Nutrient cycling and successional dynamics: implications for green roof design and management

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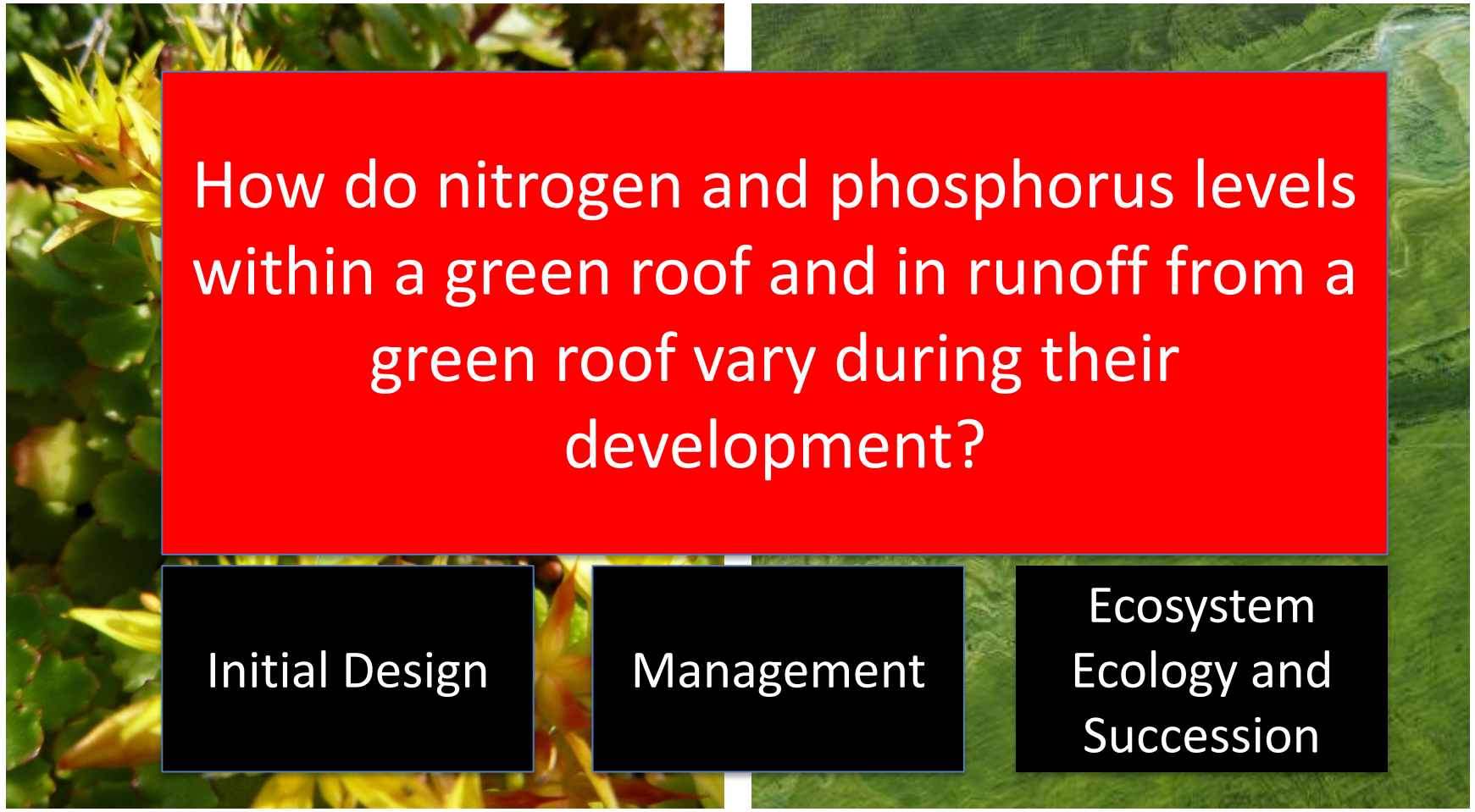
The Nutrients Nitrogen and Phosphorus Limit Ecosystem Productivity



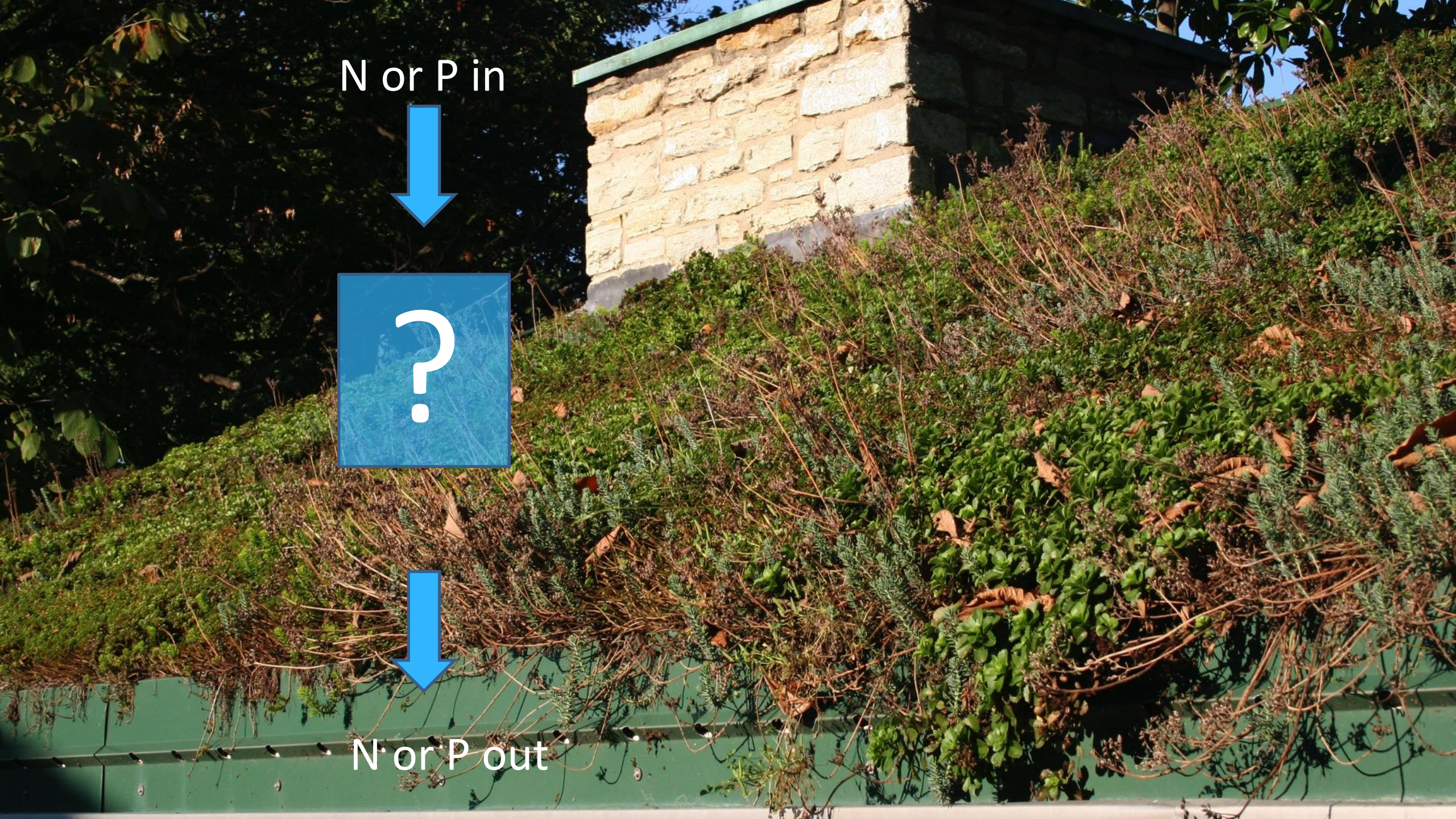
How do nitrogen and phosphorus levels within a green roof and in runoff from a green roof vary during their development?

