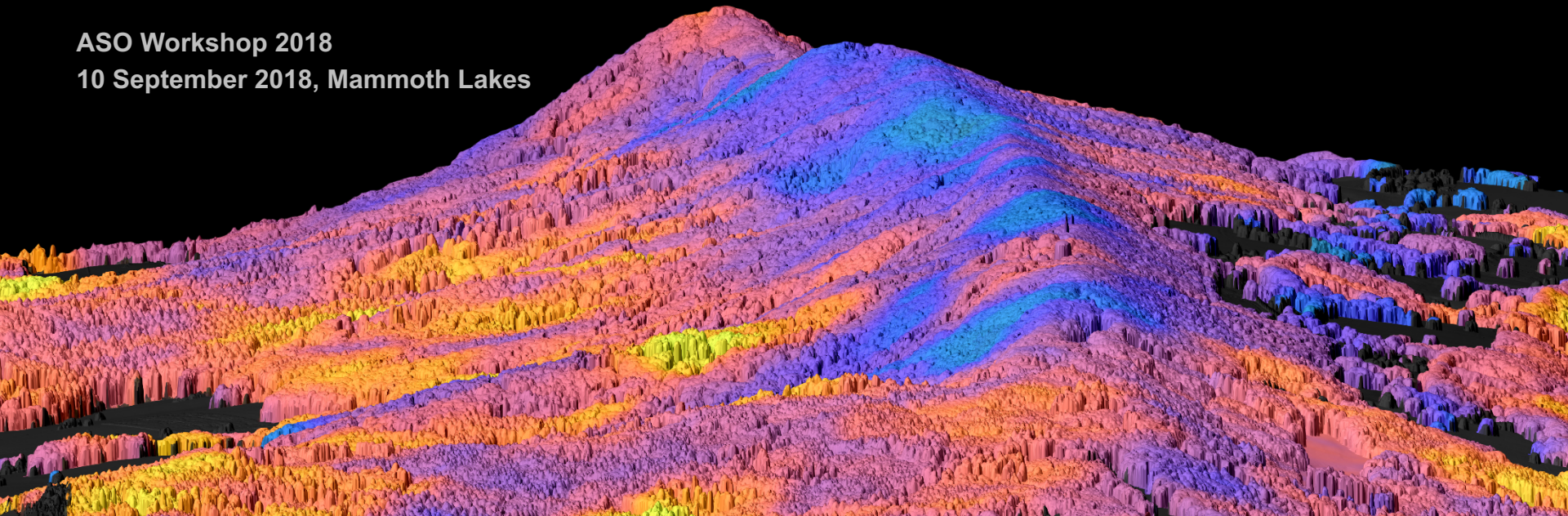
Jet Propulsion Laboratory
California Institute of Technology

Characterizing vegetation habitats and biodiversity with ASO lidar and imaging spectroscopy

FD Schneider, A Ferraz, P Townsend, R Pavlick, P Moorcroft, DS Schimel

ASO Workshop 2018
10 September 2018, Mammoth Lakes



Biodiversity-Productivity Relationship

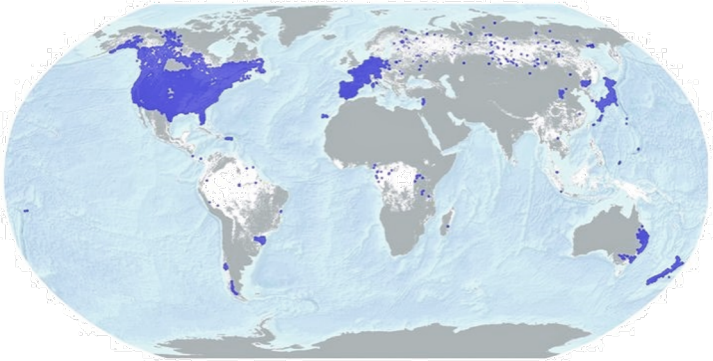
Plant diversity as indicator for ecosystem health, stability and functioning

RESEARCH ARTICLE

FOREST ECOLOGY

Positive biodiversity-productivity relationship predominant in global forests

Jingjing Liang,[1*] Thomas W. Crowther,[2,3]† Nicolas Picard,[4] Susan Wiser,[5] Mo Zhou,[1] Giorgio Alberti,[6] Ernst-Detlef Schulze,[7] A. David McGuire,[8] Fabio Bozzato,[9]

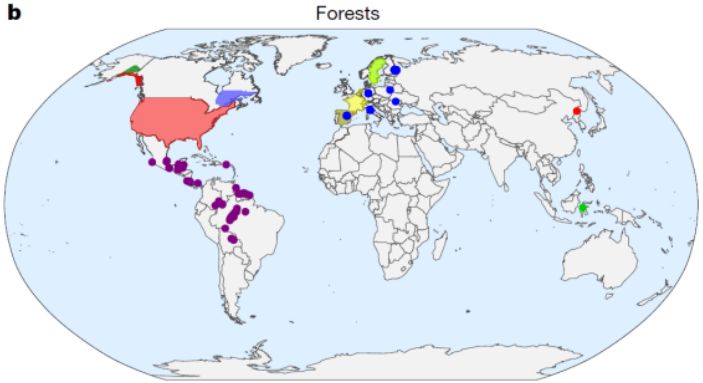


LETTER

doi:10.1038/nature23886

Biodiversity effects in the wild are common and as strong as key drivers of productivity

J. Emmett Duffy[1], Casey M. Godwin[2] & Bradley J. Cardinale[2]



Liang, et al. (2016) Science; Duffy, et al. (2017) Nature

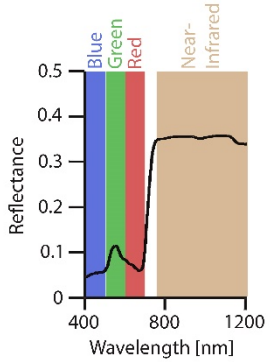
How do we measure Biodiversity?

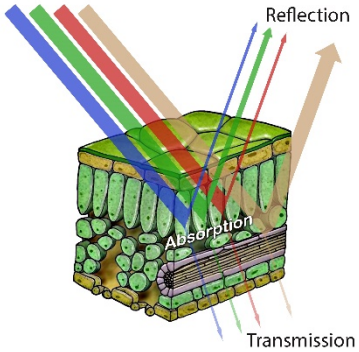
Remote Sensing of Plant Functional Traits

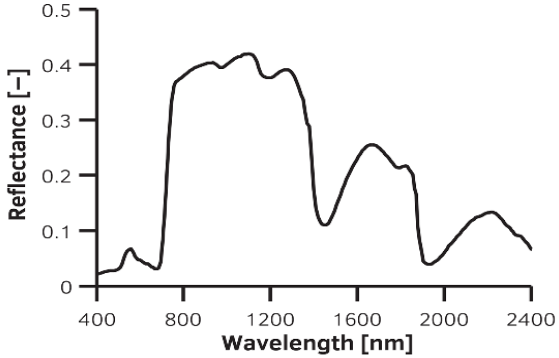
"Just going for species numbers doesn't allow us to harness all this incredibly rich information of how the real world operates."

