Short rotation forest bioenergy synthesis

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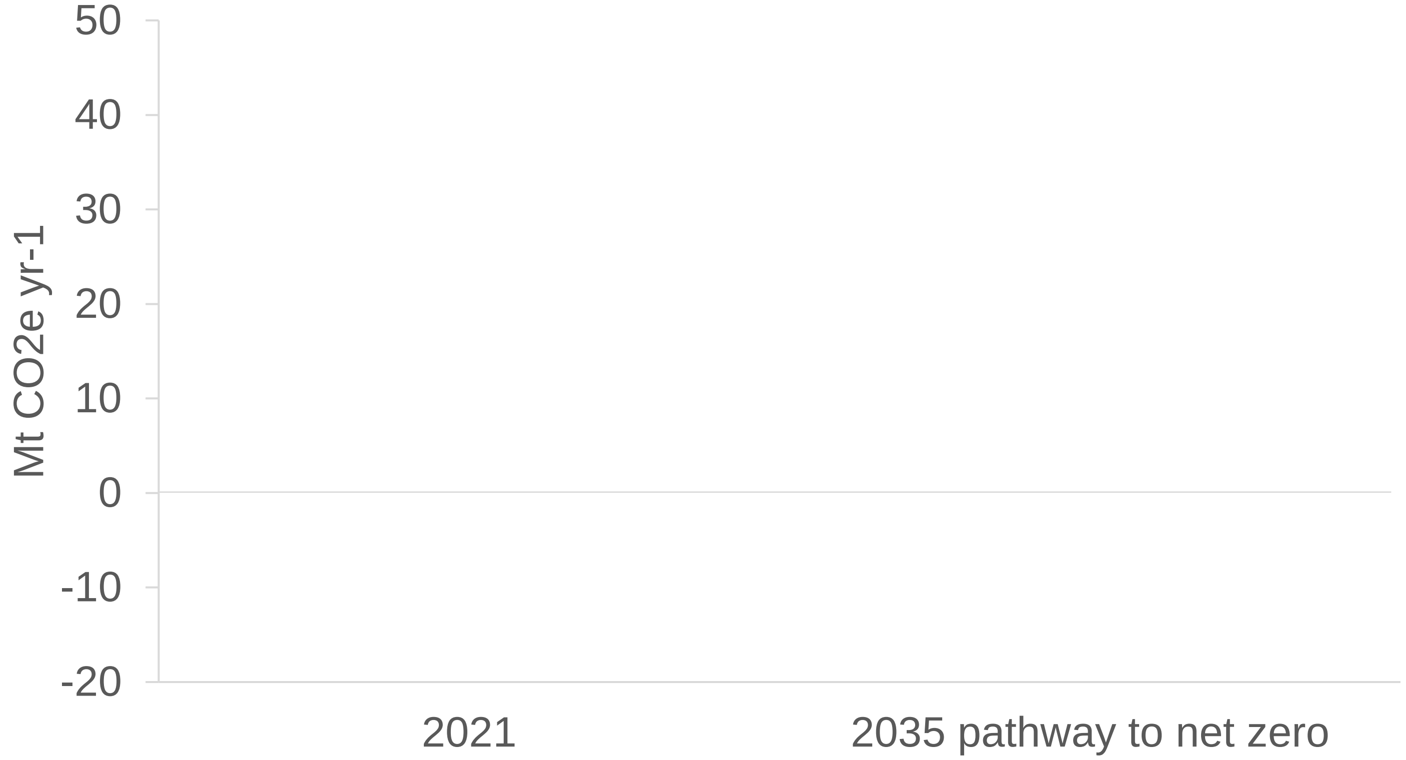

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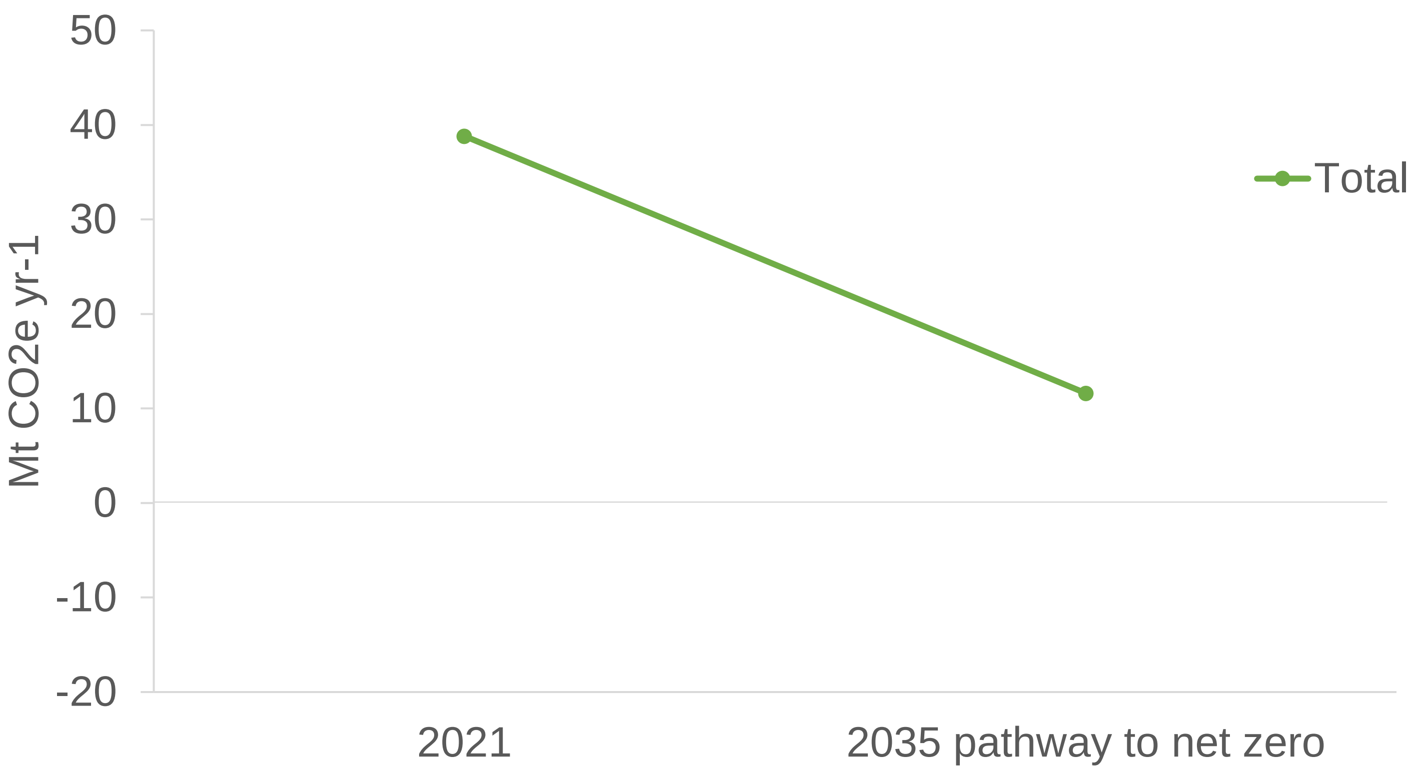

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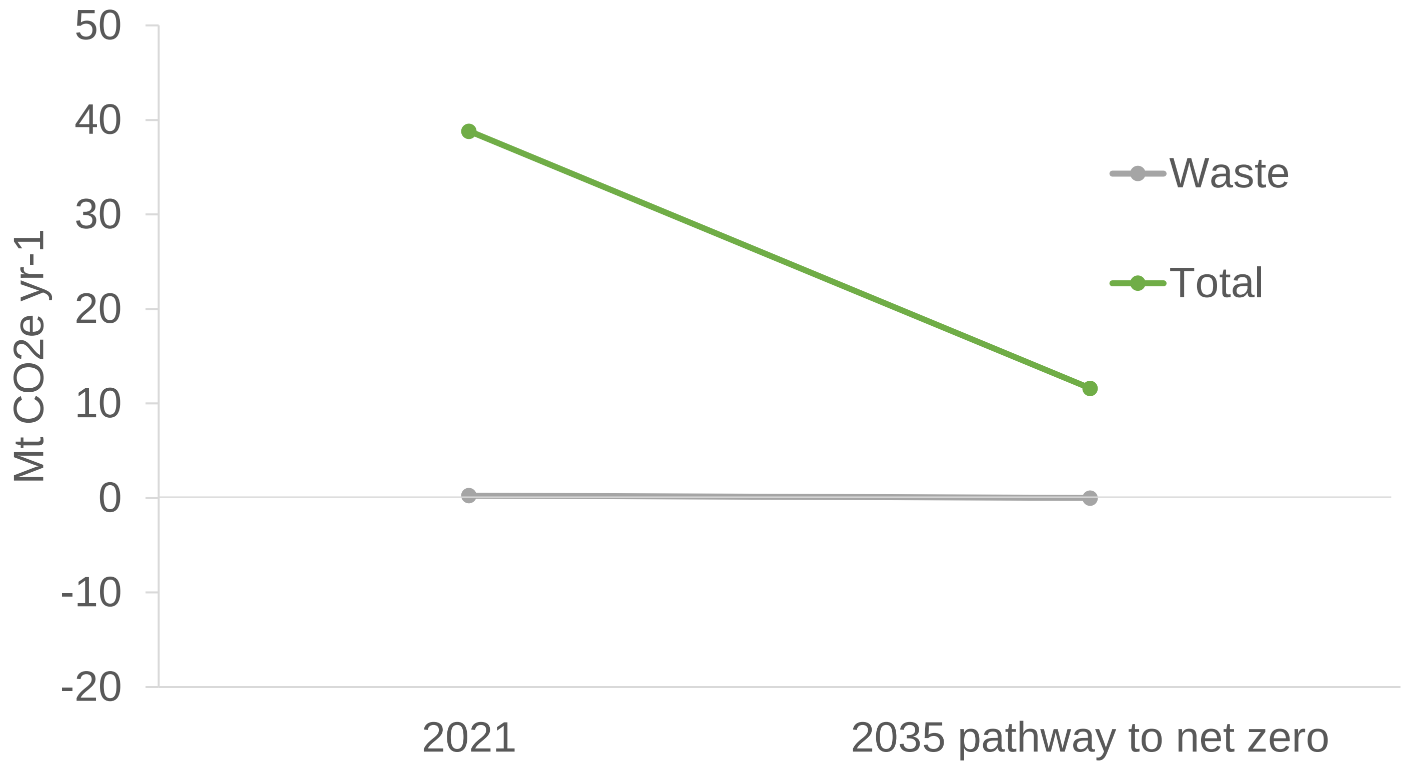
11.6 Mt CO_2e yr^{-1} total reduction in emissions



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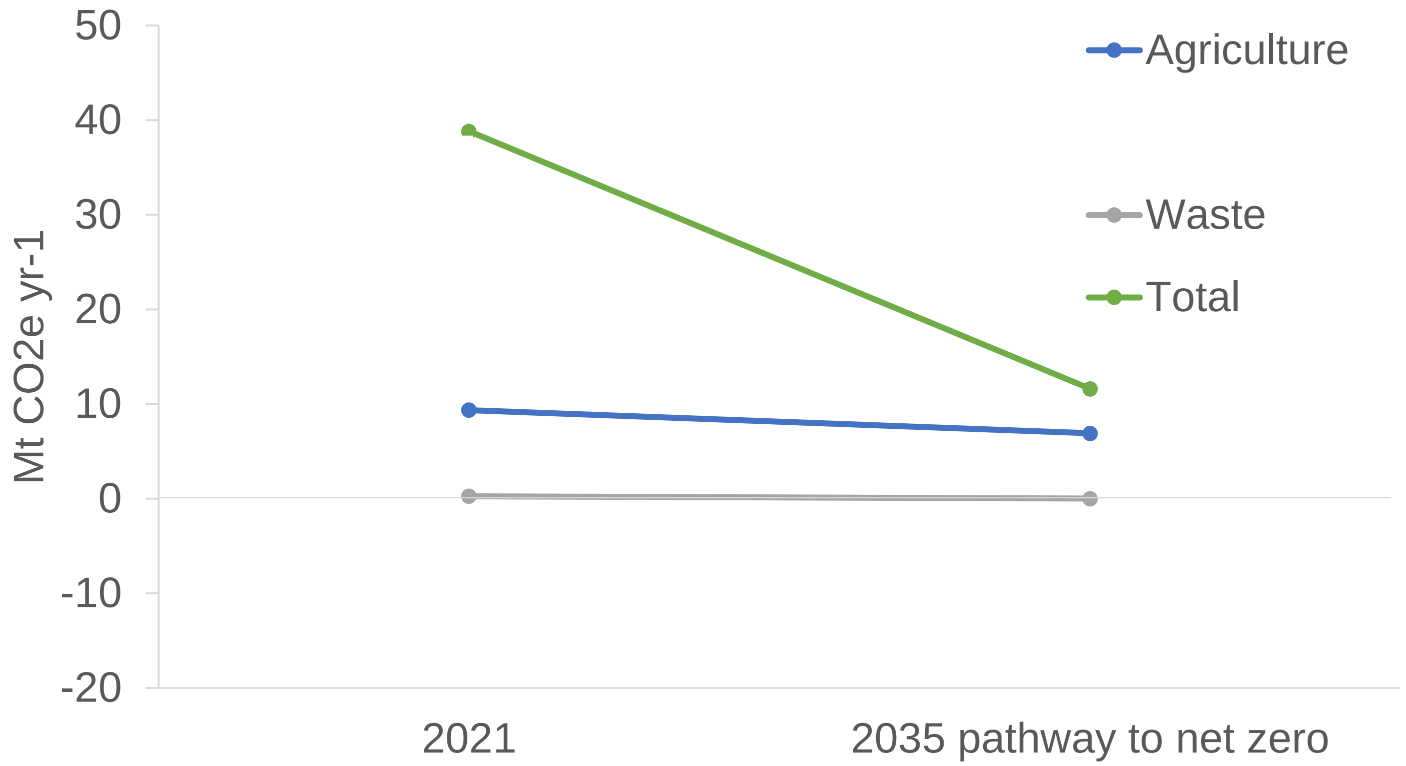

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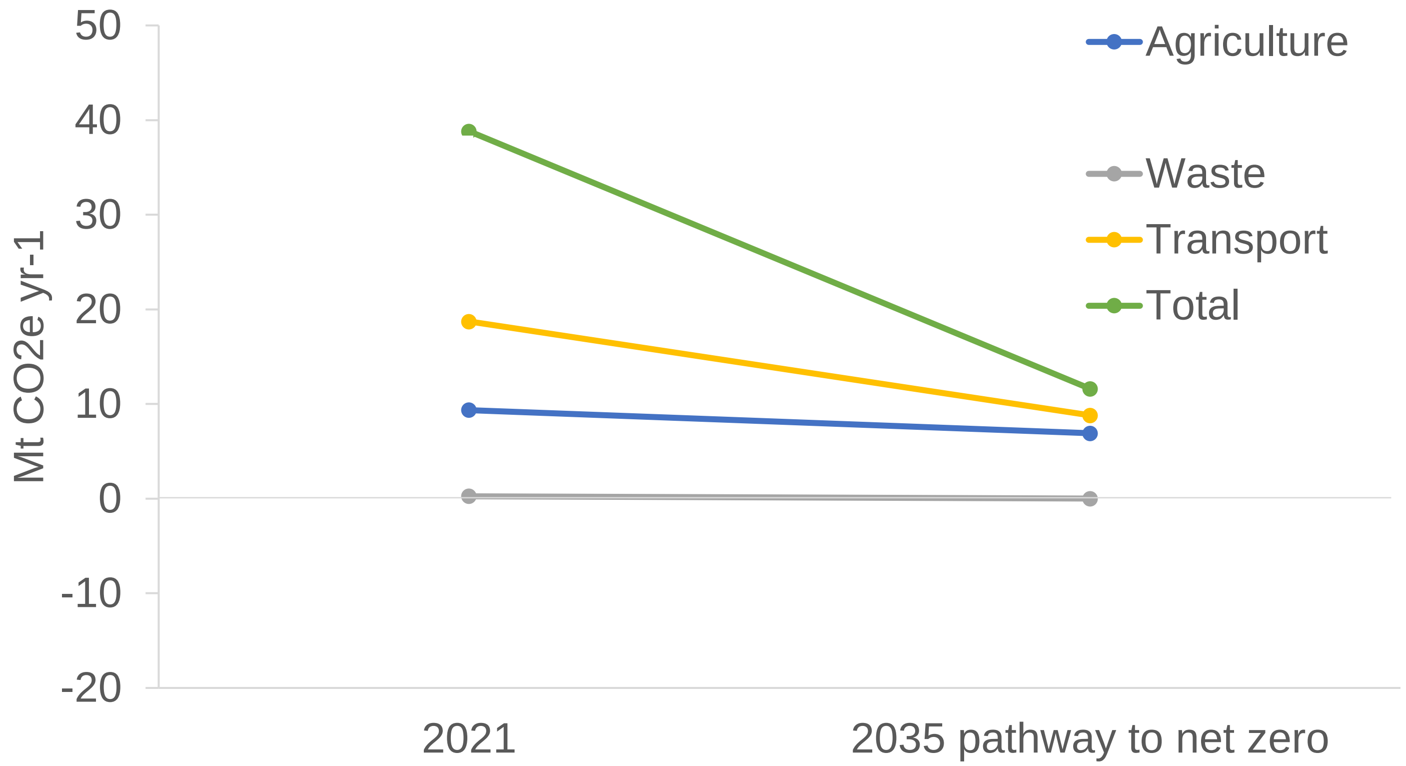

