Forest Research

Integrating Ecological & Empirical Models for Forest Management Planning

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Outline

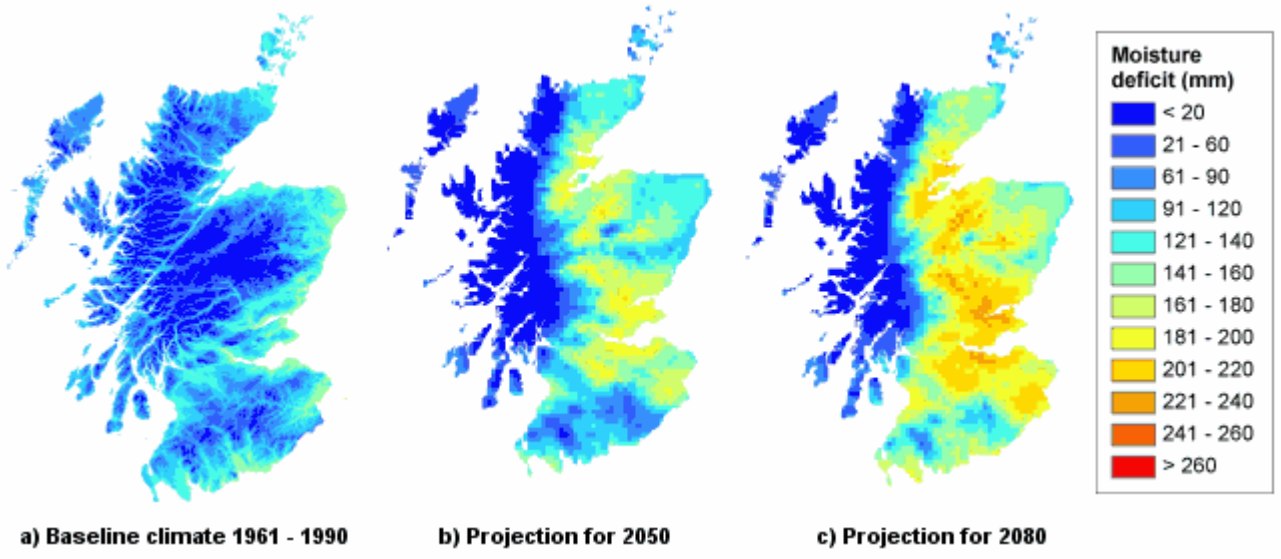
- Background and approach
- Models
  - Ecological Site Classification
  - Growth and yield
  - Biophysical yield class model
  - Timber quality
- Simulations
- Conclusions

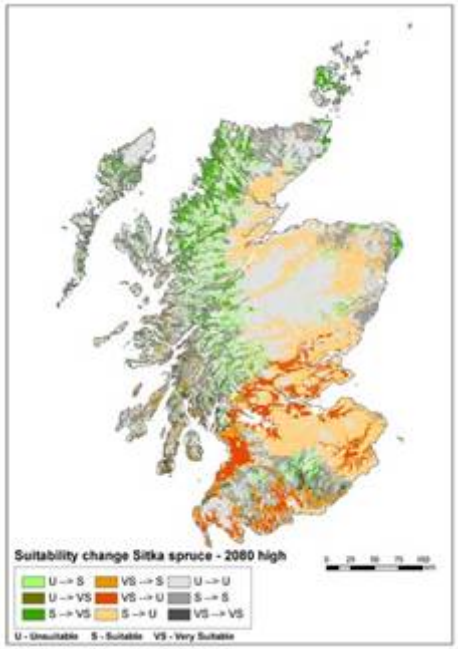
Background

- 20th century: extensive areas of conifer plantations established in Britain → **timber production**
- Growth and yield models for even-aged stands developed to predict timber volumes and inform management decisions
- Now, increasing requirement for forests to deliver a range of environmental and social benefits, as well as timber
- Silvicultural decision making is becoming more complex necessitating **new modelling approaches**

Changing climate – changing growth?

- Yield predictions have been based on assumption that yield class (site index) remains constant for a site throughout forecast period
- Evidence of climate change and resultant changes in site quality suggest that yield class may alter during forecast period
- New modelling approaches are needed to estimate the impact of these changes





Modelling approach

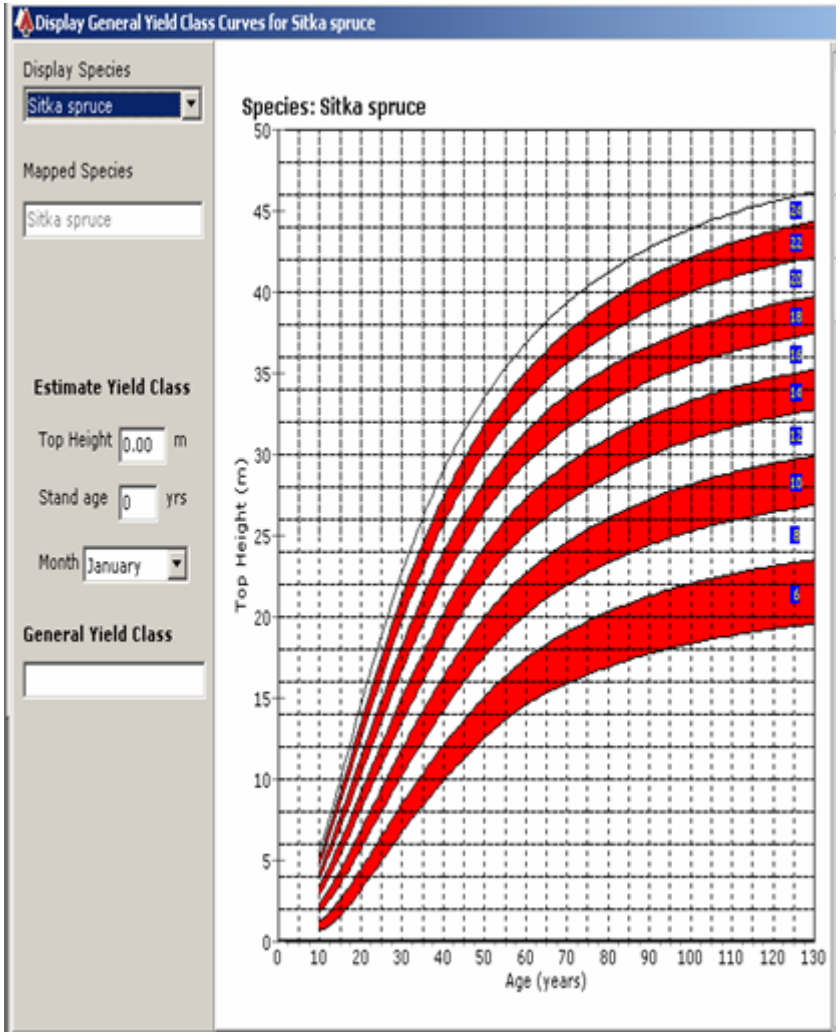
- Process-based models can be used to predict the impact of changing climate on tree growth – but require huge amounts of data
- Alternative approach: link models developed independently
- We aim to demonstrate how the delivery of selected ecosystem services can be assessed by integrating three existing modelling systems:
  1. Ecological Site Classification (ESC)
  2. Empirical yield models
  3. Timber quality models

