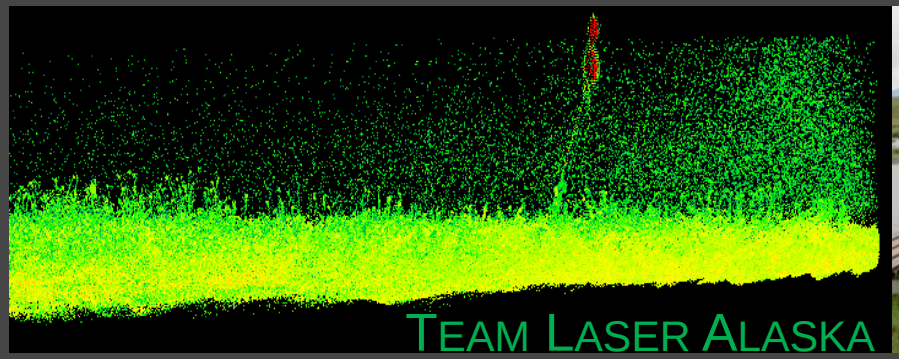
Reflecting on Toolik: Recent advances for understanding Arctic ecology using lidar data



Lee Vierling

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Co-PI's: Natalie Boelman, Jan Eitel, Kevin Griffin, Shahid Naeem

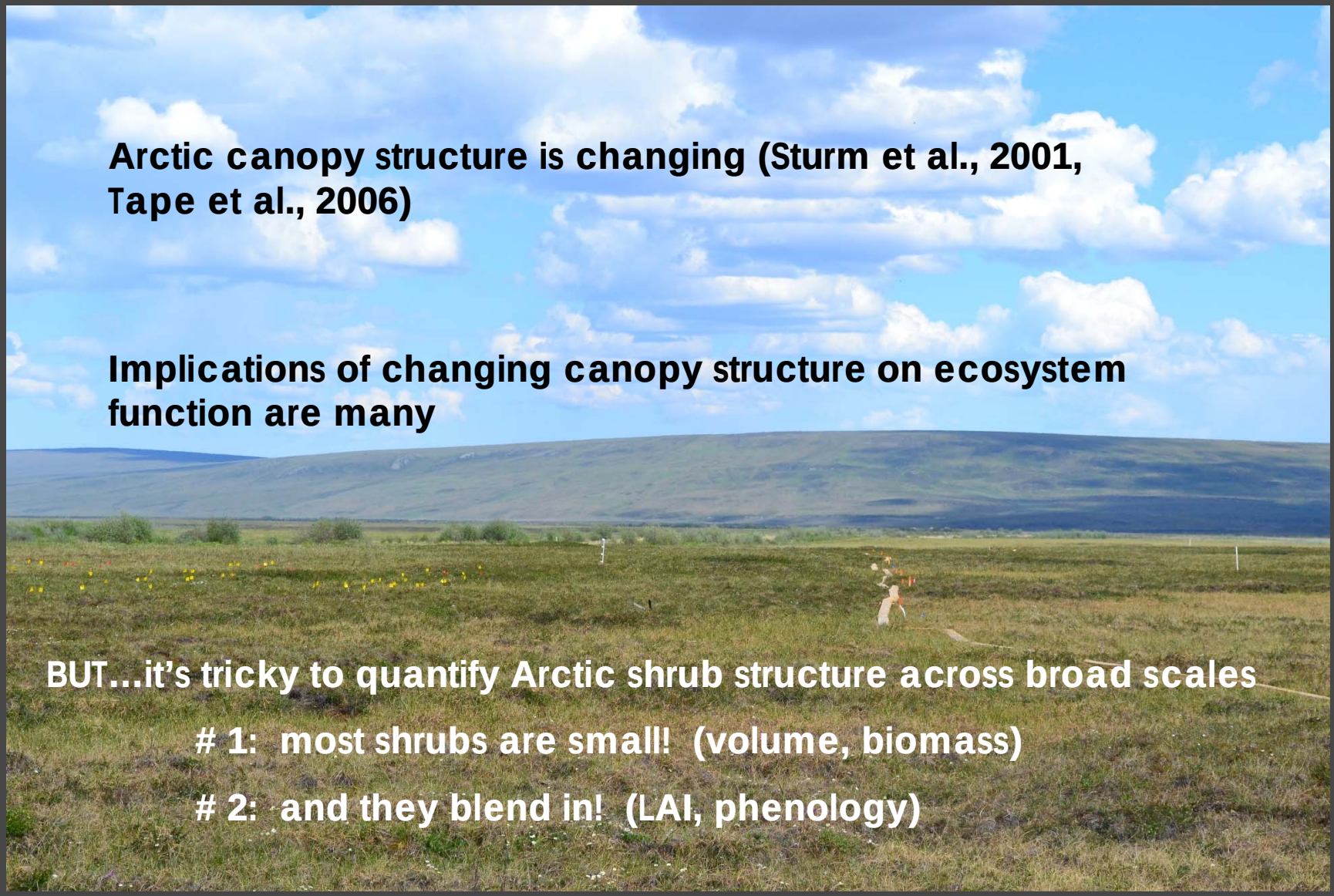
University of Idaho
College of Natural Resources

Lamont-Doherty Earth Observatory
COLUMBIA UNIVERSITY | EARTH INSTITUTE

Toolik All-Scientists Meeting

1/27/2017

Arctic canopy structure and function



Arctic canopy structure is changing (Sturm et al., 2001, Tape et al., 2006)

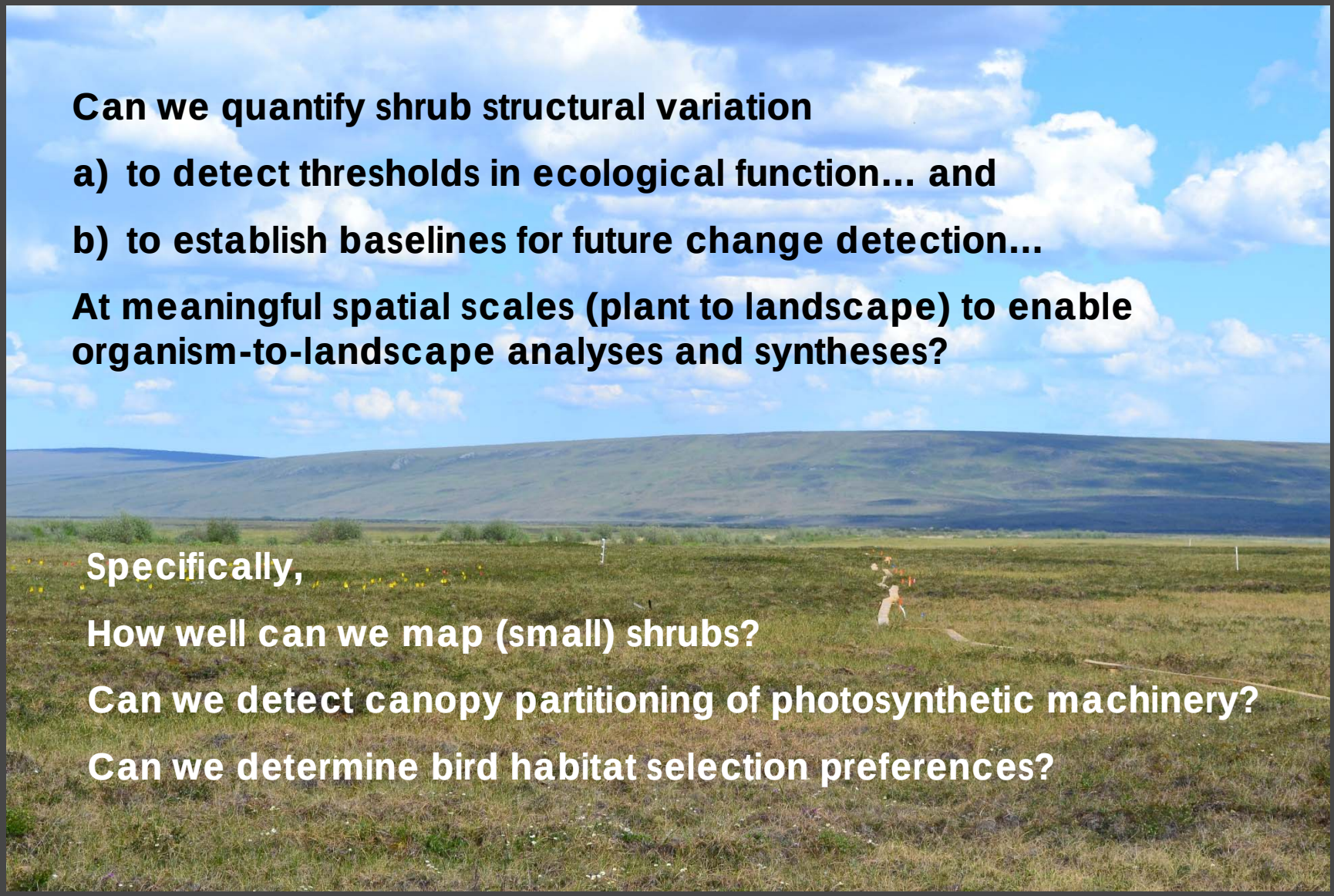
Implications of changing canopy structure on ecosystem function are many

BUT…it's tricky to quantify Arctic shrub structure across broad scales

 # 1: most shrubs are small! (volume, biomass)

 # 2: and they blend in! (LAI, phenology)

Main goals and questions



Can we quantify shrub structural variation

a) to detect thresholds in ecological function… and

b) to establish baselines for future change detection…

At meaningful spatial scales (plant to landscape) to enable organism-to-landscape analyses and syntheses?

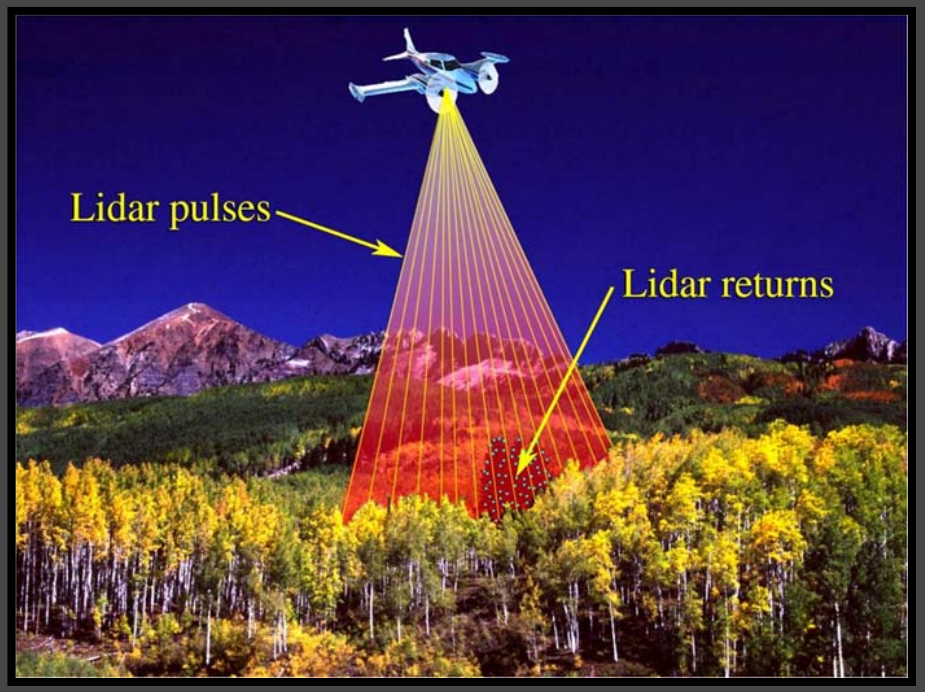
Specifically,

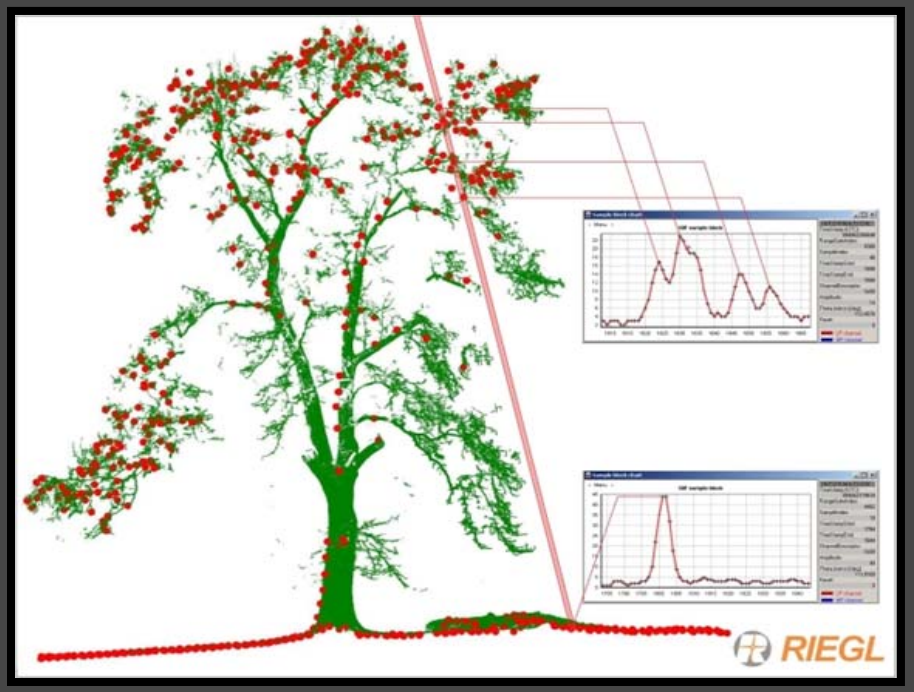
How well can we map (small) shrubs?

Can we detect canopy partitioning of photosynthetic machinery?

