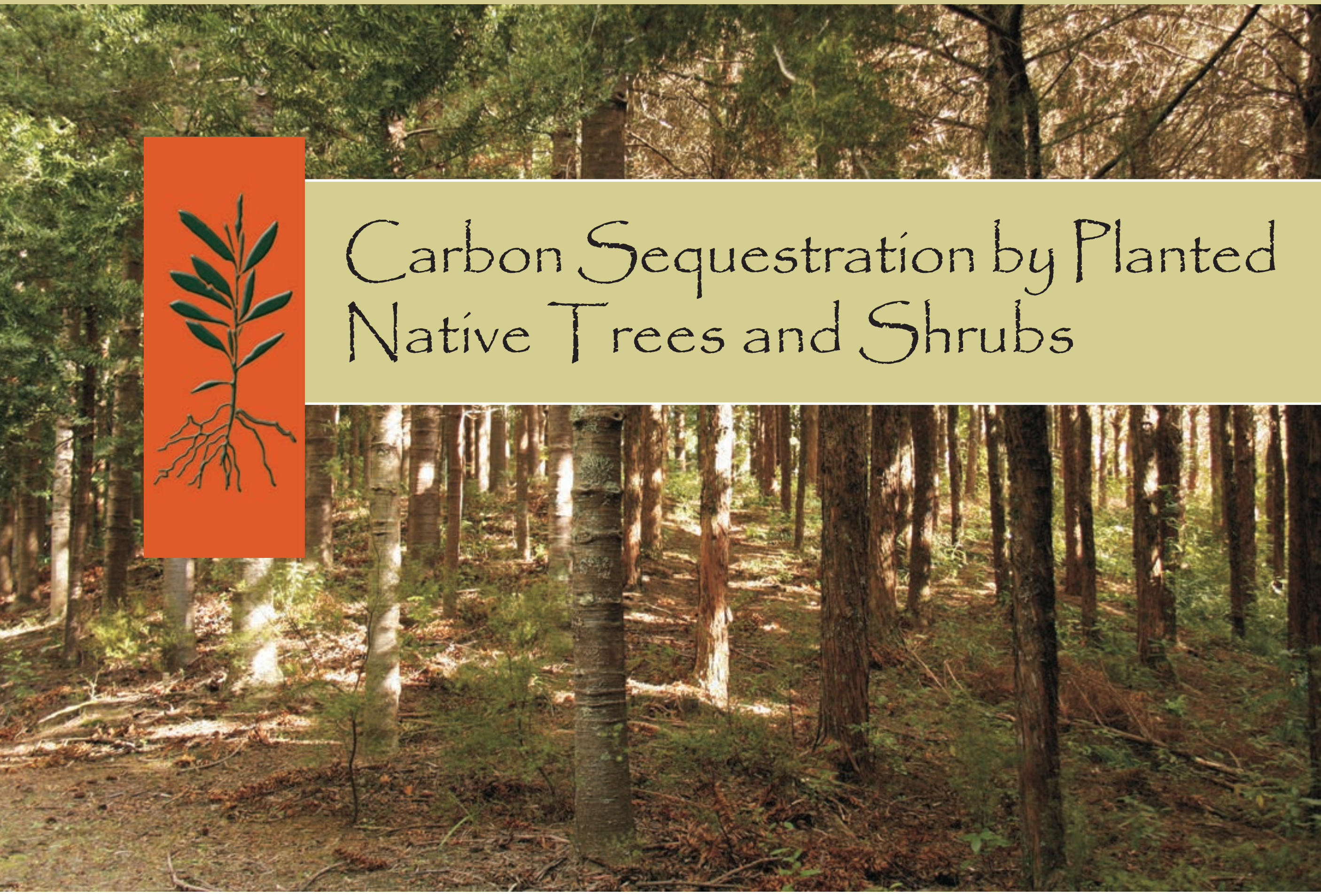


Carbon Sequestration by Planted Native Trees and Shrubs

INTRODUCTION

Forests store large amounts of carbon which can be released into the atmosphere as a result of deforestation or forest degradation. Deforestation has contributed significantly to the increase in atmospheric CO_2 since pre-industrial levels. According to the Intergovernmental Panel on Climate Change (IPCC), about 22% of the elevation in atmospheric CO_2 from pre-industrial times is believed to have come from loss of forests. Protection of existing forests and planting of new forests can therefore play an important role in countering global warming.

In New Zealand, there is considerable interest in planting trees for carbon sequestration. While most of the focus is on establishing fast growing exotics such as pines and eucalypts, there is also considerable interest in using native species.

To determine the potential of a species for carbon sequestration, both tree measurements and models for predicting carbon sequestration from these measurements are required. Tāne's Tree Trust has recently completed a survey of native tree plantations throughout the country including growth measurements (refer to earlier articles in Section 10 of the Tāne's Tree Trust Technical Handbook). This article uses these measurements and carbon models to determine typical carbon sequestration rates for a range of planted New Zealand native tree and shrub species.

Loss of Natural Forest Cover in New Zealand

New Zealand has contributed to the global trend of forest destruction. The area of natural forests in New Zealand has reduced from approximately 85% of total land area prior to human habitation (McGlone, 1989) to current levels of 24%, only partly offset by the planting of exotic forests which currently cover 7% of land area (Anon., 2009).