Methods to Measure Traits

Imaging Spectroscopy and Laser Scanning

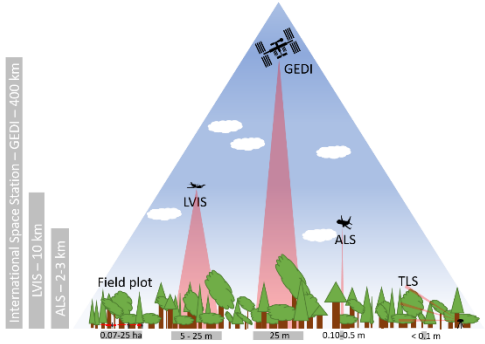


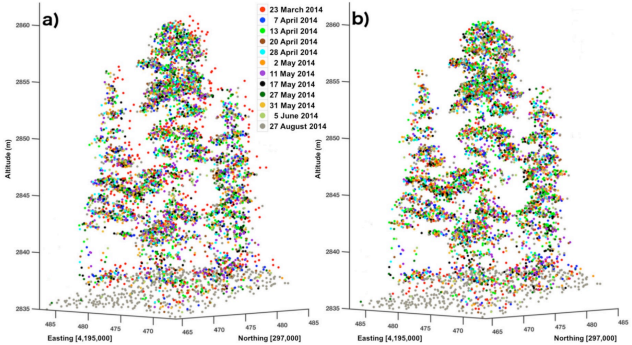


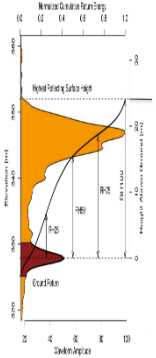


APEX
400 – 2500 nm
@3-14 nm and 2 m

AVIRIS Classic
400 – 2500 nm
@10 nm and 15 m





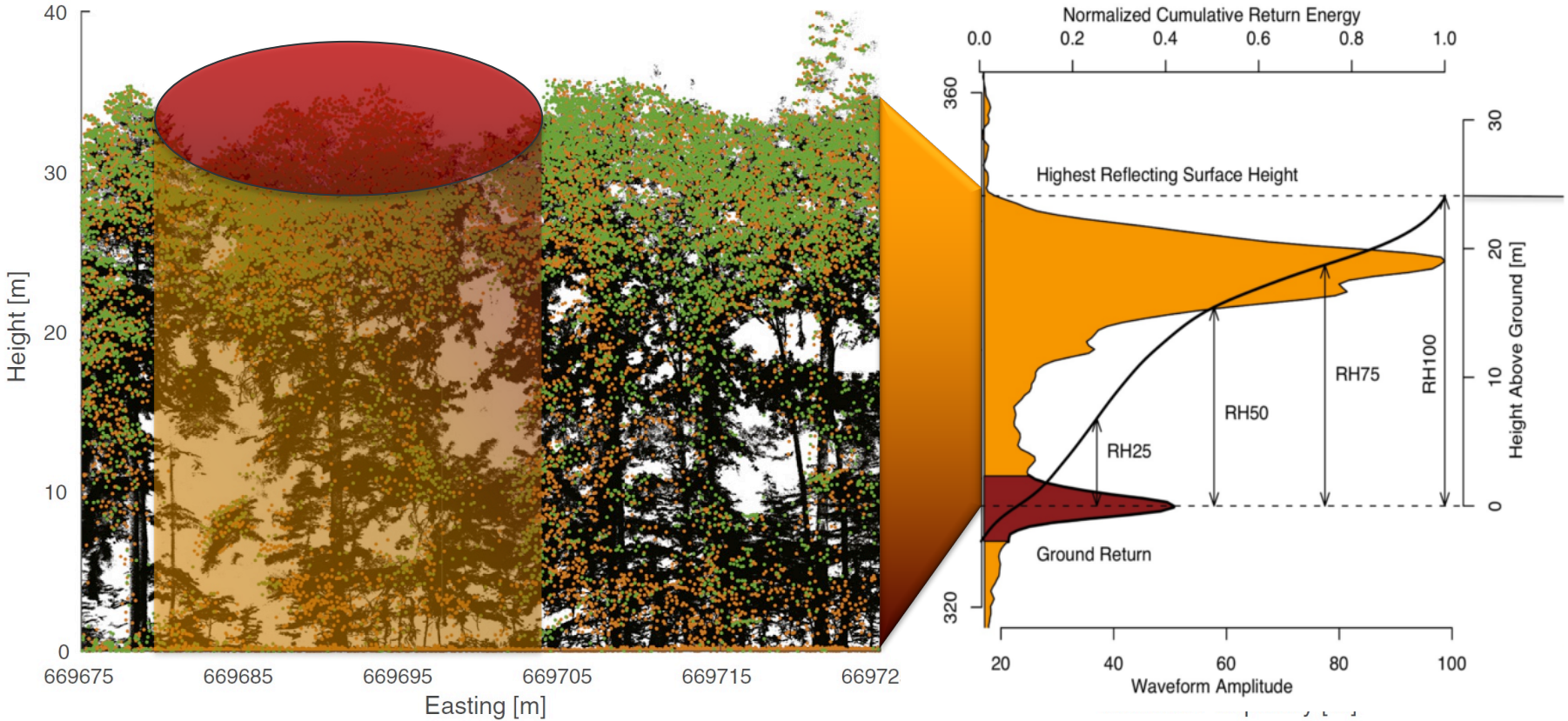


Airborne LiDAR
30 cm Footprint
5-40 pts per m2

Spaceborne LiDAR
25 m Footprint
10-30 pts per km2

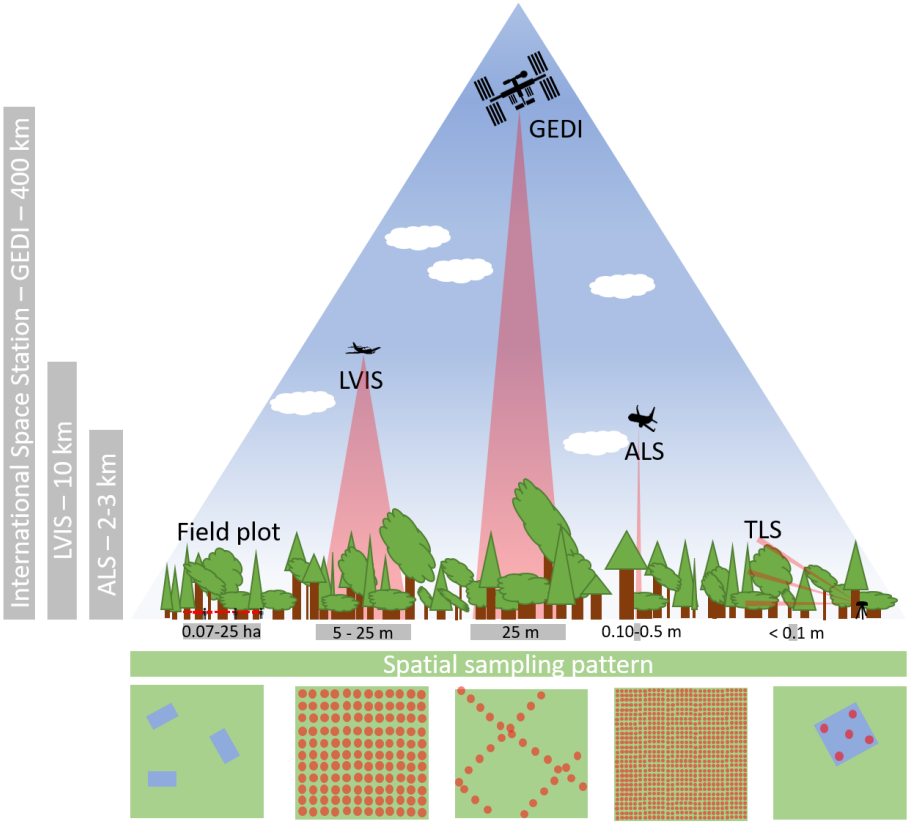
Schaepman, et al. (2015) RSE; Lee, et al. (2015) RSE; Schneider, et al. (2014) RSE; Ferraz, et al. (2018) RS

