Survival and growth monitoring of *Eucalyptus grandis* and *Flindersia brayleyana* plantings in the Waiakea Timber Management Area

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I. Introduction

The Division of Forestry and Wildlife periodically plants seedlings of selected timber species in the Waiakea Timber Management Area (WTMA). In 1998 four regeneration transects were installed and measured to initiate a program to monitor survival and growth of two important timber species in the WTMA – *Eucalyptus grandis* and *Flindersia brayleyana*. The transects were subsequently measured three additional times. This report provides a summary of seedling and sapling survival and growth on these transects to date. Historic information and data relating to the establishment and management of these plantings are provided where available.

II. Methods

Two transects were installed for each species. All transects are comprised of five 0.05 acre circular plots, spaced at 100 foot intervals. A metal pipe was placed as the plot center monument for each plot. Site preparation in block KN06 apparently involved bull dozing and piling of debris in windrows, so transect lines were oriented to traverse the areas between windrows for Transects 3 and 4. The transects are located as follows:

Transect	WTMA block
1	CN01
2	CN02
3	KN06
4	KN06

Seedlings or saplings of all potential timber species were numbered. Diameter at breast height (DBH), total height, and tree vigor were recorded for each tree. Tree vigor assessments were based on the following rating scale:

Rating	Tree vigor
1	excellent
2	average
3	poor

Trees that died were removed from the database, while other seedlings were added as a result of natural recruitment. Tree data from all plots of a given transect were combined for statistical analyses, and were presented by individual species. For the March 2000 re-measurement, three plots of Transect 1 and all five Plots of Transect 2 could not be re-measured due to safety issues arising from an unexpected enforcement stakeout.

III. Results

Flindersia brayleyana: During the first year after planting, the following management regime was applied to all seedlings in the blocks represented by both (except as noted) transects:

1. No weed control, each seedling fertilized with 4 ounces of 10-30-10 fertilizer.
2. Hand weeding around each seedling, 4 ounces of slow-release 16-16-16 fertilizer.
3. Hand weeding around each seedling, 4 ounces of slow-release 16-16-16 fertilizer.

4. *Transect 1 only*: hand weeding around each seedling, 4 ounces of slow-release 16-16-16 fertilizer.

Each of these treatments were spaced two or more months apart. Transect 1 seedlings received a fourth treatment because they appeared stressed and were not becoming well established.

Seedlings on both transects became established with little mortality through December 1998. Despite the fact that Transect 2 was planted 9 months after Transect 1, seedling survival, mean DBH and mean height indices were higher in Transect 2 by April 2002. This difference may be attributed to two factors. First, Transect 1 planting stock was grown in dibble tubes while Transect 2 planting stock was raised in larger polyethylene bags. At the time of planting, Transect 1 and 2 seedlings were approximately six and 16 inches tall, respectively. Surface soils of Waiakea can dry out quickly after short periods without rain, and it was noted that surface soils are somewhat shallower in Transect 1 than Transect 2. The combination of differences in seedling (and root system) size and site potential probably gave seedlings planted in Transect 2 advantages in nutrient uptake, drought tolerance, and competitive ability with weeds. Second, *Melastoma* spp. thickets (up to 10 feet in height) were more common in Transect 1 by 2002, providing heavy competition for many *Flindersia brayleyana* saplings in this planting area.

<u>*Eucalyptus grandis*</u>: Accurate planting and seedling management records for these two transects have not been located. In 1998 Howard Horiuchi provided an estimated planting date of October 1990 for block KN06. A major difference in tree growth between Transects 3 and 4 was apparent by 2002. Growth potential between areas represented by these two transects varies due to differences in the soil substrate, site preparation methodology, or a combination of these factors.

Eucalyptus grandis trees in Transect 3 appear to be struggling to become established, a situation that may include direct competition from *Toona ciliata* and *Metrosideros polymorpha*. *Eucalyptus grandis* trees in Transect 4 have moved beyond the establishment phase, exhibiting notable diameter and height growth between each measurement. Not surprisingly, tree vigor in Transect 4 was slightly higher than that for Transect 3 in all four measurements. Trees in both transects exhibited survival rates greater than 90% during the period studied. However, tree mortality between planting and the first transect measurements in 1998 remain unknown.

