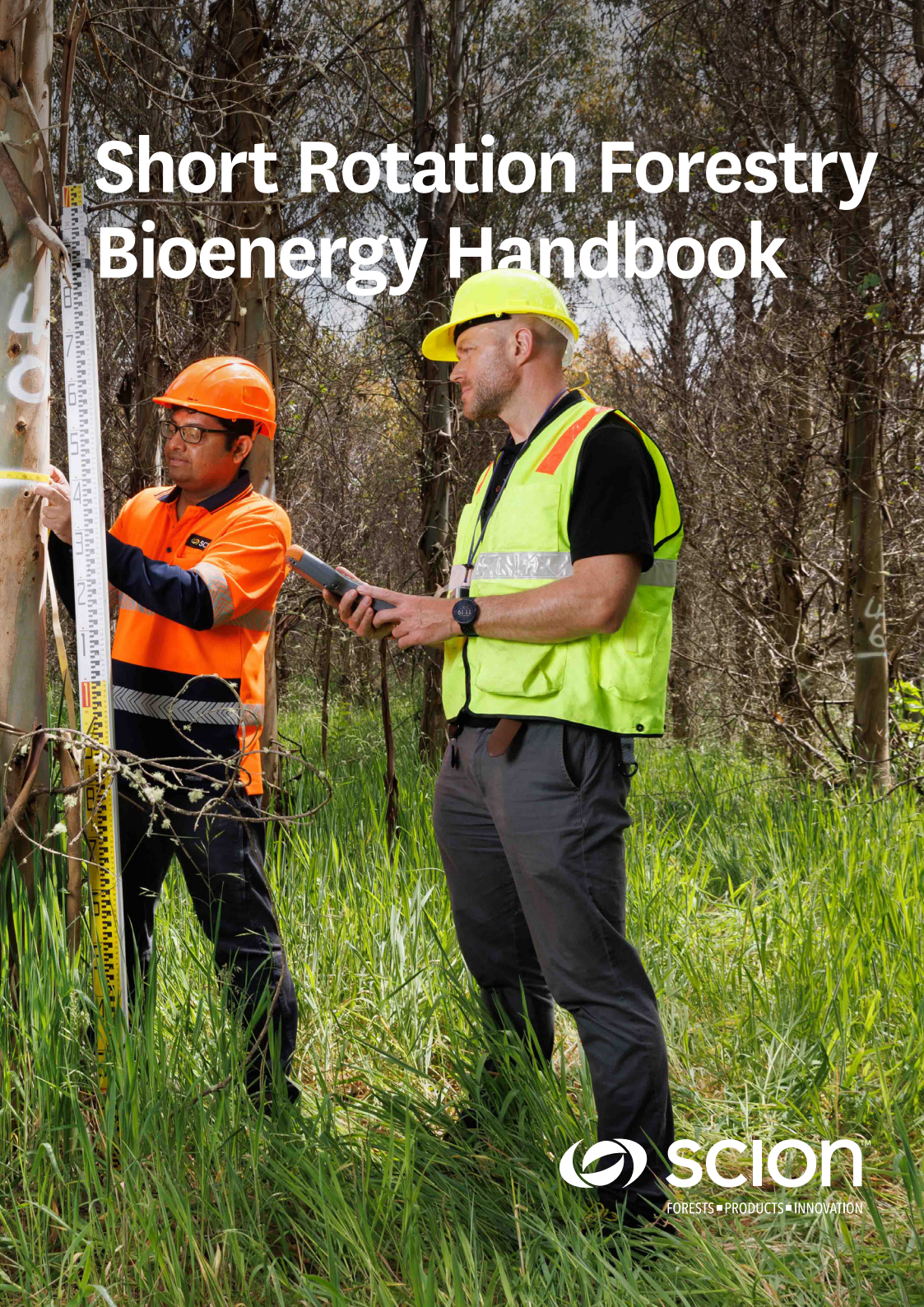
Short Rotation Forestry Bioenergy Handbook



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Introduction

New Zealand needs to invest in sustainable energy sources to meet its net-zero commitments by 2050, a rapid increase in demand for bioenergy is expected over the next decade. Utilisation of woody biomass is currently the largest single source of bioenergy globally, with this contribution arising from consumption of a mixture of waste material from industrial wood processing, combined with large volumes of *ad-hoc* extraction of woody material used in some developing countries.

