Improving Forest Modeling with Spectrally Derived Traits

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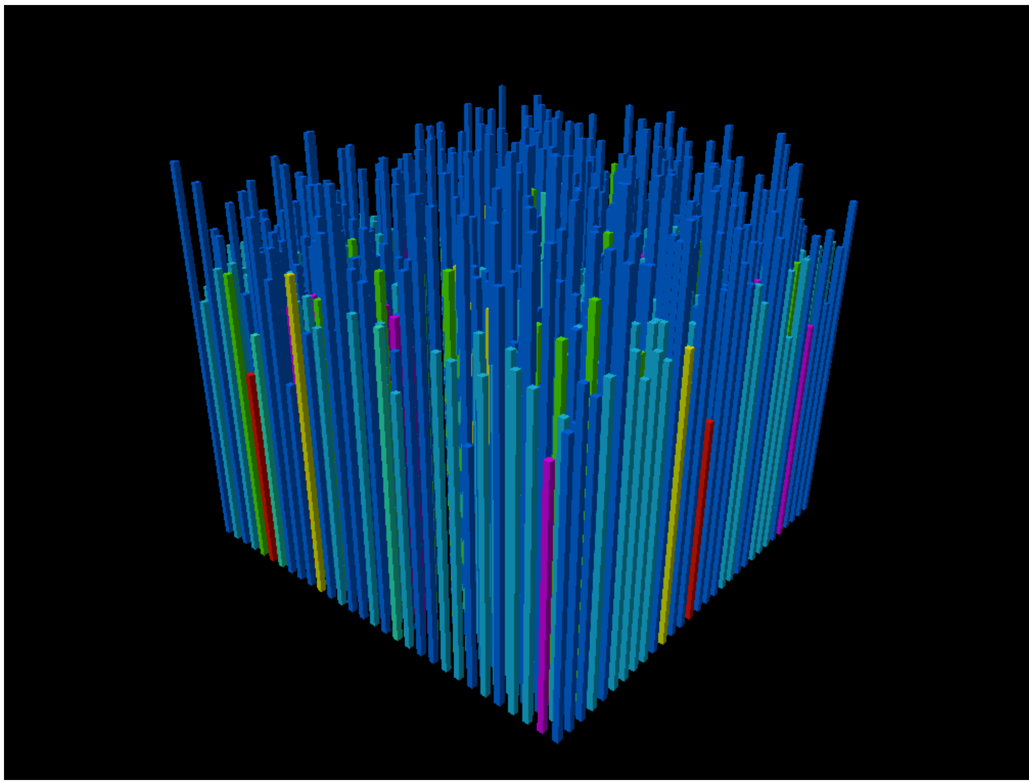

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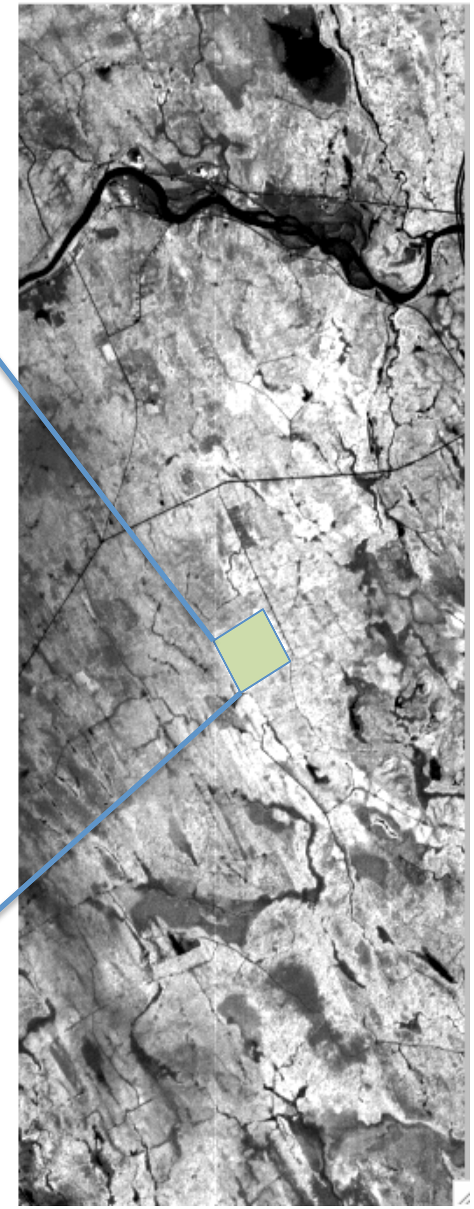
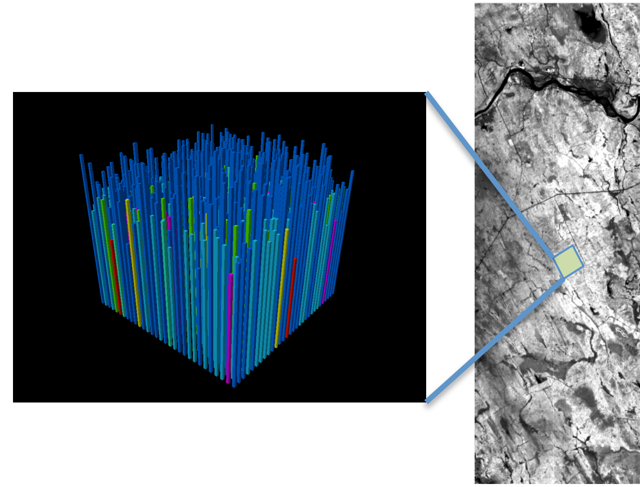


Acknowledgements: Paul Montesano, Guoqing Sun and Jon Ranson

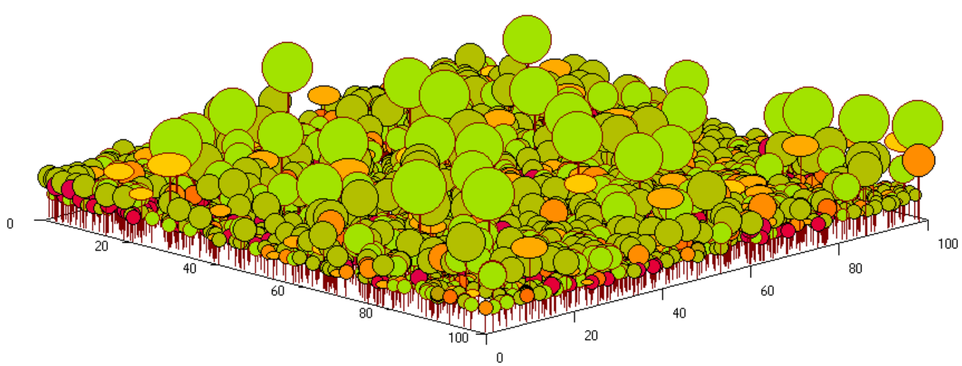
Individual-Based Gap Models



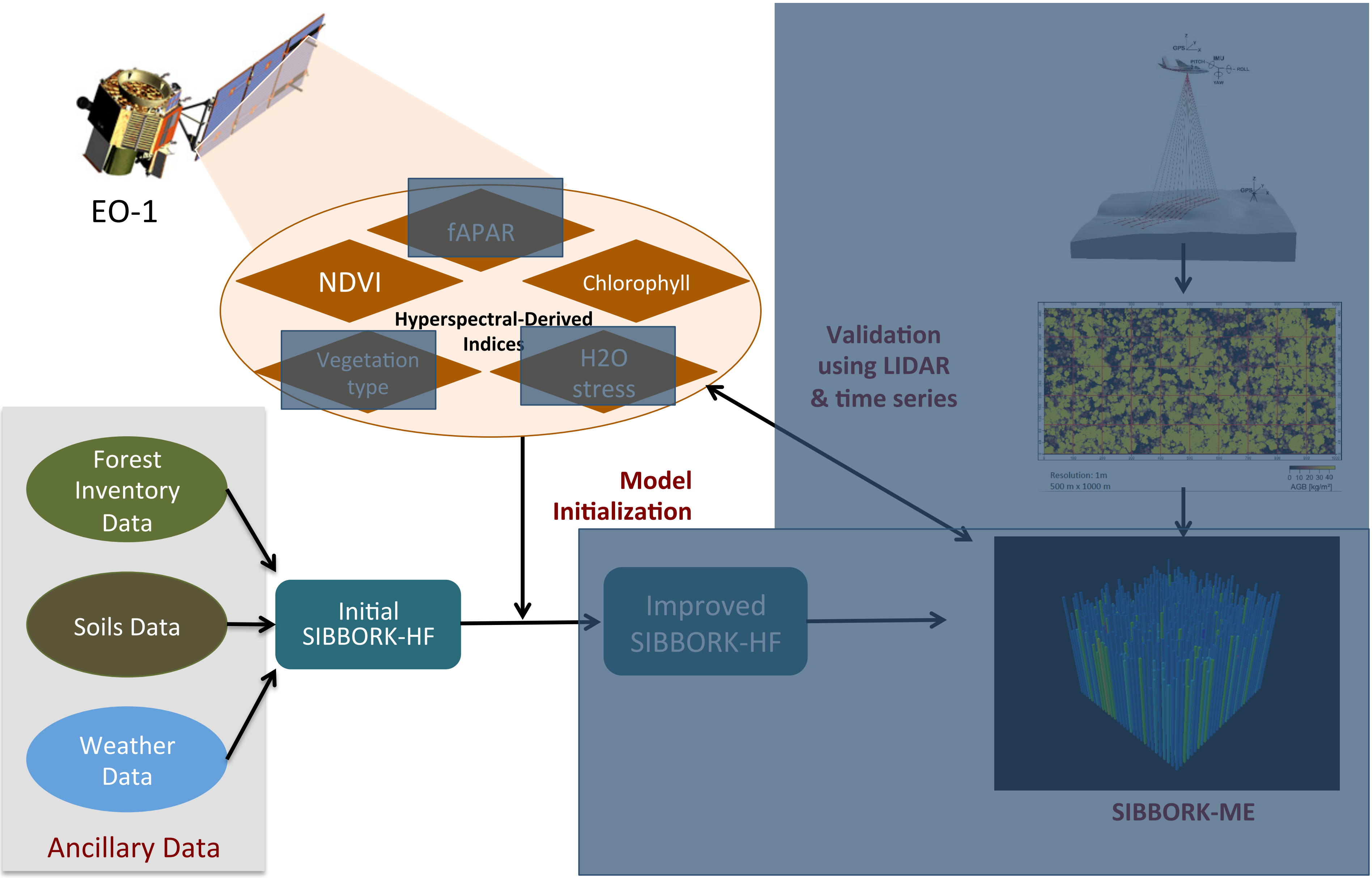
- Well established class of models
- Life history of each individual is simulated as a unique entity
- Main processes: establishment, diameter growth, and mortality
- Each tree on a modeled plot is subjected to simple interaction rules (shading, competition, resource limitation) in conjunction with the main processes
- Gap models have high levels of accuracy/prediction at the scale of small plots, but computer processor limitations previously prevented this resolution to extend across landscapes
- Higher resolution remote sensing and cloud computing has given rise to the capability to build models that are spatially explicit and can be linked to larger landscape level simulations
- Synergy with hyperspectral derived vegetation indices

