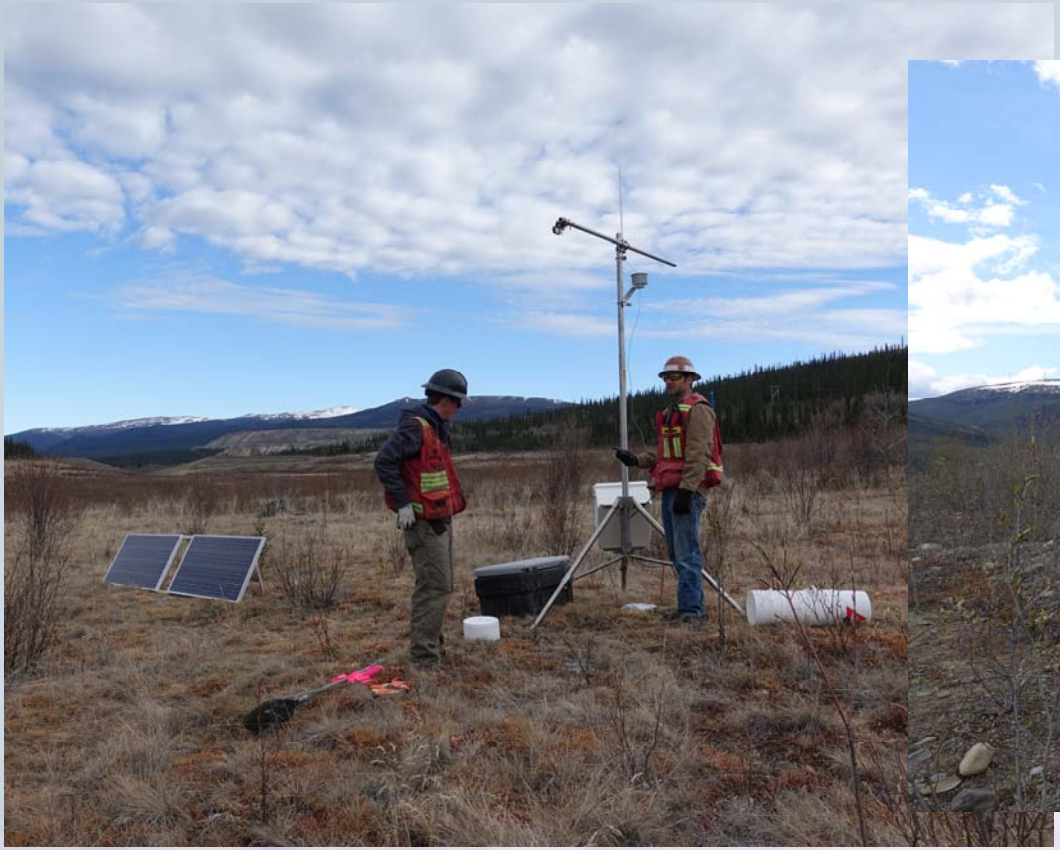

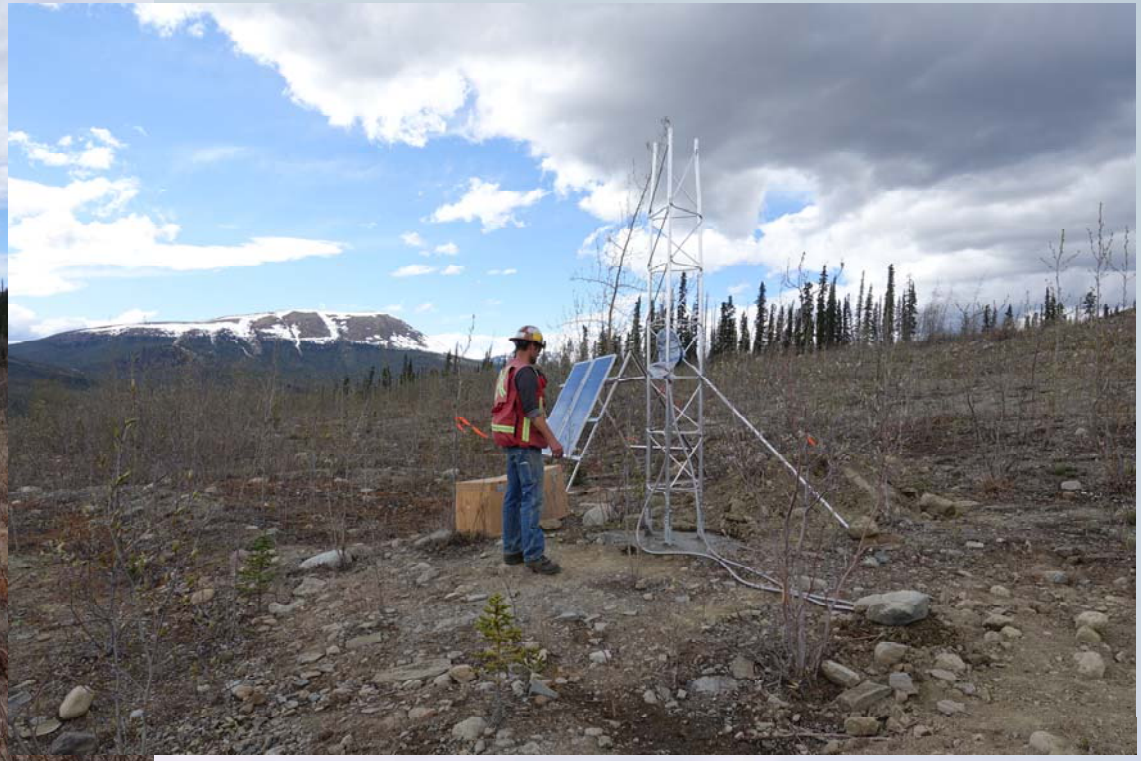

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Conclusions

- Flux measures are integrative over space and time, and measure the ability of a number of ecosystem functions to support carbon, water, and energy cycling

- These measures can be used to define natural ranges of variation (performance envelopes derived from reference-site data)

- These ranges in turn can be used to provide a function-based definition of land capability

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Conclusions

- We can relate flux measures to ground-based (and potentially remote) biometrics that can be spatially deployed across a much broader range of sites and used to assess performance and capability

- Key site characteristics (soil water regime) can be used to stratify site performance

- Data to date suggests reclaimed sites are achieving equivalent capability as defined by this approach, and supporting ecosystem functions that allow them to perform similarly to non-mine sites

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Objective

- Leverage the integrative nature of flux measurements to develop simple and scalable measures of reclamation function, performance, and equivalent capability

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Ways in which flux measures are integrative

Image courtesy of S. Strilesky.

1. Literally
2. Spatially
3. Temporally
4. In the functions represented

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