Long term effects of alternative group selection harvesting designs on stand production

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Objectives

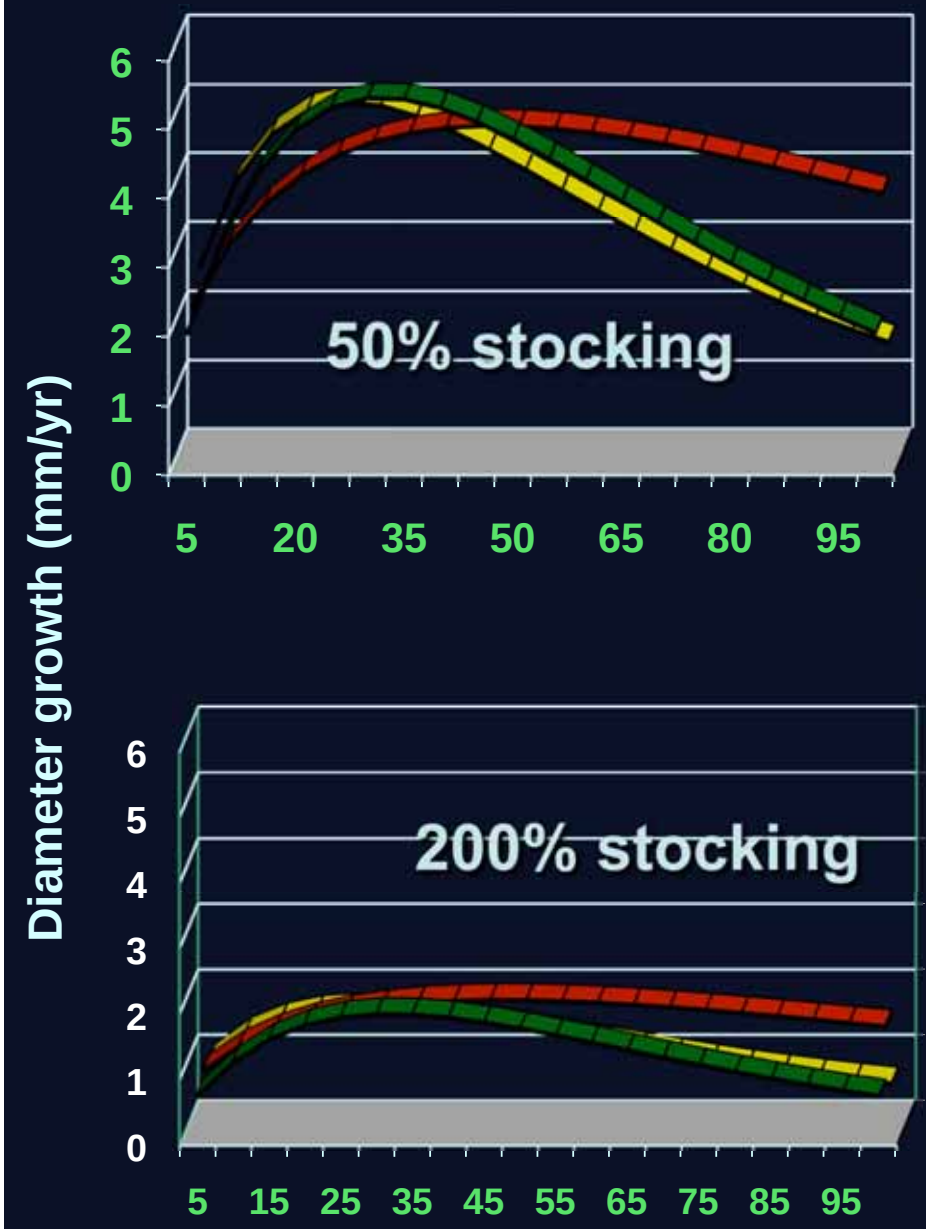
- To assess group selection's impact on
  - Stand-level volume production
  - Stand-level growing space efficiency
  - Tree-level volume production
  - Tree-level growing space efficiency

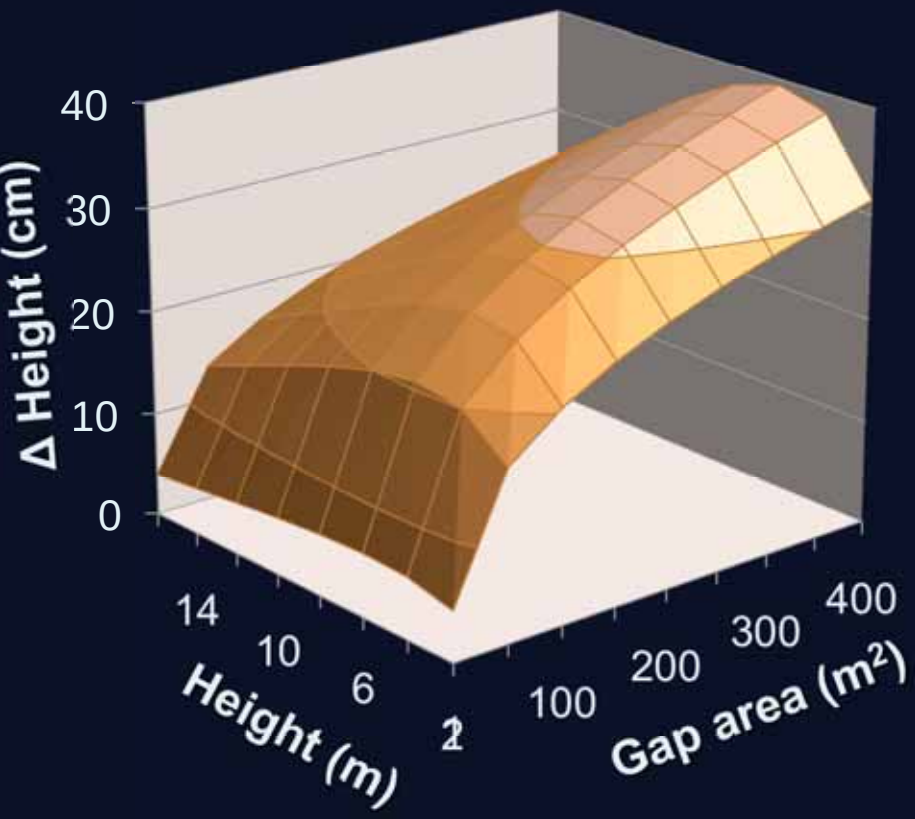
Approach

- Use CANOPY to simulate
  - A range of group selection alternatives
  - Standard silvicultural benchmarks

