Forest Research

The importance of carbon sequestration rate considerations in area targets for afforestation: a strategic analysis for Scotland

Understanding forest carbon sequestration?

Mike Perks & Keith Matthews

- Keith Matthews, Doug Wardell-Johnson, Dave Miller, Robin Matthews
- Nuala Fitton, Ed Jones, Pete Smith
- Mike Perks, Steven Bathgate, Tim Randle, Duncan Ray

The James Hutton Institute
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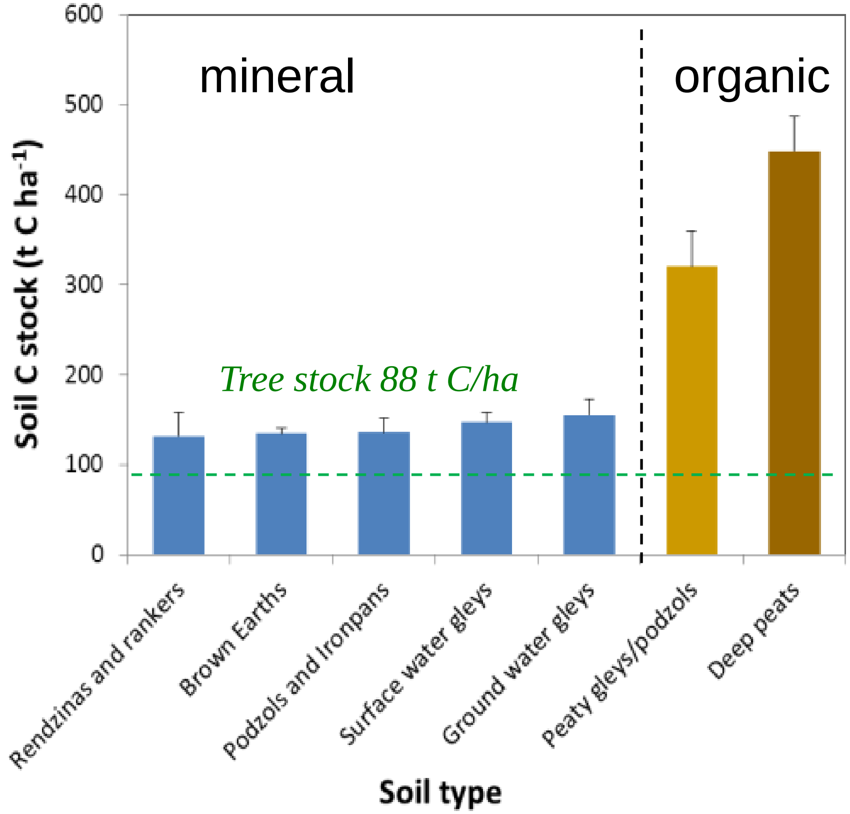
Forest Research

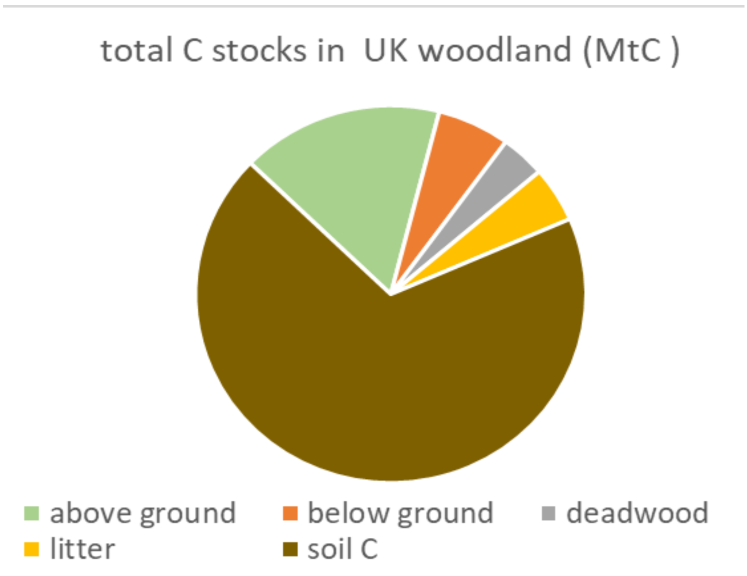
Carbon sequestration - a question of balance!