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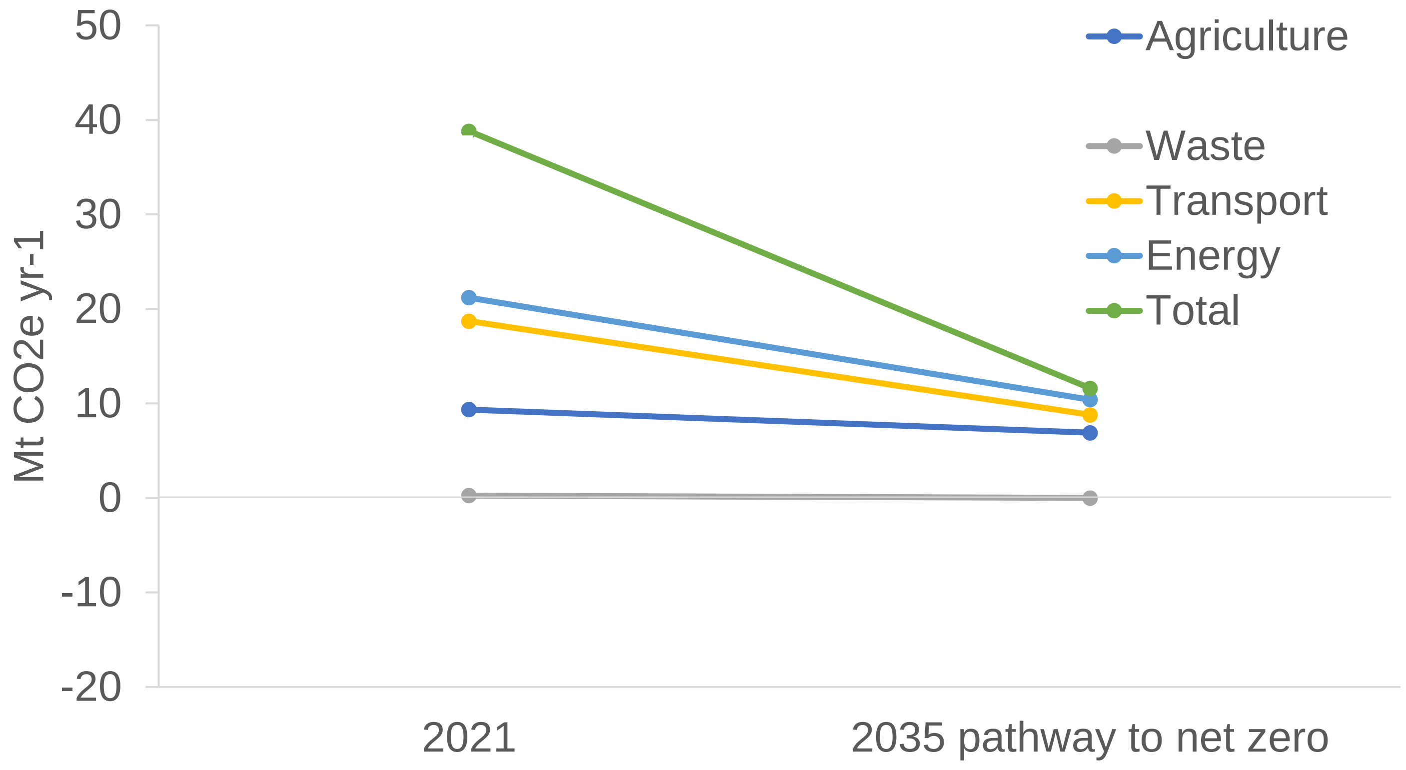

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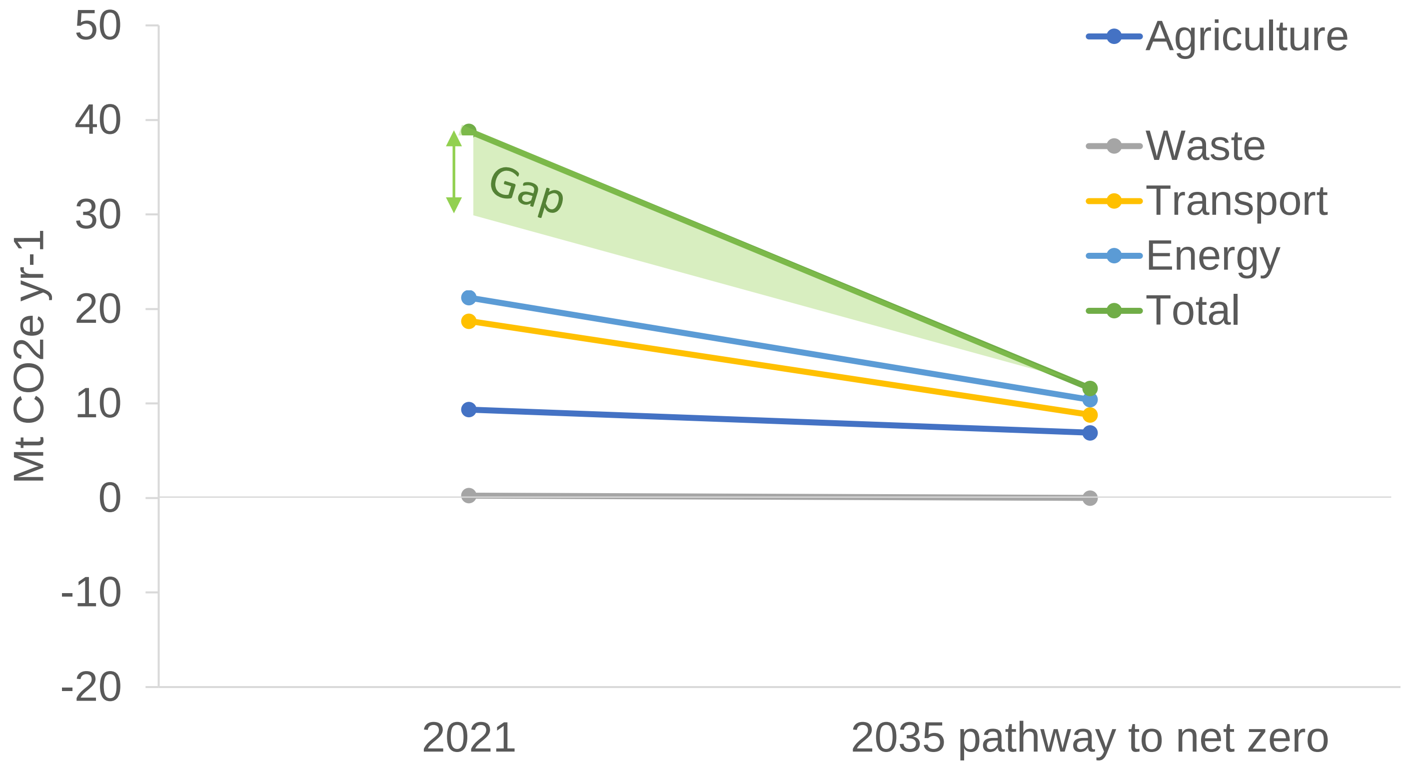

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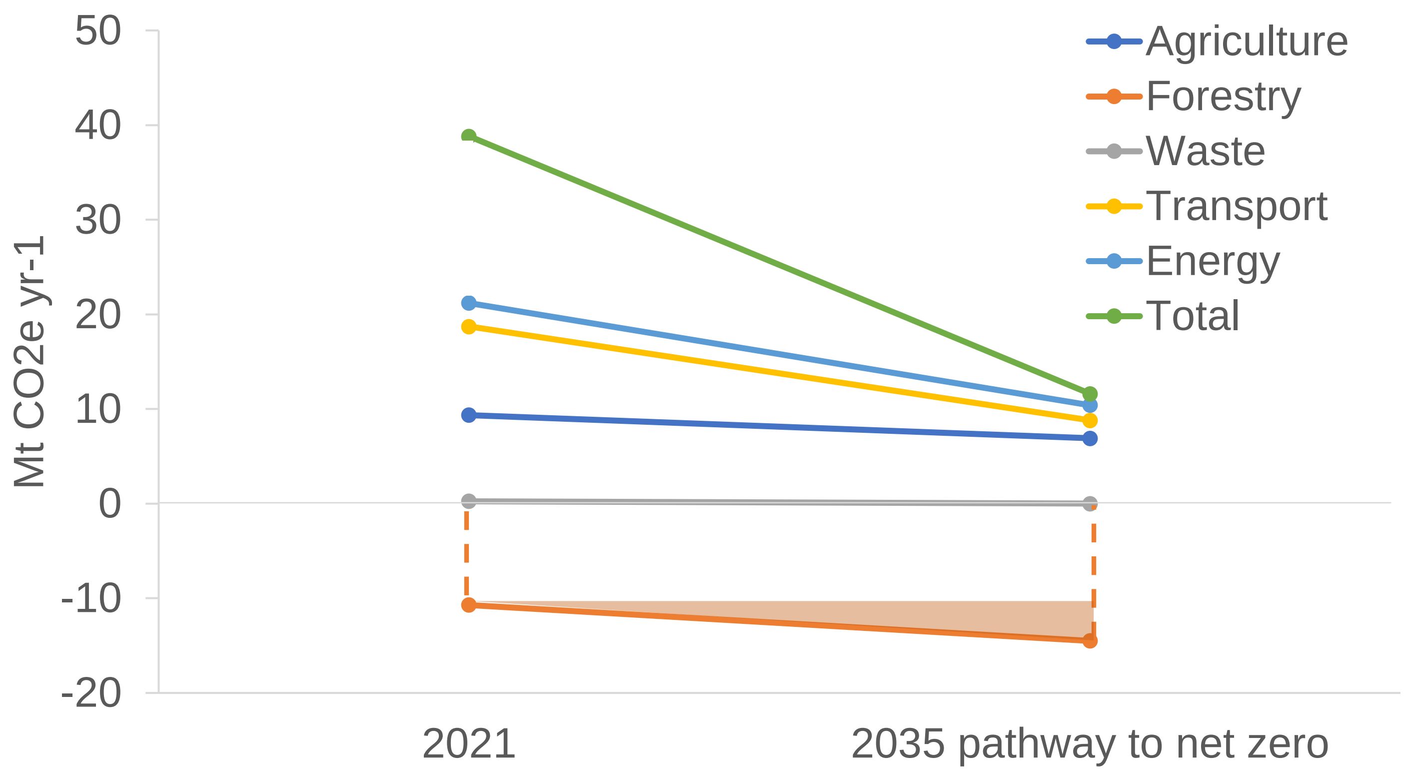

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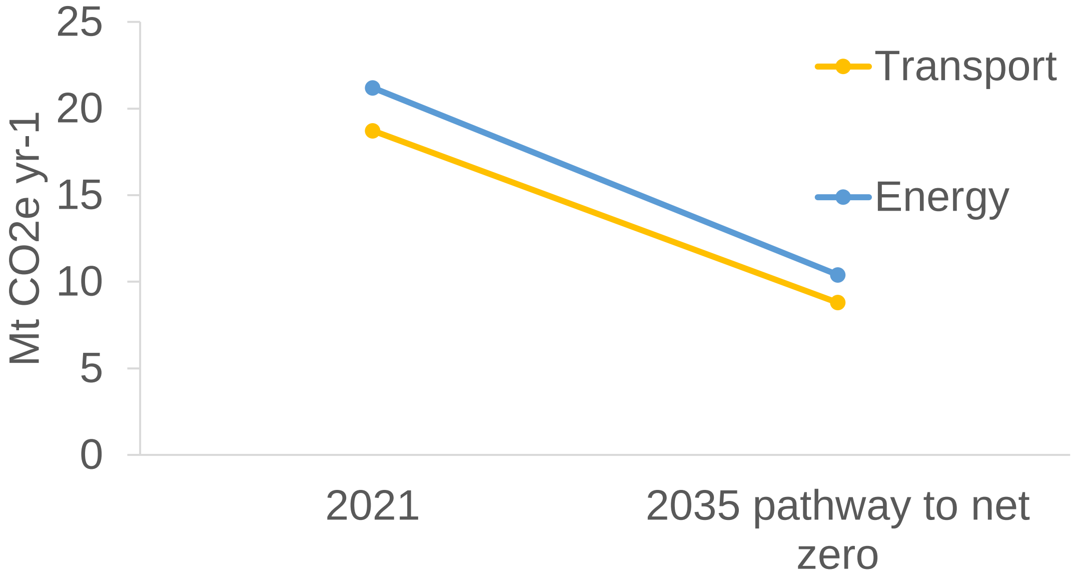

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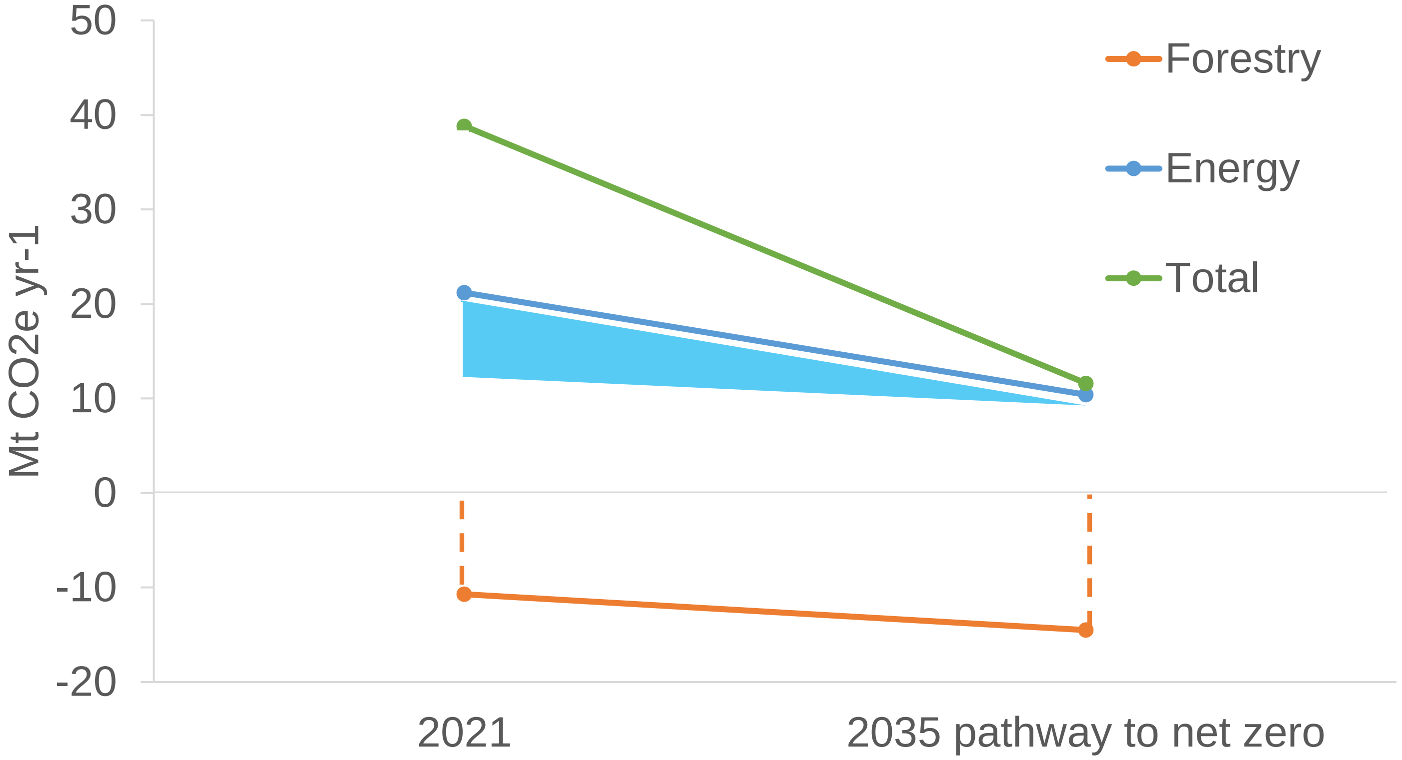
Sector	Current Bioenergy demand (PJ yr^{-1})	Bioenergy demand in 2035 (PJ yr^{-1})	Increase
Liquid biofuels	0.1[d]	9.5	9.4
Buildings heat[b]	9.0	9.0	0.0
Industrial heat[a]	0.5	12.0	11.5
Electricity generation	7.2	7.2	0.0
Total PJ yr^{-1} from biomass	**16.7**	**37.7**	**21**