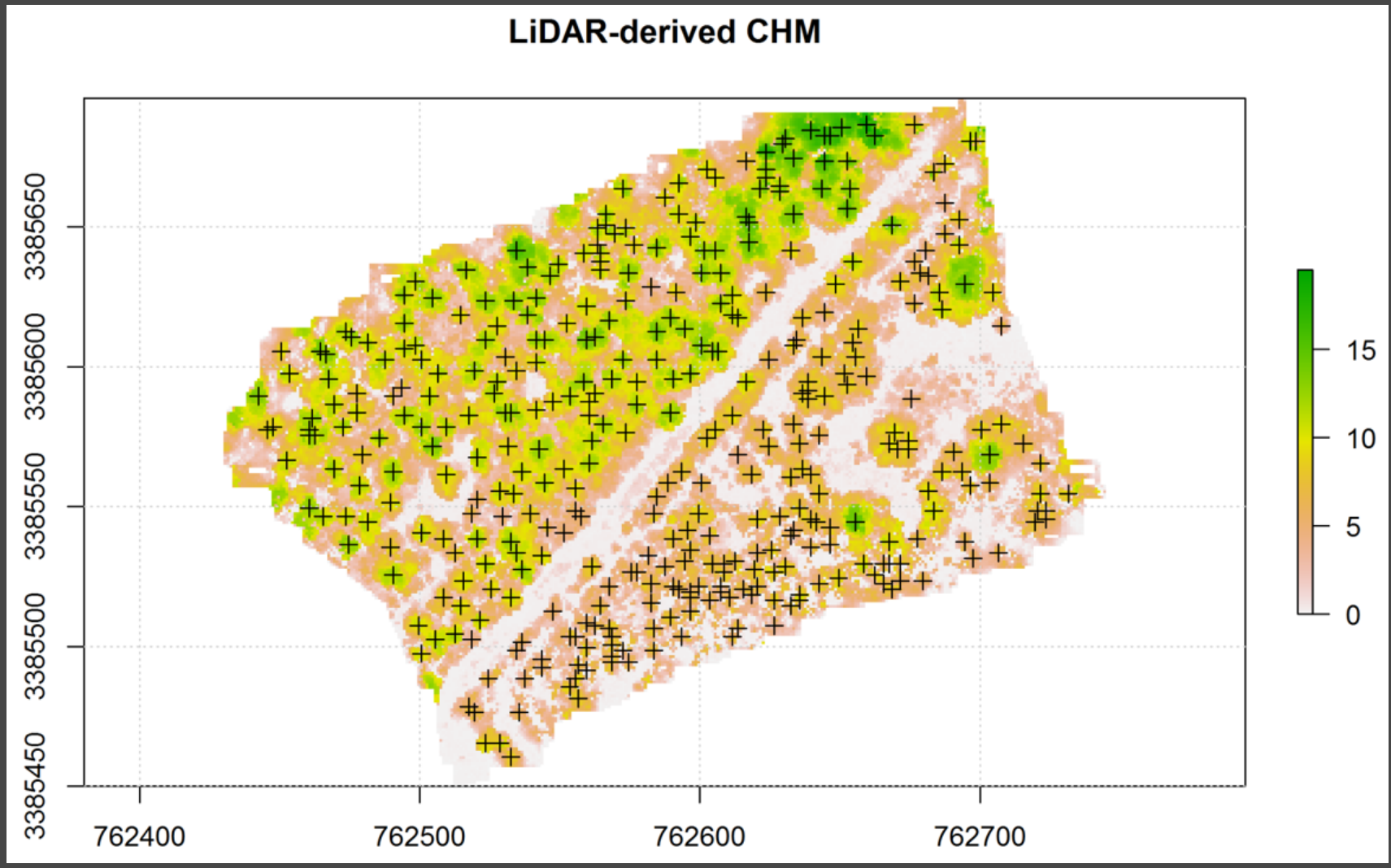
Can we determine bird habitat selection preferences?

...can we do *this* in the tundra?





...and maybe this too?

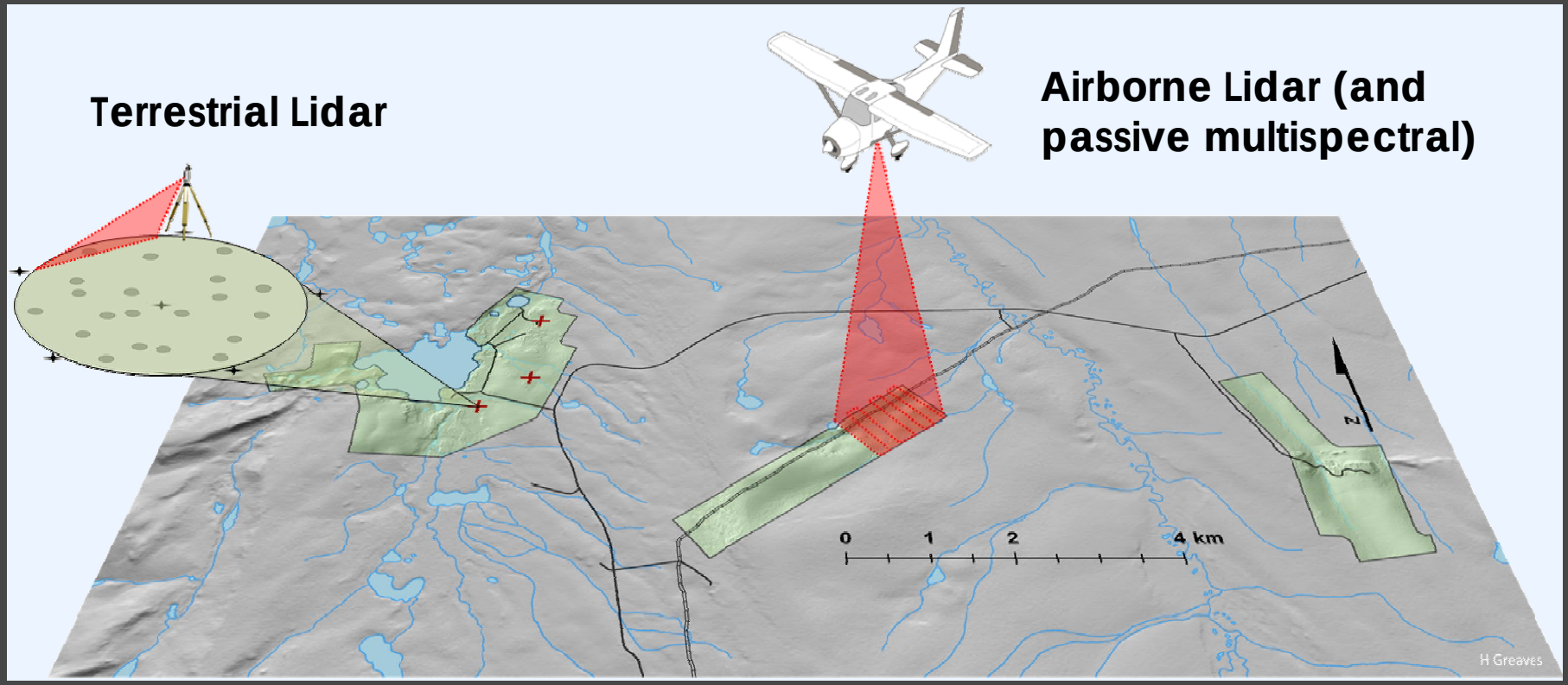


Silva et al., in prep

The signal-noise problem

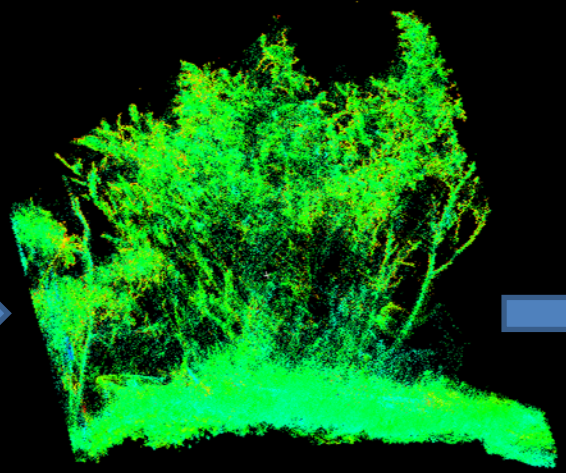
14

Team Laser's approach

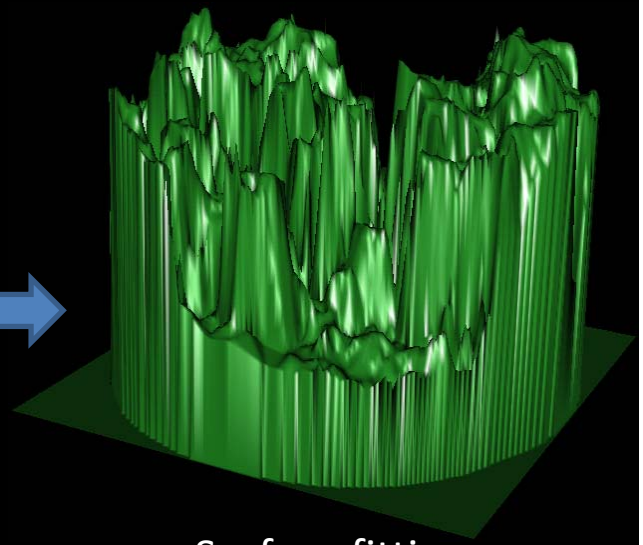


Can we derive shrub biomass from terrestrial Lidar?