Study Objectives

- Parameterize SIBBORK for Howland Forest, Maine (SIBBORK-ME)
- Use atmospherically corrected Hyperion data to derive vegetation indices across the Howland Forest, 2009-2010
- Compare indices (e.g. vegetation type, stress variables) with inventory data (calibrate at plot level, scale to Hyperion tiles)
- Test model parameterization with vegetation indices
- Validate Hyperion indices over time using LIDAR and modeled forest output raster datasets

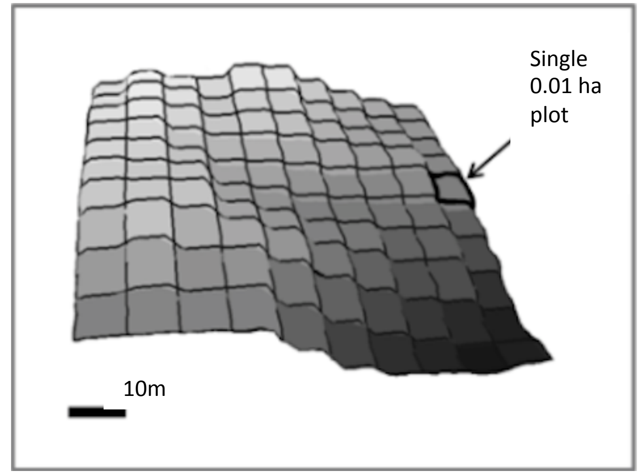


SIBBORK-ME Study Framework
(On-going Effort)



The SIBBORK Model

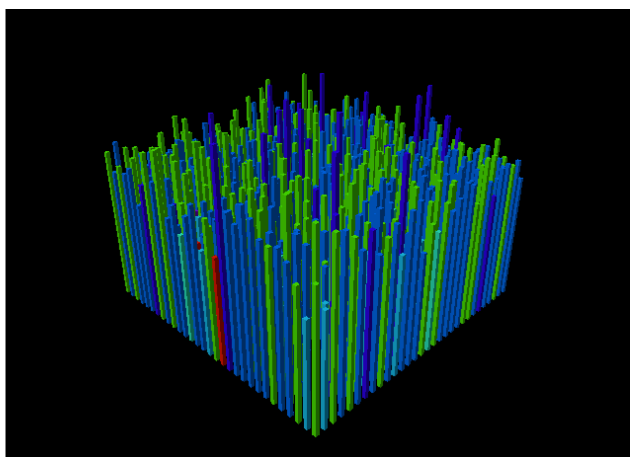
- Model by Brahznick and Shugart (2015) individual-based 3D gap model
- based on ZELIG (Urban, 1990)
- 3D light environment (topographic position)
- Compatible with hyperspectral derived vegetation indices in resolution and data format (raster)



Model Framework

Inputs

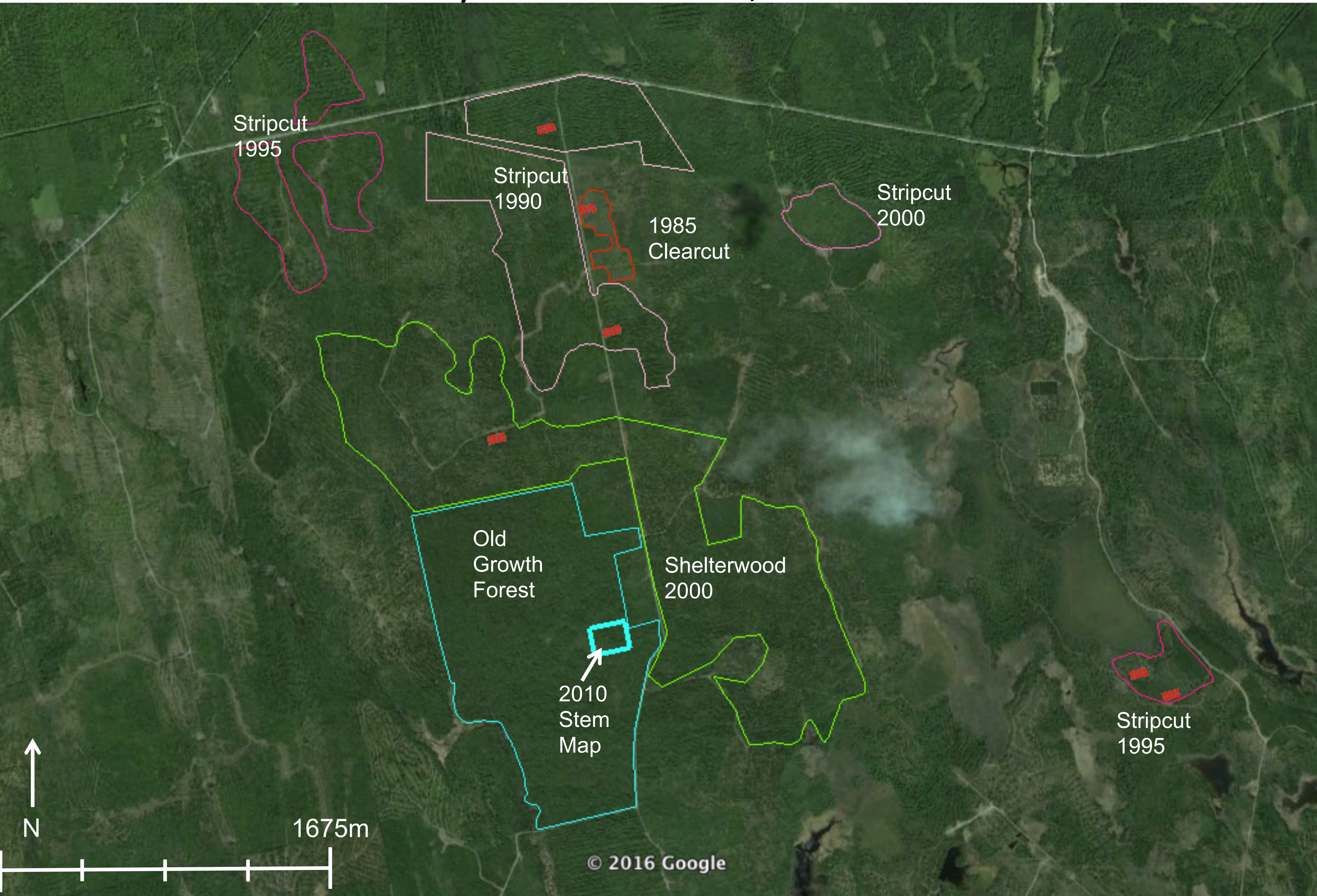
- Site Conditions
- Mortality
- Growth
- Regeneration
- Light Climate



Outputs (annual, per plot)

- Monthly temp, precip, total degree days, relative dry days
- # live trees in each size class, # dead trees from stress, # dead natural causes
- # live trees in each size class, # dead trees from stress, # dead natural causes
- # individuals per species, DBH size distribution, DBH, HT, crown height, diameter increment, stress flags due to: light, drought, soil fertility, temp, other env factors
- # and species of new sapplings, seed dispersal dependent on env factors
- For each species and each stand: stem density, BA, AGB, mean DBH, mean Ht, biovolume, LAI,