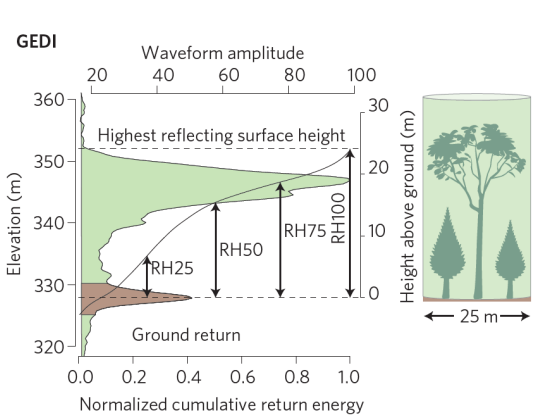
Airborne Laser Scanning data

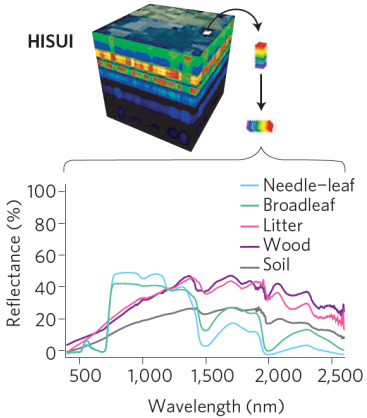


Kükenbrink, et al. (2017) RSE; gedi.umd.edu

Spaceborne Laser Scanning







Gedi.umd.edu; Stavros, et al. (2017) NEE

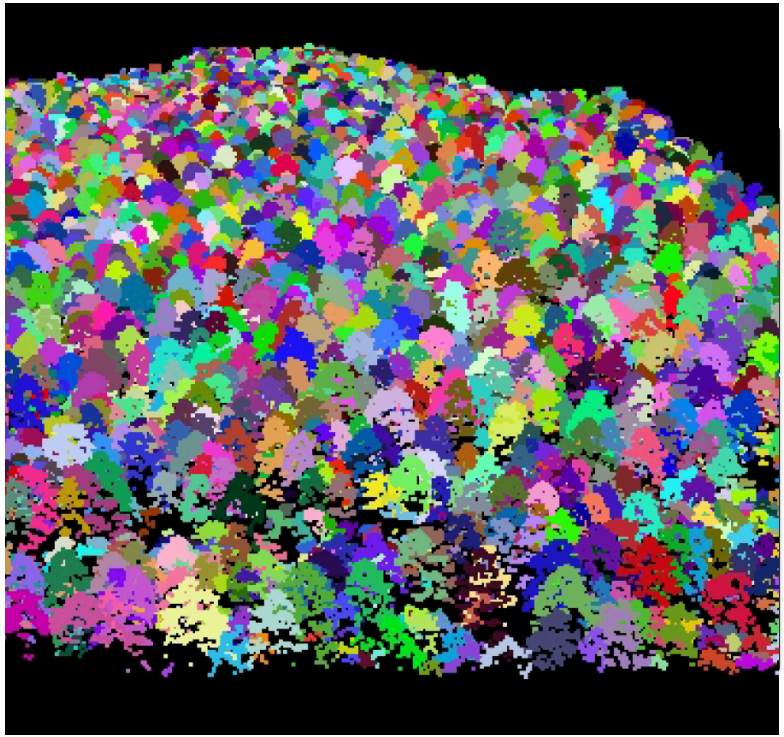
Test Case in California

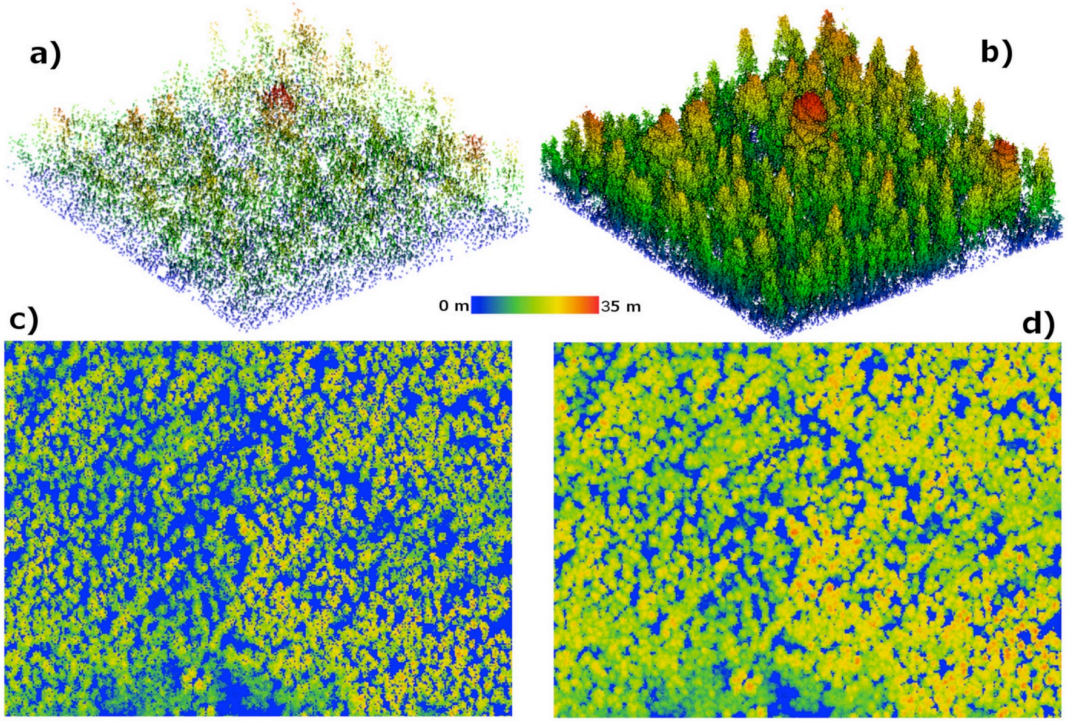
Large-Scale Airborne Data at Community Level

https://upload.wikimedia.org/wikipedia/commons/d/d1/Kings_Canyon_National_Park_03.jpg

