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Towards understanding the effect of tree size on harvester productivity using machine StanForD data, in a South African context

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Introduction

- Unique opportunity to study a Greenfields operation the Mpumalanga Highveld of South Africa
- A full system of CTL machines were purchased and Forestry at Stellenbosch University was given full access to these operations
- Study was done on *Pinus spp.* saw timber
- Two different capacity machines were studied
  - Ponsse Bear and
  - Ponsse Beaver
  - These machines were purchased for clear-felling and thinning operations respectively

Introduction

- All the machines recorded tree data in the StanForD standard
- Strong relationship between tree size and harvesting productivity
- Machine productivity is influenced by the operator and this is well researched but difficult to apply in large tree data set and this was part of another study
- Is there a proverbial ‘sweet spot’ when harvesting trees
  - Best suited for the capacity of the machine
  - Most productive and optimal in terms of cost
- Traditionally harvesting productivity assessments are done as a snapshot in time
  - Single machine on a limited time frame
  - Selection of trees
- This study was done on most of the trees for an extended time frame

Introduction

- Using harvester data could be the next evolution of machine productivity assessments
  - All data is collected, trends are visible and accurate (depending on the level of machine calibration)
  - Much cheaper than conventional time studies (traditional time studies contain greater detail)

Objectives

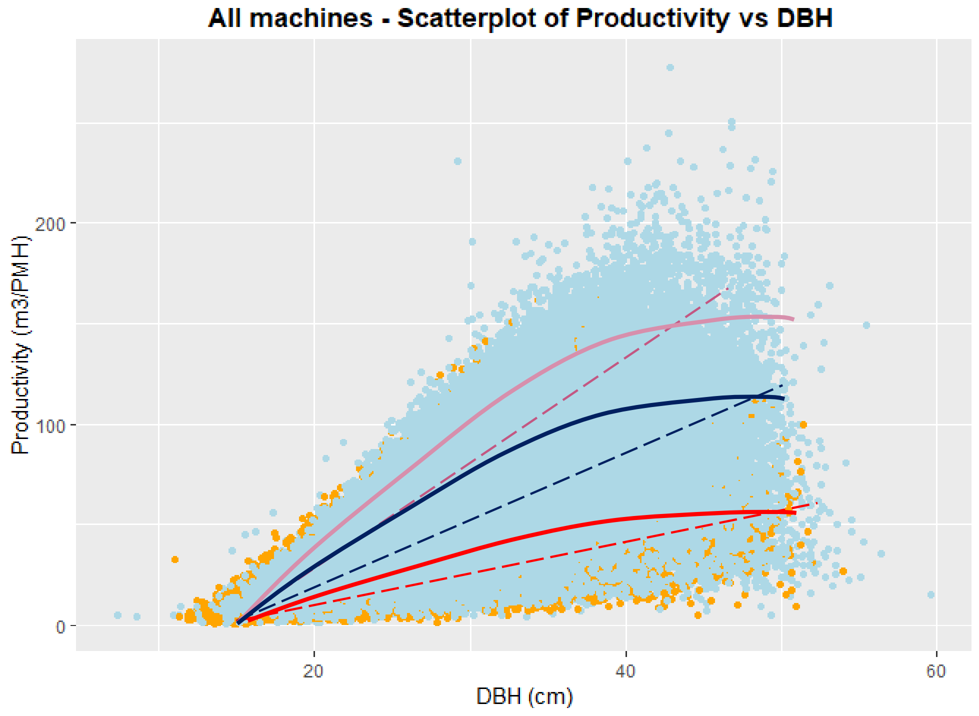
- Model harvester productivity on a big StanForD data set
- Understand the differences in productivity between machines
- Attempt to close the gap in the understanding of the cost, tree size and productivity relationship

