

# Mapping leaf traits within and among forest canopies with airborne remote sensing

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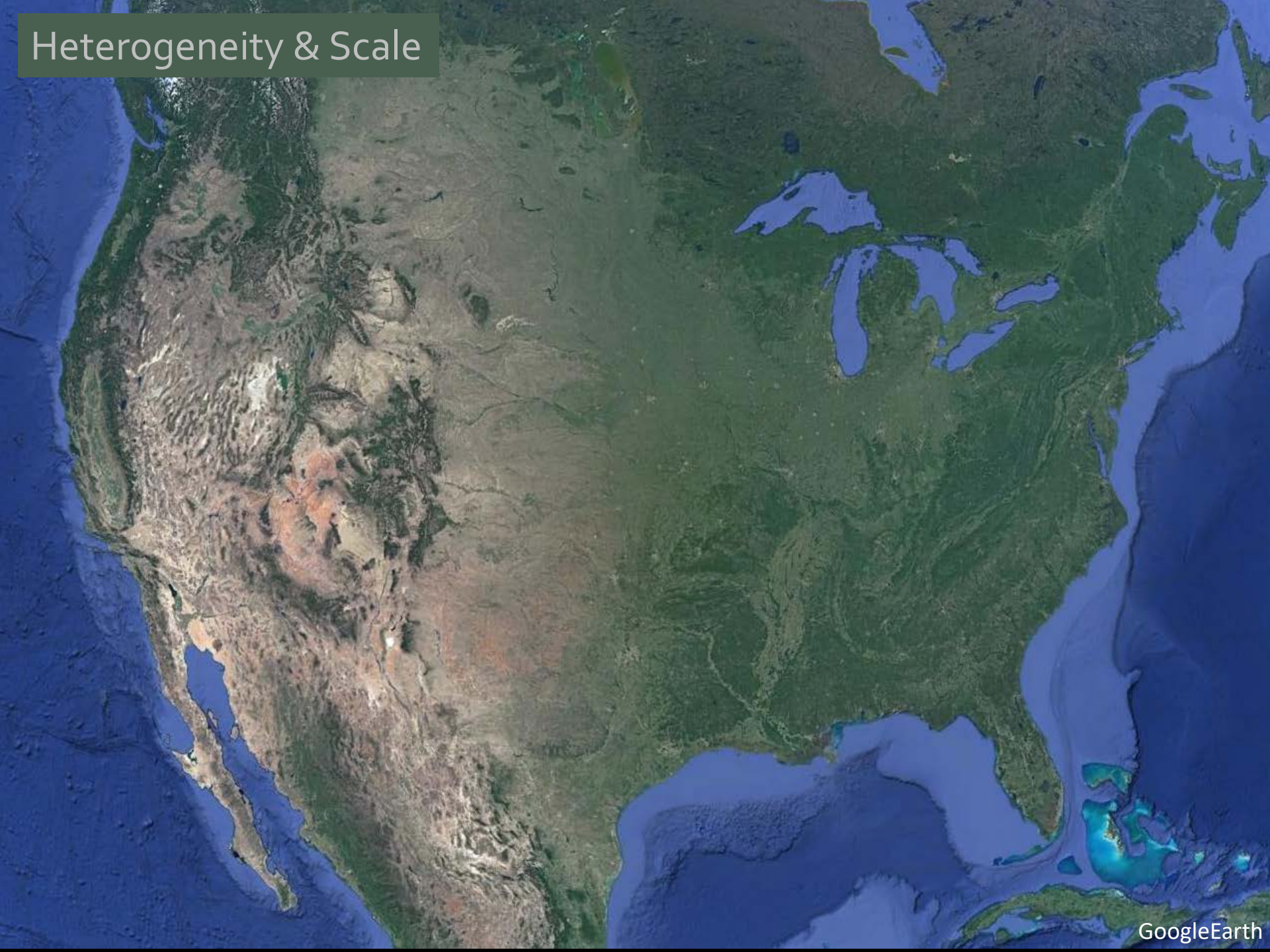
Michigan State University

August 7, 2018

“Earth system models disagree wildly about the magnitude and frequency of carbon-climate feedback events, and data to this point have been astonishingly ineffective at reducing this uncertainty.”

- Sellers et al. 2018 *PNAS*

# Heterogeneity & Scale



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photo credit: Getzin & Wiegand formind.org