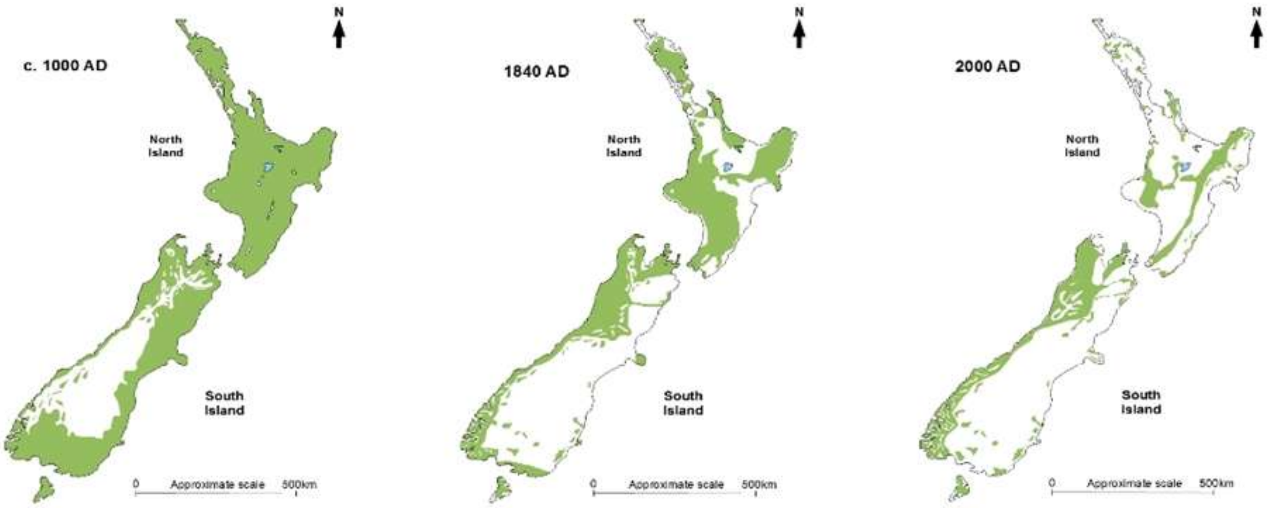


Figure 1: Decline in extent of native forest in New Zealand from about 80% cover at approximately 1000 AD (left) to 50% forest cover at the time of the first European surveys in about 1770 AD (middle) and to about 24% currently (right). Drafted by Michael Bergin, adapted from McGlone (1989) and Stevens et al. (2007).

Carbon equations for native trees

Equations for predicting carbon sequestration for New Zealand native trees have been developed by Scion Research for the Ministry of the Environment using biomass and tree measurements from a database of felled or fallen trees (Beets et al., 2012). These equations estimate the carbon stored in an individual tree from readily obtainable measurements of tree diameter and height.

Discs taken from wind fallen trees within old-growth indigenous forest have been used to determine biomass for developing carbon equations.

The equations were mainly developed using measurements from old-growth natural forest stands. The only biomass study performed on a native plantation in New Zealand appears to be a study conducted by Scion of trees thinned from a 69-year old Taranaki kauri stand. The estimate of CO_2 sequestration obtained from the biomass measurements in this stand was 1306 t/ha. Applying the carbon equations to the tree height and diameter measurements from the stand gave a very similar estimate of 1326 t/ha giving confidence that the carbon equations developed from natural stands can also be applied to planted native stands.

Tree assessment includes measuring diameter at breast height for all stems within each plot (above) and a sample of trees for height (using a Vertex Hypsometer, below).

Establishing plots

To apply the carbon equations to a planted stand of native trees, it is necessary to obtain tree measurements. Trees are usually measured in one or more measurement plot or plots of known horizontal area established within the stand. All stems in each plot are counted and the stocking obtained by dividing the stem count by the plot area. Plot size can vary but ideally a one-twenty-fifth hectare (400 m^2 or 0.04 ha) plot is used and is referred to as a Permanent Sample Plot or PSP. Methods for establishing PSPs are given in Ellis and Hayes (1997).

For example, in a 102 year-old stand of planted totara at Puhipuhi in Northland, a Permanent Sample Plot of 0.04 hectares was established. This plot contained 49 trees meaning that its stocking was 1225 stems/hectare.

Tree measurements

The diameter over bark (DBH) at breast height (1.4 m above ground) is measured for all stems within each plot. Heights are also measured but generally only for a sample of trees. Heights of all trees in the plot are then estimated from a height/diameter curve fitted to the stems measured for height. In the Puhipuhi stand, the average DBH was 38 cm and the mean height was 25 m.

Carbon in tree stems

The carbon equations (Beets et al., 2012) are then used to estimate the carbon contained in each measured tree. Firstly an equation is used to predict stem volume from the DBH and height measurements. Stem volume is defined as the volume of portions of the tree greater than 10 cm in diameter (the diameter selected by NZ under the Kyoto Protocol) including both wood and bark. In the Puhipuhi stand, the stem volume is estimated to be 1753 m^3/ha. Note that this over-bark measurement of stem and large branch volume is considerably greater than the more commonly used under-bark stem volume.