Woodland Carbon stocks

Estimates from the BioSoil survey (2005-10) and Forestry Statistics 2020



(Vanguelova et al., Soil Use & Man., 2013)

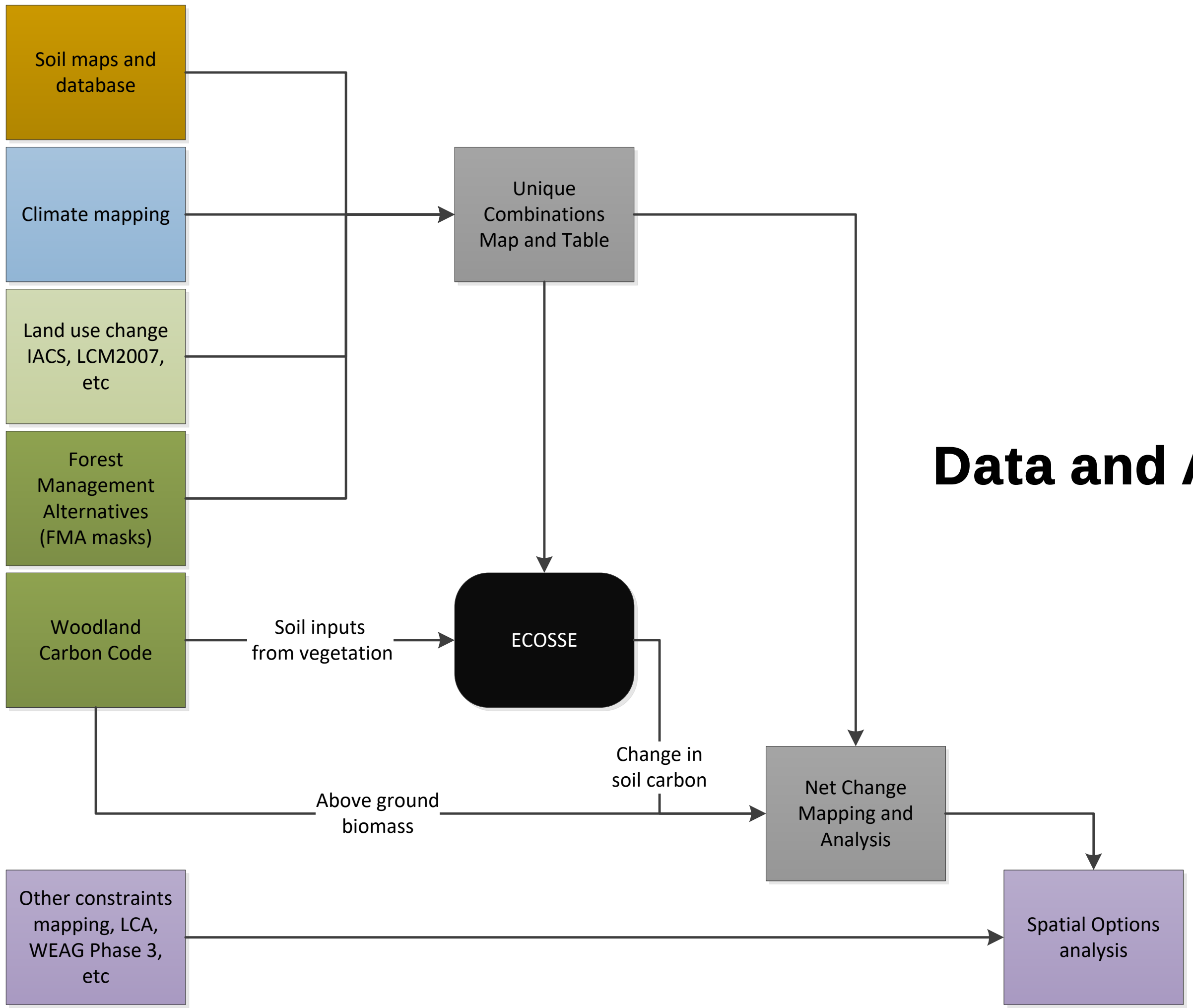


soils 69% of total

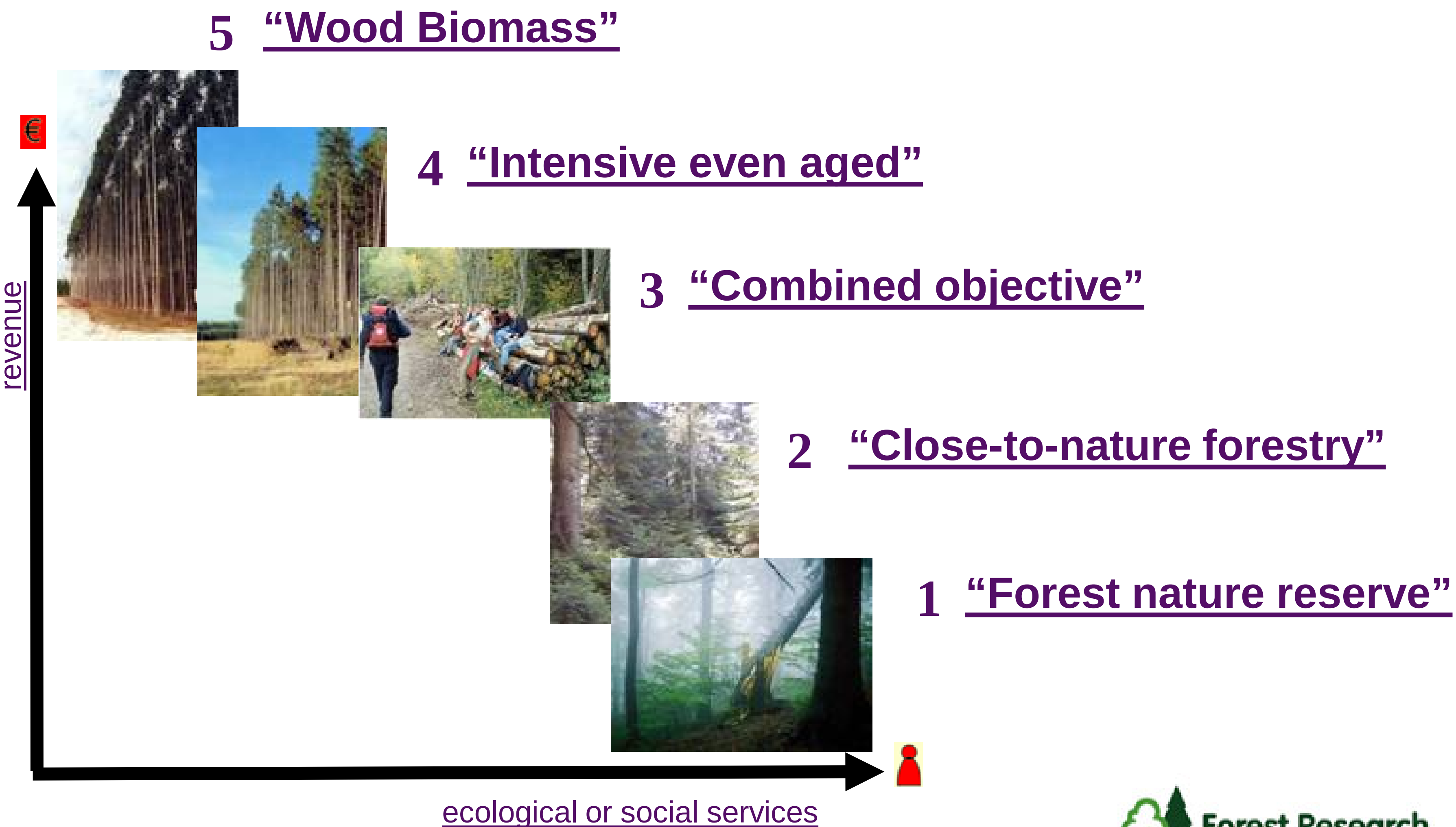
total UK C stock 'in forest' = 1,095 Mt C