<u>Other species</u>: *Toona ciliata* and *Metrosideros polymorpha* are the most common secondary tree species in these planting areas. In all transects most trees of these two species were residuals remaining after site preparation work for *Flindersia brayleyana* or *Eucalyptus grandis* planting operations. Many of these residual overstory trees are in decline. Mean diameter and height indices were relatively static over time, while stocking and tree vigor indices typically declined. An exception to these trends was observed on Transect 4 where considerable natural recruitment of both *Toona ciliata* and *Metrosideros polymorpha* was observed by 2002. Both residual trees and natural recruitment trees appeared to be relatively vigorous compared to individuals of the same species from other transects. By 2002 the combined stocking level of these two secondary species exceeded the stocking level of *Eucalyptus grandis* on Transect 4.

Transect 1 - *Flindersia brayleyana* (planted July 1997)

	July 1998	December 1998	March 2000[A]	April 2002
Age (years)	1.0	1.4	2.7	4.8
tree count on plots	51	50	15	39
trees per acre equivalent	204	200	NA	156
percent of 7/98 stocking	100	98	NA	76
mean DBH (inches)	0.0	0.0	0.0	0.2
minimum DBH	0.0	0.0	0.0	0.0
maximum DBH	0.0	0.0	0.0	2.6
DBH standard deviation	0.0	0.0	0.0	0.6
mean height (feet)	3.8	4.8	7.3	10.3
minimum height	2.0	2.0	5.0	3.0
maximum height	6.0	8.0	11.0	28.0
height standard deviation	1.0	1.5	1.8	4.8
mean tree vigor	2.06	1.74	2.07	1.90

[A]Data for 2000 collected on two plots only - three plots were not measured.

Transect 1 - *Toona ciliata* (planted June 1961)

	July 1998	December 1998	March 2000[B]	April 2002
Age (years)	37.1	37.5	38.8	40.8
tree count on plots	10	10	NA	8
trees per acre equivalent	40	40	NA	32
percent of 7/98 stocking	100	100	NA	80
mean DBH (inches)	10.5	10.5	NA	11.0
minimum DBH	6.7	6.7	NA	6.5
maximum DBH	18.3	18.5	NA	18.6
DBH standard deviation	3.5	3.5	NA	3.8
mean height (feet)	42	42	NA	46
minimum height	30	27	NA	28
maximum height	69	65	NA	67
height standard deviation	14	12	NA	13
mean tree vigor	2.30	2.90	NA	2.88

[B]Data from only two plots in 2000 do not provide a sufficient basis to present accurate tree statistics.

Transect 1 - *Metrosideros polymorpha* (age unknown)

	July 1998	December 1998	March 2000[C]	April 2002
tree count on plots	5	4	NA	4
trees per acre equivalent	20	20	NA	16
percent of 7/98 stocking	100	100	NA	80
mean DBH (inches)	8.9	10.0	NA	10.0
minimum DBH	4.7	6.1	NA	6.2
maximum DBH	19.2	19.2	NA	19.2
DBH standard deviation	5.9	6.2	NA	6.2
mean height (feet)	41	45	NA	46
minimum height	35	32	NA	36
maximum height	49	61	NA	62
height standard deviation	5	12	NA	12
mean tree vigor	1.80	2.50	NA	2.75

[C]Data from only two plots in 2000 do not provide a sufficient basis to present accurate tree statistics.

Transect 2 - *Flindersia brayleyana* (planted April 1998)

	July 1998	December 1998	March 2000[D]	April 2002
Age (years)	0.3	0.7	1.9	3.9
tree count on plots	50	50	NA	47
trees per acre equivalent	200	200	NA	188
percent of 7/98 stocking	100	100	NA	94
mean DBH (inches)	0.0	0.0	NA	0.8
minimum DBH	0.0	0.0	NA	0.0
maximum DBH	0.0	0.0	NA	2.5
DBH standard deviation	0.0	0.0	NA	1.0
mean height (feet)	2.2	3.5	NA	13.7
minimum height	1.0	2.0	NA	5.0
maximum height	3.0	5.0	NA	27.0
height standard deviation	0.6	0.9	NA	5.7
mean tree vigor	2.26	1.10	NA	1.83

[D]Data not collected on all five plots in 2000.