# Heterogeneity & Scale

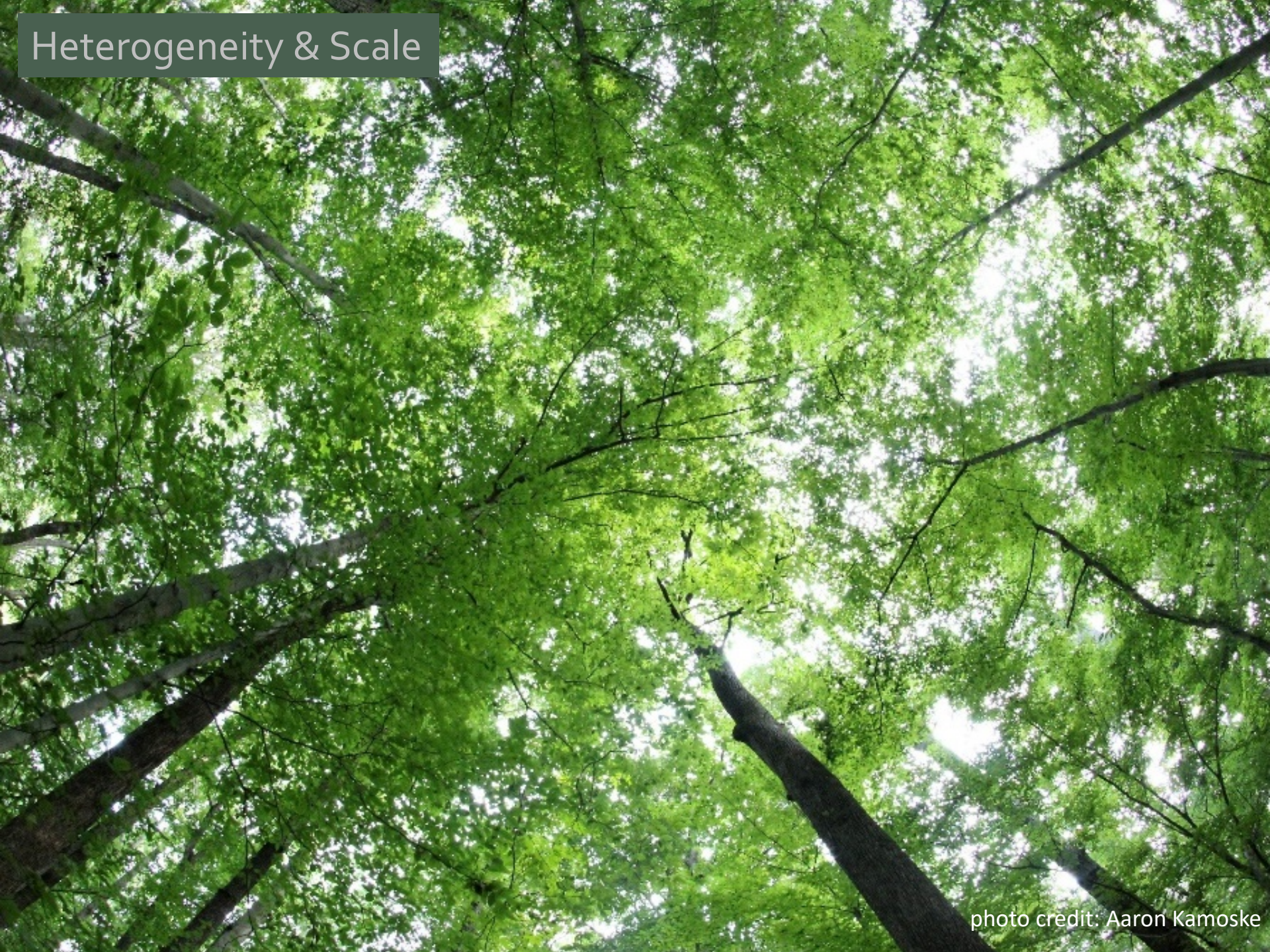
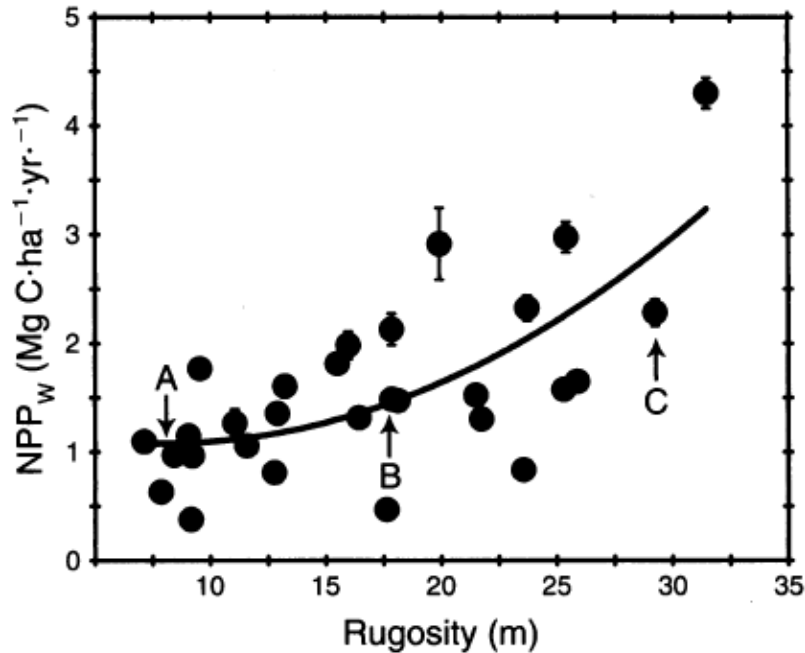


photo credit: Aaron Kamoske

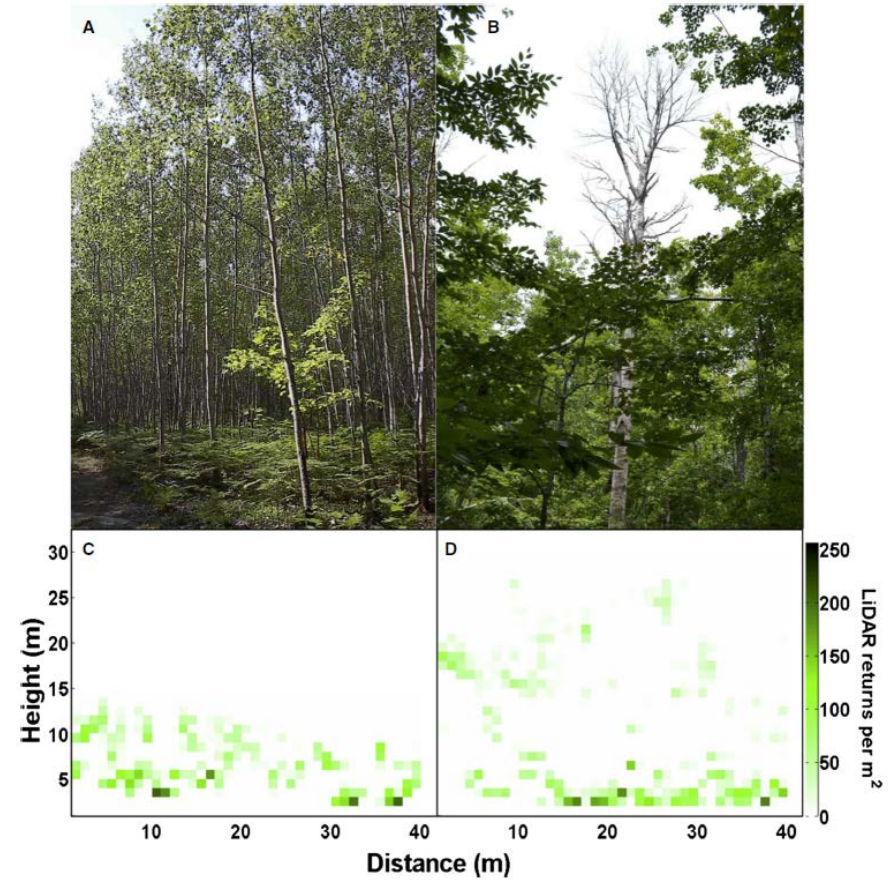


How important is variation in  
**vertical space (3-D)?**

How important is variation in **structure** in vertical space (3-D)?



