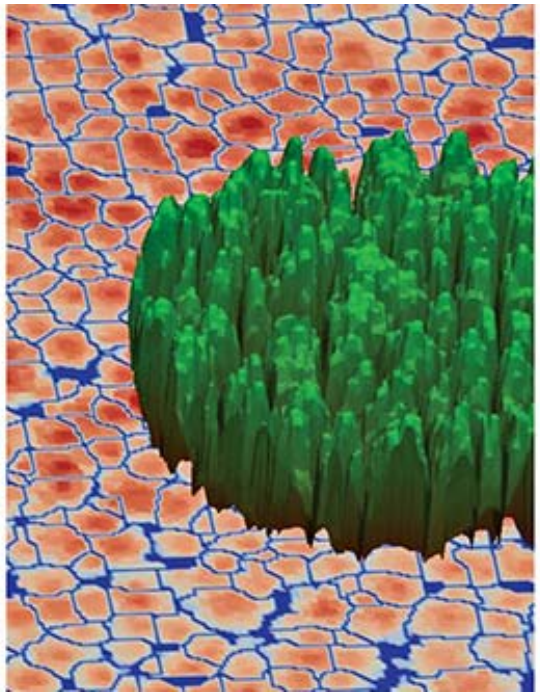
Growing confidence in forestry's future Research Programme

SCION
FORESTS ▪ PRODUCTS ▪ INNOVATION

Regional differences in maximum carrying capacity of sites – the need for site-specific silviculture

Yue Lin & John Moore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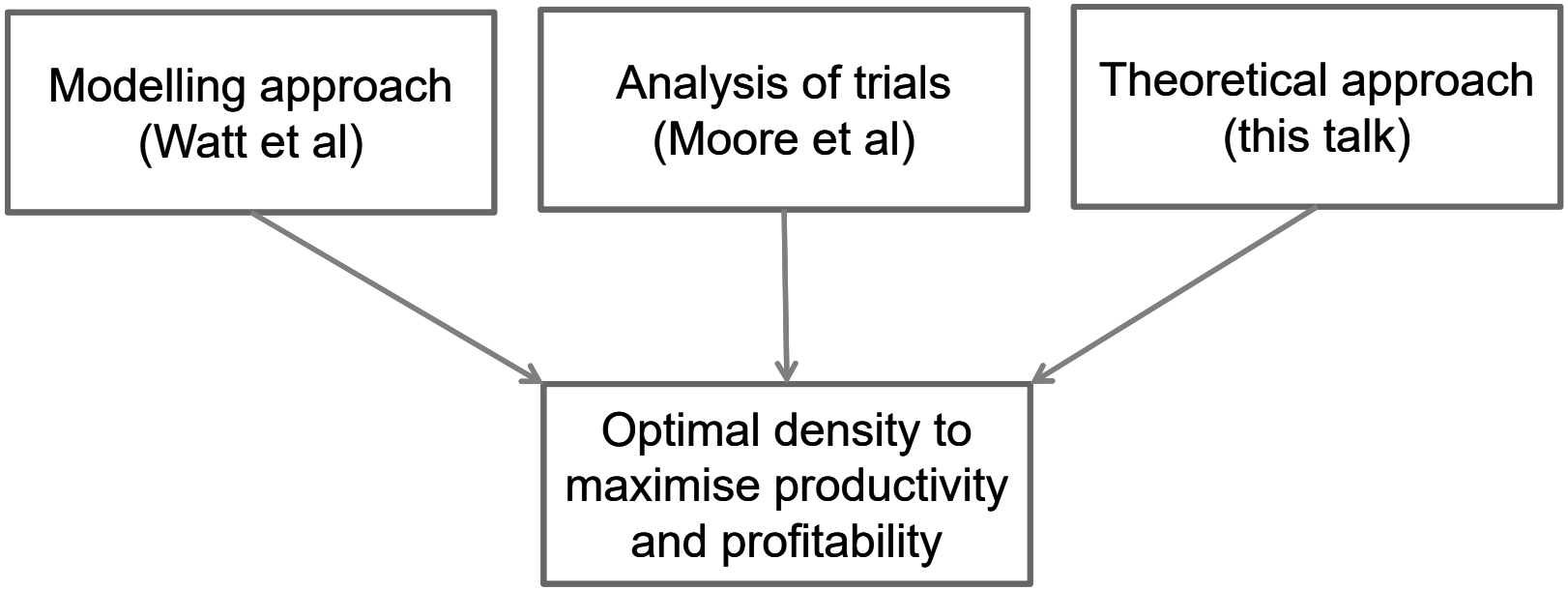
Stocking control is a key driver of productivity

- Evaluating the maximum tree density and biomass is crucial for maximizing forest yield and timber production