Short rotation forestry can provide biomass to supply an emerging bioenergy market expected to develop rapidly over the next decade.

Even if we efficiently use available residual forestry waste as a bioenergy feedstock, we will still need to grow new forests to keep up with increased demand for bioenergy in the future, and to supply liquid biofuels for transport. New Zealand, with its abundance of hill country, is suitable for growing forests and its expertise in fast-growing plantation forestry could become a world leading example of sustainable bioenergy.

One way to meet the increasing demand for bioenergy is to plant dedicated biomass forests - where the trees are harvested and the wood (biomass) is used for the production of bioenergy.

These bioenergy forests, unlike traditional timber production forests, could benefit from shorter rotation length; known as short rotation forestry.

Short rotation forestry as a feedstock for bioenergy has the potential to replace 6% of New Zealand's annual fossil fuel demand using less than 1% of its land area.

Scion's research, summarised in this guide, gives recommendations for landowners, forest investors and government agencies on how to approach establishing a bioenergy forest operating under short rotation forestry.

What is short rotation forestry?

Traditional production forestry based on radiata pine forests operates on a 20-25 year cycle but for dedicated biomass forests trees can be grown at high density and rotation time can be shortened. Scion has conducted a two-year study to assess the feasibility of upscaling short rotation forestry, and assessed the most suitable regions around New Zealand to plant these forests. The ideal tree species for short rotation forestry are also described.

What species?

The four preferred forestry species for short rotation crops have been identified using Scion growth modelling analysis. These species are already established in New Zealand forestry. *Pinus radiata*, together with *Eucalyptus fastigata*, *Eucalyptus regnans* and *Eucalyptus nitens* all have rapid growth traits favourable for short rotation bioenergy forestry.

The optimal species to produce bioenergy biomass are radiata pine, followed by *Eucalyptus fastigata*, *E. regnans* and *E. nitens*.

The species with the greatest overall potential for short rotation forestry planting is *Pinus radiata*, owing to rapid growth rates and a relatively high degree of adaptability to a range of possible growing locations. This species also benefits from decades of genetic improvement work on wood productivity and disease resistance, together with an advanced existing silvicultural knowledge base.

The other species may have suitability within specific environmental ranges and may be more suitable for select locations, where known traits of these species will suit a particular site.

Pinus radiata

Scion's modelling analysis has shown *P. radiata* has the greatest overall potential for short rotation forestry establishment and the widest economically viable area for future plantings. *Pinus radiata* also has the lowest overall risk from introduced pests or disease with well-developed management protocols for existing risks. In our economic analyses we accounted for returns from the Emissions Trading Scheme (ETS) and assumed an 8-year 'averaging' point for standing carbon under ongoing 16-year rotations. Returns from short rotation forestry would be widely profitable from this regime under a $50 per tonne CO_2 price point, across 1.5 million hectares of lower value grazing land nationally.

Our economic analysis of profitability includes income from the Emissions Trading Scheme, based on a 16 year rotation and 8 year averaging point for carbon payment.

Eucalyptus

Eucalyptus regnans and *E. fastigata* are both cold-adapted species, while *E. fastigata* can be sited further north. They are currently grown in some areas of New Zealand for pulp production, at similar stocking rates as those proposed by our productivity modelling for short-rotation bioenergy. The national situation assessed for *E. fastigata* indicates this has a much smaller economically viable area for short rotation forestry compared with *P. radiata* overall.

Other *Eucalyptus* species (*E. regnans* and *E. nitens*) have similar growth characteristics to *E. fastigata*, so the trends projected here may be broadly indicative of economic relationships with other eucalypts, recognising that in terms of site suitability *E. nitens* is likely to be situated in colder sites only, which may preclude some North Island regions. The greatest wood supply regions of economic suitability for *E. fastigata* are in the North Island, particularly Northland, Central North Island, East Coast and Hawke's Bay.

Pests/risks

Eucalyptus species included in our study are generally more susceptible to pests and diseases than *P. radiata*. *Eucalyptus nitens* has the greatest challenges, due to its susceptibility to defoliating insects. This may be overcome by siting in cooler locations, which reduce insect numbers.