Initial Design

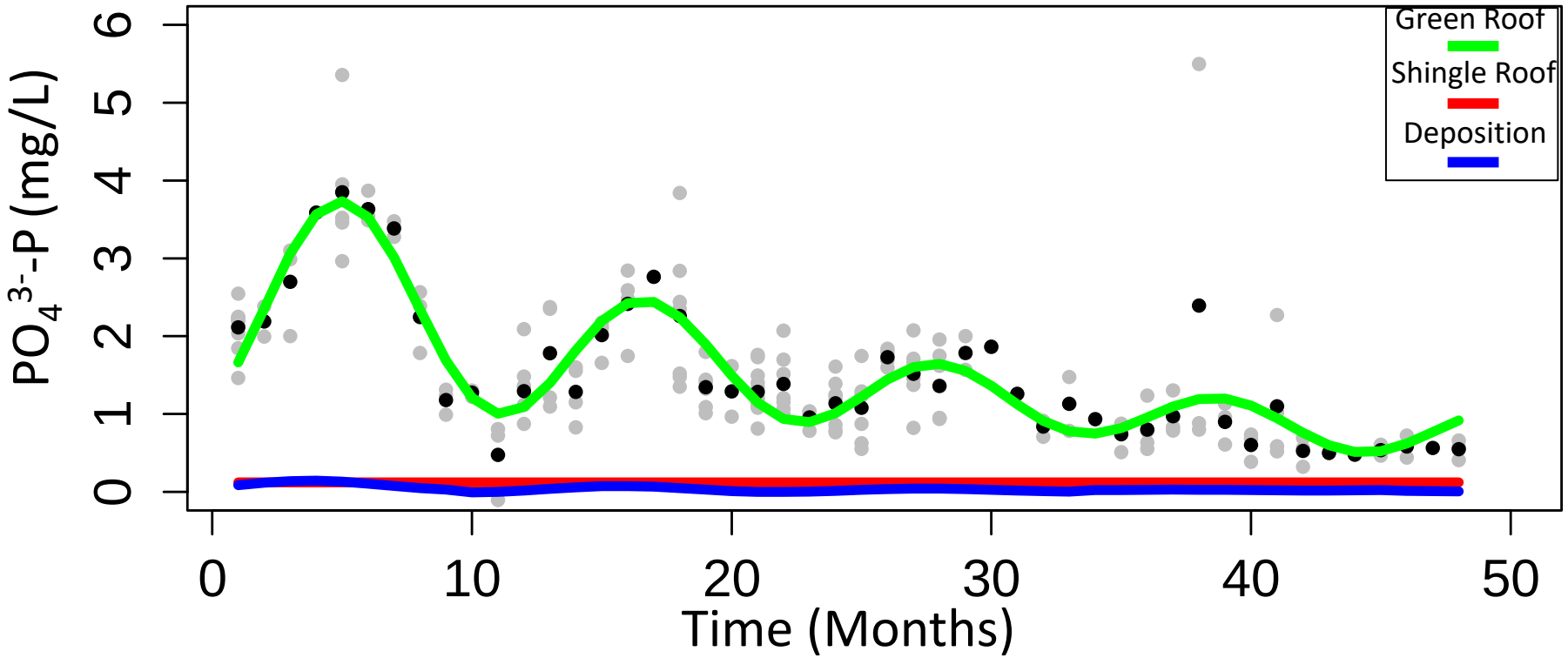
Management

Ecosystem Ecology and Succession

nationalgeographic.com

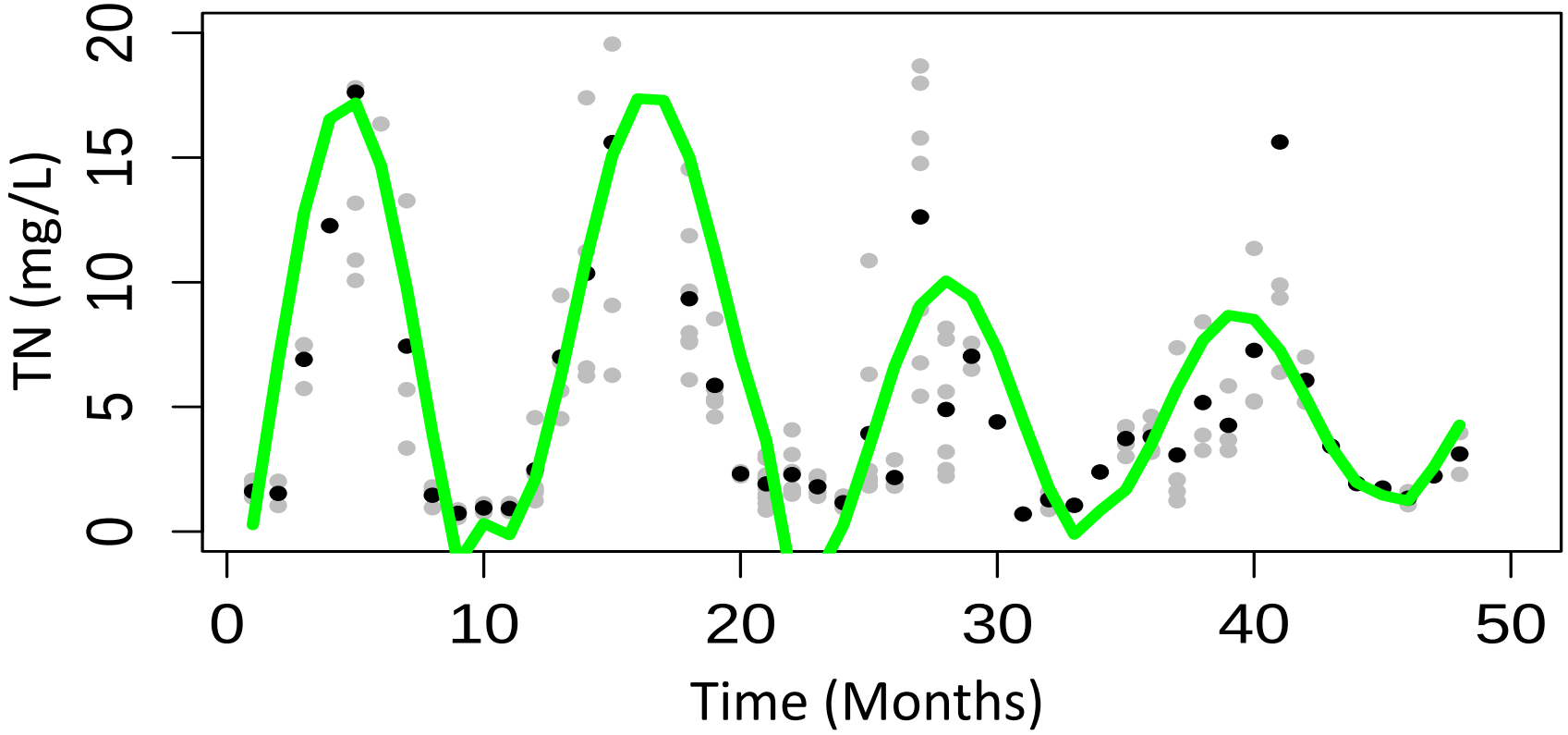

N or P in
?
N or P out

How do green roof Nitrogen and Phosphorus dynamics change over time?



Mitchell et al. 2017

How do green roof Nitrogen and Phosphorus dynamics change over time?

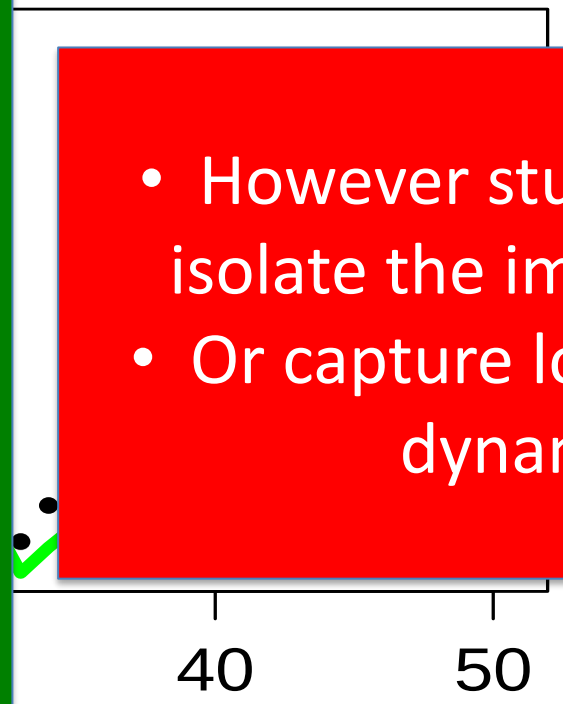


Mitchell et al. 2016

How do green roof Nitrogen and Phosphorus dynamics change over time?

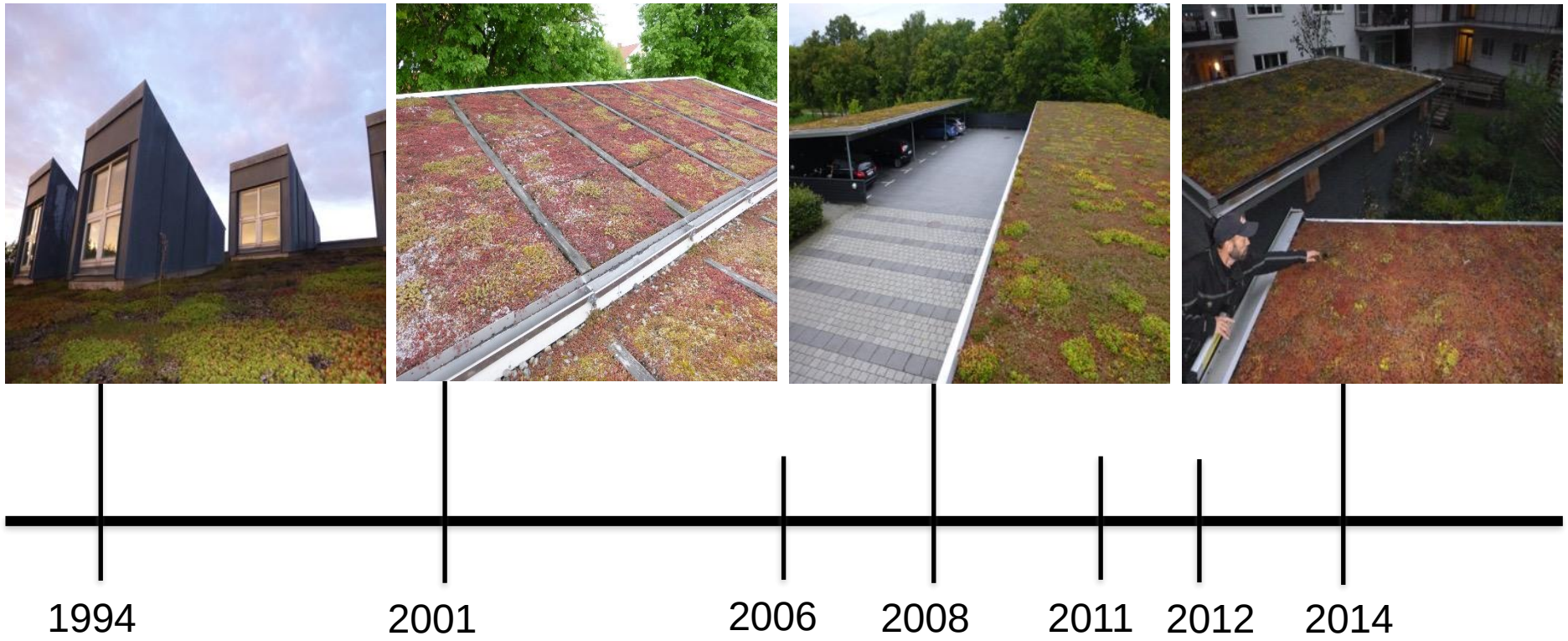
- Indicates surplus of N and P relative to biological demands
- Suggests a declining pool of N and P in the ecosystem and/or an establishing plant community
- Models suggest several roofs in the region will serve as sources of N for several years and P for 10 or more years following installation

- However study did not isolate the impact of age
- Or capture longer-term dynamics