Models – Ecological Site Classification

- ESC-DSS: developed to guide selection of tree species that are ecologically suited to sites
- Species requirements matched with climate and soil variables:
  - Warmth
  - Moisture Deficit
  - Continentality
  - Windiness
  - Soil nutrients
  - Soil moisture

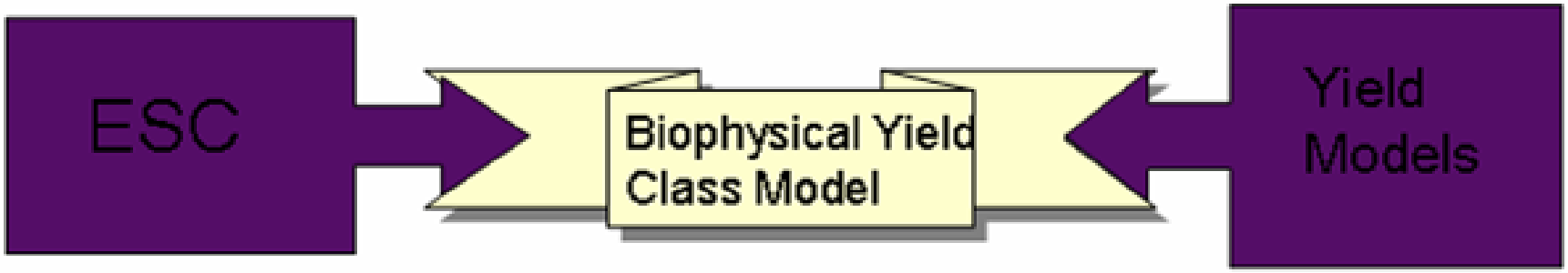
- ESC has been used extensively in Britain to assess the impact of various climate change scenarios on species suitability

Models – empirical yield models



- Models for stand growth and yield developed for major forest tree species in Britain (Edwards and Christie, 1981)
- Equations derived from look-up tables to facilitate climate change simulations and spatial analysis:
  - Top height
  - Quadratic mean diameter
  - Stems per ha.
  - Volume per ha

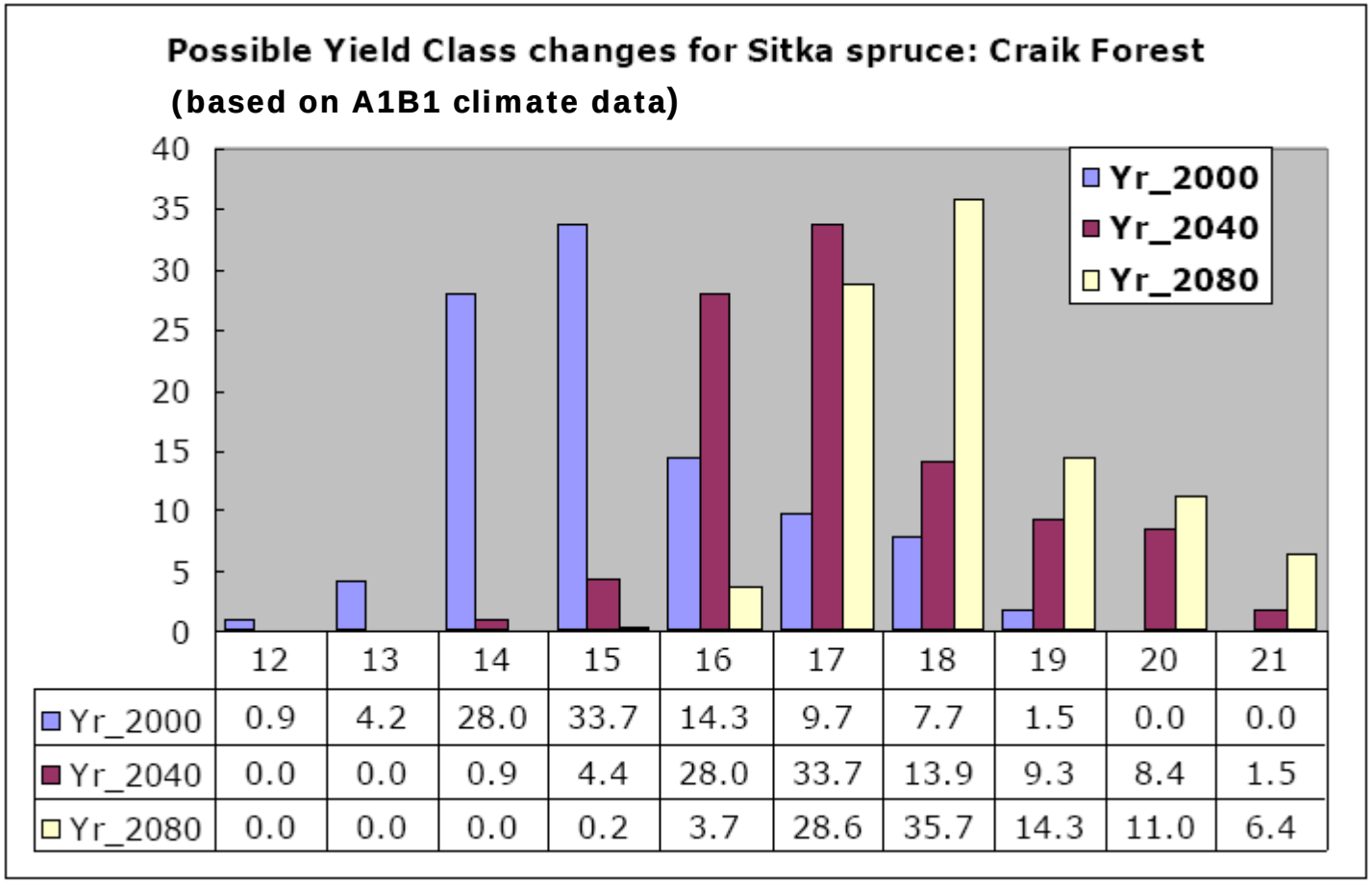
Linking ESC and yield models



- A biophysical yield model has been developed to link ESC to empirical yield models
- Growth and yield data from permanent sample plots in northern Britain were analysed with ESC climate variables
- The model predicts Yield Class from site climate data and elevation
- This approach enables prediction of Yield Class under different climate change scenarios, which can then be used to initiate yield models