The estimated stem volume is then multiplied by a tabulated value of wood density for the species to obtain stem biomass (or dry weight). Tabulated densities for important native tree species are shown in Table 1. Note that these densities are lower than those usually quoted because they include allowances for bark, stem fluting and hollowing, etc. As the tabulated density for totara is 370 kg/m^3, the stem biomass for the Puhipuhi stand is estimated to be 648 t/ha. Because 50% of forest biomass can be assumed to be carbon, the stem carbon for the stand is estimated to be 324 t/ha.

Discs sampled from thinned stems of a managed kauri plantation in Taranaki were used to determine biomass.

Table 1: Whole stem wood densities of some native trees for use in carbon calculations.

Species	Botanical name	Whole stem density (kg/m^3)
Kauri	*Agathis australis*	435
Rimu	*Dacrydium cupressinum*	433
Totara	*Podocarpus totara*	370
Kahikatea	*Dacrycarpus dacrydioides*	351
Matai	*Prumnopitys taxifolia*	499
Tanekaha	*Phyllocladus trichomanoides*	489
Red beech	*Nothofagus fusca*	448
Black beech	*Nothofagus solandri* var. *solandrii*	536
Silver beech	*Nothofagus menziesii*)	455
Puriri	*Vitex lucens*	476
Tawa	*Beilschmiedia tawa*	505
Taraire	*Beilschmiedia tarairi*	527
Kanuka	*Kunzea ericoides*	635
Karaka	*Corynocarpus laevigatus*	476

Carbon in branches and roots

The next step is to estimate the carbon in the branches less than 10 cm in diameter, and in the foliage. Equations are used to estimate these components directly from the tree DBH measurements. In the Puhipuhi stand, the small branches and foliage are estimated to contain 78 t/ha of carbon. The combined above ground biomass in this stand is therefore estimated to contain 402 t/ha of carbon.

The carbon contained in the roots is generally estimated as a simple ratio of the above-ground carbon. There is very little information on the ratio of below- to above-ground biomass in native plantations. However, a somewhat conservative assumption that root biomass is 20% of above ground biomass is used in this article. For the Puhipuhi stand, the below-ground biomass is therefore estimated to contain 80 t/ha of carbon. The combined above and below-ground biomass in this stand is therefore estimated to contain 483 t/ha of carbon.

Carbon in native shrubs

A modification of the tree methodology is used for native shrubs. This also relies on accurate measurements in sample plots. Measurements of stocking, stem diameter made 10 cm above the ground (referred to as root collar diameter), and height are required. A direct conversion of these measurements is then used to estimate carbon. The shrub carbon methodology currently does not attempt to distinguish between species.

Many shrubs invariably are multi-stemmed from near ground level so diameters of stems are measured 10 cm above ground (root collar diameter).

Conversion to CO_2 equivalents

The final step in the carbon sequestration calculation is to convert the carbon stock contained in the plantation into the equivalent mass of atmospheric carbon dioxide (CO_2). It is assumed that for each atom of carbon in the biomass, a molecule of CO_2 was removed from the atmosphere. To convert from biomass carbon to CO_2 equivalents, a conversion of 3.67 is used (44/12). Therefore, the Puhipuhi totara stand is estimated to have sequestered 1770 t/ha of CO_2 from the atmosphere.

EXAMPLES OF CARBON SEQUESTRATION IN NATIVE PLANTATIONS

Planted native trees

A reliable per hectare estimate of carbon sequestration can only be obtained from a reasonably large and well managed stand of trees. This is necessary so that a sufficiently large measurement plot or series of plots can be installed, avoiding edge trees which can show atypical growth characteristics.

Many plantings of New Zealand native trees assessed in surveys to date (refer to Handbook Technical Articles 10.2 and 10.3) are in small stands, sometimes of mixed species, and often at irregular spacings, where reliable carbon estimates may not be possible. However, a number of stands with the required characteristics have been measured in the Tāne's Tree Trust survey, and sequestration estimates for these stands are given in Table 2.

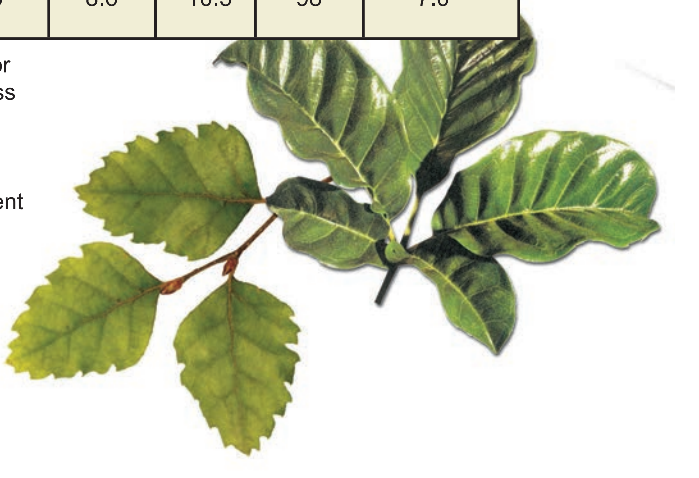
These stands are mainly of native conifers with several well stocked older stands of kauri and totara having accumulated carbon equivalent to more than 1300 tonnes of CO_2 per ha. There are few examples of native hardwoods with good carbon estimates except for one older puriri stand, and several young beech stands. Mean annual increment (CO_2 sequestration divided by stand age) for stands over 30 years old range from 6 to 20 t/ha/yr and average 13 t/ha/yr. As expected, carbon sequestration in these stands is highly variable, depending strongly on age and stocking and also on underlying site productivity and in the level of maintenance after planting.