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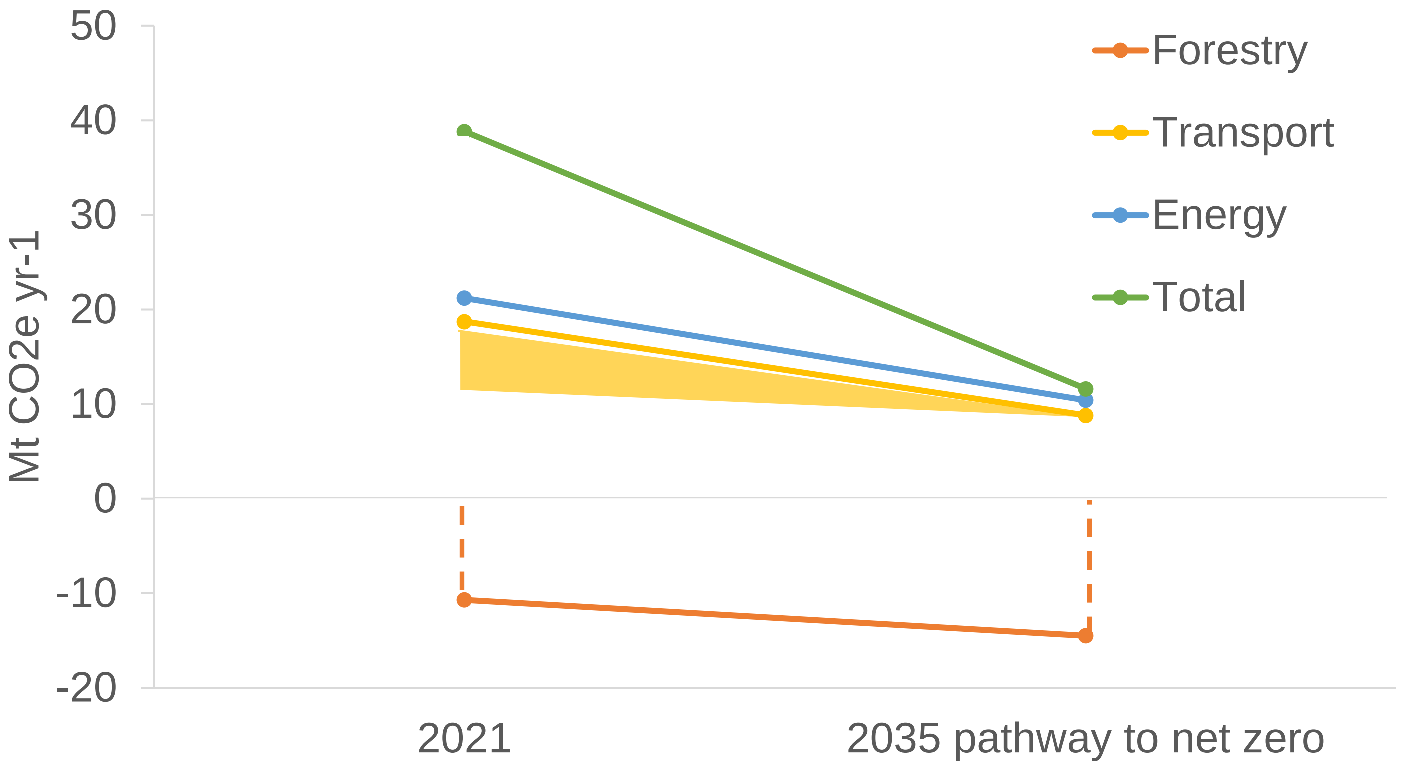

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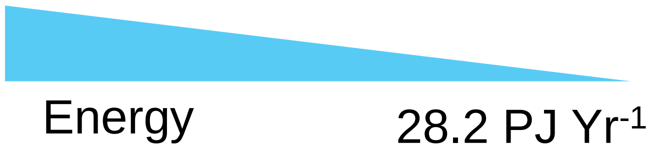

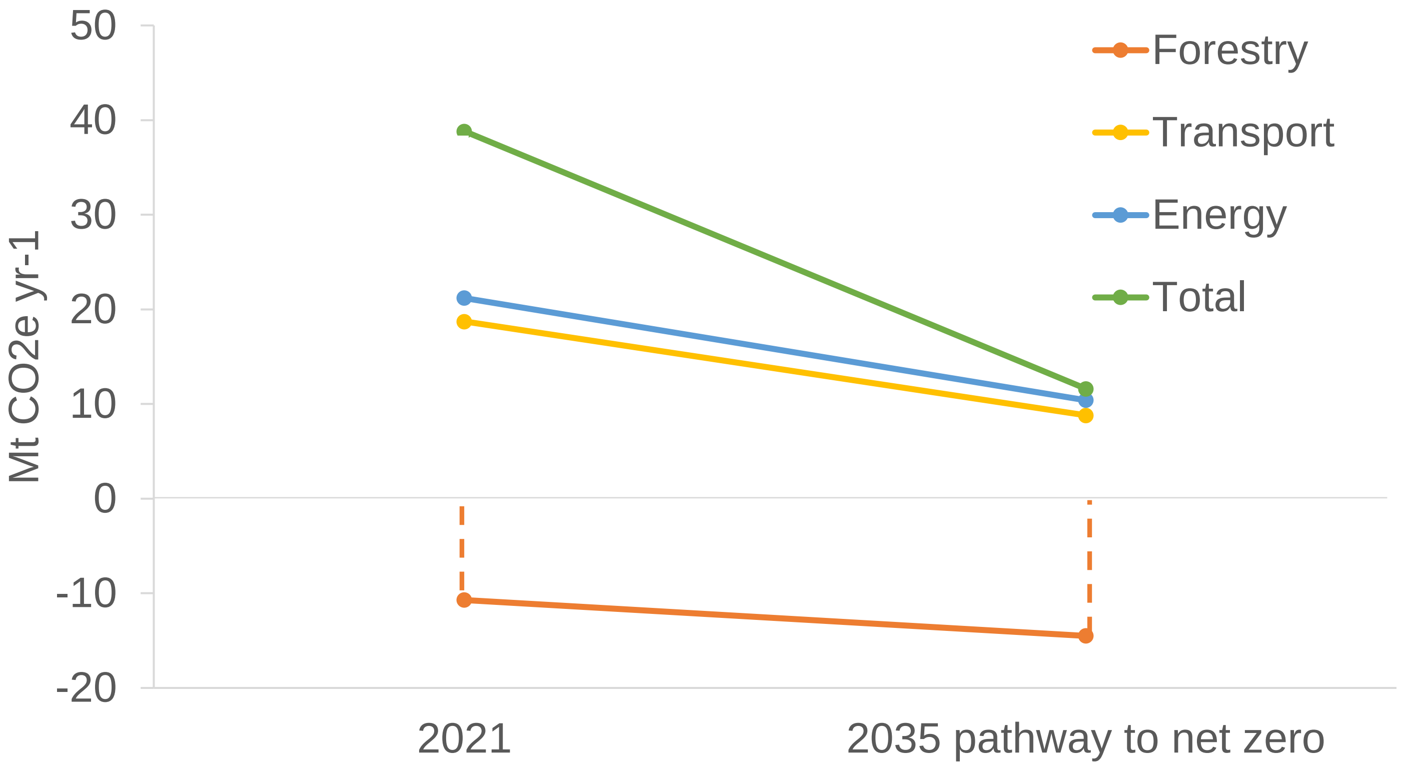

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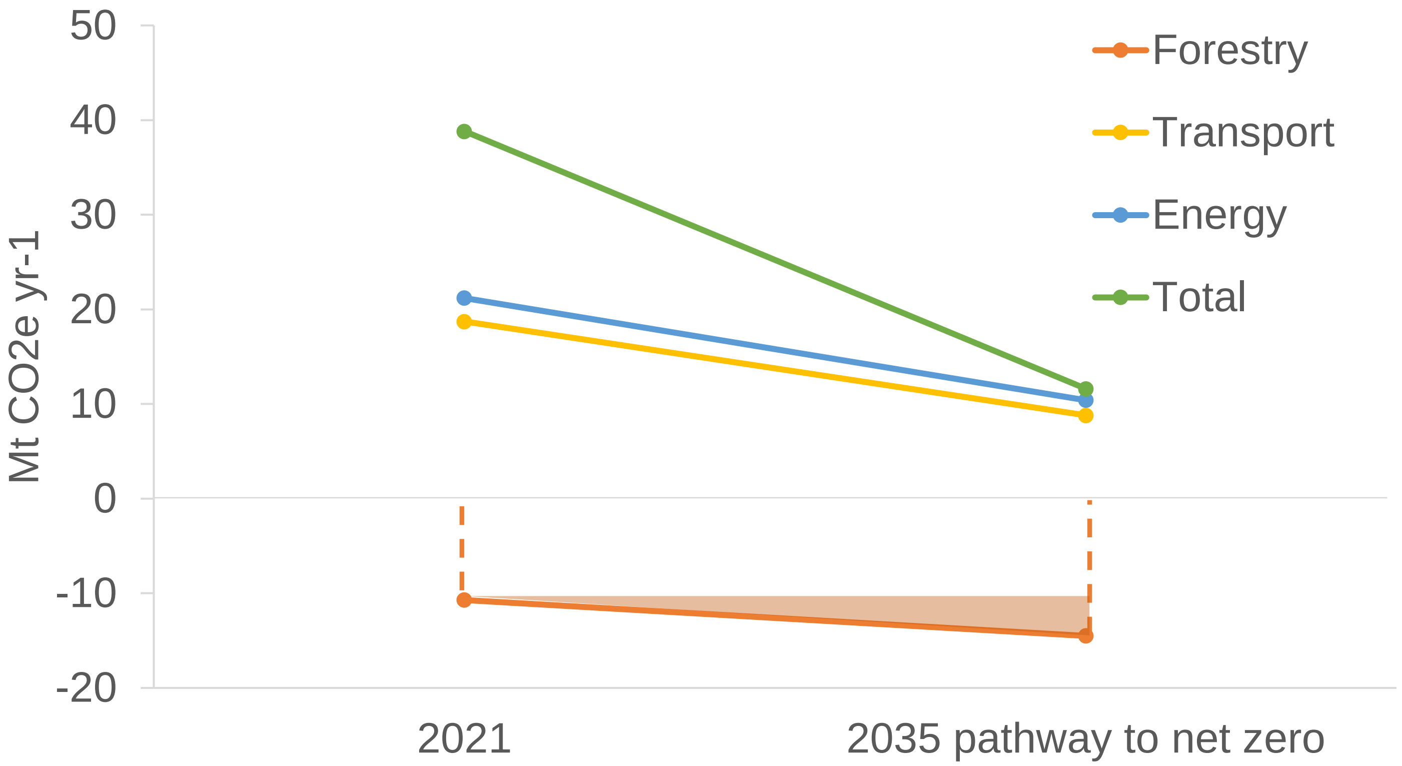
Energy 28.2 PJ Yr^{-1}

Transport 9.5 PJ Yr^{-1}



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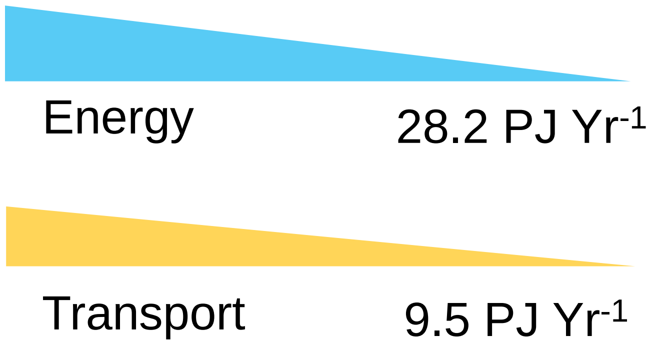