Transect 2 - *Toona ciliata* (planted October 1963)

	July 1998	December 1998	March 2000[E]	April 2002
Age (years)	34.8	35.2	36.4	38.5
tree count on plots	5	5	NA	6
trees per acre equivalent	20	20	NA	24
percent of 7/98 stocking	100	100	NA	120
mean DBH (inches)	9.1	9.0	NA	8.4
minimum DBH	8.2	7.9	NA	4.5
maximum DBH	10.8	10.8	NA	10.9
DBH standard deviation	1.2	1.3	NA	2.2
mean height (feet)	42	43	NA	41
minimum height	36	38	NA	23
maximum height	47	45	NA	50
height standard deviation	4	3	NA	10
mean tree vigor	2.00	2.40	NA	2.83

[E]Data from only two plots in 2000 do not provide a sufficient basis to present accurate tree statistics.

Transect 2 - *Metrosideros polymorpha* (age unknown)

	July 1998	December 1998	March 2000[F]	April 2002
tree count on plots	1	1	NA	3
trees per acre equivalent	4	4	NA	12
percent of 7/98 stocking	100	100	NA	300
mean DBH (inches)	5.9	5.9	NA	3.0
minimum DBH	5.9	5.9	NA	0.0
maximum DBH	5.9	5.9	NA	5.8
DBH standard deviation	NA	NA	NA	2.9
mean height (feet)	37	37	NA	27
minimum height	37	37	NA	15
maximum height	37	37	NA	40
height standard deviation	NA	NA	NA	13
mean tree vigor	2.00	2.00	NA	2.67

[F]Data from only two plots in 2000 do not provide a sufficient basis to present accurate tree statistics.

Transect 3 – *Eucalyptus grandis* (planted October 1990)

	July 1998	December 1998	April 2000	April 2002
Age (years)	7.8	8.2	9.5	11.5
tree count on plots	65	66	65	62
trees per acre equivalent	260	264	260	248
percent of 7/98 stocking	100	102	100	95
mean DBH (inches)	5.4	5.6	6.0	6.7
minimum DBH	0.0	1.5	1.6	1.6
maximum DBH	12.3	12.8	14.3	16.5
DBH standard deviation	3.0	3.1	3.5	4.0
mean height (feet)	59	61	69	78
minimum height	21	19	22	10
maximum height	105	119	121	141
height standard deviation	24	26	28	32
mean tree vigor	2.08	1.91	1.68	2.24

Transect 3 - *Toona ciliata* (planted December 1966)

	July 1998	December 1998	April 2000	April 2002
Age (years)	31.6	32.0	33.3	35.3
tree count on plots	18	18	16	14
trees per acre equivalent	72	72	64	56
percent of 7/98 stocking	100	100	89	78
mean DBH (inches)	5.4	5.5	5.8	5.7
minimum DBH	0.0	0.0	1.5	1.7
maximum DBH	15.3	15.4	15.9	16.6
DBH standard deviation	5.1	5.1	4.8	5.0
mean height (feet)	29	29	38	44
minimum height	10	10	15	13
maximum height	72	72	88	90
height standard deviation	17	18	21	22
mean tree vigor	2.17	2.11	2.74	2.14

Transect 3 - *Metrosideros polymorpha* (age unknown)

	July 1998	December 1998	April 2000	April 2002
tree count on plots	1	1	3	3
trees per acre equivalent	4	4	12	12
percent of 7/98 stocking	100	100	300	300
mean DBH (inches)	6.4	6.5	6.2	6.2
minimum DBH	6.4	6.5	6.0	5.9
maximum DBH	6.4	6.5	6.4	6.4
DBH standard deviation	NA	NA	0.2	0.3
mean height (feet)	45	36	38	42
minimum height	45	36	32	39
maximum height	45	36	44	46
height standard deviation	NA	NA	6	4
mean tree vigor	2.00	2.00	1.00	1.67

Transect 4 – *Eucalyptus grandis* (planted October 1990)