Shrub in quad



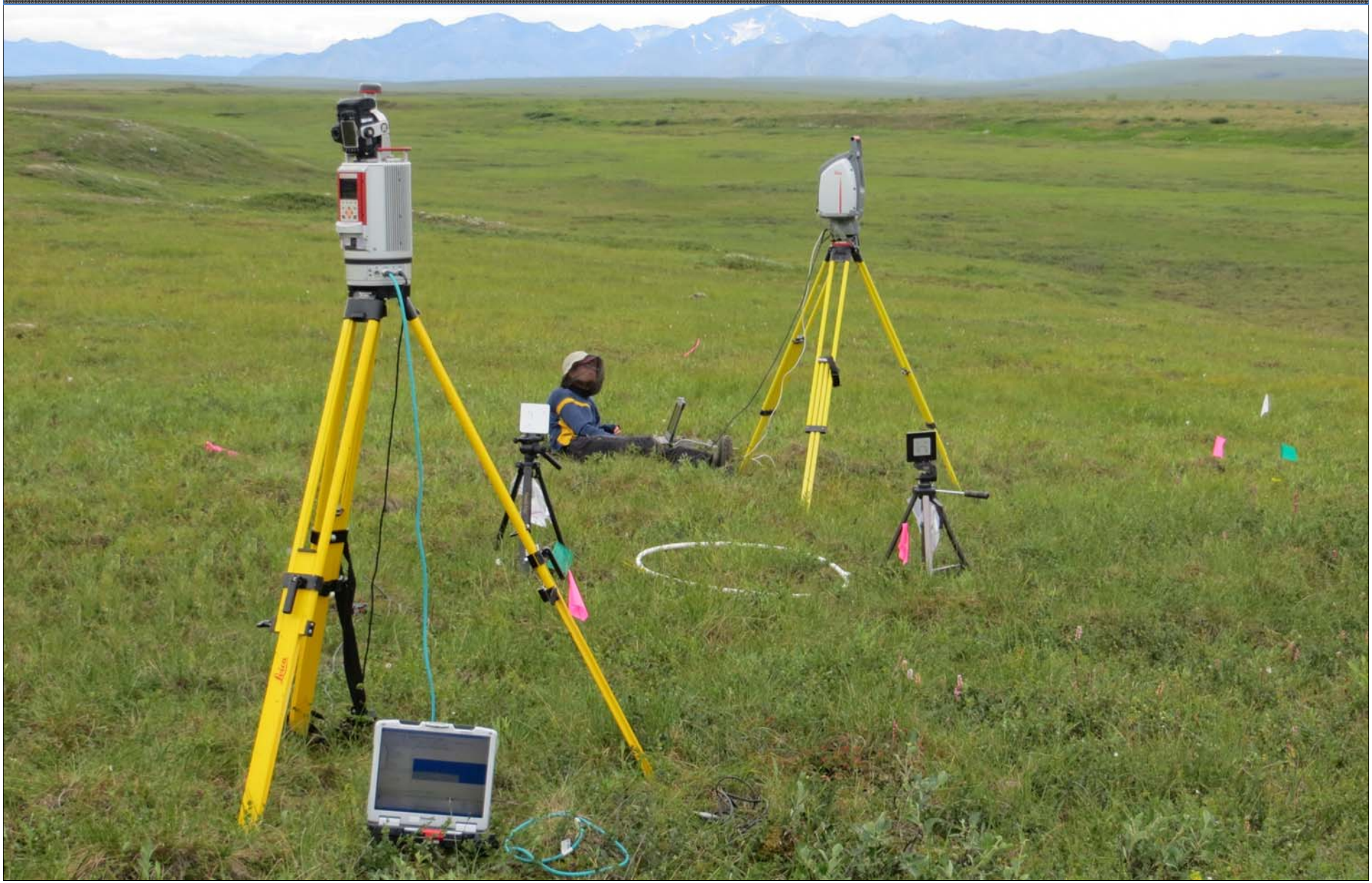
Quad point cloud



Surface fitting

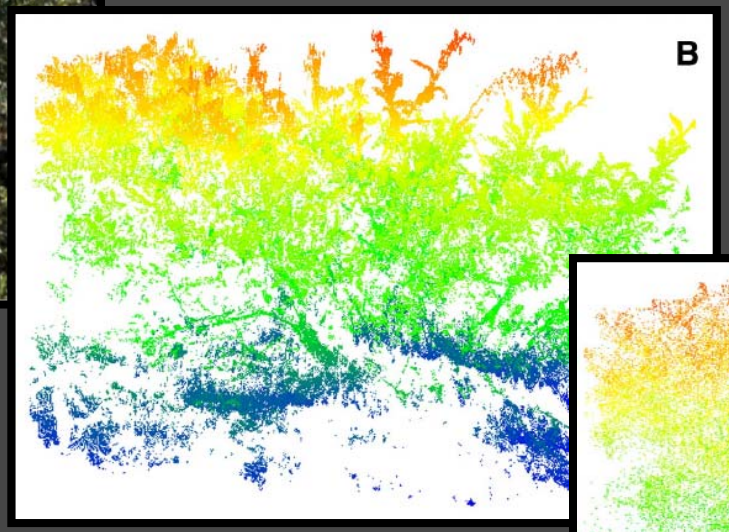
Shrub volume estimation

Terrestrial Lidar (TLS): Millimeter-scale laser scanning

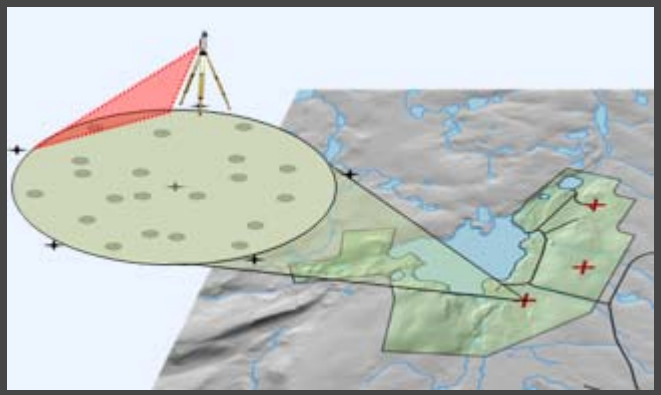


Estimating shrub biomass at fine scale

Individual plant scan

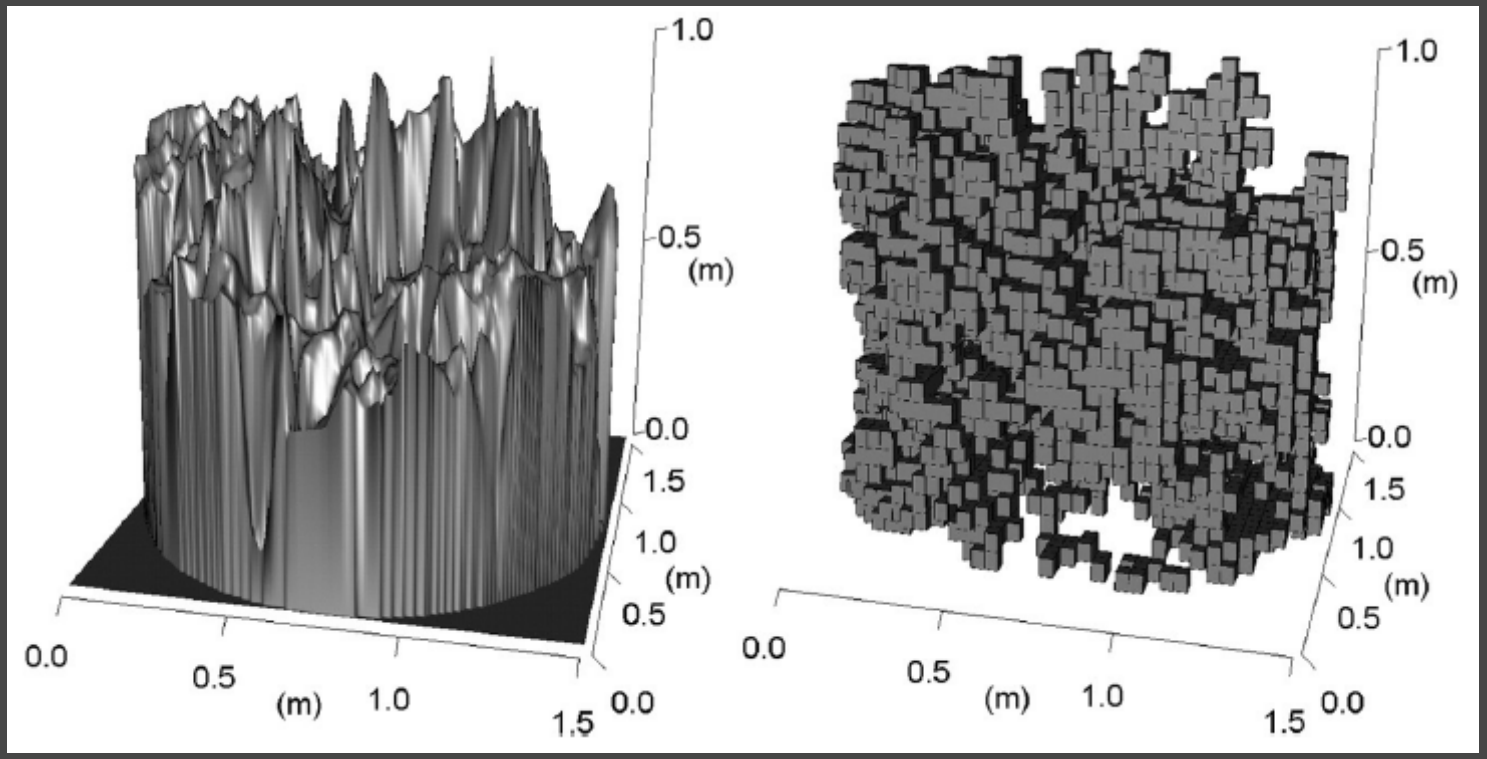


From 50m diameter plot scan



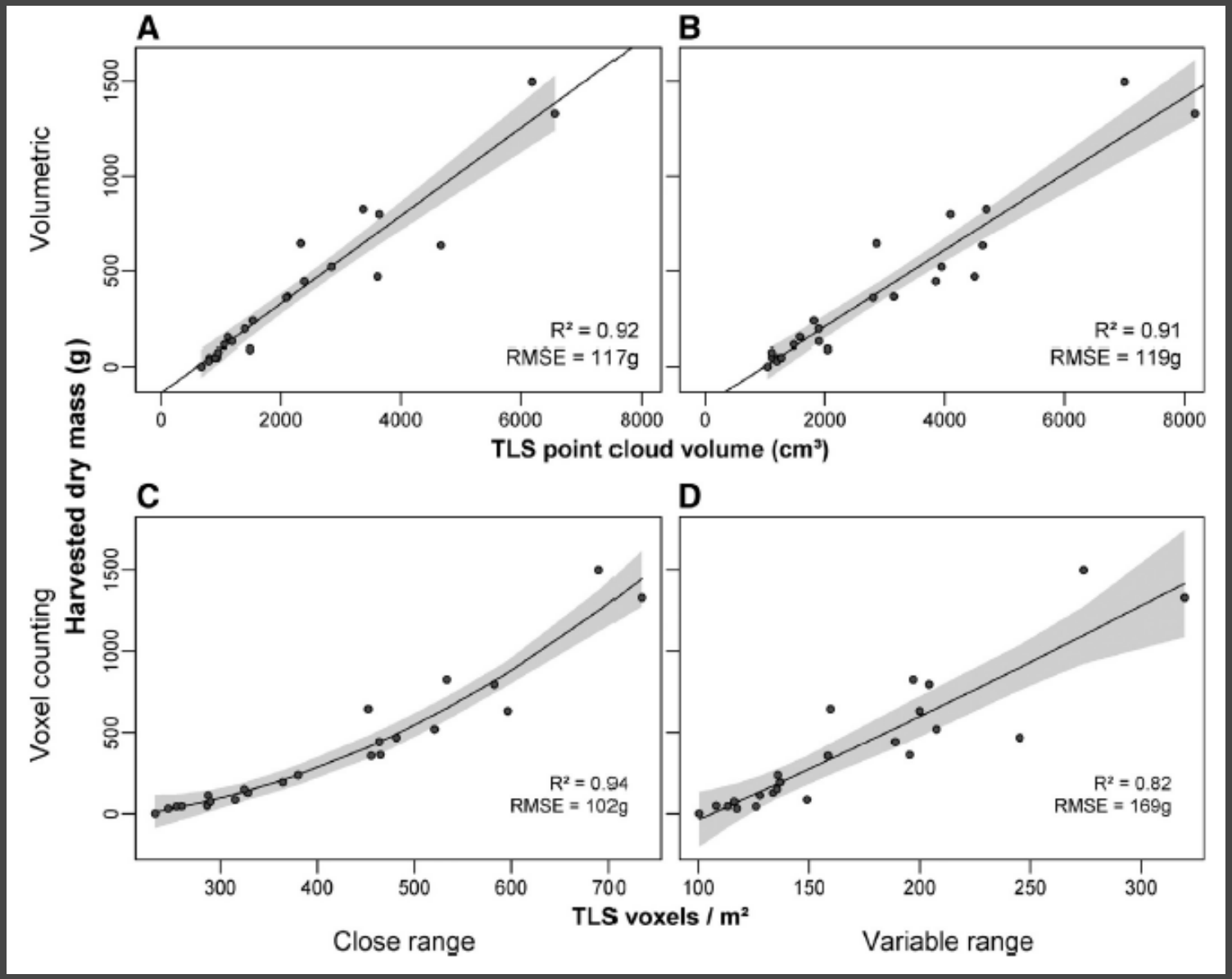
Greaves et al., 2015

Estimating shrub biomass at fine scale



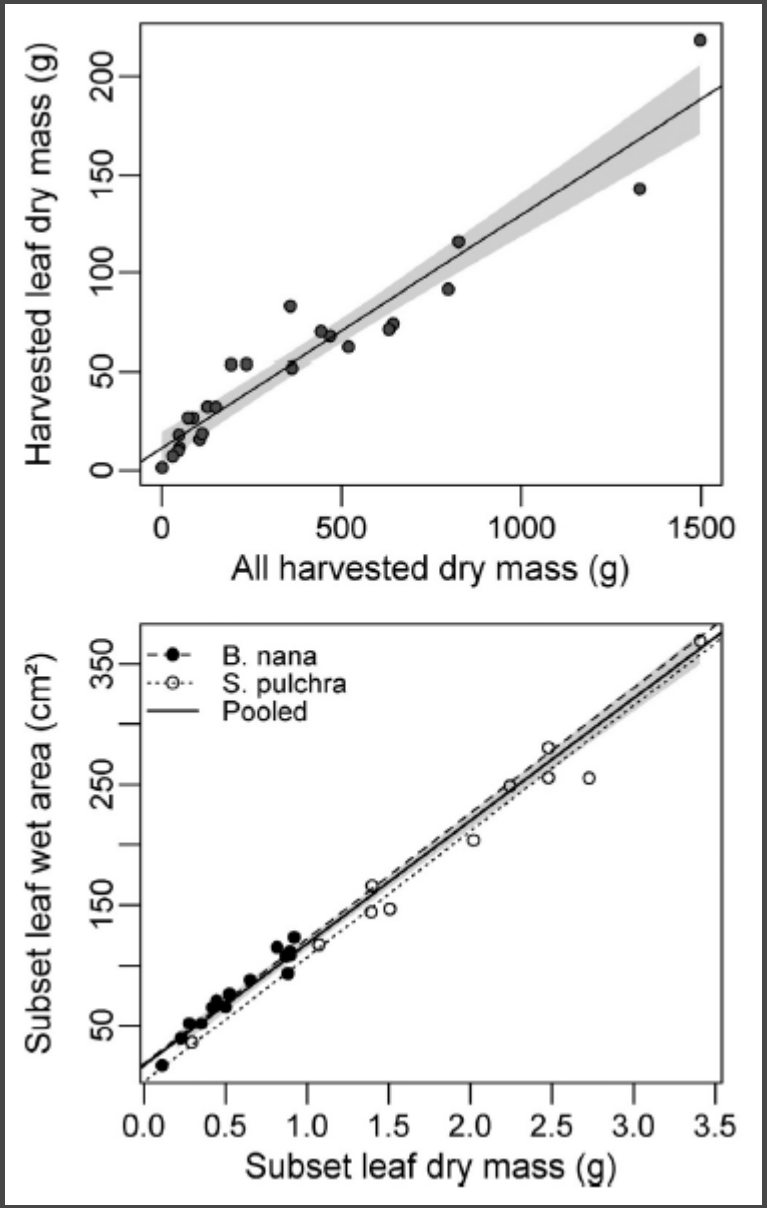
Greaves et al., 2015

Estimating shrub biomass at fine scale



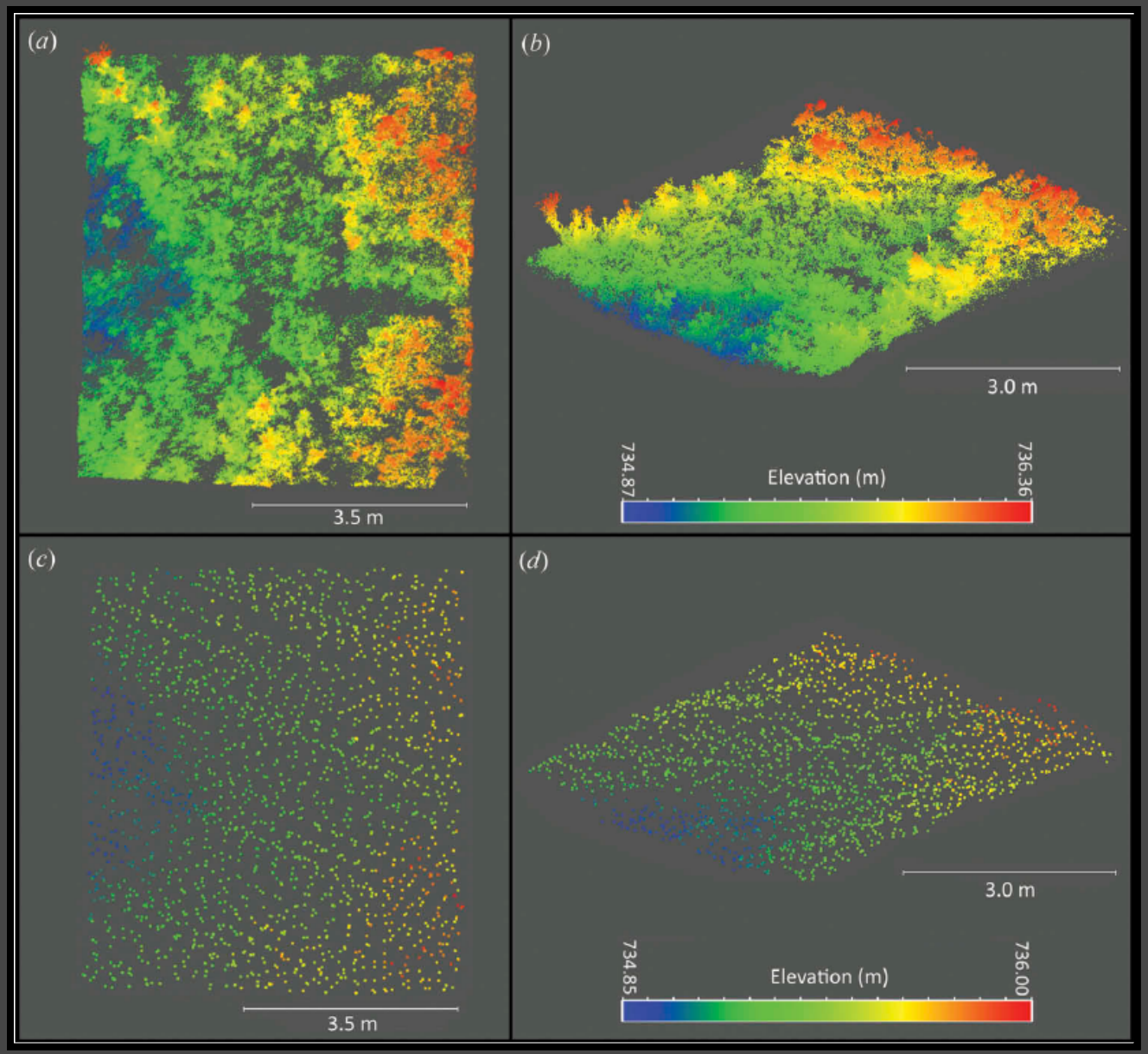
Greaves et al., 2015

Extension to leaf area index



Greaves et al., 2015

Can we map shrub biomass across the landscape?



Terrestrial Lidar

R^2 ~ 0.82-0.94,
RMSE ~ 102-169 g

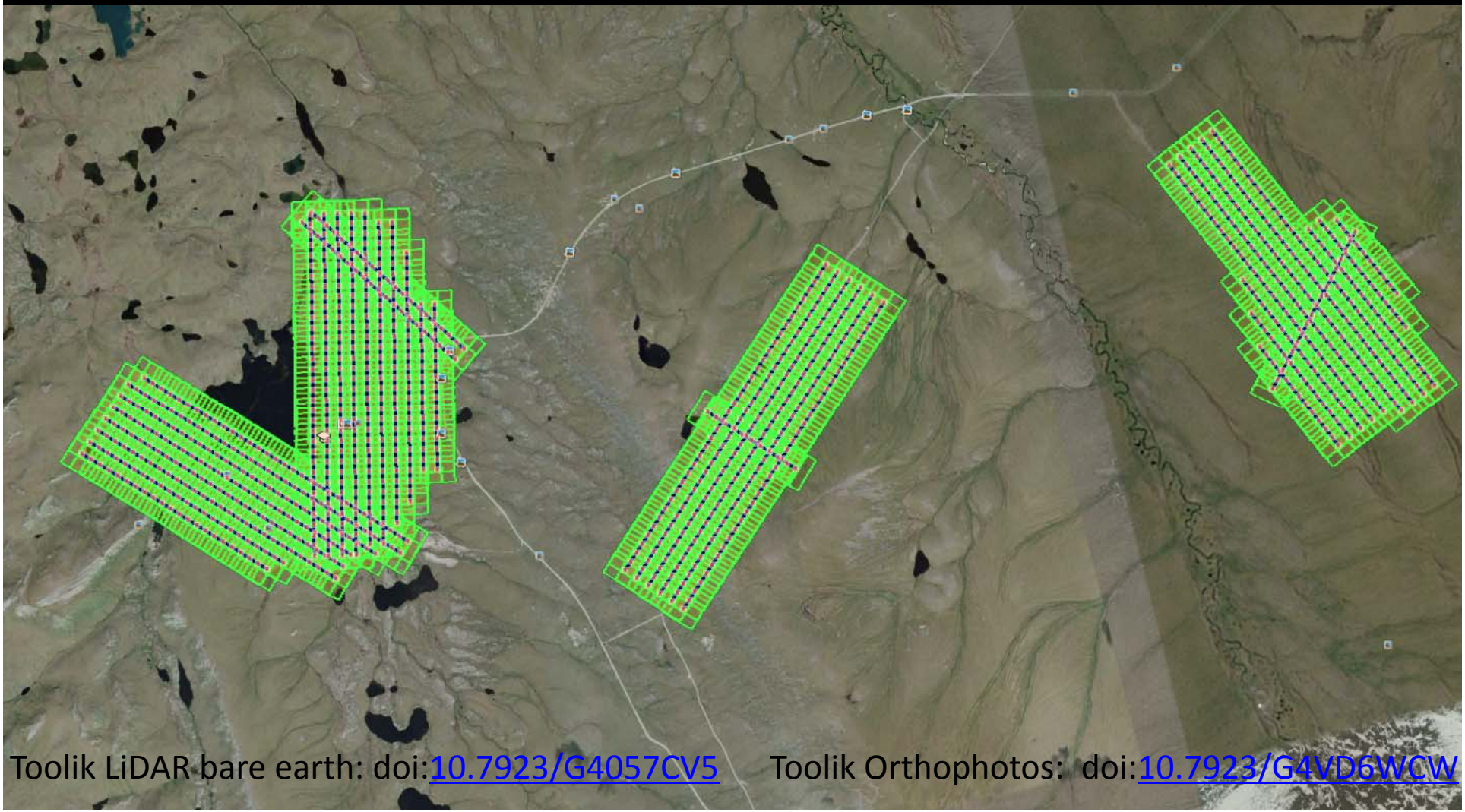
Airborne Lidar

???