Table 2: CO_2 sequestration estimates and other stand characteristics of selected native forest plantations. Estimates for the two Taranaki kauri stands are based on multiple measurements whereas all other estimates are based on a single measurement of different stands.

Species	Location	Age (years)	Stocking (stems/ha)	Height (m)	DBH (cm)	CO_2* (t/ha)	MAI+ (t/ha/yr)
Kauri	Northland	67	492	25.6	40.8	926	13.8
	Taranaki, Fred Cowling Reserve	38	1402	14.3	20.2	413	10.9
		51	1256	15.0	25.6	614	12.0
		69	1325	23.1	31.0	1306	18.9
	Taranaki, Brooklands Park	50	630	20.1	33.6	663	13.3
		71	630	21.6	40.7	1027	14.5
		83	630	22.3	41.9	1116	13.4
	Hawkes Bay	48	1700	18.9	25.3	966	20.1
	Northland	36	650	13.0	30.0	393	10.9
Totara	Northland	102	1225	25.3	38.4	1770	17.4
	Northland	102	1825	23.3	28.4	1357	13.3
	Northland	58	816	8.7	31.4	376	6.5
	Hawkes Bay	48	1975	11.8	18.6	382	8.0
	Waikato	30	1475	8.2	16.6	182	6.1
Kahikatea	Waikato	30	2831	10.2	14.4	289	9.6
Puriri	Bay of Plenty	69	588	18.3	43.8	1046	15.2
Red Beech	Waikato	16	738	12.4	17.3	147	9.2
	Southland	14	1579	8.4	10.4	87	6.2
Black Beech	Southland	14	1508	8.6	10.5	98	7.0

* Carbon sequestered by the stand in CO_2 equivalents. The estimate for the 69-year-old Taranaki kauri stand was obtained from direct biomass measurements. All other estimates were calculated from stand measurements using carbon equations.

+ Mean annual increment in CO_2 sequestration averaged over the current life of the stand.



Planted native shrubs

Millions of native shrubs are planted annually in restoration programmes throughout New Zealand and especially along riparian areas retired from pastoral farming (Bergin and Gea, 2007). In addition to their role in restoration plantings, pioneer shrub species are often required to provide initial shelter on difficult sites when establishing conifer and hardwood tree species. A number of examples of such plantings were measured for stem and height growth in the Tāne's Tree Trust survey of plantations (refer to Technical Article No. 10.4 in this handbook).

Table 3: CO_2 sequestration estimates and other stand characteristics of mixed species native shrub and small tree plantings.

Location	Age (years)	Stocking (stems/ha)	Height (m)	RCD* (cm)	CO_2* (t/ha)	MAI+ (t/ha/yr)
Canterbury	24	3086	8.8	19.7	596	24.8
Nelson	13	3265	6.5	16.7	337	25.9
Waikato	12	4444	6.6	16.5	457	38.1

* Root collar diameter measured 10 cm above ground

A limited number of native shrub and small tree species, most of which are hardwoods, make up most restoration programmes. These tend to be the hardy pioneer species such as manuka (*Leptospermum scoparium*), kanuka (*Kunzea ericoides*), *Pittosporum* species, *Coprosma* species, *Hebe* species, akeake (*Dodonea viscosa*) and whauwhaupaku (*Pseudopanax arboreus*). While selected monocotyledons such as ti kouka, harakeke and toetoe are also used extensively, these are not included in carbon estimates.

Of interest is whether the hundreds of hectares of restoration plantings using native shrub species contribute significantly to carbon storage. Three examples of carbon sequestration estimates based on measurements are given in Table 3. These show that because of the high stockings typically used in shrub plantings, substantial levels of carbon sequestration are possible within 20 years of planting, with the mean annual increments for these three stands averaging 30 t/ha/yr.

CARBON YIELD CURVES FOR SELECTED NATIVE SPECIES

Predicting carbon over time

Carbon sequestration yield curves for several native tree species were obtained by applying the carbon equations to the height and DBH growth curves described in Technical Handbook Articles 10.2, 10.3, and 10.4. Predictions were obtained for 3 commonly grown conifers (kauri, totara and rimu), for 3 hardwoods (red and black beech, and puriri), and for mixed native shrub plantings.

It was necessary to make assumptions about the stocking levels likely to be used in planted native stands as these have a considerable impact on carbon sequestration. To ensure that stockings compatible with the growth curves were used, they were kept similar to those in the stands used to derive the growth curves. Initial stockings of 750 stems/ha were assumed for the hardwoods and 1600 stems/ha for the conifers. An annual mortality rate of 0.6% was assumed for all tree species. For the mixed shrub planting, an initial stocking of 3086 stems/ha (corresponding to a 1.8 m x 1.8 m spacing) and a mortality rate of 2% was used. Predictions were made to age 80 years for totara, kauri and rimu where models are based on good long-term growth data, but only to age 60 years for puriri and 40 years for the beeches, and to age 30 years for the mixed shrub plantings.

For comparison, radiata pine (*Pinus radiata*) carbon estimates based on the lookup table for Bay of Plenty post-1989 radiata pine forest provided by the Ministry of Primary Industries (Anon., 2011) are also presented. This radiata pine table assumes a typical timber regime. Faster rates of sequestration might be expected using higher stocked ‘carbon’ regimes. Because these lookup tables have an allowance for unstocked areas, their values were increased by 20%. Note that all carbon values presented in this article assume full stocking and, should be adjusted to account for understocked areas when applied to a complete plantation.