	July 1998	December 1998	April 2000	April 2002
Age (years)	7.8	8.2	9.5	11.5
tree count on plots	34	36	36	31
trees per acre equivalent	136	144	144	124
percent of 7/98 stocking	100	106	106	91
mean DBH (inches)	1.2	1.3	1.5	2.2
minimum DBH	0.0	0.0	0.0	0.0
maximum DBH	6.1	6.1	6.1	6.3
DBH standard deviation	1.5	1.5	1.6	1.6
mean height (feet)	15	17	19	23
minimum height	5	5	2	5
maximum height	47	54	41	47
height standard deviation	8	10	9	11
mean tree vigor	2.18	2.06	2.03	2.35

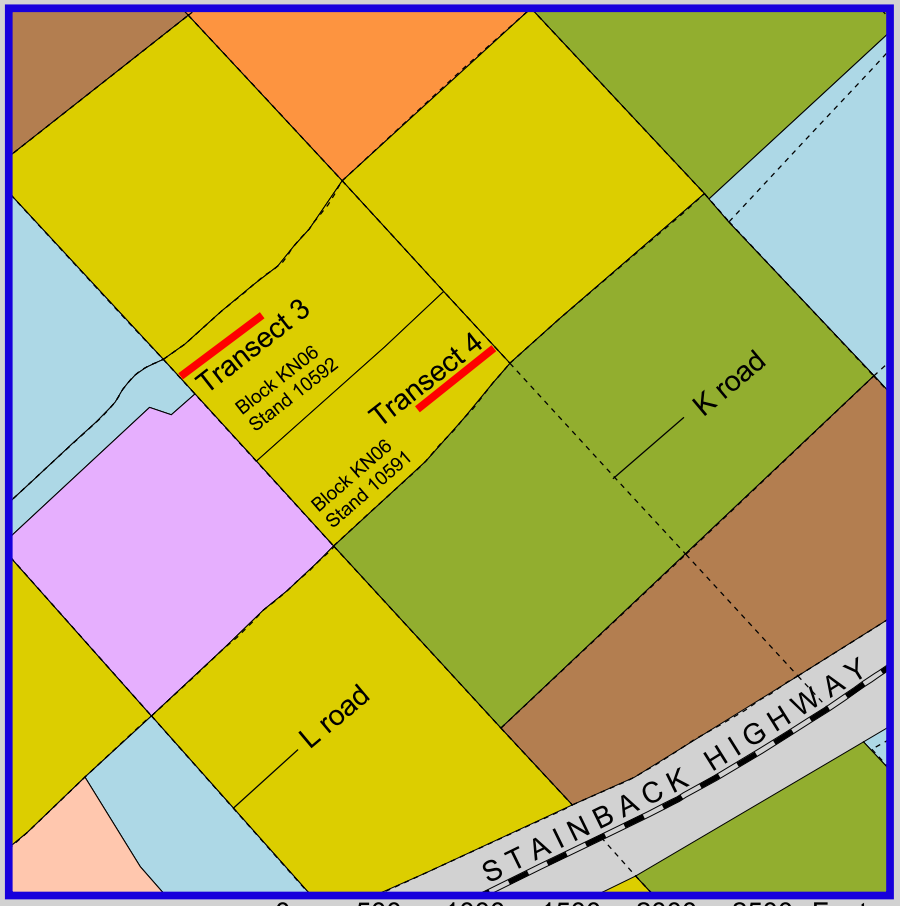
Transect 4 - *Toona ciliata* (planted December 1966)