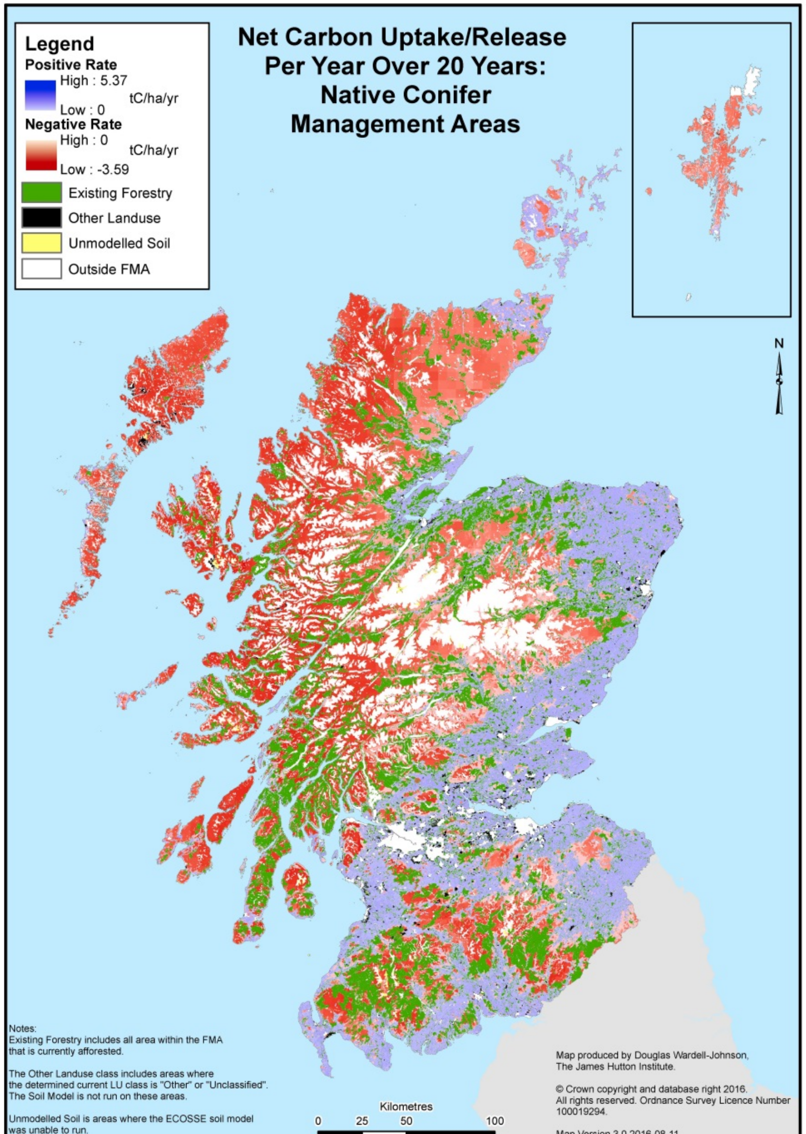
Updated from Morison et al., 2012. Understanding carbon and GHG balance of forests