Carbon sequestration rates

Predicted mean carbon sequestration rates on average sites are shown in Figure 1 and tabulated predictions are given in Table 4. Of the native species, red and black beech are expected to provide the most rapid carbon sequestration on suitable sites, combining a fast growth rate with a high wood density (Table 4). However, the growth rate data for native beech plantations is very limited making these predictions somewhat speculative.

Of the native conifers, kauri should provide the fastest sequestration followed by totara and rimu. There is little information on hardwood tree species other than the beeches although puriri, the most widely planted of these, shows similar sequestration rates to the faster growing conifers.

Because of high initial stockings, mixed species plantings of native shrubs can have higher early sequestration rates than native tree plantations but they typically plateau at ages 20-30 years (Figure 2).

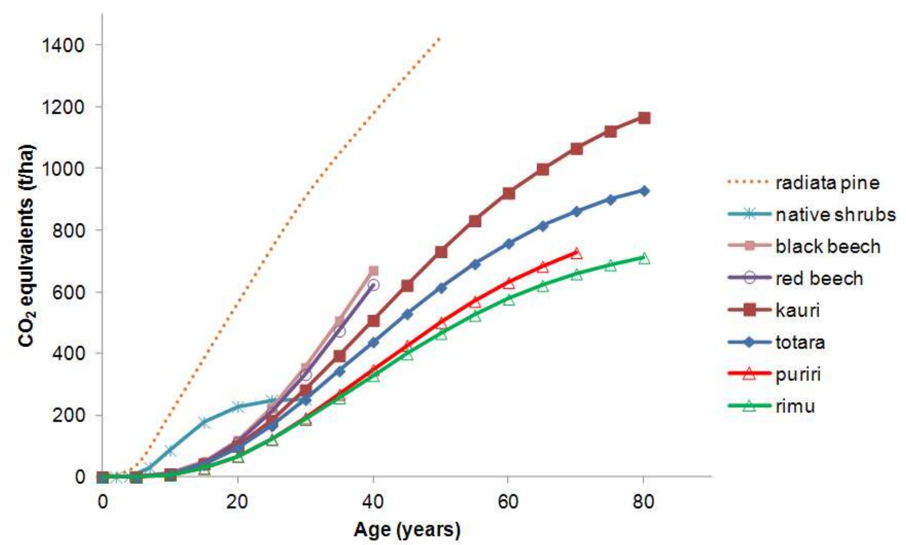


Figure 2: Predicted carbon sequestration rates on average sites for several native tree species, a mixed species shrub planting, and a typical radiata pine stand.

The tree and shrub plantation data available for this survey included few examples of mixed tree and shrub plantings. However, Figure 2 suggests that mixed plantings of shrubs and trees could achieve a substantial boost in carbon sequestration within the first two decades of planting. Such mixed plantings on open sites also provide tree species with shelter in early years. However, native trees growth rates can be much slower under shelter than when established in pure stands because shelter competes with tree species. Therefore such mixed shrub and tree plantings need to be carefully managed.

Table 4: Predicted carbon sequestration rates (t/ha of CO_2 equivalents) on average sites for several native tree species at ages 20, 40 and 80 years.

Species	20 years	40 years	60 years	80 years
Black beech	120	670		
Red beech	113	624	631	
Puriri	67	348	920	1165
Kauri	101	508	757	929
Totara	93	437	577	712
Rimu	68	329		
Mixed shrub species*	228			

Comparison of natives with exotics

None of the native species can compare in early sequestration rates with the fastest growing exotics such as radiata pine. Beyond about age 20 years the fastest growing native species such as kauri, red beech and black beech, can approach exotics in terms of current annual increment. However, the growth rate of natives gradually slows beyond about age 60 years.

COMPARISON BETWEEN PLANTATIONS AND NATURAL FORESTS

Biomass studies in natural forests

Biomass in natural forest stands can be highly variable depending on age, stand density, and species composition. For example, in a biomass study of four kauri stands ranging from a regenerating pole stand to mature forests, CO_2 sequestration ranged from 95 to 2800 t/ha of CO_2 equivalents (Silvester & Orchard, 1999) (Table 5). The stand with the highest sequestration had more carbon than any plantation (Table 4) and shows the potential of this species for storing a large carbon pool. However, its age is likely to be several hundred years old and growth rates of kauri in natural stands have generally been found to be much slower than in planted stands (Steward, 2011).

Biomass in natural beech stands can also be highly variable. In a biomass study by Benecke and Nordmeyer (1982), a 52-year-old naturally-regenerating even-aged pole stand of mountain beech (Table 5) achieved a similar sequestration to equivalent aged red or black beech plantations (Table 6). However, based on biomass figures from Beets (1980), a much older mature lowland mixed forest predominantly of hard beech achieved only a slightly greater carbon sequestration than the young pole stand.

Carbon inventory of natural forests

An inventory of carbon stocks stored within New Zealand's natural forests was undertaken by the Ministry for the Environment during 2002-2007 (Beets et al. 2009). Trees were measured in a representative sample of 887 forest plots and 347 shrubland plots. Carbon was estimated for each plot using the same methodology described in this article.