Greaves et al., 2017

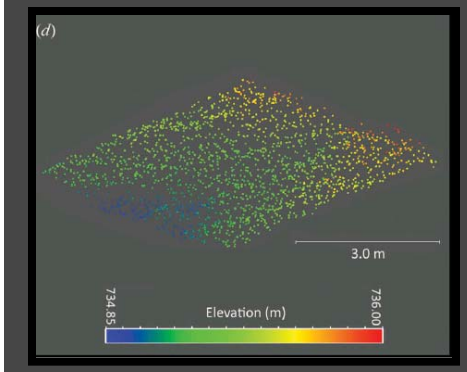
Airborne Lidar acquisition 2013

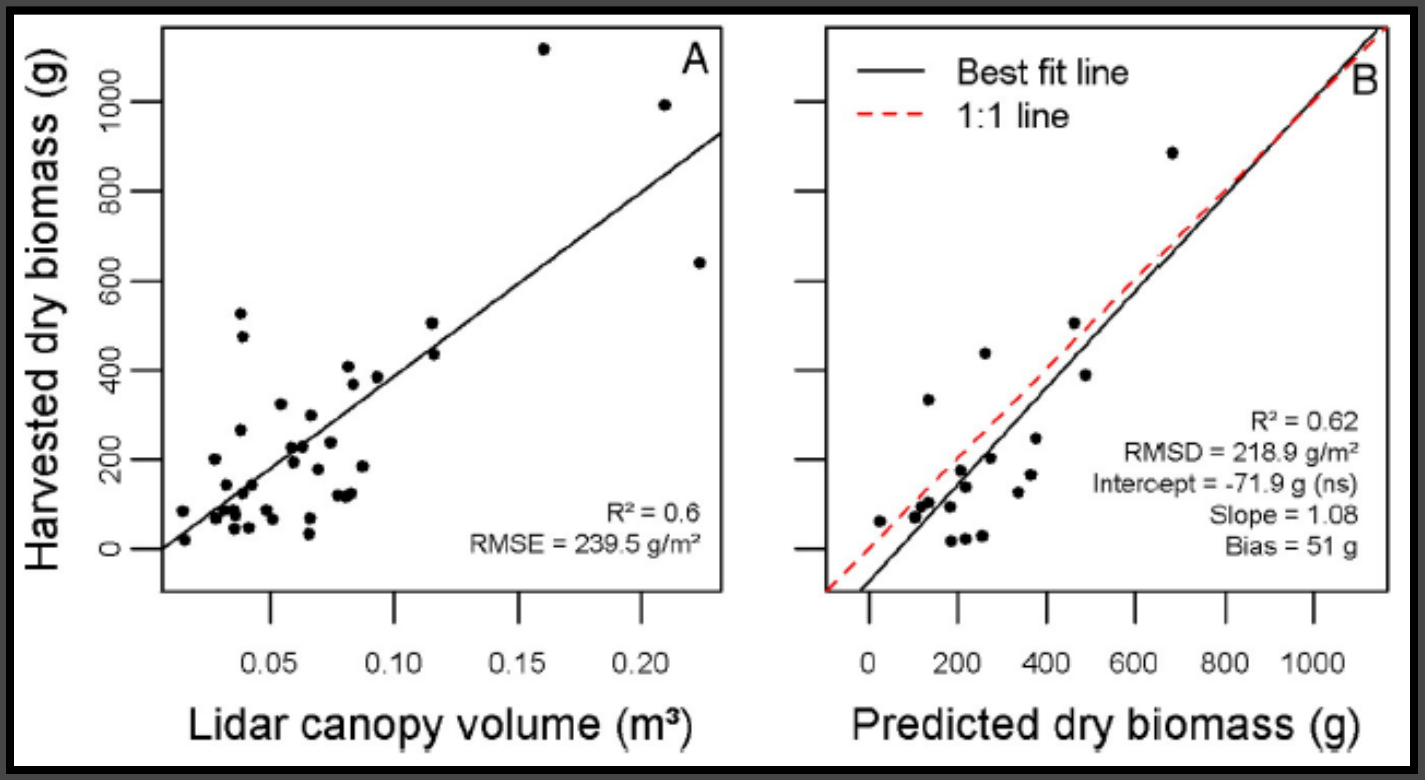
- Minimum point density of 27 points/m²
- 5 cm resolution RGB NIR orthorectified aerial photographs
- These locations + SagDOT & Roche



Toolik LiDAR bare earth: doi:10.7923/G4057CV5 Toolik Orthophotos: doi:10.7923/G4VD6WCW

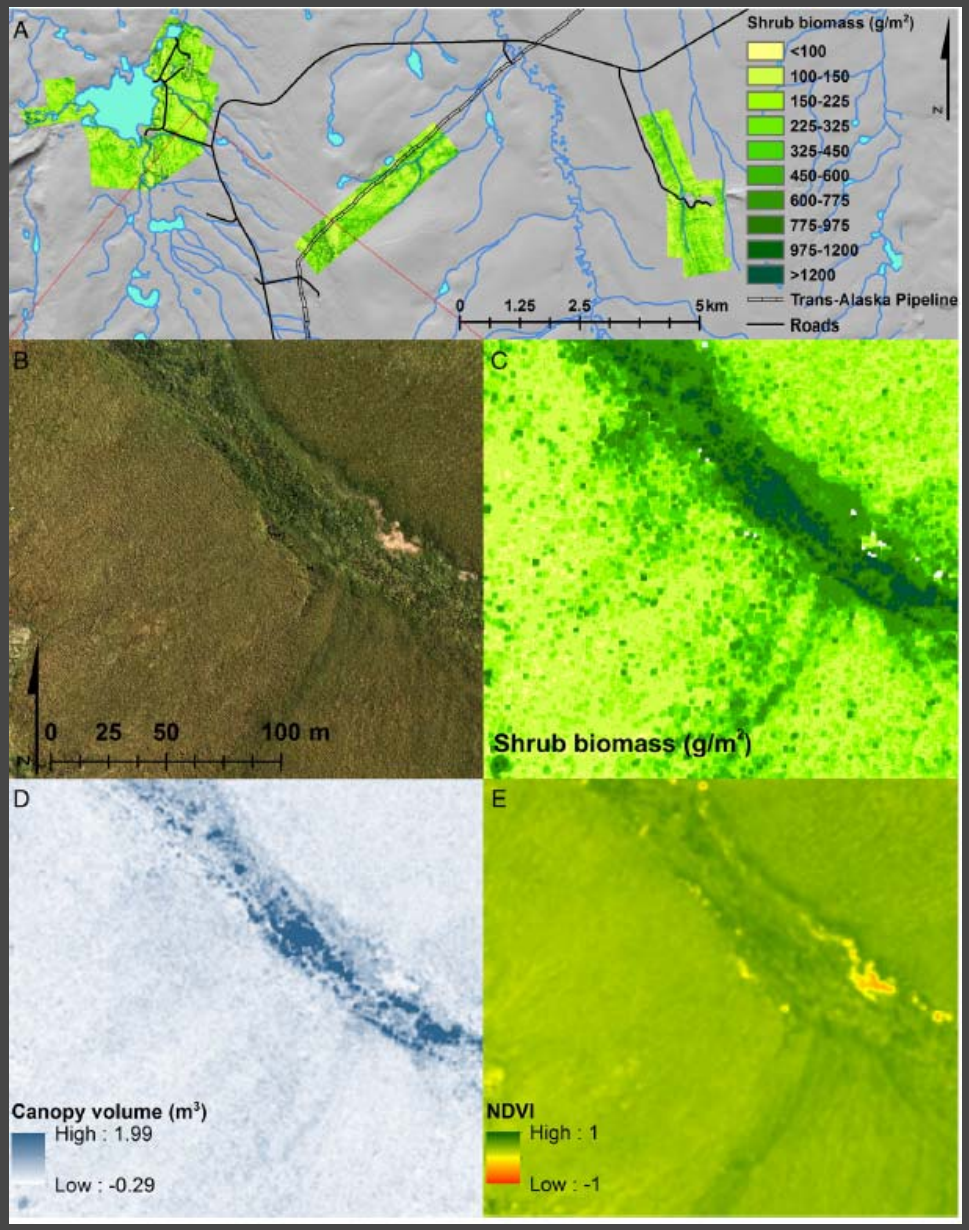
Mapping shrub biomass across the landscape





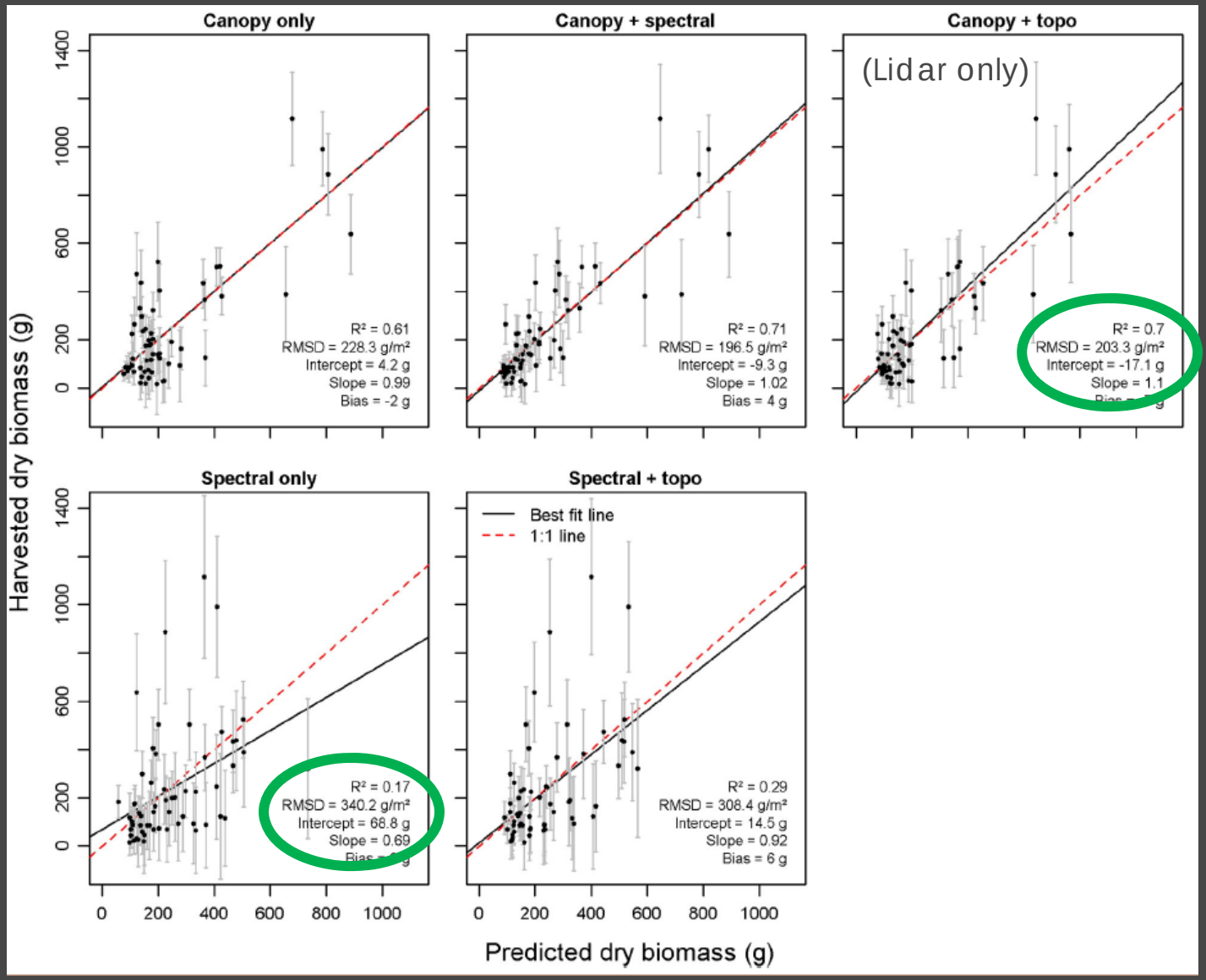
Greaves et al., 2016

Mapping shrub biomass across the landscape



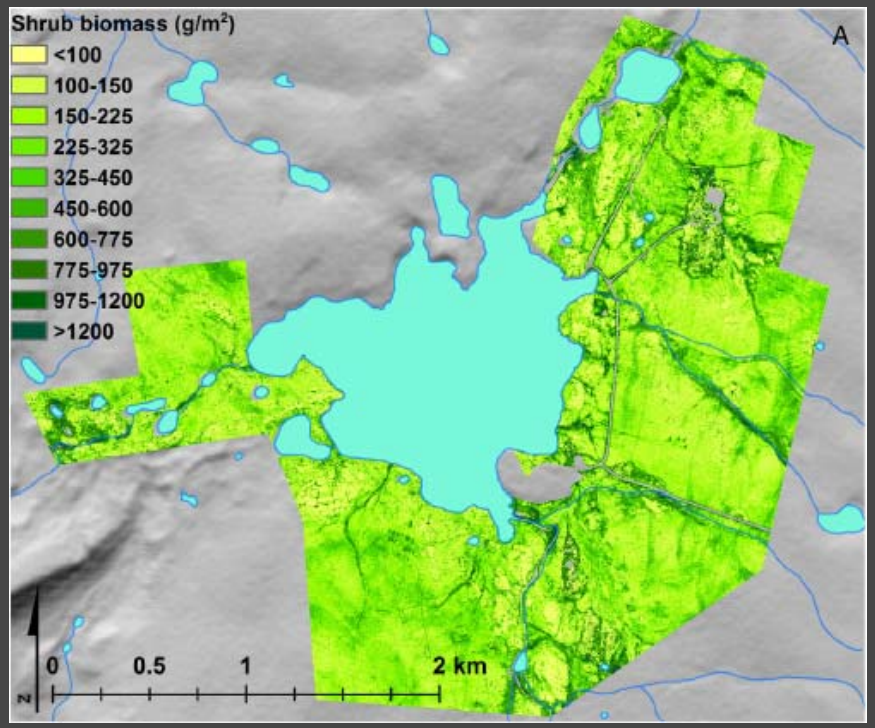
Greaves et al., 2016

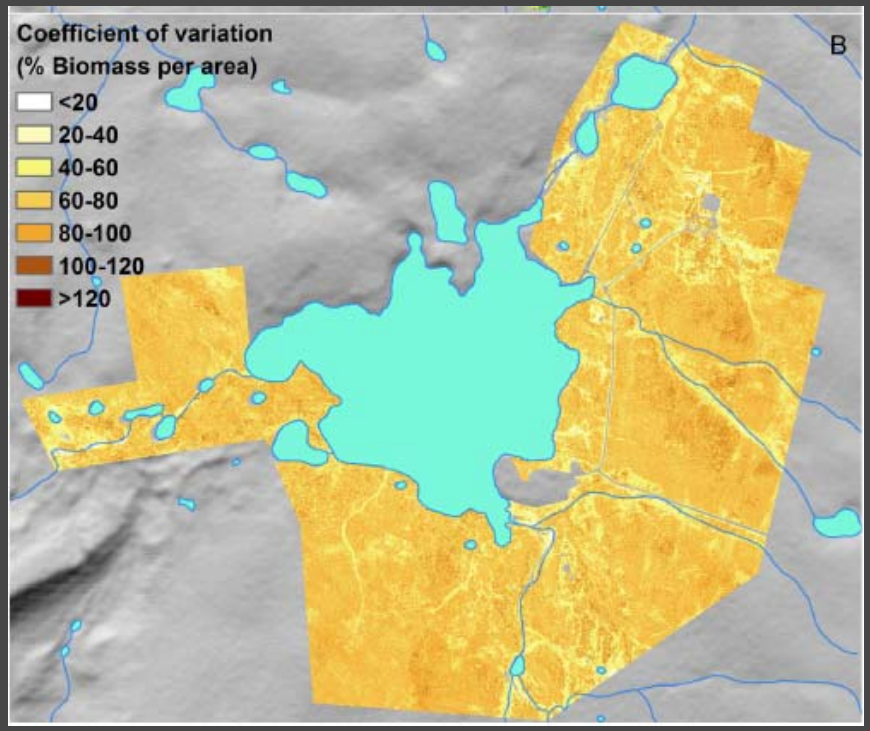
How do passive data (e.g. NDVI) compare?