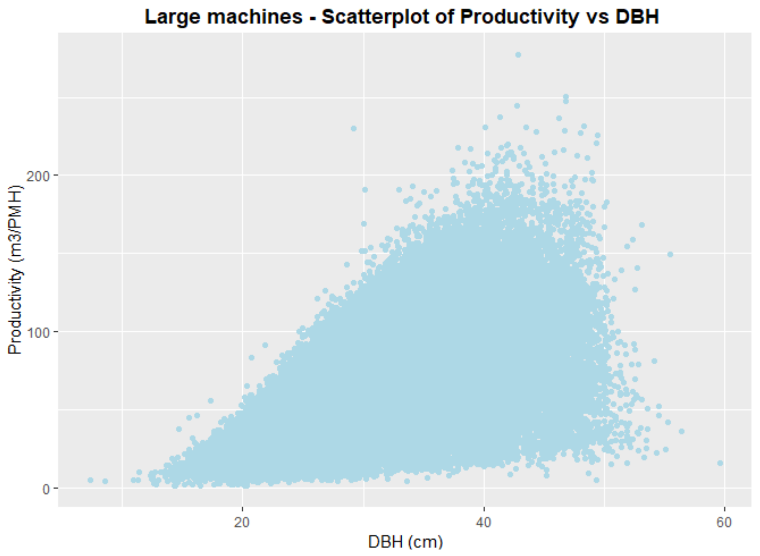
Methodology

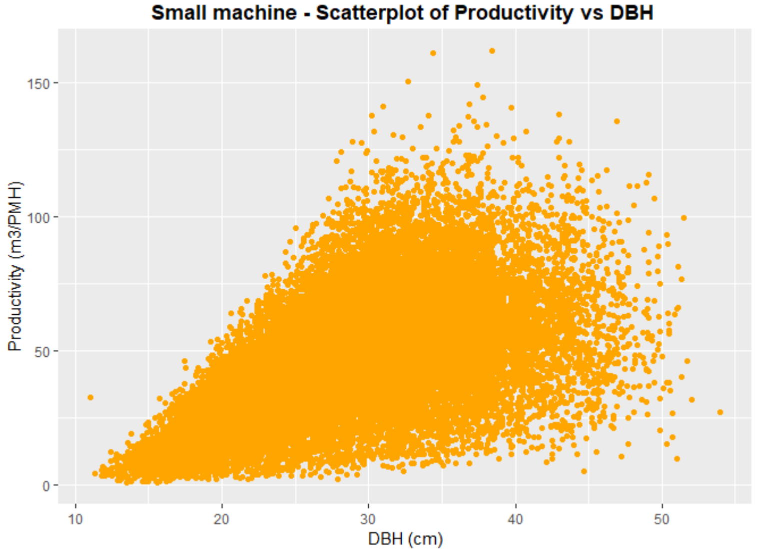
- One years data collected on 4 machines
- Only clear-felling and *Pinus patula* data assessed
- Data was cleaned – only to avoid striking errors
  - Time to harvest tree >300seconds
  - If the tree produced <1 log
  - Removing trees that were harvested at a point of delay;
  - If the stem length was < 250cm
- The data were interrogated, and a representative curve was fitted to these data
- A non-linear mixed effects in R were used
- An iterative approach was used to determine the best combination of fixed and random effects to use

Results and discussion

What does the data look like?