Table 5: Carbon sequestration based on biomass studies of young to mature natural native kauri (Silvester and Orchard, 1999), mountain beech (Beneke and Nordmeyer, 1982), and hard beech (Beets, 1980).

Species	Description of stand	Carbon (t/ha of CO_2 equivalents)
Kauri	Regenerating pole stand	95
	Young mature	1291
	Mature	1225
	Mature	2805
Mountain beech (*Nothofagus solandri*)	52-year-old pole stand	606
Hard beech (*Nothofagus truncata*)	Mature lowland mixed forest	823

The wide range in distribution of carbon stored in above and below ground forest biomass found in this inventory (Figure 3) reflects the diversity in successional stage, stand structure, forest type and site that is found in natural forest. In forest plots, carbon storage averaged 736 t/ha CO_2 equivalents, with most plots ranging from 400 to 1200 t/ha CO_2 equivalents, and 14% of plots exceeding 1000 t/ha. Carbon stocks in indigenous shrubland plots averaged 201 t/ha CO_2 equivalents. For comparison, depending on the species and site, plantation grown natives can exceed 1000 t/ha within 80 years (Table 4, Figure 2).

This inventory provides an indication of the upper bound of carbon storage that is potentially possible in New Zealand native forests. However, the predicted carbon yield curves for plantations suggest that they will achieve these high levels of sequestration in a much shorter time frame than in naturally regenerating forests.

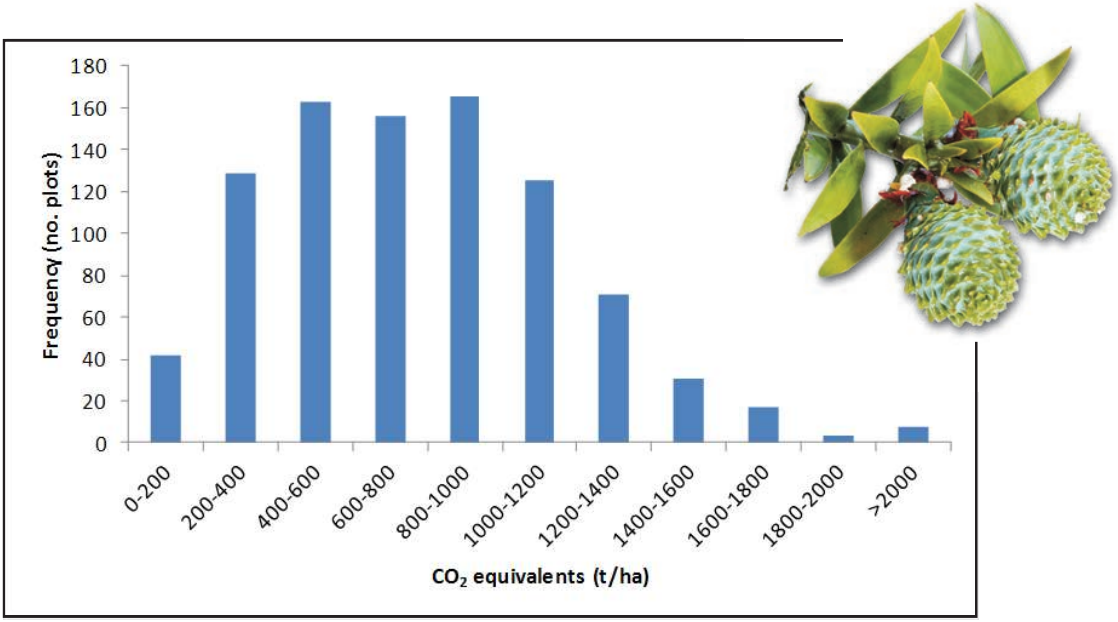


Figure 2: Distribution of carbon sequestration by plot in New Zealand's carbon inventory of natural forests excluding shrubland (from Beets et al., 2009).

69-year-old kauri plantation at Fred Cowling Reserve, New Plymouth.