Greaves et al., 2016

Shrub structure/biomass maps, with uncertainty

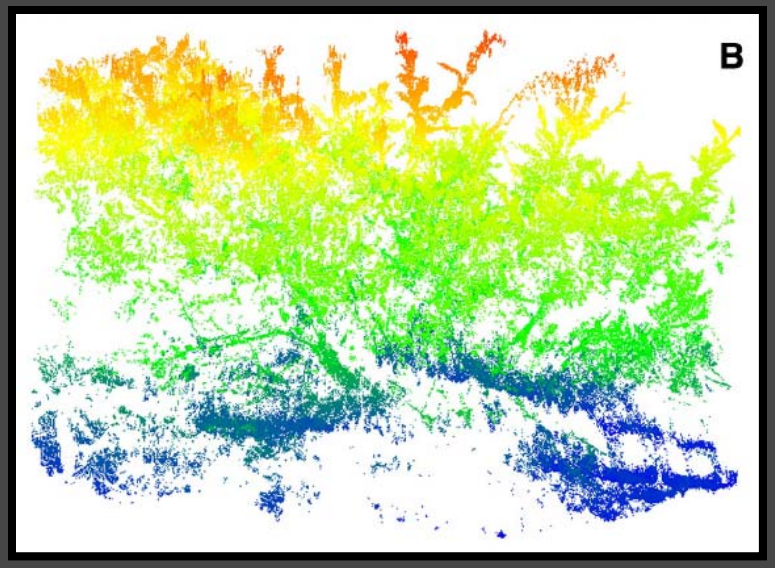




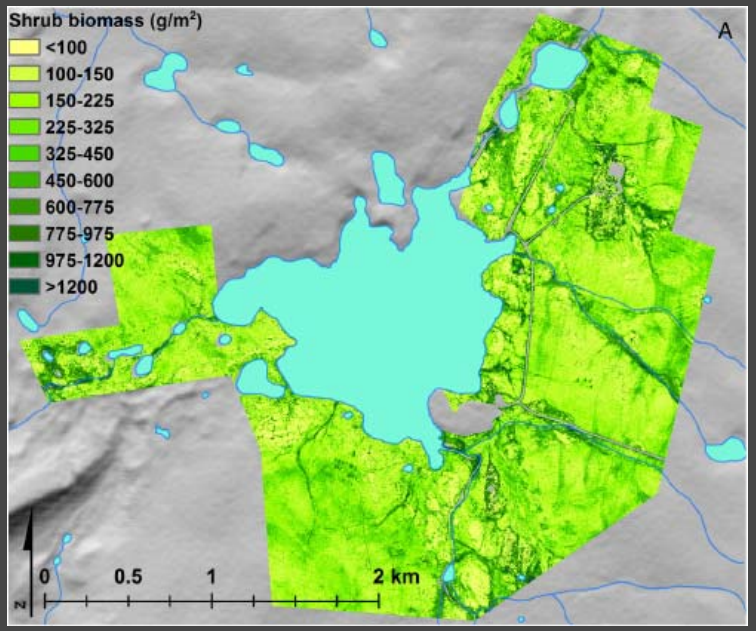
Mapped at 0.8 m spatial resolution

Greaves et al., 2016

New insights into ecosystem function?



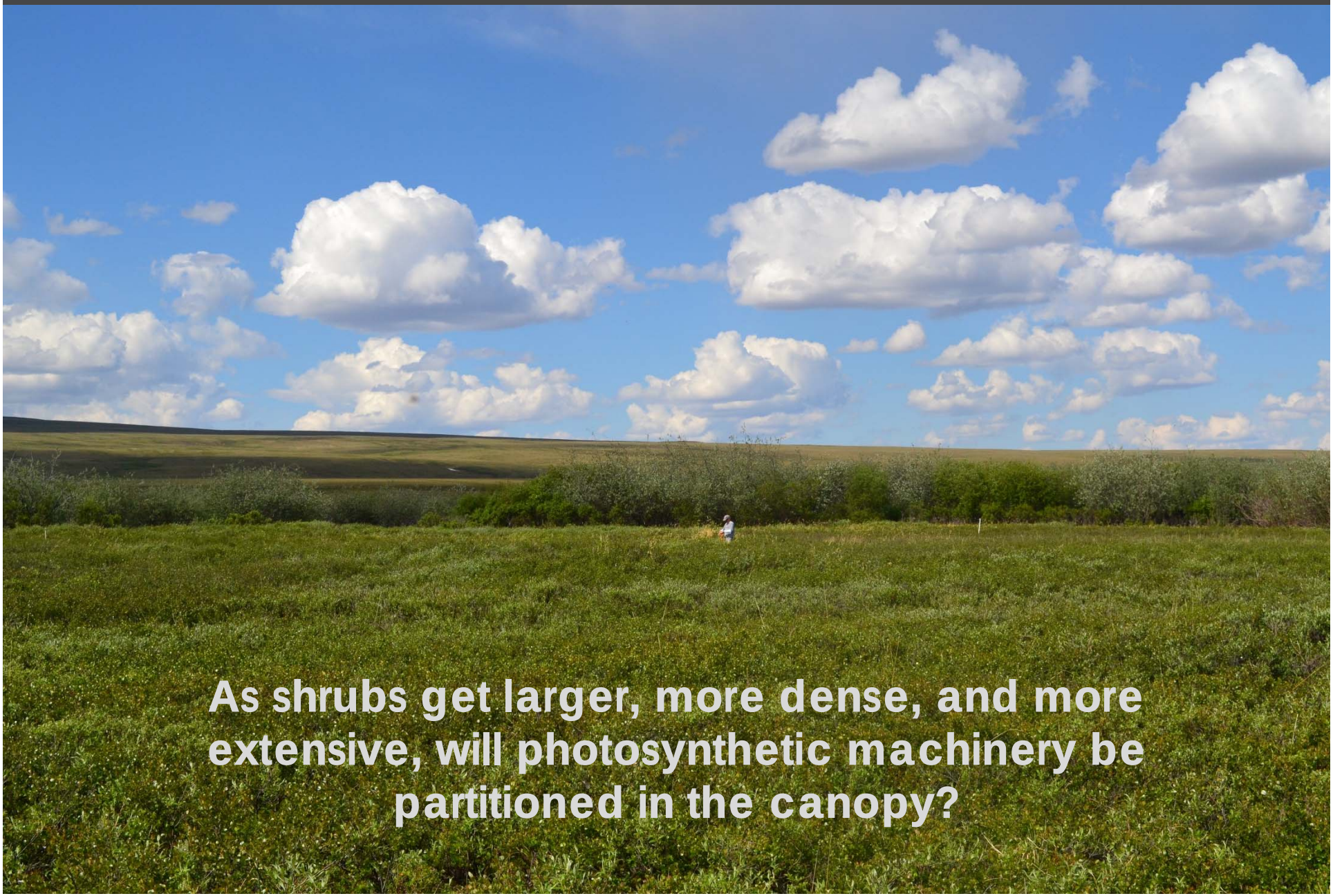
~ 4 mm spatial resolution (TLS)



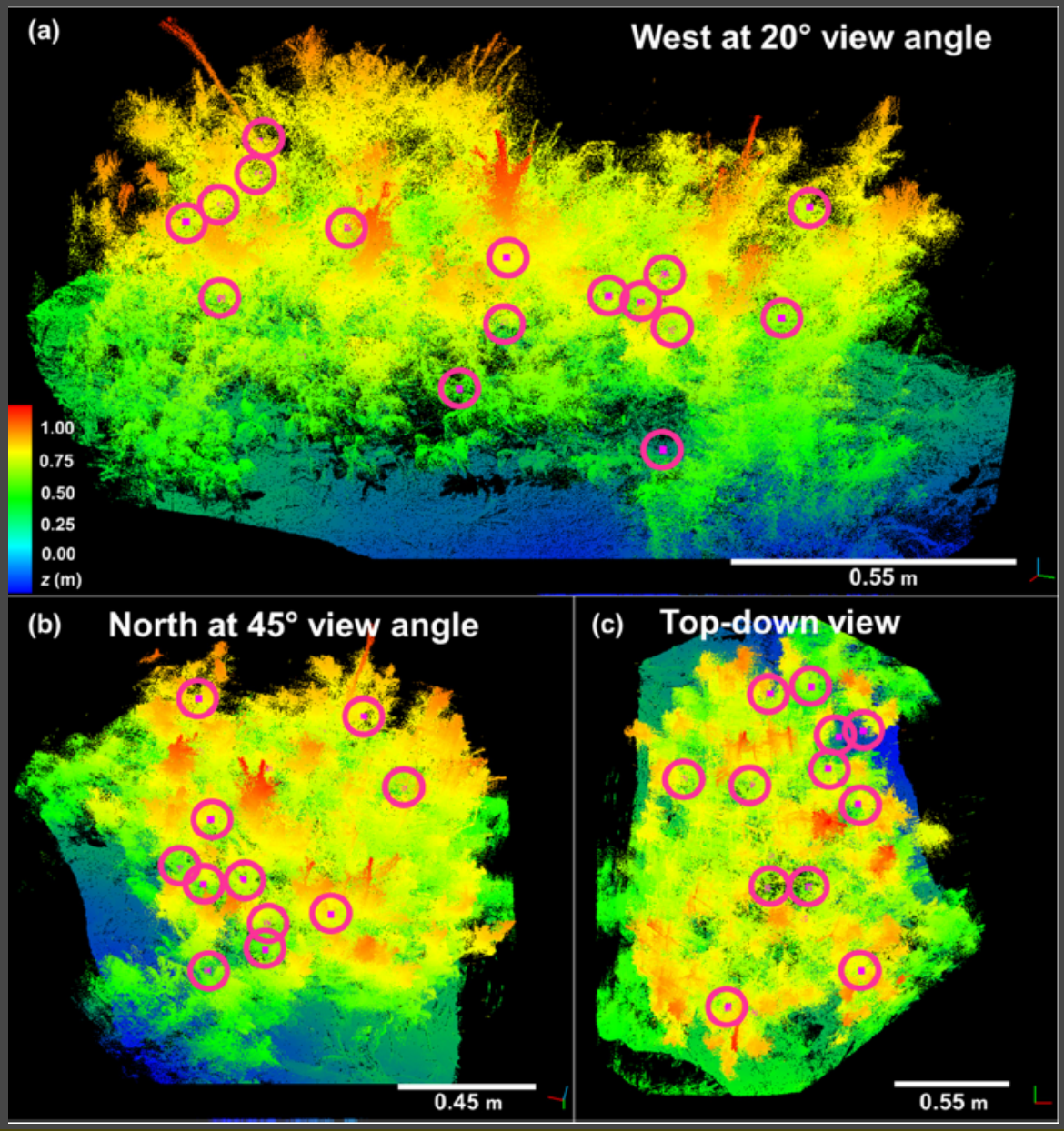
0.8 m spatial resolution (ALS)

Greaves et al., 2015, 2016

Function insights at the fine scale…leaf-to-shrub



At the fine scale…leaf-to-shrub

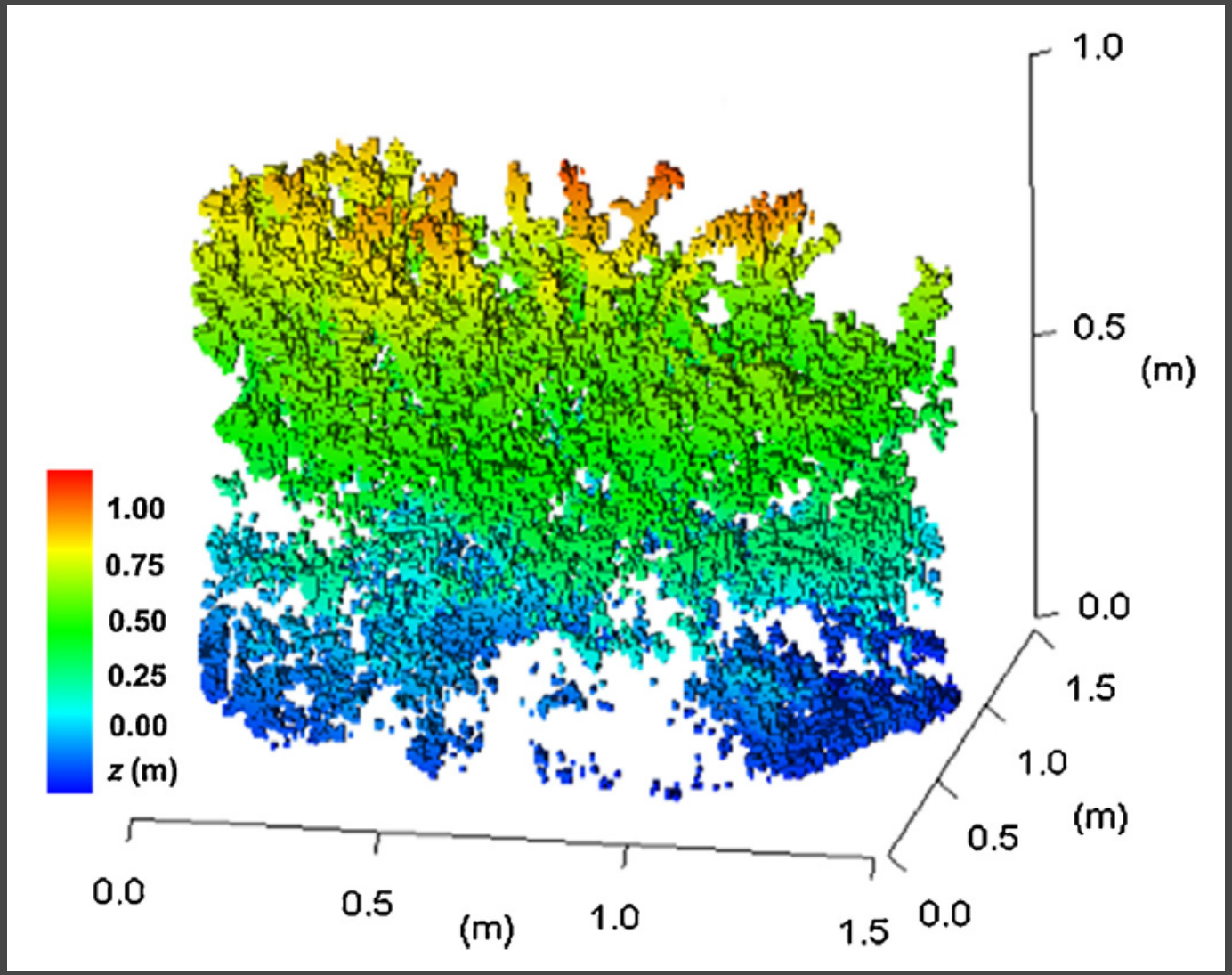


Does the photosynthetic machinery within these leaves differ?