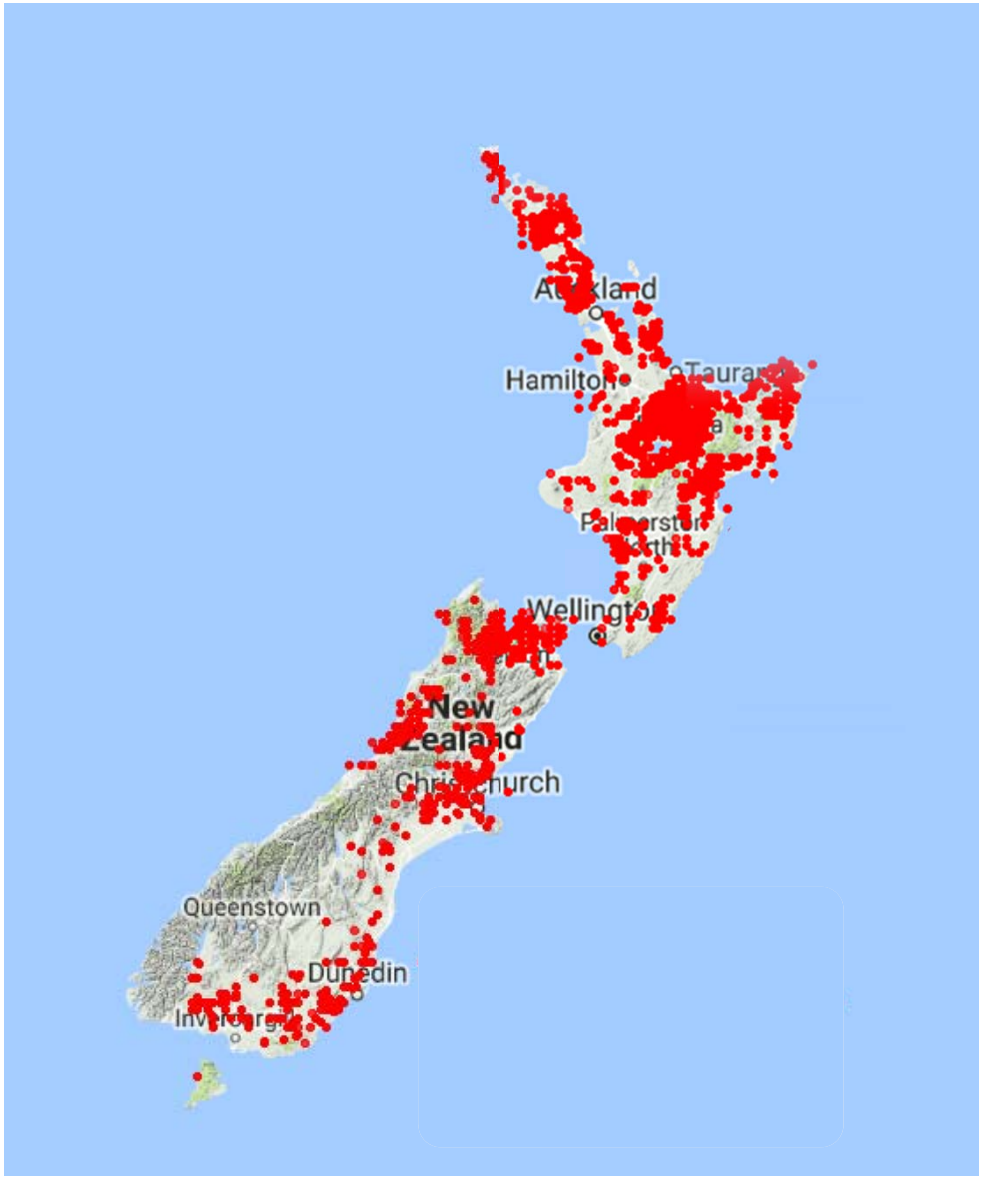
Outline of approach (and this presentation)

- Based on comprehensive forest growth data from across New Zealand (PSP database)
- Explore regional differences in tree growth and forest productivity of sites across New Zealand
- Examine environmental factors that control tree growth and alter size-density relationships
- Test observed size-density relationships against theoretical predictions
- Use results to develop site-specific silvicultural regimes
- This is a work in progress – so we are presenting the concepts and preliminary results