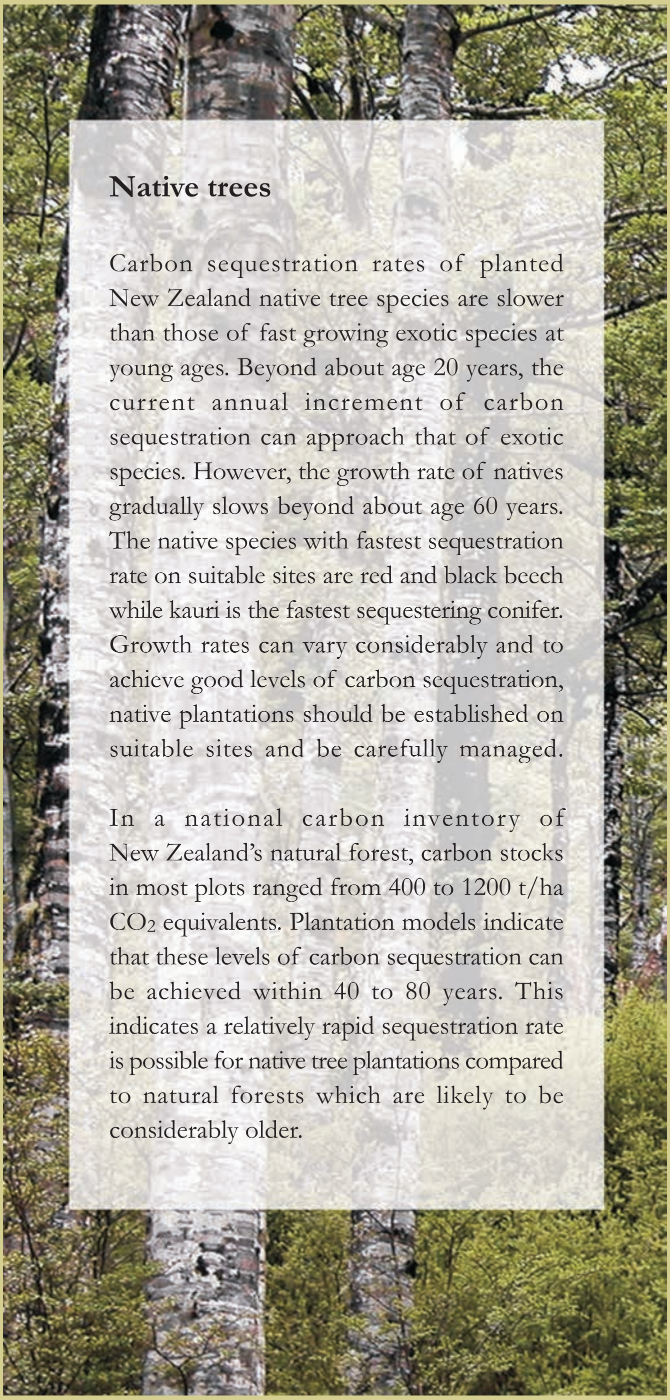
50-year-old totara plantation at Te Karaka, East Coast.

Site selection

The results presented in Table 4 and Figure 1 are best estimates of the sequestration that should be achieved on an average site. Considerably faster rates of sequestration can be obtained on more fertile sites, but much slower growth rates will occur on harsher sites. To achieve good levels of carbon sequestration, native plantations should be established on suitable sites and be carefully managed.

When selecting the species most suitable for planting at a given site, consideration should be given to the natural range of each species. For example, although kauri has been grown successfully in Southland, the advisability of planting the species so far outside its natural geographic range could be questioned. Conversely, the beech species generally only occur naturally on cooler sites and their suitability on warmer sites may also be questioned. Species with a wide natural geographic range such as totara, and rimu on higher rainfall sites, are suitable for planting throughout New Zealand.

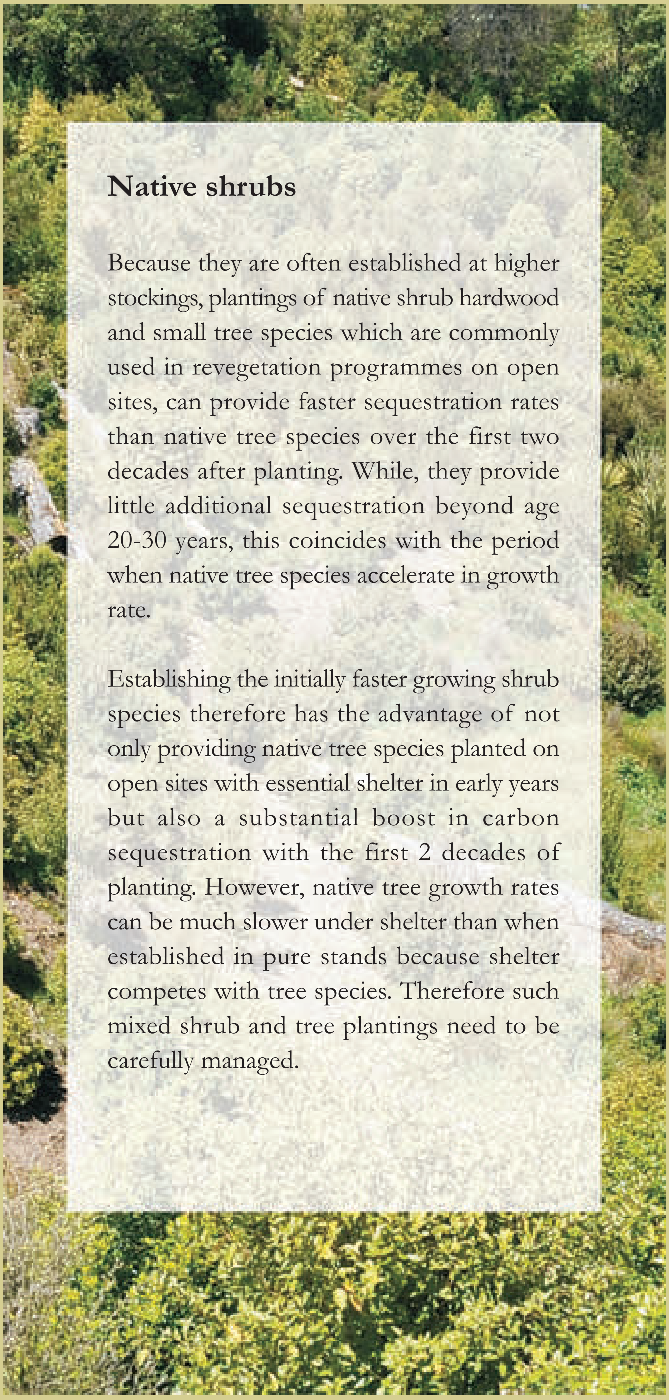
CONCLUSIONS



Native trees

Carbon sequestration rates of planted New Zealand native tree species are slower than those of fast growing exotic species at young ages. Beyond about age 20 years, the current annual increment of carbon sequestration can approach that of exotic species. However, the growth rate of natives gradually slows beyond about age 60 years. The native species with fastest sequestration rate on suitable sites are red and black beech while kauri is the fastest sequestering conifer. Growth rates can vary considerably and to achieve good levels of carbon sequestration, native plantations should be established on suitable sites and be carefully managed.