[Hardiman et al 2011](#)

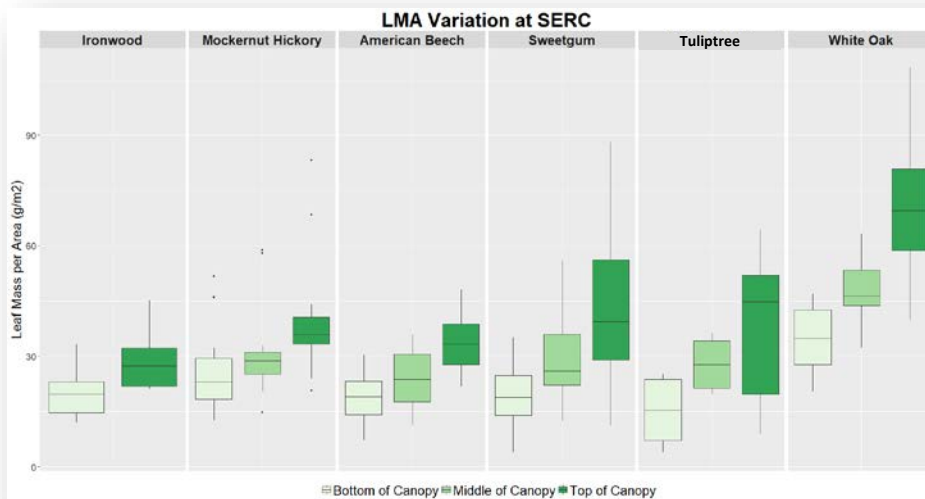


[Gough et al 2016](#)

**VERY IMPORTANT!**

# How important is variation in **function** in vertical space (3-D)?

*Quercus montana*  
Upper canopy (left)  
Lower canopy (right)



Preliminary data

\* LMA = Leaf Mass per Area

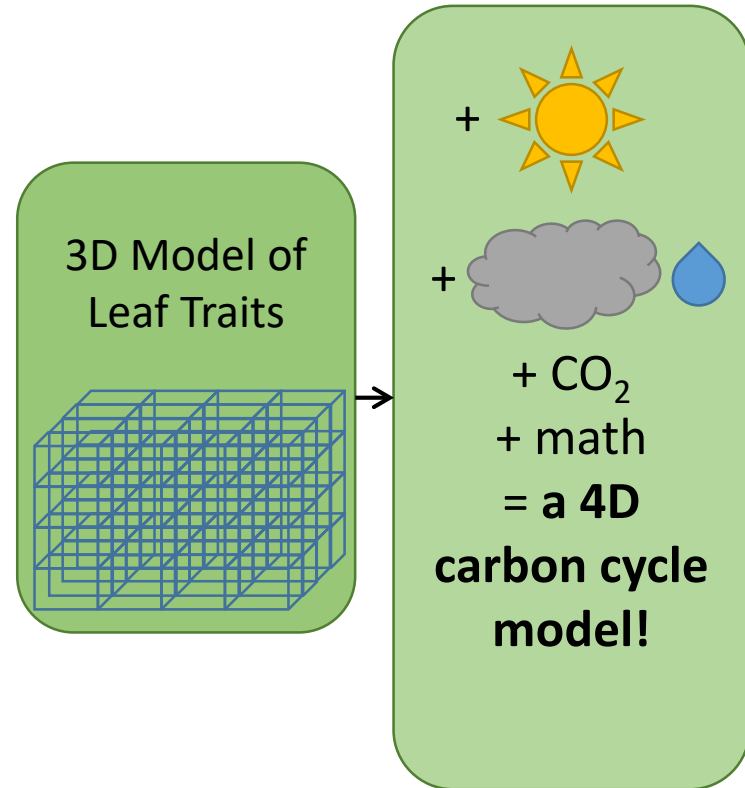
**VERY  
IMPORTANT!**

# More Questions!

- Can we **quantify** 'very important'?
- Is the importance **scale dependent**?
- Is the importance **biome** or **ecosystem** dependent?

**We need a model!**

# #foliar4D



# #foliar4D

LiDAR Point  
Cloud

Hyperspectral  
Reflectance

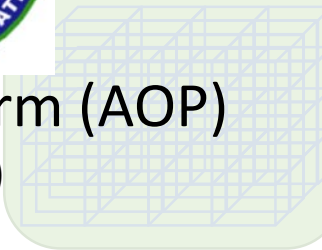
neon



National Ecological Observatory Network



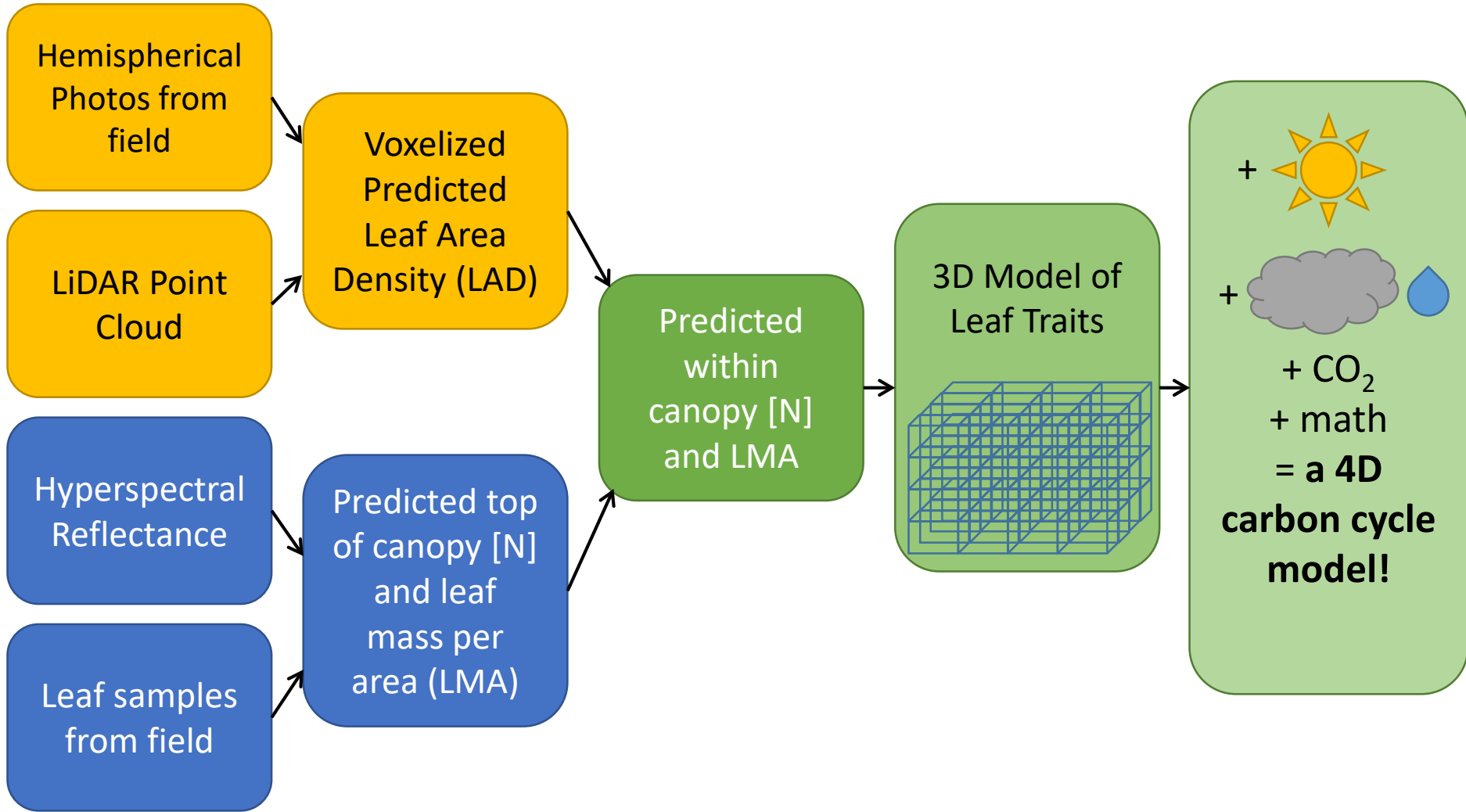
Airborne Observation Platform (AOP)  
([neonscience.org/data/airborne-data](https://neonscience.org/data/airborne-data))