Scion's PSP (Permanent Sample Plot) database

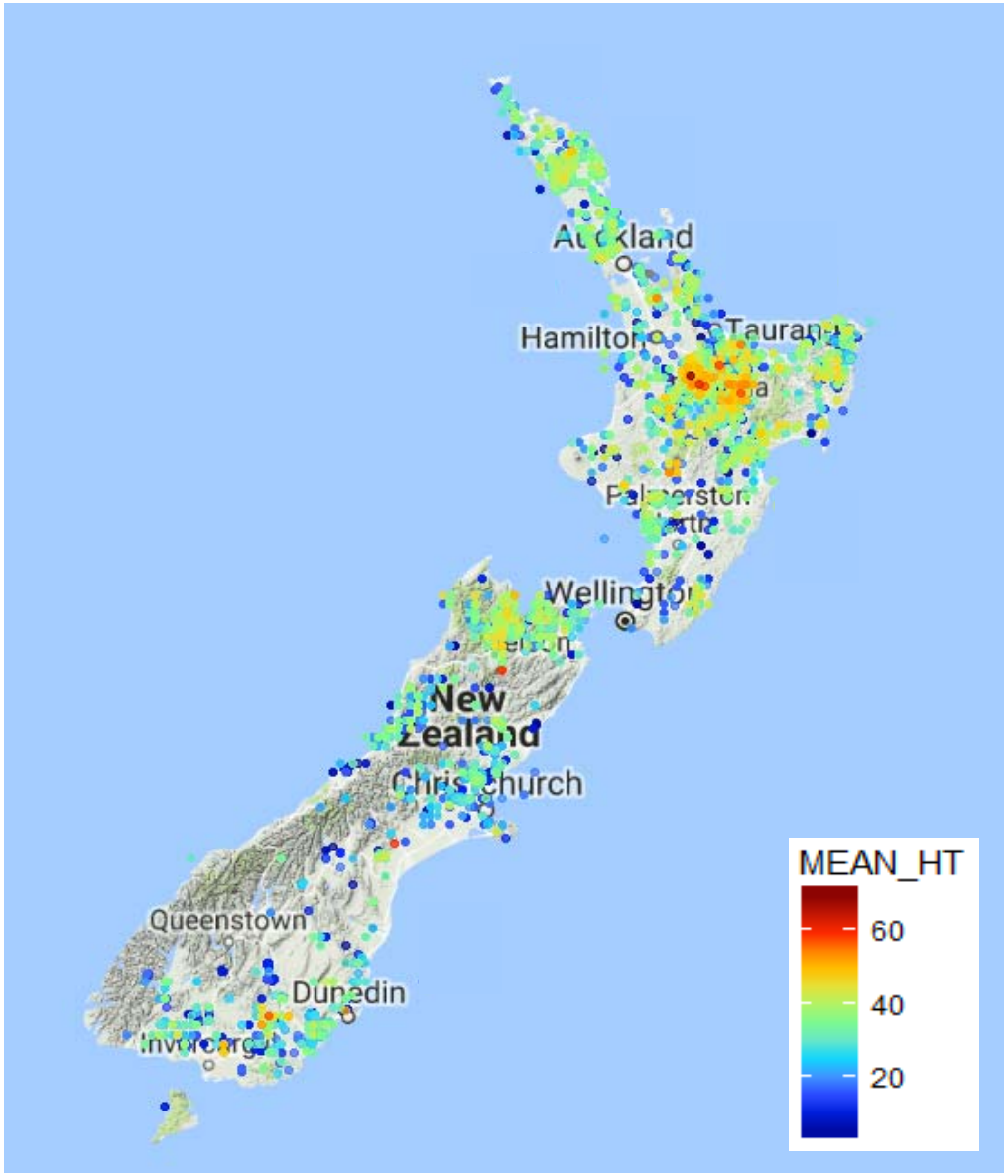
PSP system

- One of the most massive databases on tree growth in the world
- > 100 years of record
- > 32,000 records
  （11,500 current
  20,500 historic)
- 145 species
  （P.RAD ～ 77% records）



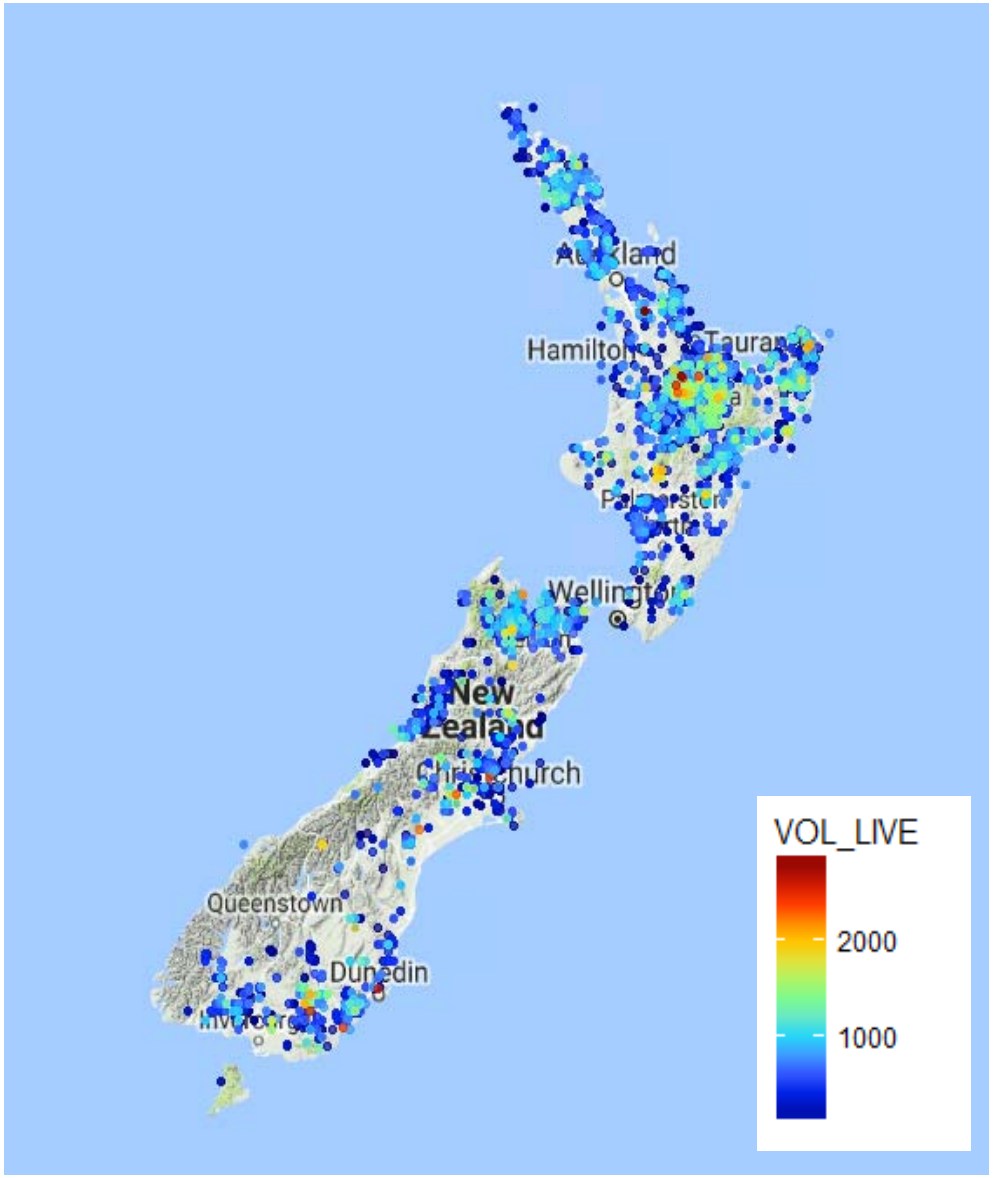
Exploring the variation in data within the PSP system

- Mean Height of Radiata Pine （Not Site Index）
- North Island 20.3±10（m）
- South Island 17.7±10（m）