Study Area: Howland, Maine



2010 NASA Forest Plots

Howland, Me SIBBORK Parameterization

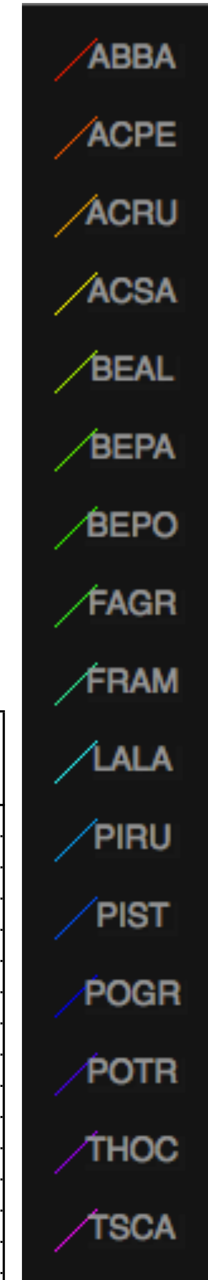
Environmental Data:

- Weather data from NOAA data product
- Soil data from ZELIG (Levine- NASA)

Tree Data:

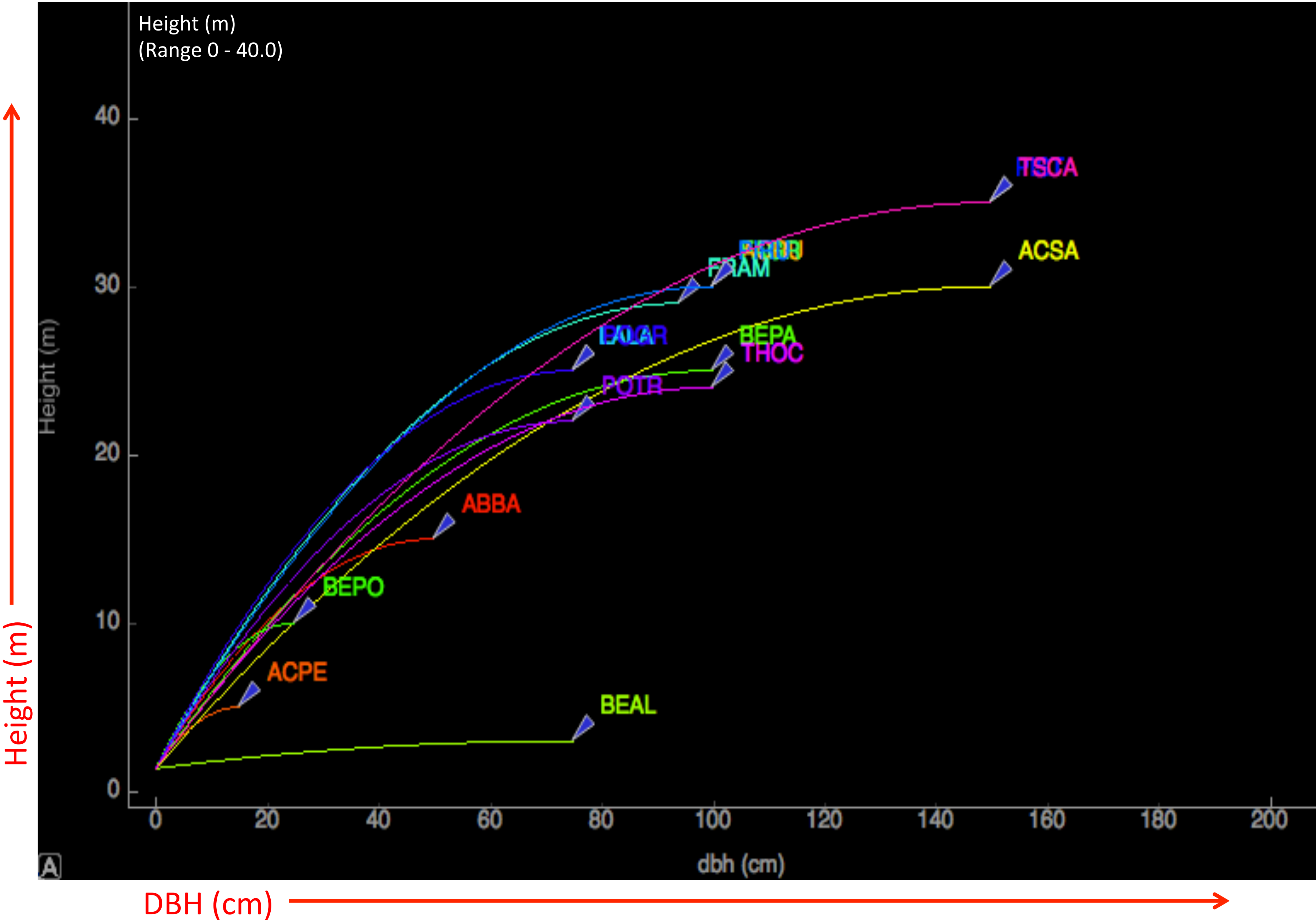
- Forestry Weight Tables: biovolume, foliar volume
- Plot data: 2009, 2010, 4 stand types
- For 16 Tree Species:
  - -life history: USDA (Agemax, Htmax, Dmax), ZELIG (Ranson et al 1995)
  - -biomass: Ter-Mikaelian and Kortzukhin, Jenkins et al 2001, 2003, 2004
  - -LAI: SLA, foliar variables – literature, weight tables
  - -stem numbers: NASA 2010 stem map (~2800 trees measured in 3ha)
  - -tree growth: ZELIG
  - -basal area: standard equation, plot data

SIBBORK Species Code	Common Name	Species
ABBA	Balsam Fir	Abies balsamea
ACPE	Striped Maple	Acer pensylvanicum L.
ACRU	Red Maple	Acer rubrum
ACSA	Sugar Maple	Acer saccharum
BEAL	Yellow Birch	Betula alleghaniensis
BEPA	White Birch	Betula papyrifera
BEPO	Gray Birch	Betula populifolia
FAGR	American Beech	Fagus grandifolia
FRAM	White Ash	Fraxinus americana
FRNI	Black Ash	Fraxinus nigra
LALA	Larch	Larix laricina
PIMA	Black Spruce	Picea mariana
PIRU	Spruce	Picea rubens
PIST	White Pine	Pinus strobus
POGR	Big-tooth Aspen	Populus grandidentata
POTR	Quaking Aspen	Populus Tremulus
THOC	Northern White Cedar	Thuja occidentalis
TIAM	American Basswood	Tilia Americana
TSCA	Eastern Hemlock	Tsuga canadensis