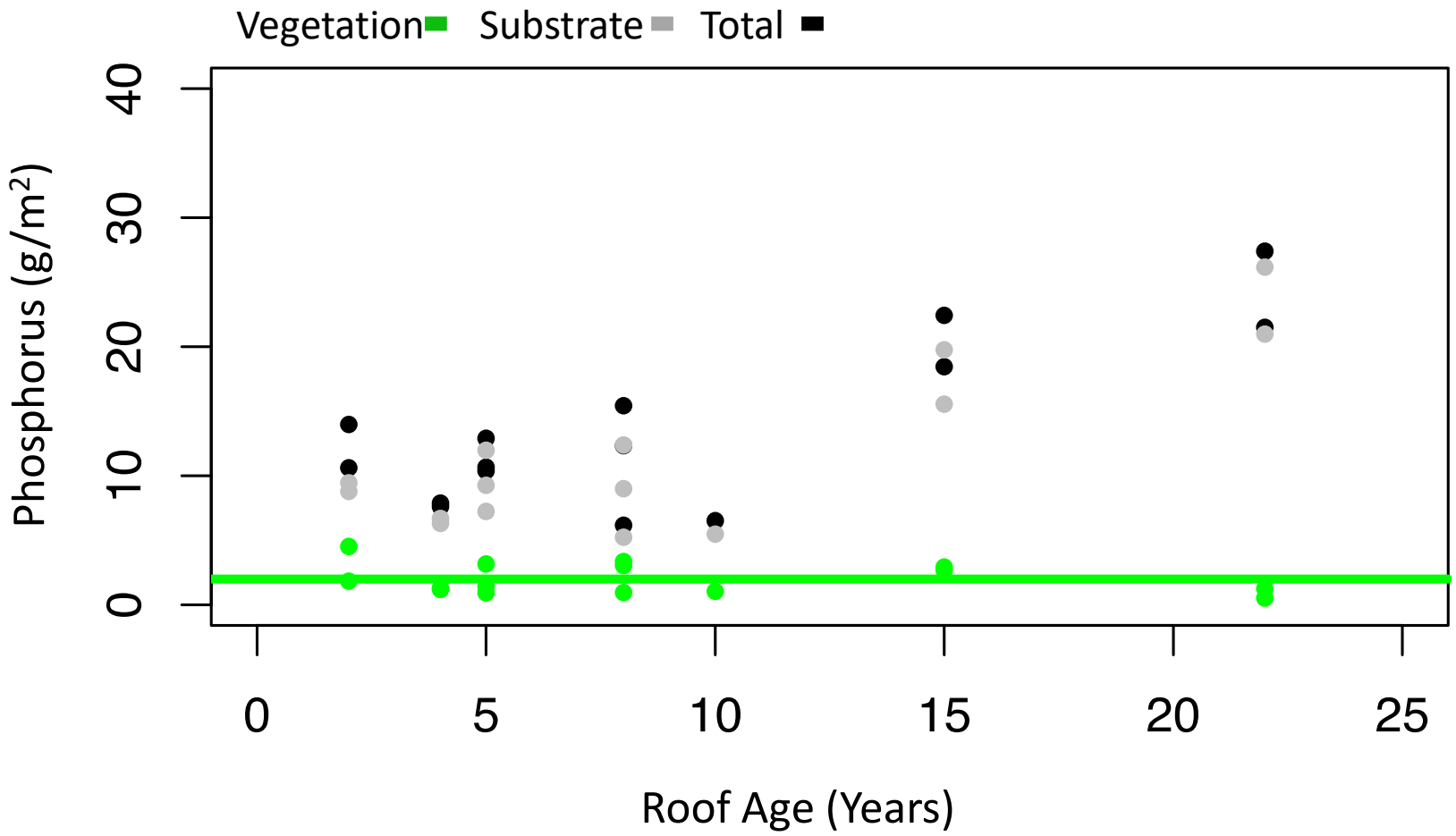
Mitchell et al. 2016

Chronosequence in Sweden: Isolating Long Term Changes in Nutrient Pools



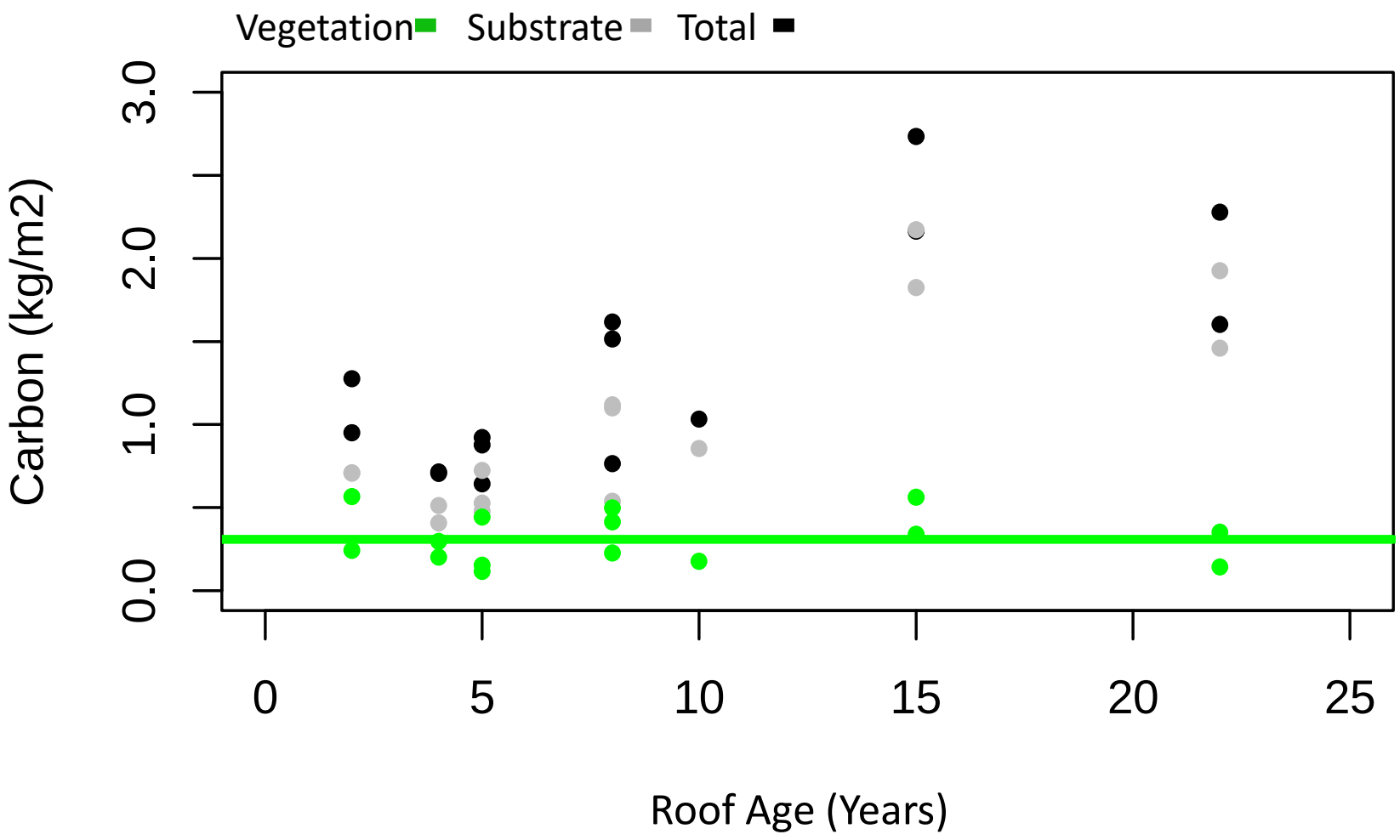
Work with Ishi Buffam and Tobias Emilsson

Phosphorus



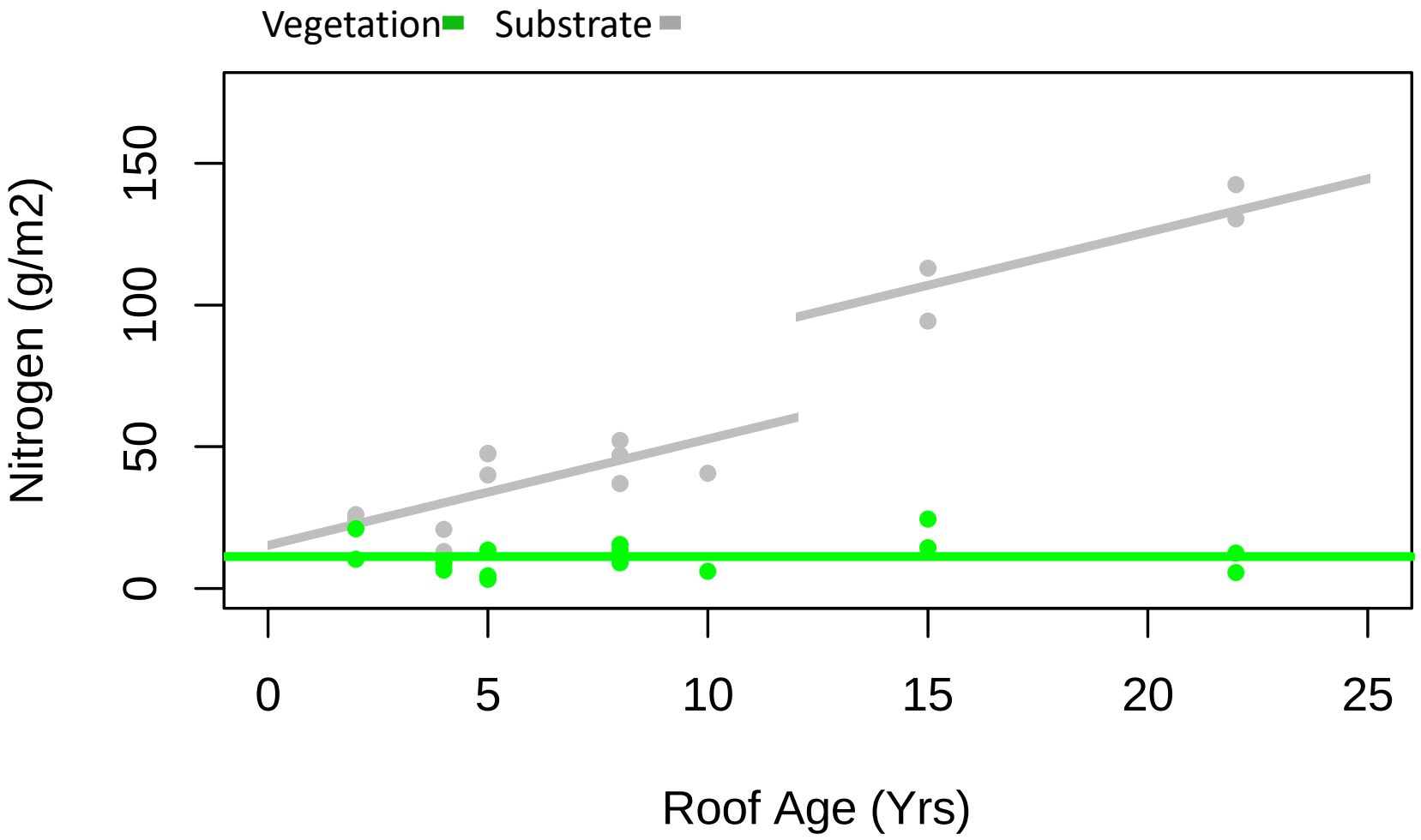
Mitchell, Emilsson, and Buffam *In Review*