Height/Diameter Growth

Large trees (>17m tall) grow in diameter
Small trees (<17m tall) grow in height



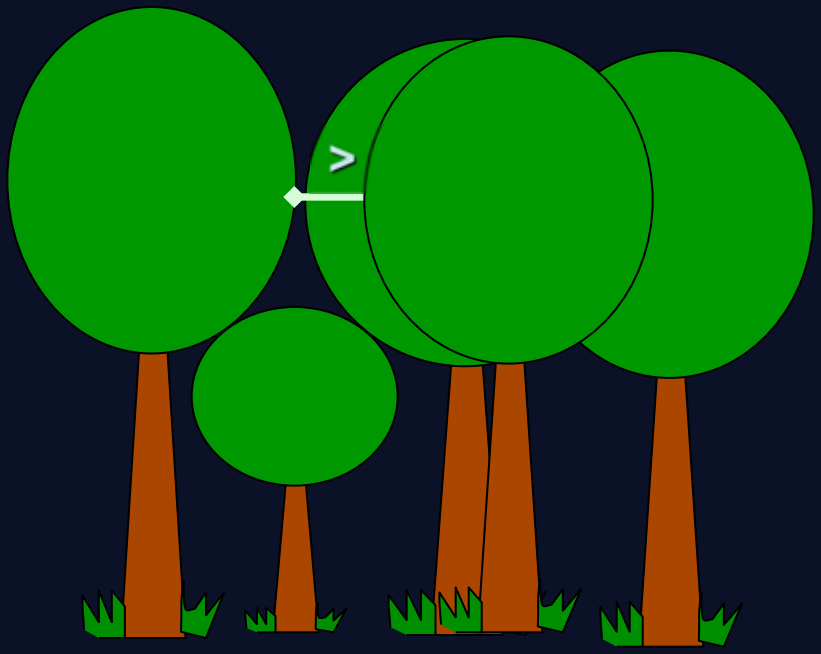


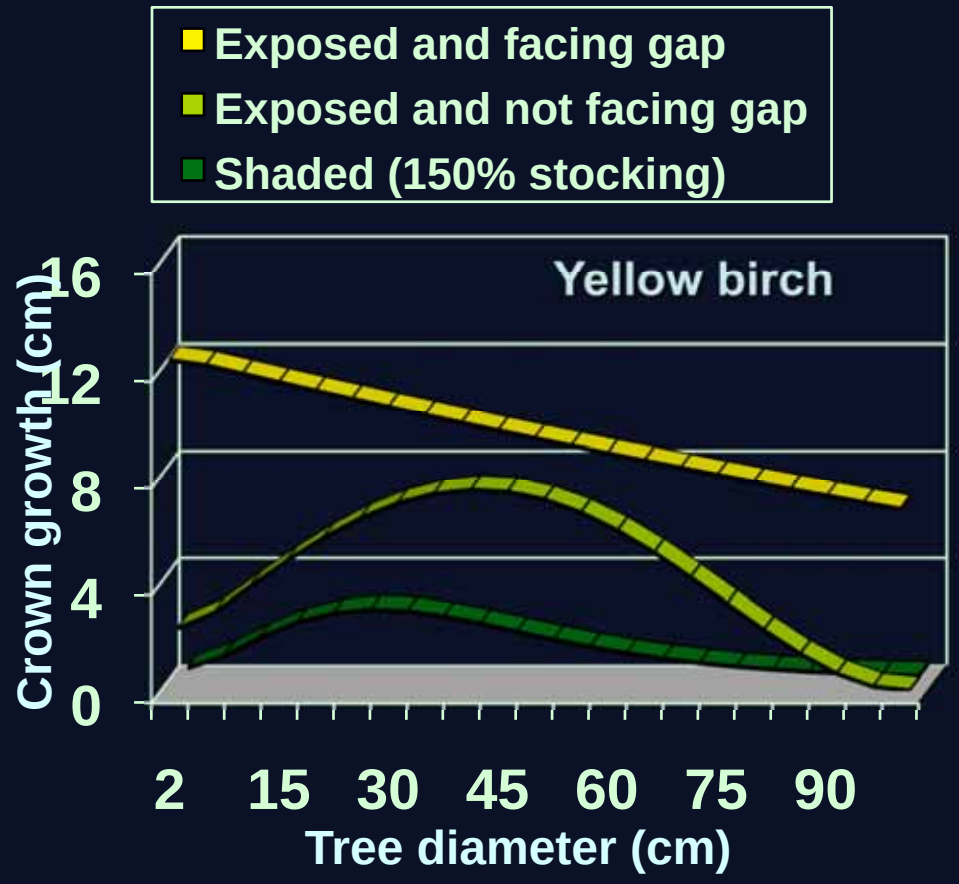
Sugar maple on AOCa

Crown growth

Crown radii can grow N, S, E, W

1. Exposed and facing gap
2. Exposed and not facing gap
3. Shaded
4. Touching



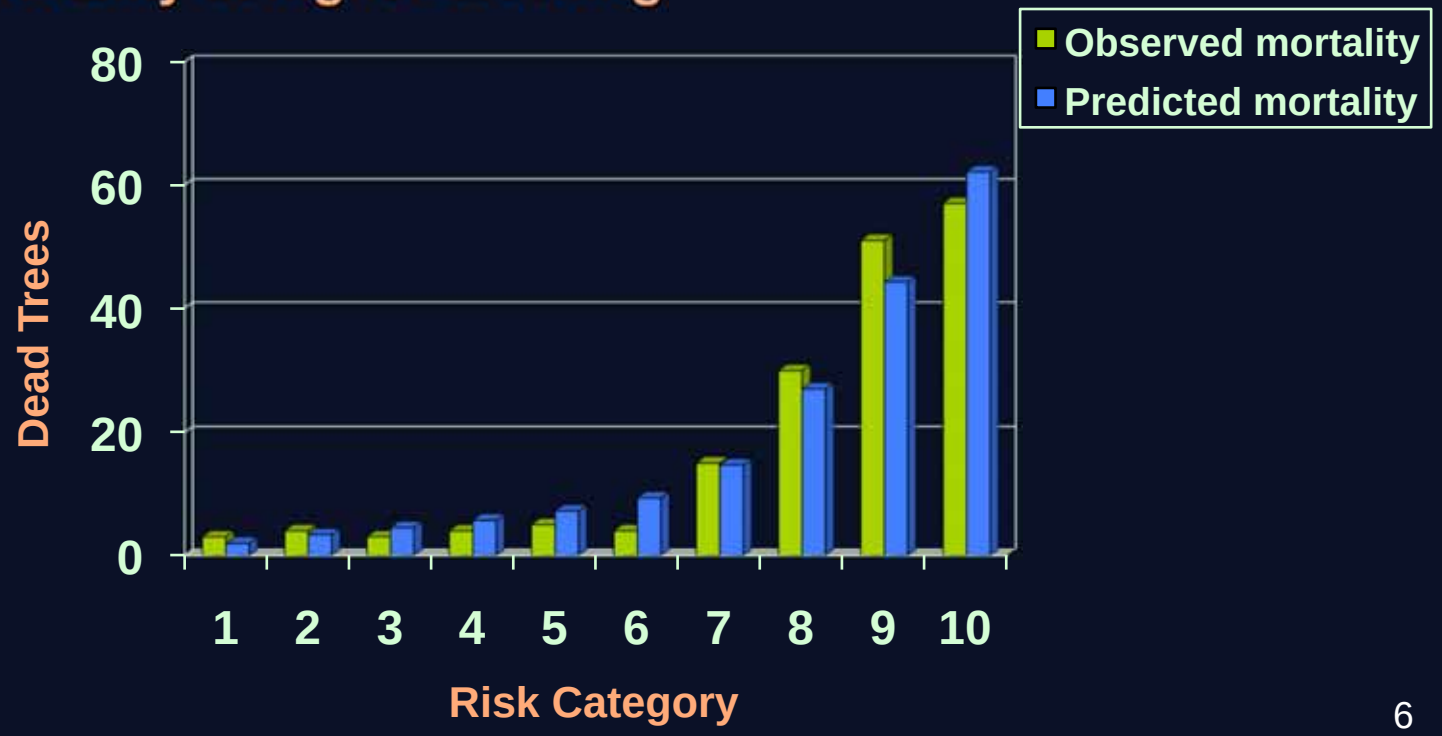


Mortality

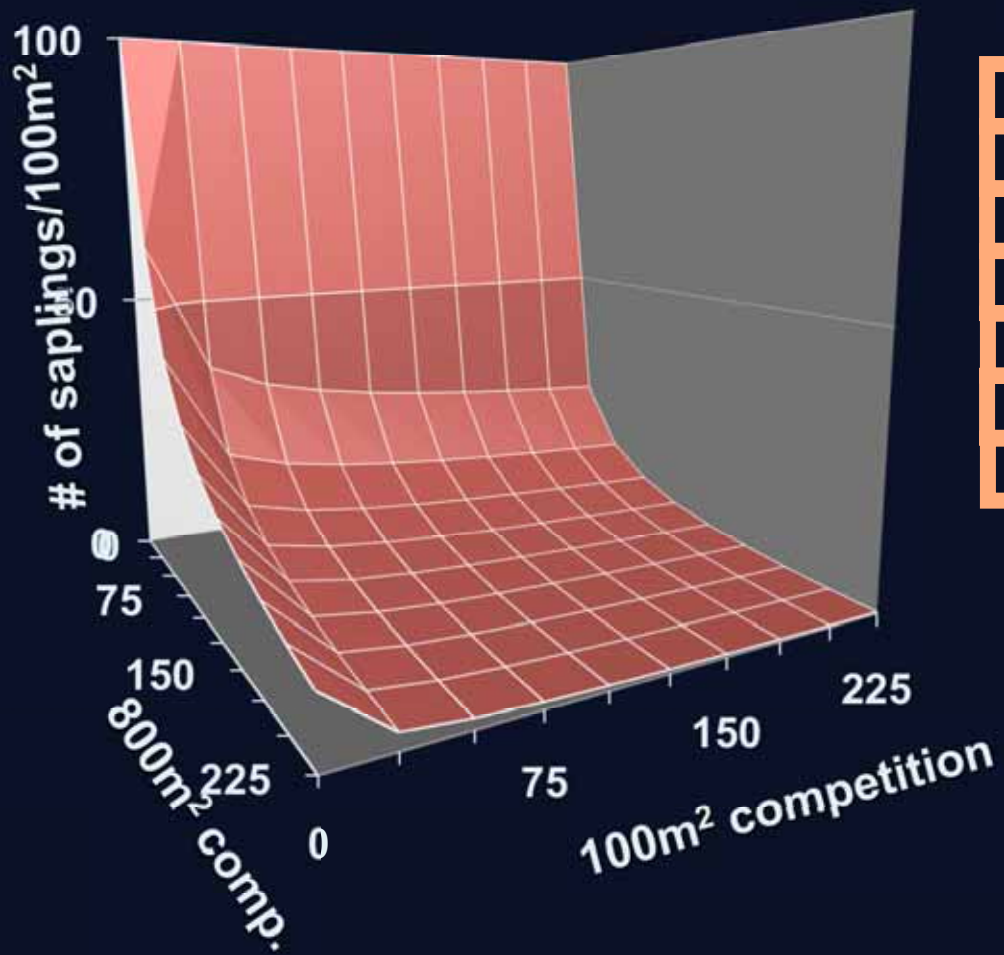
Mortality is stochastic

Annual probabilities of mortality given by a Logistic function of diameter and stocking