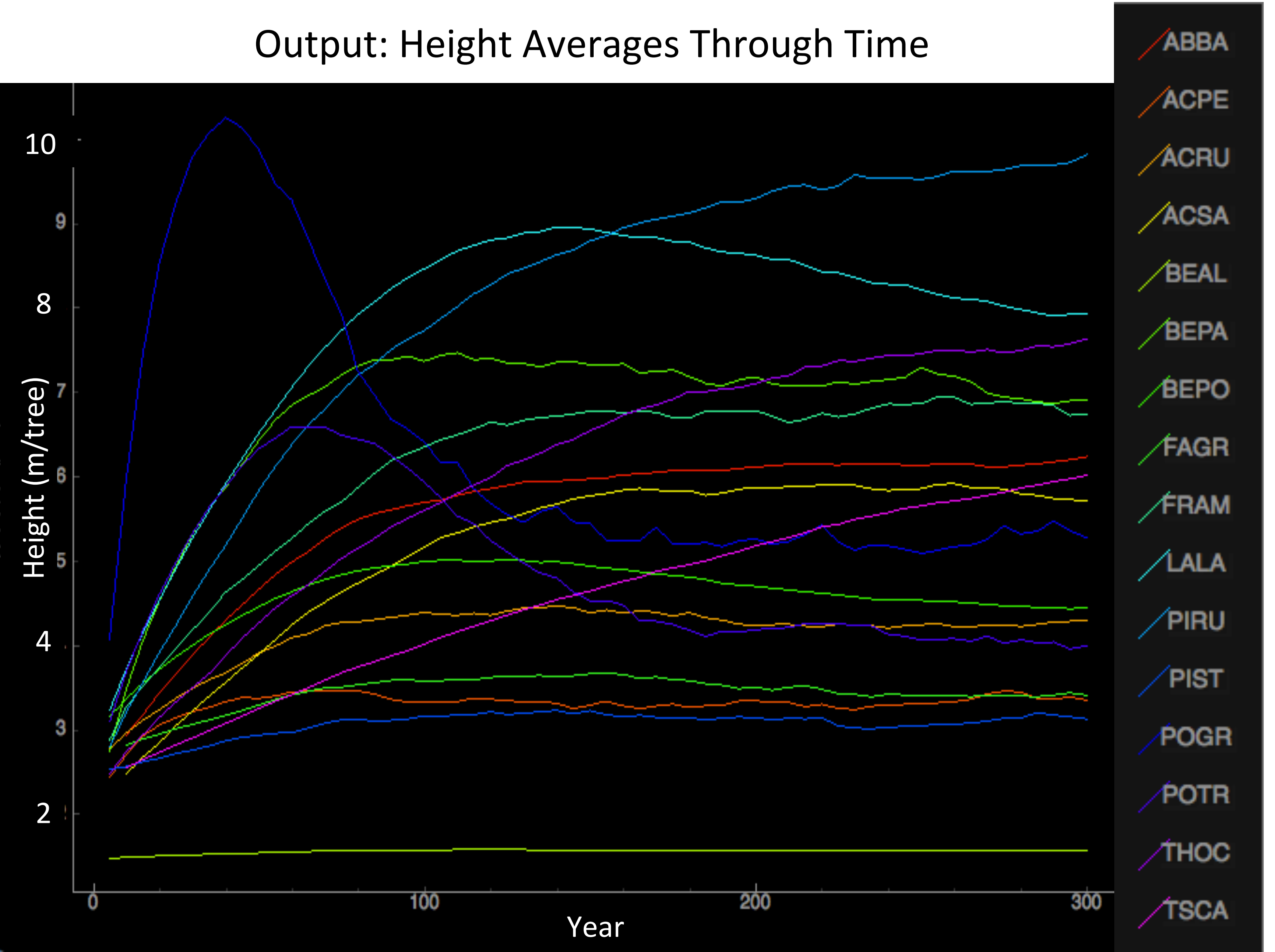


Tree Species Codes

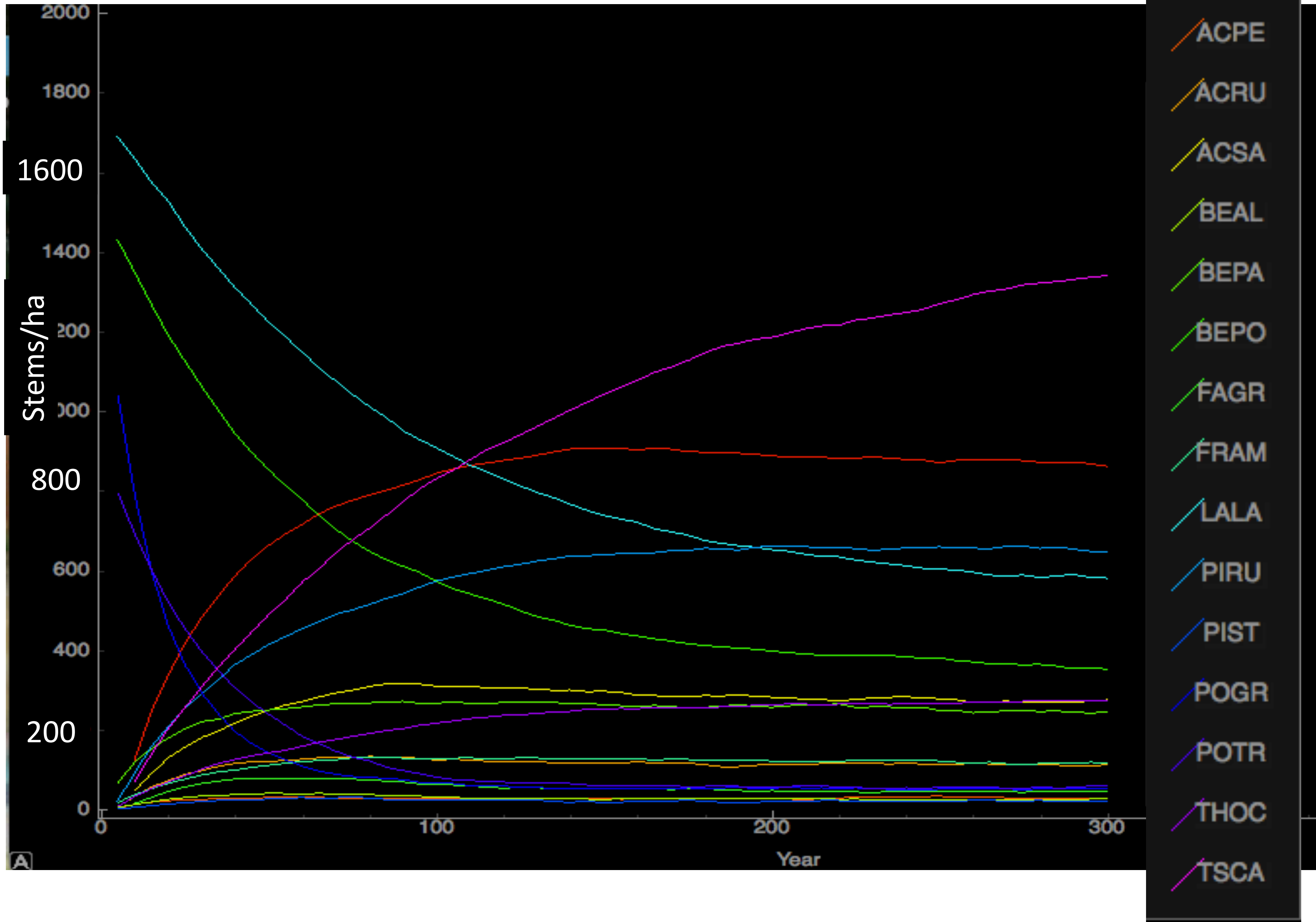
SIBBORK-ME Model Equations



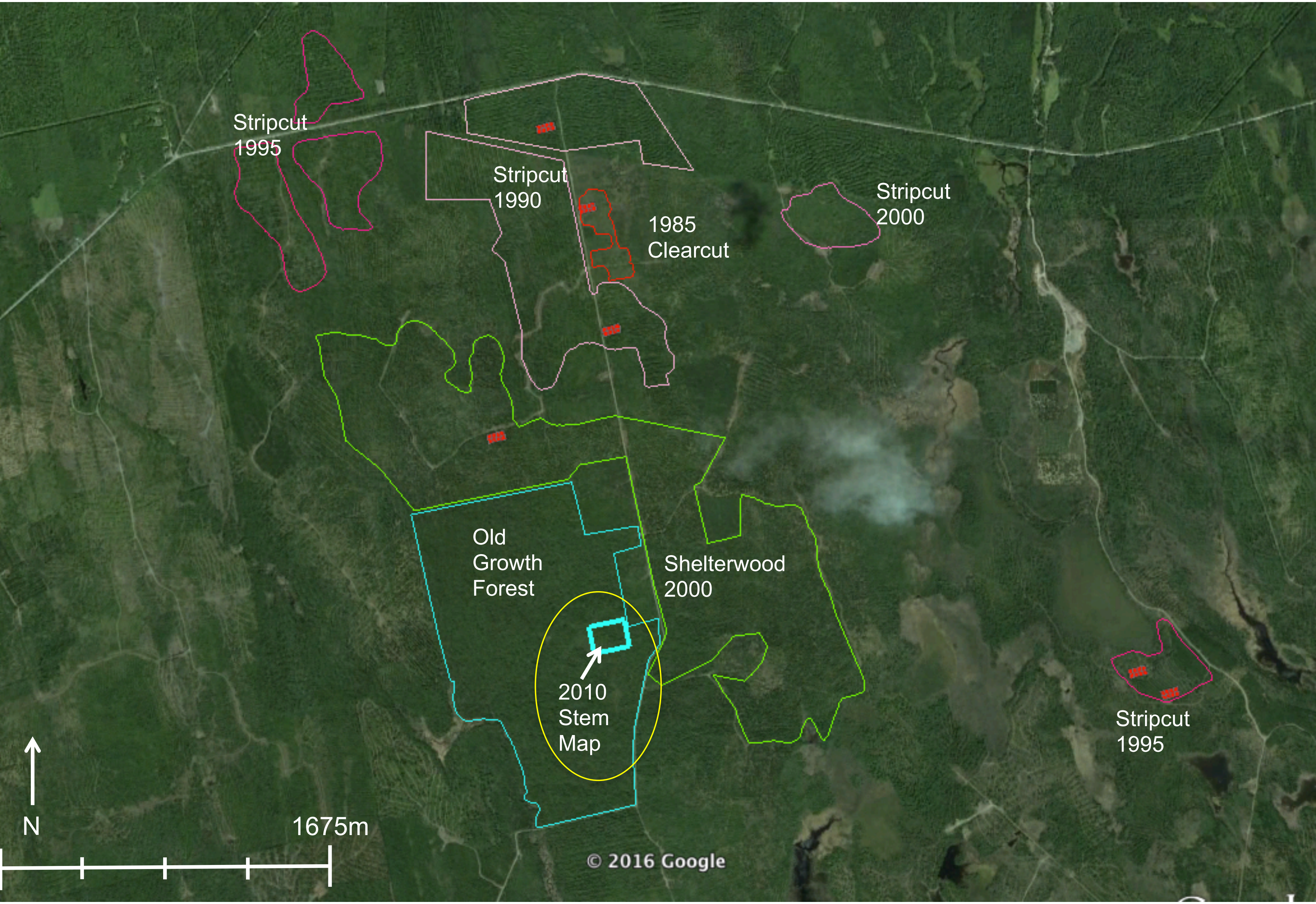
Output: Height Averages Through Time



SIBBORK-ME Captures Succession…

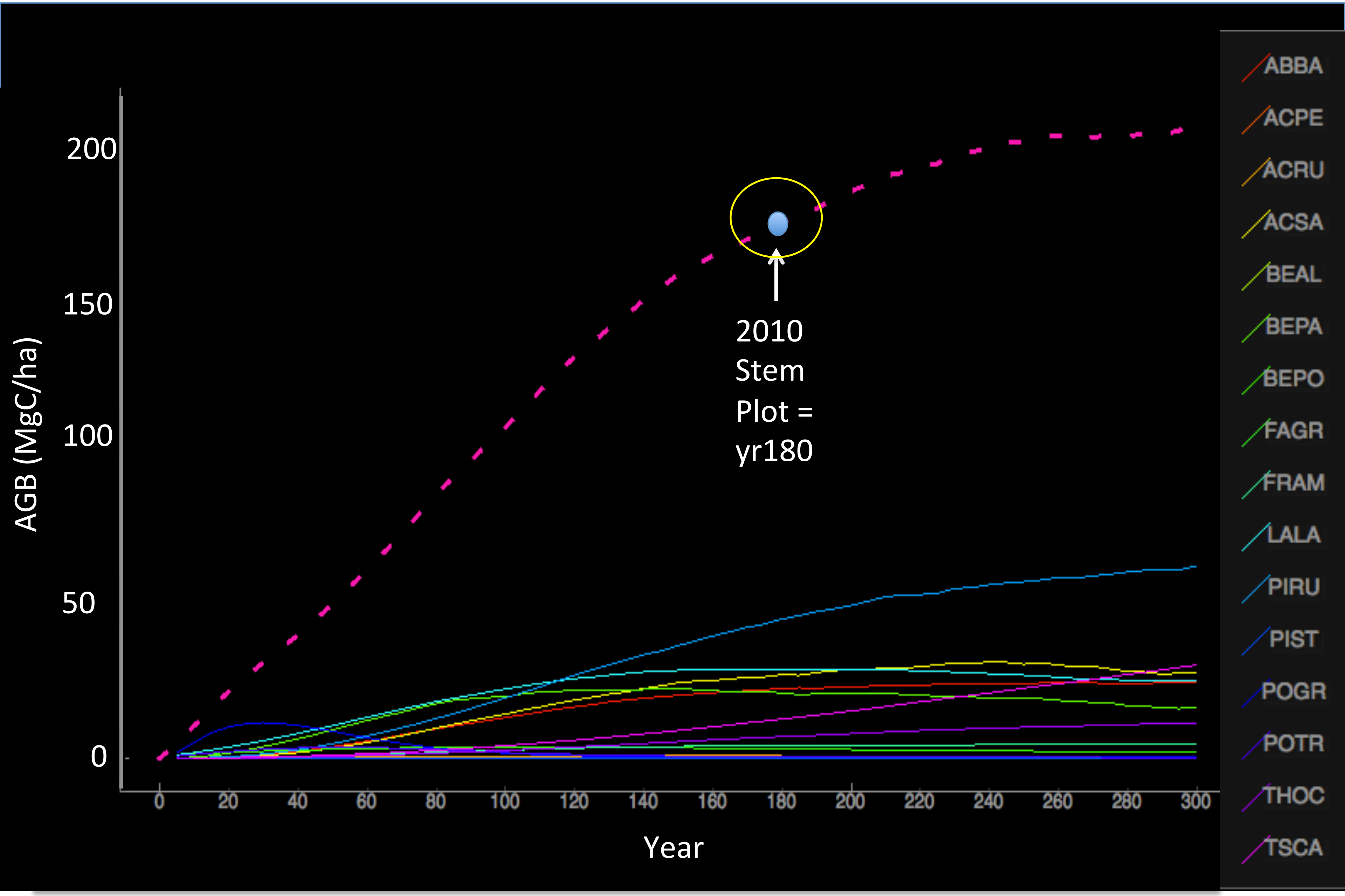


Study Area: Multiple Forest Stand Types

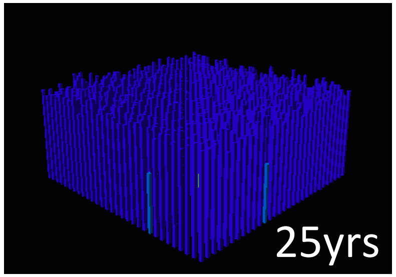


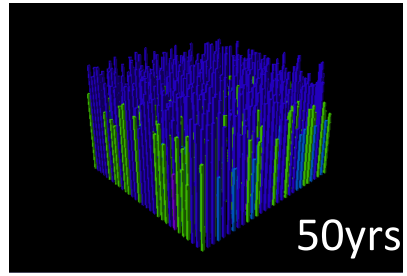
2010 NASA Forest Plots