Stocking density

Scion's productivity modelling for short rotation forestry shows that stocking at between 650 and 1250 stems per hectare for each of these species is ideal for bioenergy. Stocking will depend on species, site and intended rotation age. More productive sites may be capable of growing at higher stocking densities with generally shorter length rotations. Under this regime with no pruning or thinning, plantations would be suitable for harvest between 12 and 18 years, returning a mean annual increment (MAI) of between 20 and 30 tonnes per hectare.

Trees can be planted at between 650 and 1250 stems per hectare, with no pruning or thinning.

Rotation length

As the name suggests, short rotation forestry operates on a shorter timeframe than traditional timber production forestry. A conventional timber rotation is approximately 27-years. Implementation of short rotation forestry involves planting trees at a high density, enabling rotation lengths to be reduced to between 12 and 18 years, while total yields can be approximately two thirds that of a conventional structural timber regime within a much reduced timeframe.

Our analysis suggests that 12 to 18 year rotations are generally optimal across all species in terms of delivering the greatest quantity of total biomass per year of growth (and therefore suggesting the greatest profitability at this point). However, other site and economic factors may influence planning decisions about harvest dates.

Plantations will be ready for harvest between 12 and 18 years.

Short rotation forestry can respond to a rapid increase in demand for bioenergy feedstocks expected by 2035. The *Eucalyptus* species we have highlighted may grow more rapidly during the initial establishment phase and hence in some instances these species may provide a preferable option on *P. radiata*, if a more rapid demand for biomass is projected. All three of the *Eucalyptus* species we highlight in this work (*E. fastigata*, *E. nitens* and *E. regnans*) are also potentially capable of coppice regrowth and this suggests a further benefit over *P. radiata* when using these species. Coppice ready bioenergy forests would not require re-planting, and this could prove more cost-effective on available areas of flat land where coppice harvesting machinery can operate.

Where to plant?

Scion's research found that short rotation forestry could be established on available areas of lower value land (e.g. Land Use Capability Class 5-7) to minimise costs. Land types that could be suitable are existing areas of economically marginal grazing land. It is also important to establish plantations locations where transport distances to processing locations can be minimized.

Our spatial analysis has identified several wood supply regions where high centres of future bioenergy demand coincide with an availability of lower value land, these include Northland, Central North Island, East Coast, Hawke's Bay, Canterbury and Otago-Southland wood supply regions.

Our economic analysis suggests lower value land will be most profitable for establishing short rotation bioenergy forestry.

Bioenergy processing

Scion's research highlighted locations where short rotation biomass could be processed for bioenergy in the near future. These locations were used to test the potential viability of transport costs for future short rotation bioenergy crops and were chosen as locations where:

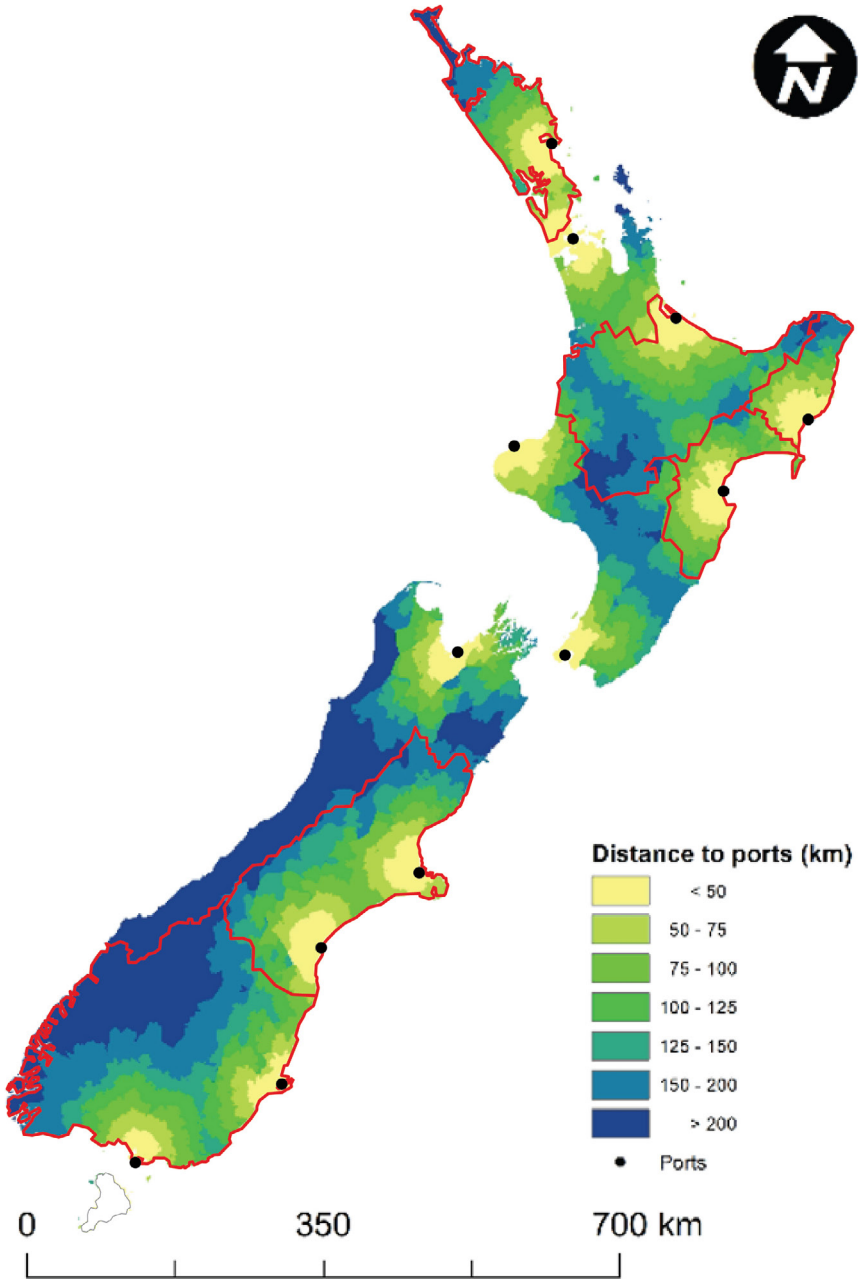
- Wood processing activity is currently taking place, or where historically this has been established.
- A high potential future demand exists for bioenergy or liquid biofuels, such as power stations or oil refineries.
- Existing ports which we expect could become distribution hubs for refined forms of bioenergy and potentially also centres of processing themselves.

Projected timelines for short rotation bioenergy forestry

2024: Identification and set up of field trials to test species regimes and supply chains suitable for providing high-quality, low-cost biomass for use as bioenergy feedstocks.

2025 - 2030: Establishment of 6 to 7 thousand hectares per annum of short rotation forestry, towards a goal of at least 150,000 hectares by 2035.

2035: 150,000 hectares of dedicated bioenergy forest established, contributing at least 5% of domestic energy demand, displacing the equivalent of 3 Mt of CO_2 emissions from oil combustion per year, or 4 Mt CO_2 from coal.



Overview of future short rotation forest biomass feedstock processing locations for refining bioenergy products, which should be aligned with existing ports and be near expected centres of high bioenergy demand. Priority wood-supply regions for short rotation biomass production are highlighted in red.

Future work

Areas of future Scion development include identifying genetic stock of *P. radiata* or *Eucalyptus* with specific traits for bioenergy.

A second area of future development is to use forestry trials to evaluate the performance of short rotation planted forests.

Key facts

- Short rotation forestry can provide biomass to supply an emerging bioenergy market expected to develop rapidly over the next decade.
- The optimal species to produce bioenergy biomass are radiata pine, followed by *Eucalyptus fastigata*, *E. regnans* and *E. nitens*.
- Trees can be planted at between 650 and 1250 stems per hectare, with no pruning or thinning.
- Plantations will be ready for harvest at between 12 and 18 years.
- Mean annual increment (MAI) at point of harvest will be between 20 and 30 tonnes per hectare.
- Our economic analysis suggests lower value land will be most profitable for establishing short rotation bioenergy forestry.
- Available areas of lower value land are likely to be Land Use Capability Class 5-7, currently used for economically marginal grazing.
- Short rotation bioenergy forestry provides an alternative investment option for growers on this land.
- Our economic analysis of short rotation forestry profitability includes income from the Emissions Trading Scheme (ETS), based on a 16 year rotation and 8 year averaging point for carbon payment.
- Short rotation bioenergy forestry will be especially needed in regions of high expected future feedstock demand, which are: Northland, Central North Island, East Coast, Hawke's Bay, Canterbury and Otago-Southland.

References

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