Fusion of ASO LiDAR Time Series

Co-Registration and Compositing

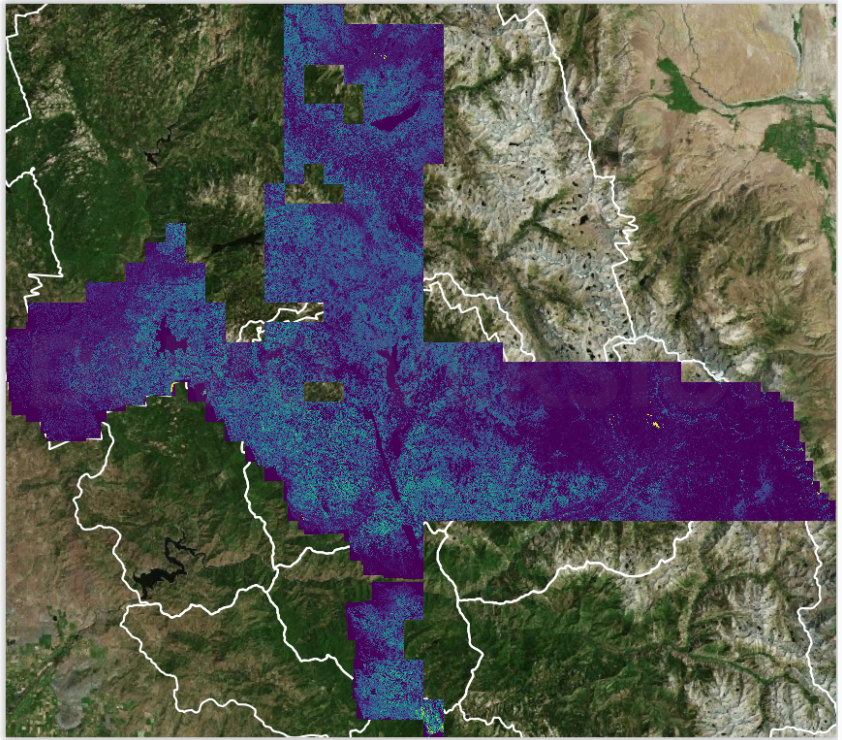


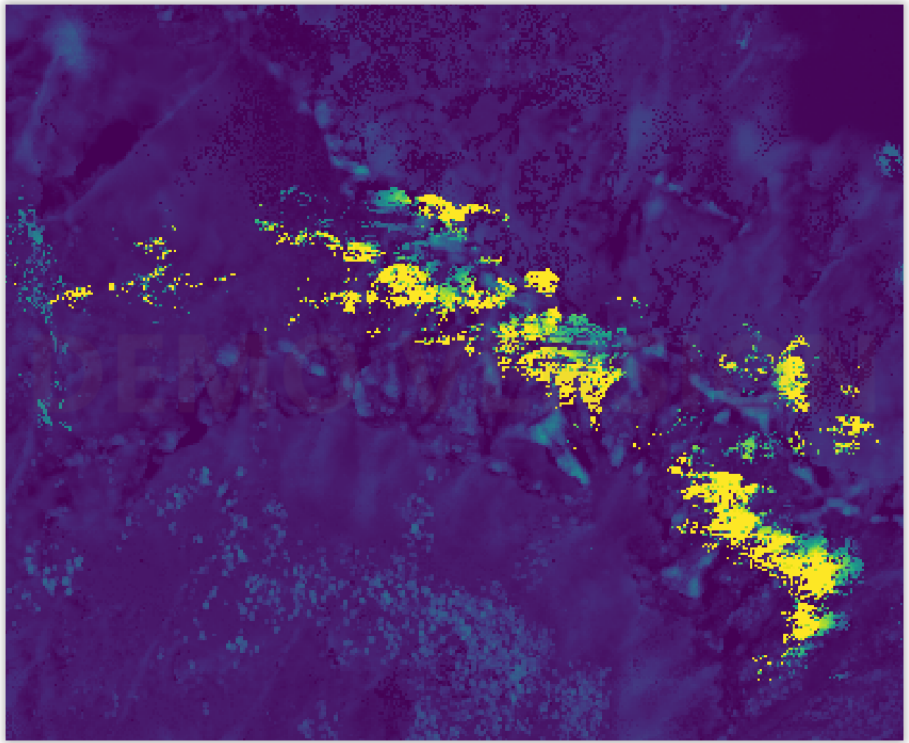


Ferraz, et al. (2018) RS

ASO LiDAR Data

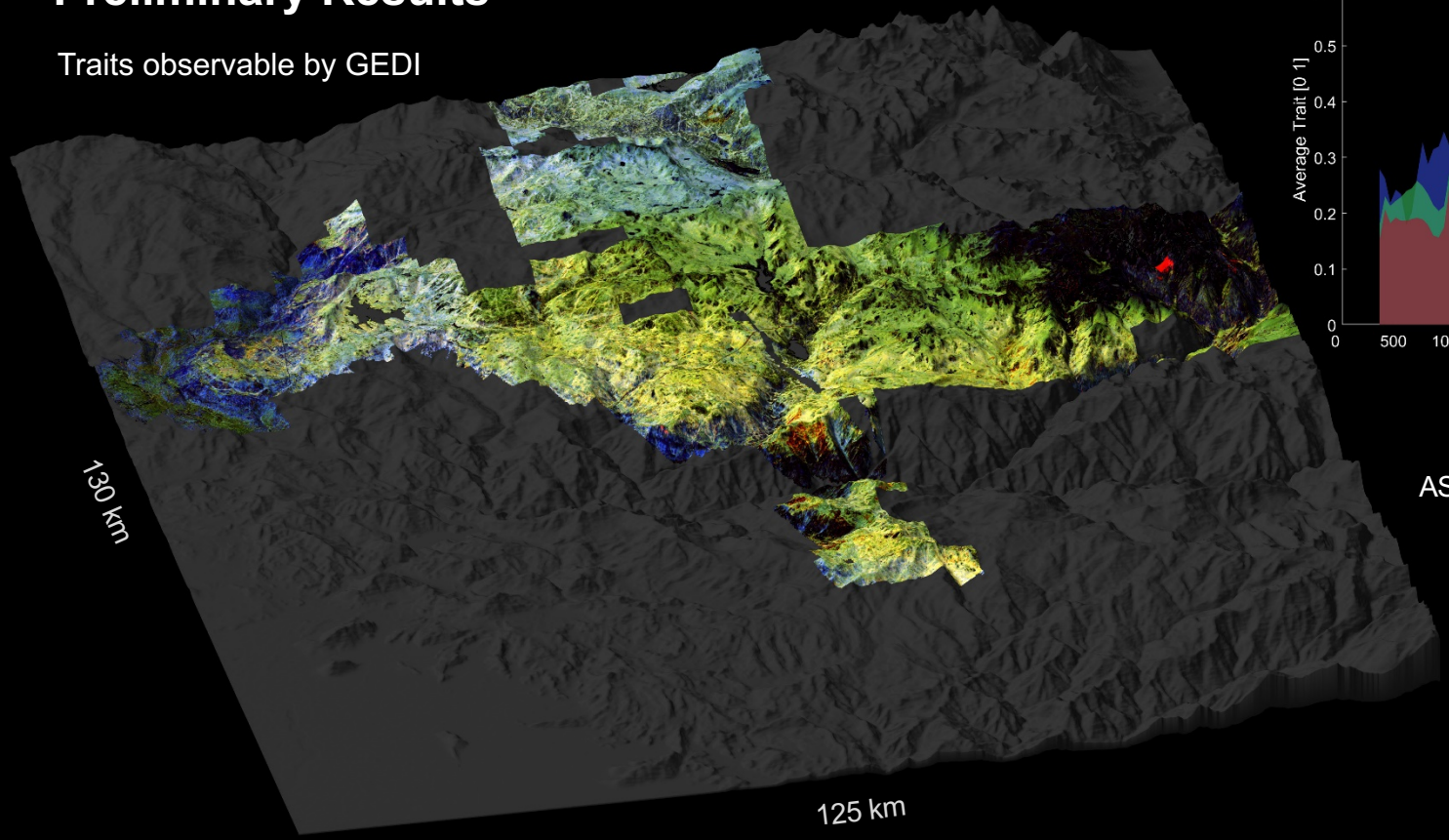
Sierra Nevada Mountains – Canopy Height Model

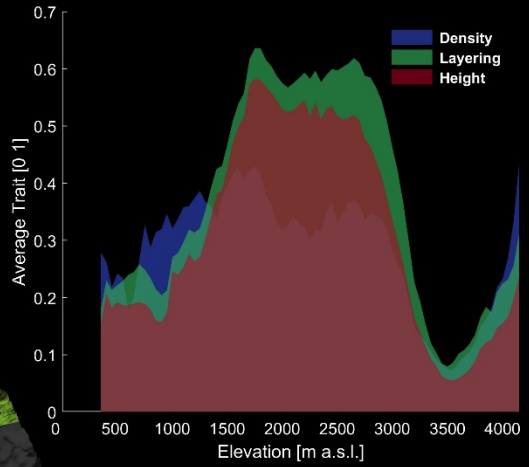




Preliminary Results

Traits observable by GEDI



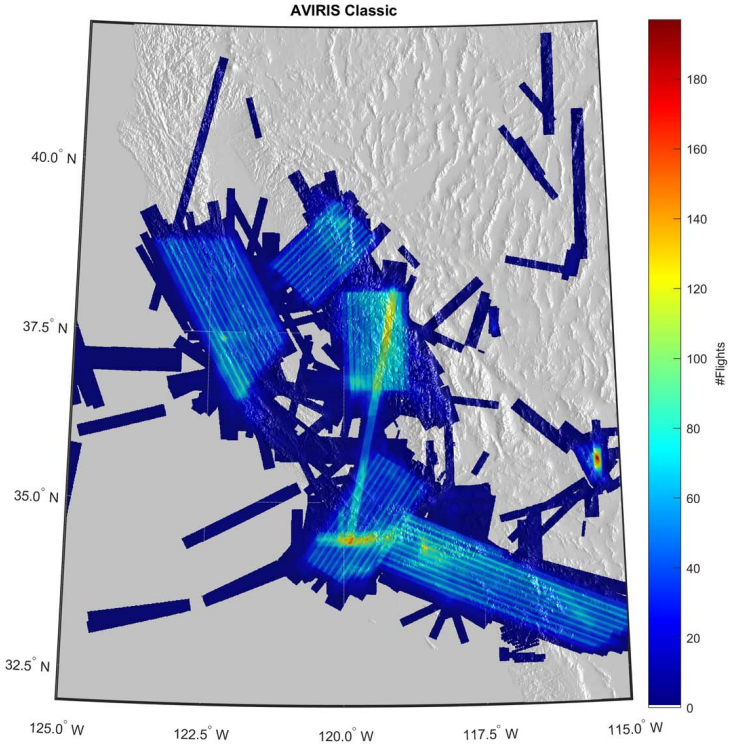


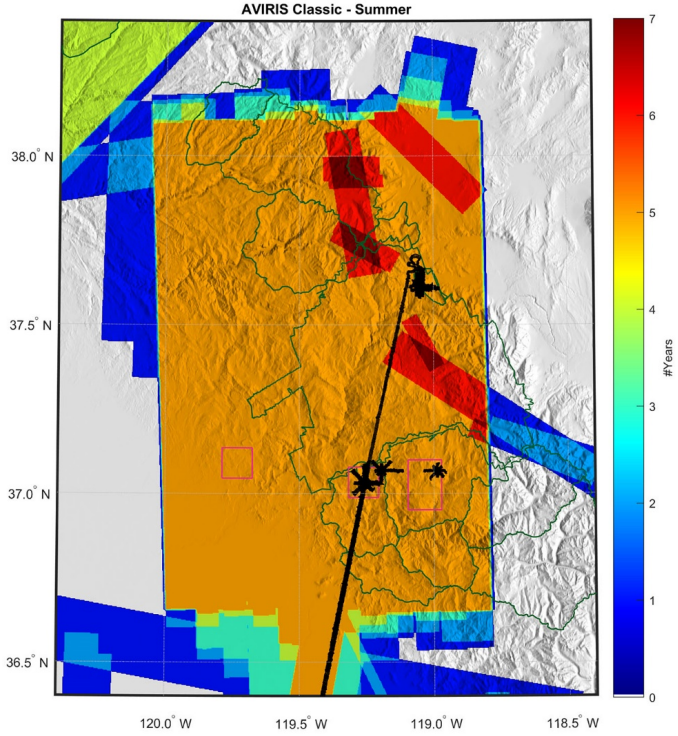
ASO LiDAR Data

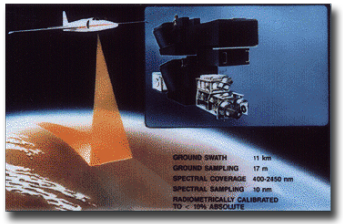
Schneider, et al. (2014) RSE; Ferraz, et al. (2018) RS