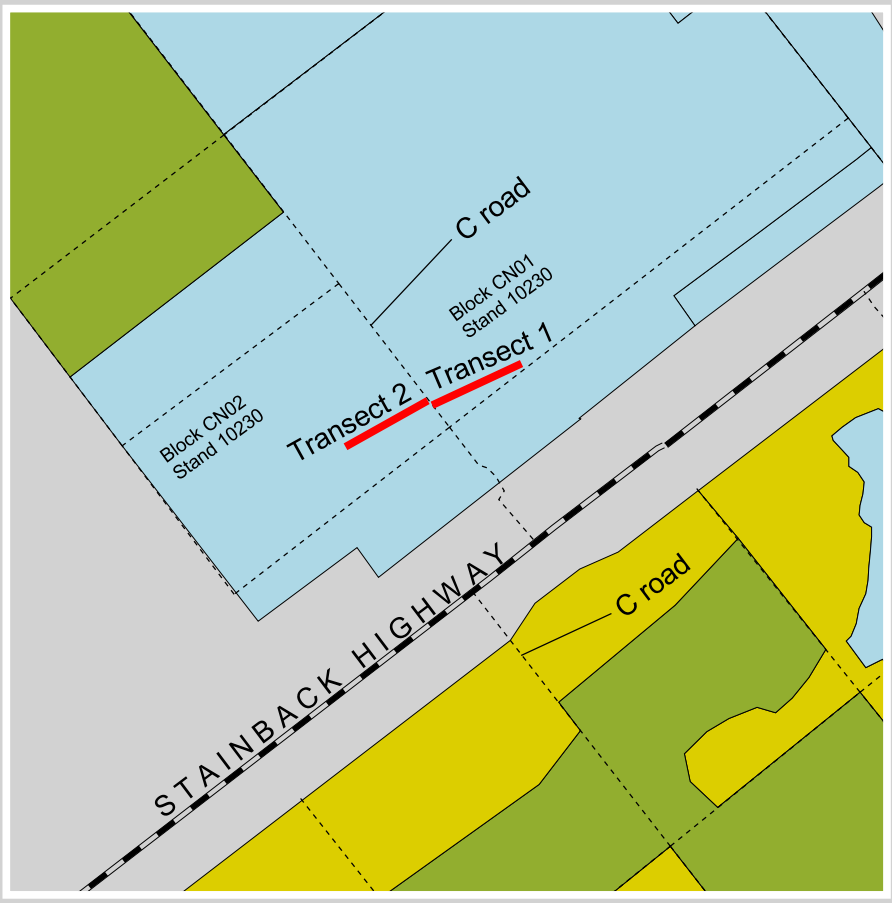
	July 1998	December 1998	April 2000	April 2002
Age (years)	31.6	32.0	33.3	35.3
tree count on plots	17	16	19	22
trees per acre equivalent	68	64	76	88
percent of 7/98 stocking	100	94	112	129
mean DBH (inches)	3.8	4.1	3.7	3.5
minimum DBH	0.0	0.0	0.0	0.0
maximum DBH	20.8	20.2	21.3	22.1
DBH standard deviation	5.8	5.8	5.8	5.6
mean height (feet)	26	29	26	26
minimum height	7	9	6	6
maximum height	75	78	90	95
height standard deviation	21	24	25	24
mean tree vigor	1.65	2.00	1.68	2.46

Transect 4 - *Metrosideros polymorpha* (age unknown)

	July 1998	December 1998	April 2000	April 2002
tree count on plots	8	8	15	15
trees per acre equivalent	32	32	60	60
percent of 7/98 stocking	100	100	188	188
mean DBH (inches)	3.3	3.3	1.8	2.0
minimum DBH	1.9	1.9	0.0	0.0
maximum DBH	5.8	5.8	5.9	6.0
DBH standard deviation	1.3	1.4	2.0	2.0
mean height (feet)	29	31	18	21
minimum height	15	20	4	7
maximum height	44	41	42	42
height standard deviation	10	7	13	12
mean tree vigor	2.13	2.13	1.67	2.07

Waiakea regeneration transect locations.





0 500 1000 1500 2000 2500 Feet

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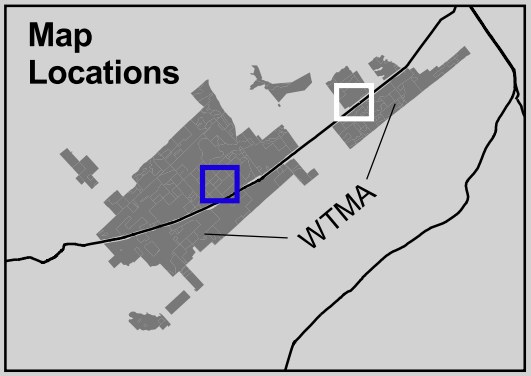
Map Locations



Transects
Block roads
Acacia koa
Cryptomeria japonica
Eucalyptus robusta
Eucalyptus grandis
Flindersia brayleyana
Fraxinus uhdei
Toona ciliata

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