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JCH INDUSTRIAL ECOLOGY LIMITED

Biomass Growth and Carbon Sequestration

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Background

JCH Industrial Ecology Ltd were asked by Abodo Wood to conduct a high-level desk study to determine the mean annual increment of the following species:

Species	Botanical name	Location
Western red cedar	*Thuja plicata*	Coastal British Columbia
Alaskan yellow cedar	*Chamaecyparis nootkatensis*	Coastal British Columbia, Alaska
White Ash	*Fraxinus americana*	Central / East USA
Spotted Gum	*Corymbia* spp.	East Coast Australia
Black Butt	*Eucalyptus pilularis*	NSW/QLD
Siberian Larch	*Larix sibirica*	Krasnoyarsk, Irkutsk, Altai
Ipê	*Tabebuia* spp.	North/central Brazil
Scots pine	*Pinus sylvestris*	Sweden/Finland

This study was to be used inform the carbon sequestration potential of wood which is to be compared to New Zealand grown radiata pine (*Pinus radiata*), which has a stated mean annual increment of 25 m^3/ha/yr (Kaingaroa - Timberlands Ltd, NZ). The mean annual increment results are summarised in a table, with references.

The mean annual increment is the volume of biomass produced per year calculated from the age of the forest/stand and the total volume of timber in the measurement area. This value will increase over time and reach a maximum, after which a decline in MAI will occur. The MAI is dependent upon many factors, which include: site type, rainfall, temperature, light availability, nutrient availability. The values that have been selected in this study are considered to be typical, but other values may be found which fall outside the typical range. The mean annual increment (MAI) should not be confused with the current annual increment (CAI), or the periodic annual increment (PAI).

- MAI = Volume of stand (m^3/ha)/Age of stand (yrs)
- CAI = (volume at end of a year – volume at the beginning of a year)
- PAI = ((volume at the beginning of a period - volume at end of period)/length of period)

Mean Annual Increment

Species	MAI (m^3/ha/yr)	Reference
WR Cedar	1.8-3.0[1], 2.4-13.5[2]	Nakoe (1978), Wang and Russell (2006)
AY Cedar	9.6[2]	USDA (2003)
White ash	2.0	Solomon and Leak (1986)
Spotted gum	4.0-10.0 (average)	Queensland Government (2013)
Black butt	0.4-3.4	Australian Govt. (2011)
Siberian larch	1.3	Bergstedt and Lyck (2007)
Ipê*	6.0[2]	Tonini et al. (2005)
Radiata pine	25.0	Kaingaroa - Timberlands Ltd
Scots pine	2.0-10.0	Persson and Beuker (1997)

[1]First growth
[2]Second growth

**Data for ipê-roxo (*Tabebuia avellanedae* Lorentz ex Griseb) was for plantation-grown timber.

Regarding timber harvesting in Amazonia, Piponiot et al. (2019) stated that periodic harvests of 20 m^3 ha^{-1} will not recover at the end of a 30-year cutting cycle. Median timber recovery was highest in Western Amazonia (0.3 m^3 ha^{-1} yr^{-1}).

Carbon Sequestration

In order to calculate the amount of carbon sequestered per hectare per year, it is necessary to know the density of the wood (at zero moisture content) and the carbon content of the wood. Given that this is a preliminary study, the following assumptions were made:

- Wood density is assumed to be the same for first-growth and plantation grown timber. In reality, it is likely that faster grown timber will have a lower density and hence a lower overall carbon content per m3.

- Carbon content was assumed to be 50% of dry mass. This is a reasonable approximation and is recommended in European Standard EN16449:2014 as the default when the exact carbon content is unknown. Given the level of uncertainty in the MAI and the density, this assumption makes no significant difference to the results.

Sequestered carbon is herein reported in units of carbon dioxide equivalents using the following formula (EN16449):

$CO_2 = (44/12) \times cf \times (\rho_\omega \times V_\omega)/(1 + \omega/100)$

Where:

- CO_2 is the carbon content of the wood in kg CO_2 equivalents
- Cf is the carbon fraction of the wood (dry), 0.5 as the default value
- ω is the moisture content of the wood (% basis)
- ρ_ω is the density of the wood at that moisture content (kg/m^3)
- V_ω is the volume of the wood at that moisture content (m^3)

The calculated sequestration of atmospheric carbon dioxide per hectare is as follows:

Species	CO_2 (tonnes CO_2e) ha^{-1} $year^{-1}$
WR Cedar	1.3-2.1, 1.7-9.7*
AY Cedar	7.6*
White ash	2.5
Spotted gum	5.8-14.5
Black butt	0.7-5.6
Siberian larch	1.4
Ipê	12.1*
Radiata pine	20.6*
Scots pine	2.0-10.1

*second growth/plantation

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