(S. pulchra)

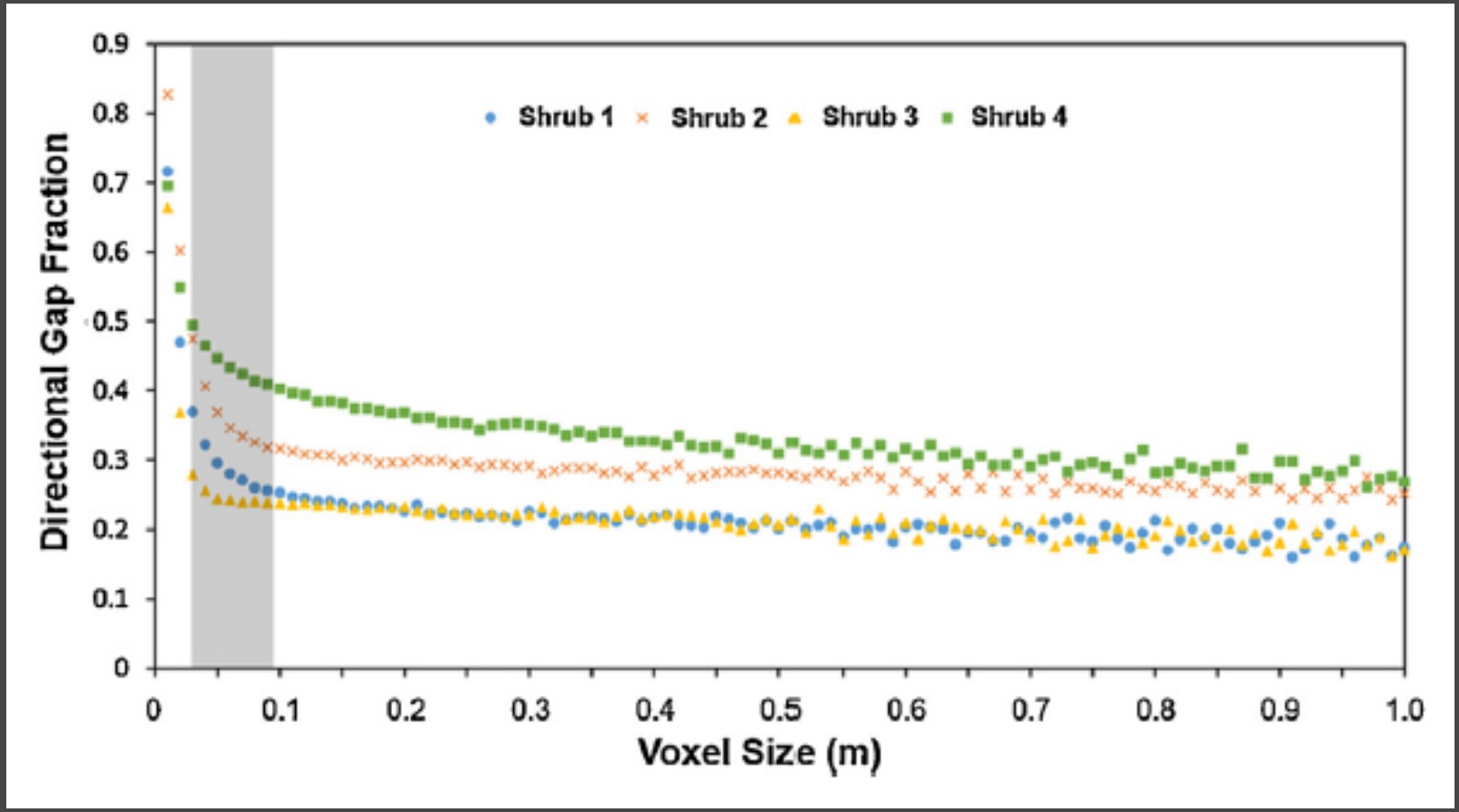
Magney et al., 2016

At the fine scale…leaf-to-shrub



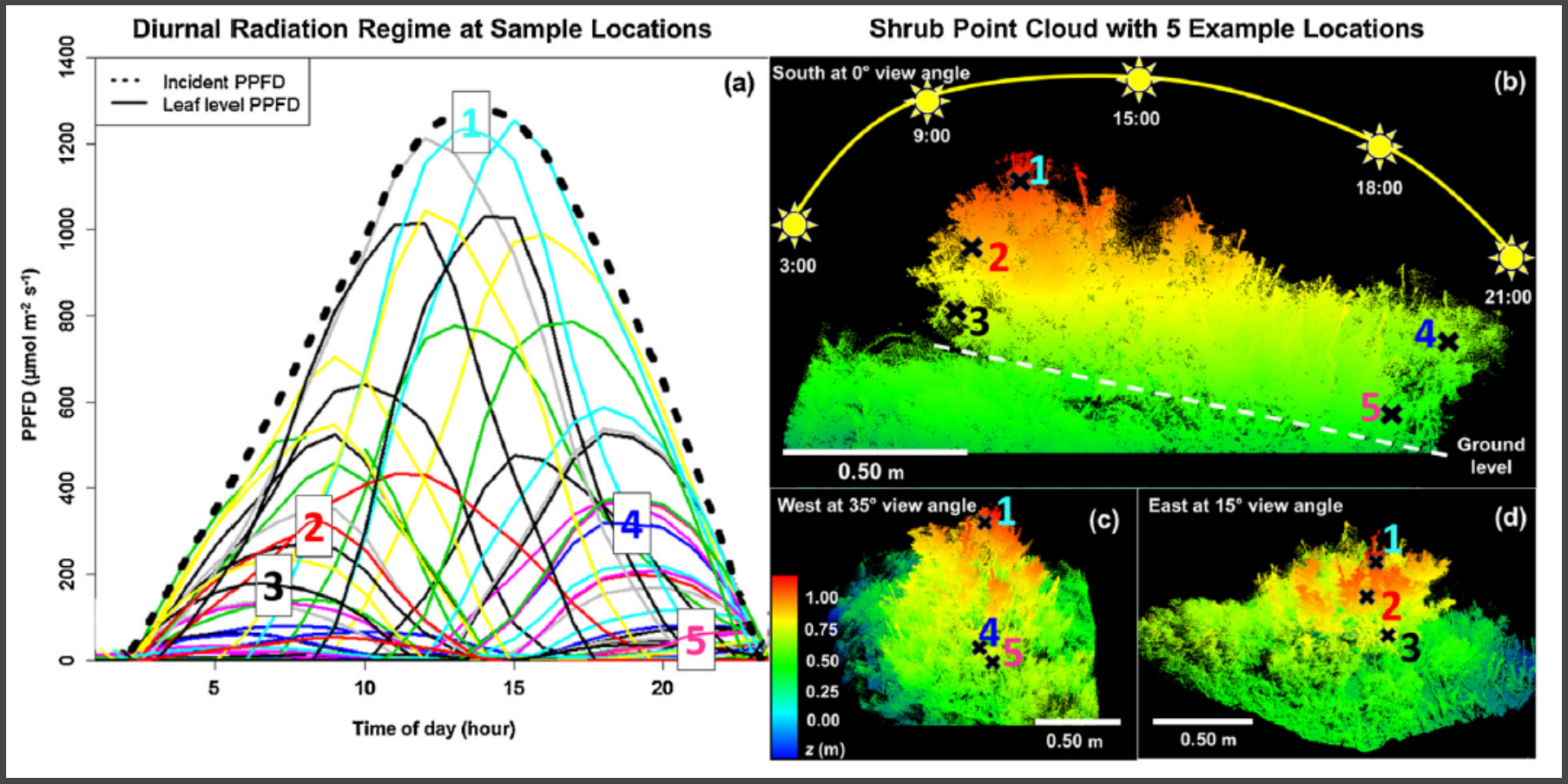
Magney et al., 2016

At the fine scale…leaf-to-shrub



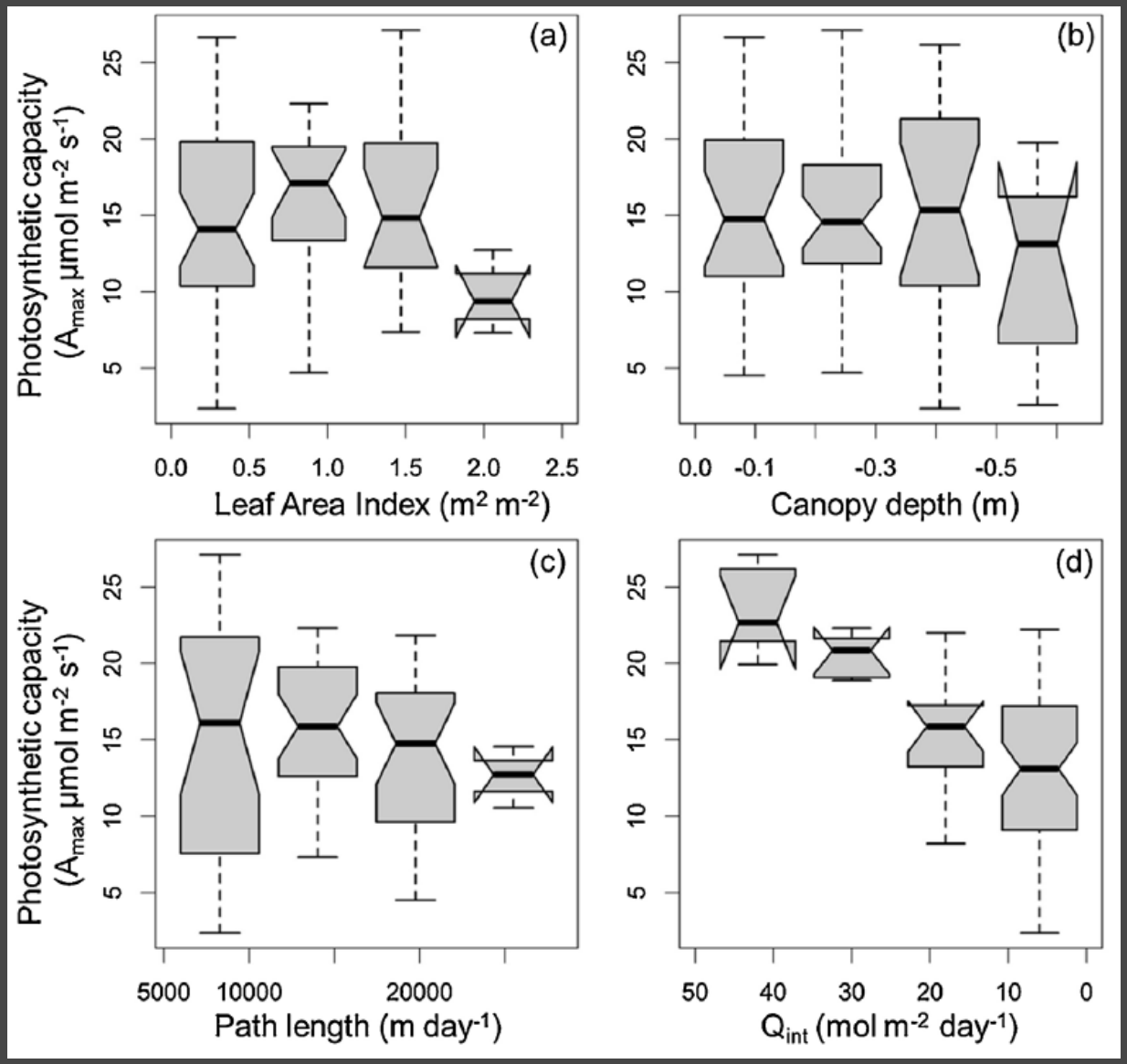
Magney et al., 2016

How does light regime vary?



Magney et al., 2016

Do leaves show characteristic patterns in canopy?

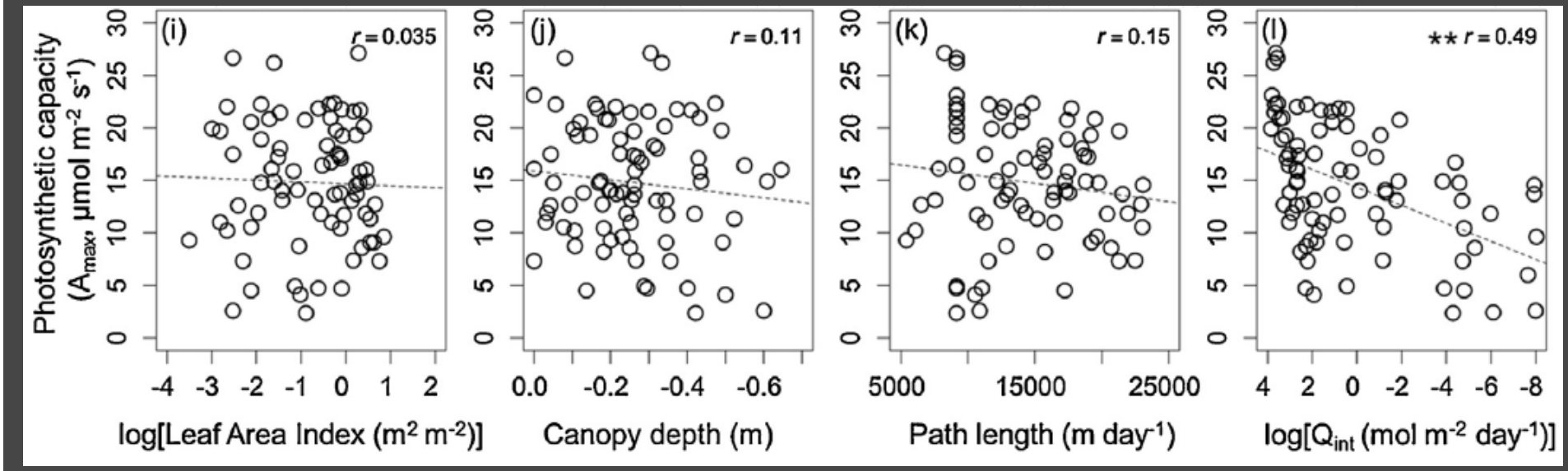


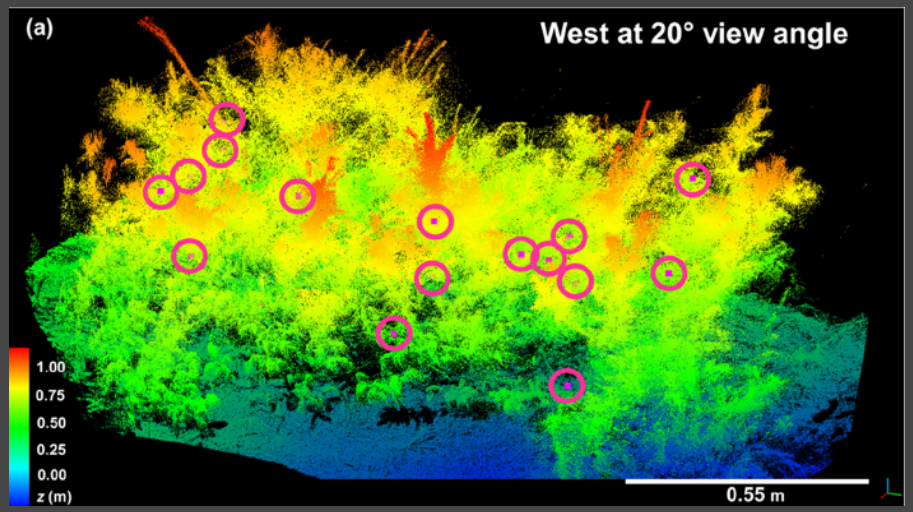
Binned by canopy position

Similar to foliar % N, Chl a:b results

Magney et al., 2016

Do leaves show characteristic patterns in canopy?