Biophysical yield model – case study

- Model applied to Craik forest, southern Scotland – case study in ForeStClim project



	12	13	14	15	16	17	18	19	20	21
Yr_2000	0.9	4.2	28.0	33.7	14.3	9.7	7.7	1.5	0.0	0.0
Yr_2040	0.0	0.0	0.9	4.4	28.0	33.7	13.9	9.3	8.4	1.5
Yr_2080	0.0	0.0	0.0	0.2	3.7	28.6	35.7	14.3	11.0	6.4

- Further results from case study in presentation by Louise Sing (Thursday)

Timber quality

- Sitka spruce is the dominant species for timber production in Britain – supply is growing
- Greatest potential for increasing market share is in the construction sector
- Structural timber must meet grading requirements in terms of:
  - Stiffness
  - Strength
  - Wood density
  - Dimensional stability

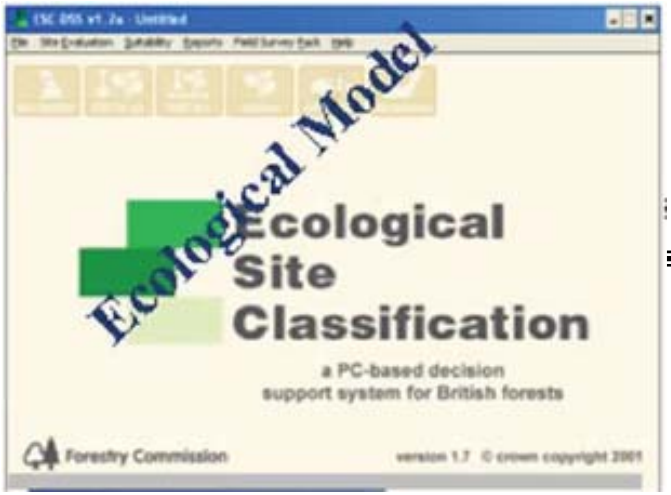
Models – timber quality

- Sitka spruce timber quality model links tree and wood properties models to predict:

1. Stem straightness
2. Branching/knots
3. Wood density
4. Stiffness & strength
5. Juvenile/mature wood

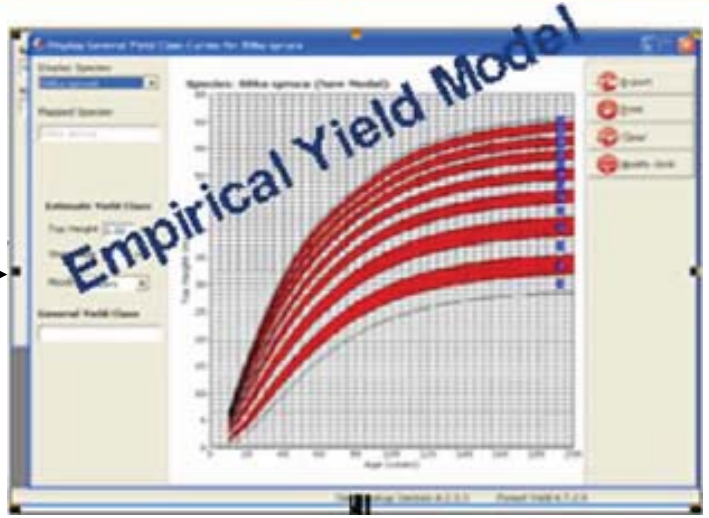
- Model inputs generally age, diameter and height, i.e. outputs from yield model

Linking Models



LINK:

BIOPHYSICAL MODEL

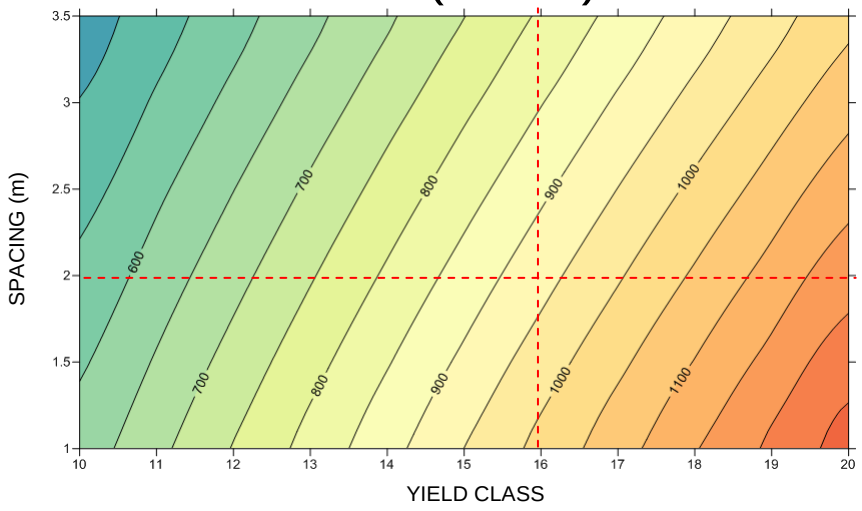


- A Biophysical Yield Model links the Ecological Site Classification DSS and the ForestYield Model.
- Timber Quality Model requires inputs from ForestYield to initialise tree and wood properties simulations

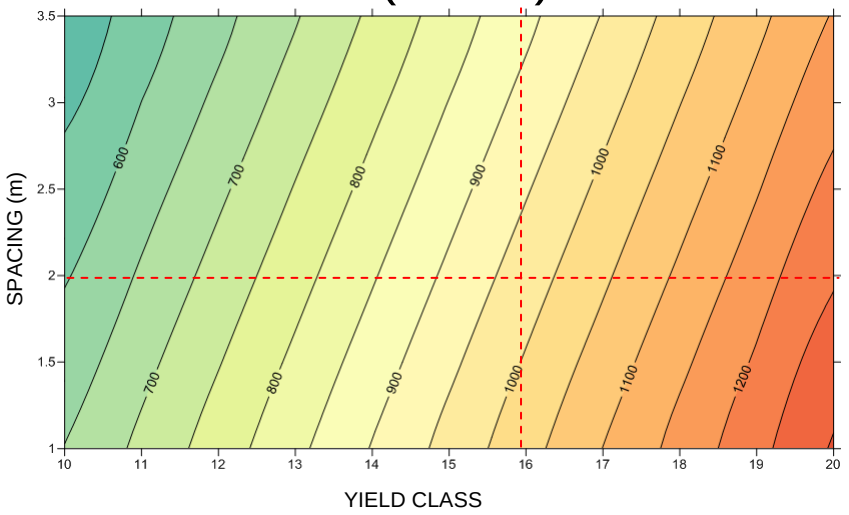
Simulations

- Carbon sequestration: identified as a key ecosystem service that has been undervalued
- Linked models used to assess forest management impacts on carbon sequestration and timber production in Sitka spruce
- Carbon sequestration indicator:
  - Cumulative carbon (t/ha)
- Timber:
  - Cumulative timber volume (m^3/ha)
  - Sawlog proportion (%)
  - Stem straightness (Stand median of score 1-7, worst – best)
  - Mature wood proportion (%)
  - Wood density (kg/m^3)
  - Wood Modulus of Elasticity, MOE (stiffness) (MPa)
- Simulations for varying spacing and Yield Class, with a fixed rotation of 60 years