AVIRIS Classic

Imaging Spectroscopy Time Series

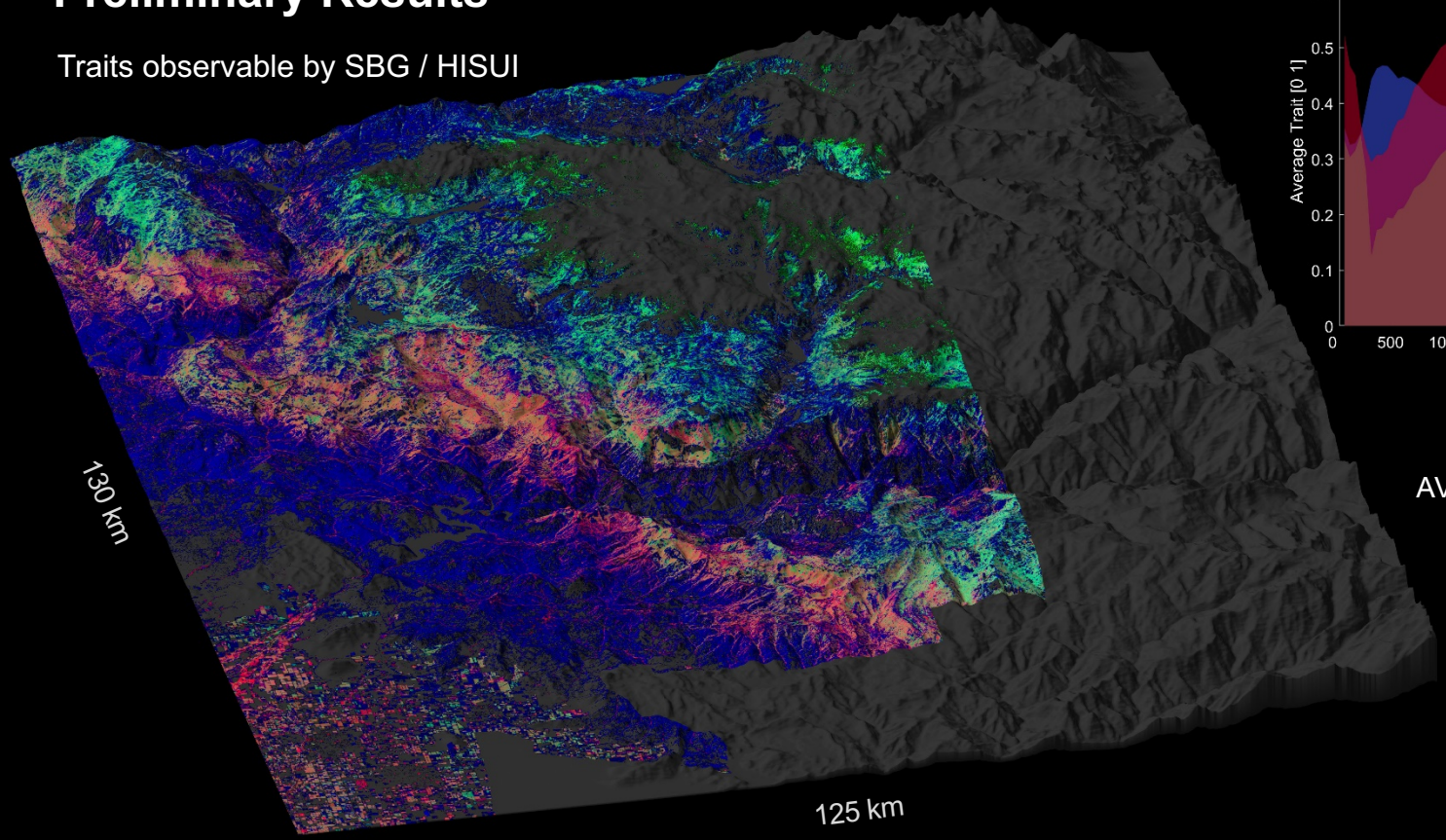


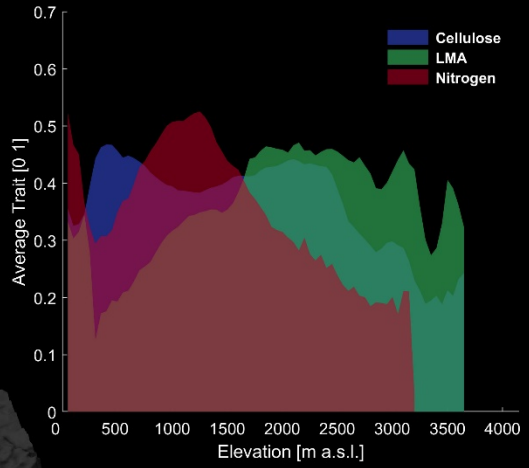




Preliminary Results

Traits observable by SBG / HISUI





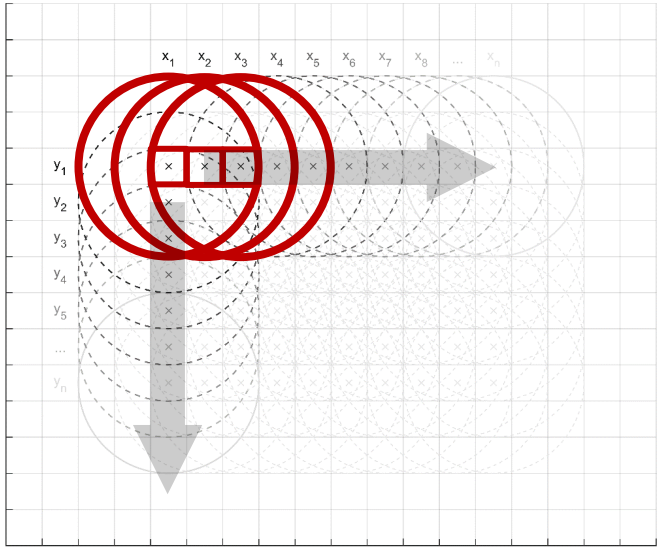
AVIRIS Classic on ER-2

Townsend, et al. (in prep); Singh, et al. (2015) EA; Serbin, et al. (2015) RSE

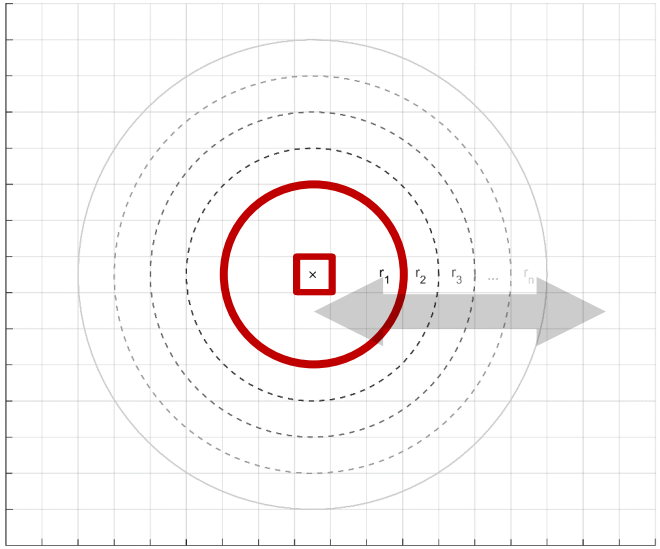
Continuous Diversity Mapping

From Traits to Diversity

Moving-Window



Radius



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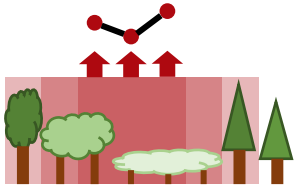
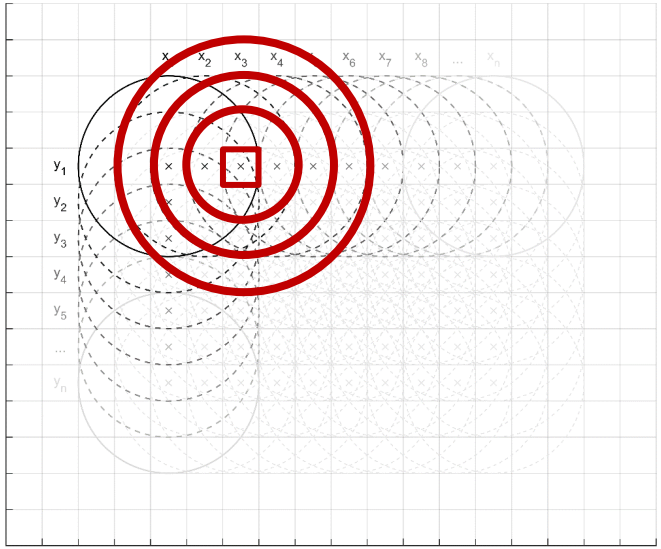
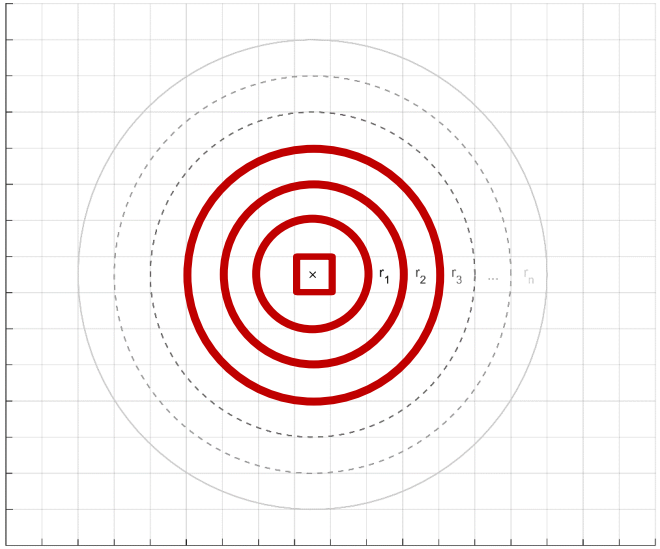