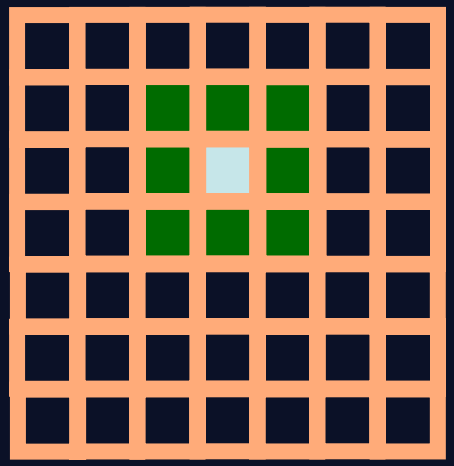
Function follows a U-shaped trend with diameter, and predicts higher mortality at higher stocking



Recruitment



The number of 2-6 cm trees expected in each 100m² area is predicted



- 100m² stocking
- 800m² stocking

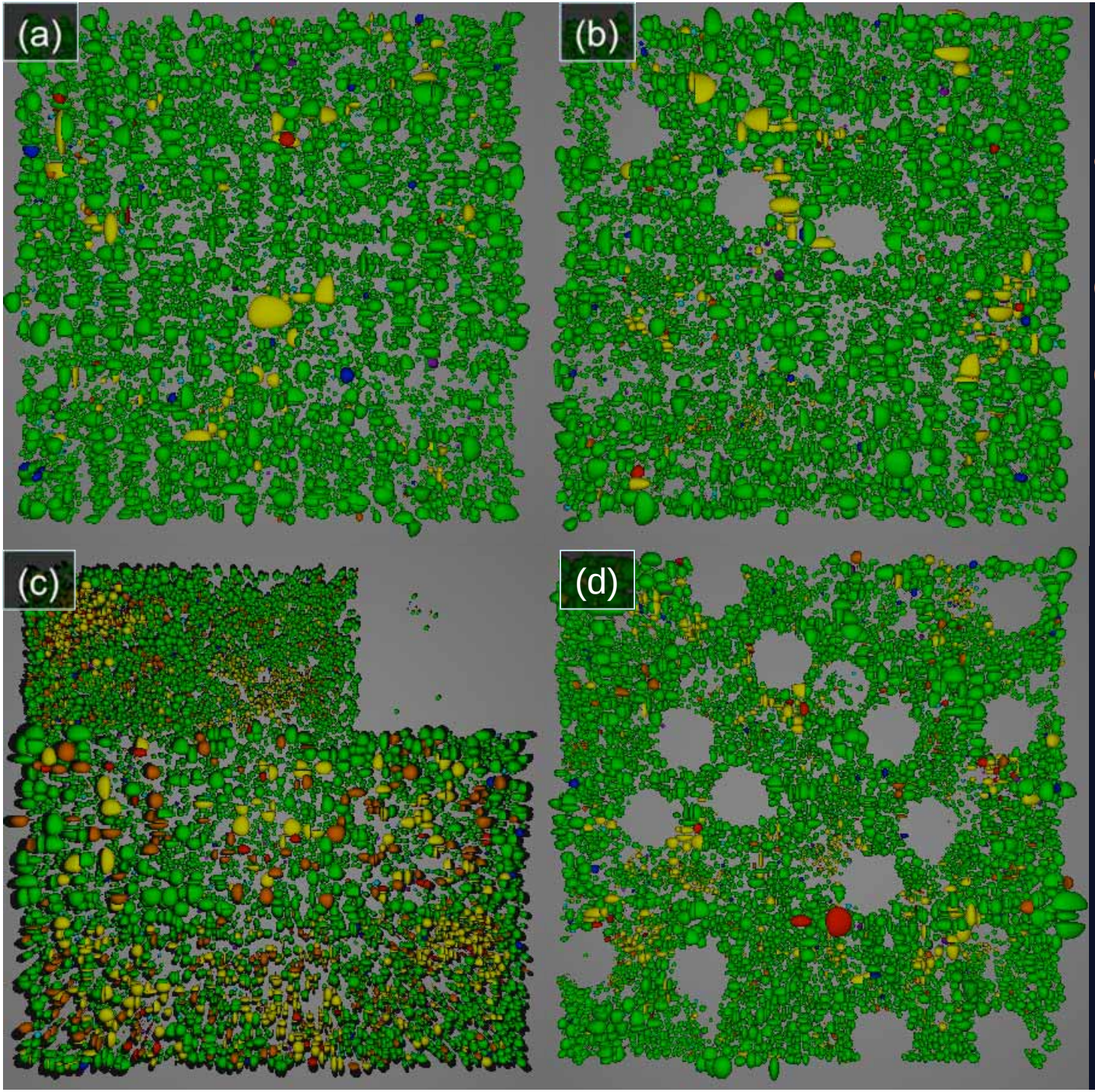
New saplings are added if there is a deficit

Species of new saplings is influenced by overstory composition

Validation

Comparing CANOPY simulations of standard single-tree selection against NH-25 field data for the same treatment:

	CANOPY Prediction	NH-25 Measurement	%Diff
Survivor Growth (m^2/ha/yr)	0.35	0.32	9.3%
Mortality (m^2/ha/yr)	0.11	0.10	10.0%
Harvest Rate (m^3/ha/yr)	4.58	4.42	3.6%



Treatments

a) Standard STS
b) GS+STS
   800m^2, 3%
c) Clearcutting
   w/ Thinning
d) GS 800m^2, 120yr

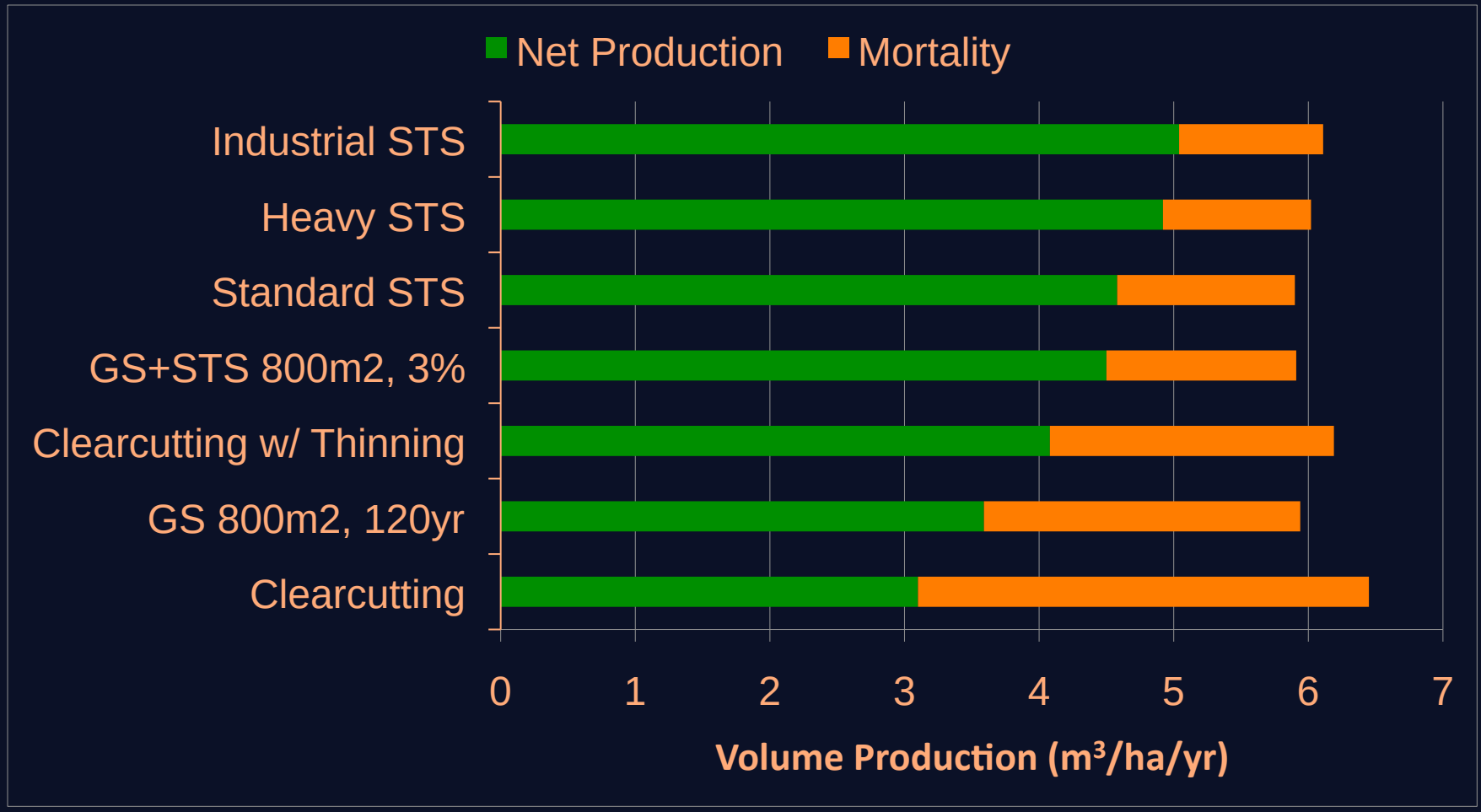
Methods

- Simulated 10 reps of each treatment
- Used last 150 years of simulation to compute annualized volumetric yield and mortality
- Life-cycle inventory for individual trees
  - A cohort of trees is tracked from birth to death
  - 5-year volume increments are used to compute yield and efficiency averaged by size class