Carbon Pools



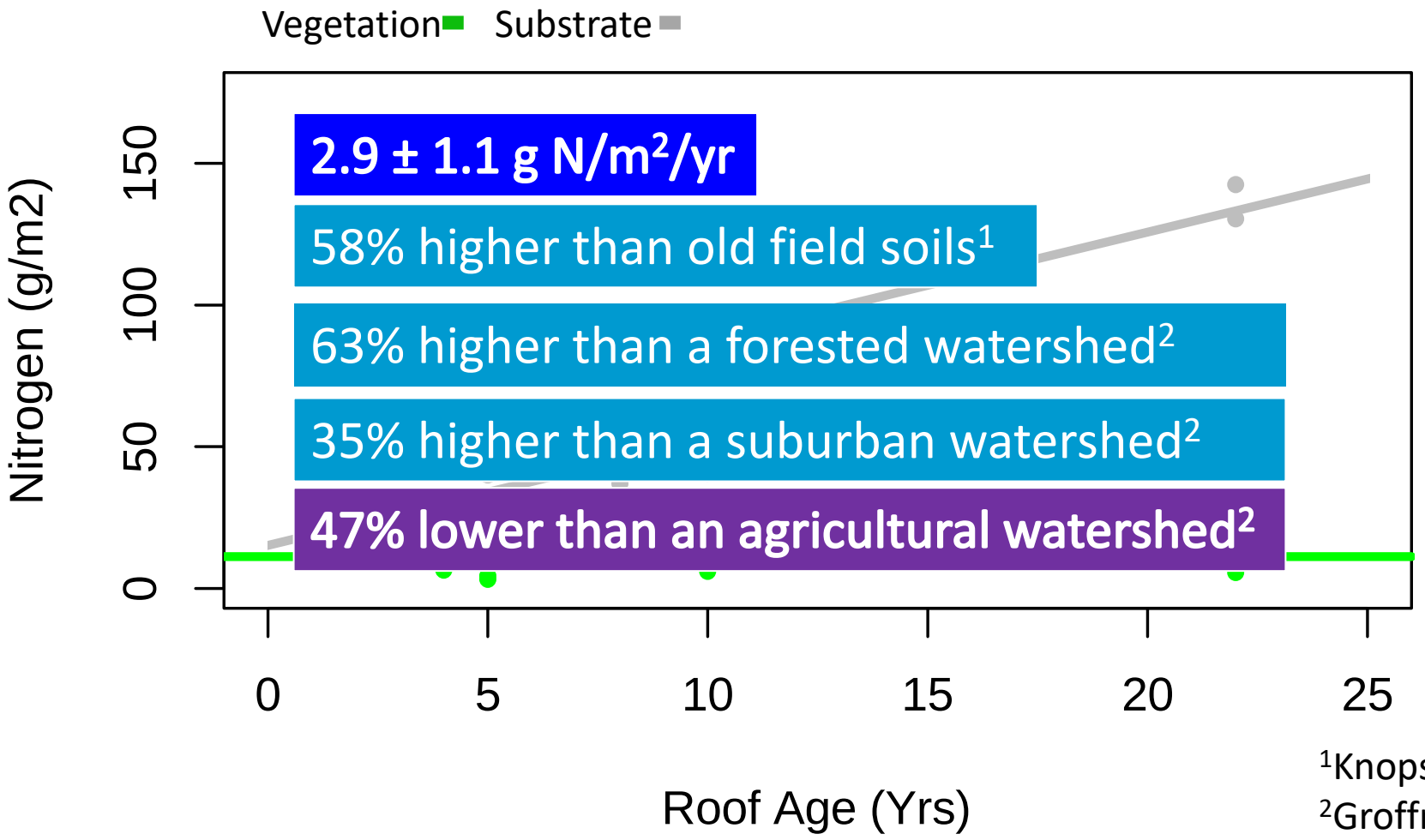
Mitchell, Emilsson, and Buffam *In Review*