3D Model of  
Leaf Traits

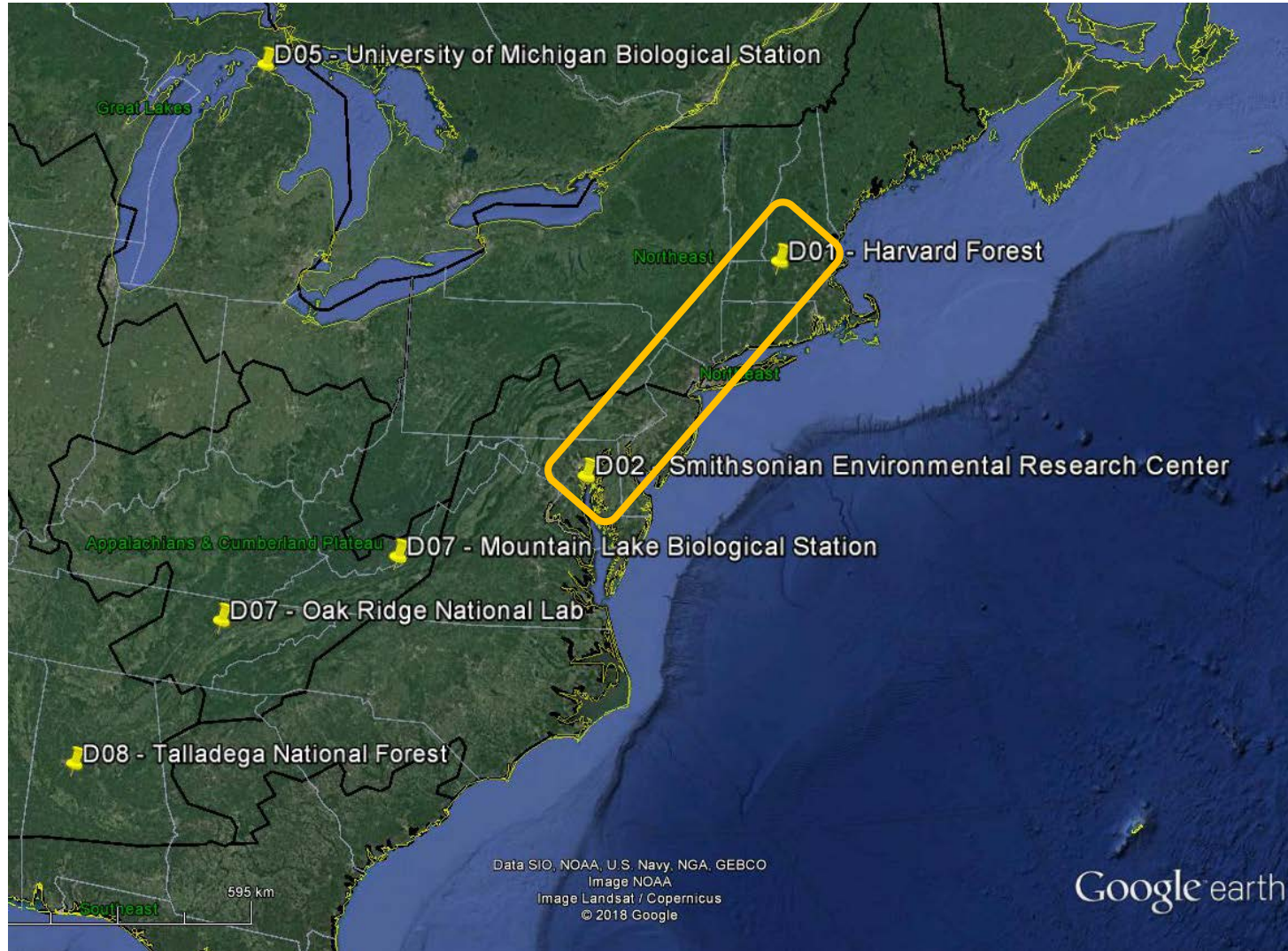


+   
+   
+ CO<sub>2</sub>  
+ math  
= a 4D  
carbon cycle  
model!