Data and Analysis Flows



'Forest Management Alternatives' Concept




Net Carbon Uptake/Release
Per Year Over 20 Years:
Native Conifer
Management Areas
Legend
Positive Rate
High : 5.37
Low : 0
tC/ha/yr
Negative Rate
High : 0
Low : -3.59
tC/ha/yr
Existing Forestry
Other Landuse
Unmodelled Soil
Outside FMA
N
Notes:
Existing Forestry includes all area within the FMA that is currently afforested.
The Other Landuse class includes areas where the determined current LU class is "Other" or "Unclassified". The Soil Model is not run on these areas.
Unmodelled Soil is areas where the ECOSSE soil model was unable to run.
Kilometres
0 25 50 100
Map produced by Douglas Wardell-Johnson, The James Hutton Institute.
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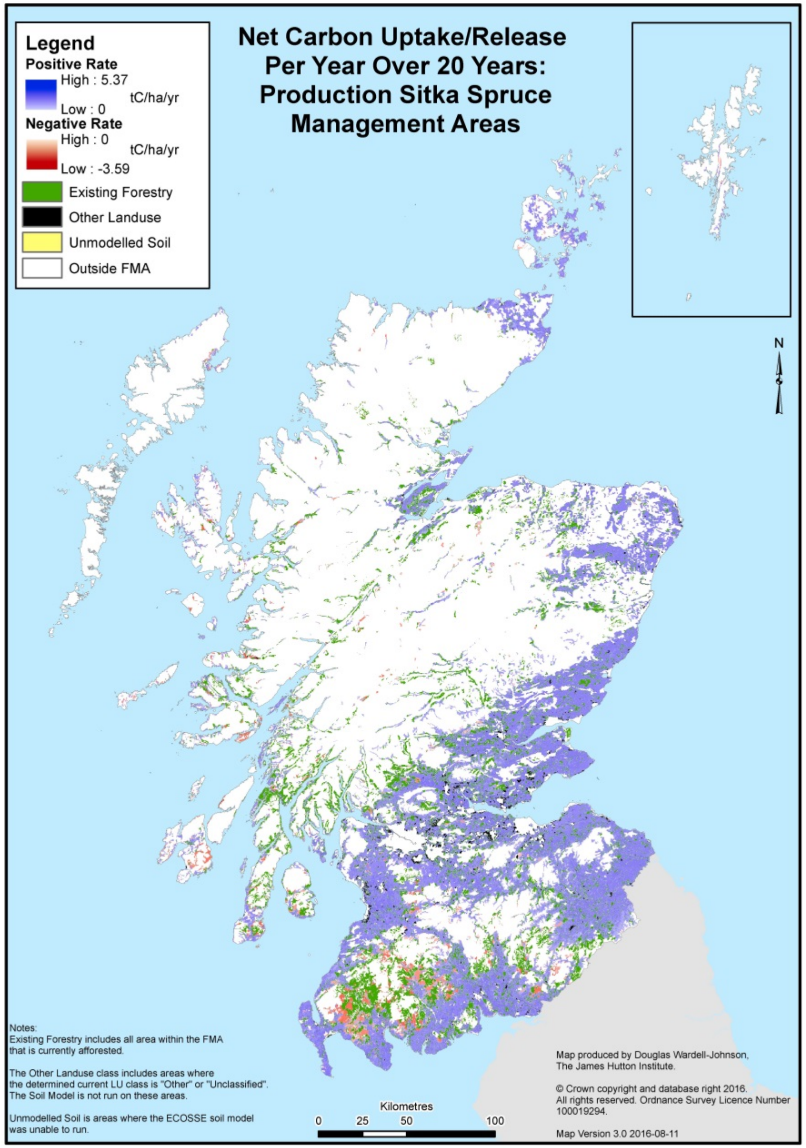
Map Version 3.0 2016-08-11