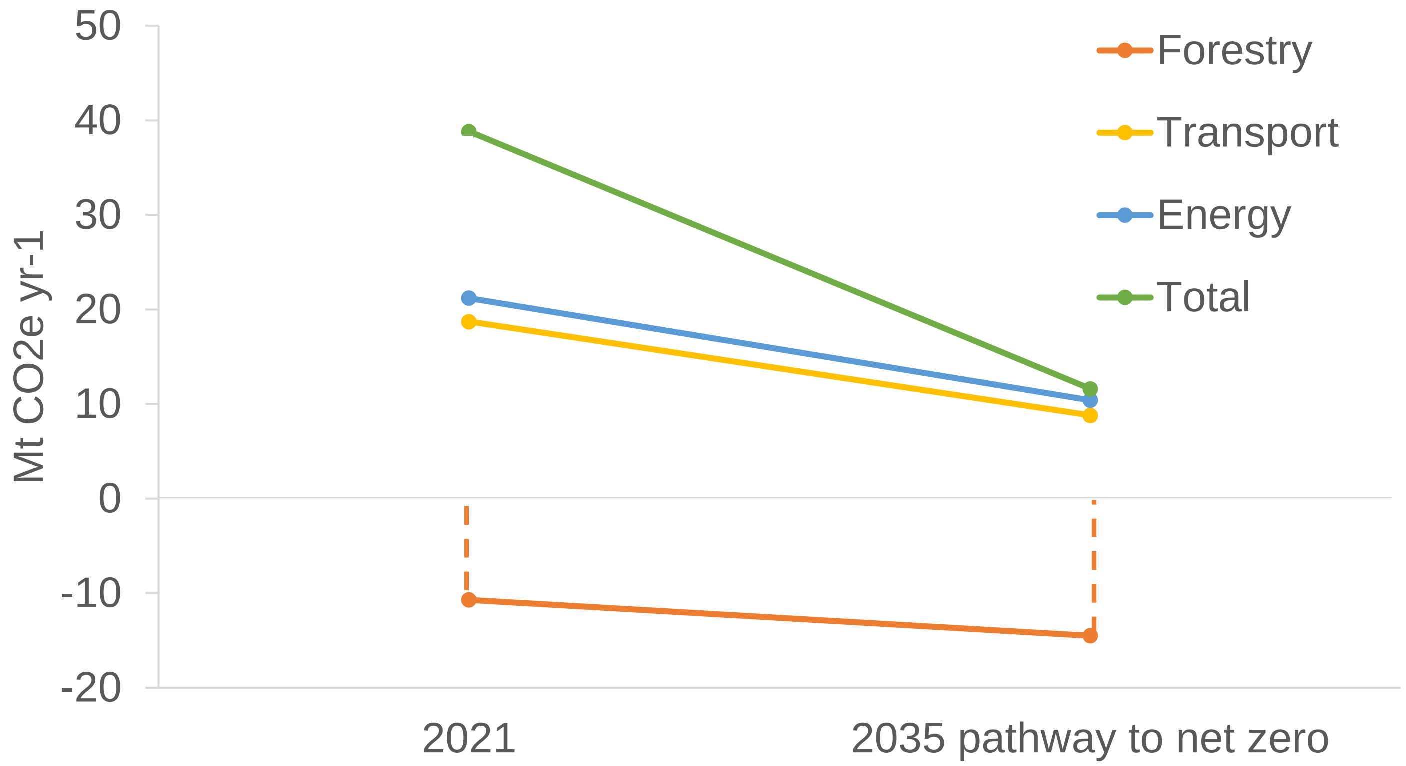

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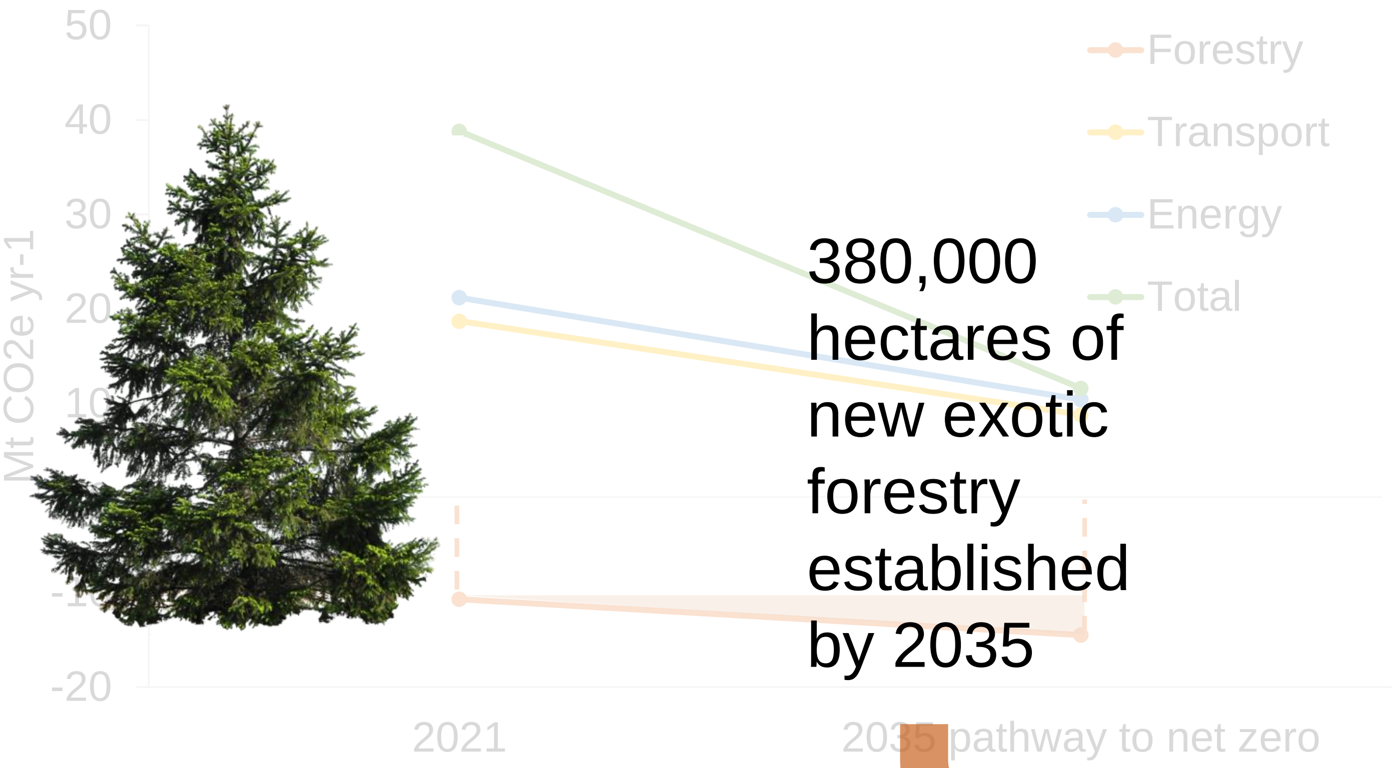
Energy 28.2 PJ Yr^{-1}

Transport 9.5 PJ Yr^{-1}

Forestry -14.5 Mt CO_2^e yr^{-1}



380,000 hectares of new exotic forestry established by 2035

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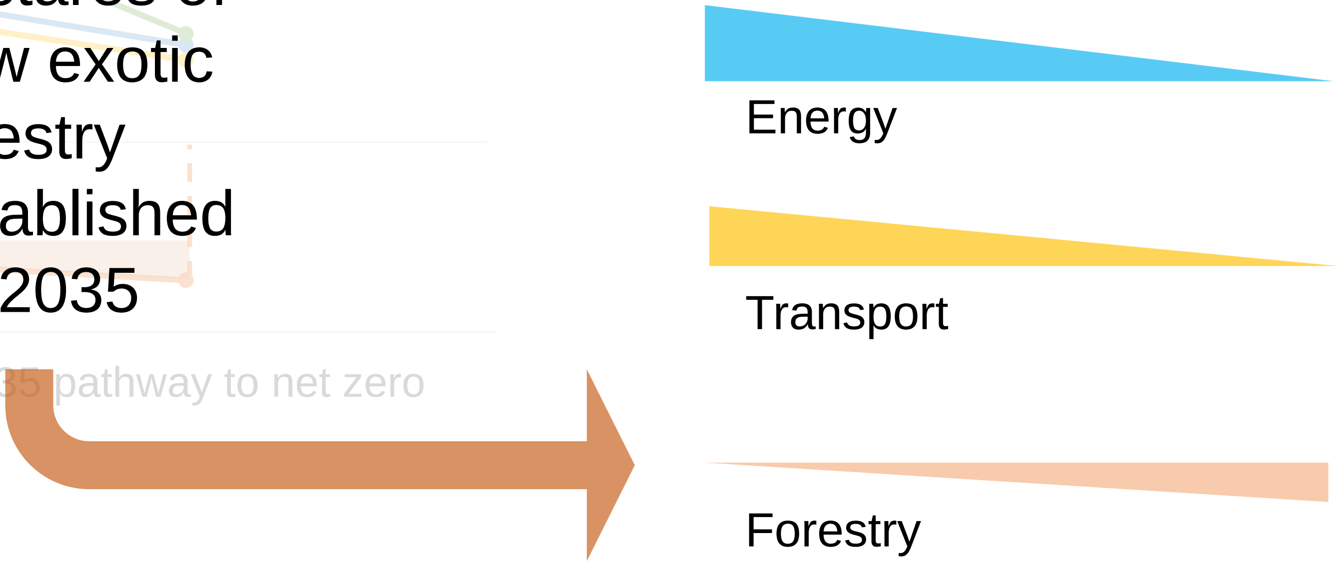

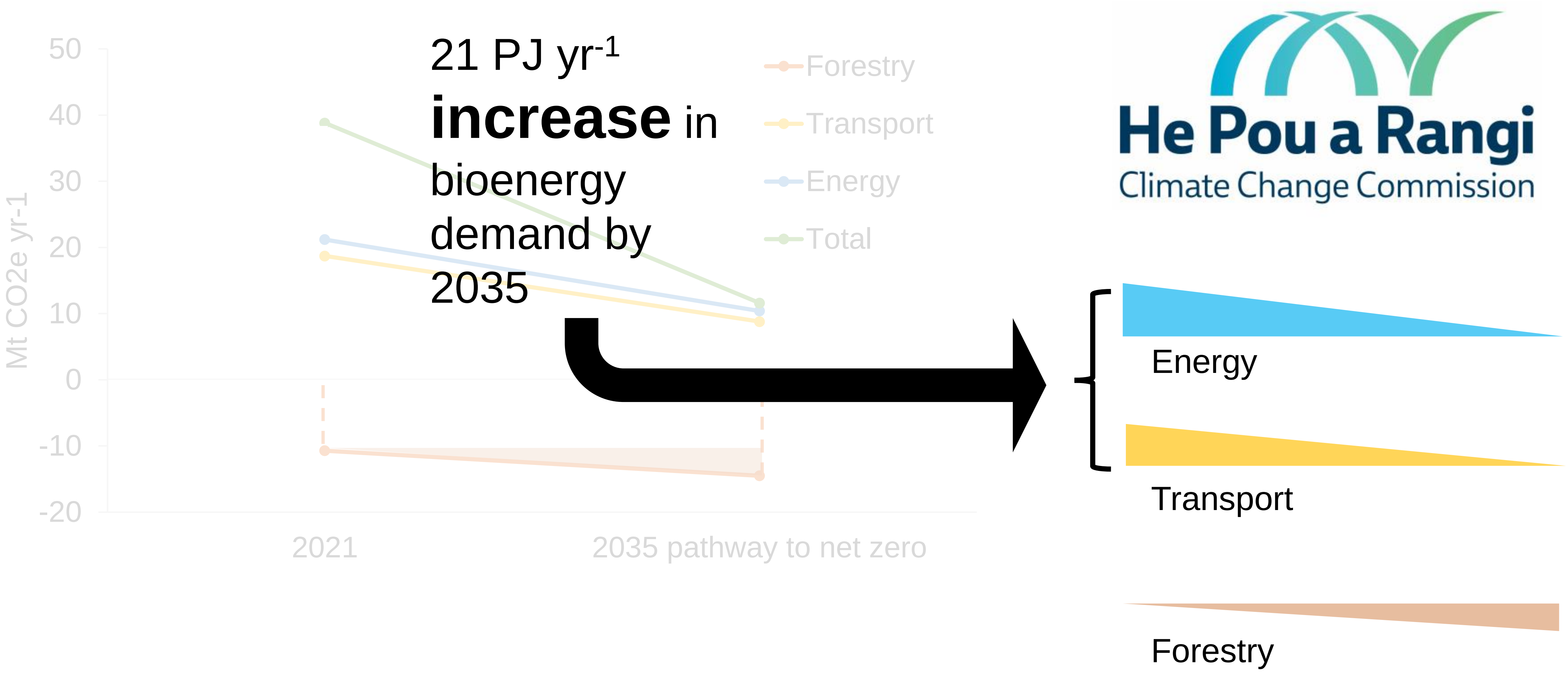
21 PJ yr-1
increase in bioenergy demand by 2035
50
40
30
20
10
0
-10
-20
Mt CO2e yr-1
2021
2035 pathway to net zero
Forestry
Transport
Energy
Total
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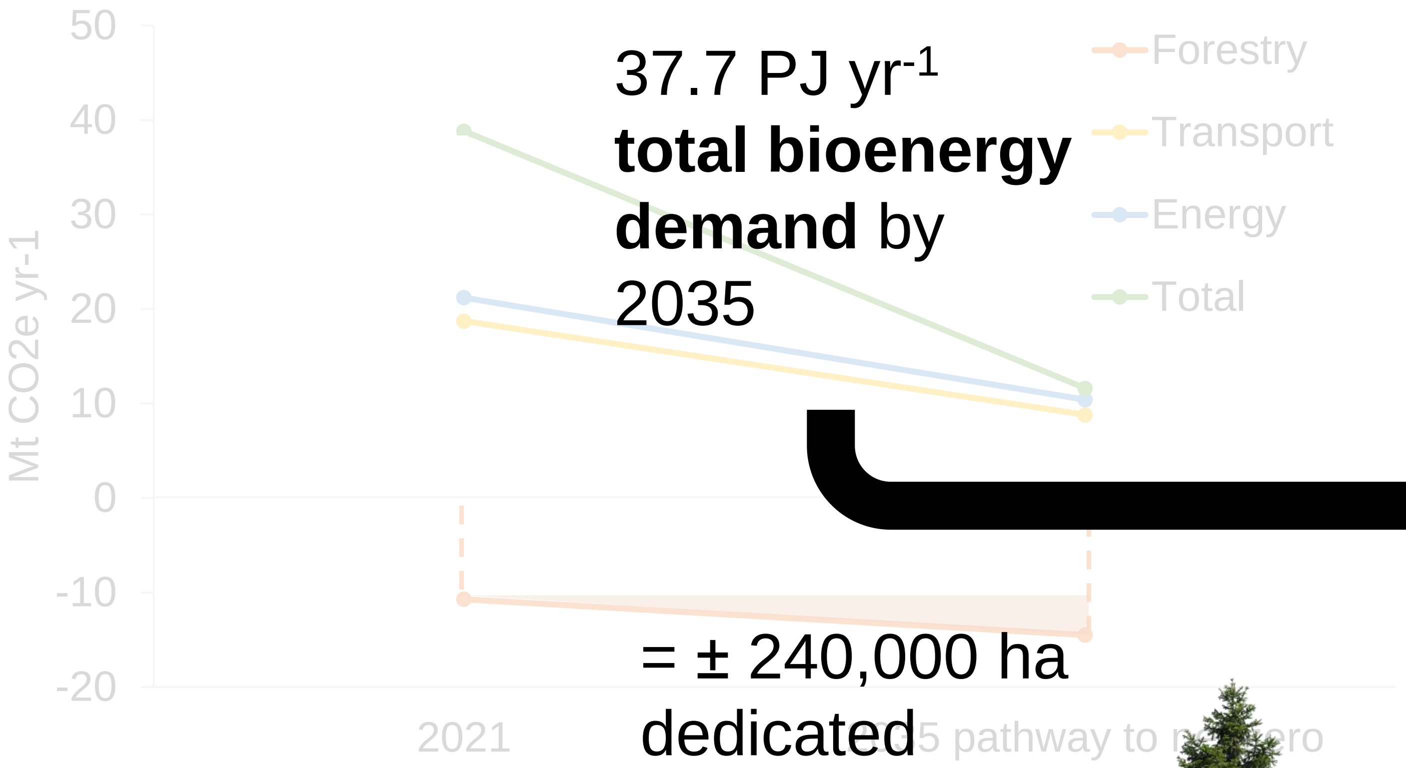
Energy
Transport
Forestry