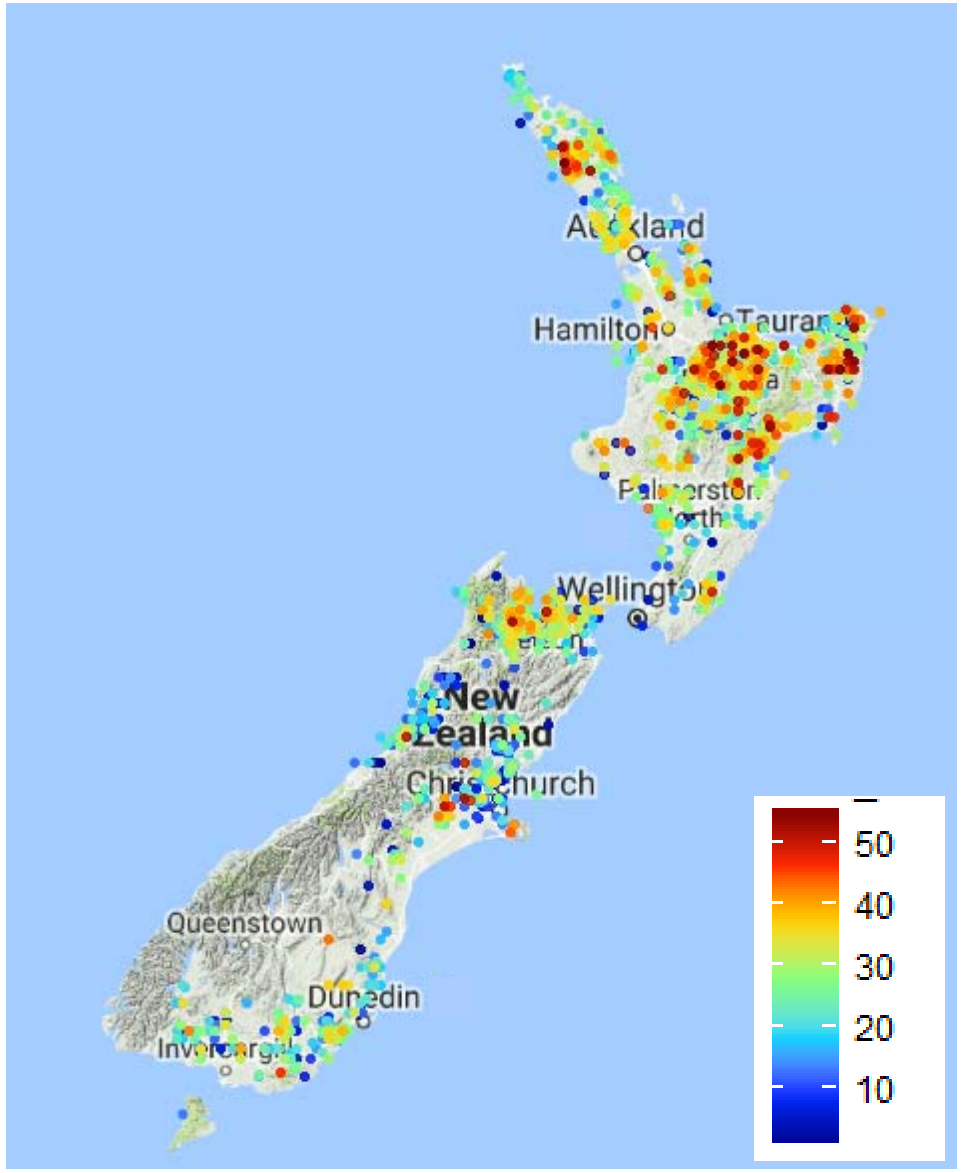
Exploring the variation in data within the PSP system

- Maximum Volume of Radiata Pine
- North Island
  424±318（m^3/ha）
- South Island
  336±322（m^3/ha）



Exploring the variation in data within the PSP system

- Maximum Volume Mean Annual Increment (MAI) of Radiata Pine
- North Island
  14.5 ± 9.4 ($m^3\,ha^{-1}y^{-1}$)
- South Island
  11.2 ± 9.5 ($m^3\,ha^{-1}y^{-1}$)



Size-Density Relationships

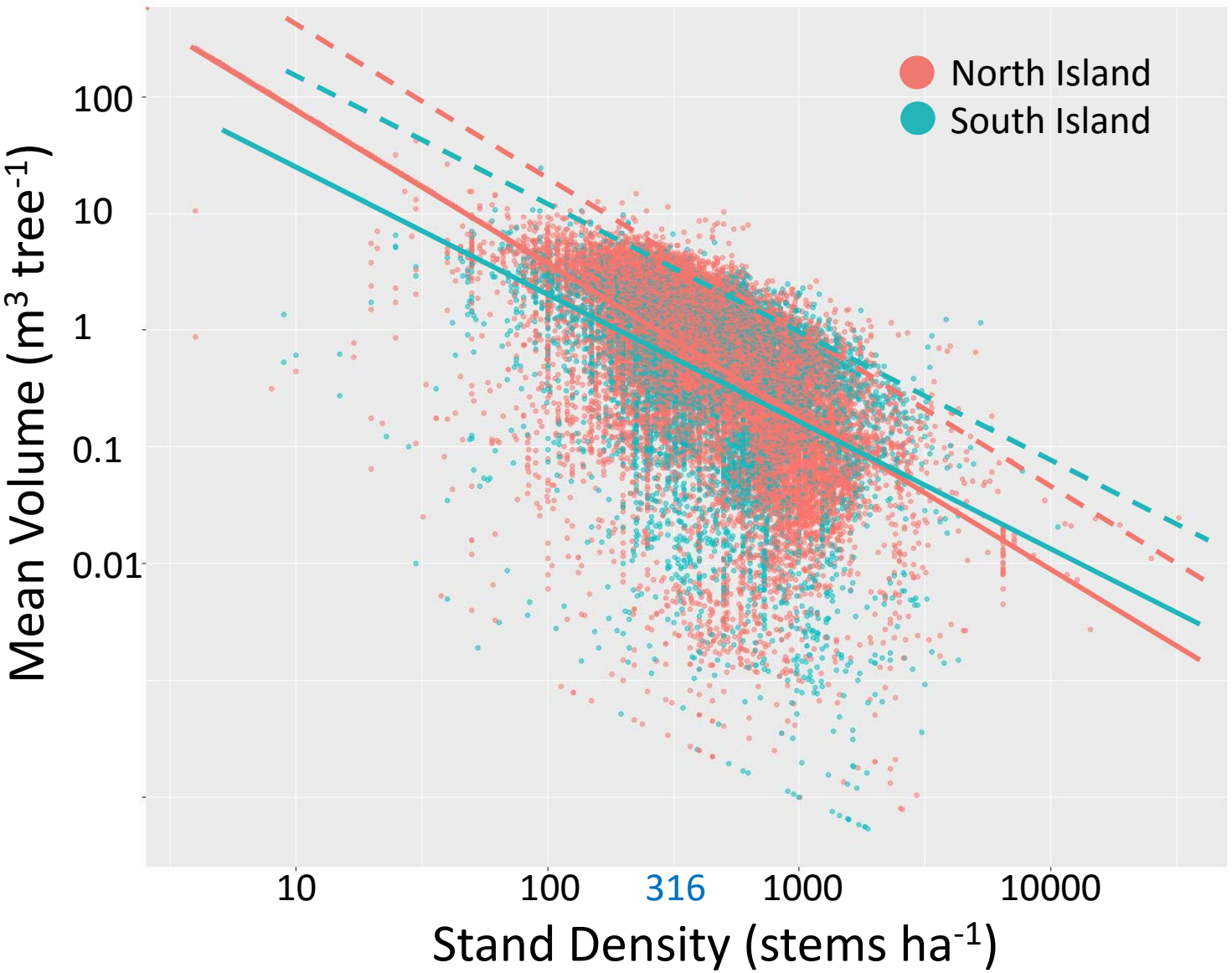
- Maximum Carrying Capacity – maximum population density and biomass that a certain area can support