Net Carbon Uptake/Release
Per Year Over 20 Years:
Production Sitka Spruce
Management Areas
Legend
Positive Rate
High : 5.37
Low : 0
tC/ha/yr
Negative Rate
High : 0
Low : -3.59
tC/ha/yr
Existing Forestry
Other Landuse
Unmodelled Soil
Outside FMA
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Notes:
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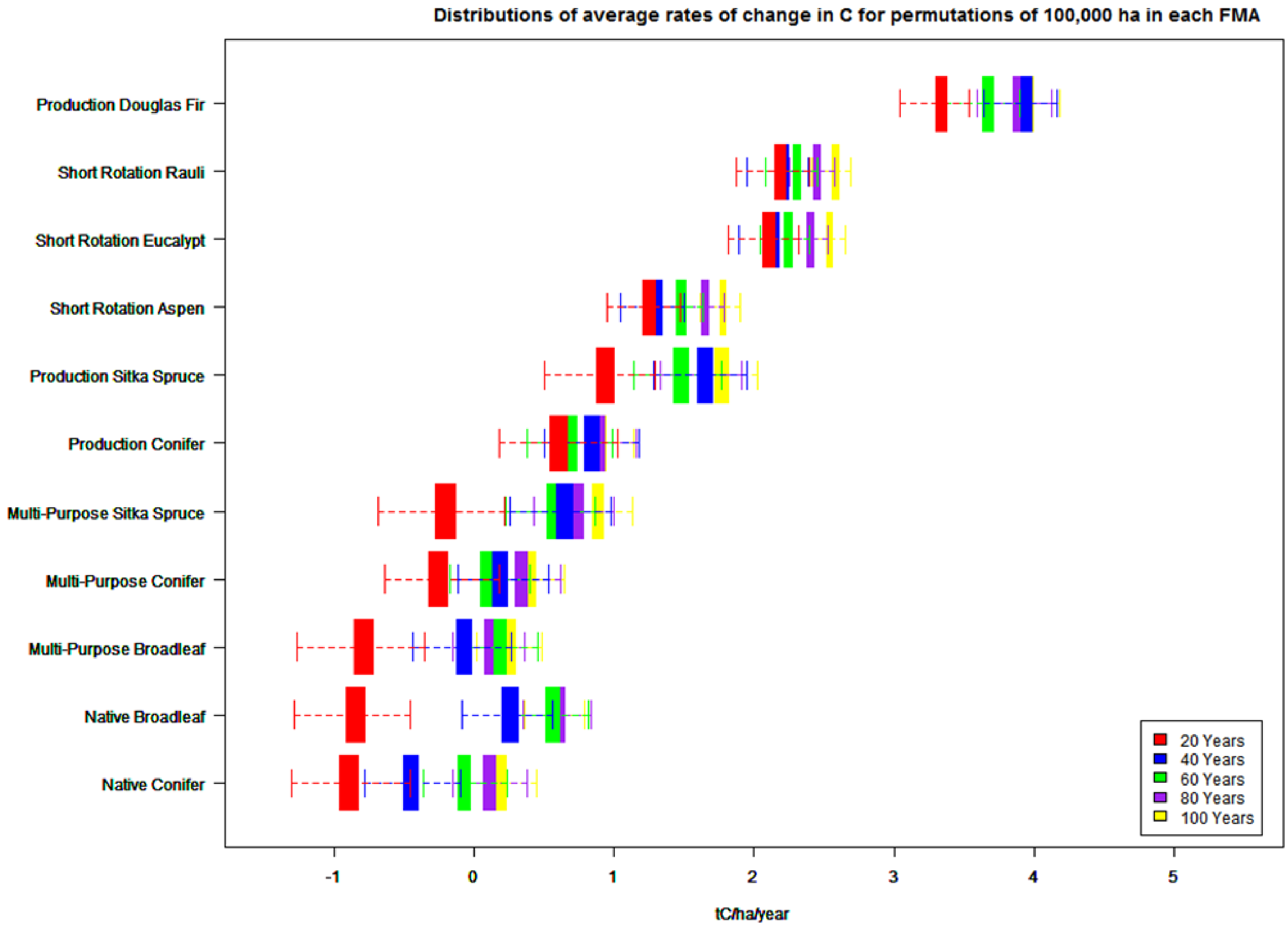
Distributions of average rates of change in C for permutations of 100,000 ha in each FMA
Production Douglas Fir
Short Rotation Rauli
Short Rotation Eucalypt
Short Rotation Aspen
Production Sitka Spruce
Production Conifer
Multi-Purpose Sitka Spruce
Multi-Purpose Conifer
Multi-Purpose Broadleaf
Native Broadleaf
Native Conifer
20 Years
40 Years
60 Years
80 Years
100 Years
-1
0
1
2
3
4
5
tC/ha/year

WEAG 2020

- 2020 re-analysis of afforestation potential
  - New land capability filters
  - Includes new peat extent data
  - Includes updated NFI extent

Fewer LCA restrictions on best quality

Includes good quality mixed agriculture

Improved peat (and woodland) mapping

LCA Class	Land use type	2020 [illegible]AG Area (hecta[illegible]s)	2011 WEAG Ar[illegible] (hectares)
1.0 – 3.1	Arable	533,[illegible]2	0
3.2 – 4.2	Mixed Agriculture	1,150,897	987,318
5.1 – 5.43	Improved Grassland	673,771	632,915
6.1 – 7.0	Rough Grazing	598,505	1,015,487

WEAG 2020

- 2020 re-analysis of afforestation potential

Area > 0 tC/ha/yr over 20 years

FMA	Name	All	Semi- Natural	Grassland	Cropping
FMA1	Native Conifer	1,876,000	23,000	800,000	1,053,000
FMA2	Native Broadleaf	1,916,000	84,000	785,000	1,047,000
FMA5	Multi-Purpose Conifer	2,553,000	729,000	786,000	1,038,000
FMA3	Multi-Purpose Broadleaf	1,810,000	5,000	764,000	1,041,000
FMA4	Multi-Purpose Sitka Spruce	2,140,000	444,000	722,000	974,000
FMA8	Production Conifer	2,132,000	466,000	698,000	968,000
FMA7	Production Sitka Spruce	2,147,000	473,000	709,000	965,000
FMA9	Short Rotation Aspen	1,789,000	305,000	596,000	888,000
FMA10	Short Rotation Rauli	1,502,000	215,000	517,000	770,000
FMA6	Production Douglas Fir	1,223,000	149,000	411,000	663,000