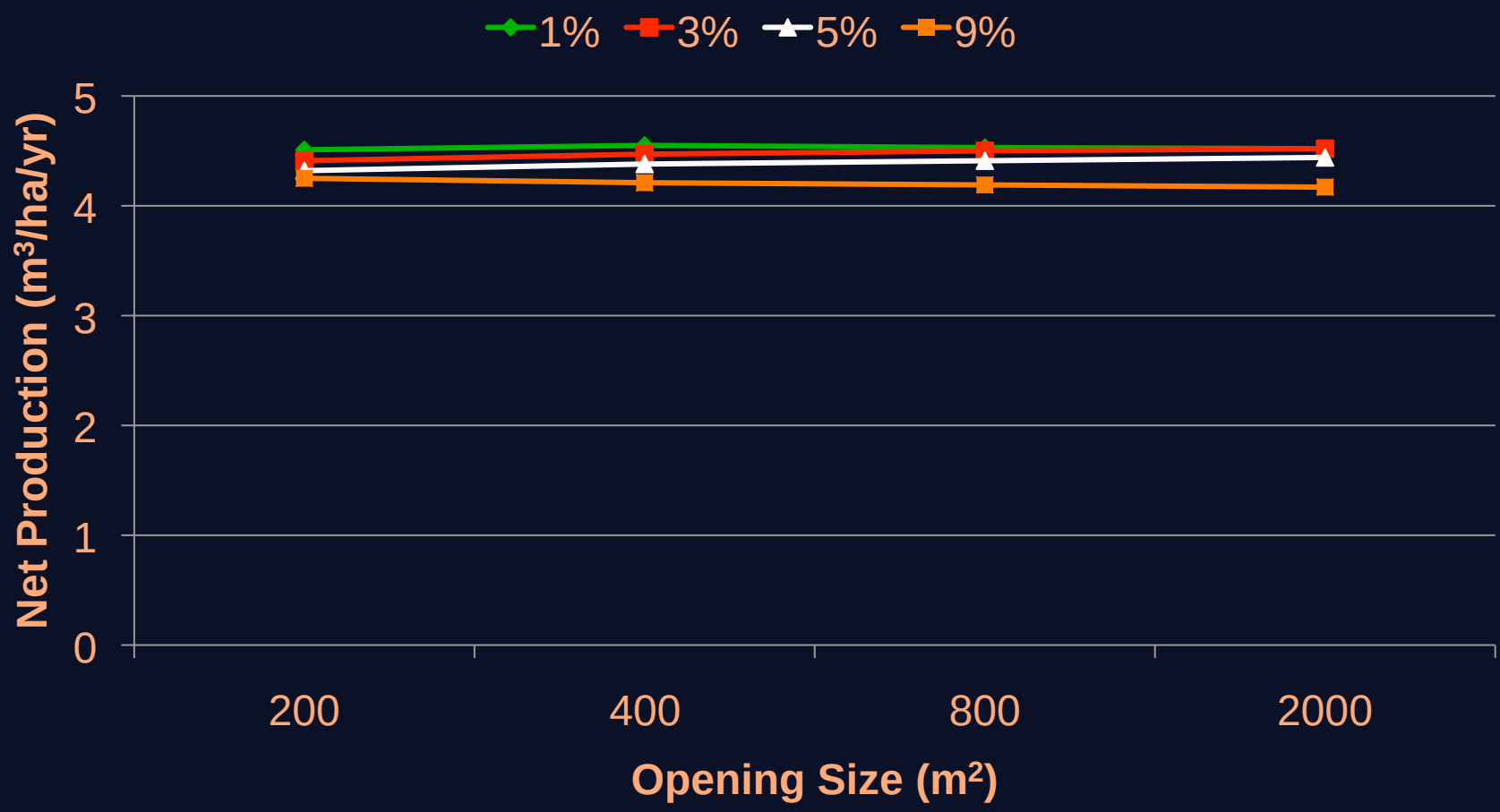
Hypotheses

- H1: Group size and the percentage of the stand occupied by groups will not affect net production rate
- H2: Under group selection alone, net production will decline as rotation age increases
- H3: Increases in sapling/pole GSE will not increase stand-level production markedly because the sapling/pole component produces only a small fraction of the total