37.7 PJ yr^{-1}
total bioenergy demand by 2035

= ± 240,000 ha dedicated bioenergy forest

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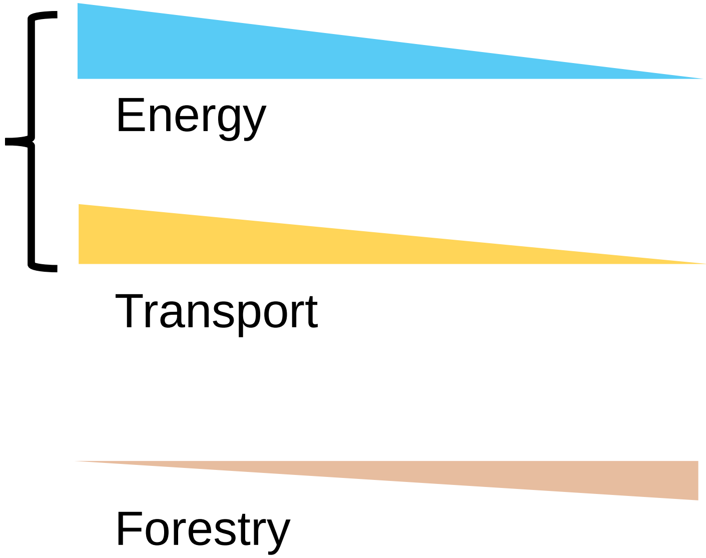
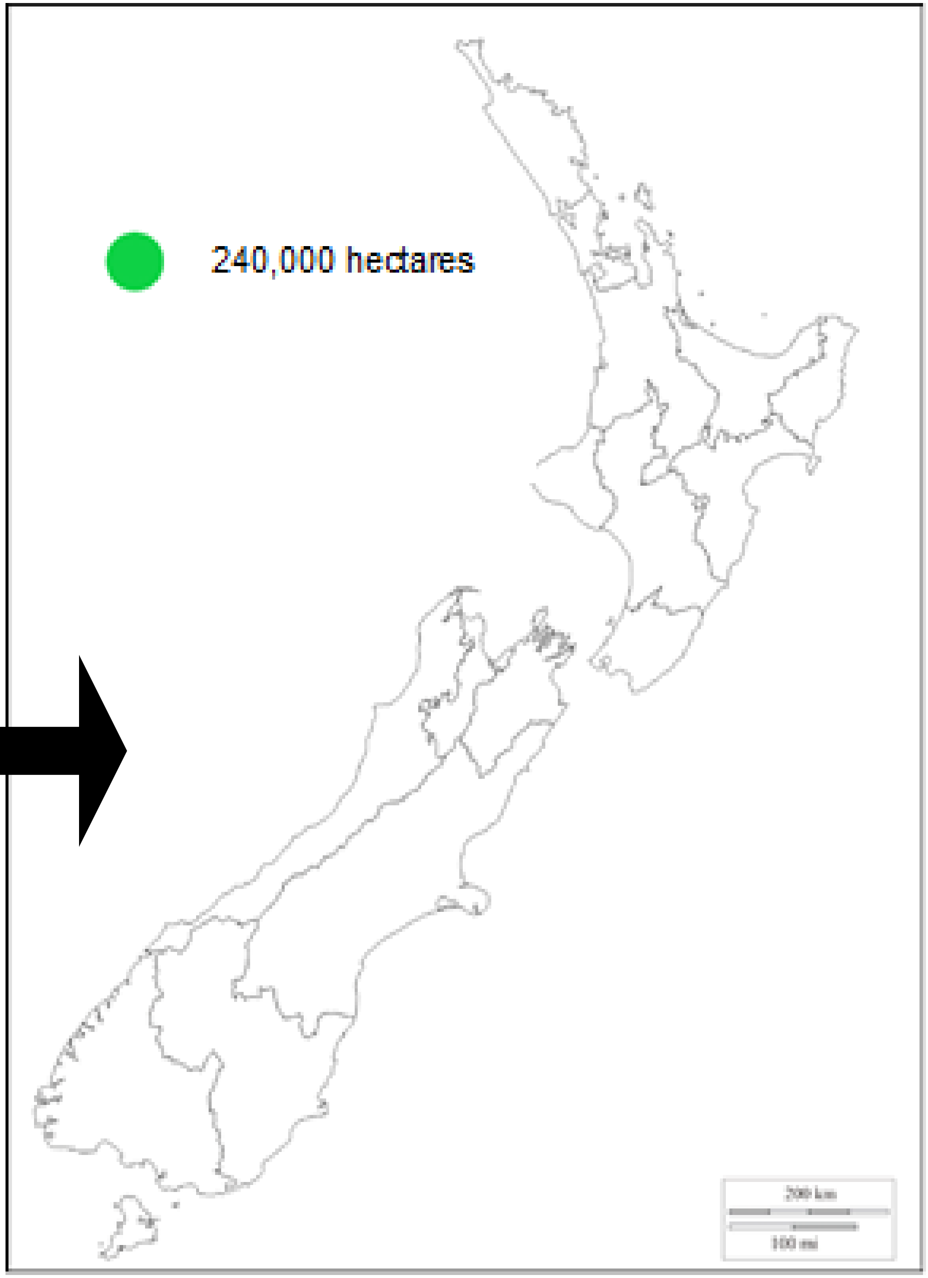
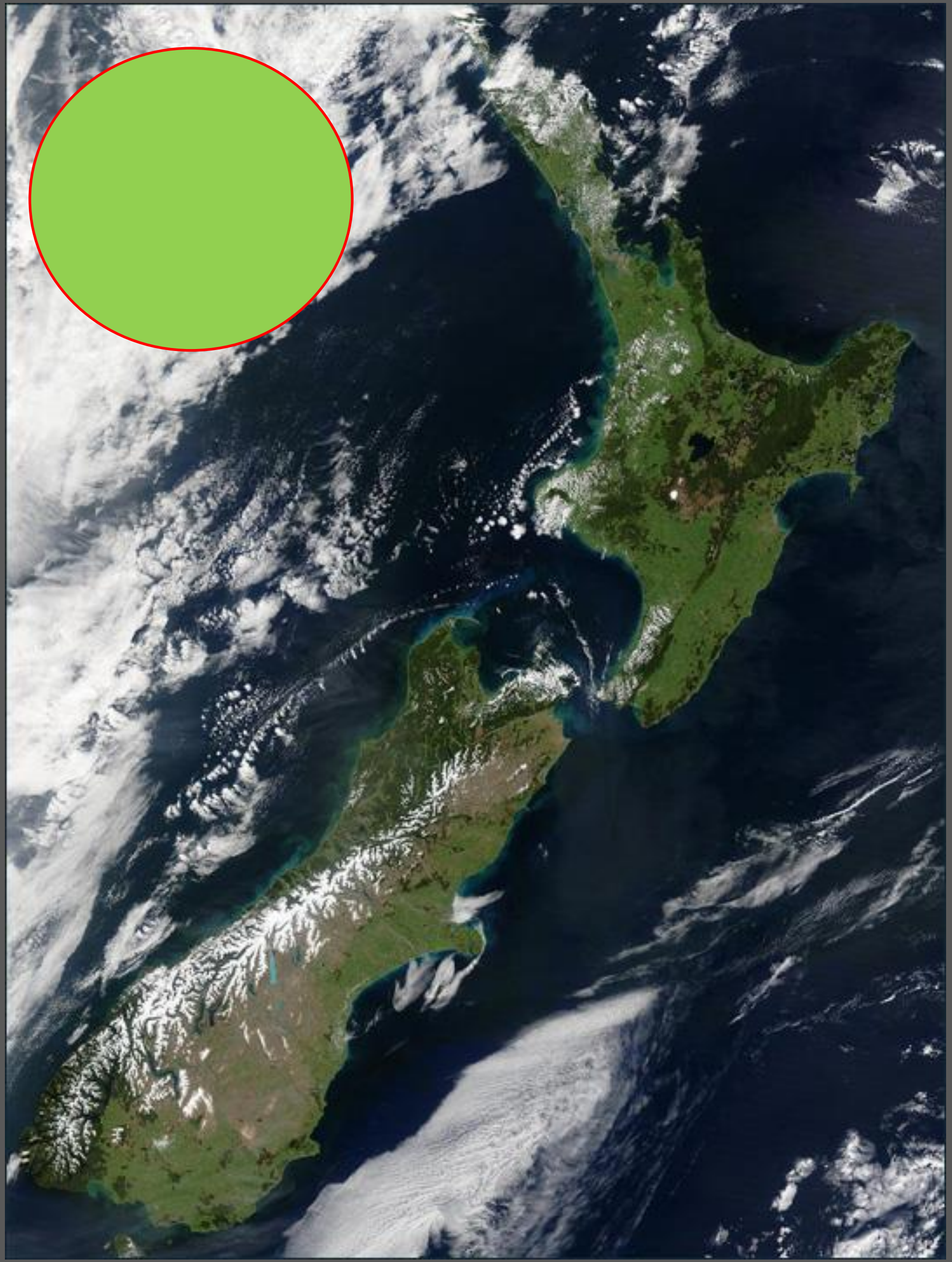


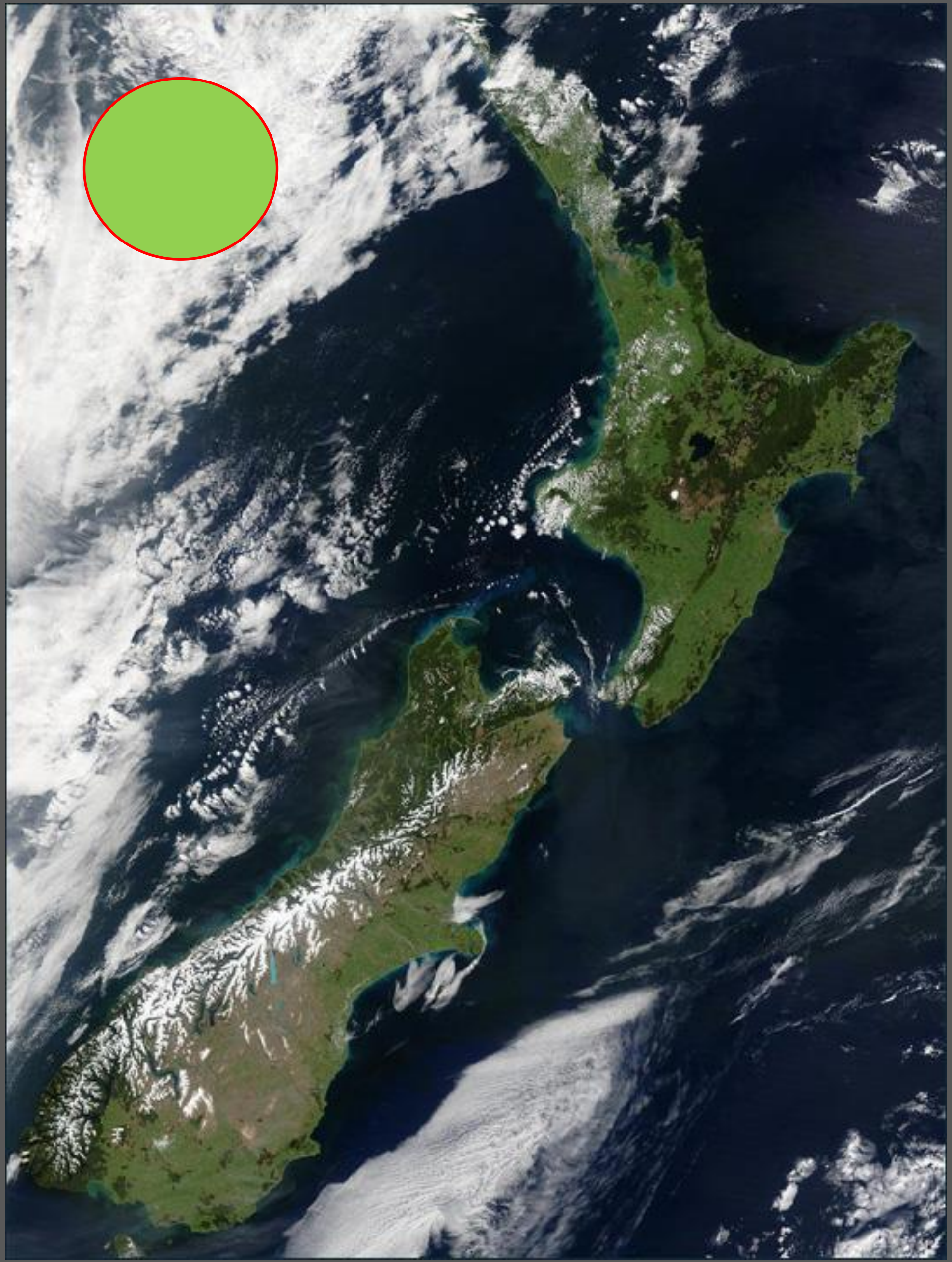
37.7 PJ yr^{-1}
total bioenergy
demand by
2035

= ± 240,000 ha
dedicated
bioenergy
forest …or
133,000 ha
(low end)

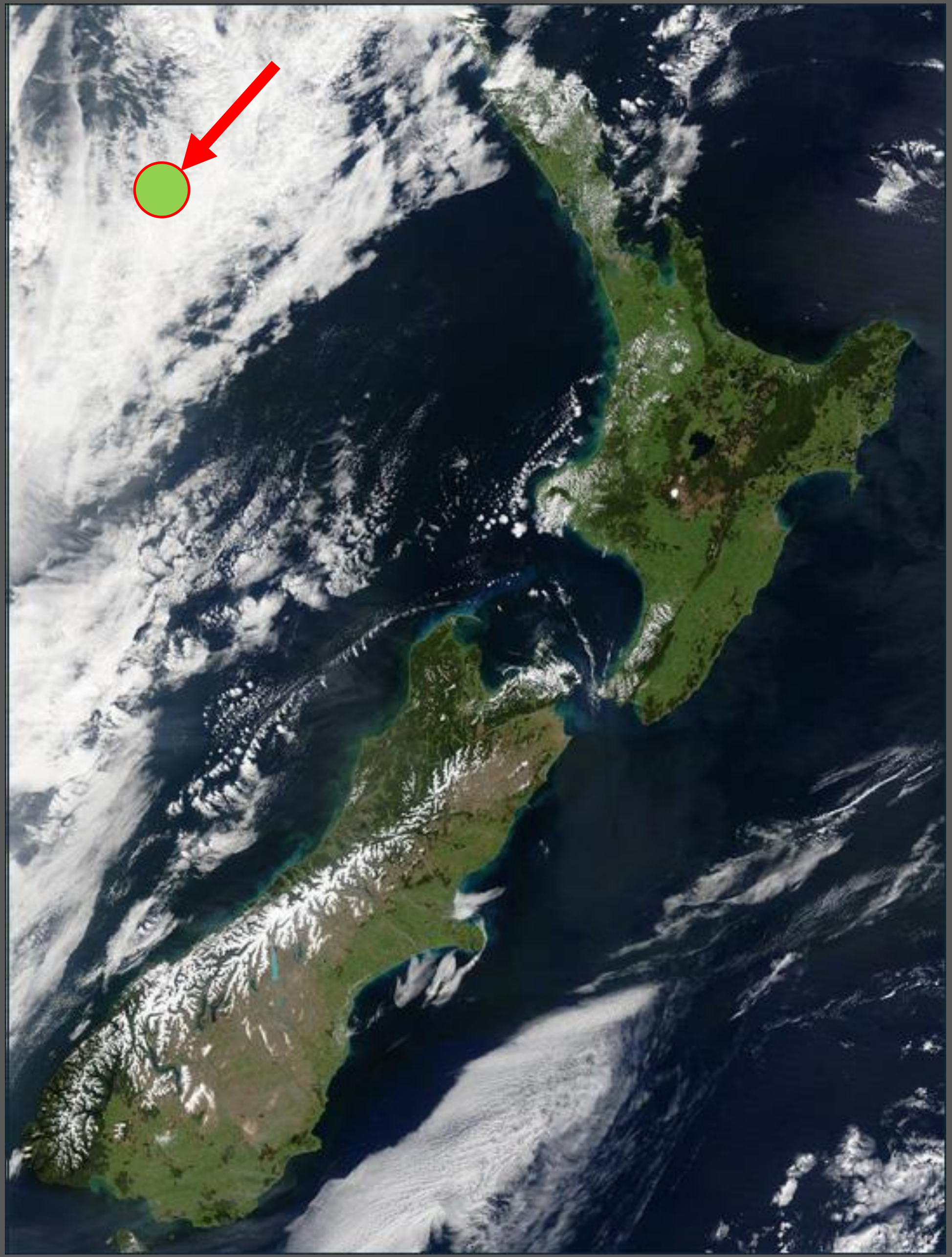




Sheep and beef farms cover 9 M hectares of NZ = 1/3 of land area



3.6 M hectares biofuel forests = NZ’s total coal, oil and gas requirement
= 13 % land area



Climate Change Commission proposal =
± 240,000 ha
<1 % land area

Challenges set by the Climate Change Commission

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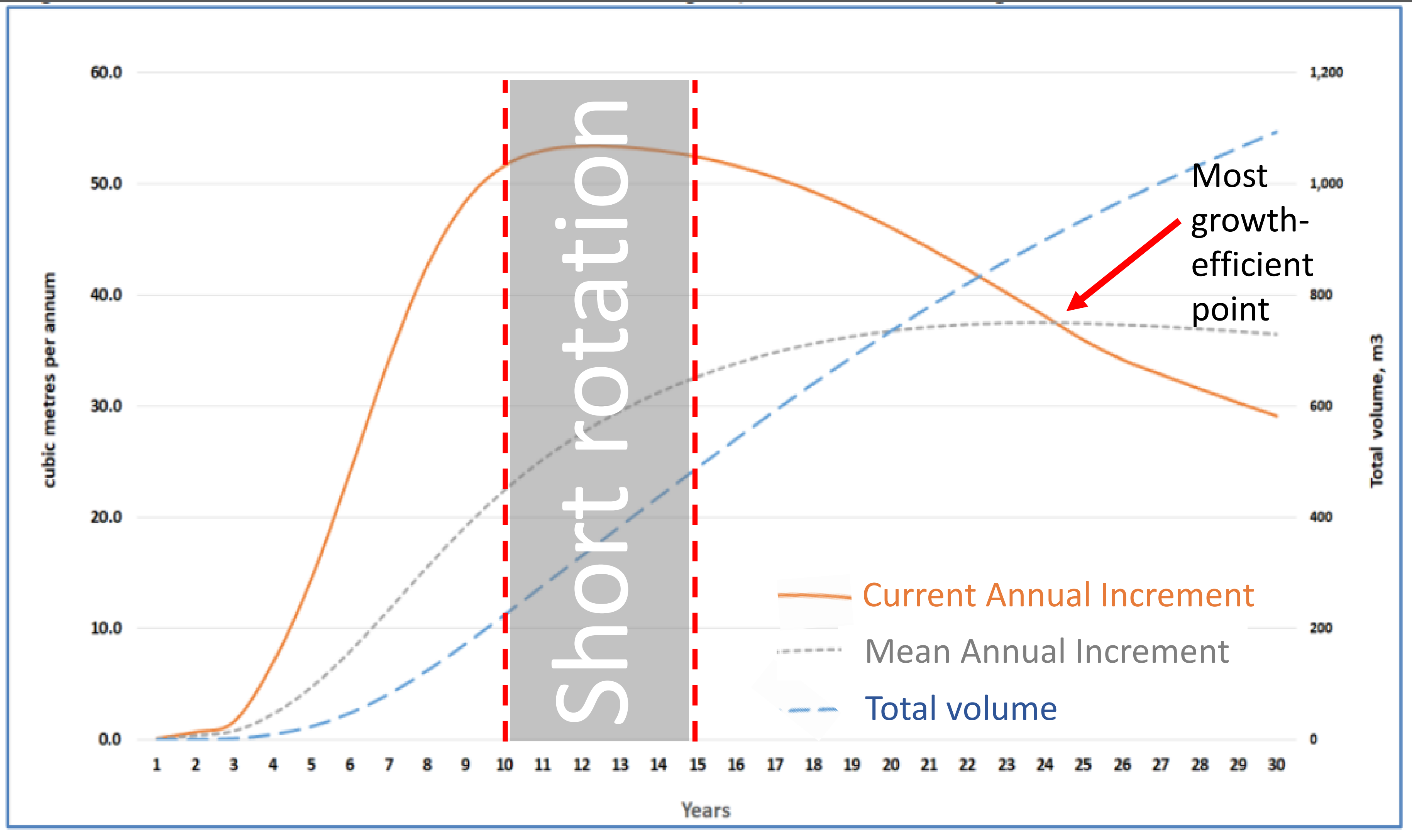
- Massive upscaling of bioenergy generation needed from environmentally sustainable sources
- ‘Net Zero’ track to be met by 2035
- Less than **15 years** to bring bioenergy feedstocks online