Area >1.05 t/ha/yr over 20 years

FMA	Name	All	Semi- Natural	Grassland	Cropping
FMA1	Native Conifer	862	-	-	862
FMA2	Native Broadleaf	-	-	-	-
FMA5	Multi-Purpose Conifer	1,517,000	-	479,000	1,038,000
FMA3	Multi-Purpose Broadleaf	-	-	-	-
FMA4	Multi-Purpose Sitka Spruce	956,000	-	-	956,000
FMA8	Production Conifer	1,645,000	1,100	672,000	968,000
FMA7	Production Sitka Spruce	1,708,000	55,000	689,000	965,000
FMA9	Short Rotation Aspen	1,479,000	3,000	587,000	889,000
FMA10	Short Rotation Rauli	1,487,000	202,000	515,000	770,000
FMA6	Production Douglas Fir	1,217,000	144,000	410,000	663,000

- 2020 re-analysis of afforestation potential

Planted area needed as % of TIMES assumptions > 1.05 tC/ha/yr					
FMA	Name	All	Semi-Natural	Grassland	Cropping
FMA1	Native Conifer	99%	-	-	99%
FMA3	Multi-Purpose Broadleaf	-	-	-	-
FMA2	Native Broadleaf	-	-	-	-
FMA5	Multi-Purpose Conifer	81%	-	97%	76%
FMA4	Multi-Purpose Sitka Spruce	85%	-	-	85%
FMA8	Production Conifer	63%	95%	72%	58%
FMA7	Production Sitka Spruce	58%	97%	65%	53%
FMA9	Short Rotation Aspen	63%	93%	72%	58%
FMA10	Short Rotation Rauli	44%	64%	46%	40%
FMA6	Production Douglas Fir	31%	45%	34%	27%

- New woodlands which achieve >1.05 tC ha^{-1} y^{-1} over the first 20 years, requires planting productive species on better quality mineral soils, bringing trees ‘down the hill’, maximising carbon capture.

- Better quality land delivers high carbon benefits from woodland and better economic return
- Integrated land use options (shelterbelts) particularly beneficial

LAND YIELD & PRODUCTIVITY	AGRICULTUTRAL LAND TYPE AGROFORESTRY TYPE [LCA CLASS]	PREDOMINANT AGROFORESTRY MANAGEMENT OPTION	LAND POTENTIAL TREE PRODUCTIVITY
LOW	Lowest Quality Rough Grazing Silvopastoral: "Sheep & Trees" [LCA 7.0]	Upland wood pasture (single trees or clusters) Native Scots pine woodland & Low productivity native broadleaf (AFMA 1) (AFMA2)	Extensive upland Poor Do not plant peat>50cm deep
	Poor Quality Upland Silvopastoral: Rough Grazing "Sheep & Trees" [LCA 6.1 – 6.3]	Lowland wood pasture (single trees or clusters) Multipurpose Broadleaf & Multipurpose Conifer (AFMA 3) (AFMA4/5/7)	Extensive upland Moderate-Good
	Improved Grassland Silvopastoral: "Livestock & Trees" [LCA 5.1 – 5.3]	Shelter Belts for Livestock: Multipurpose Broadleaf & Productive Conifer (AFMA 3) (AFMA 7/8)	Intensive upland Moderate-Very Good
	Mixed agriculture Silvopastoral: "Livestock & Trees" [LCA 3.2 – 4.2]	Buffer Strips or Shelter Belts for Livestock: Productive Broadleaf & Productive Conifer (AFMA 3/9) (AFMA 6/7)	Lowland Very Good – Excellent
HIGH	Arable agriculture Silvoarable: "Crops & Trees" [LCA 2.0 – 3.1]	Rows and buffer strips for Arable Short Rotation Forestry, Productive conifer and broadleaves, silvo-arable planting (AFMA 9) (AFMA 7)	Lowland Very Good - Excellent

- Soil C stock is large – minimise soil C losses
  - in existing woodlands management
  - in woodland expansion
- Cultivation usually increases soil C loss
- Drainage of wet soils increases C losses through increased decomposition and more dissolved C loss
- Need to strike appropriate balance between soil C loss and good establishment and growth (yield class, stems ha^{-1} & wood density)
- Peaty soils are a particular concern
- Arable & rotational grassland soils typically have low C content
- Balancing other objectives at local/regional scales is key (biodiversity, access, wellbeing, economics)

