Baseline and Stand Structural Attributes Changes in Arid Woodland Vegetation

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Abstract: For evaluating sequestrated carbon amount by planted trees, baseline carbon stock change must be estimated. Since present land use type is natural vegetation, baseline carbon stock change is equivalent to stand biomass change. Repeated tree census in 15 sites inside the research area have been carried out about ten years, and then stand biomass and stand structural attribute changes were observed. Stand growth of Acacia forest and woodland, dominant vegetation type in the research area, varied from -0.57 to 5.98 Mg ha⁻¹ year⁻¹, excluding artificial disturbance, and its average was 0.14 Mg ha⁻¹ year⁻¹, equivalent to 0.068 Mg-carbon ha⁻¹ year⁻¹. Thus, afforestation method which overcomes this baseline stand growth must be adopted for the future afforestation designing.

Keywords: Basal area, Biomass, Canopy cover, Leaf area index, Stand growth

1. Introduction

As one of the counter measures for global warming, arid land afforestation experiment has been proposed and implemented in an arid land of Western Australia (Yamada, 2004; Kojima et al., 2006). The experimental area, Sturt Meadows, locates 600 km from Perth, the provincial capital of Western Australia, and its coordinate is 120°58'E, 28°40'S. From UNFCCC (2006), sequestrated carbon amount by afforestation must be calculated from carbon stock changes in 5 types of carbon pools. This 5 carbon pools consist of above-ground biomass, below-ground biomass, litter, dead wood and soil organic carbon. Among 5 carbon pools, we focused on above-ground biomass, below-ground biomass in this study.

For accounting carbon amount for emission credit, in addition to evaluating the significant changes in carbon pools inside afforestation boundary, baseline and leakage must be considered (UNFCCC, 2006). Since main industries in this arid area are mining and extensive grazing, leakage was considered as nearly zero. There spreads vast unused land. On the other hand, present land use type in this research area is Acacia forest and woodlands (National Land and Water Resources Audit, 2002), so baseline is stand growth of this natural vegetation. Thus, stand growth in the representative sites in the research area were observed in this research.

2. Materials and Methods

15 representative natural vegetation sites were set for baseline monitoring in the research area, where mean annual rainfall is around 200 mm year⁻¹ and no obvious dry-season exists. As the major vegetation type is Acacia forests and woodlands in this research area, 9 sites were set where Acacia aneura was dominant tree species. 4 sites were set where Eucalyptus camaldulensis was dominant tree species. 2 sites were set where halophyte or salinity tolerant shrub distributed.

Repeated tree censuses have been carried out inside these 15 sites from June 1999 to August 2007. Most of the sites were monitored three times. Measured values were, tree species, tree height, girth at breast height (1.3 m) and canopy width. From these measurement data, stand biomass, stand growth canopy cover (CC), stand basal area (SBA), leaf area index (LAI) were calculated. Stand biomass was calculated using allometric equations which were described as power function (Y=aXᵇ). The coefficients are shown on Table 1. As allometric equations were made only for dominant tree species, other tree species biomass were calculated from generalized allometric equations which were made by mixing 5 tree

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Table 1. Allometric equations.

<table>
<thead>
<tr>
<th>Species</th>
<th>Dependent variable</th>
<th>Independent variable</th>
<th>Coefficient</th>
<th>R square</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Y (kg)</td>
<td>X (unit)</td>
<td>a</td>
<td>b</td>
<td></td>
</tr>
<tr>
<td><strong>Acacia aneura</strong></td>
<td>Ws + Wb (m²)</td>
<td>DBH² (m²)</td>
<td>5255.4</td>
<td>1.084</td>
<td>0.992</td>
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<tr>
<td></td>
<td>Wl (m²)</td>
<td>DBH² (m²)</td>
<td>77.6</td>
<td>0.676</td>
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<td>Ws + Wb (m²)</td>
<td>Cpa (m²)</td>
<td>1.44</td>
<td>1.442</td>
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<tr>
<td></td>
<td>Wl (m²)</td>
<td>Cpa (m²)</td>
<td>0.53</td>
<td>0.847</td>
<td>0.982</td>
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<tr>
<td></td>
<td>Wr (kg)</td>
<td>Wabose (kg)</td>
<td>0.40</td>
<td>1</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Eucalypts camaldulensis</strong></td>
<td>Ws + Wb (m²)</td>
<td>DBH² (m²)</td>
<td>6212.9</td>
<td>1.188</td>
<td>0.990</td>
</tr>
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<td>Wl (m²)</td>
<td>DBH² (m²)</td>
<td>189.2</td>
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<td>Ws + Wb (m²)</td>
<td>Cpa (m²)</td>
<td>0.59</td>
<td>1.734</td>
<td>0.961</td>
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<td>Wl (m²)</td>
<td>Cpa (m²)</td>
<td>0.35</td>
<td>1.153</td>
<td>0.948</td>
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<td>Wr (kg)</td>
<td>Wabose (kg)</td>
<td>0.72</td>
<td>1.0</td>
<td>N/A</td>
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<td><strong>Melaleuca sheathiana</strong></td>
<td>Ws + Wb (m²)</td>
<td>Cpa (m²)</td>
<td>0.13</td>
<td>2.222</td>
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<td>Wl (m²)</td>
<td>Cpa (m²)</td>
<td>0.03</td>
<td>1.931</td>
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<td></td>
<td>Wr (kg)</td>
<td>Wabose (kg)</td>
<td>0.40</td>
<td>1</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>other species</strong></td>
<td>Ws + Wb (m²)</td>
<td>Cpa (m²)</td>
<td>1.38</td>
<td>1.211</td>
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<td>Cpa (m²)</td>
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<td>0.900</td>
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<tr>
<td></td>
<td>Wr (kg)</td>
<td>Wabose (kg)</td>
<td>0.27</td>
<td>1</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Species data (Acacia ramosa, A. tetragonophylla, Eremophila forestii, Eremophila macmillaniana, Lawrenzia squamata). Stand growth was calculated as mean annual increment (MAI) which is simple arithmetic average of stand biomass change per year. CC, SBA and LAI were calculated from following formulas:

\[
CC = \frac{\sum Cpa}{\text{Plot}} \quad (1)
\]

\[
SBA = \sum \frac{\pi(DBH^2)}{10000} \quad (2)
\]

\[
LAI = \frac{\sum Wl}{\text{LMA} \times 10000} \quad (3)
\]

where Cpa [m²] is crown projection area: Plot [m²] is site area: DBH [m] was diameter at breast height: Wl [kg] is leaf biomass and LMA [kg m²] was leaf mass per unit area. CC in this research was just a cumulative value of crown projection area, which is approximated as ellipse, inside the monitoring site, thus this value became over 1.0. SBA was the normalized value per 1 hectare. The LMA of E. camaldulensis was 169.5g m² (n=170, SE=3.3), and that of A. aneura was 327.9 g m² (n=75, SE=7.9) reported in Yamada (2004). For convenience, The LMA’s of the other species were set as the same value of A. aneura because of insufficient data and similarity of leaf thickness.

3. Results and Discussion

From repeated tree censuses, species compositions in each site were obtained. Excluding site 10, dominance of Acacia aneura was 94.4% (SD=8.5) among Acacia woodland sites. Site 10 was mixture of A. aneura (57.1%), A. coolgardiendsis (18.3%) and Eucalyptus kingsmilli (17.4%). Dominance of Eucalyptus camaldulensis was 95.4% (SD=8.8) among Eucalypts sites. Since species compositions in each site were judged from basal area dominance, thus trees less than 2 m were neglected, and dominant species of site 3 and site 6 were judged from appearance ratio. Species compositions in each site have been relatively stable, because not so many trees appeared or died. Precisely, small trees (less than 1 m) and herbaceous species varied a lot. Observed tree species in Acacia and Eucalypts forests and woodlands were listed as follows, excluding above mentioned species. Acacia burkittii, Acacia craspedocarpa, Acacia ramosa, Acacia tetragonophylla, Atriplex rhagodioides, Canthium lineare, Cassia artemisioide, Cassia chatelainiana, Cassia desolata, Cassia nemophila, Cratylystus subspinescens, Eremophila forrestii, Eremophila fraseri, Eremophila georgei, Eremophila glabra, Eremophila granitica, Eremophyla longifolia, Eremophila maculata, Grevillea berryana, Hakea suberea, Maireana convexa, Pimelea microcephala, Ptilotus divaricatus, Rhagodia drummondii, Rhagodia eremaea and Scaevola spinescens.

Table 2 shows the summary of stand biomass change and basic site information. Mean annual increment of Acacia forests and woodlands (Acacia aneura) varied from -0.57 to 5.98 Mg ha⁻¹ year⁻¹, excluding artificial disturbance. Before third census of Site 2, not so many but not negligible number of trees were cut down by some Aboriginal activity. Therefore we considered the tree loss inside site 2 as artificial disturbance, and then mean annual increment of site 2 between 2nd and 3rd census was excluded from following consideration. Baseline data of this Acacia forests and woodlands were considered as arithmetic average of mean annual increment, thus baseline was calculated as 0.81 Mg ha⁻¹ year⁻¹ (SD=
1.67). But as shown in SD value, the difference was relatively large. From Suganuma et al. (2006), average stand biomass in this research area was calculated as 7.57 Mg ha\(^{-1}\), relatively small, so Site 2, 4 and 7 was considered to be not representative sites for baseline calculation. Excluding these high stand biomass sites, the average of mean annual increment, baseline, was 0.14 Mg ha\(^{-1}\) year\(^{-1}\) (SD=0.41). Since carbon conversion factor from biomass to carbon was reported as 0.477 (Yamada et al., 1999), baseline
carbon accumulation by Acacia forests and woodlands was 0.068 Mg ha\(^{-1}\) year\(^{-1}\), which is quite small value. Therefore, most of the research area, where Acacia forests and woodlands distributed, was considered as afforestation candidate.

From Table 2, mean annual increment data of Eucalypts forests and woodlands were also obtained, and their values were also varied. Judging from these data, mean annual increment value appeared to vary site by site. Particularly in site 1, mean annual increment has large minus value. The reason of this minus value was derived from dying many trees. Originally, site 1 was mature forest, thus mean annual increment value was considered as small or 0, but such massive death was unexpected. In consequence, since baseline values varied from large minus to large plus, Eucalypts forests and woodlands should be excluded from afforestation candidate in present situation.

Table 3 reports stand structural attributes changes in each site. Though mean annual increment value varies a lot, canopy cover (CC) did not change so much. On the other hand, stand basal area (SBA) and leaf area index (LAI) changed and had same tendency compared to mean annual increment (Fig. 1). This reason was considered that stand biomass, SBA and LAI were calculated based on girth at breast height, and thus these values had high correlations, originally. In other words, mean annual increment of this research area will be obtained from monitoring SBA change or LAI change. SBA can be monitored using laser lider, and LAI can be monitored using satellite imagery, generally. Though baseline value was obtained as simple value in this research, satellite image analysis or laser lider analysis will be expected to provide baseline distribution in future analysis. Either ways, afforestation method which overcomes observed baseline must be adopted for the future afforestation designing.

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References