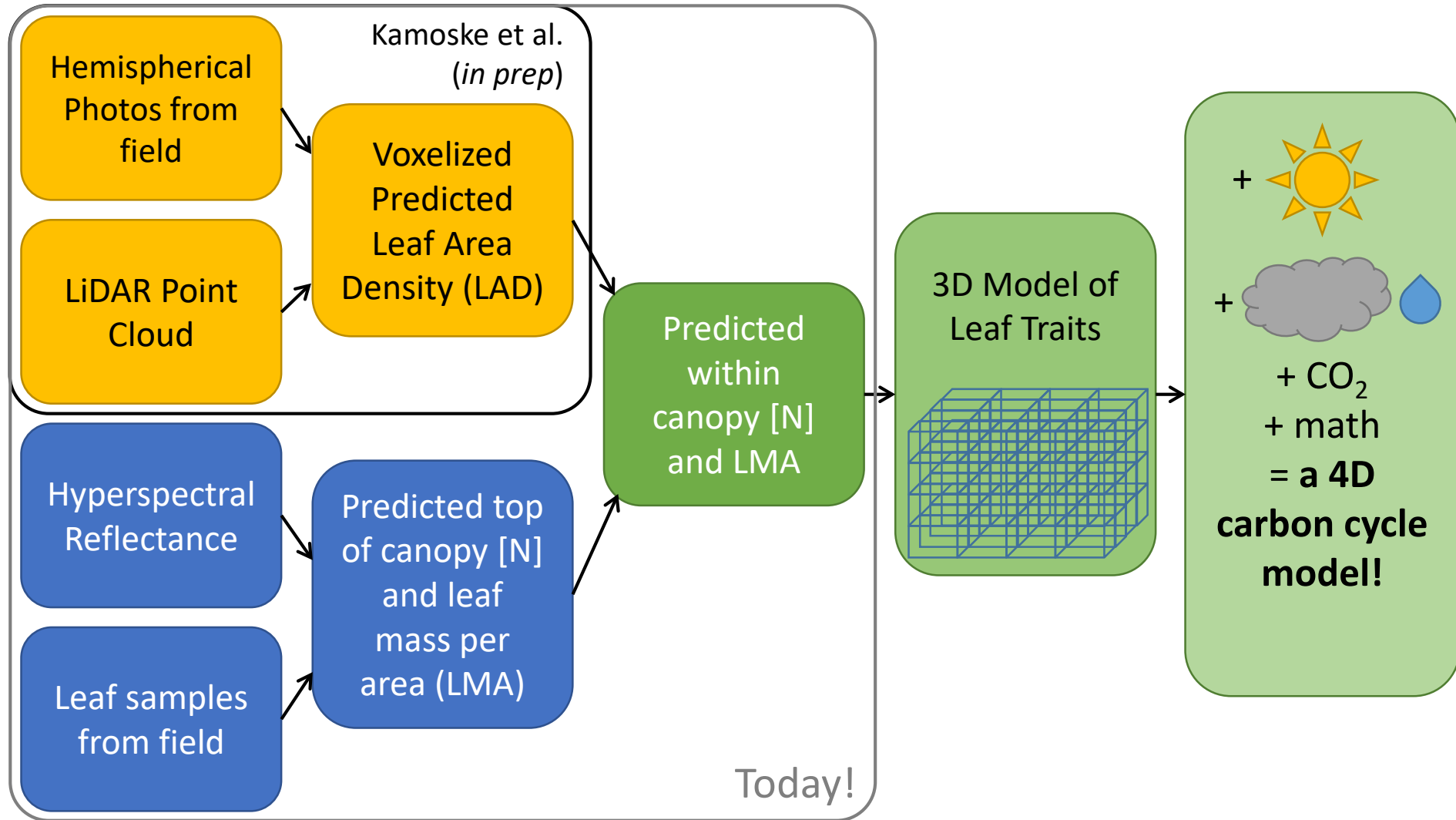
# #foliar4D



# #foliar4D



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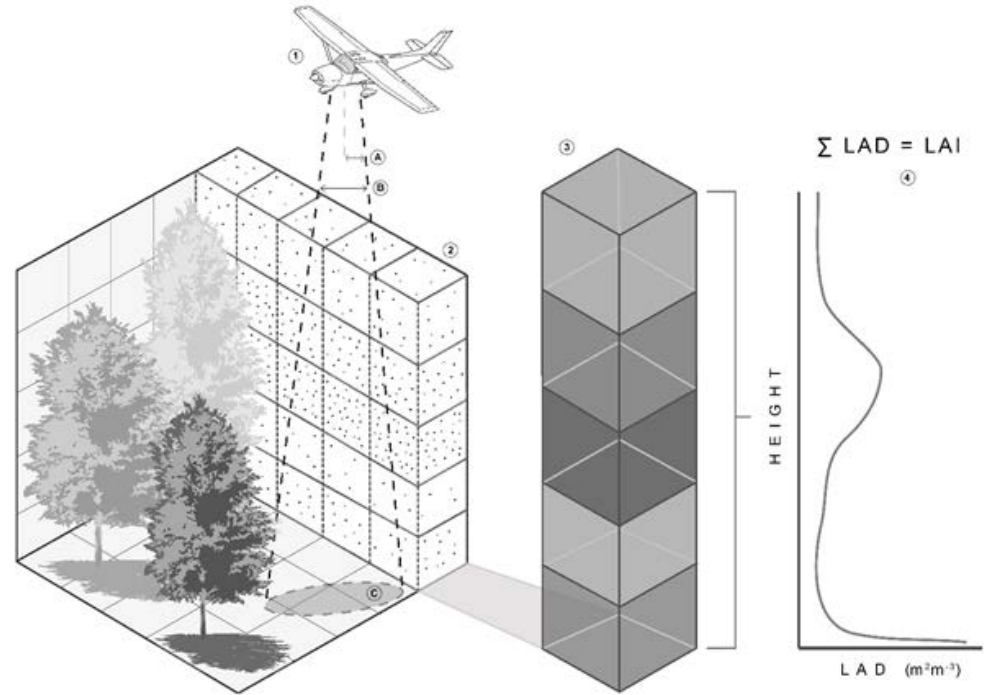


# #foliar4D

Hemispherical  
Photos from  
field

LiDAR Point  
Cloud

Voxelized  
Predicted  
Leaf Area  
Density (LAD)



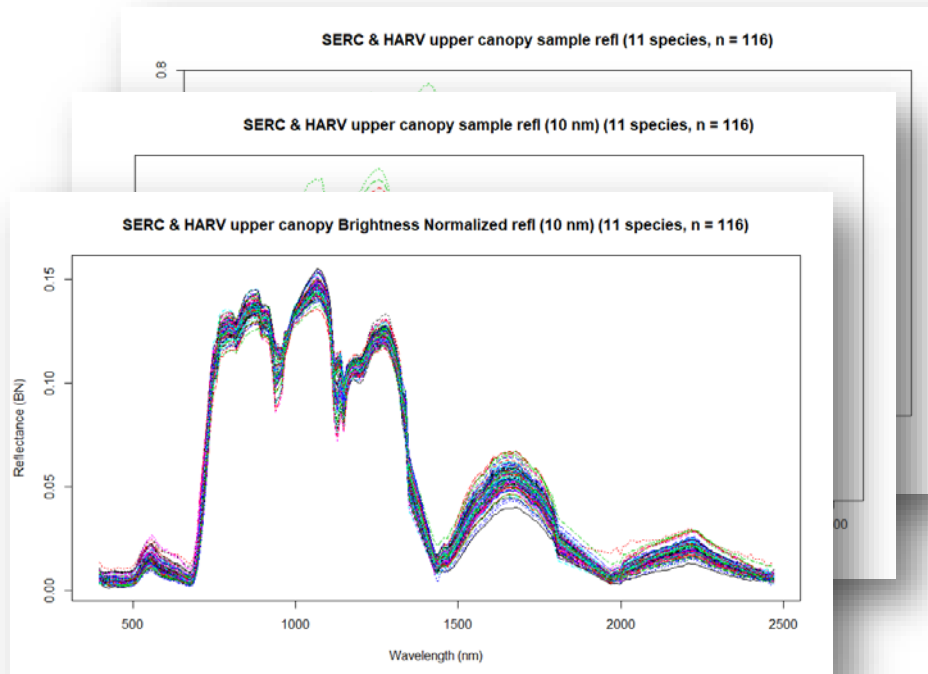
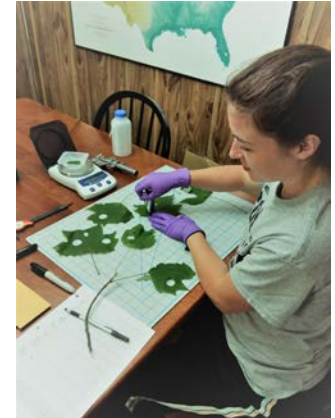
Kamoske et al *in prep*;  
see also [Stark et al 2012](#) & [2015](#)