Solution

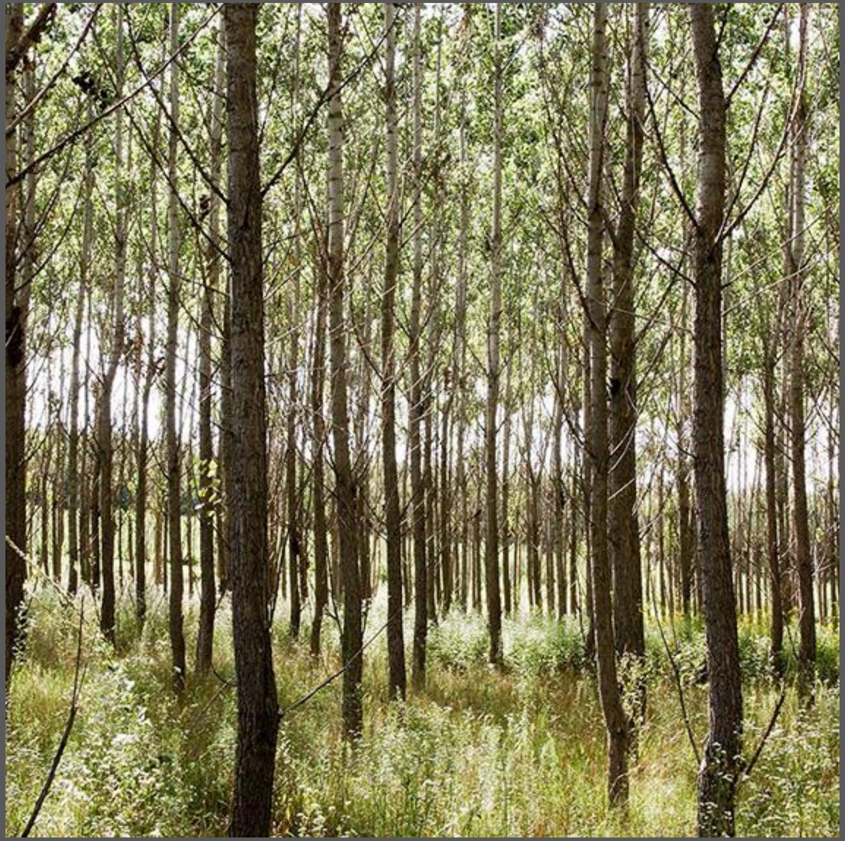
- Short rotation bioenergy forestry

Short rotation harvest regime **challenge**



low relative growth efficiency

Solution: high stocking densities + fast-growing species



Typically 1,000 – 1,500 stems ha^{-1}

Challenge:

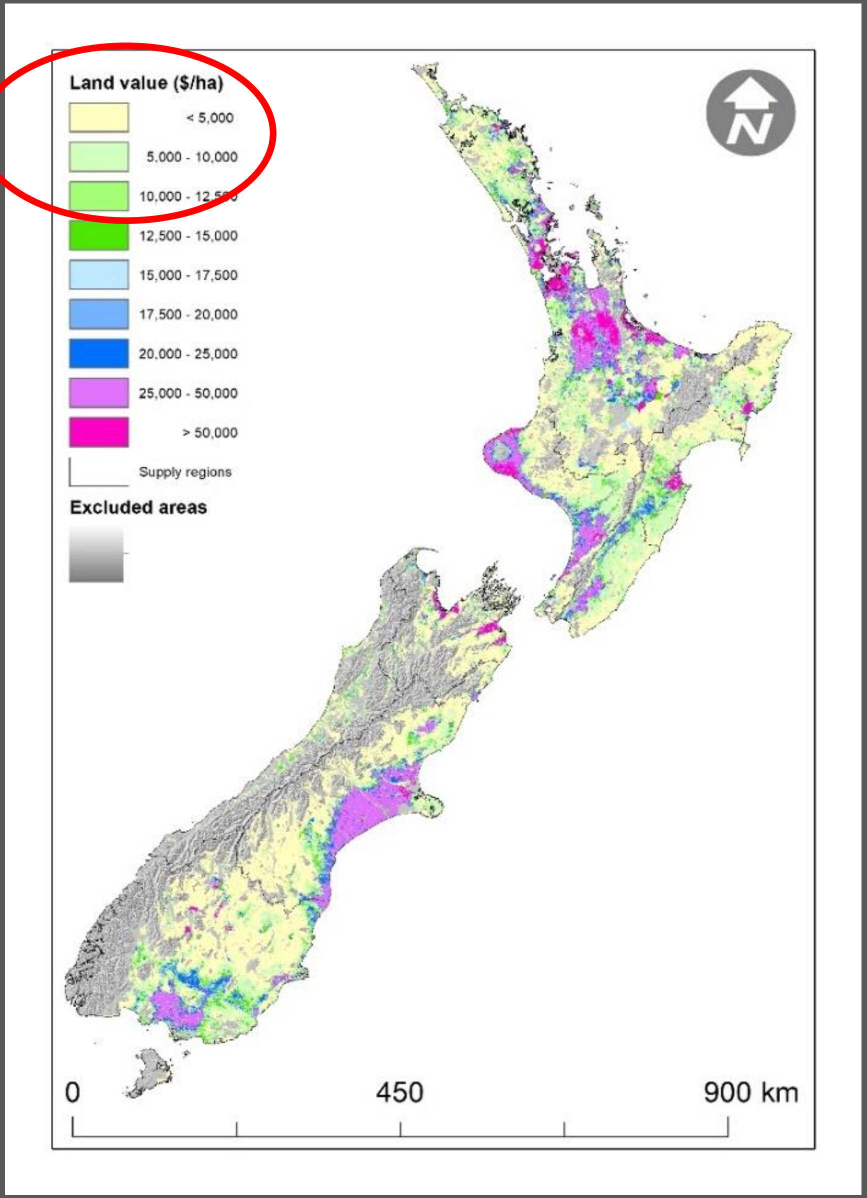
Potential low profitability of bioenergy forestry

- Returns (at current market rates) are low
- Reduce land costs
- Reduce harvesting costs
- Reduce transport costs

Challenge:

Need to avoid conflict with food production

Solution: Land Use Capability Class 5-8 land

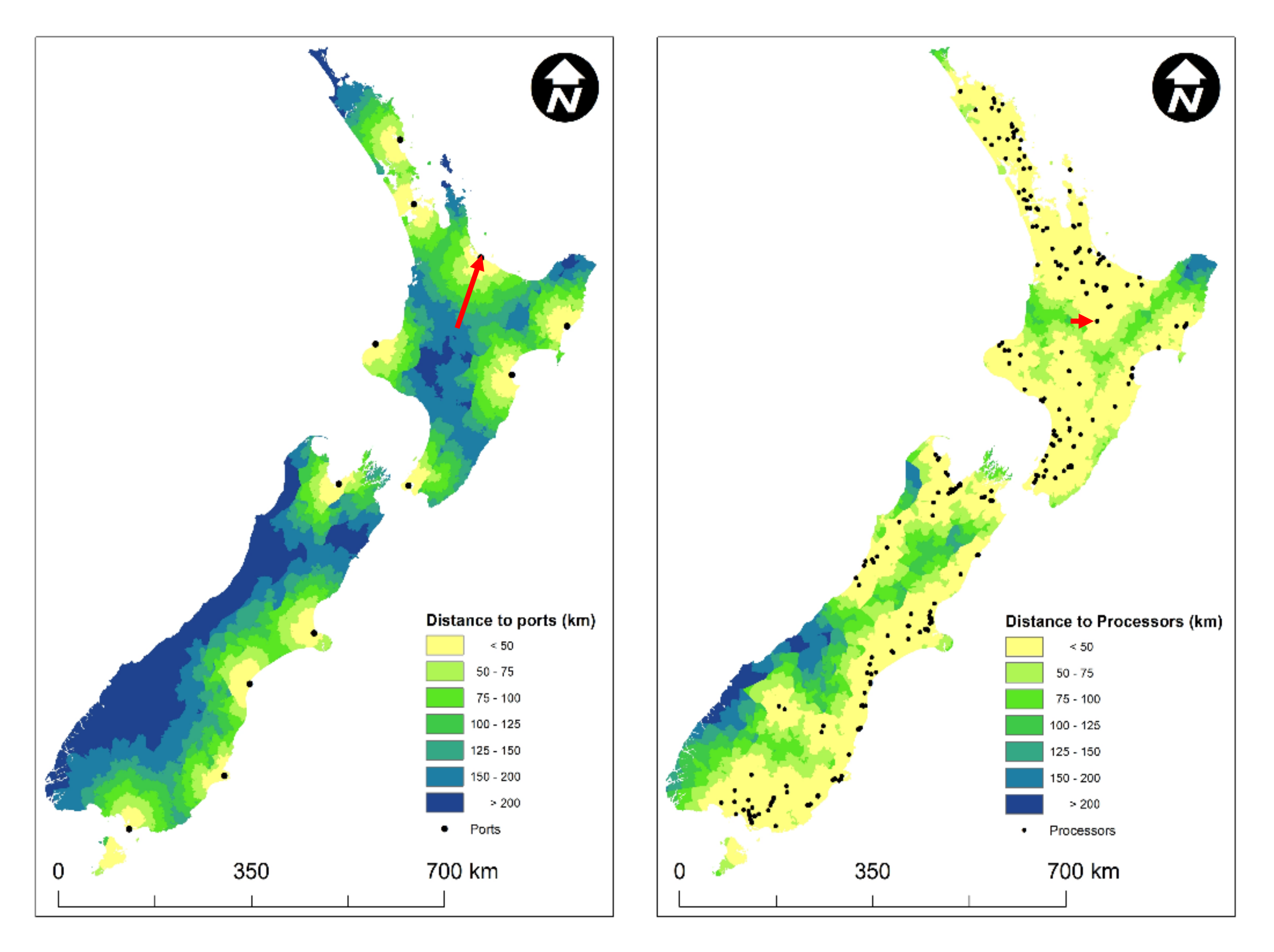


Hill country

Challenge: Erosion risks and harvesting challenges

Some risks can be mitigated by careful design, management and automated technology

Challenge: transport costs

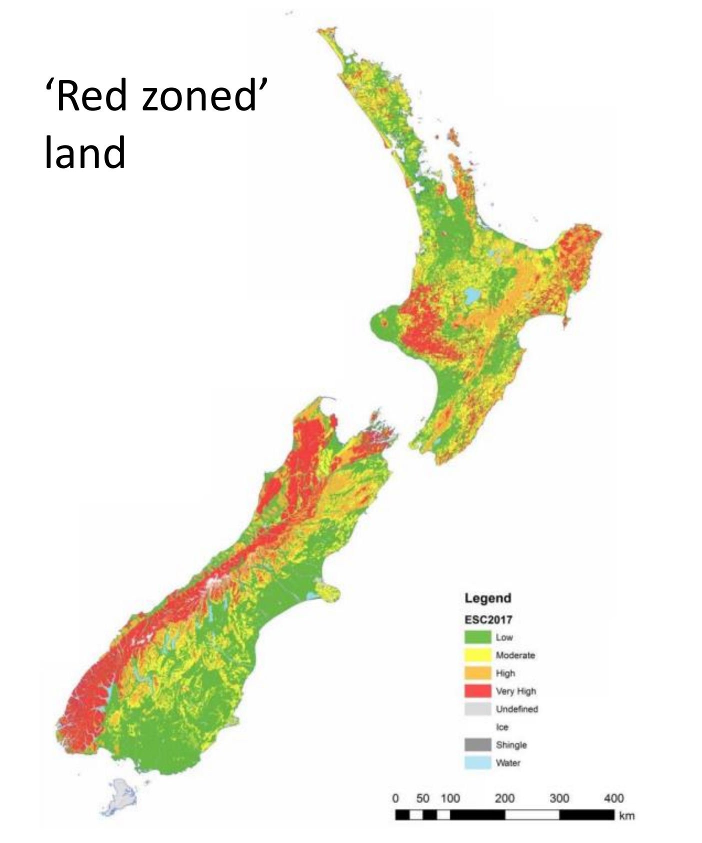


Distance-to-processing centres for ports and major wood processing centres used as proxies

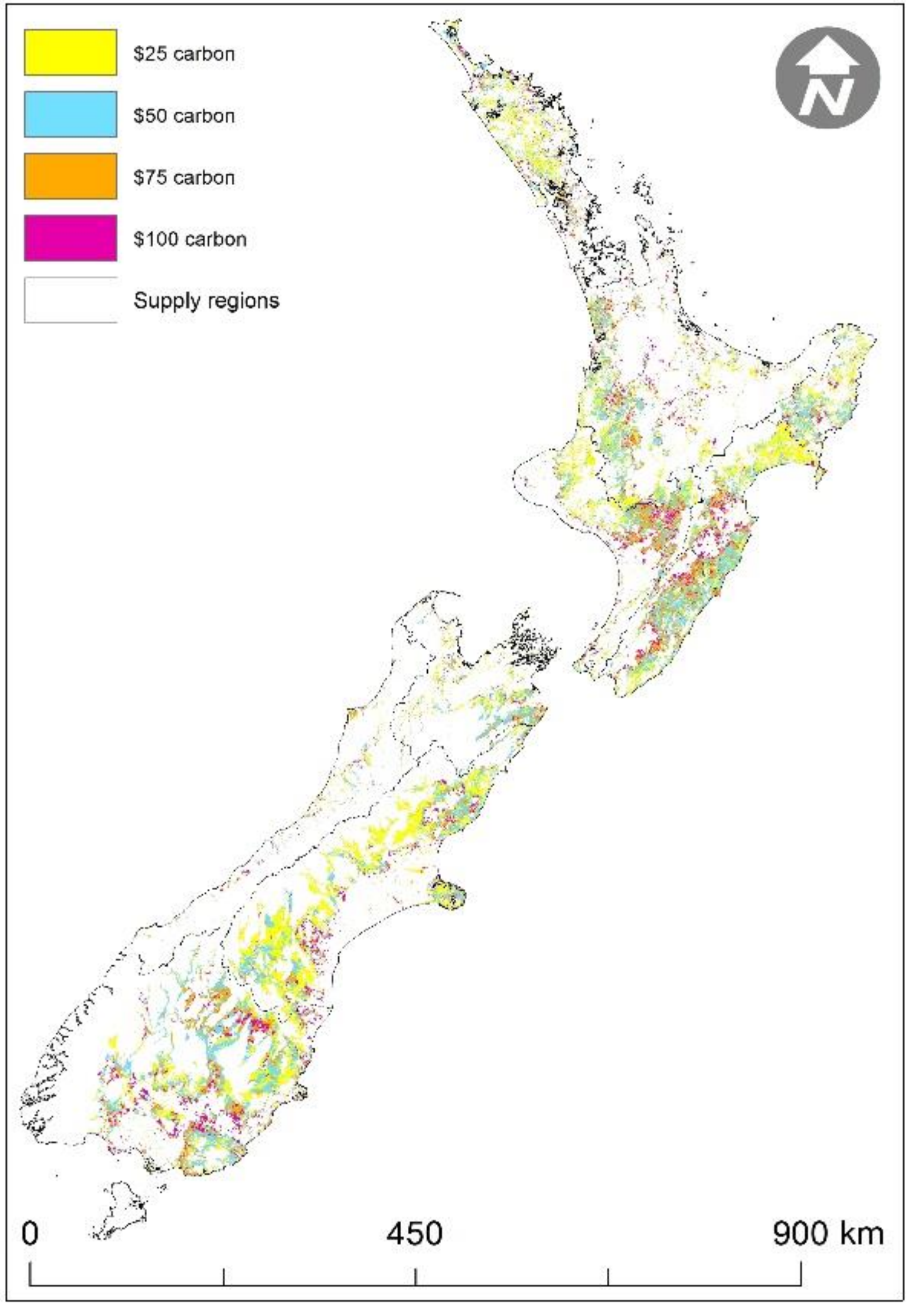
Analysis of costs and revenues modelled in Forestry Investment Framework (FIF)