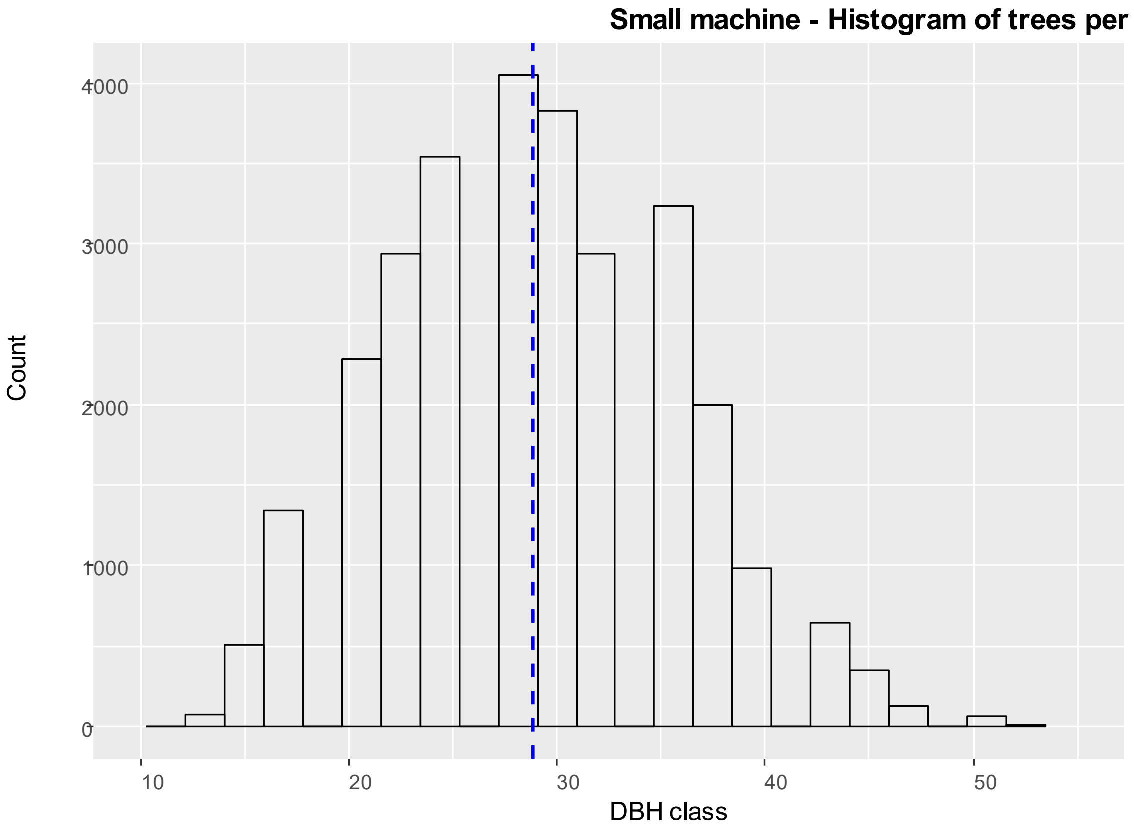


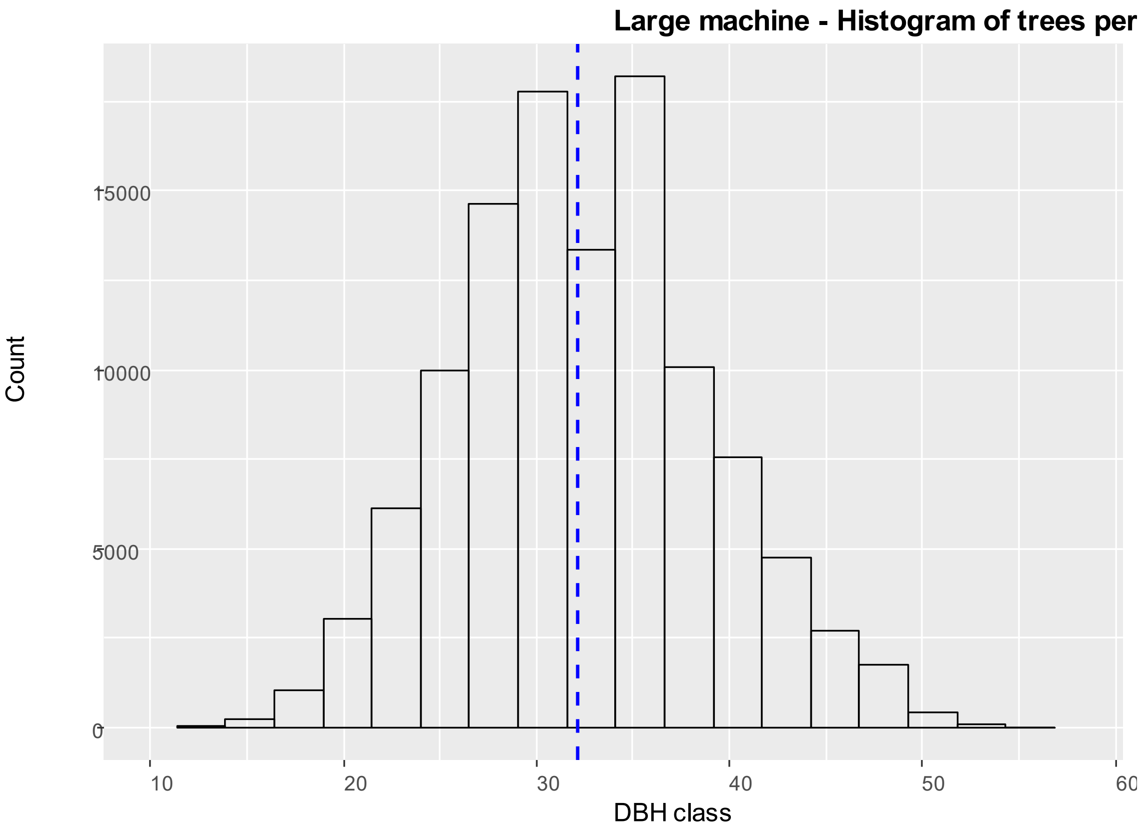




Results and discussion

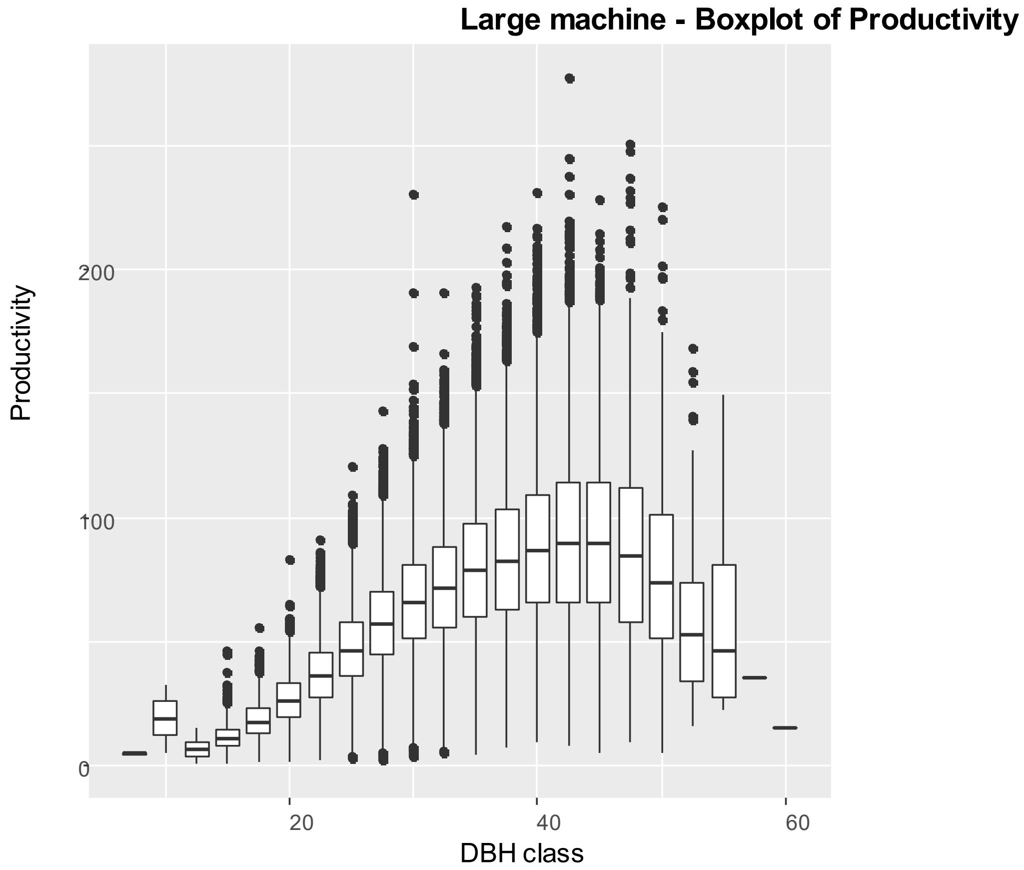