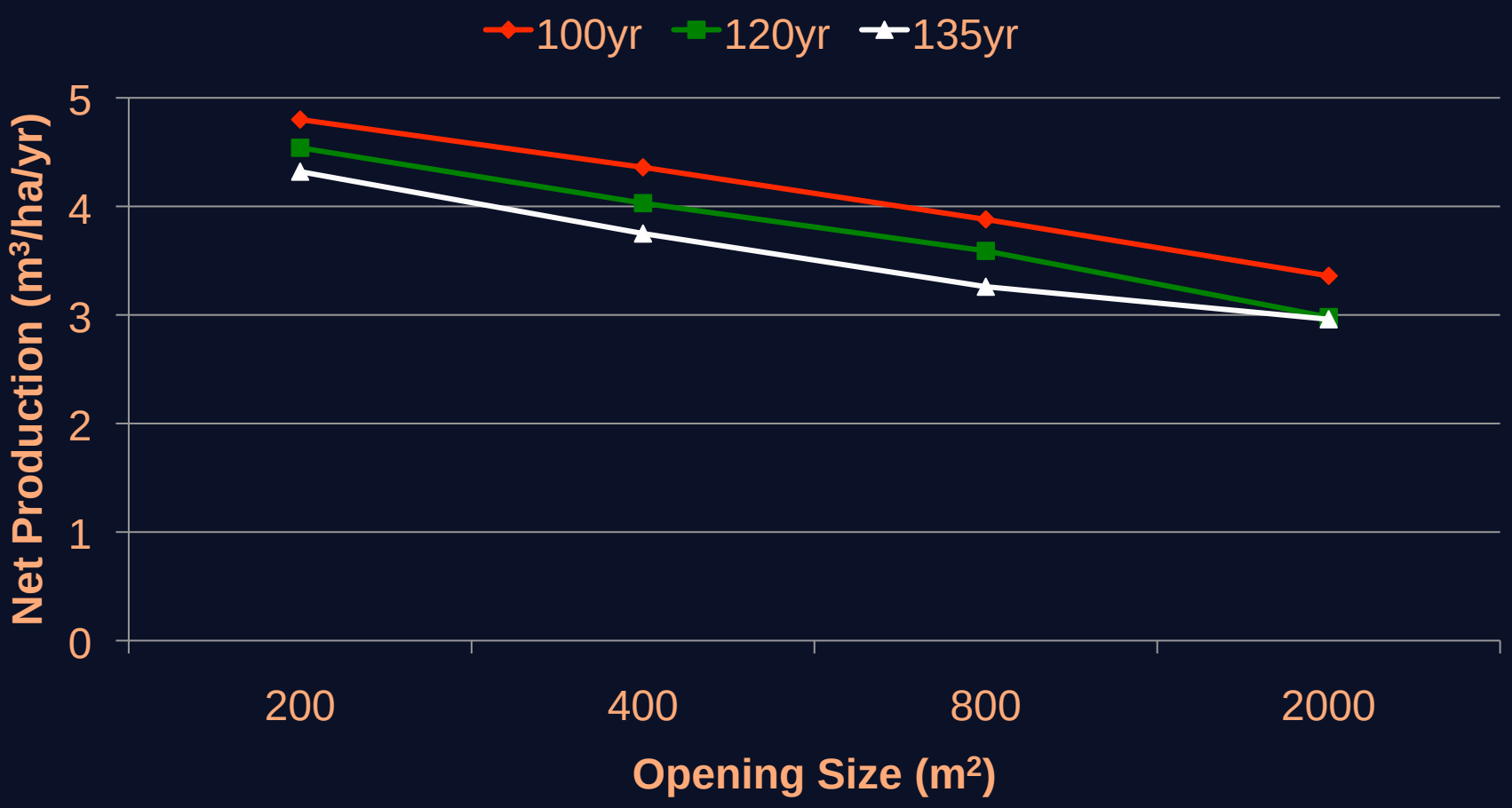
Stand-level Production



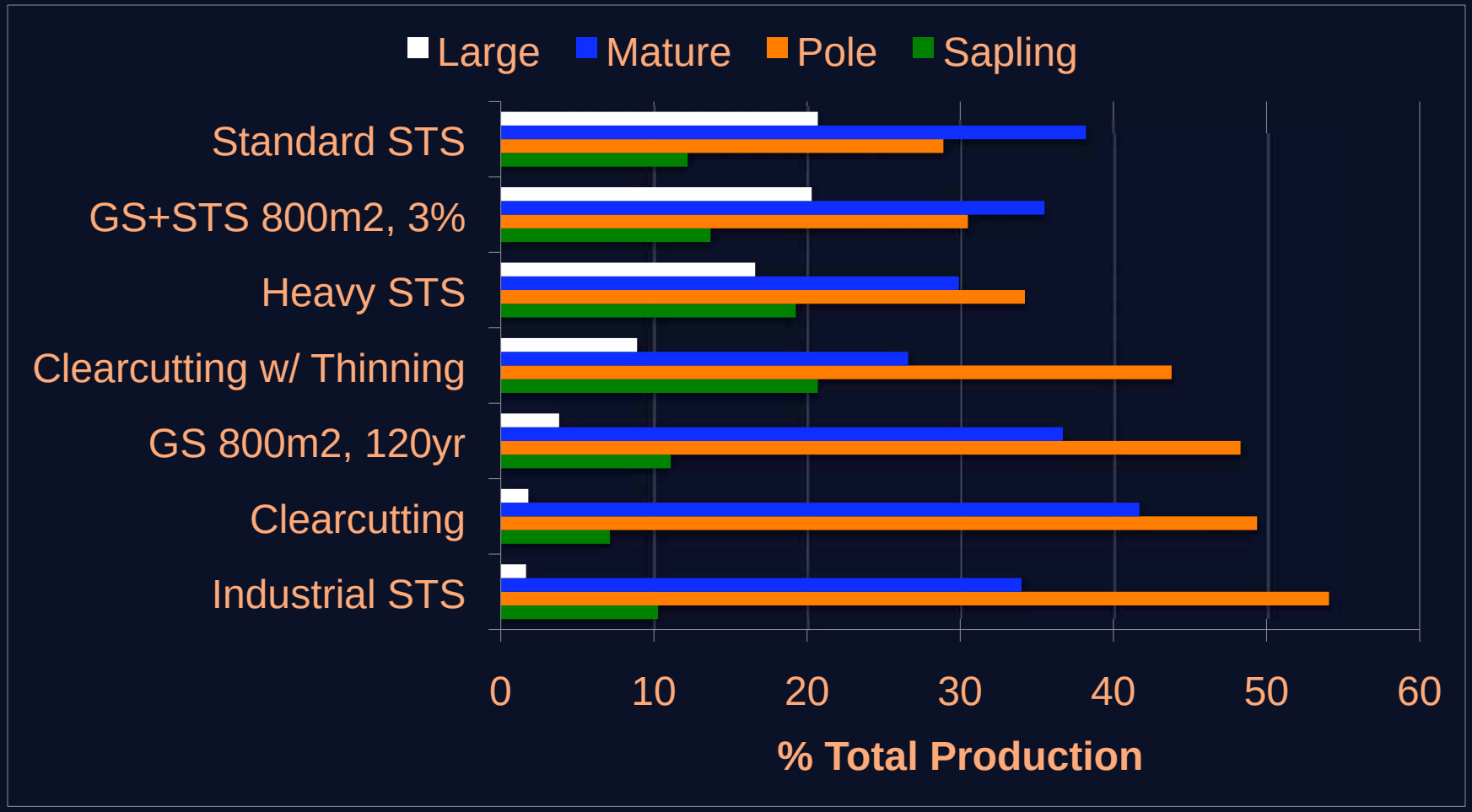
Group Selection with Single-tree Cutting between groups