Nitrogen Pools



Mitchell, Emilsson, and Buffam *In Review*

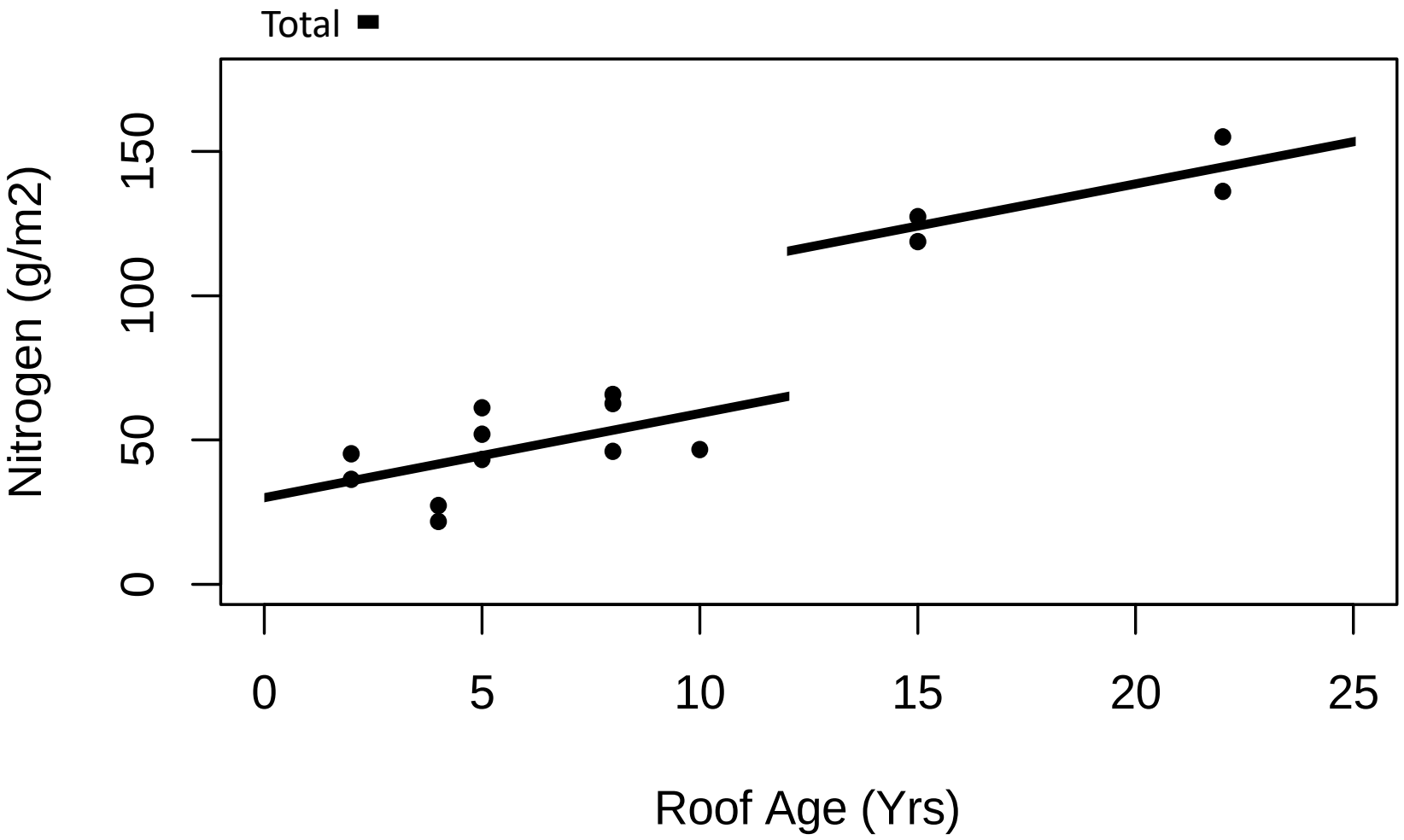
Nitrogen Pools



[1]Knops and Tilman 2000
[2]Groffman et al. 2004

Mitchell, Emilsson, and Buffam *In Review*

Total Nitrogen Pools



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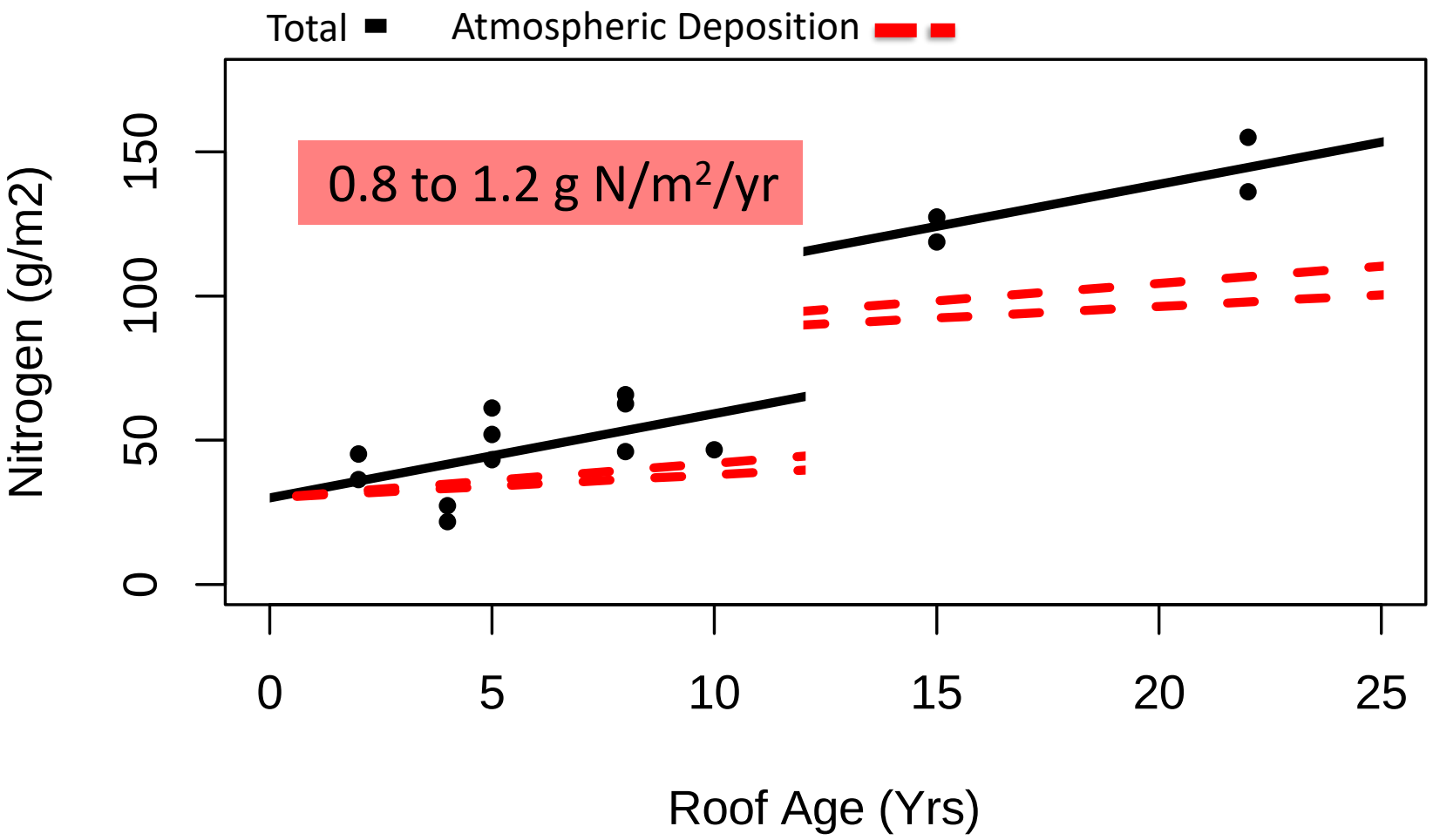
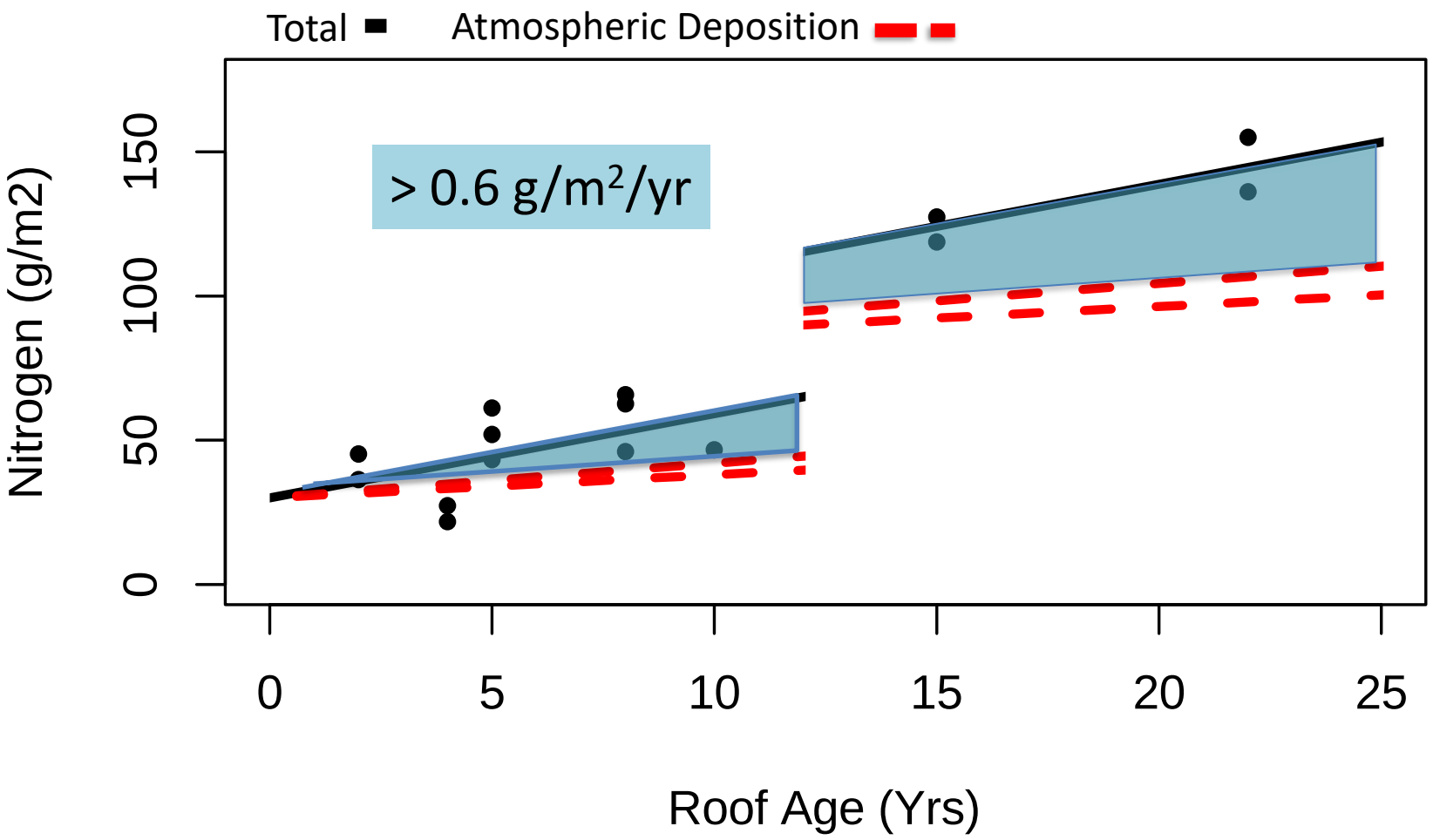
Atmospheric Deposition



Mitchell, Emilsson, and Buffam *In Review*

Missing Nitrogen: Nitrogen Fixation?



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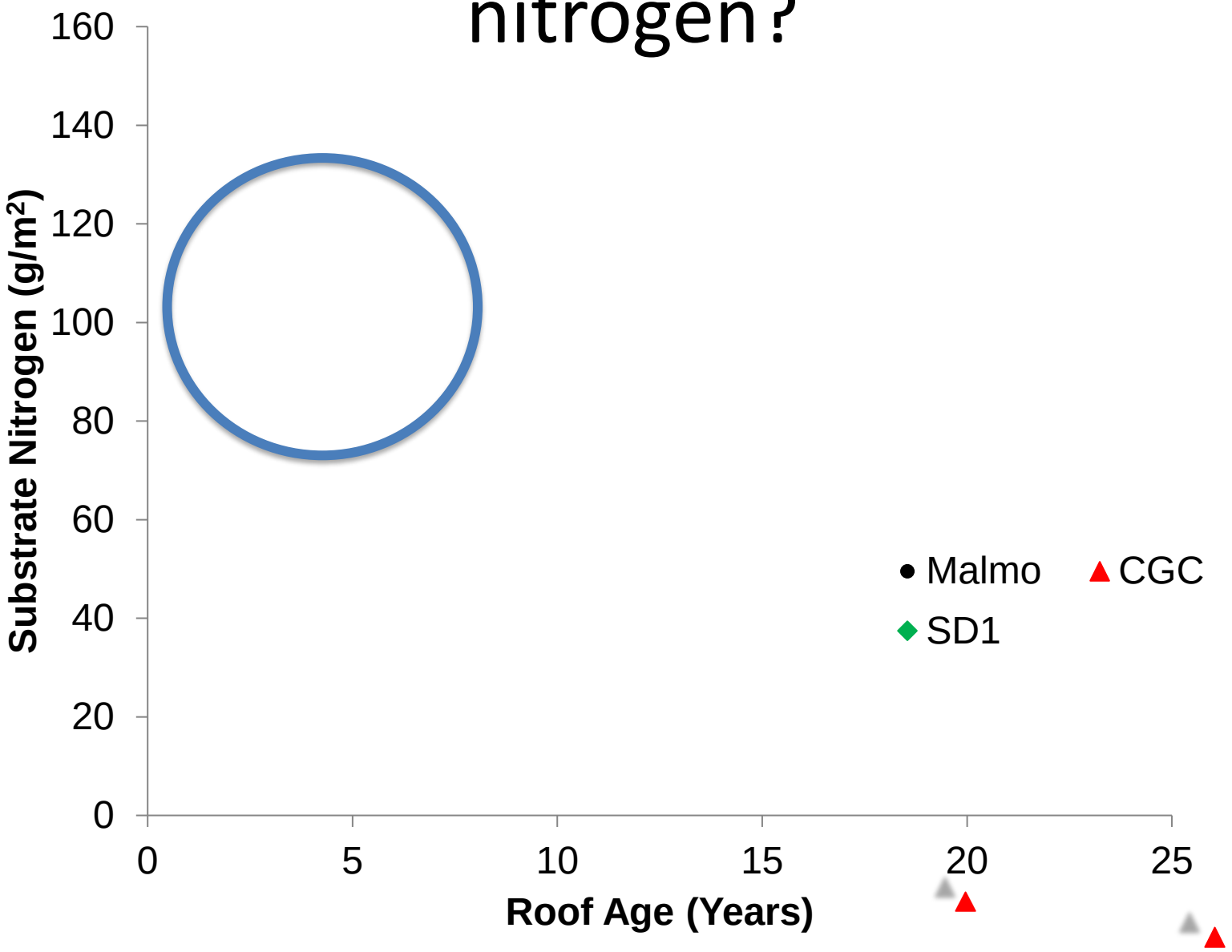
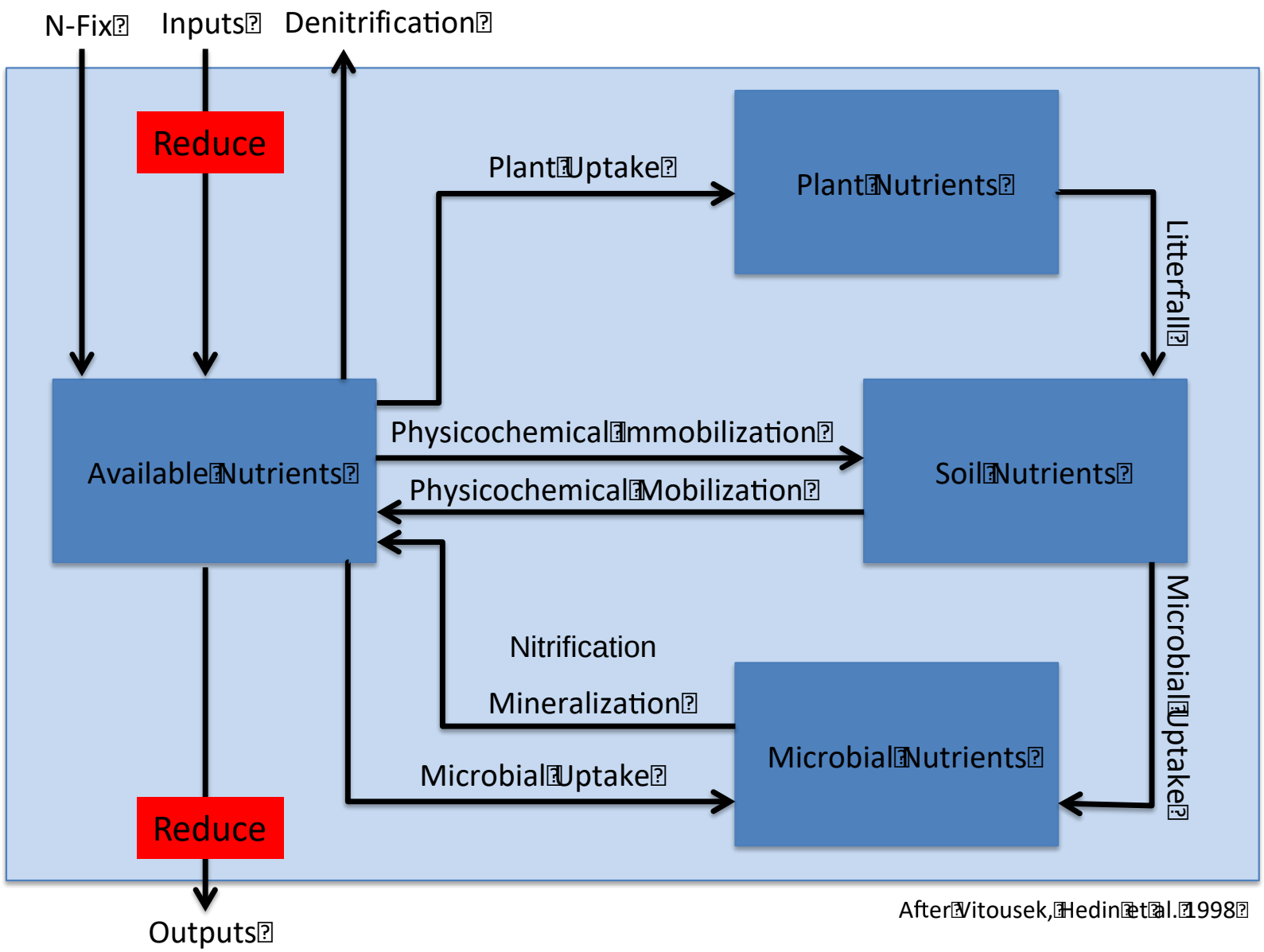
Why are some roofs sources and others sinks for nitrogen?