- The general relationship between timber volume (Vol) and density (N) of standing trees can be described by a power function

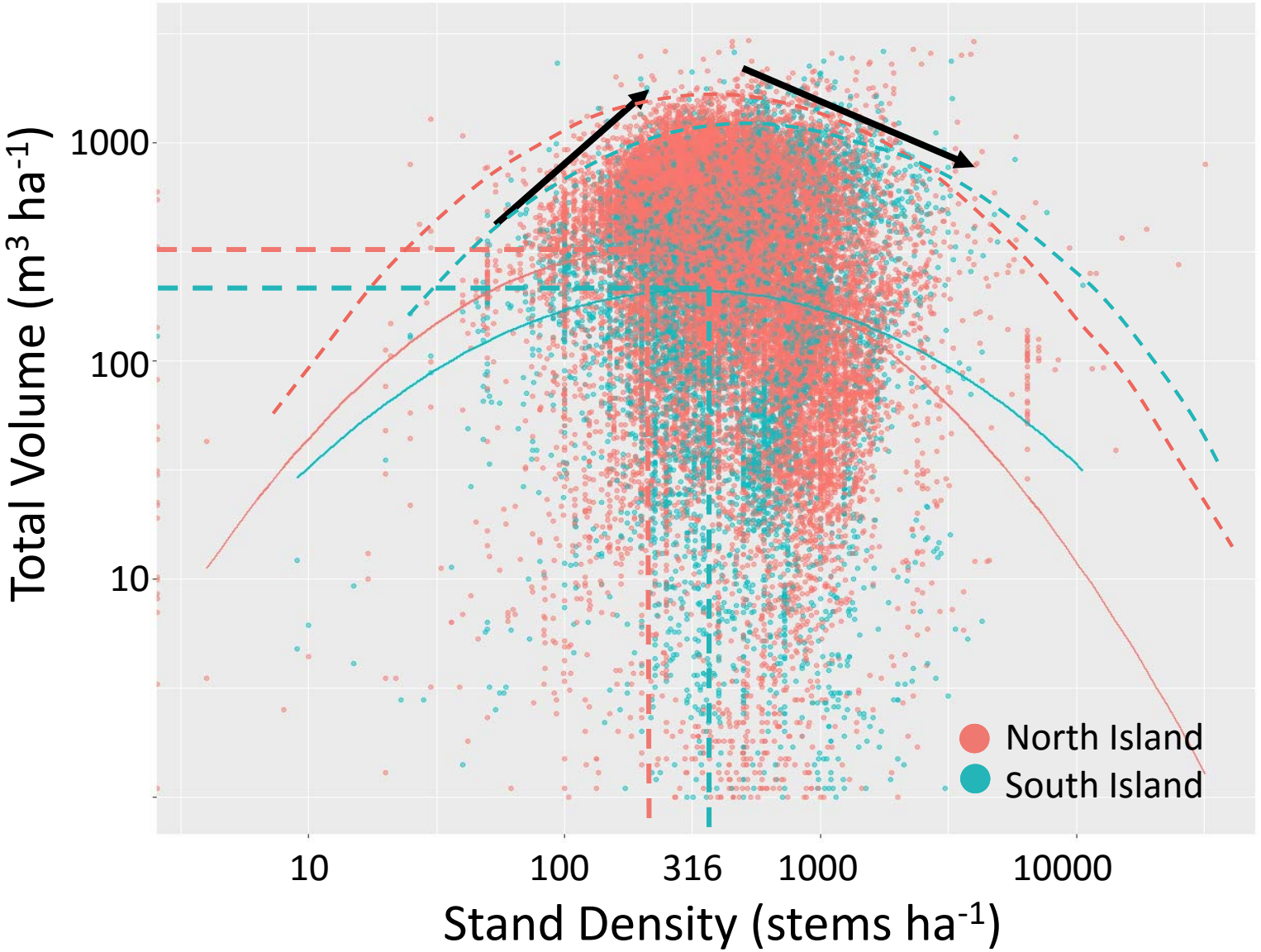
$$Vol_{mean}=KN^{-b} \quad \text{or} \quad Vol_{total}=KN^{-b}N^{-1}$$

- The Volume-Density relationship can be altered by abiotic limit factors (e.g., radiation, temperature, soil, precipitation) and biotic factors (e.g., mortality and growth decline induced by density-dependent competition among trees) that can result in various outcomes in different regions