Continuous Diversity Mapping

From Traits to Diversity

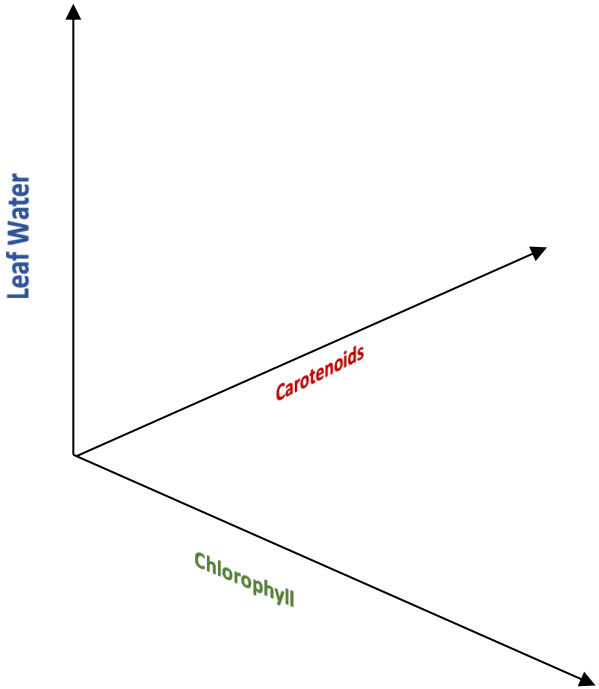


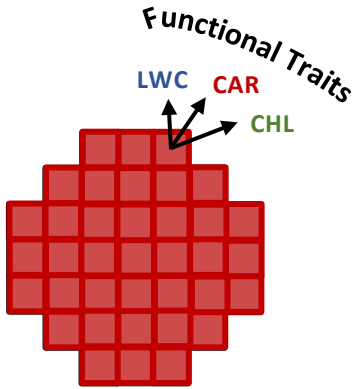
Radius



Functional Diversity Measures

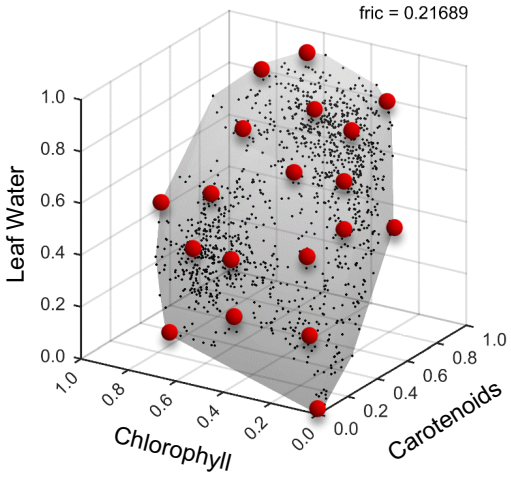
Analyzing the Trait Space



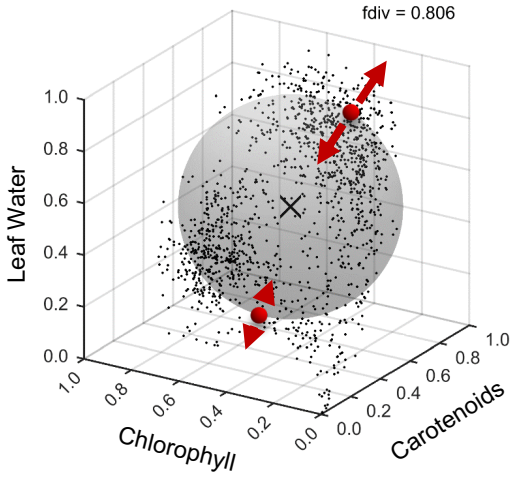


Functional Diversity Measures

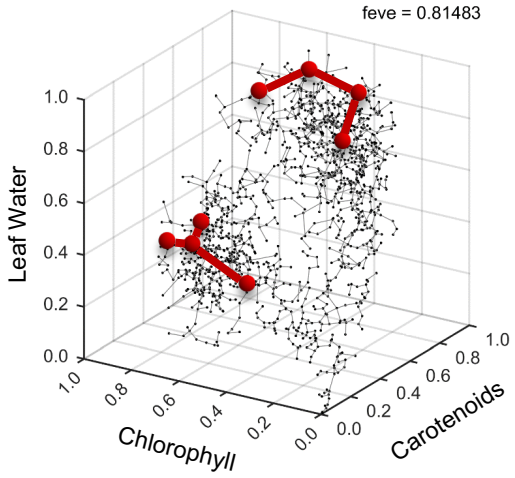
Analyzing the Trait Space



Functional Richness



Functional Divergence

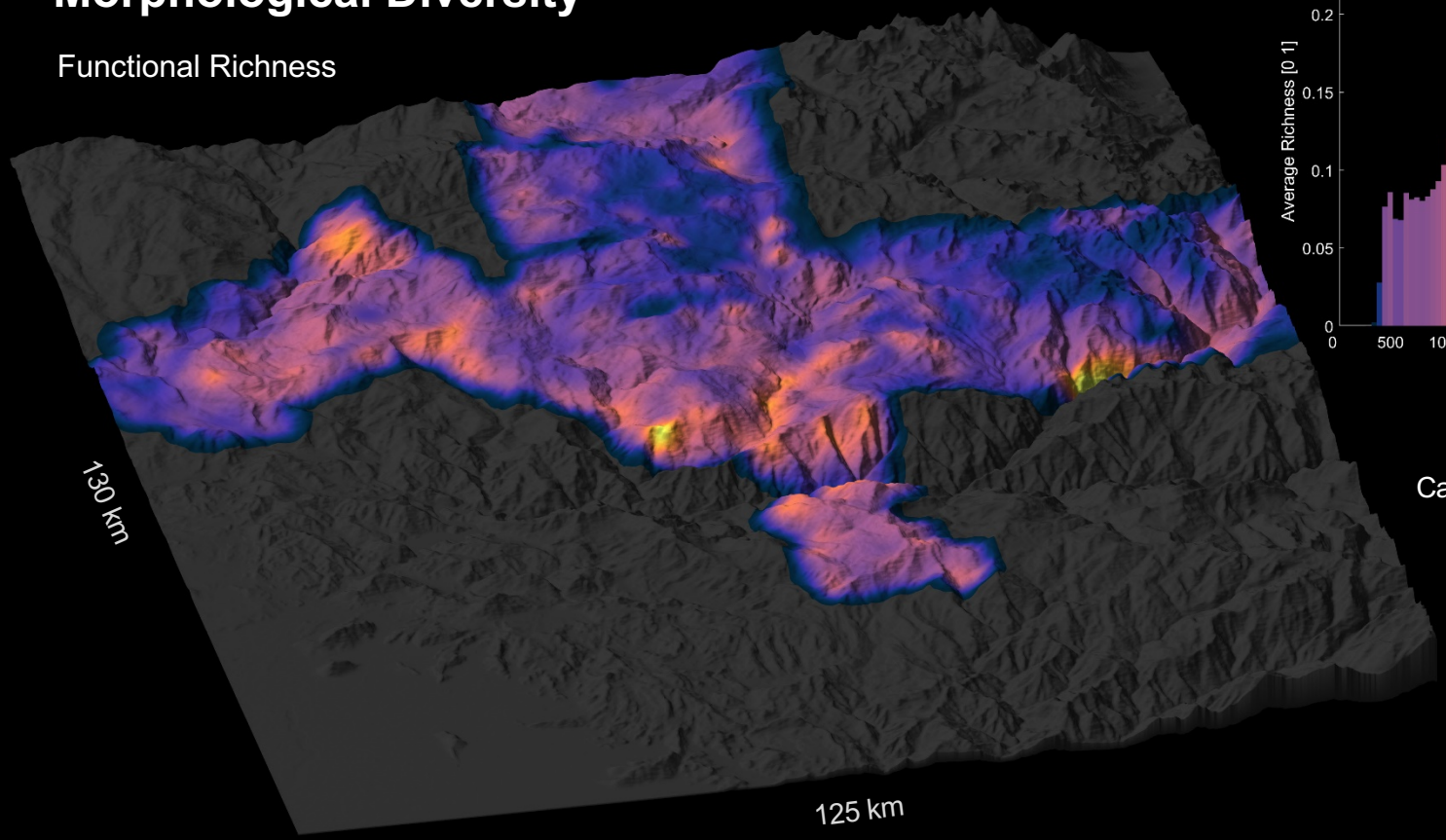


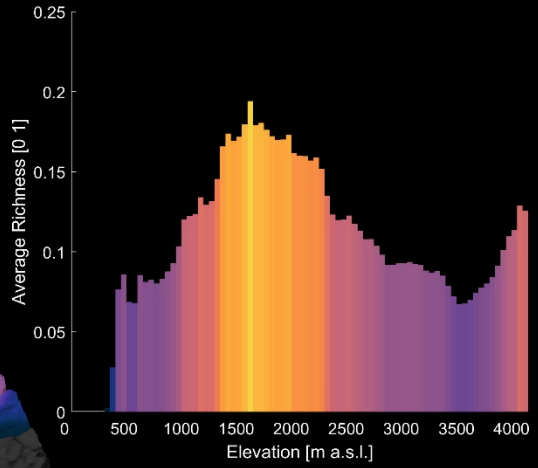
Functional Evenness

Schneider, et al. (2017) NComms; Villéger, et al. (2008) Ecology

Morphological Diversity

Functional Richness



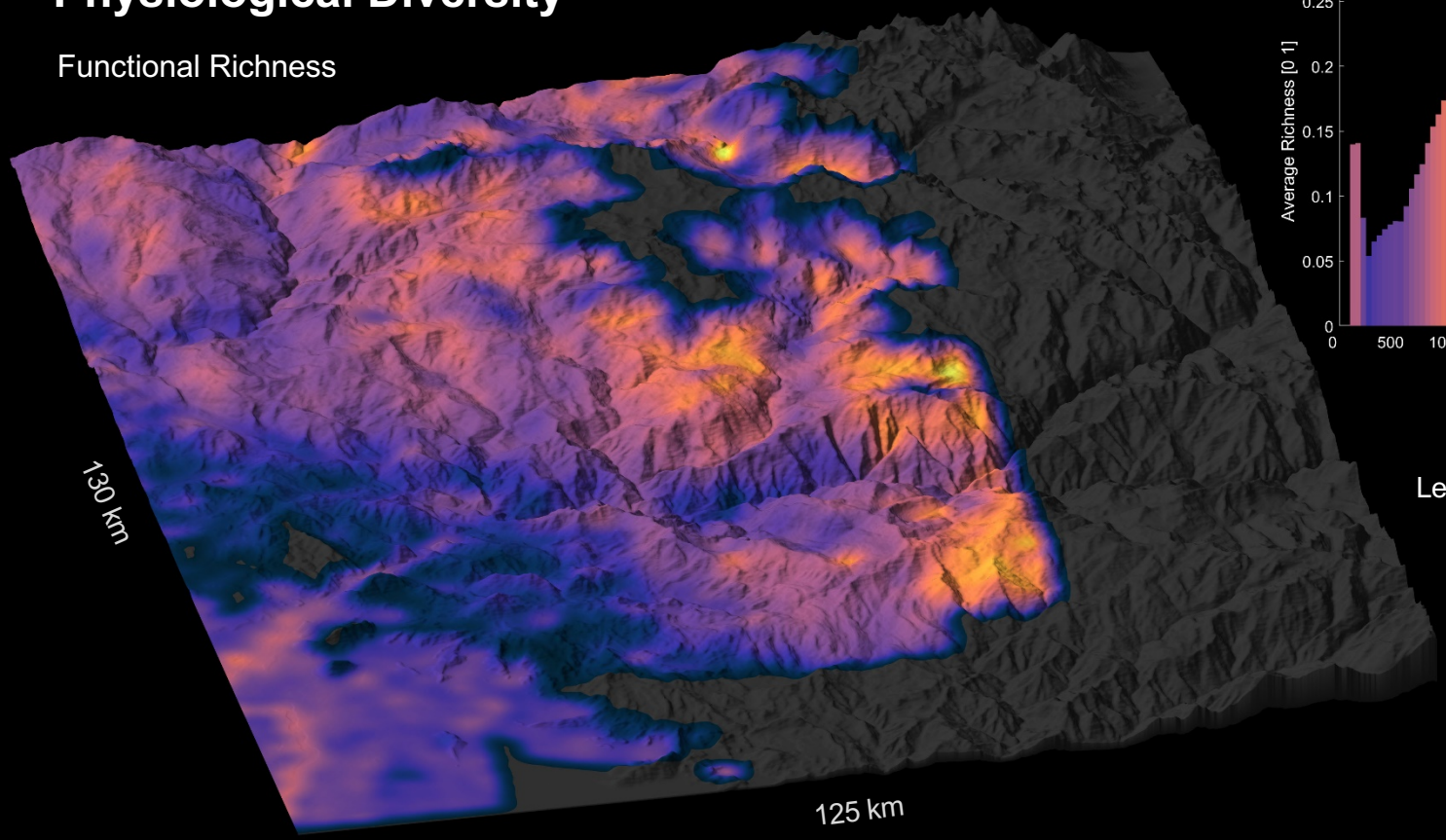


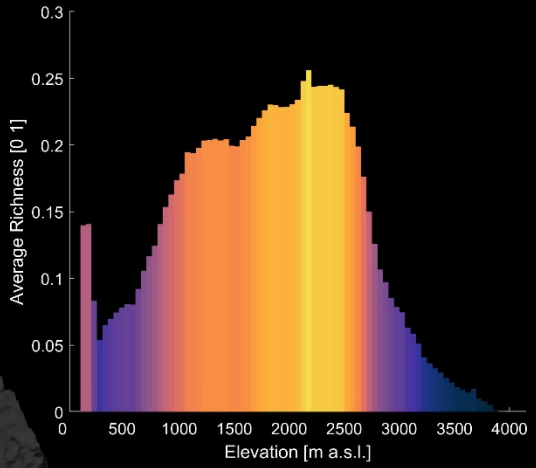
Canopy Structure
1 km Radius

Schneider, et al. (2017) NComms