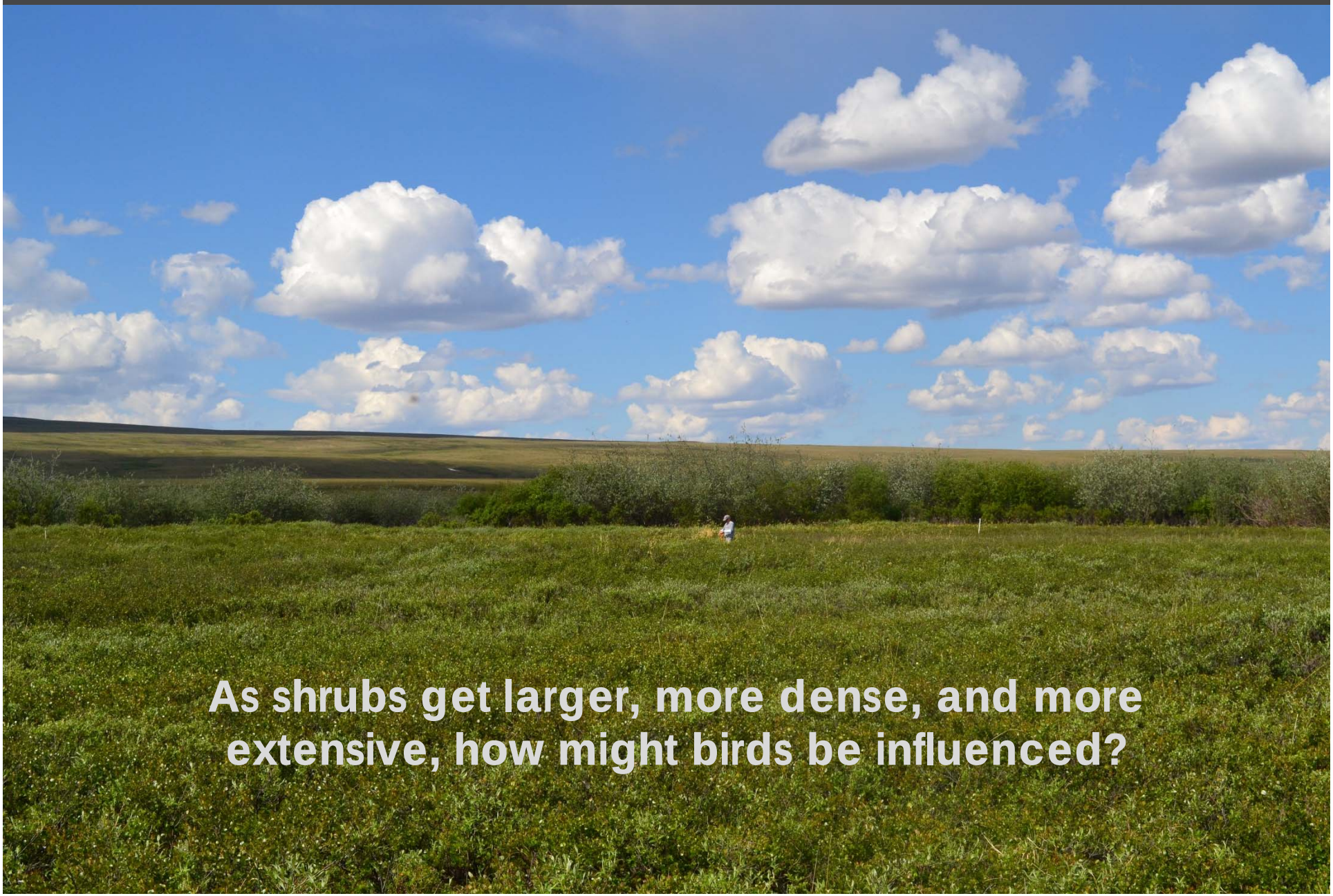


(Individual leaves)

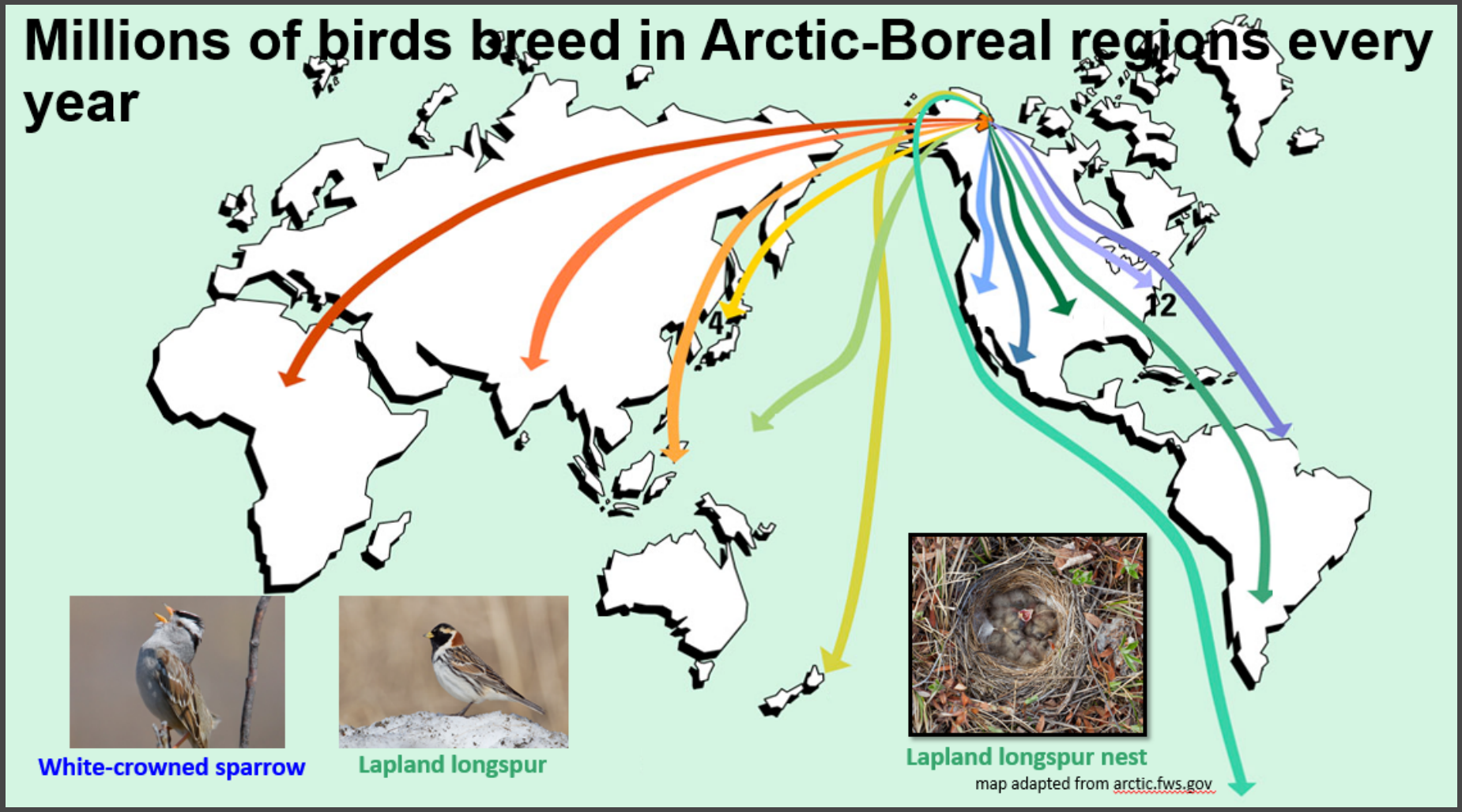
Potential implications for C flux modeling?

Magney et al., 2016

Community function at the landscape

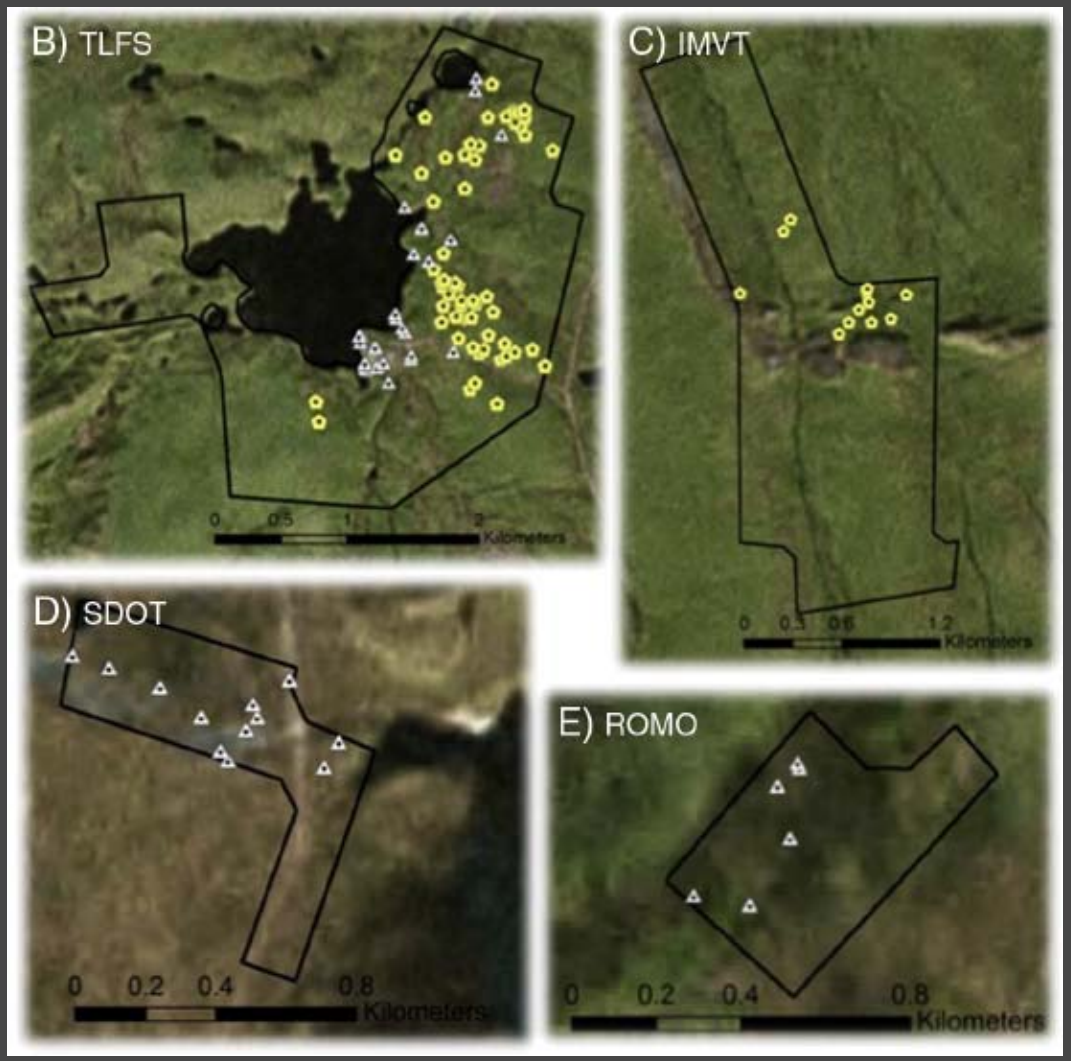


Ecological insights at the landscape



Does canopy architecture govern bird nest site selection?

Does veg structure influence nest site selection?