Tree distributions

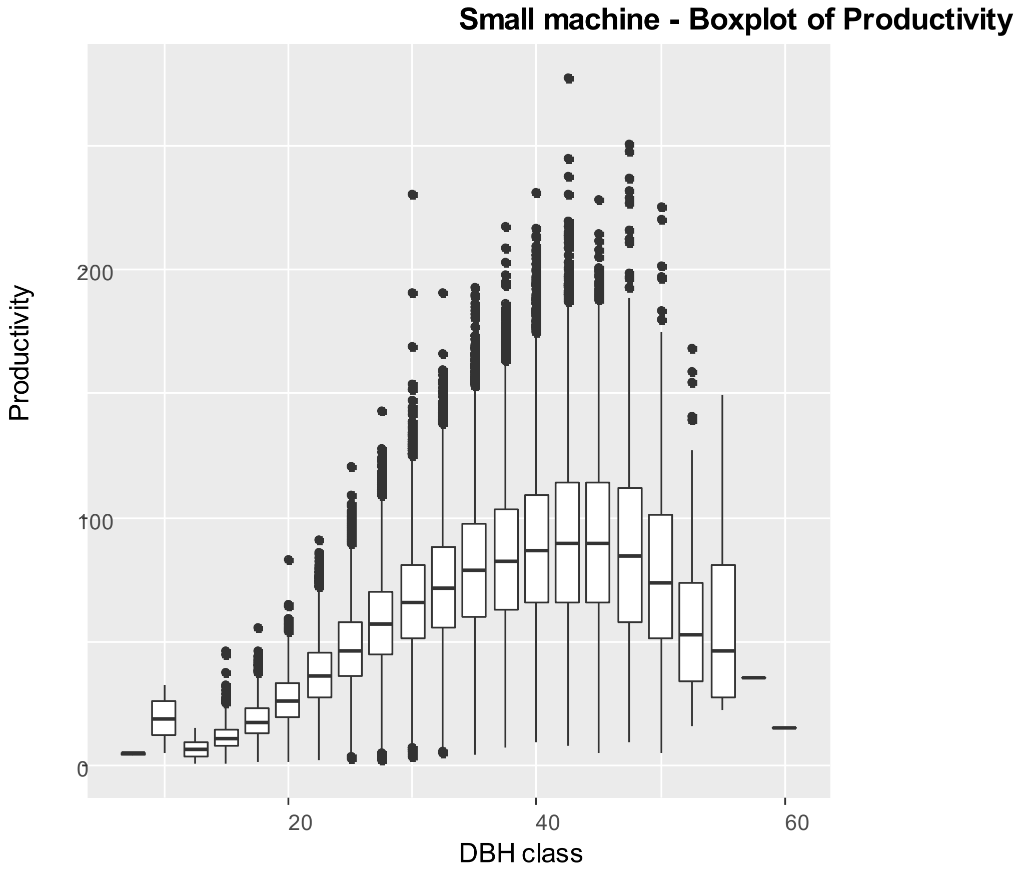




Results and discussion

Productivity based on DBH class



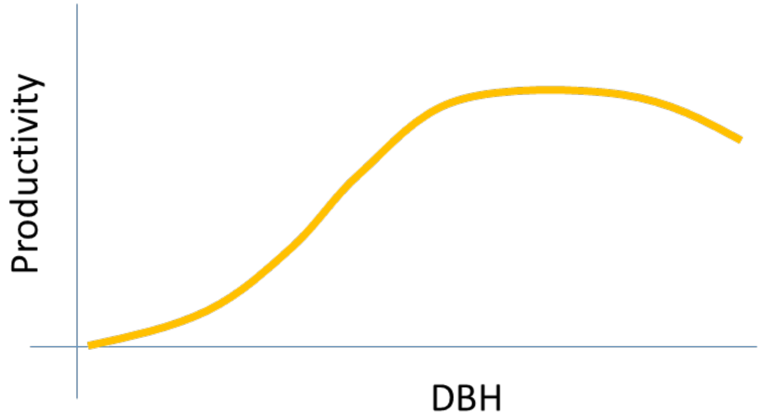


The model

- A Type II combined exponential and power function was fitted to these data using a Non-Linear Mixed Effects in R