Physiological Diversity

Functional Richness



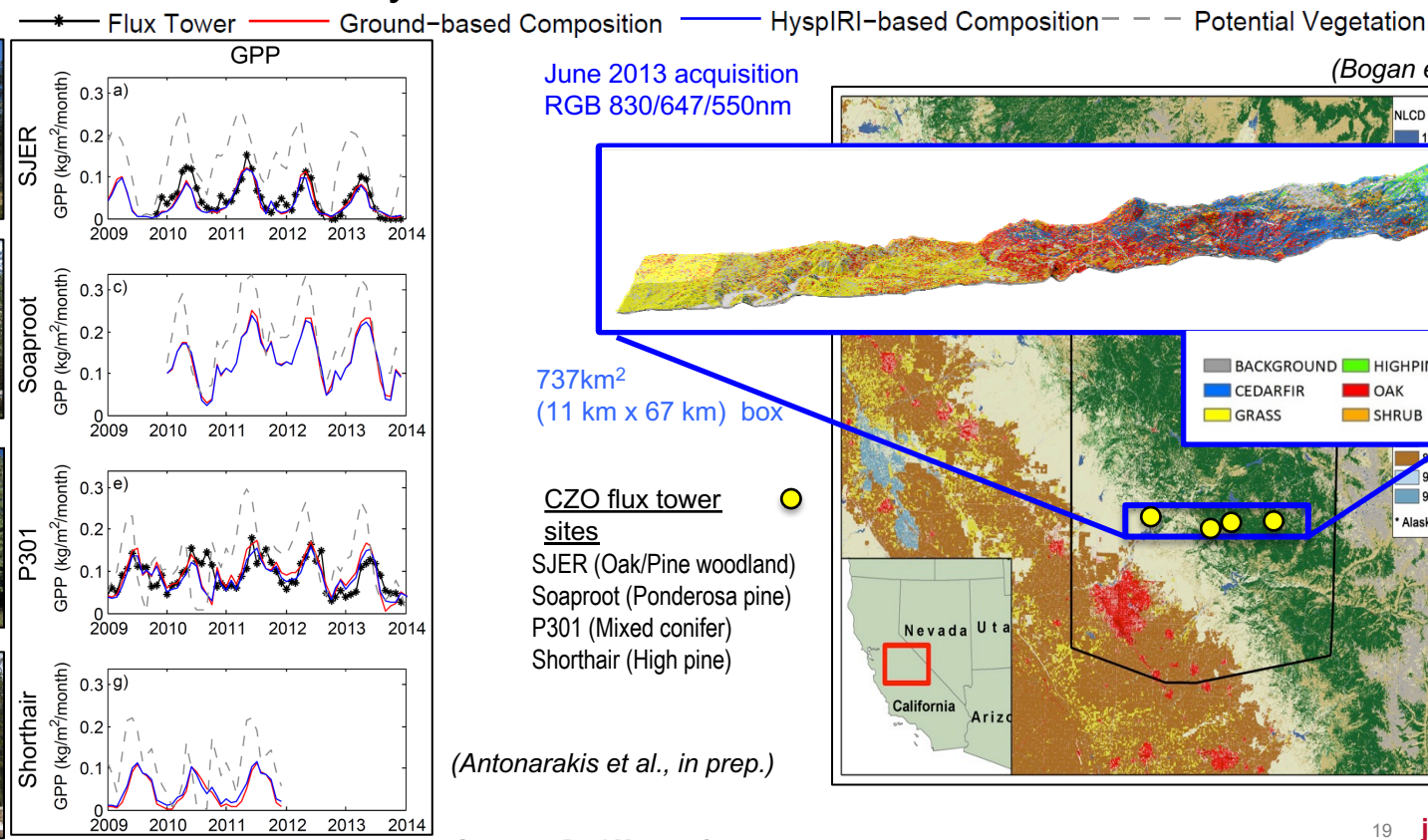


Leaf Physiology
1 km Radius

Schneider, et al. (2017) NComms

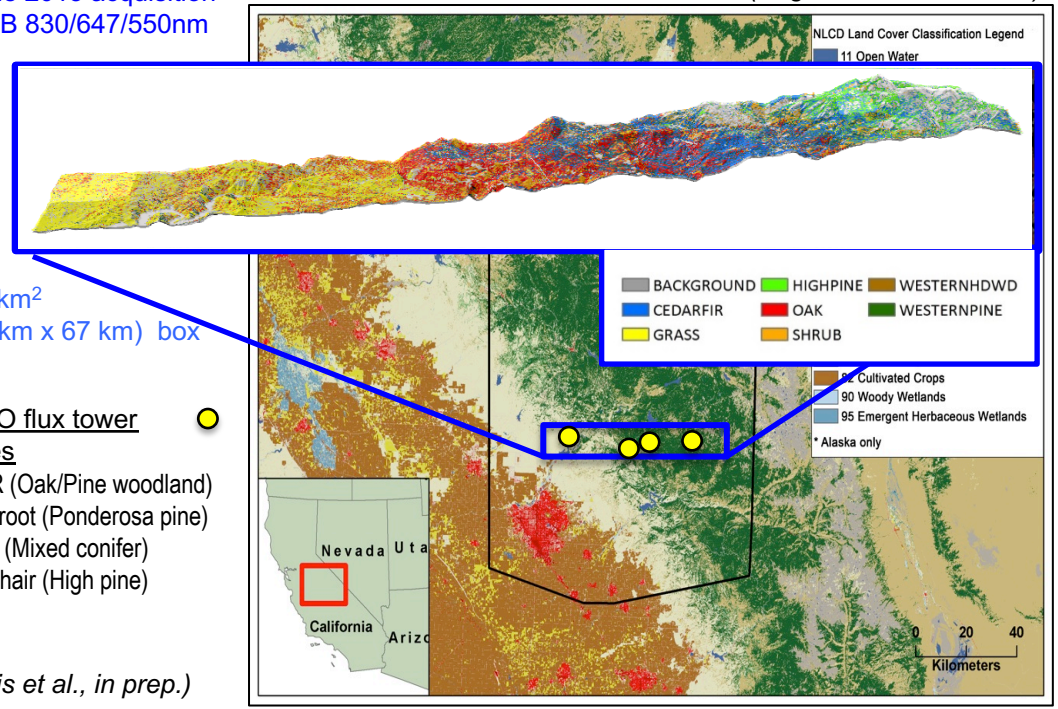
Ecosystem Demography Modeling

Critical Zone Observatory Flux Towers



June 2013 acquisition
RGB 830/647/550nm

(Bogan et al., in revision)



737km²
(11 km x 67 km) box

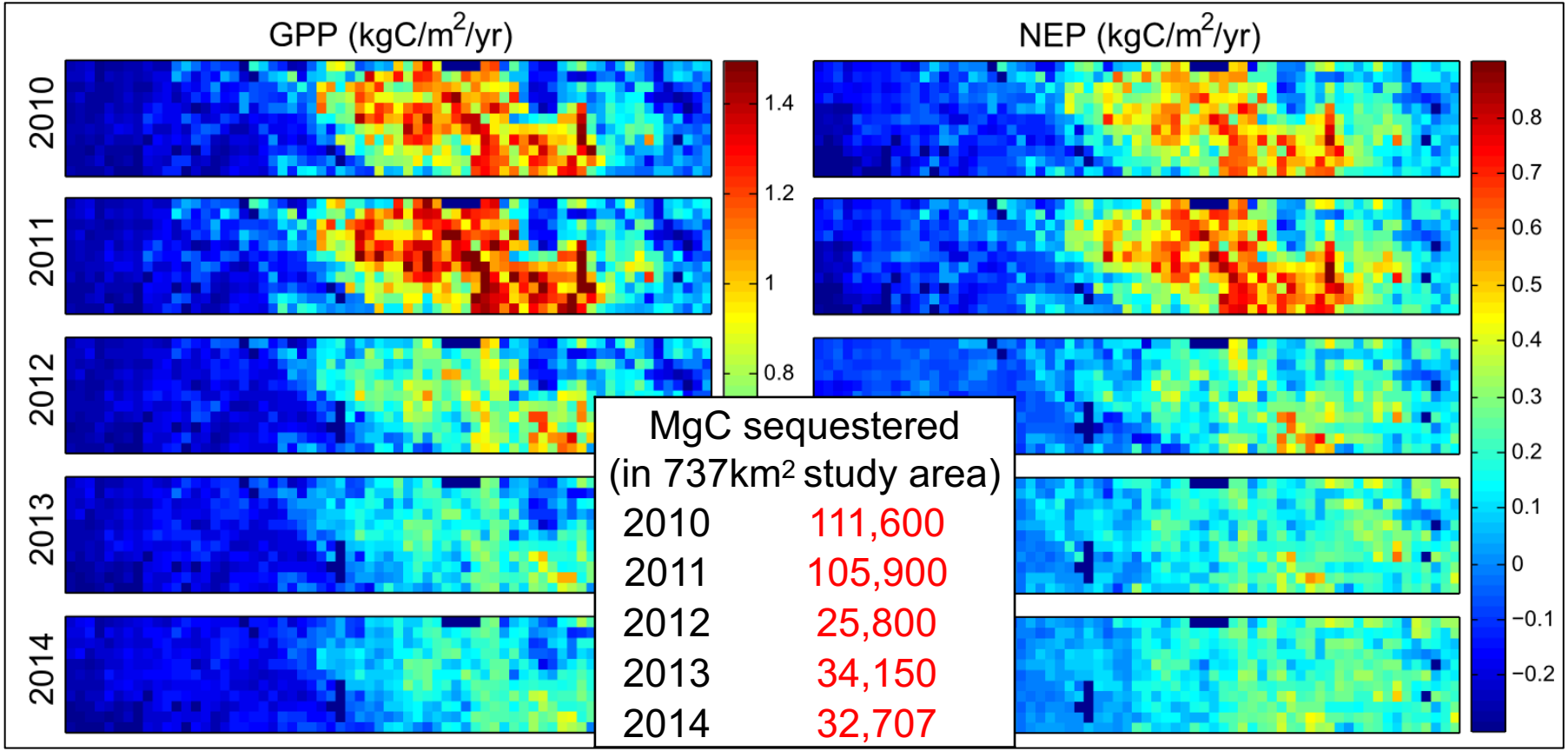
<u>CZO flux tower sites</u>

SJER (Oak/Pine woodland)
Soaproot (Ponderosa pine)
P301 (Mixed conifer)
Shorthair (High pine)

(Antonarakis et al., in prep.)

Courtesy: Paul Moorcroft

California GPP Prediction



MgC sequestered (in 737km² study area)	
2010	111,600
2011	105,900
2012	25,800
2013	34,150
2014	32,707

Courtesy: Paul Moorcroft

Conclusion

- Diversity mapping based on plant functional traits
  - Which traits are most relevant and how much of total diversity can be explained?
- Community-scale measurements from space
  - Airborne campaigns for scaling between in-situ and spaceborne measurements
- Link diversity patterns to ecosystem stability and productivity
  - Global biodiversity observatory
- Integration with ecosystem models
  - Wall-to-wall functional traits and trait diversity can help to improve modeling and predicting energy, water and carbon fluxes

Thank you

Michael Schaepman, Felix Morsdorf,
Bernhard Schmid, Owen Petchey, David Thompson,
Tom Painter, John Chapman, Adam Chlus, Zhiwei Ye

URPP Global Change and Biodiversity

Jet Propulsion Laboratory
California Institute of Technology

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