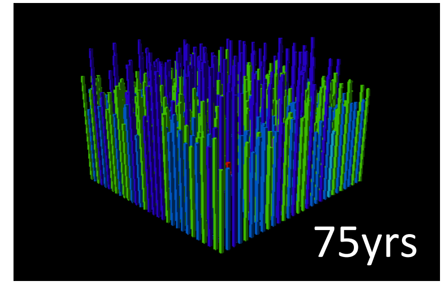
Initial Model Testing Results



Initial Model Results Through Simulation

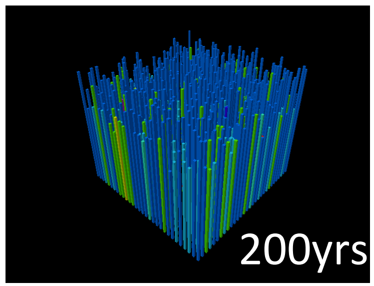


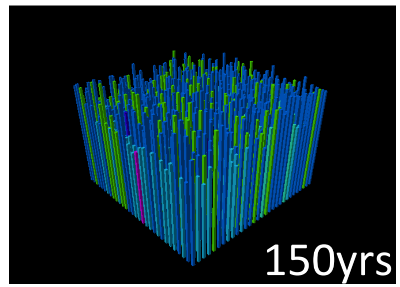


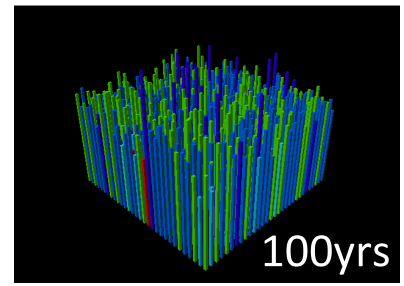


SIBBORK output

Species	% of Stems
ABBA	17.2%
ACPE	0.6%
ACRU	2.2%
ACSA	5.3%
BEAL	0.5%
BEPA	4.9%
BEPO	7.1%
FAGR	0.9%
FRAM	2.3%
LALA	11.6%
PIRU	13.0%
PIST	0.4%
POGR	1.1%
POTR	1.1%
THOC	5.4%
TSCA	26.2%