Size-Density Relationships

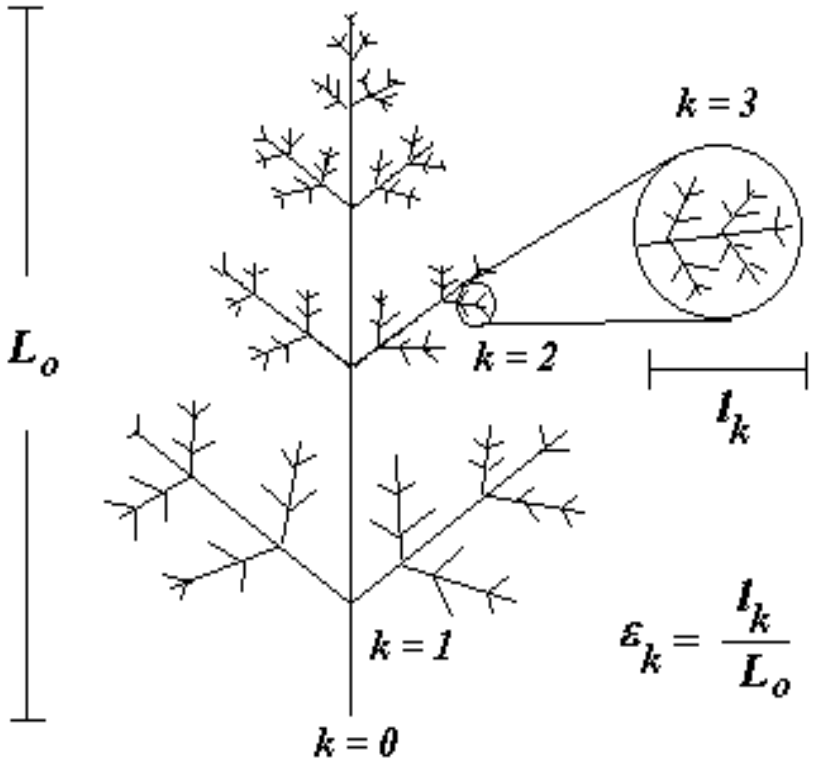


Size-Density Relationships



How to maximize carrying capacity ?

- Maximum Carrying Capacity is an ecological concept
- Ecological Insight – Metabolic Theory of Ecology
  - Fractal structures & Energy transportation
  - Linking physiological processes of individual organisms with macroecology



Lucas Máximo Alves (2012)

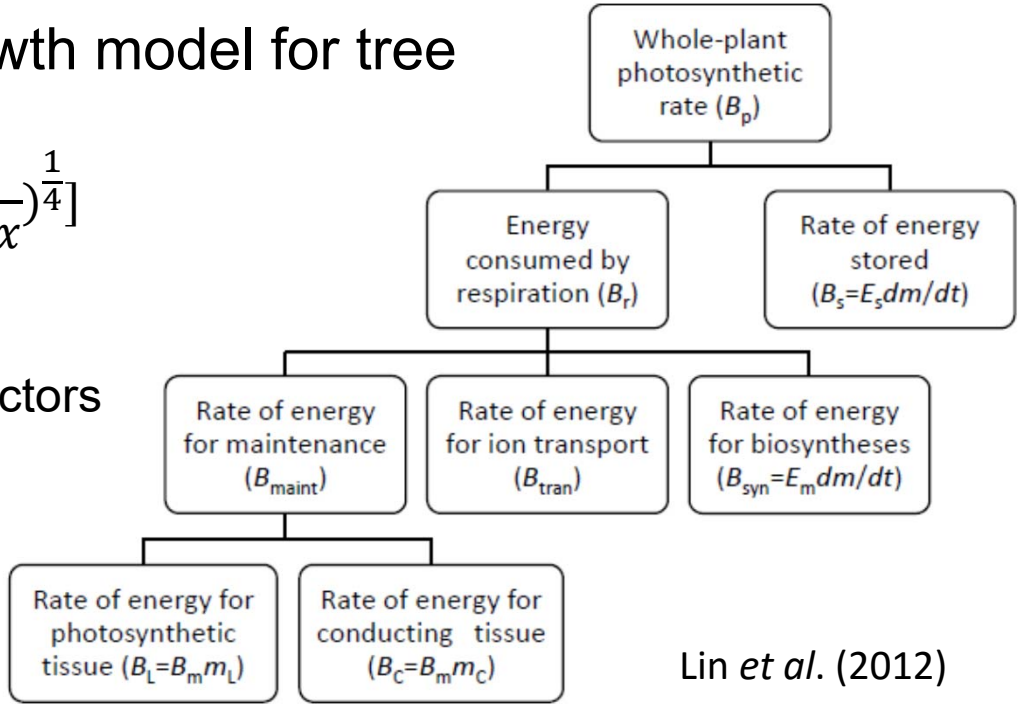
How to maximize carrying capacity？

- Maximum Carrying Capacity is an ecological concept
- Ecological Insight – Metabolic Theory of Ecology
- Effects of environmental factors on tree growth
- A general ontogenetic growth model for tree