What does this mean for green roof design and management?

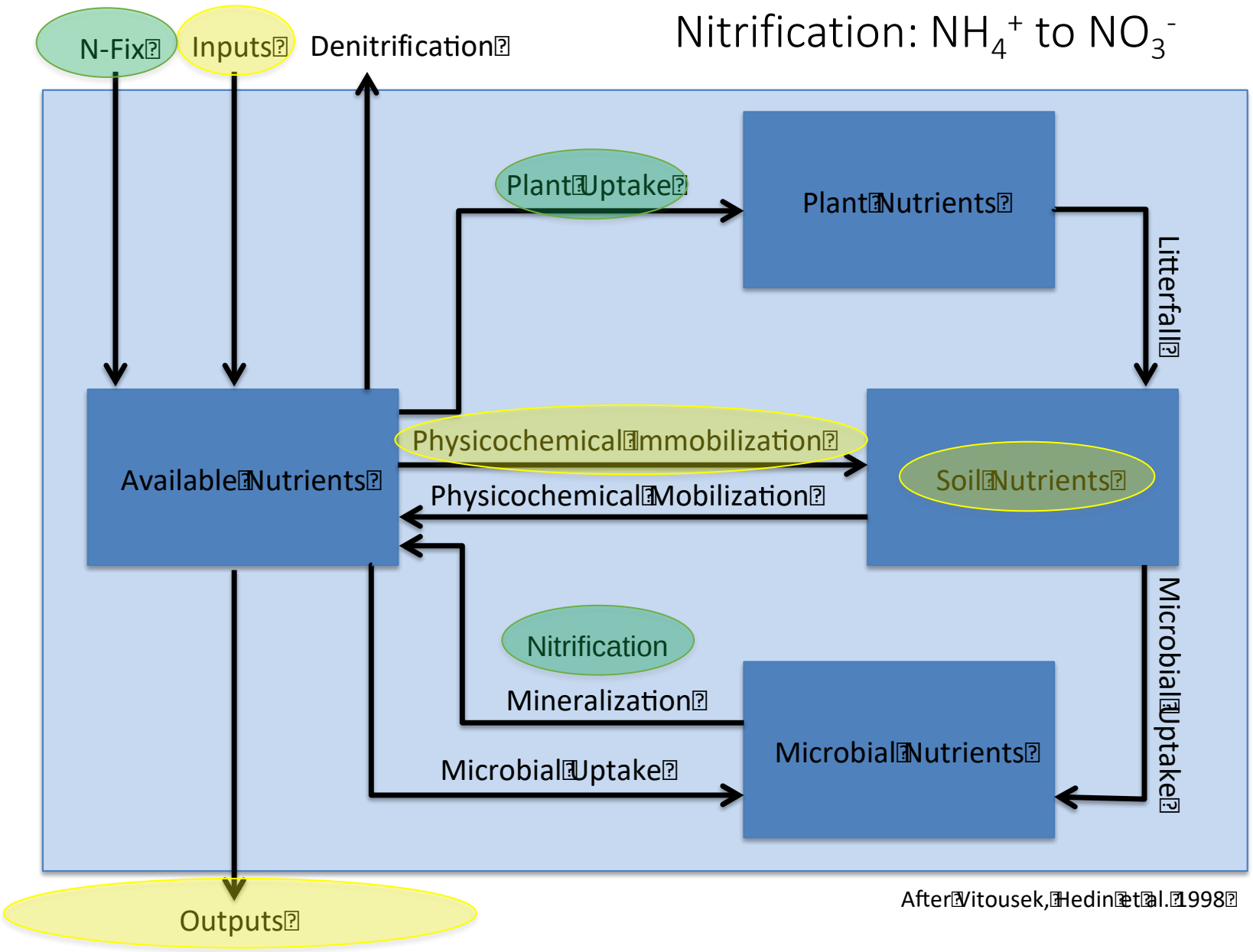
- To make green roofs more sustainable, we need to improve their nutrient retention through improvements in design and management
  - Reduce outputs to aquatic ecosystems
  - Reduce the need for fertilization



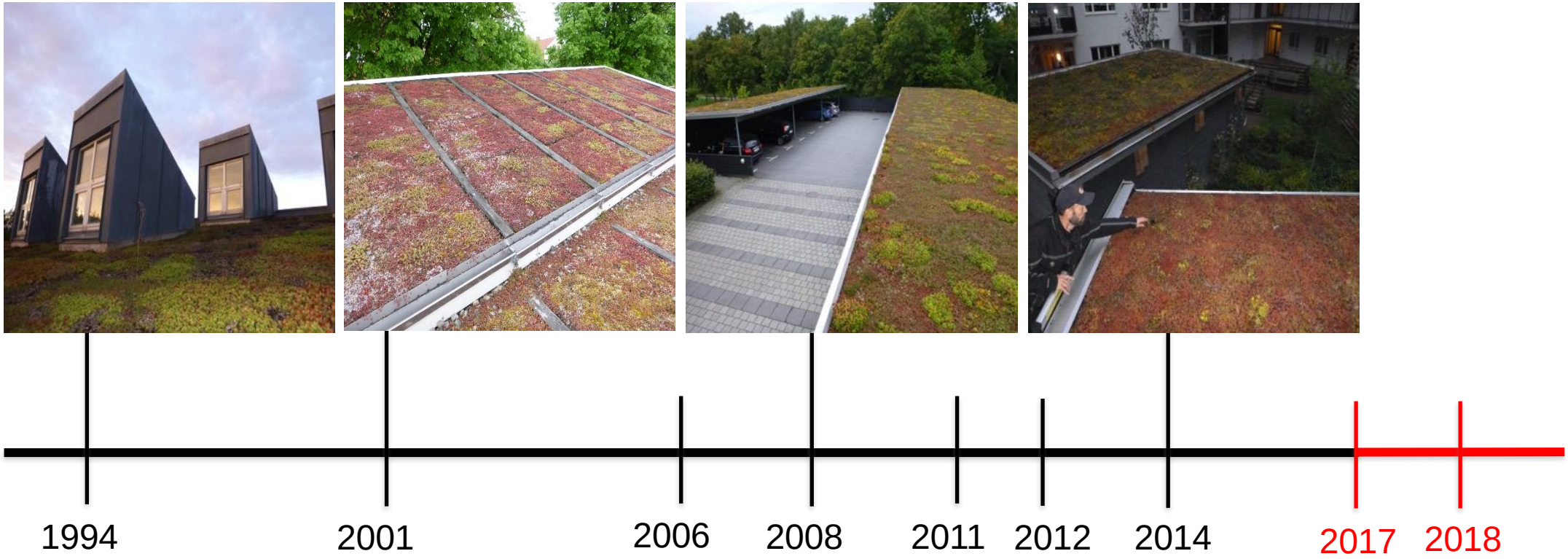
After Vitousek, Hedin et al. 1998

How do we design and manage green roofs for nutrient sustainability?

- Engineering/management solutions
  - Reduce inputs (fertilizers)
  - Reduce nutrient content of substrate when installed
  - Collect runoff and use on-site
  - Improve binding capacity of substrate
- Biological solutions
  - Improve plant uptake
    - Plant choice or incorporate mycrorrhizae?
  - Nitrification inhibitors?
  - Nitrogen fixation?
    - Legumes?
    - Lichens, mosses, *Nostoc*?