- The function:

$$Producitivity = a \cdot DBH^{b} \cdot e^{c \cdot DBH}$$

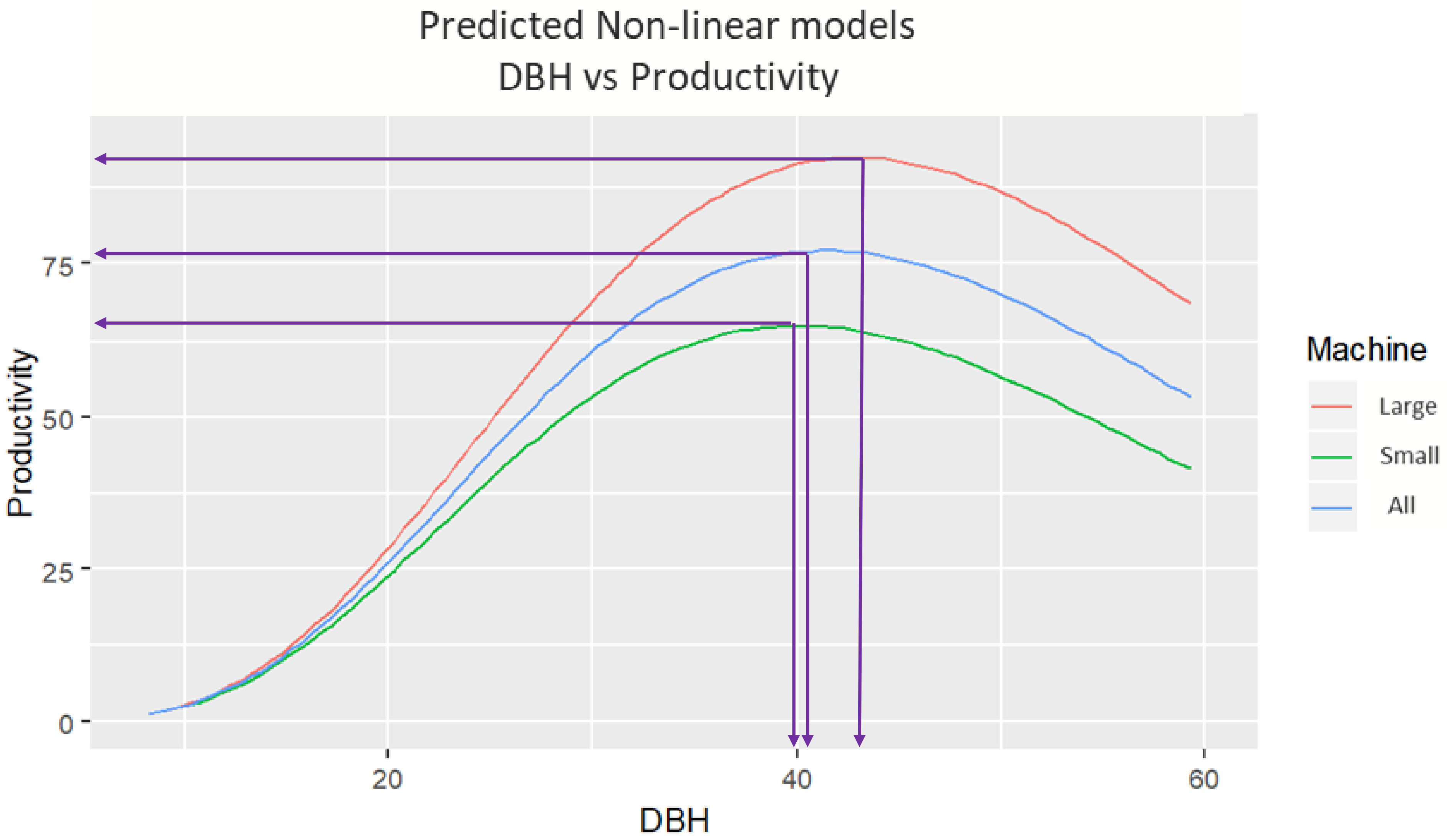


- Constants a, b and c were set as fixed effects and in order to characterise the differences in productivity, the machine types were set as random effects
- Other factors like operator and site were also tested
- Similarly productivity over volume