$$\frac{dV}{dt} = f(E)aV^{\frac{3}{4}}[1 - (\frac{V}{Vmax})^{\frac{1}{4}}]$$

$V \sim$ Volume of tree

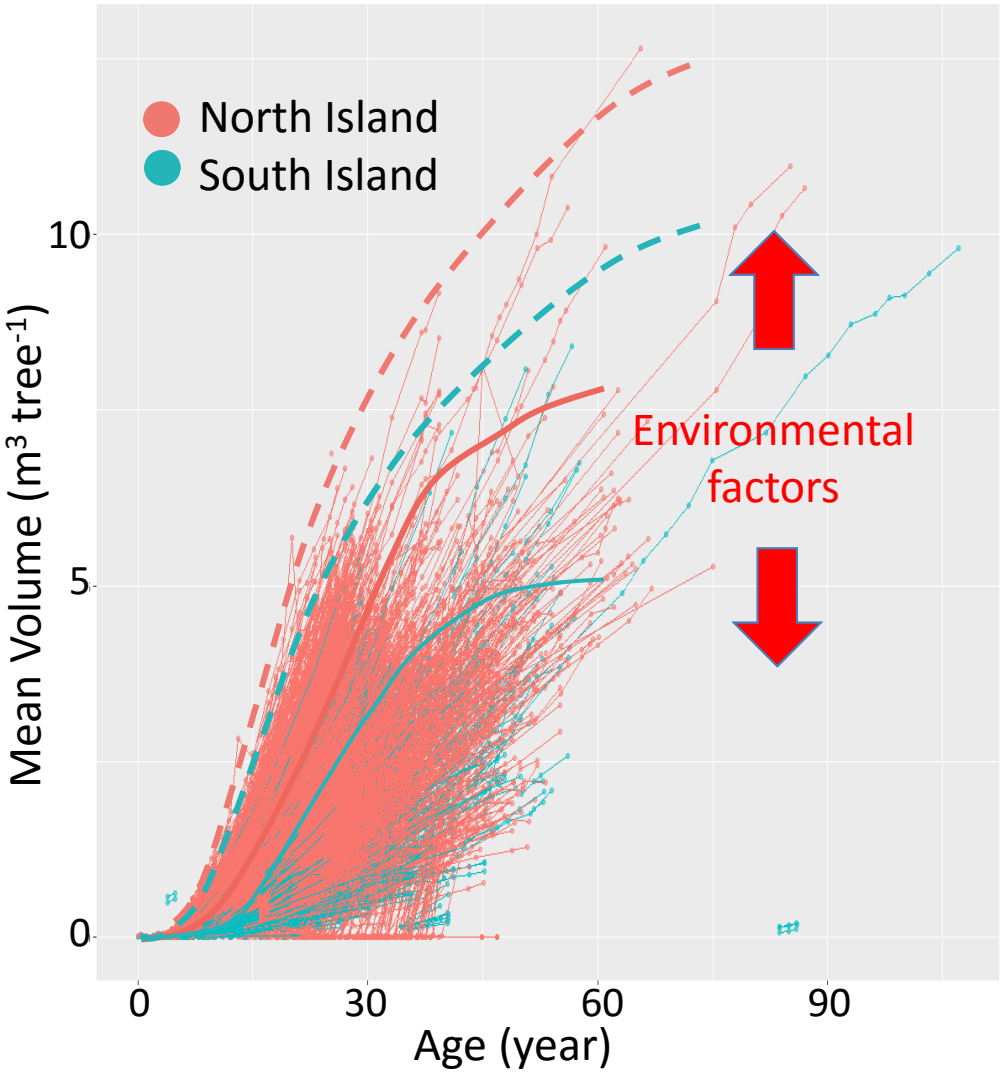
$f(E) \sim$ Environmental factors



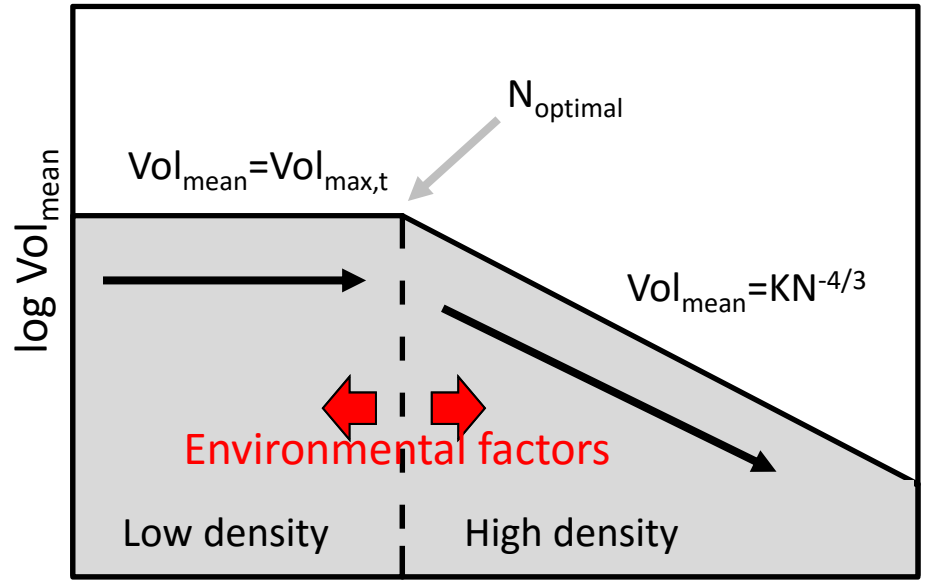
Lin *et al*. (2012)