Costs (C) Structural	Revenues (R)
Establishment	Timber ($/tonne)
Access road construction	
Internal landings	Carbon ($/NZU)
Internal road construction	
Harvesting	
Transport from harvest site to road network	
ETS compliance	

Economic analysis combined with spatial analysis of land suitability



- 'Red zoned' erosion-prone land excluded
- DOC conservation estate excluded
- Existing forest areas excluded
- Existing agricultural land excluded
- Site suitability criteria for tree species evaluated



Resolution: a total potential afforestable area for short rotation bioenergy forestry = 3.7M hectares

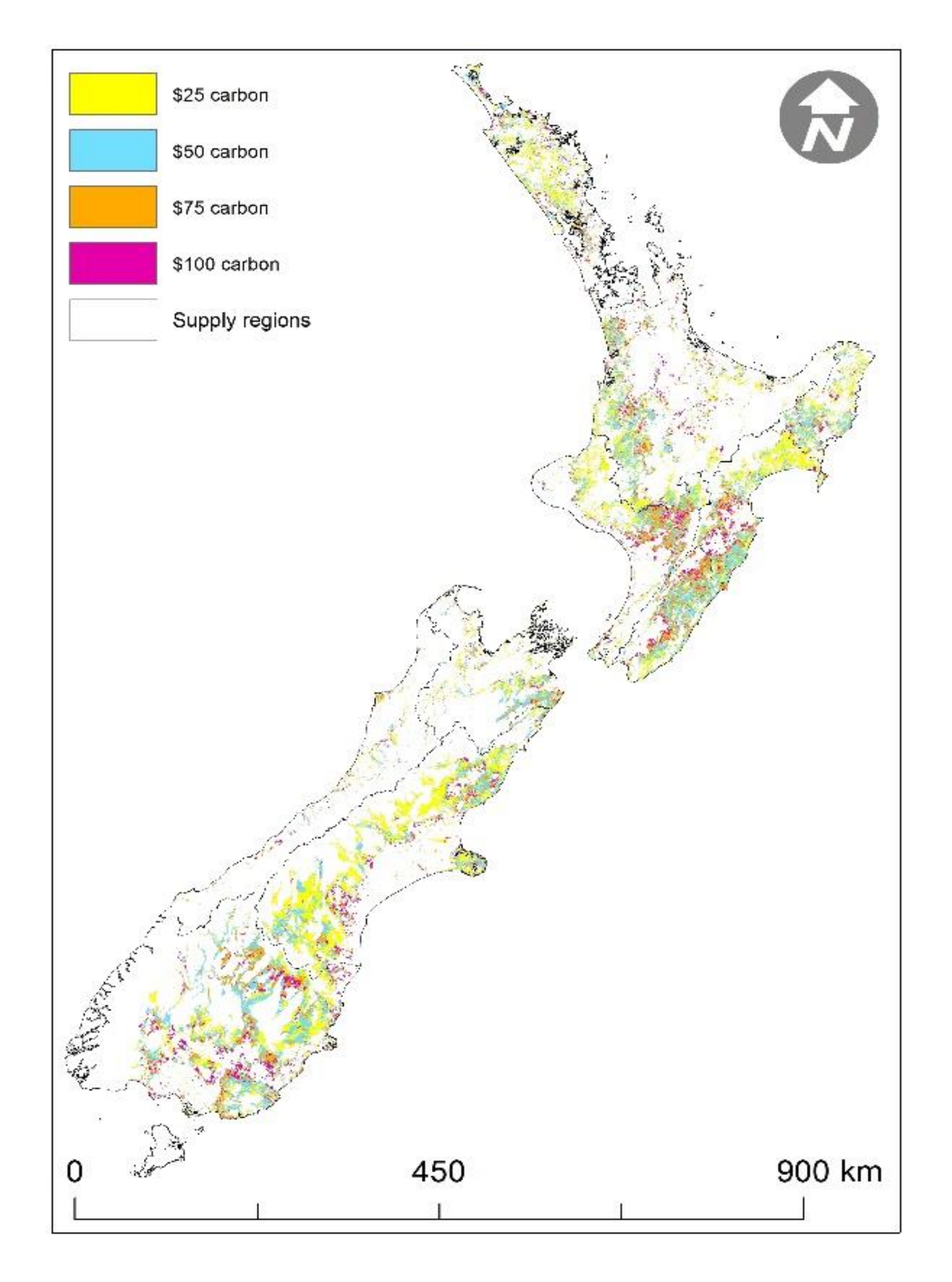
- Based on four possible scenarios for future ETS carbon returns:
- $25
- $50
- $75
- $100

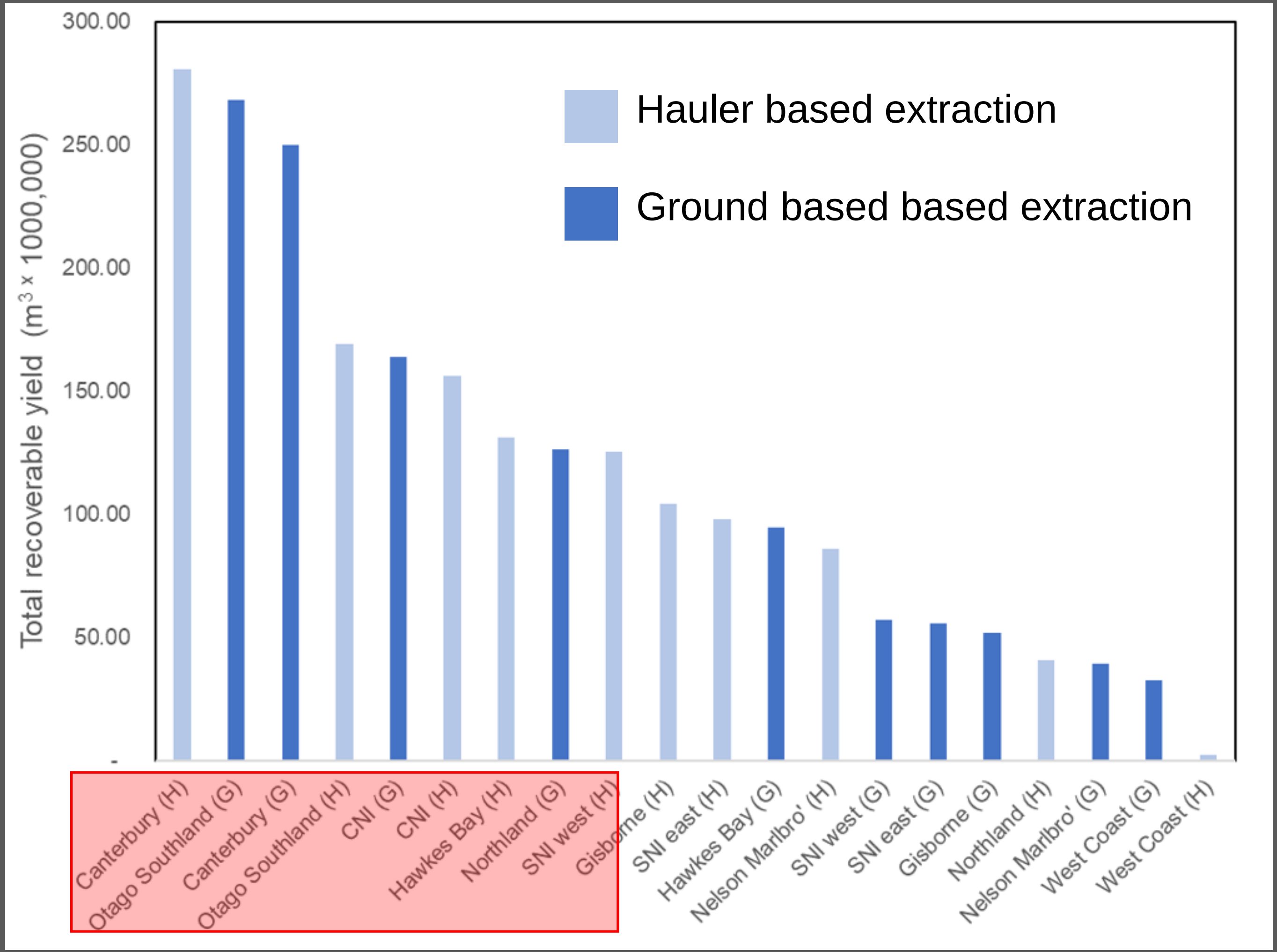
Climate Change Commission suggests a $140 t^{-1} carbon price will be needed by 2030

Which species?

Rank	Species	Median oven-dry stem yield (t ha-1 yr^{-1})	Min ave. temp. (°C)	Precip. range (mm)	Overall suitability?	Notes
1	*Pinus radiata*	26.0 [8]	10 [57]	<750 - >1250 [58]	Excellent	Performs well across a range of sites
2	*Eucalyptus fastigata*	23.0 [8]	12 [59]	750 - 1900 [59]	Excellent	Performs well across a range of sites
3	*E. regnans*	21.0 [8]	10 [60]	750 - 2000 [59]	Excellent	Performs well across a range of sites
4	*E. nitens*	22.1 [8]	-3 [61]	750 – 17501 [61]	Good	Limited to colder high-altitude sites only
5	*E. saligna*	20.6 [8]	8 [62]	800 – 1800 [62]	Good	Will not tolerate strong winds[63]
6	*E. maidenii*	17.6 [8]	Mediterranean climate[64]		Average	Relatively low productivity
7	*E. botryoides*	14.7 [8]	Wet sites[65]		Average	Relatively low productivity, prone to pests
8	*E. globoidea*	12.5 [8]	>-9 [66]	800 – 2500 [67]	Average	Relatively low productivity
9	*E. delegatensis*	11.5 [8]	>-14 [68]	Moist sites [68]	Average	Relatively low productivity
10	*Cupressus macrocarpa*	10.9 [8]	10 [69]	500 – 2000 [69]	Low	Susceptible to disease when stressed[53]
11	*C. lusitanica*	10.4 [8]	5.5 [70]	1000 – 3000 [71]	Low	Susceptible to disease when stressed[53]

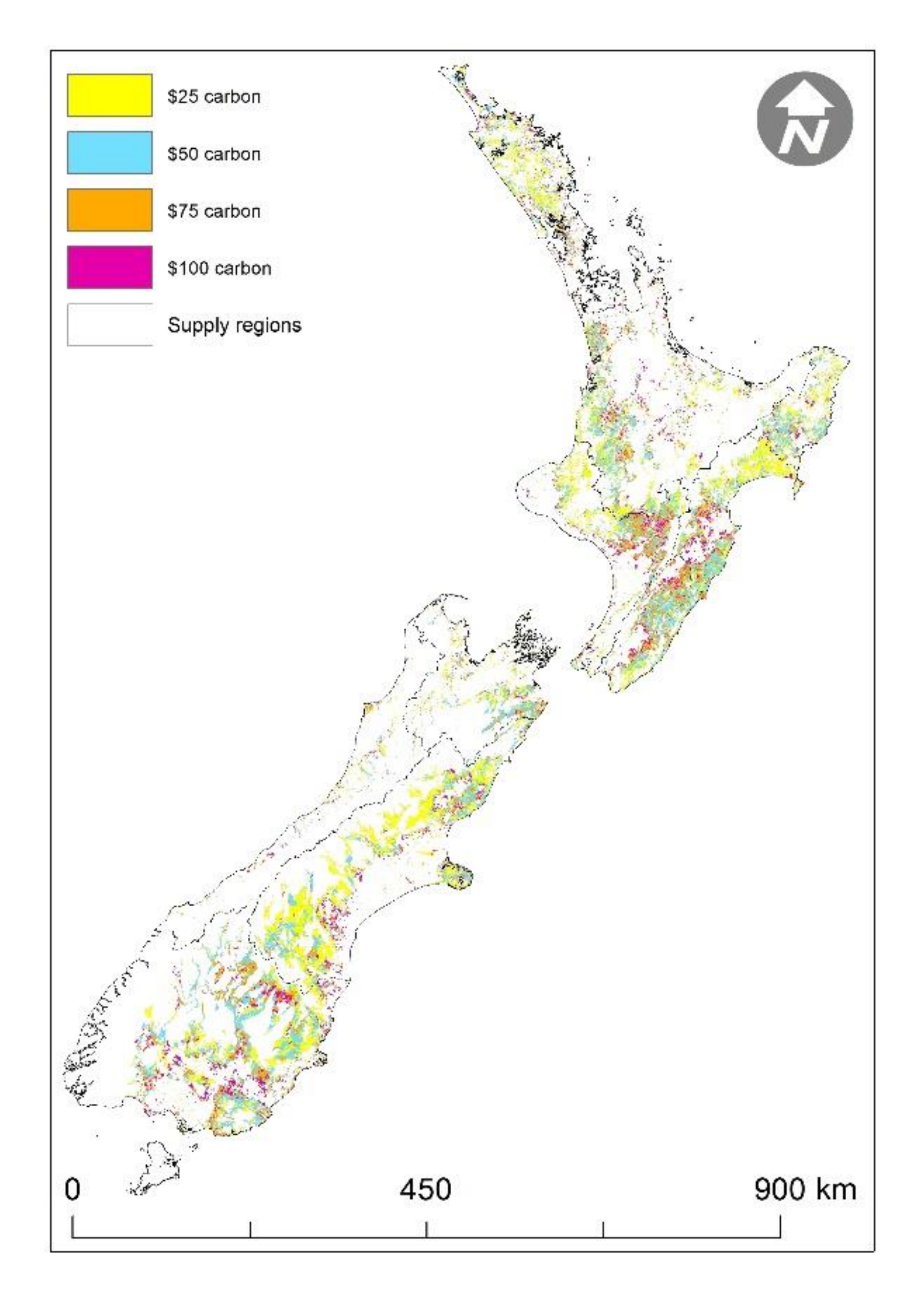
Productivity surfaces (total volume ha^{-1}) modelled for *P. radiata*: 16 year rotation