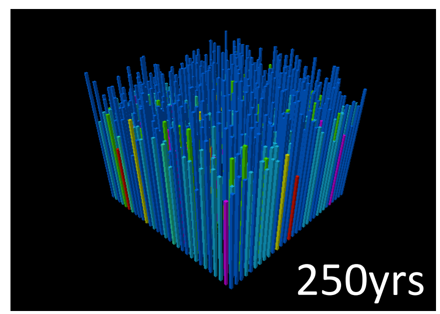


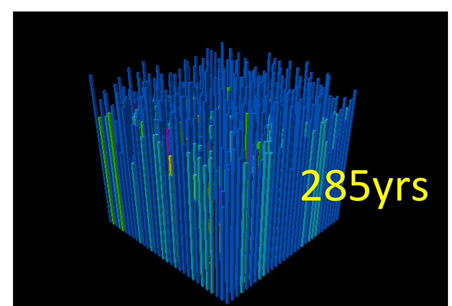


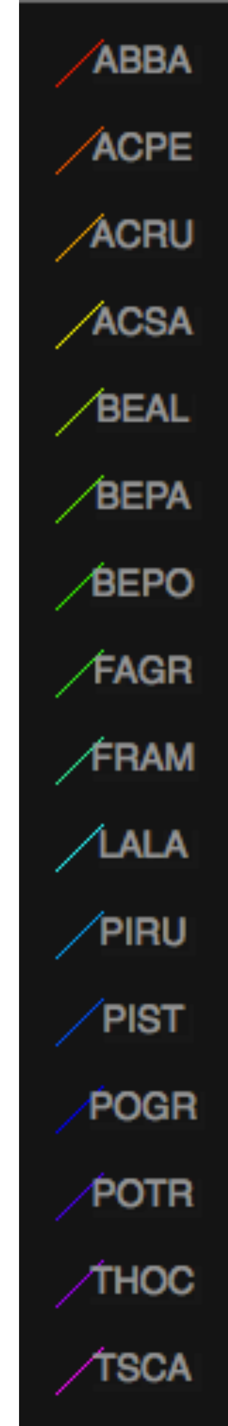


2010 Stem Map

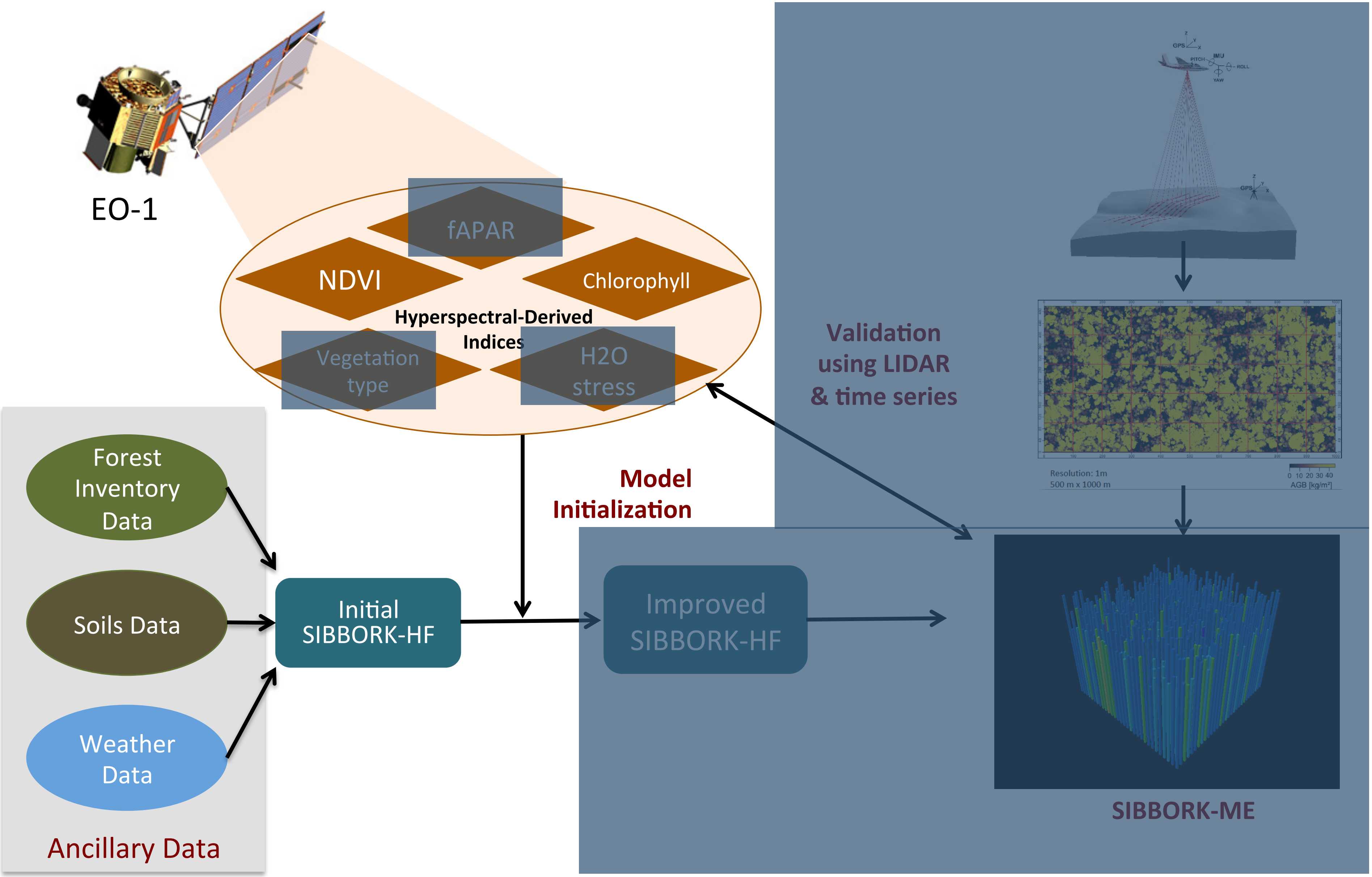
Species	% of Stems
ABBA	16.0%
ACRU	10.4%
BEPA	0.4%
LALA	0.0%
PIRU	39.7%
PIST	1.0%
THOC	14.9%
TSCA	17.6%



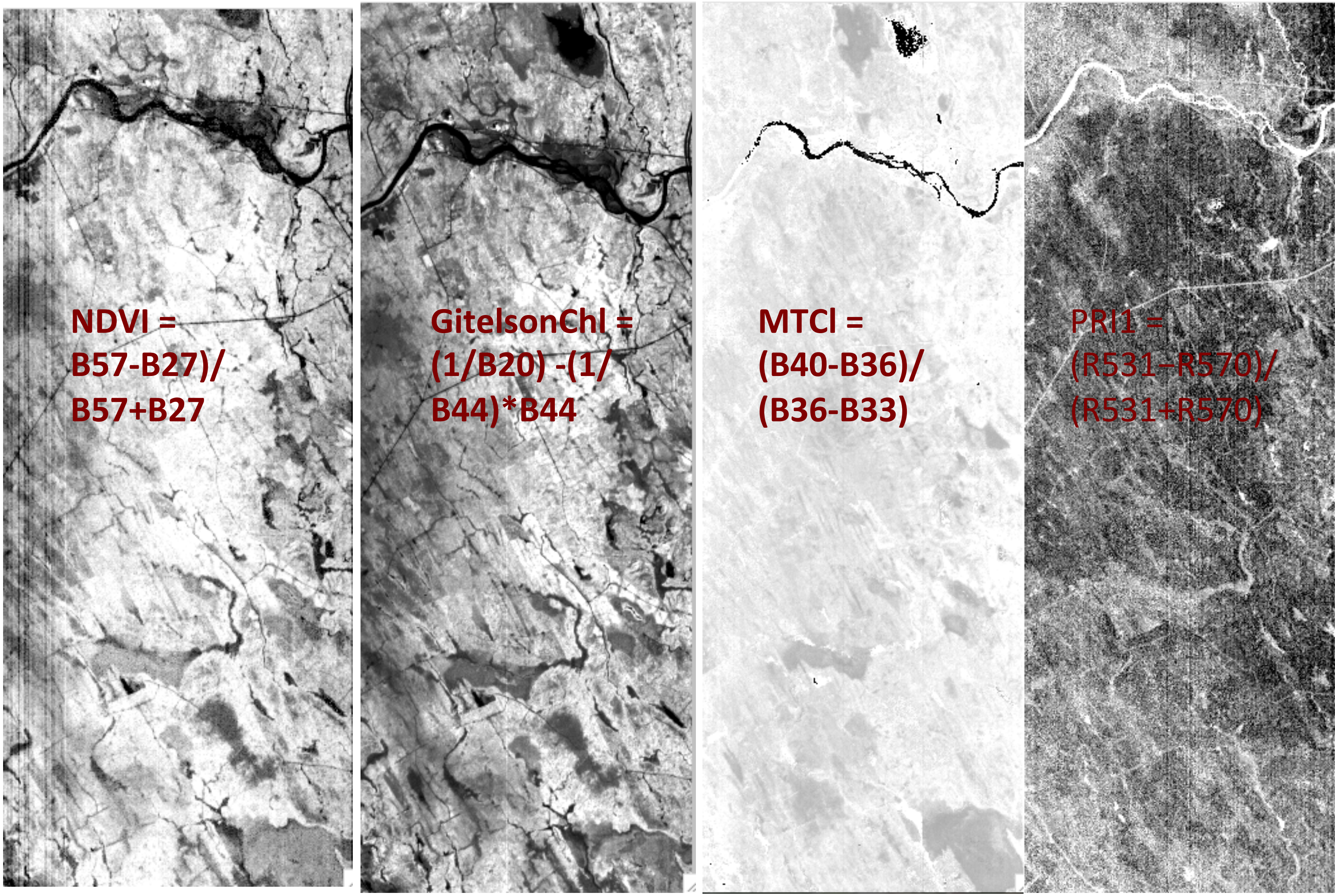




SIBBORK-ME Study Framework
(On-going Effort)