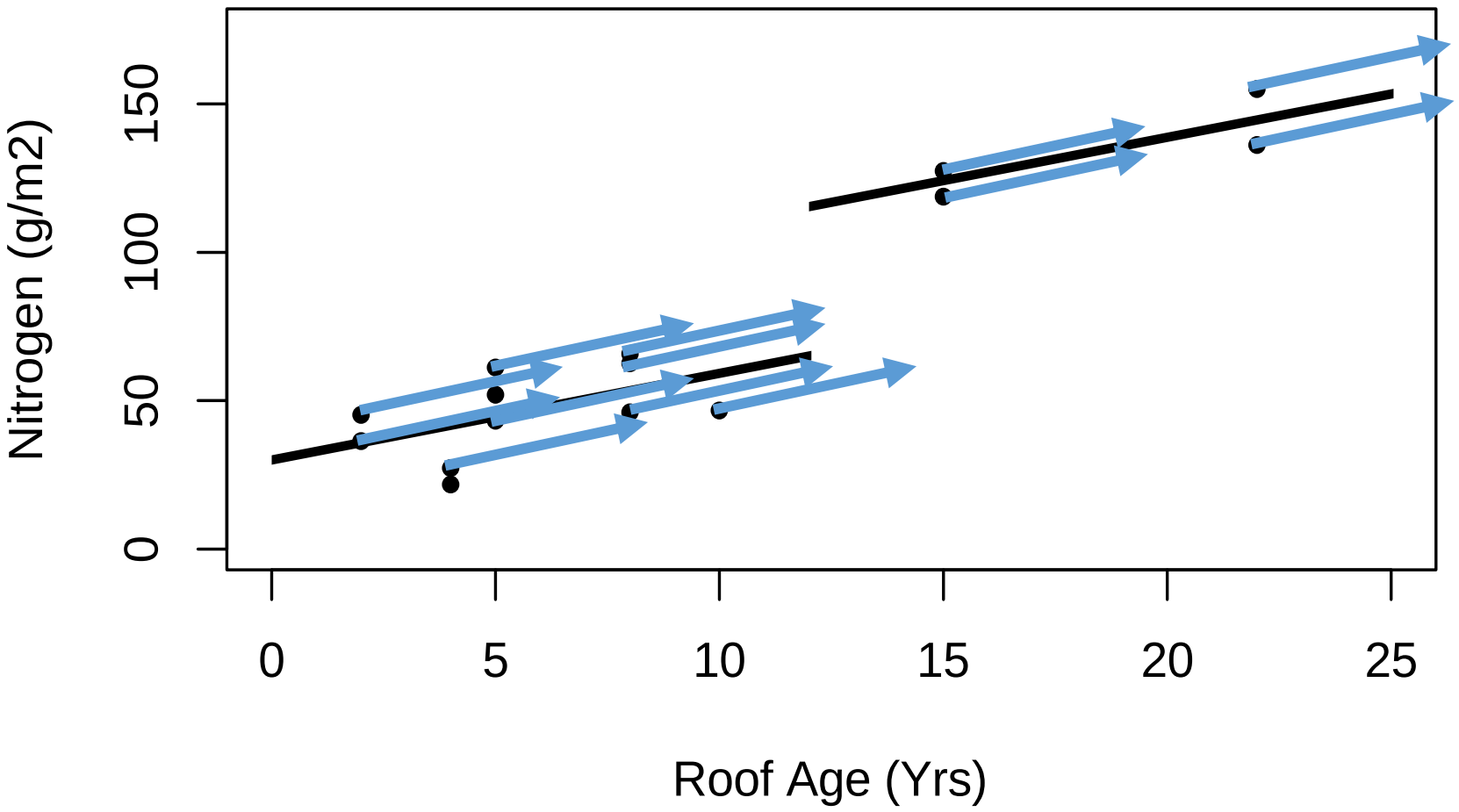


Ongoing Chronosequence Work in Sweden: Adding More Roofs and Resampling Previously Studied Roofs



Ongoing work with Ishi Buffam, Tobias Emilsson, Susanna Lehvävirta, Åsa Ode Sang, Ayako Nagase

Ongoing Chronosequence Work in Sweden: Adding More Roofs and Resampling Previously Studied Roofs



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Acknowledgements

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- Kristy Hopfensperger
- Tobias Emilsson
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- Brad Rowe

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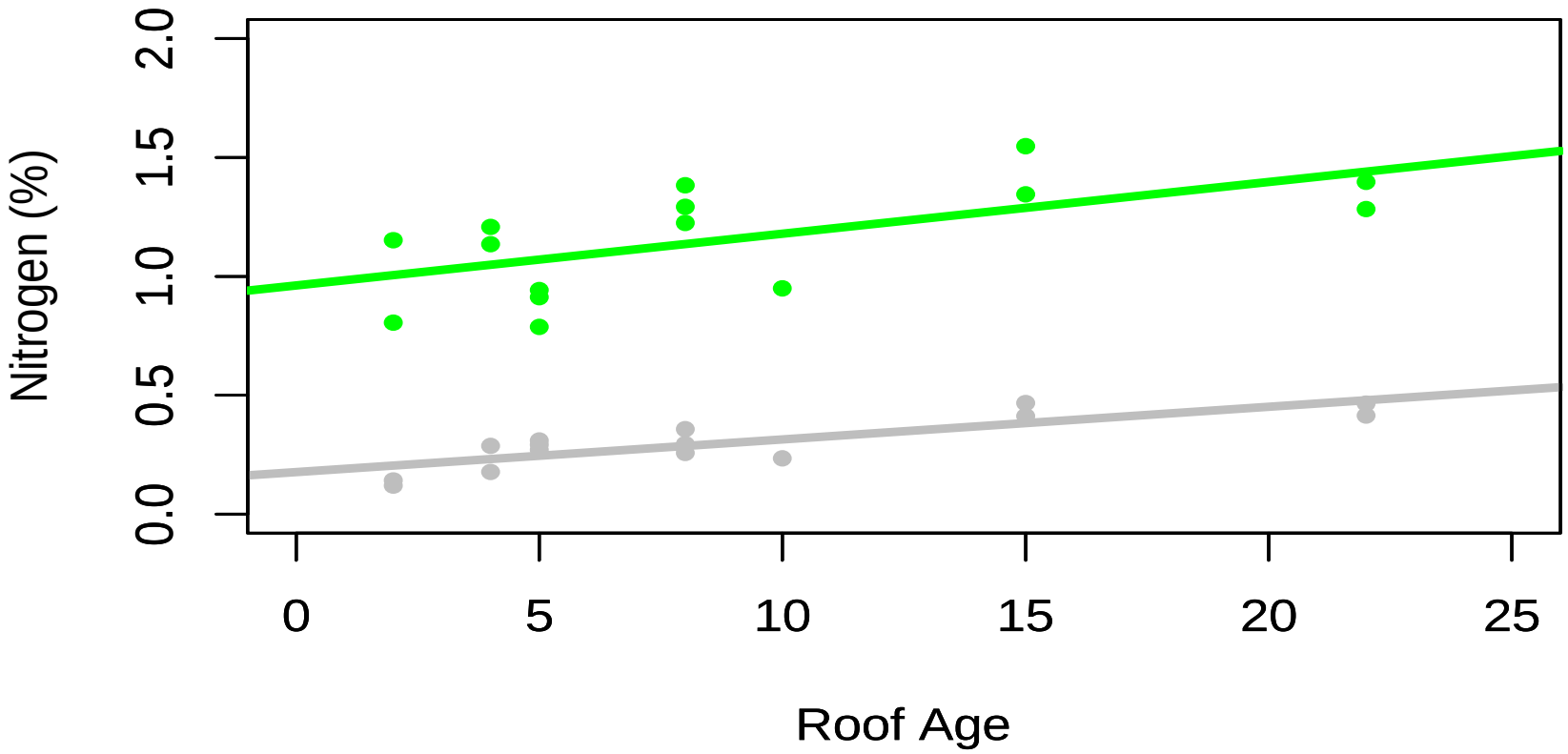
- The Civic Garden Center
- Swedish University of Agricultural Sciences
- Sanitation District 1
- Turkeyfoot Middle School
- Heidelberg University

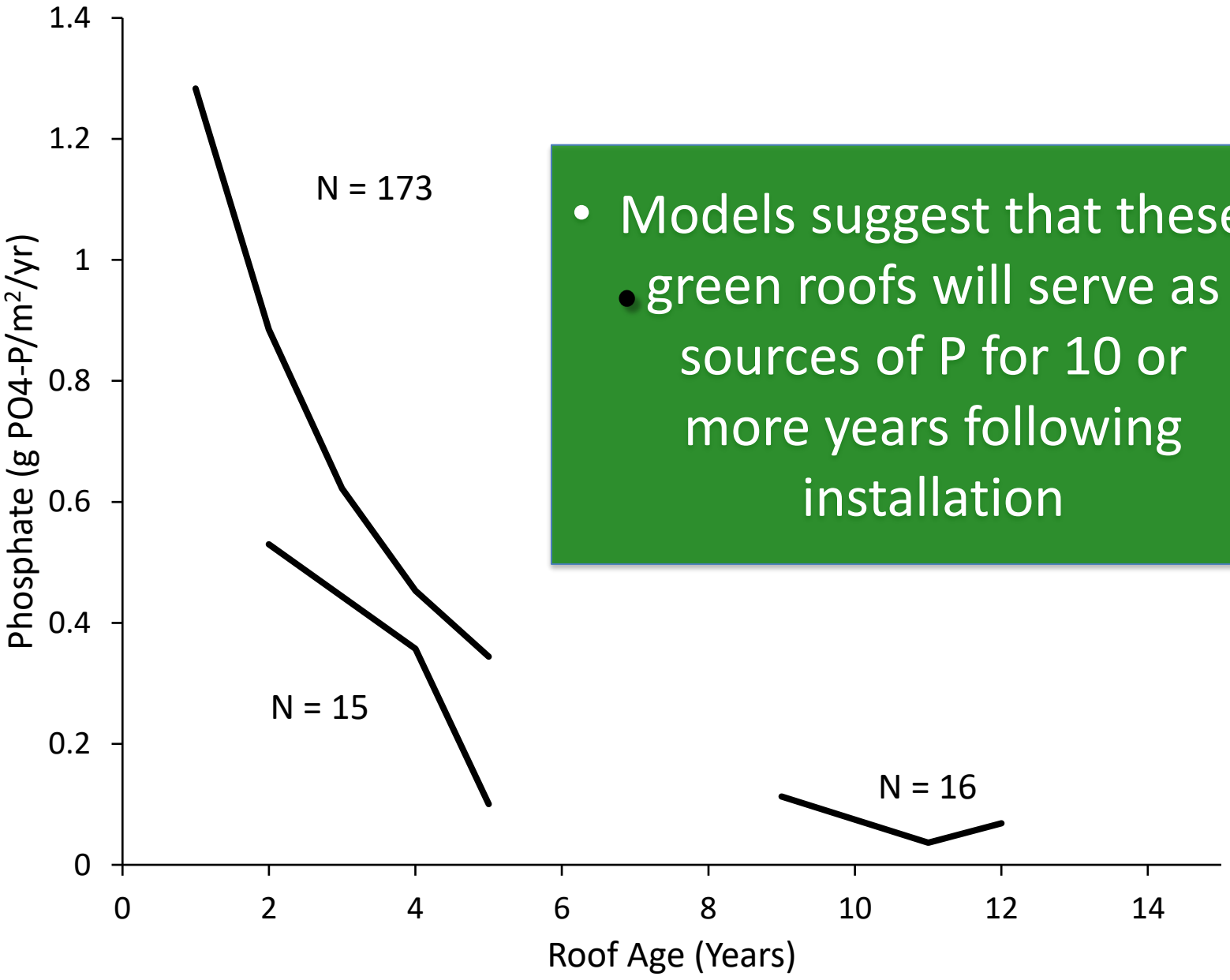
Support

- American-Scandinavian Foundation
- Sigma X
- Green Infrastructure Foundation
- Green Roofs Healthy Cities