In a national carbon inventory of New Zealand's natural forest, carbon stocks in most plots ranged from 400 to 1200 t/ha CO_2 equivalents. Plantation models indicate that these levels of carbon sequestration can be achieved within 40 to 80 years. This indicates a relatively rapid sequestration rate is possible for native tree plantations compared to natural forests which are likely to be considerably older.



Native shrubs

Because they are often established at higher stockings, plantings of native shrub hardwood and small tree species which are commonly used in revegetation programmes on open sites, can provide faster sequestration rates than native tree species over the first two decades after planting. While, they provide little additional sequestration beyond age 20-30 years, this coincides with the period when native tree species accelerate in growth rate.

Establishing the initially faster growing shrub species therefore has the advantage of not only providing native tree species planted on open sites with essential shelter in early years but also a substantial boost in carbon sequestration with the first 2 decades of planting. However, native tree growth rates can be much slower under shelter than when established in pure stands because shelter competes with tree species. Therefore such mixed shrub and tree plantings need to be carefully managed.

References:

Anon. 2009: New Zealand Plantation Forest Industry Facts and Figures 2008/2009. Ministry of Agriculture and Forestry.

Anon. 2011: Look-up Tables for Forestry in the Emissions Trading Scheme. Ministry of Agriculture and Forestry.

Beets, P.N. 1980: Amount and distribution of dry matter in a mature beech/podocarp community. *New Zealand Journal of Forestry Science, 10*: 395-418.

Beets, P.N.; Kimberley, M.O.; Oliver, G.R.; Pearce, S.H.; Graham, J.D.; Brandon, A. 2012: Allometric equations for estimating carbon stocks in natural forest in New Zealand. *Forests, 3,* 818-839.

Beets, P.N.; Kimberley, M.O.; Goulding, C.J.; Garrett, L.G.; Oliver, G.R.; Paul, T.S.H. 2009: Natural forest plot data analysis: carbon stock analyses and remeasurement strategy. Available on request from the Ministry for the Environment. 136p.

Beneke, U.; Nordmeyer, A.H. 1982: Carbon uptake and allocation by *Nothofagus solandri* var. *cliffortioides* (Hook. f.) Poole and *Pinus contorta* Douglas ex. London ssp. *contorta* at montane and sub-alpine altitudes. Pp. 9-21. *In* Waring, R.H. (Ed.). *Carbon uptake and allocation in subalpine ecosystems as a key to management*. Oregon State University, Corvallis.

Bergin, D.O.; Gea, L. 2007. Native trees – planting and early management for wood production. *New Zealand Indigenous Tree Bulletin No. 3*. New Zealand Forest Research Institute. Revised edition. 44p.

Ellis, J.; Hayes, J. 1997: Field guide for sample plots in New Zealand forests. New Zealand Forest Research Institute, Rotorua. *FRI Bulletin No. 186*. 84p.

McGlone, M.S. 1989. The Polynesian settlement of New Zealand in relation to environmental and biotic changes. *New Zealand Journal of Ecology, 12*: 115-129.

Silvester, W.B.; Orchard, T.A. 1999: The biology of kauri (*Agathis australis*) in New Zealand. 1. Production, biomass, carbon storage, and litter fall in four forest remnants. *New Zealand Journal of botany, 37*: 553-571.

Stevens, M.I.; Winter, D.J.; Morris, R.; McCartney, J.; Greenslade, P. 2007: New Zealand's giant Collembola: New information on distribution and morphology for *Holacanthella* Borner, 1906 (Neanuridae: Uchidanurinae). *New Zealand Journal of Zoology, 34*: 63-78.

Steward, G.A. 2011: Growth and yield of New Zealand kauri (*Agathis austrails* (D.Don) Lindl.). Master of Forestry Science, University of Canterbury. 150p.

The 102 year-old plantation of totara established at Puhipuhi in Northland used to demonstrate calculation of carbon sequestration:

- A 0.04 ha Permanent Sample Plot established within this stand comprised 49 trees indicating stocking was 1225 stems/ha.
- The stand has an average DBH of 38 cm and mean height 25 m with a stem volume estimated to be 1753 m^3/ha.
- Based on a wood density of 370 kg/m^3 for totara, and allowing for the assumption that 50% of forest biomass is carbon, the combined above and below ground biomass in this stand is therefore estimated to contain 483 t/ha of carbon.
- By converting the carbon stock contained in this to atmospheric carbon dioxide, this totara plantation is estimated to have sequestered 1770 t/ha of CO_2 from the atmosphere.

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The Ministry for Primary Industries does not necessarily endorse or support the content of the publication in any way.

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Tāne's Tree Trust
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Tāne's Tree Trust promotes the successful planting and sustainable management of New Zealand native trees and shrubs for multiple uses.

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