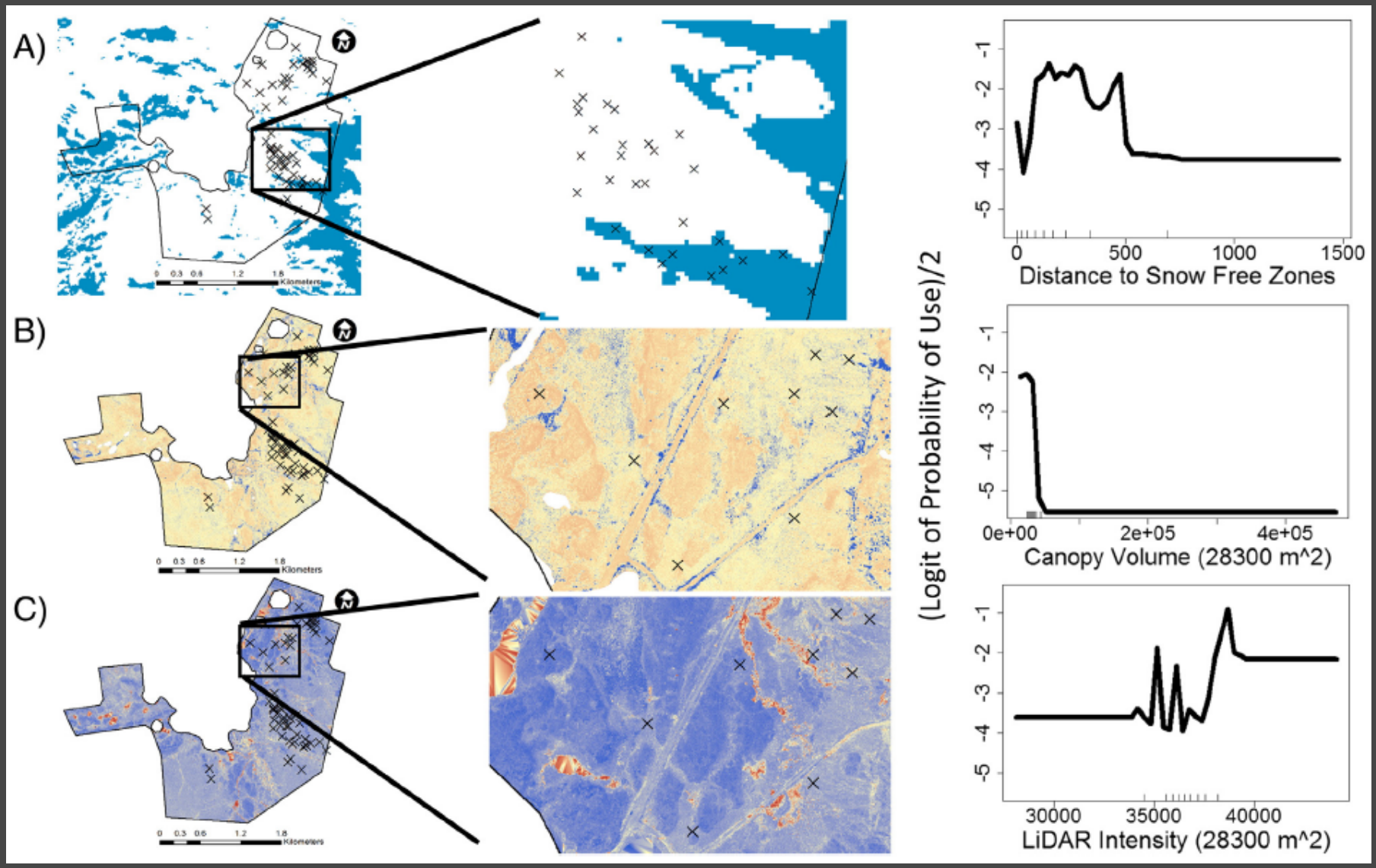
White-crowned sparrow

Lapland longspur

Nests located 2011-2014

Boelman et al., 2016

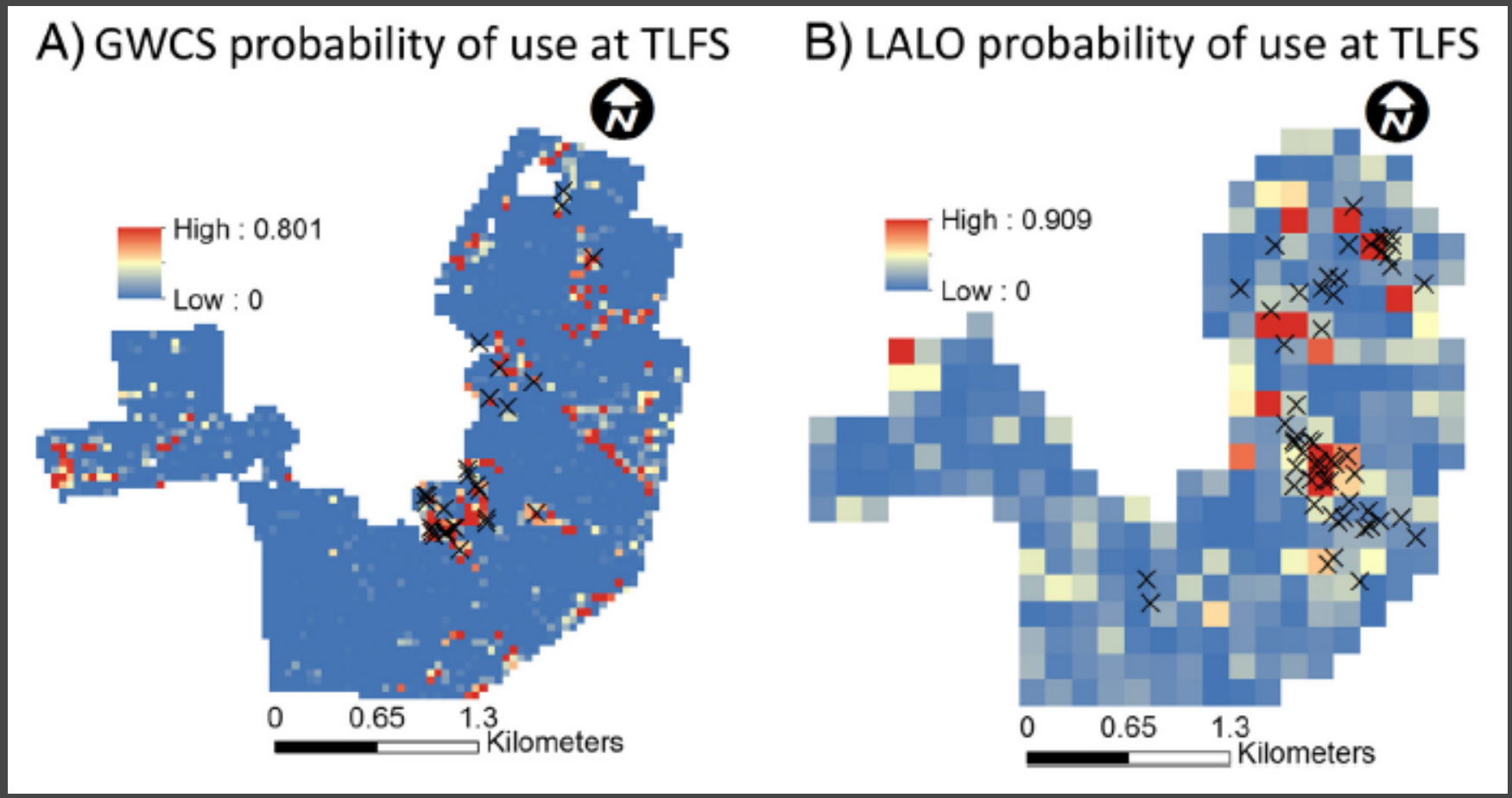
Does veg structure influence nest site selection?



Lapland longspur

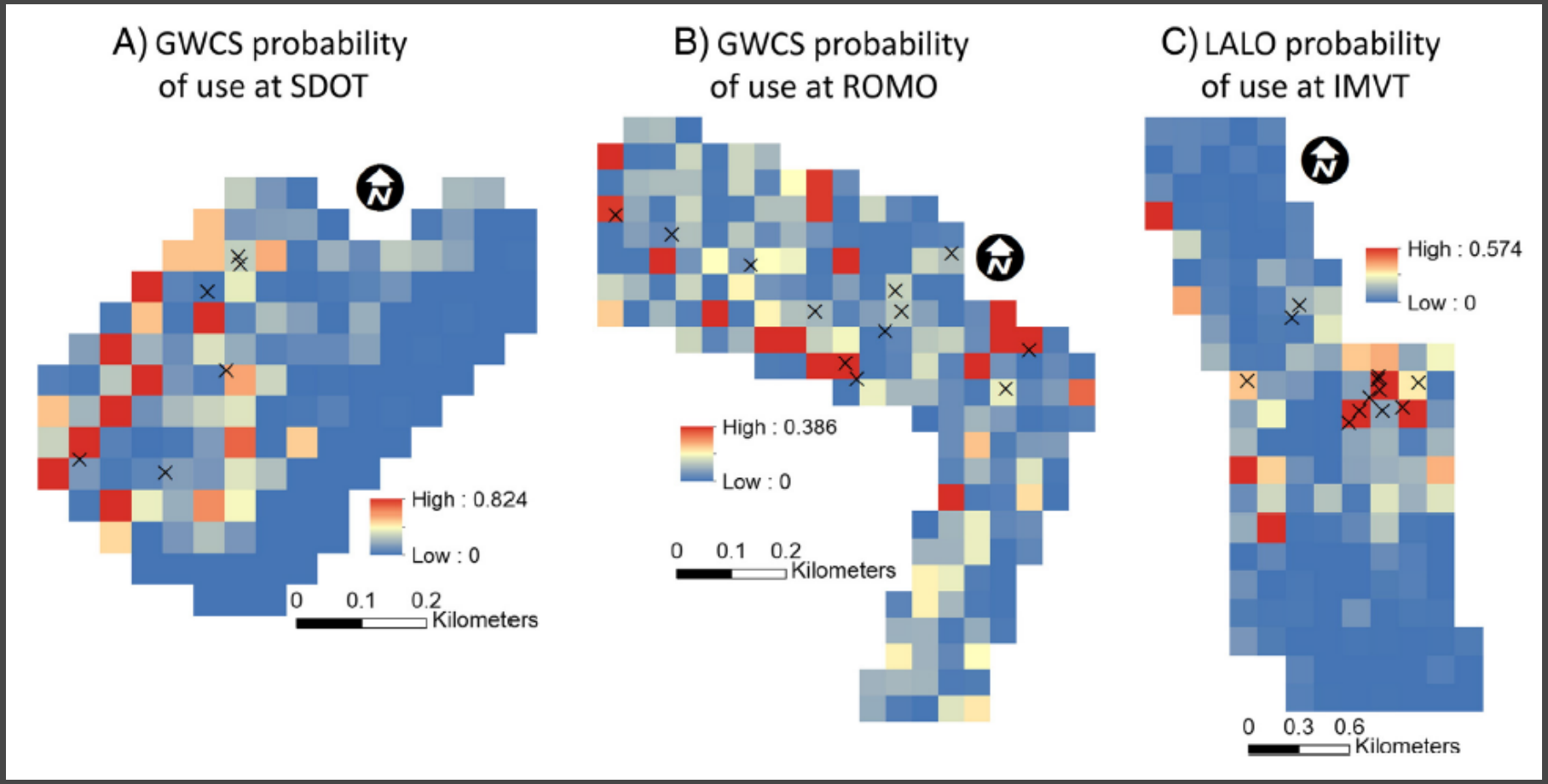
Boelman et al., 2016

Probabilities of nesting habitat selection



Boelman et al., 2016

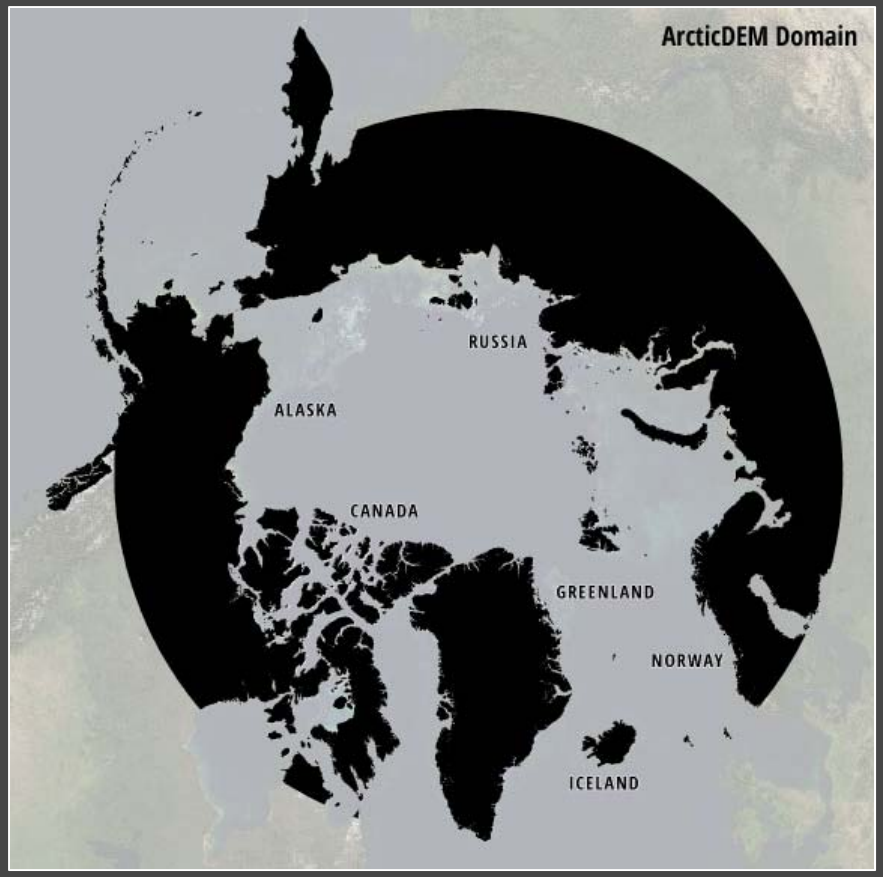
Probabilities of nesting habitat selection



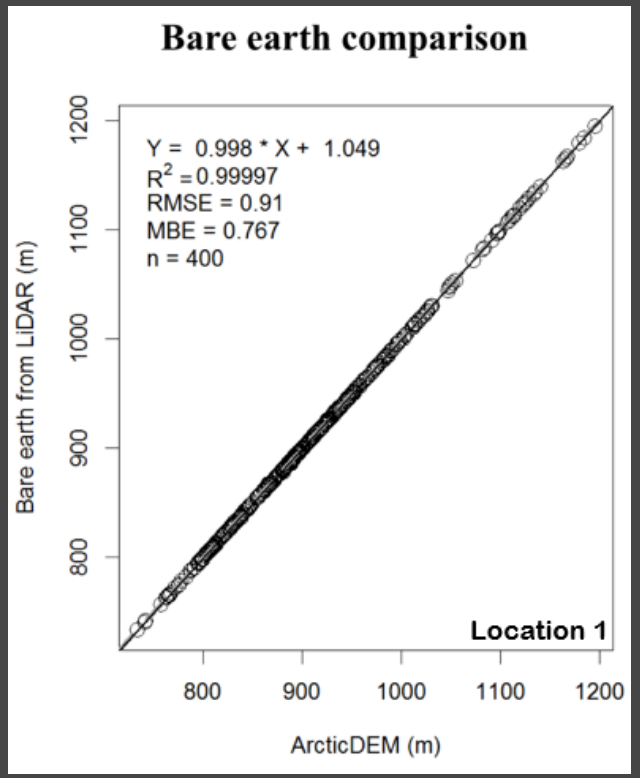
Note: NDVI was not a significant predictor

Boelman et al., 2016

Coming Soon…



Toolik intercomparison (5m res.)



ABoVE ARCTIC – BOREAL VULNERABILITY EXPERIMENT

NASA

New opportunities for collaboration between ecologists and RS scientists

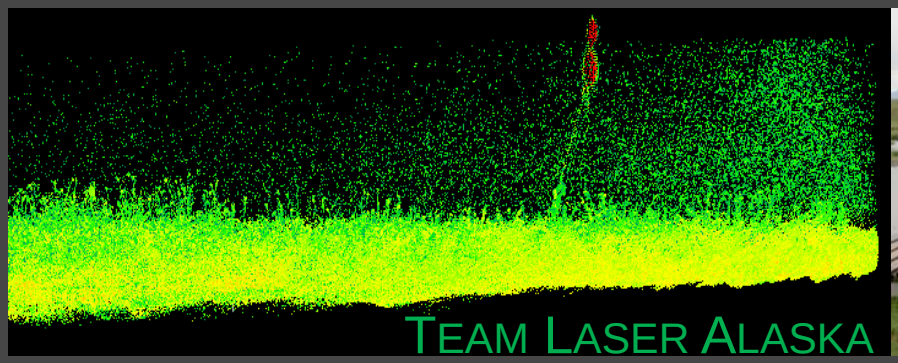
Meddens et al., in prep

Conclusions

- Very high resolution ecosystem structural mapping possible in Arctic tundra
  - Shrub canopy
  - "Bare earth"

- Fine structural data can uniquely reveal ecosystem functions
  - Photosynthetic partitioning in S. pulchra (LAI-2000 missed)
  - Nesting habitat of Arctic migrant birds (passive RS missed)

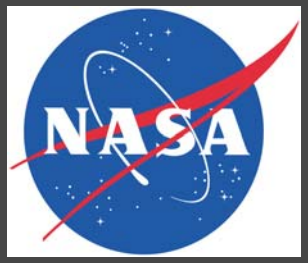
- New opportunities coming via NASA ABoVE and data sharing



Thank you!

Logistical, scientific, moral, technical support:
GIS, Mobile Lab Construction

Instrumentation support



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Team Bird: Boelman, Laura Gough, John Wingfield, Jesse Krause, Jonathan Perez, Helen Chmura, Ashley Asmus, Shannon Sweet, et al.

…and wide cast of collaborators