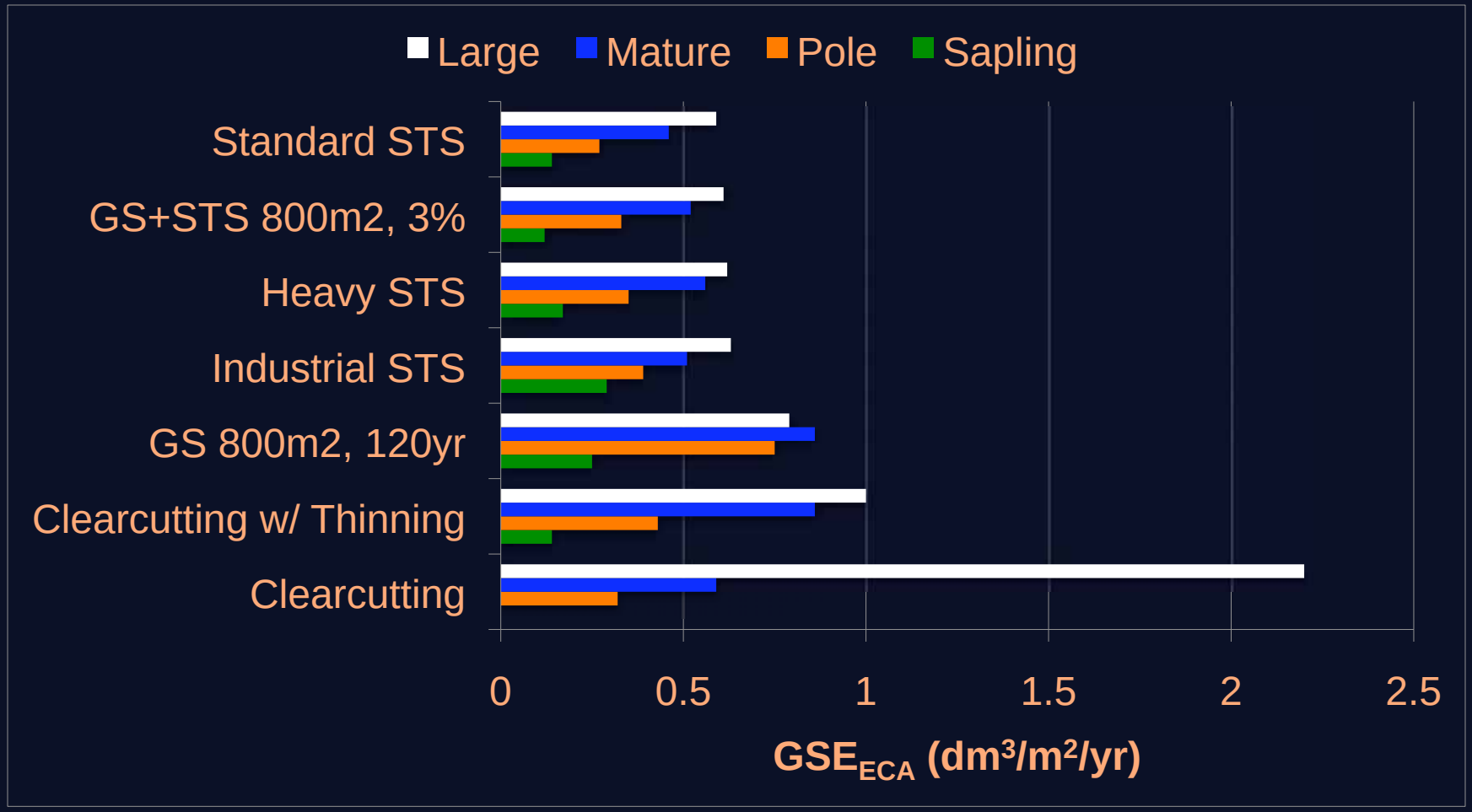
Group Selection Alone



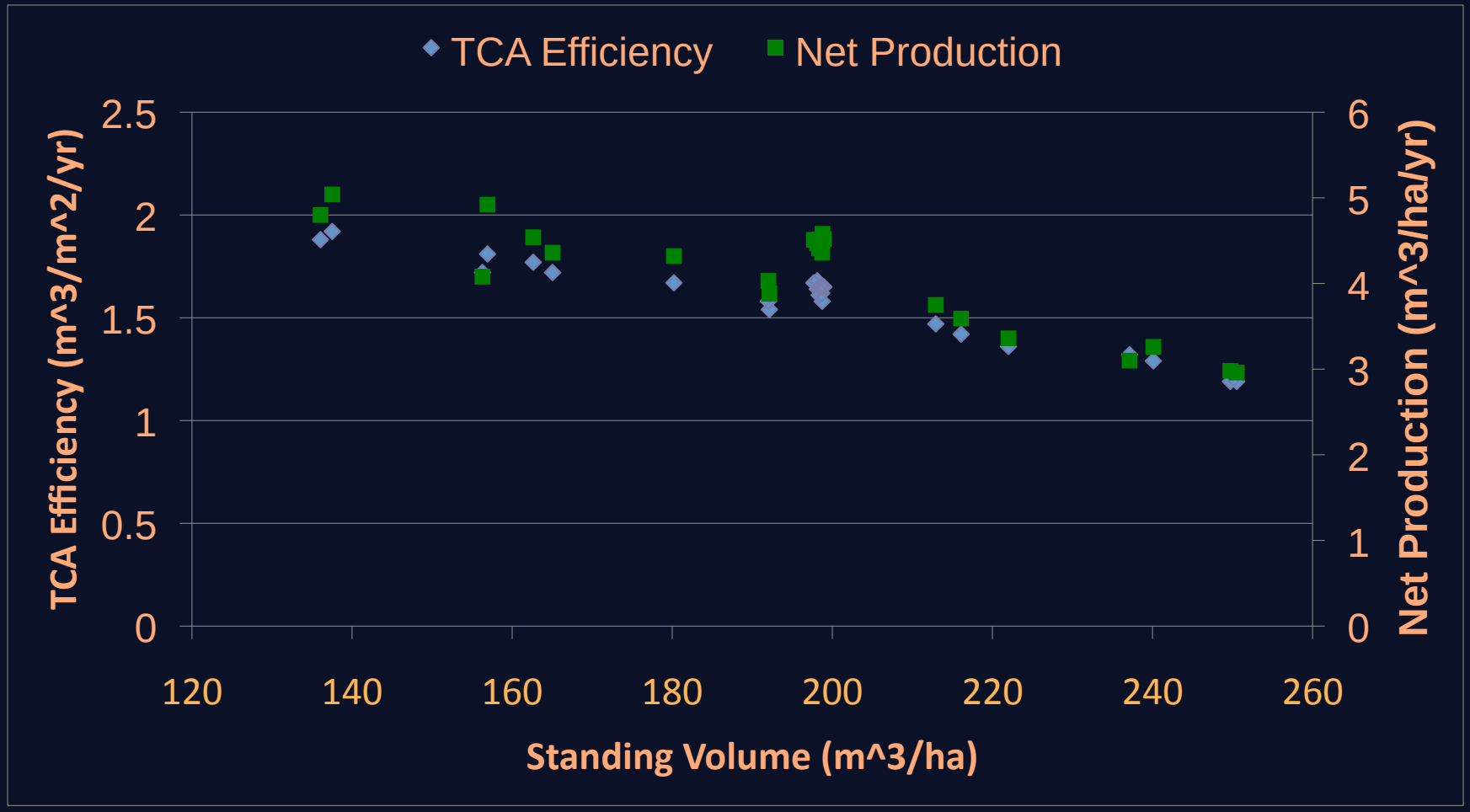
Relative volume produced by trees in each size class



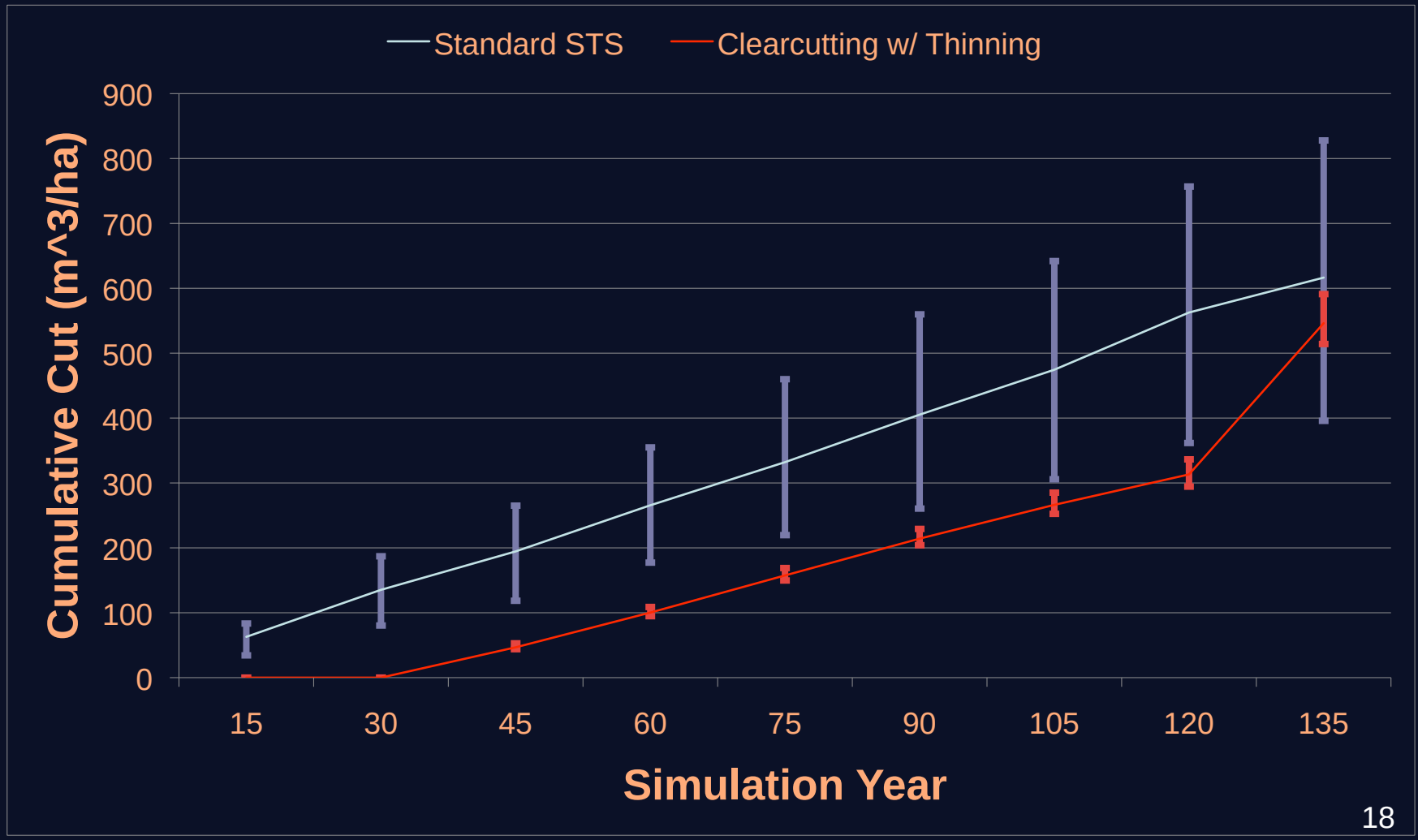
Lifetime Average GSE_{ECA}



Production and Stand-level GSE_{TCA}



Relative Production of Clearcutting and Standard STS



Evaluation of Hypotheses

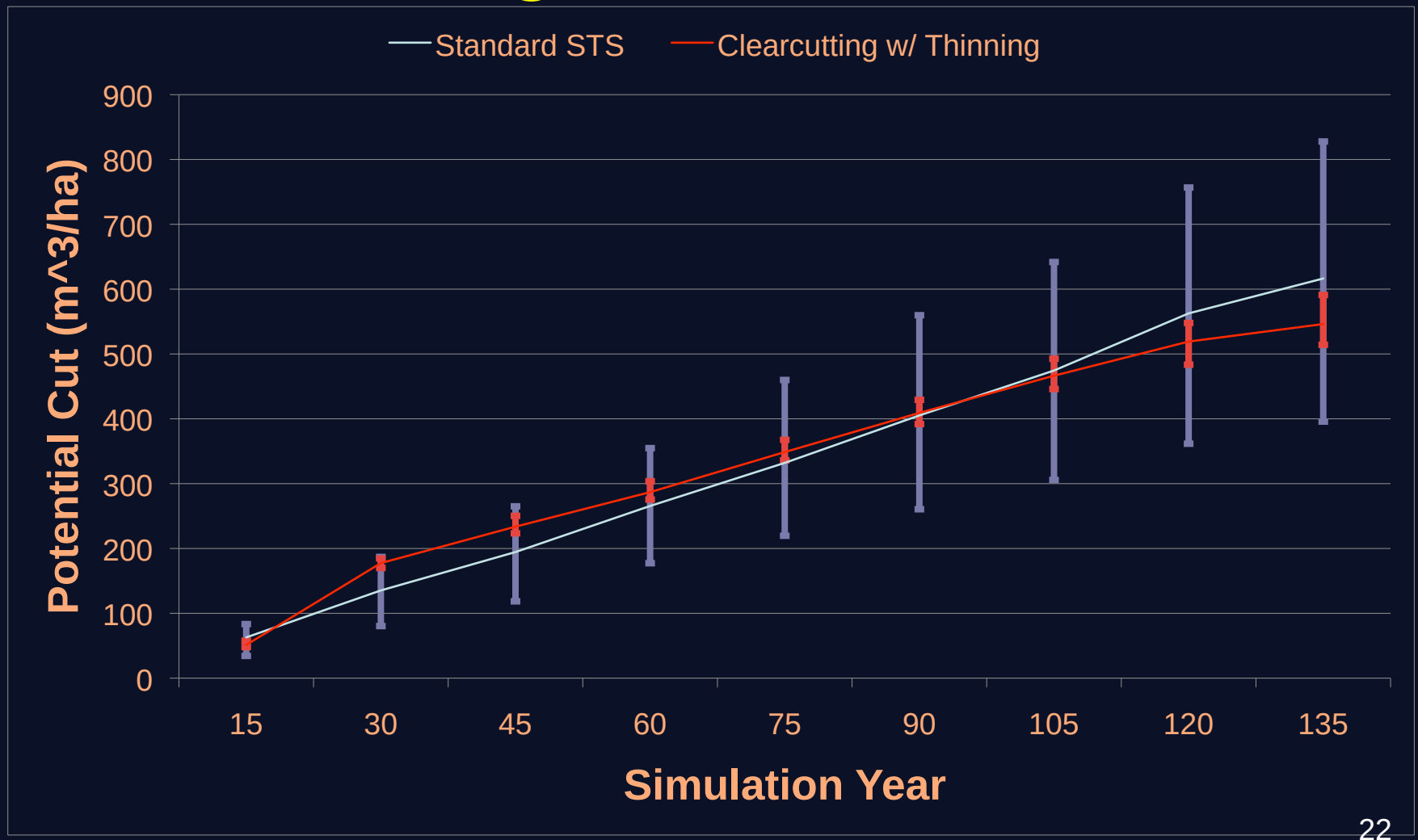
- H1: Group sized/extent does not affect net production
  - Supported by data
- H2: Under group selection alone, net production will decline as rotation age increases
  - Supported by data
- H3: Increases in sapling/pole GSE will not increase stand-level production markedly because the sapling/pole component produces only a small fraction of the total
  - NOT supported by data