# #foliar4D

Hyperspectral  
Reflectance

Predicted top  
of canopy [N]  
and leaf  
mass per  
area (LMA)

Leaf samples  
from field



Dahlin et al *preliminary work*;  
see also [Dahlin et al 2013](#), [Serbin et al 2014](#), & more  
BN from [Feilhauer et al 2010](#)

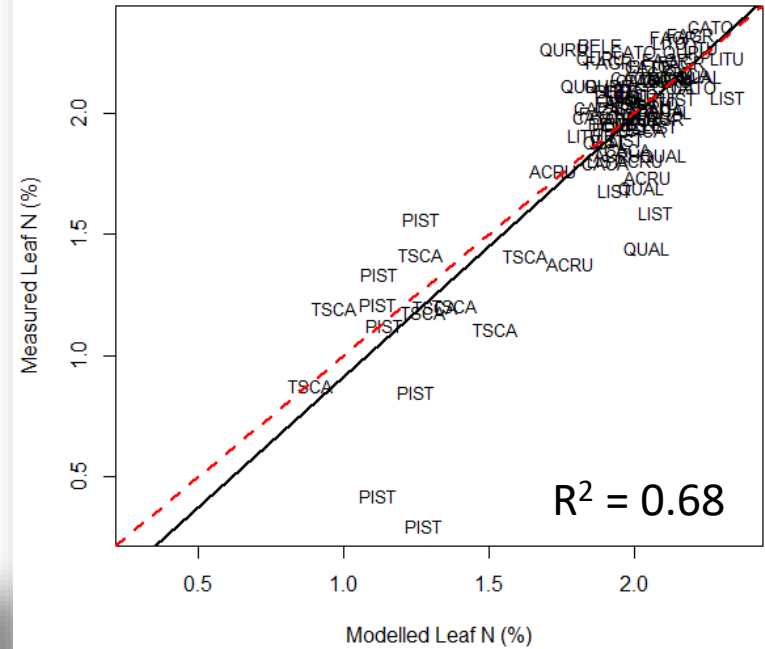
# #foliar4D

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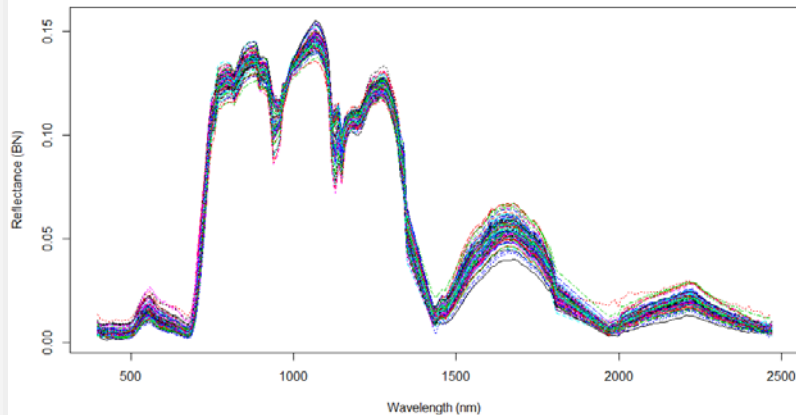
PLSR Modelled Top of Canopy Leaf N



SERC & HARV upper canopy sample refl (11 species, n = 116)

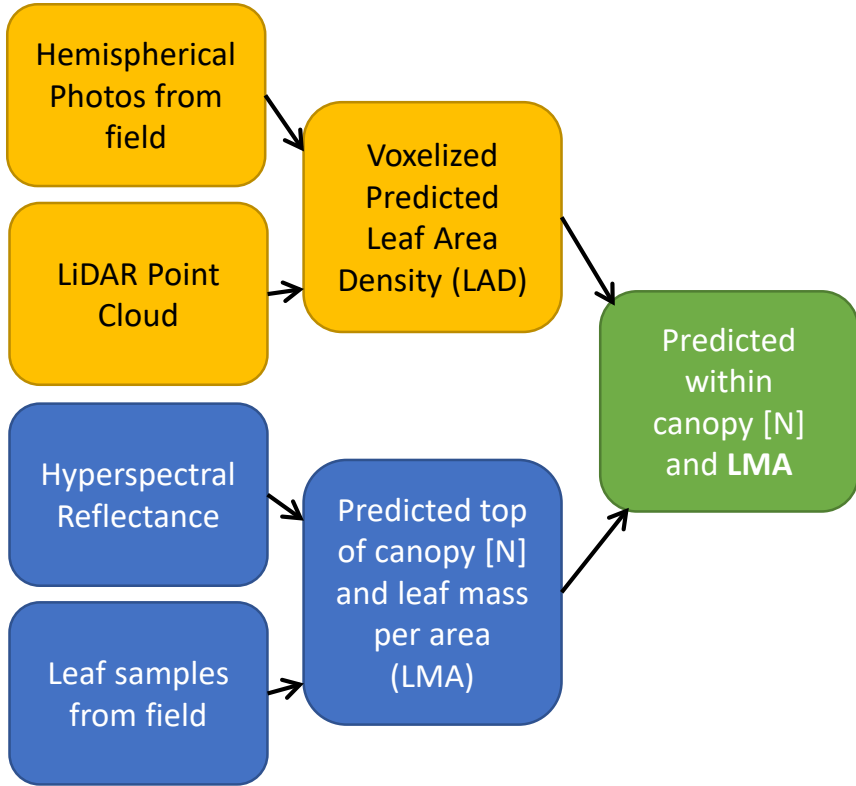
SERC & HARV upper canopy sample refl (10 nm) (11 species, n = 116)

SERC & HARV upper canopy Brightness Normalized refl (10 nm) (11 species, n = 116)