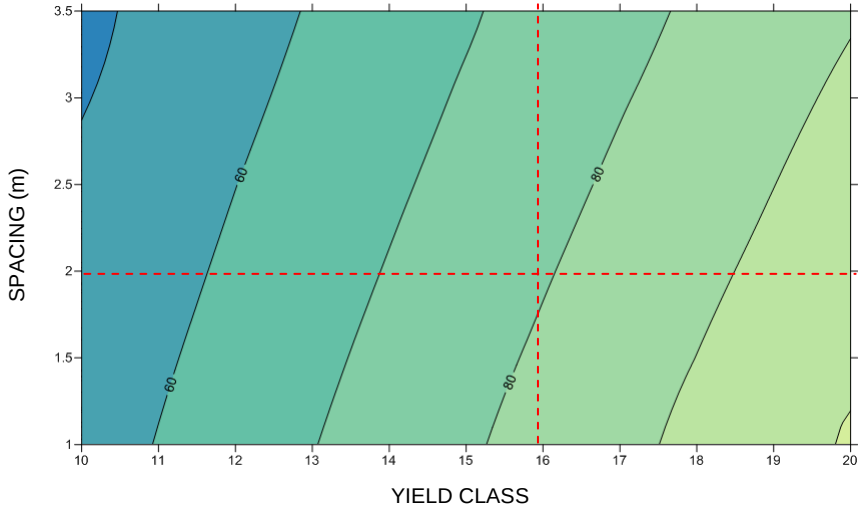
Timber volume (m^3/ha) – thinned



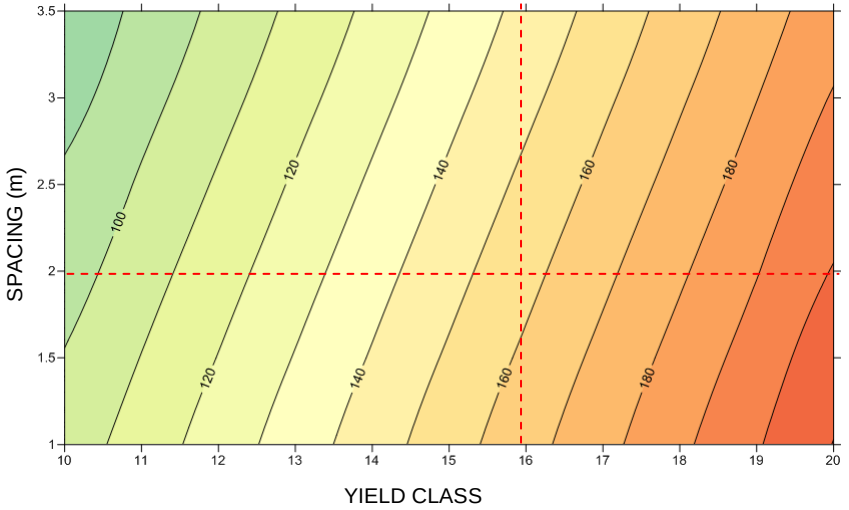
Timber volume (m^3/ha) - unthinned



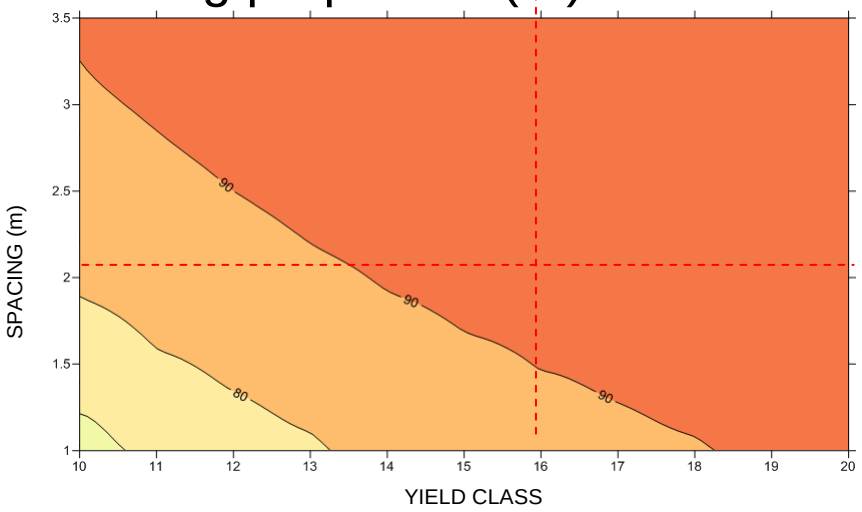
Carbon (t/ha) – thinned



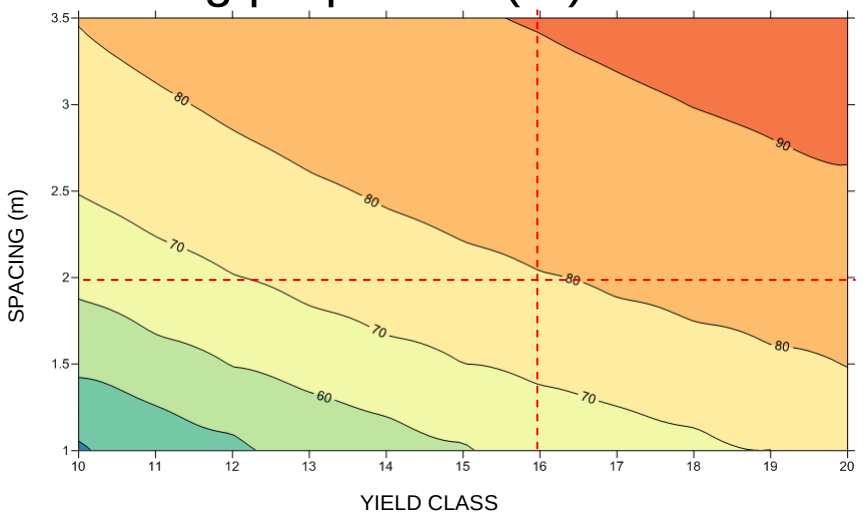
Carbon (t/ha) - unthinned



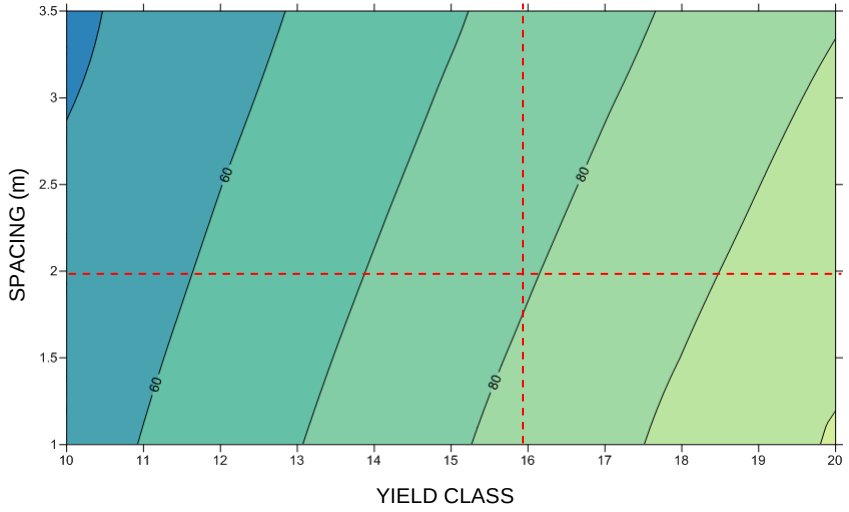
Sawlog proportion (%) – thinned