Results and discussion

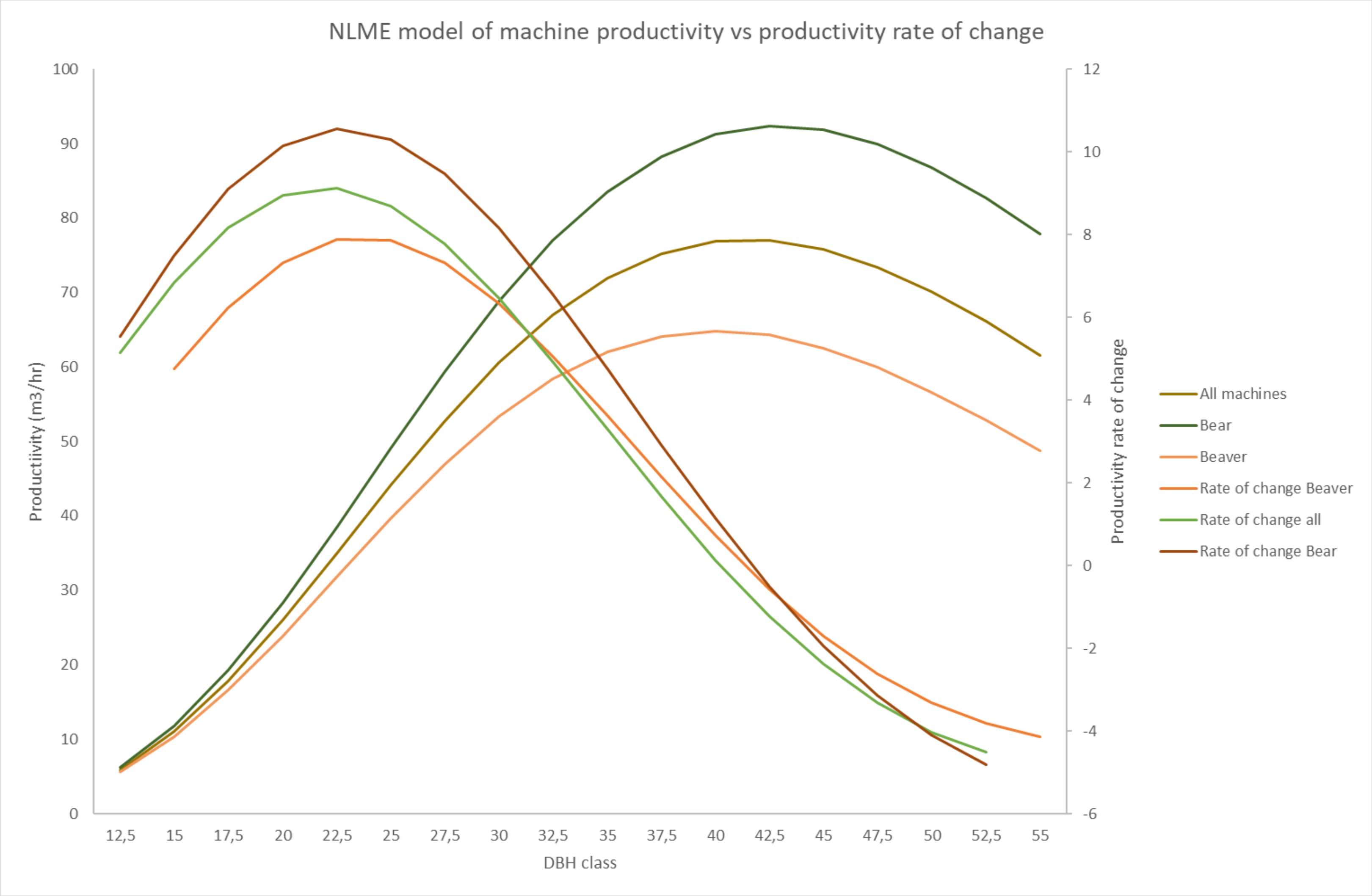
Productivity trends

All machines:
40cm DBH, 1.2m^3 tree volume
77m^3/hr
Bear:
42.5cm DBH, 1.4m^3 tree volume
92m^3/hr
Beaver:
40cm DBH, 1m^3 tree volume
64m^3/hr



Rate of productivity change

- We can now see where the machine work optimally
- Not really a point but more of a range
- Target where the machine work optimally



Conclusion

- Machine productivity is limited by tree size
- The efficiency of the machines is better in the ideal tree size range
- Need to optimise costs, productivity and tree growth
- It is not cost effective applying a machine not suited a particular tree size to an area
  - Repair costs go up
  - Productivity goes down
- Big data in this case has a lot of noise, but the trends are still there
- Unique approach for RSA forestry