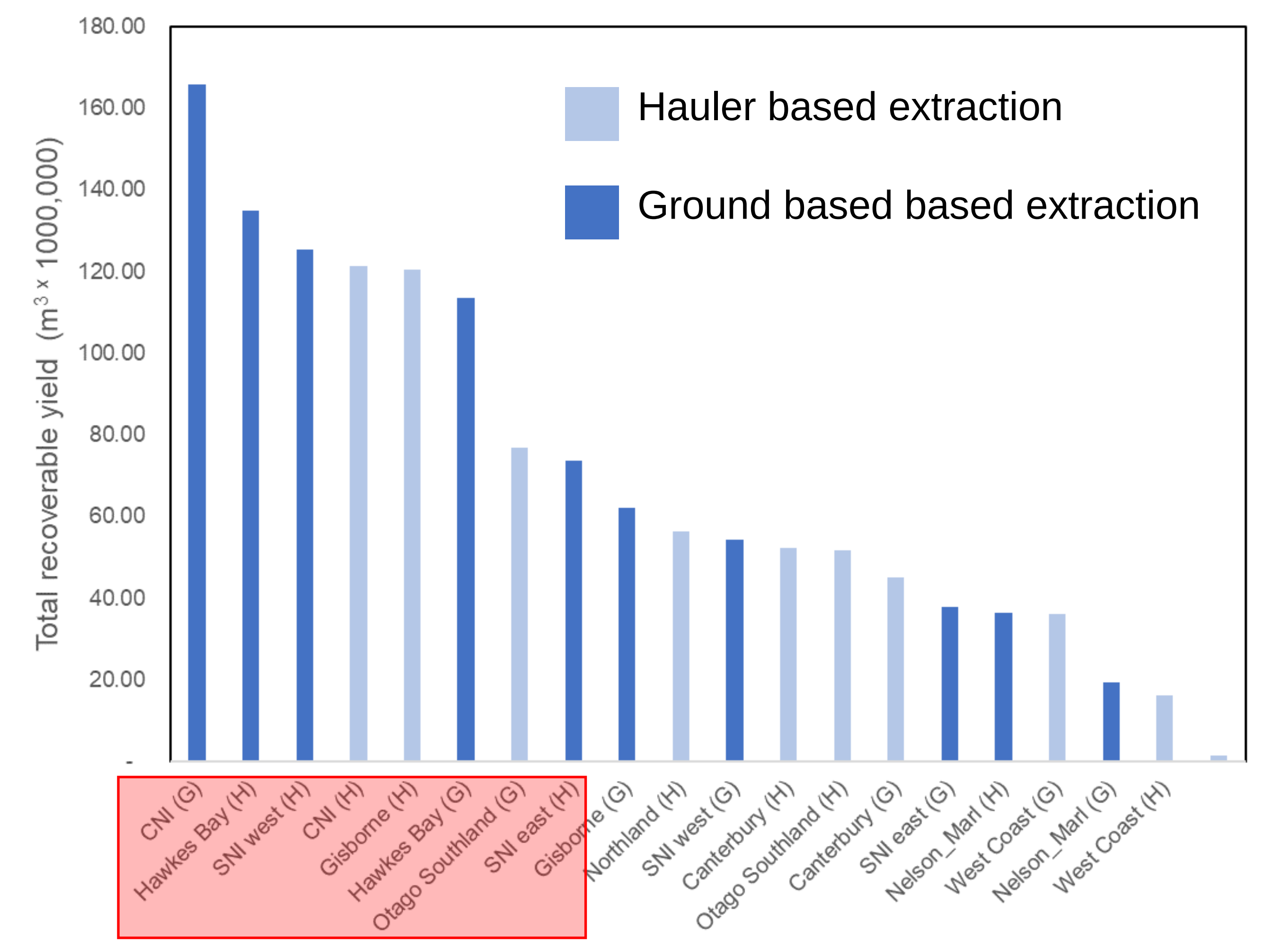




Yields per wood supply region for *P. radiata* under a $50 tonne scenario

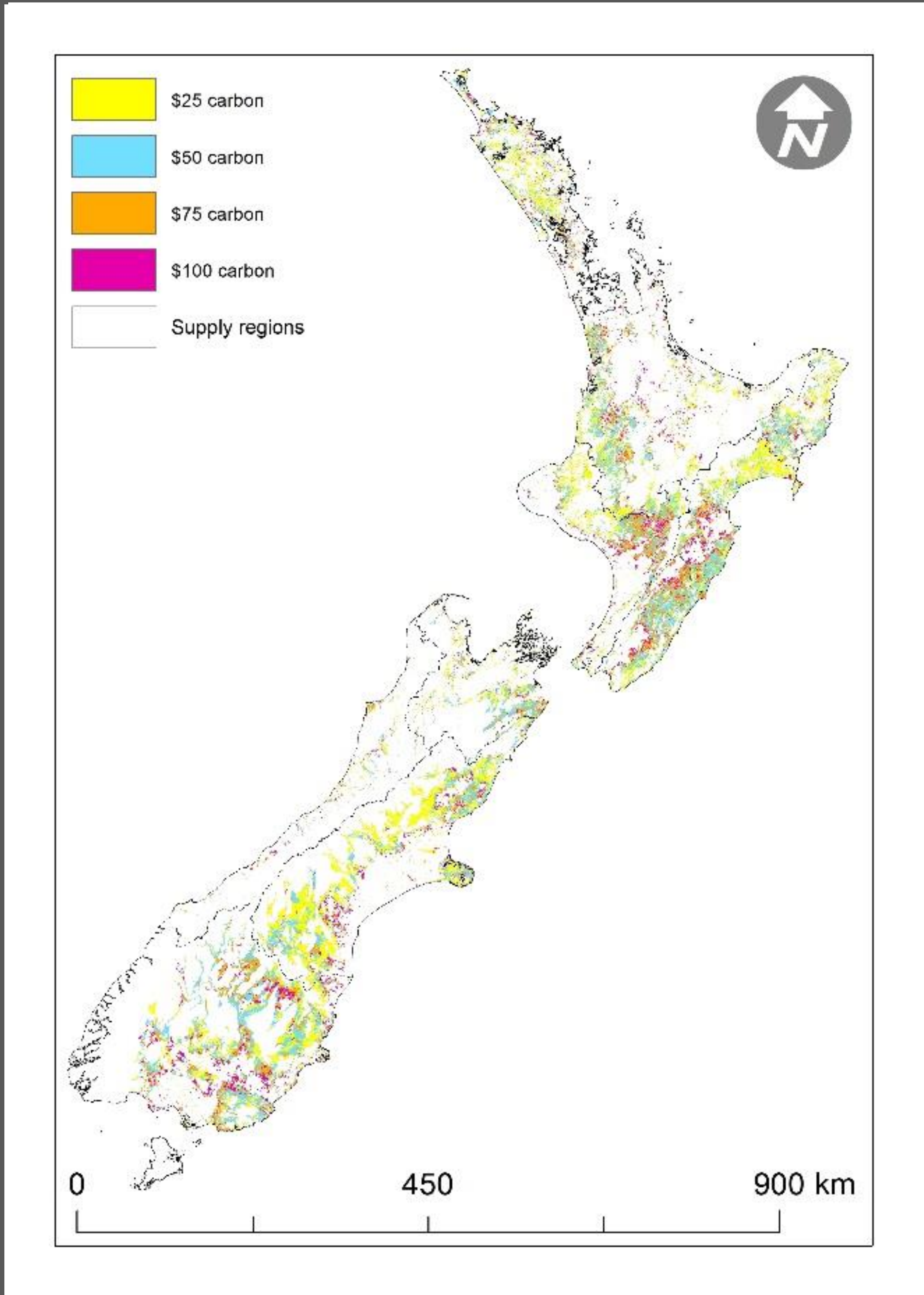
Productivity surfaces (total volume ha^{-1}) modelled for *E. fastigata*: 16 year rotation

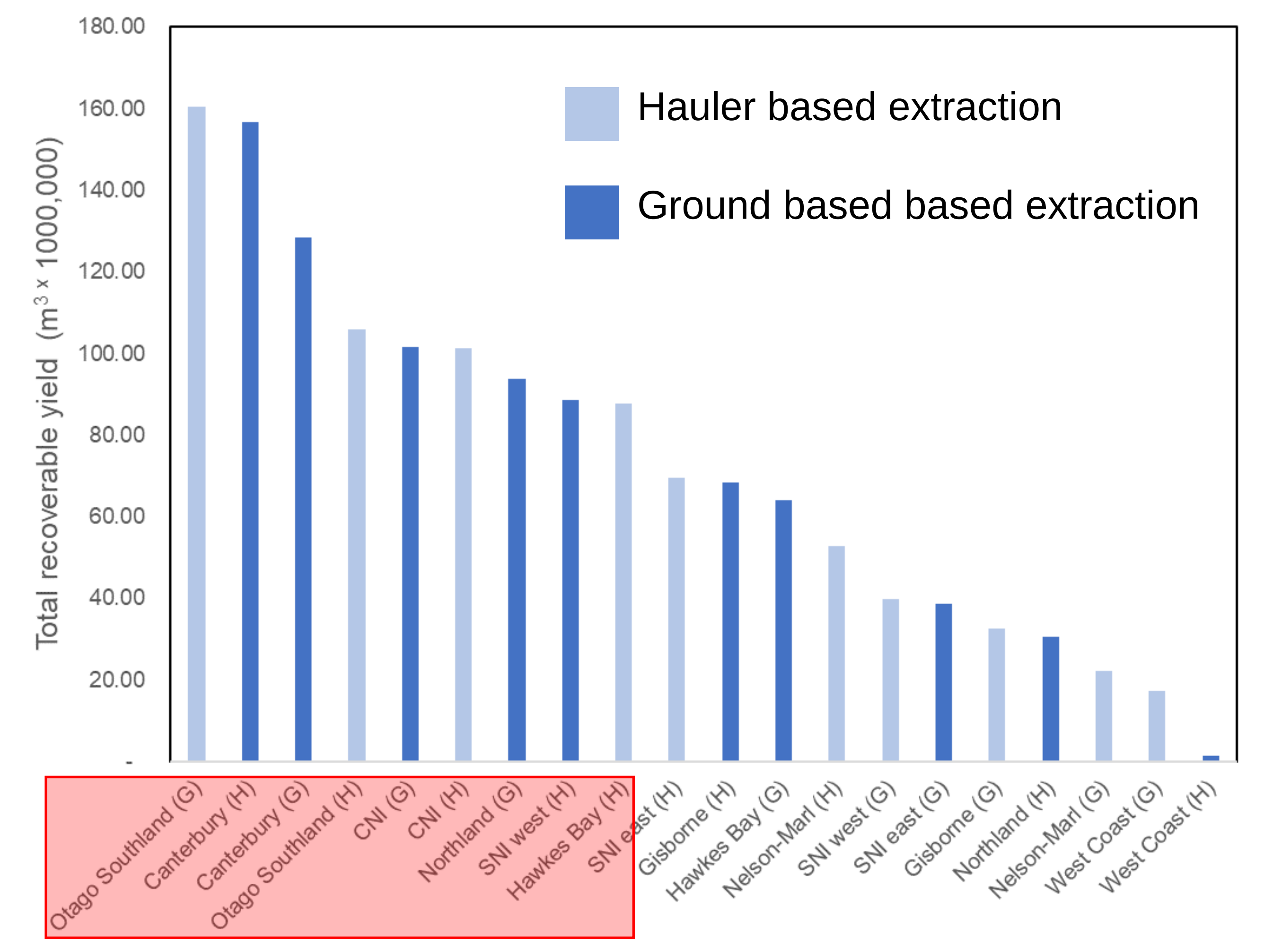




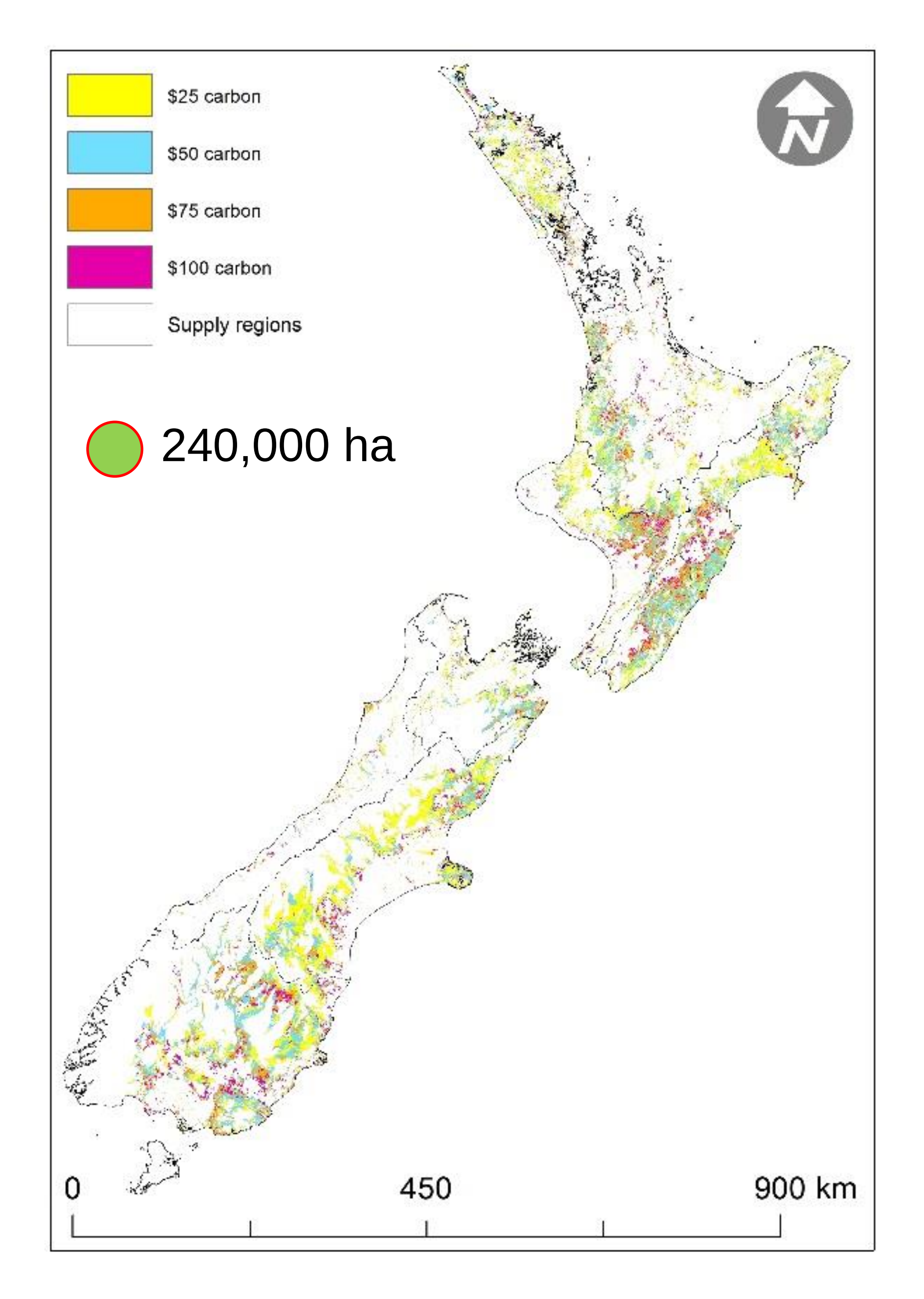
Yields per wood supply region for *E. fastigata* under a $50 tonne scenario

Productivity surfaces (total volume ha^{-1}) modelled for *E. regnans*: 16 year rotation





Yields per wood supply region for *E. regnas* under a $50 tonne scenario



How much energy would 240,000 ha short rotation bioenergy forest produce in 16 years?

- 878 PJ total after 16 years
- or 55 PJ yr^{-1}
- Exceeding the Climate Change Commission's advisory 2035 target of 37 PJ yr^{-1}

Knowledge gaps and research priorities

Theme	Key question	How to test
Species choice	Which candidate tree species is suitable for which site conditions?	Controlled plots varying species selection established across a range of sites and conditions
Stocking density	Which stocking density provides the optimal yield for each species?	Controlled plots varying stocking density established across a range of sites and conditions
Tree stock quality	What impacts do stock type and stock quality have on growth and yield?	Controlled plots varying tree stock quality established across a range of sites and conditions
Regime length	What is the most effective regime length for each species?	Controlled plots varying regime length established across a range of sites and conditions
Altitude / slope	Which species is most effective growing on high-altitude or steepland sites?	Specifically target high-altitude or steepland sites in trial
Site suitability	How suitable is short rotation forestry on frost-prone sites?	Specifically target frost-prone sites in trial
Impact of soil fertility	How strongly does soil fertility impact yield in short rotation regimes?	Specifically target sites across a range of known fertility
Impact of additional fertilization	What is the most effective rate of additional fertilization?	Test by adding fertilization at different rates
Impact of spraying	What is the most effective level of spraying treatment?	Test by spraying at different rates
How to harvest	What is the most effective harvest method for given site criteria?	Test different techniques across a range of plots at harvest
How to plant	What is the most efficient planting and site preparation regime for each species at high stocking densities?	Test different techniques across a range of plots at harvest
Wind damage	How susceptible are high stocking densities to wind damage?	Evaluate wind damage impacts throughout trial according to site and stocking
Pest damage	How susceptible are high stocking densities to pest damage?	Evaluate pest damage impacts throughout trial according to site and stocking
Soil fertility impacts	What are the impacts of short rotation on soil fertility?	Evaluate changes in soil fertility throughout trial
Soil erosion risks	What are the impacts of short rotation on soil erosion risks?	Measure rates of soil erosion throughout trial
Soil carbon impacts	What are the impacts of short rotation on soil carbon?	Evaluate changes in soil carbon throughout trial
Water use	What impact will short rotation hardwood plantations have on water yields?	Evaluate soil water use and catchment hydrology throughout the trial
Costs of planting	How cost-effective is planting under short-rotation regimes?	Evaluate planting costs within a trial according to trial site, relief and stocking density. From these criteria develop spatial models to predict such costs at scale
Costs of harvesting	How cost-effective is harvesting under short-rotation regimes?	Evaluate harvesting costs within a trial according to trial site, relief and stocking density. From these criteria develop spatial models to predict such costs at scale
Commercial viability	Can short rotation regimes be diversified to allow sawlog production?	Evaluate yield of sawlog-viable timber from trial

Next steps: short rotation bioenergy forest trial

What is the **opportunity**?

- New Zealand can potentially exceed the Climate Change Commission's bioenergy target for 2035 through short rotation bioenergy forestry
- Marginal land <1% NZ's land area could deliver >5% current fossil fuel energy demand
- Priority species for this are likely to be *P. radiata*, *E. fastigata*, *E. regnans*
- Critical unknowns include: silviculture, erosion risks, planting regime, harvesting regime, processing and transport costs
- Urgently-needed knowledge can be gained through rapidly implementing a short rotation bioenergy forest trial

Thank you

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Peter Hall, Dave Palmer, Serajis Salekin, Dean Meason