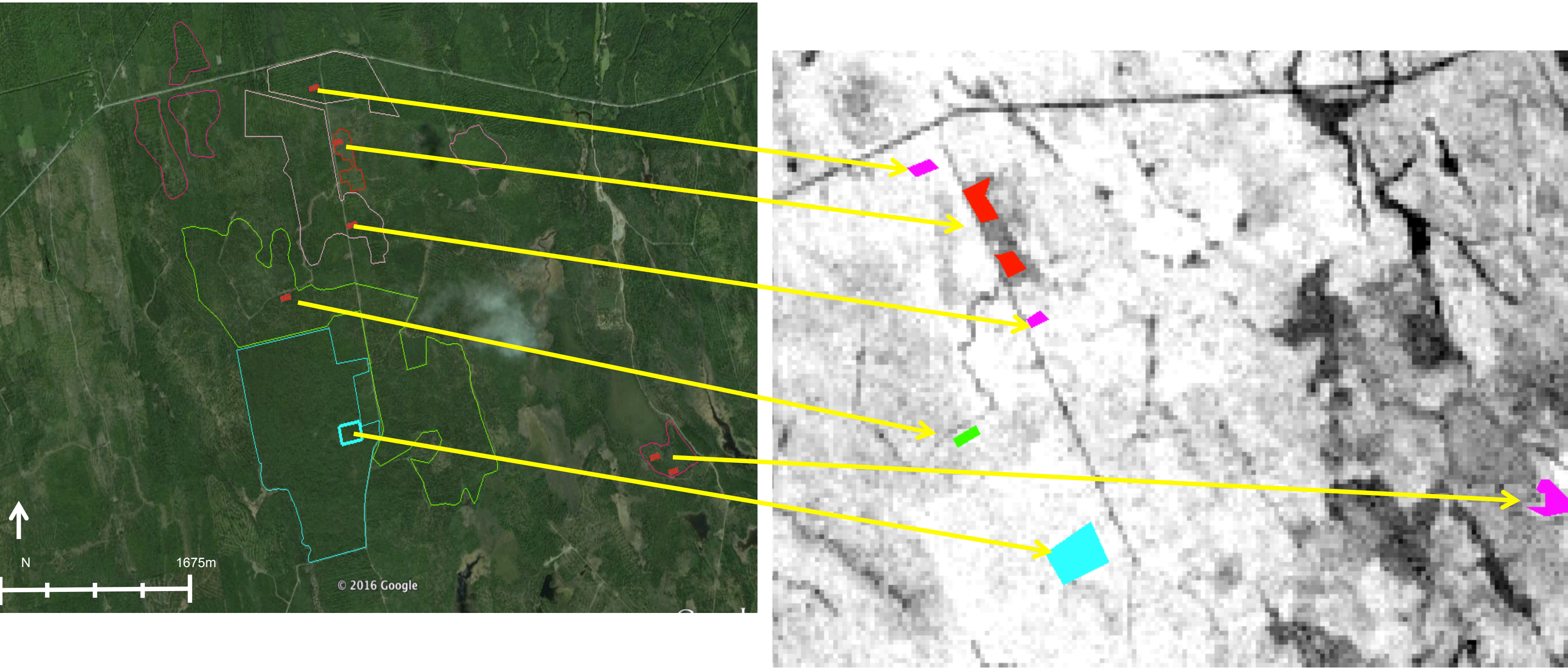
Hyperion Vegetation Indices



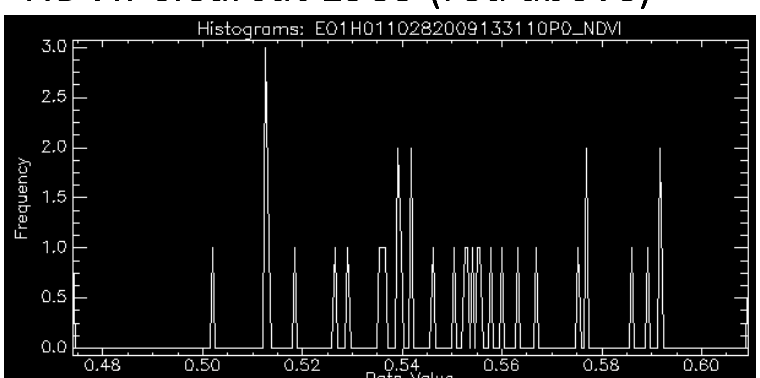
NDVI GitCl MTCI PRI

Image Year: 2009

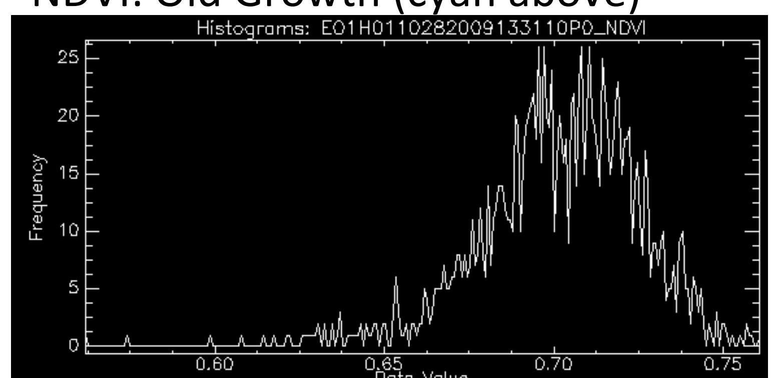
Relating Vegetation Indices to Field Data



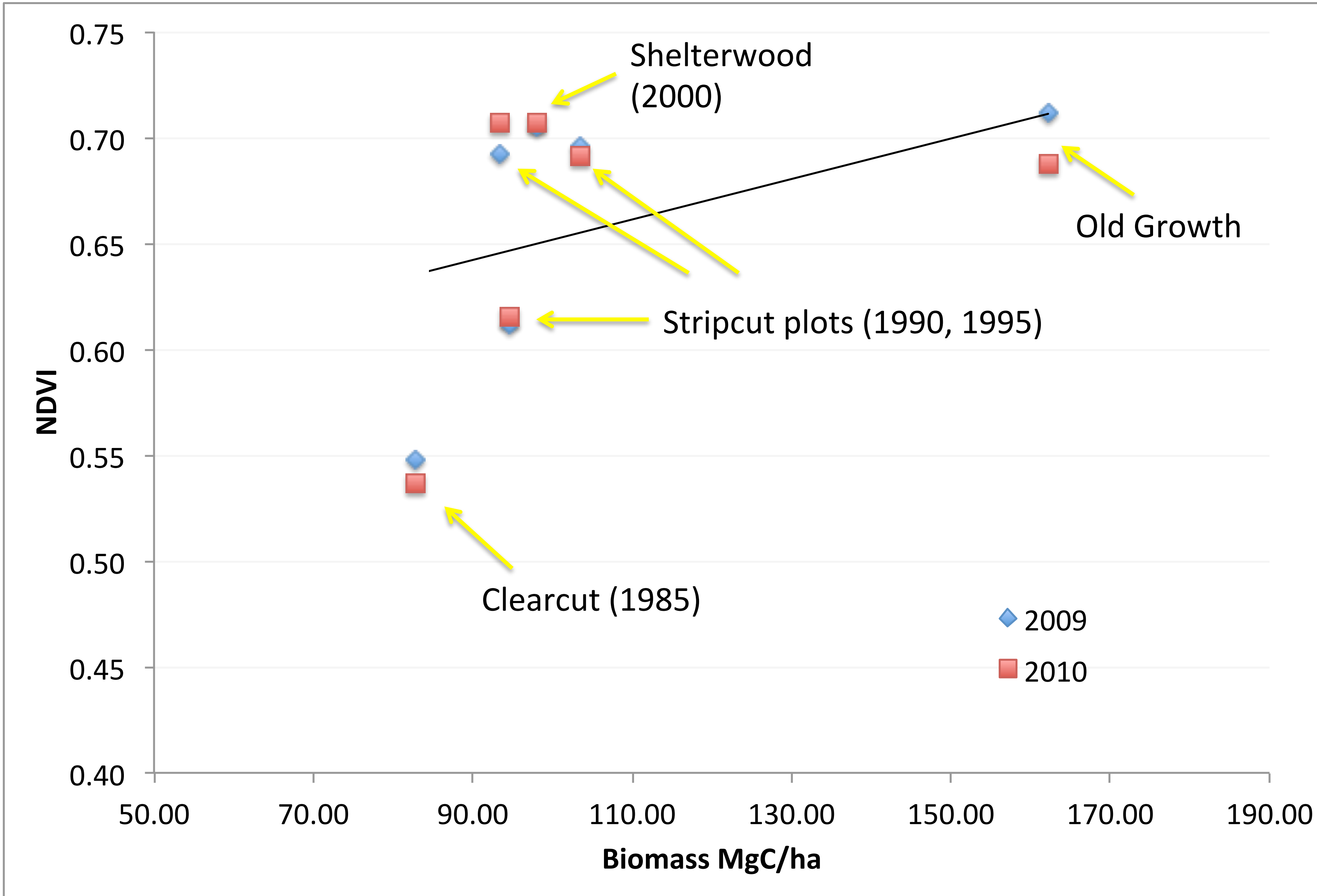
NDVI: Clearcut 1985 (red above)



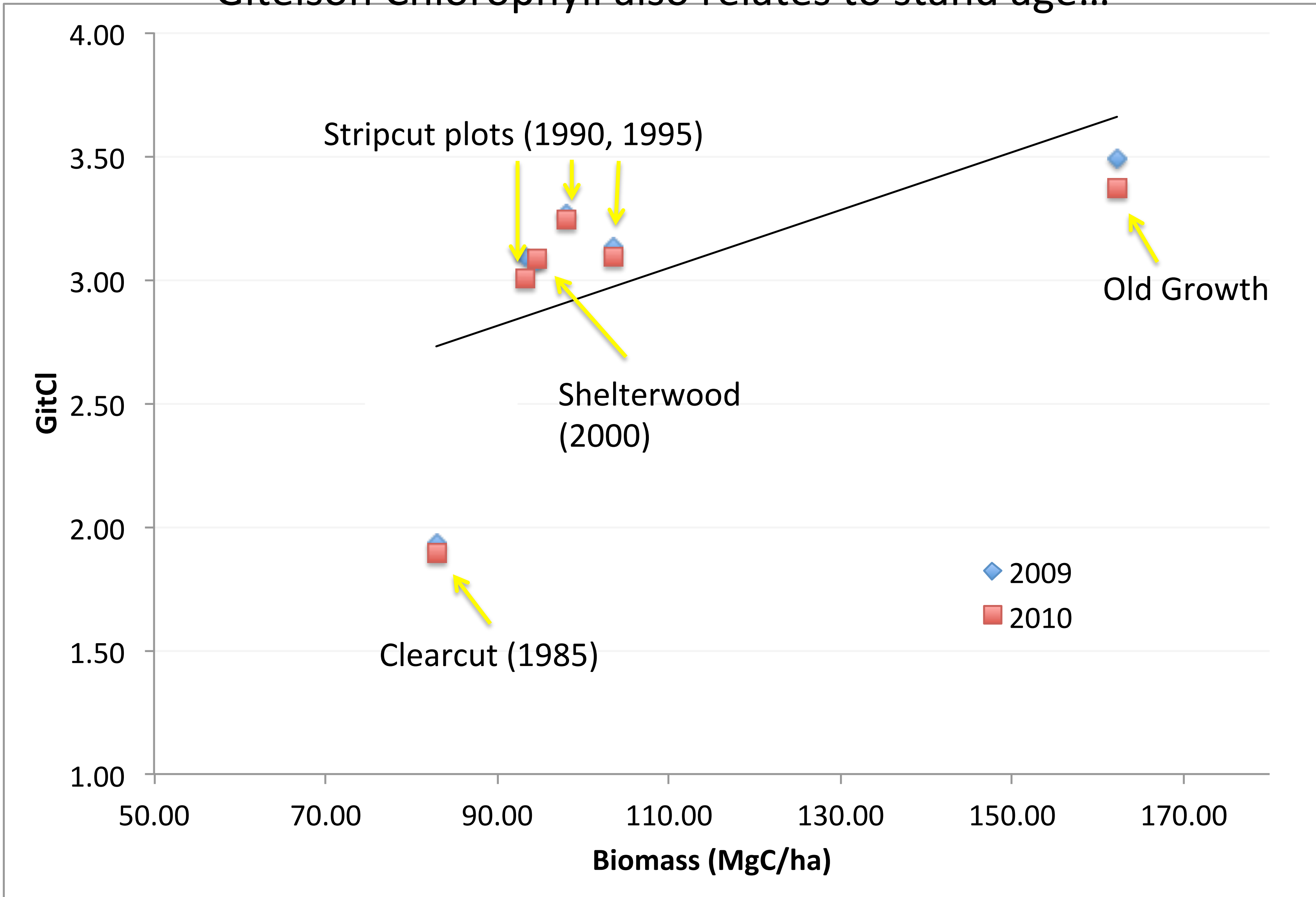
NDVI: Old Growth (cyan above)