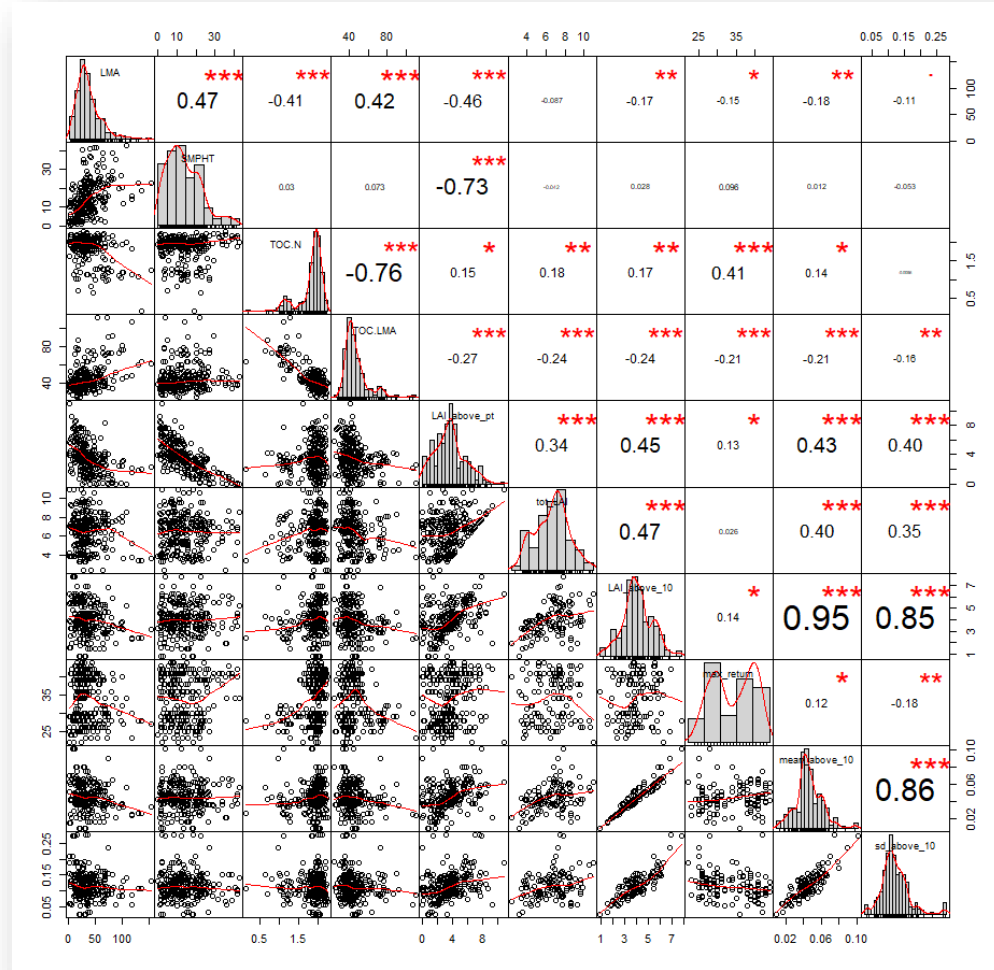


Dahlin et al *preliminary work*;  
see also [Dahlin et al 2013](#), [Serbin et al 2014](#), & more  
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# #foliar4D



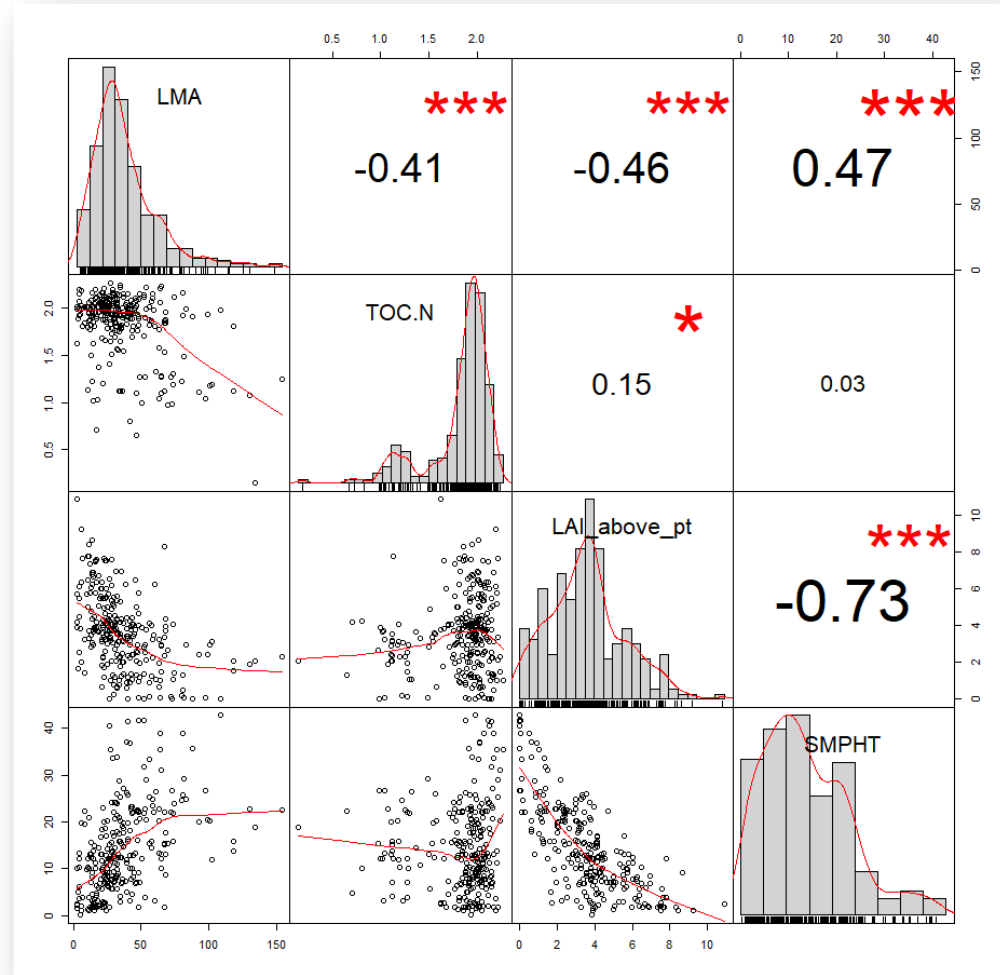
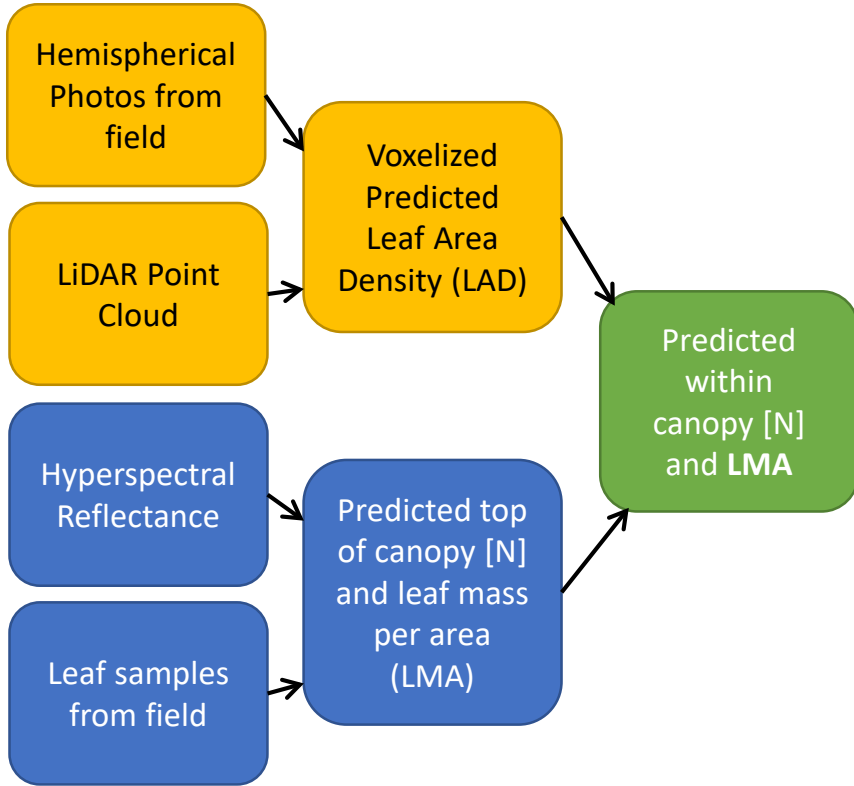
## Possible RS-derived Predictors of LMA