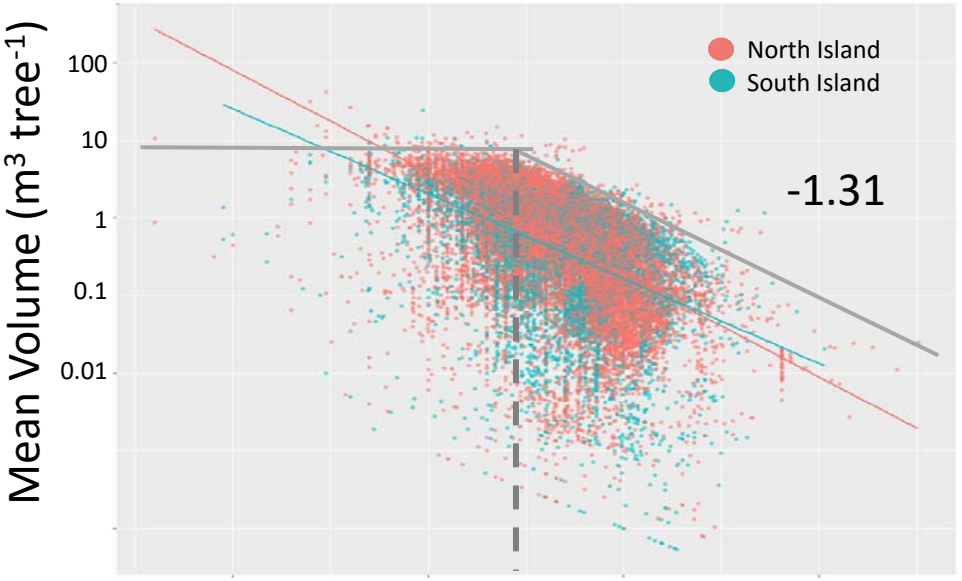
How to maximize carrying capacity？

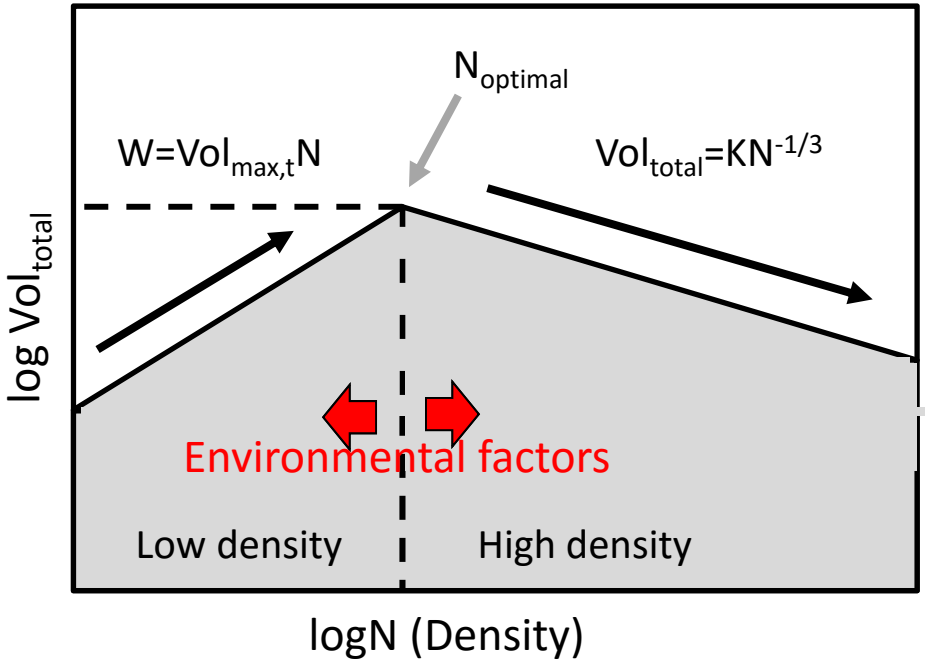
- Sigmoidal growth of tree (Radiata Pine)
- Effects of environmental factors on tree growth
- $N_{optimal} = f(E) \cdot Vol_{mean,t}^{-3/4}$

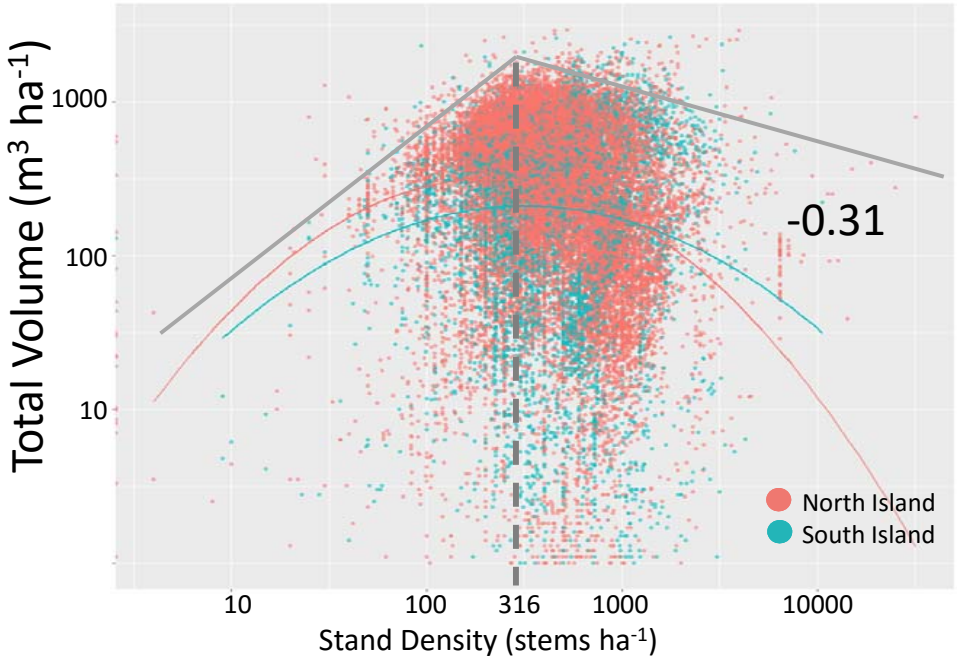


Theoretical Predictions









How to maximize carrying capacity?

- A general framework to predict optimal density and maximum carrying capacity of forest stands on the basis of growth of individual trees.

$$N_{optimal} = f(E) \cdot Vol_{mean,t}^{-3/4}$$

Machine Learning Approaches

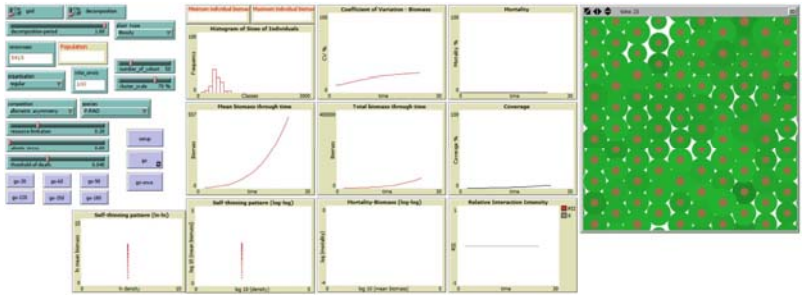
Evaluating environmental effects

Estimating parameters

Fitting and Predicting tree growth model

Individual-Based Model

Exploring different scenarios



Site-Specific Silvicultural Approaches

Tree species or breeds

Site conditions

Climatic factors

Pruning & Thinning

Yield & Density

Summary & Outlook

- We have a comprehensive database of tree growth information that we can use to test these concepts
  - Regional differences are large across NZ

- We have developed a general framework to predict optimal density and maximum carrying capacity
  - NOT “one number” for all sites across NZ

- Further development will include:
  - Individual tree ontogenetic growth model – flexible
  - Evaluating relative effects of abiotic & biotic factors on tree growth
  - Data mining & Machine learning approaches
  - Spatially-explicit Individual-based forest model
  - Regional- and site-specific silviculture methods

Growing confidence in forestry's future Research Programme

SCION FORESTS PRODUCTS INNOVATION

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supported by forestgrowers commodity levy

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