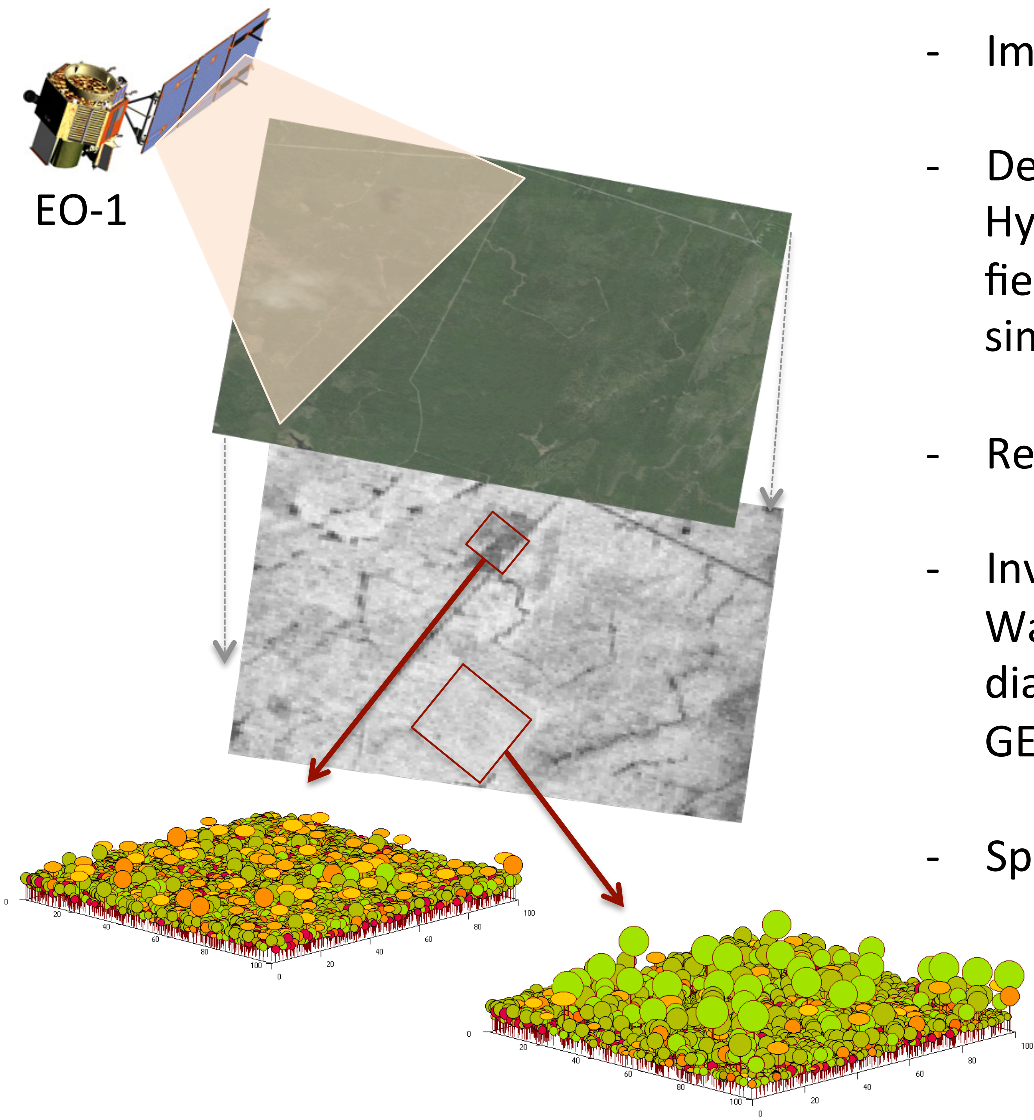
NDVI shows expected differences across stand age...



Gitelson Chlorophyll also relates to stand age…

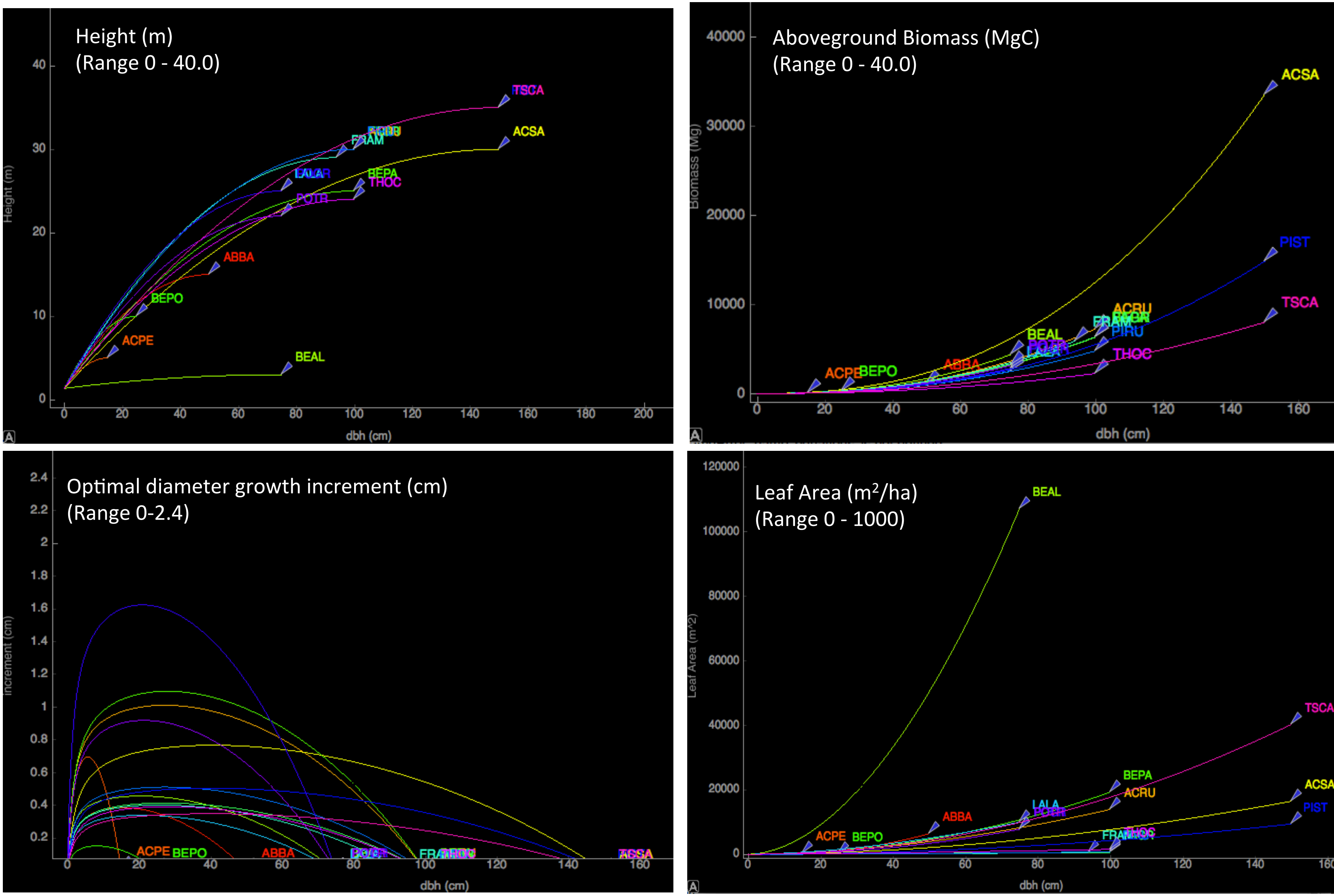


Model Refinement with Vegetation Indices



- Improve model accuracy
- Derive forest composition from Hyperion spectral indices, compare to field data and model output to expand simulation area
- Relate PRIs to LUE for model ingestion
- Investigate fAPAR (Zhang et al.) and Water stress characteristics for diameter growth increment limitation, GEP effects
- Spatially explicit simulation

Initial Model Equations



X-axis = DBH (cm)

Initial Model Testing Results