Concluding Remarks

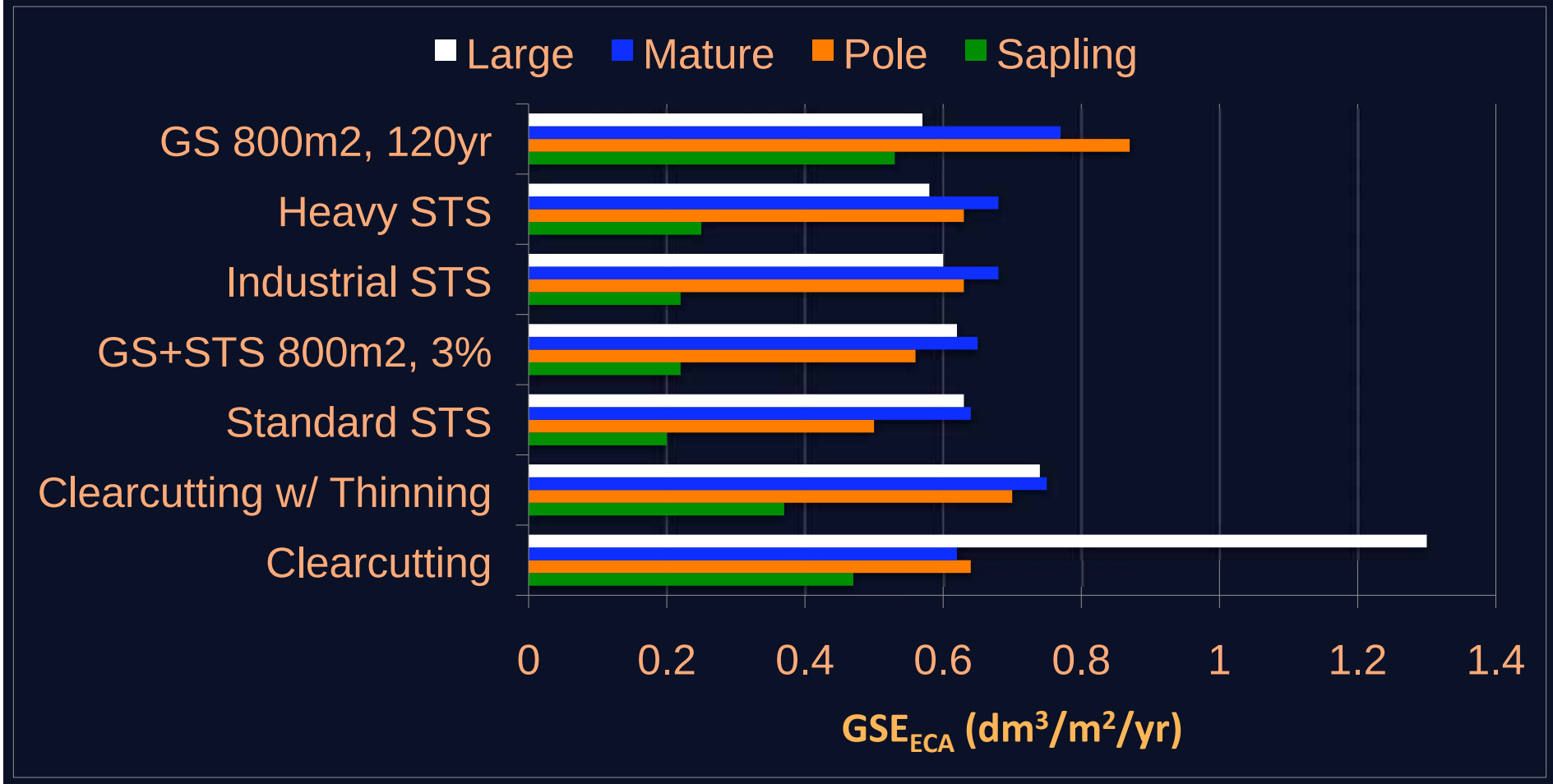
- Paradox of efficiency vs yield
  - Clearcutting without thinning is less productive than STS because of unsalvaged mortality
  - Clearcutting with thinning is very similar in production to STS despite clear GSE advantages
    - GSE advantage is mitigated by lower site occupancy

Questions ?

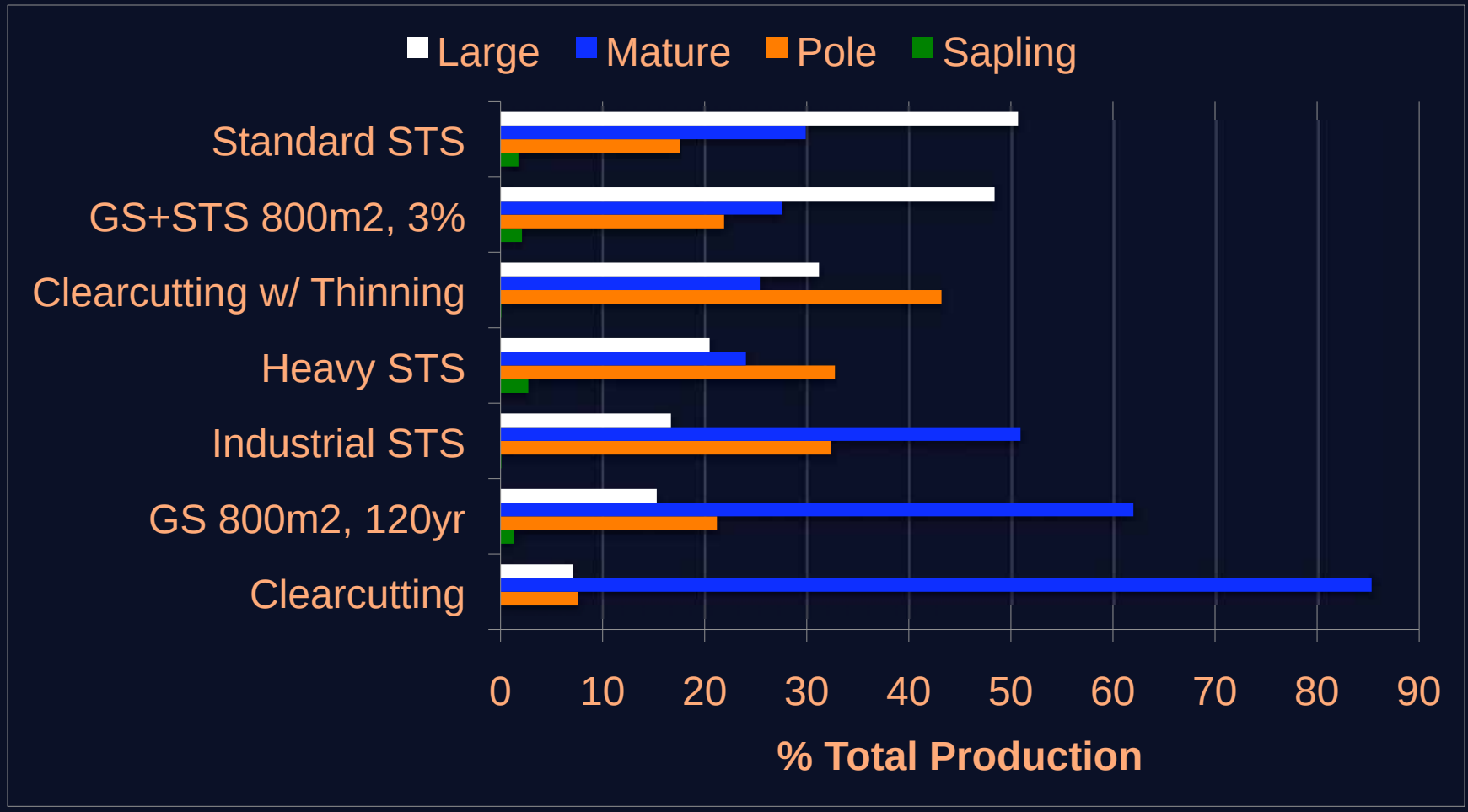
Potential Production of Clearcutting and Standard STS