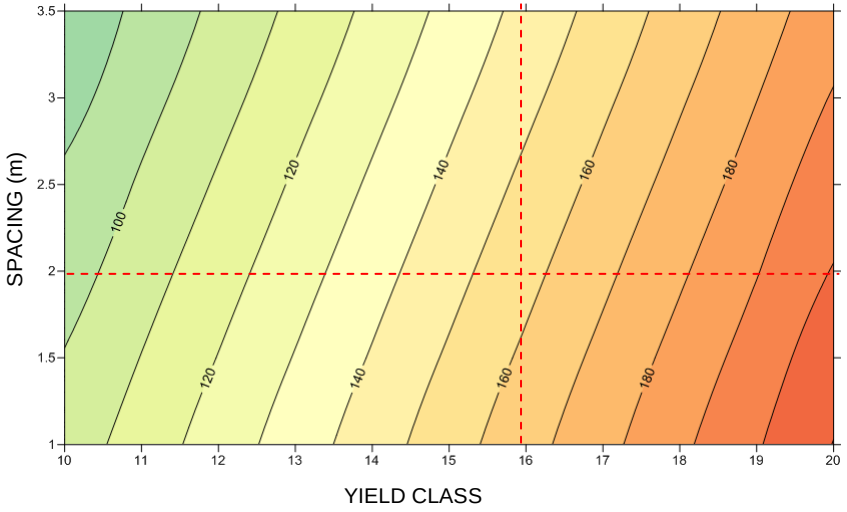
Sawlog proportion (%) - unthinned



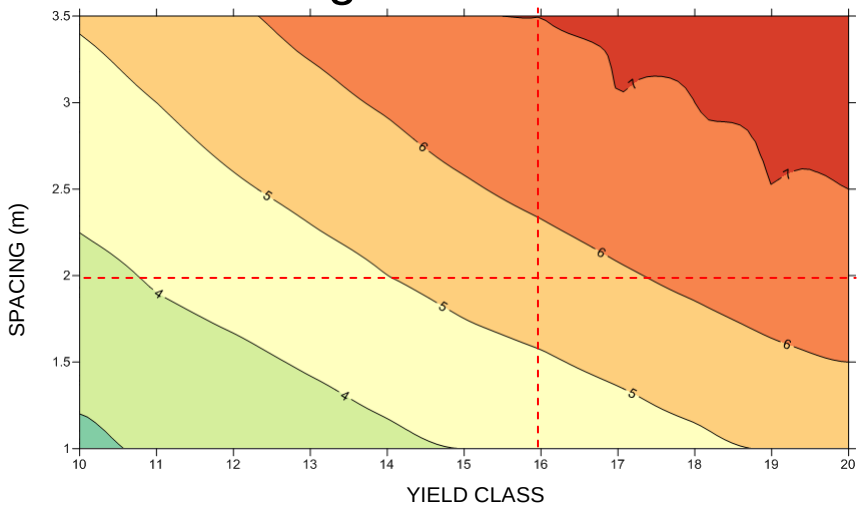
Carbon (t/ha) – thinned



Carbon (t/ha) - unthinned

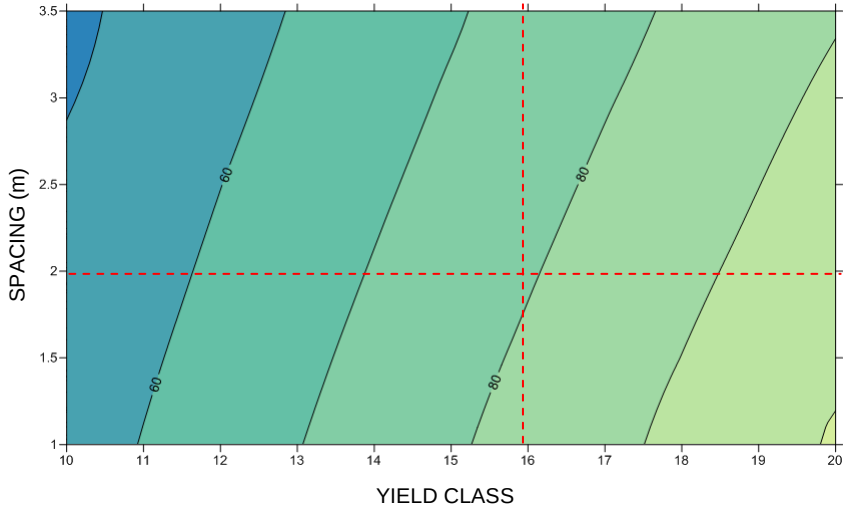


Stem straightness – thinned

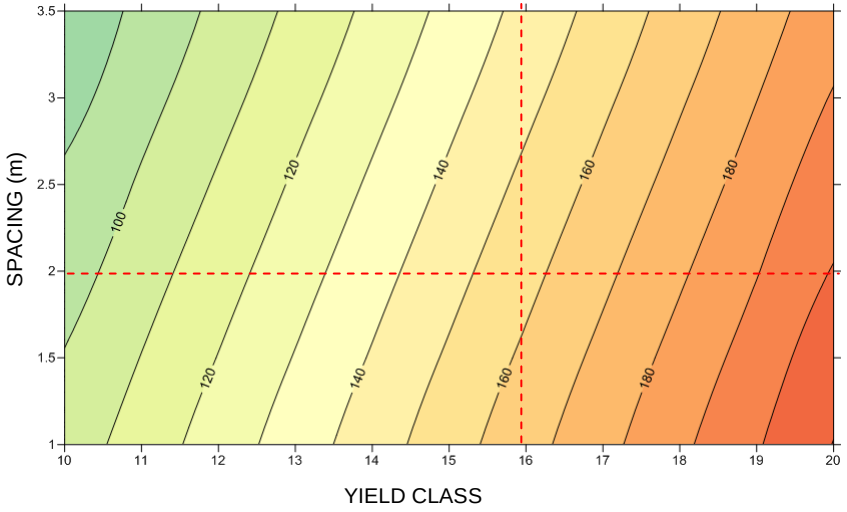


Stem straightness - unthinned

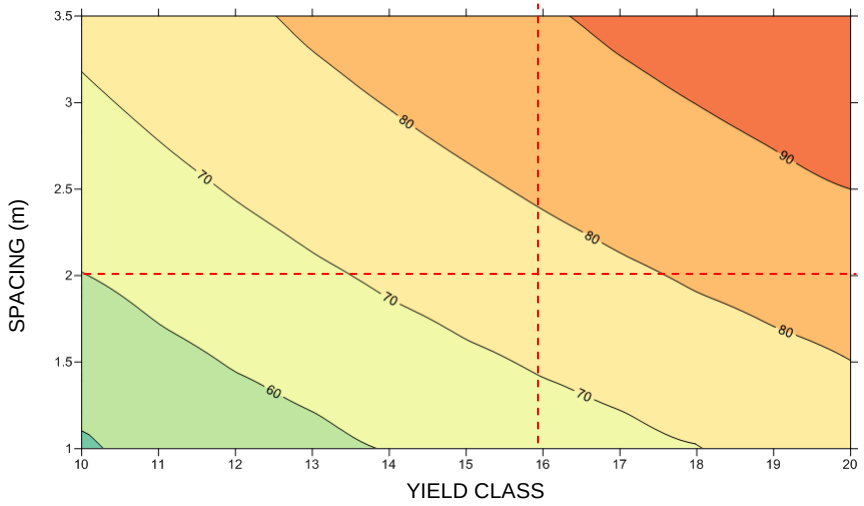
Carbon (t/ha) – thinned