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Not seeing the carbon for the trees? Why area-based targets for establishing new woodlands can limit or underplay their climate change mitigation benefits

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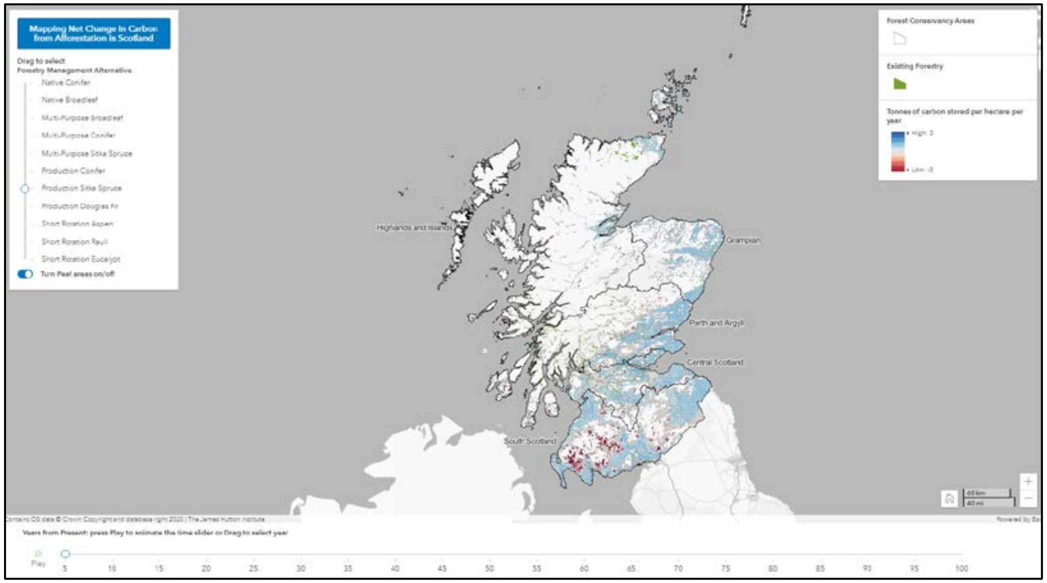
ABSTRACT

Area-based targets for afforestation are a frequent and prominent component of policy discourses on forestry, land use and climate change emissions abatement. Such targets imply an expected contribution of afforestation to the net reduction of greenhouse gas emissions, yet the nature of afforestation undertaken and its geographical distribution means that there is considerable uncertainty over the eventual emission reductions outcomes. This uncertainty is reduced if the net carbon balance is calculated for all potential afforestation sites, considering climate, soil characteristics and the possible types of afforestation (species and management regimes). To quantify the range of possible emissions outcomes for area-based afforestation targets, a new spatial analysis method was implemented. This improved the integration of spatial data on antecedent land use with mapped outputs from forest models defining the suitability and productivity of eleven forestry management alternatives. This above ground carbon data was then integrated with outputs from the ECOSSE (Estimation of Carbon in Organic Soils – Sequestration and Emissions) model which simulates the soil carbon dynamics. The maps and other model output visualisations combining above and below ground carbon highlight where net carbon surpluses and deficits are likely to occur, how long they persist after afforestation and their relationships with antecedent land use, soils, weather conditions and afforestation management strategies. Using more productive land classes delivers more net sequestration per hectare and could mean greater carbon storage than anticipated by emissions reduction plans. Extensive establishment of lower yielding trees on low-quality ground, with organo-mineral soils could, though, result in net emissions that persist for decades. From the spatial analysis, the range of possible outcomes for any target area of planting is substantial, meaning that outcomes are highly sensitive to policy and implementation decisions on the mix of forestry systems preferred and to spatial targeting or exclusions (both at regional and local scales). The paper highlights the importance of retaining the existing presumption against planting of deep peat areas, but also that additional incentives or constraints may be needed to achieve the aggregate rates of emission mitigation implied by policy commitments. Supplementary carbon storage tonnage targets for new forestry would introduce a floor for carbon sequestration outcomes, but would still allow for flexibility in achieving an appropriate balance in the trade-offs between carbon sequestration and the many other objectives that new woodlands are expected to deliver.

& online
https://woodlandexpansion.hutton.ac.uk/



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