Dahlin, Kamoske, Serbin & Stark (preliminary work)

# #foliar4D

## Viable RS-derived Predictors of LMA



Dahlin, Kamoske, Serbin & Stark (preliminary work)



# Conclusions

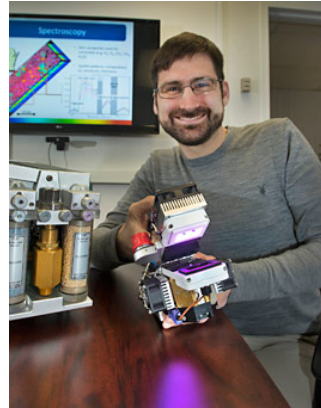
- **Seems possible** to build a 3D model of forests using hyperspectral imagery and LiDAR
- There are a **LOT of important steps** to getting this right/working at all
- Important next step – quantifying layers upon layers of **uncertainty**

# Acknowledgements

## Collaborators!



Aaron Kamoske



Shawn Serbin



Scott Stark

**NEON!** Data, technical support, general help.


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# Thanks! Questions?

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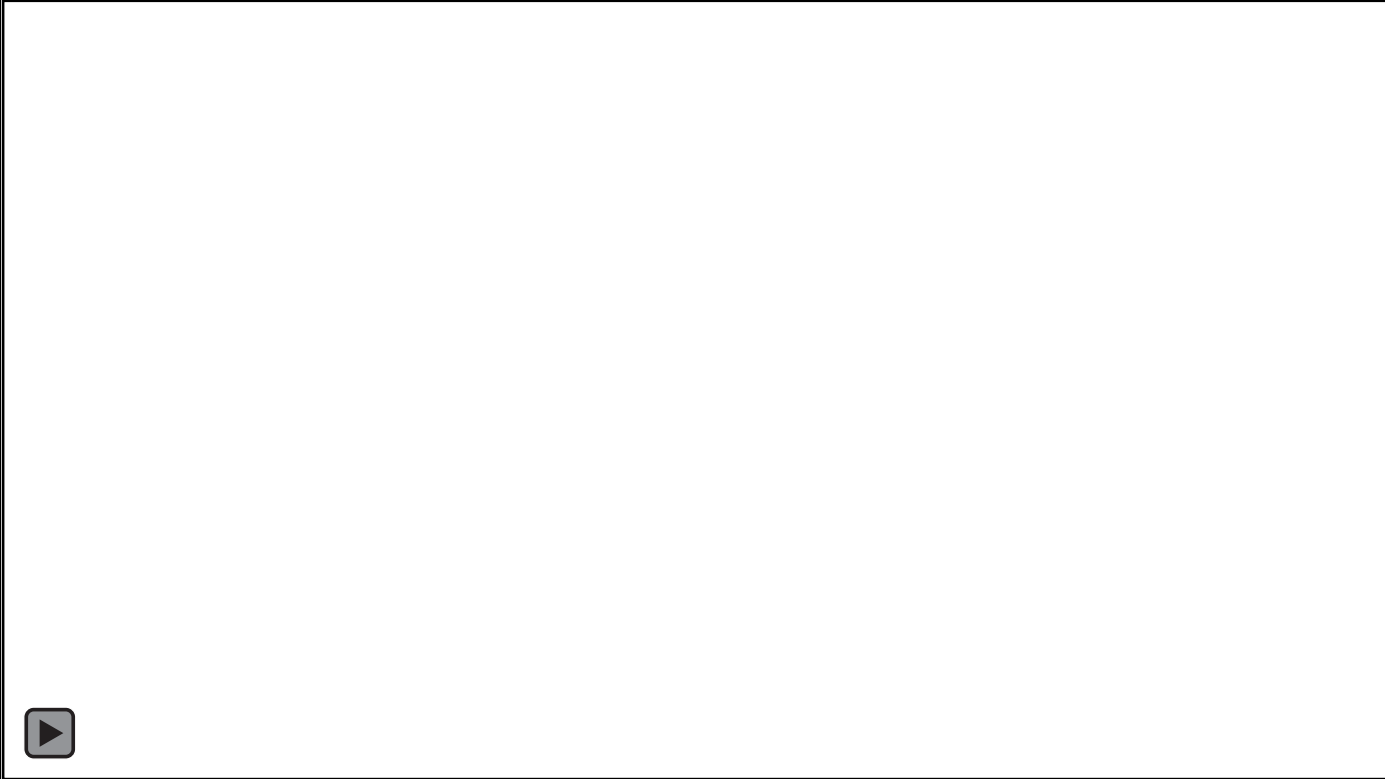
[@bristleweed](#) & [@ERSAM\\_Lab](#)

slides @ [www.ersamlab.com](http://www.ersamlab.com)

[instagram.com/ersam.lab](https://www.instagram.com/ersam.lab)

# #foliar4D

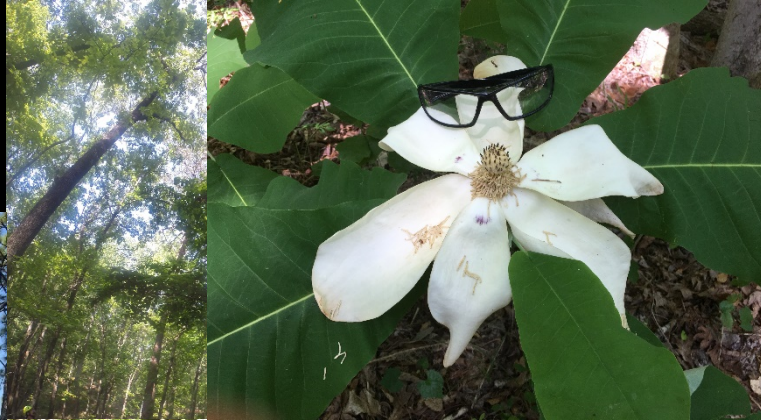
(Talladega NF, Alabama, 2018)



More photos: [www.instagram.com/ersam.lab](http://www.instagram.com/ersam.lab)  
Tweets & Insta: #foliar4D

# #foliar4D

(Talladega NF, Alabama, 2018)



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