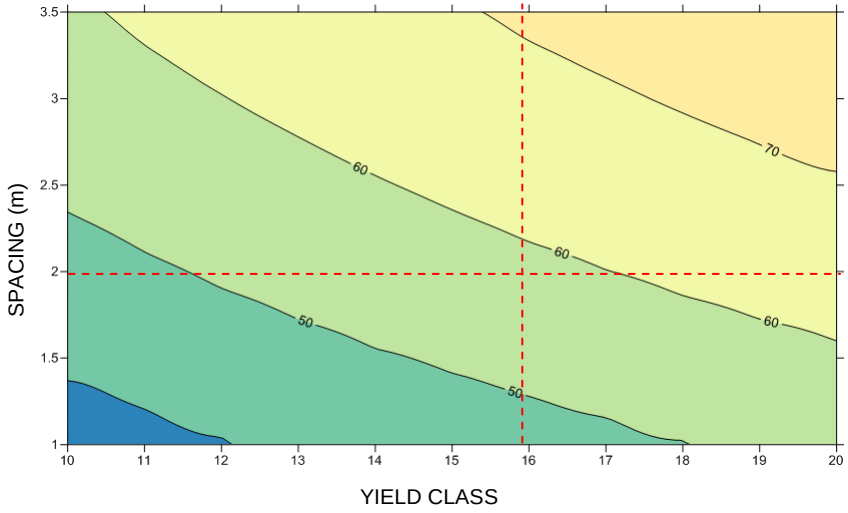
Carbon (t/ha) - unthinned



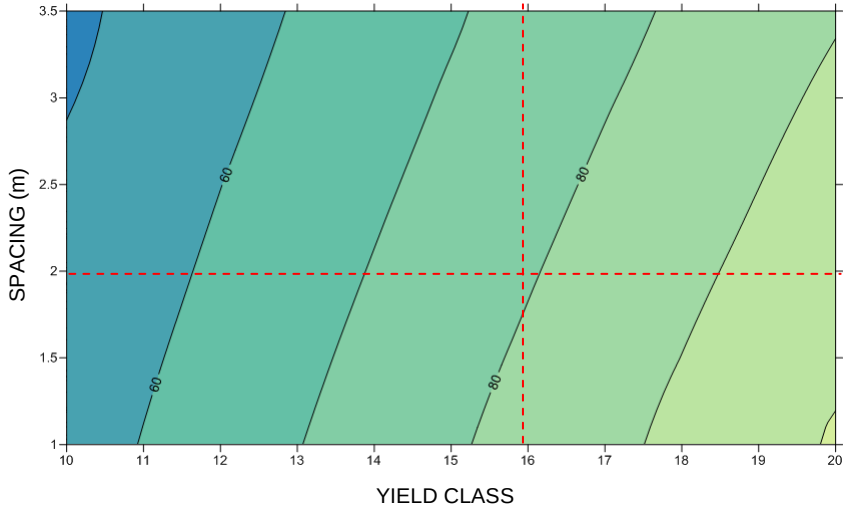
Mature wood % – thinned



Mature wood % - unthinned



Carbon (t/ha) – thinned



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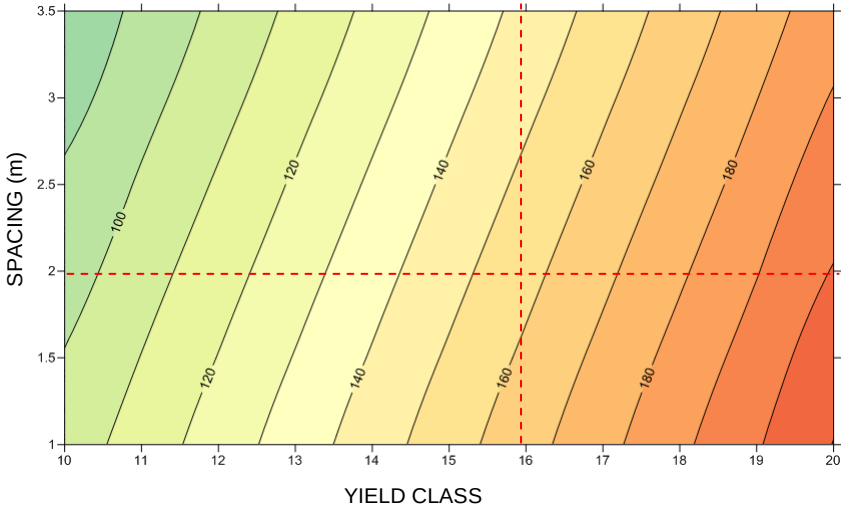
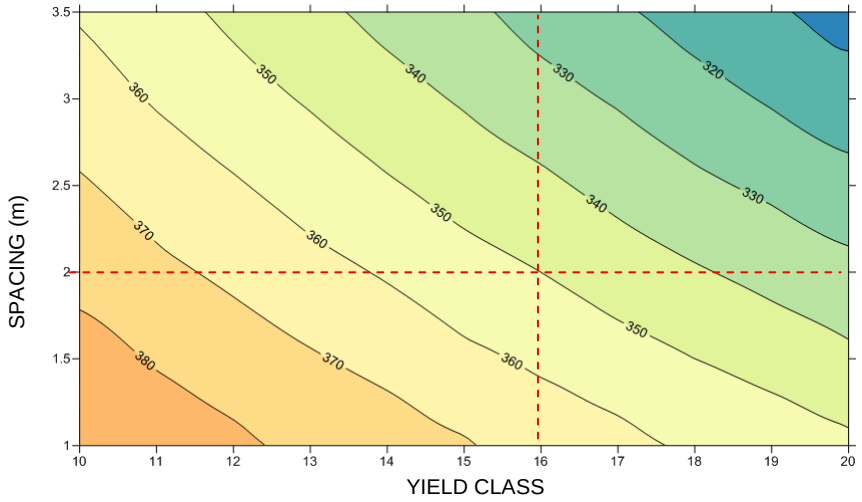
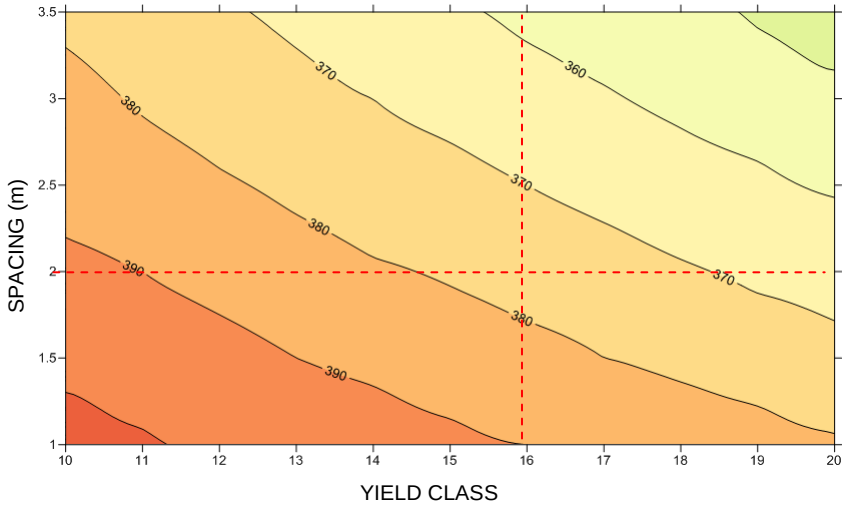