GSE_{ECA} within a size class



Relative volume harvested from each size class



Diameter growth equations

Canopy and non-gap trees

For each habitat type:

$$\ln(\Delta \text{Diameter}) = A + B*\ln(\text{Diameter}) - C*(\text{Diameter}) - D*\text{Stocking}$$

1. Calibrate equation using 2/3 of data (Sugar maple example)

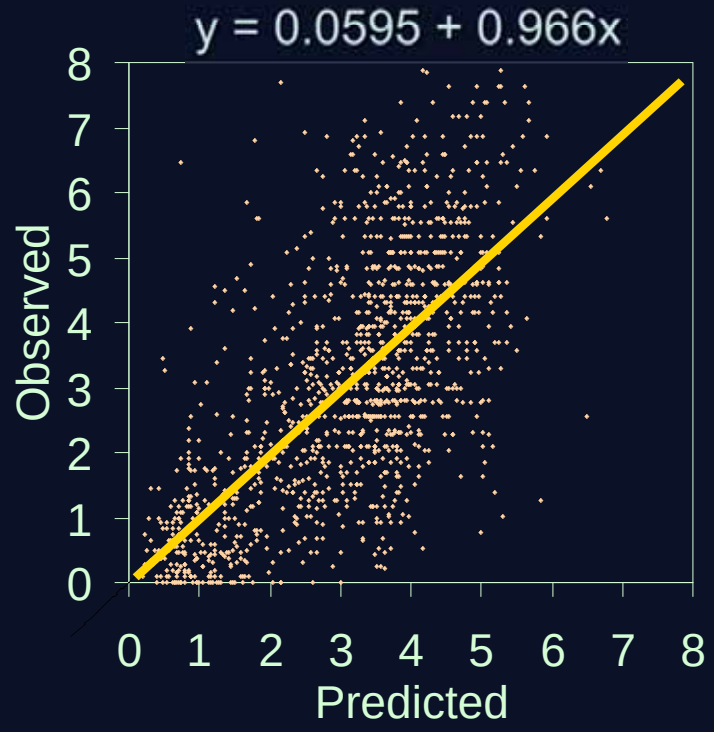
$$\ln(\Delta D) = -0.245 + 0.904*\ln(D) - 0.028*(D) - 0.008*\text{Stocking} \quad R^2 = 0.403$$

2. Evaluate equation using reserved 1/3 data

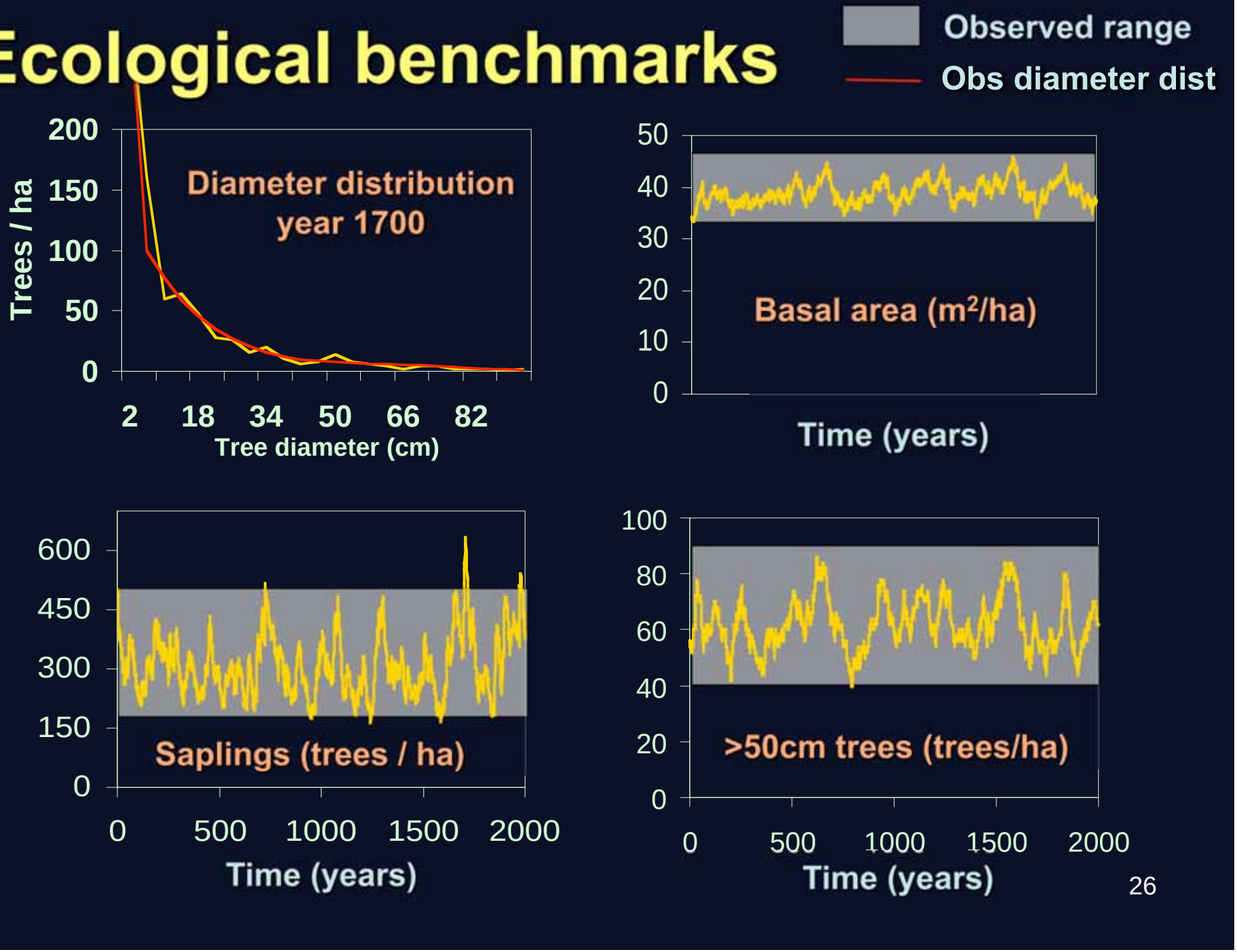
Compare predicted to observed growth using the "Simultaneous F-test":

Do predicted = observed?

Not significantly different
p = 0.305

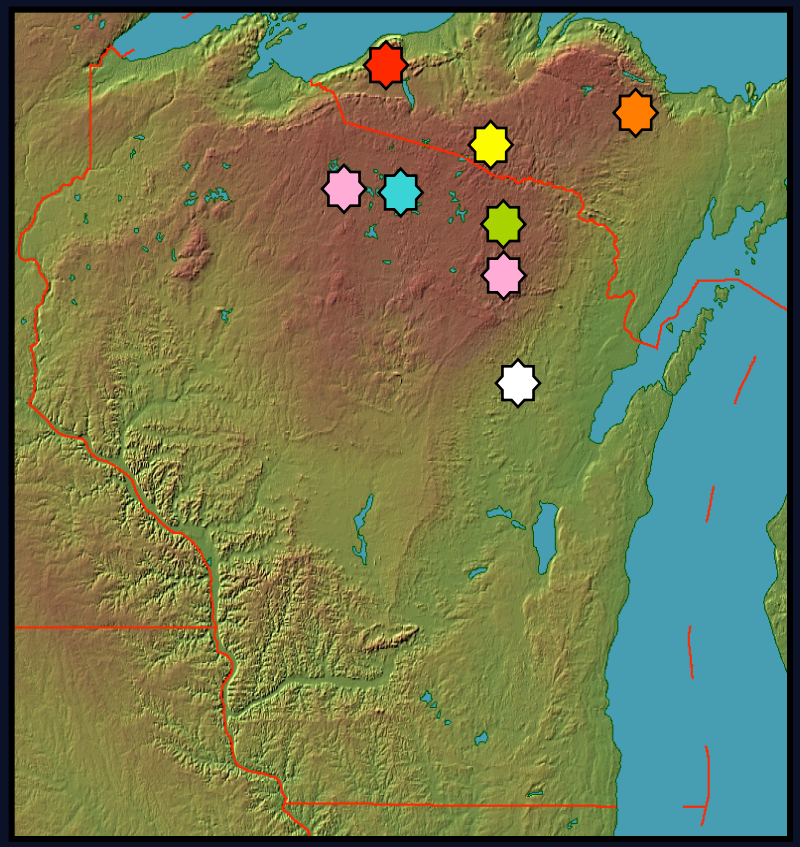


Ecological benchmarks



Building a database

Variety of stand conditions



Over 13,000 trees

- **Porcupine Mountains: 1981-2004**
  Unmanaged late successional / old growth
- **Dukes Experimental Forest: 1952-2002**
  Selection harvests in old forest
- **Sylvania Wilderness**
  Unmanaged late successional / old growth
- **NHAL: 1983-1996**
  Single-tree selection
- **Argonne Exp. Forest: 1951-2001**
  Selection harvests in young forest
- **Chequamegon/Nicolet National Forest**
  Selection harvests
- **Menominee Reservation: 1979-1999**
  Selection harvest with big trees