Extra Slides

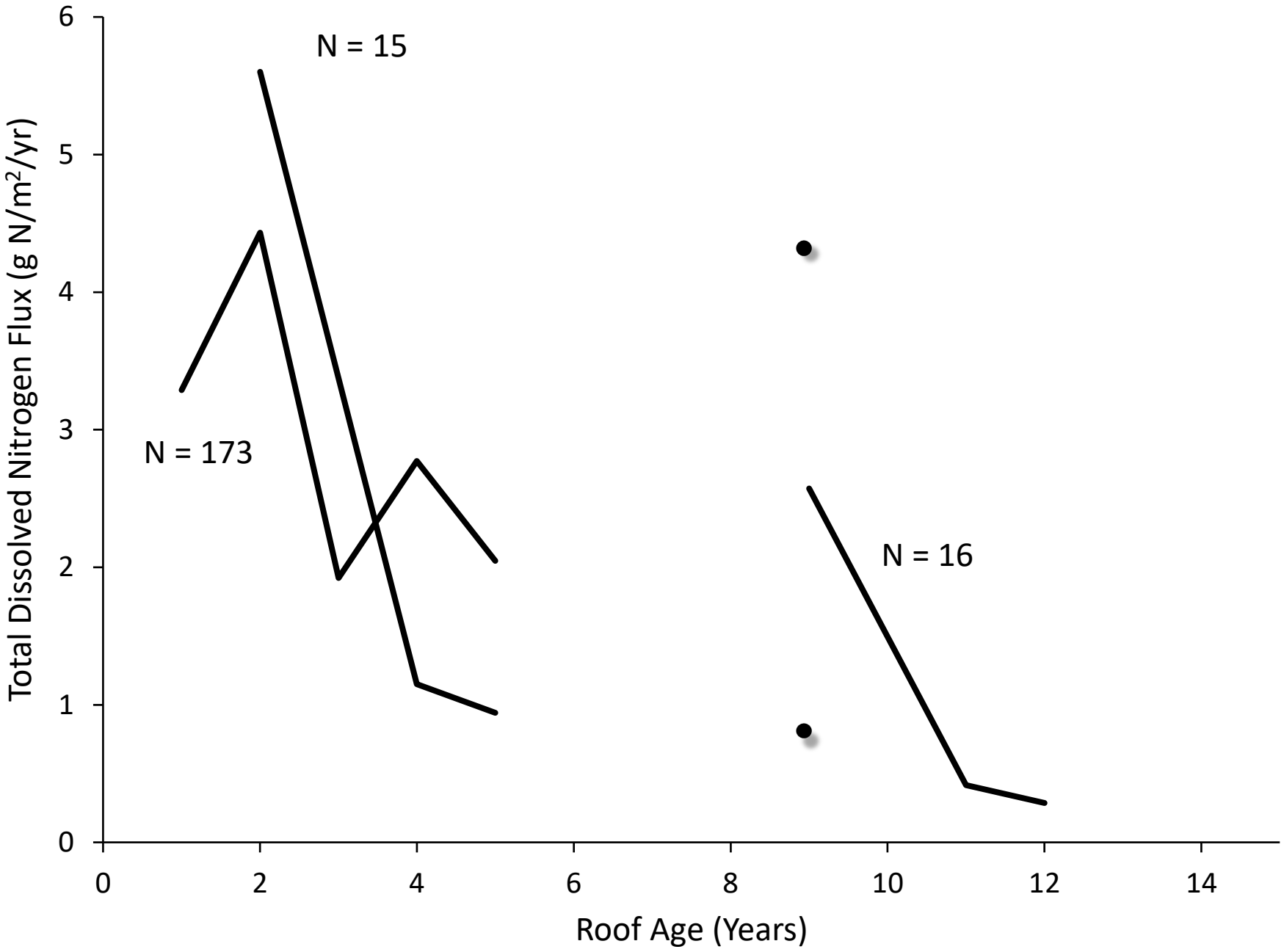
Nitrogen Content





- Models suggest that these green roofs will serve as sources of P for 10 or more years following installation

Mitchell et al. 2016



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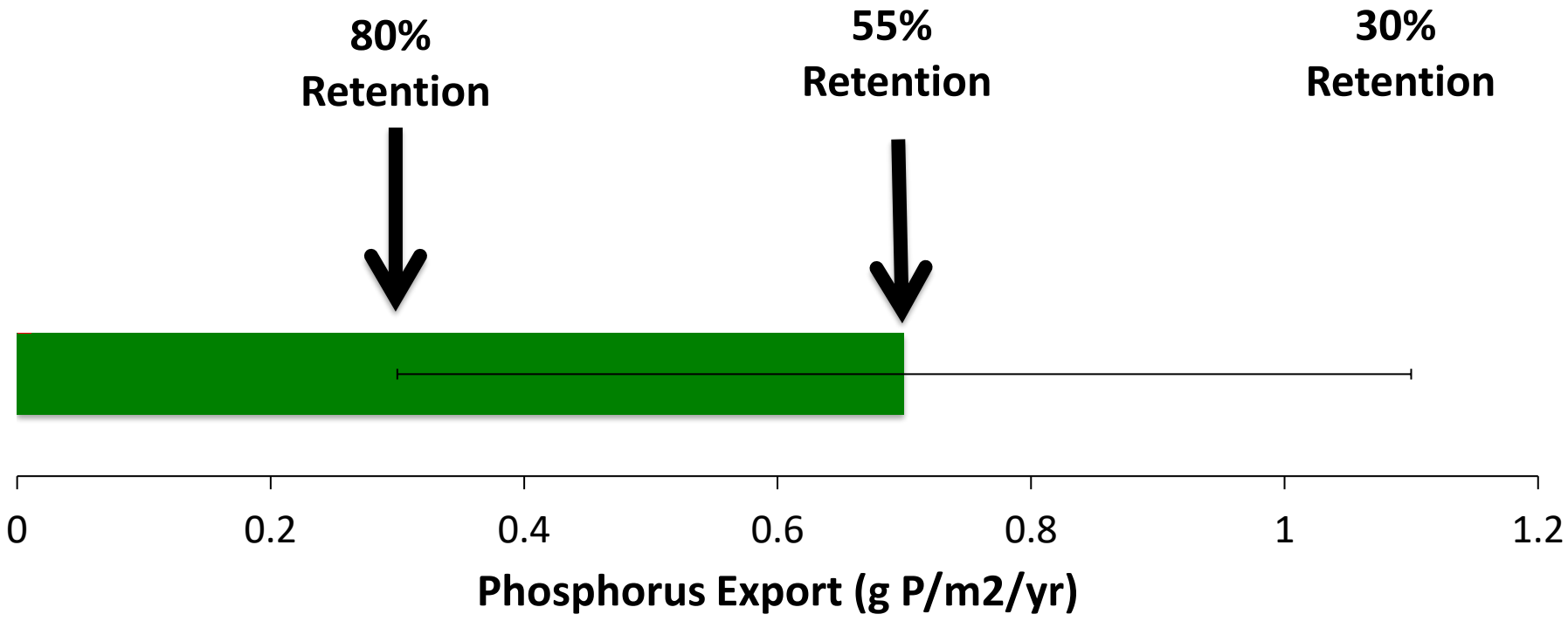
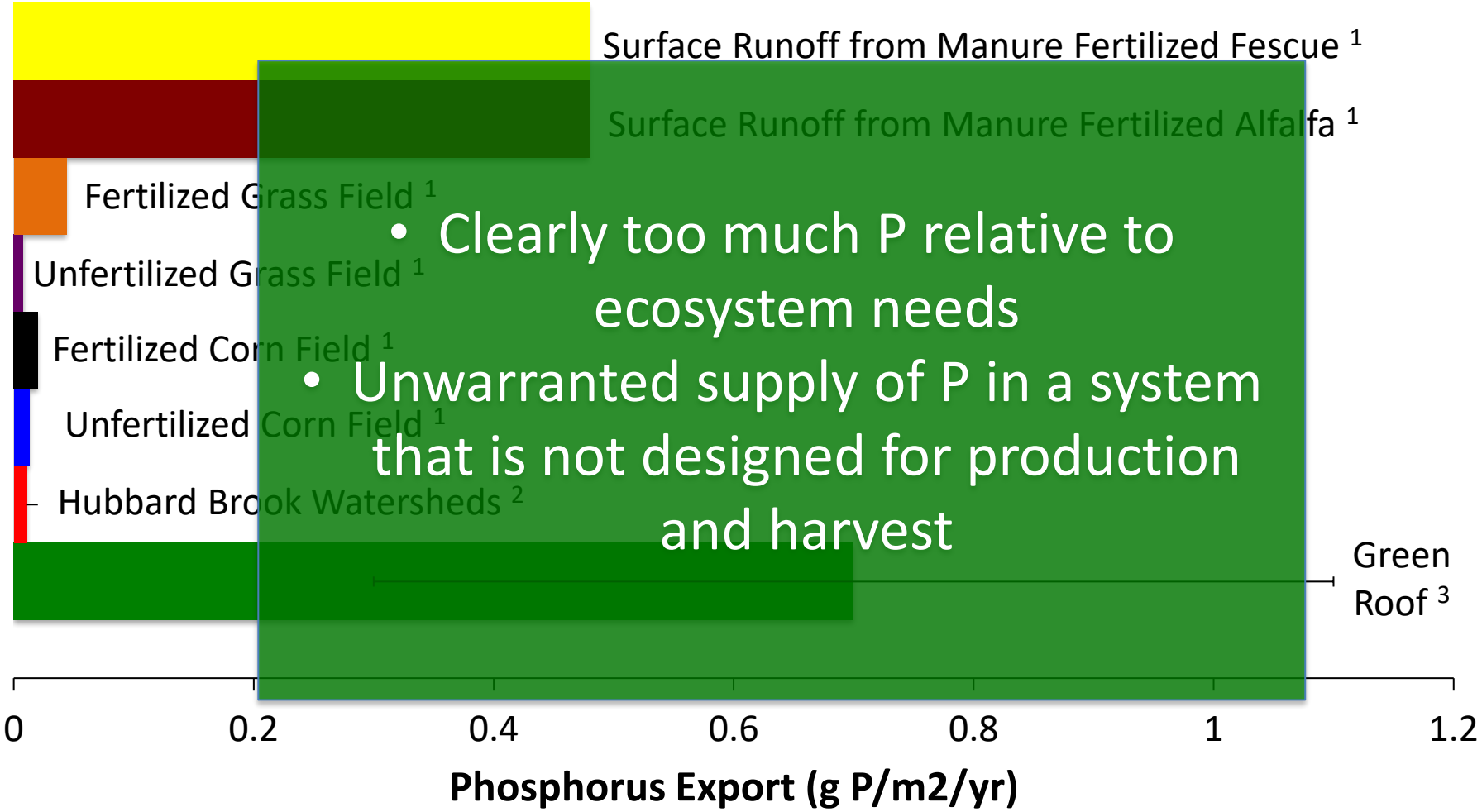


[3]Mitchell et. al. 2017



- Clearly too much P relative to ecosystem needs
- Unwarranted supply of P in a system that is not designed for production and harvest

[1]Reviewed in Sharpley et al. 2001
[2]Hobbie and Likens 1973
[3]Mitchell et. al. 2017