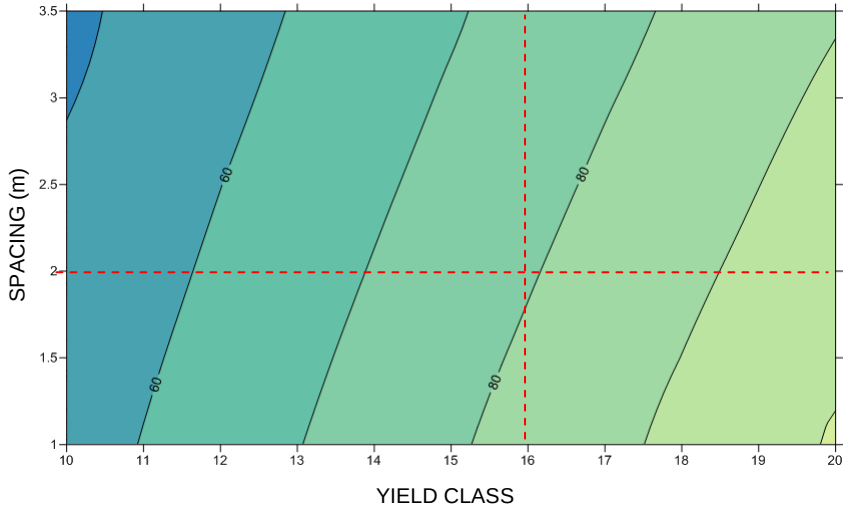
Wood density (kg/m^3) – thinned



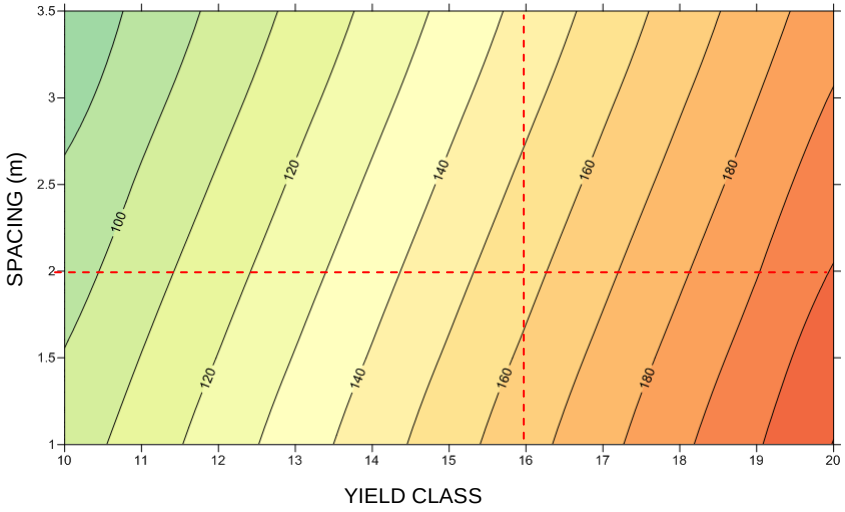
Wood density (kg/m^3) - unthinned



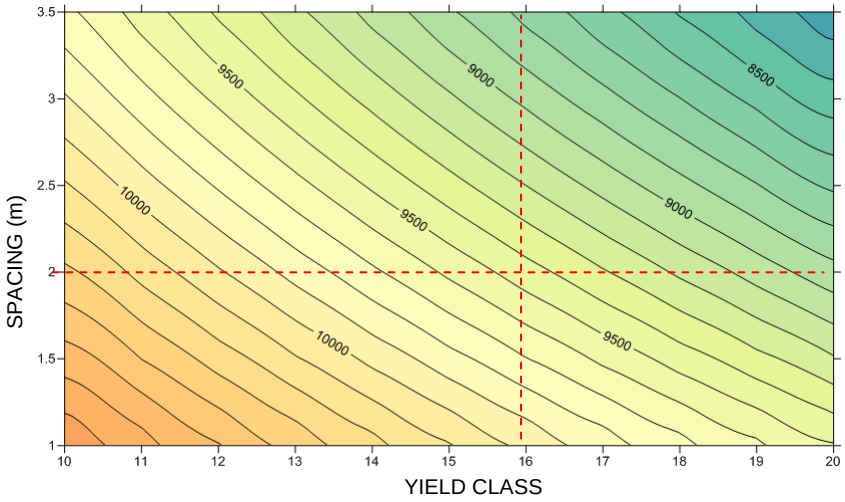
Carbon (t/ha) – thinned



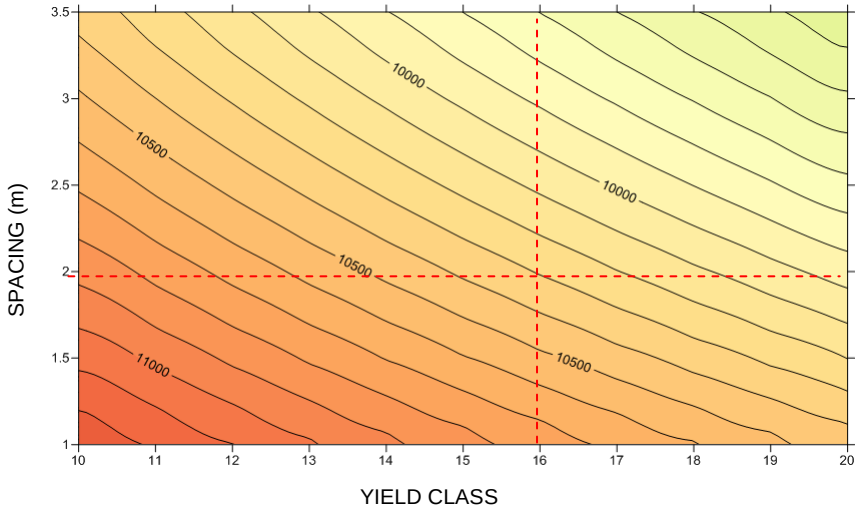
Carbon (t/ha) - unthinned



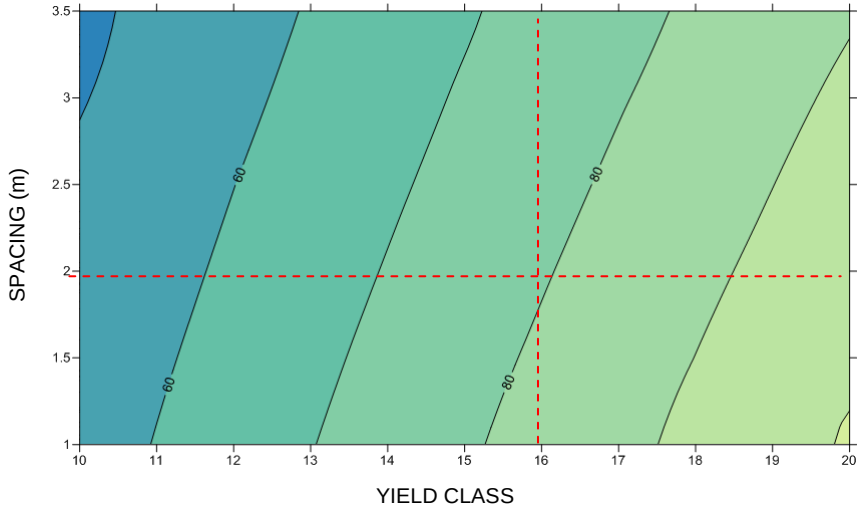
Wood MOE (MPa) – thinned



Wood MOE (MPa) - unthinned



Carbon (t/ha) – thinned



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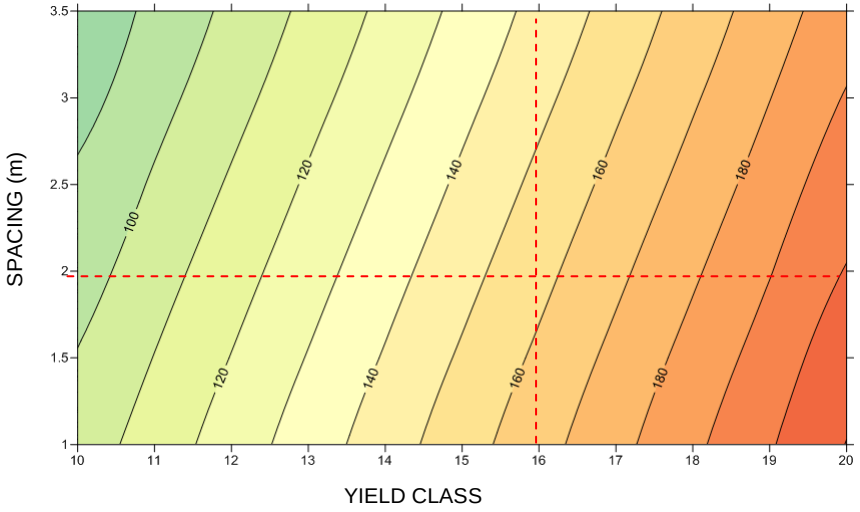

Conclusions

- A biophysical yield model allows tree growth and yield to be predicted from a limited number of easily available input data (climate variables and elevation)
- Model can be implemented spatially to facilitate landscape/regional level planning
- Predictions can be used to:
  - Inform afforestation decisions
  - Evaluate climate change impacts on a number of ecosystem services
- Outputs from a biophysical yield model can be used to drive models for a range of ecosystem services – as demonstrated for carbon and timber

Acknowledgements:

- Funding:
  - EU Interreg. North West Europe Programme
  - Forestry Commission
- Forestry Commission and Forest Research colleagues – sample plot data

Further information: **www.forestclim.eu**

Thank-you!