Available at www.sciencedirect.com

ScienceDirect

http://www.elsevier.com/locate/biombioe

Firewood harvest from forests of the Murray-Darling Basin, Australia. Part 2: Plantation resource required to supply present demand

P.W. West[a,b], *E.M. Cawsey*[c,*], *J. Stol*[c], *D. Freudenberger*[d]

[a]*School of Environmental Science and Management, Southern Cross University, Lismore, NSW 2480, Australia*
[b]*SciWest Consulting, 16 Windsor Court, Goonellabah, NSW 2480, Australia*
[c]*CSIRO Sustainable Ecosystems, GPO Box 284, Canberra, ACT 2601, Australia*
[d]*Greening Australia, PO Box 74, Yarralumla, ACT 2600, Australia*

ARTICLE INFO

Article history:
Received 5 February 2008
Accepted 29 February 2008
Available online 2 May 2008

Keywords:
Firewood
Murray-Darling Basin
Eucalypt
Plantations

ABSTRACT

The Murray-Darling Basin covers 1 M km^2 and occupies most of inland, south-eastern, mainland Australia. Large areas have been cleared and are now used for agriculture. In this paper, estimates are made of the minimum area of *Eucalyptus globulus* plantation forests needed to be established in the Basin to supply 2.25 M oven-dry t yr^{-1} of firewood annually, the amount of firewood harvested presently from the native forests which remain in the Basin. If plantations were established in higher rainfall areas along the eastern and southern boundaries of the Basin, it was estimated that a minimum of just over 200,000 ha of plantations would be required, grown on a 10-yr rotation. If plantations were restricted to less productive areas of lower rainfall (<900 mm yr^{-1}), or to areas where land clearing for agriculture has been particularly intensive, a minimum of just under 350,000 ha would be required, grown on an 11-yr rotation. If planting was restricted to soils in the Basin at high risk of salinisation from agriculture, which are generally in areas of lower rainfall, a minimum of about 600,000 ha would be required, grown on a 20-yr rotation. It is considered that the practicalities of plantation establishment in the Basin would require appreciably larger areas of plantations than these minima.

1. Introduction

The previous paper in this series [1] has described generally the Murray-Darling Basin and present concerns about the harvest of firewood from its native forests. The Basin is 1 M km^2 in area and occupies most of inland, south-eastern, mainland Australia. Although extensively cleared for agriculture in times past, native forests still occupy at least 29% of its area. About 2–2.5 M t of firewood (all firewood amounts referred to in this paper are oven-dry weights) are harvested annually from these forests, mostly through collection of fallen, coarse woody debris.

There is concern that continued removal of coarse woody debris from the native forests of the Basin may prejudice its floral and faunal biodiversity. In [1], the possibility was considered of obtaining firewood by harvesting live trees from these native forests, instead of collecting coarse woody debris. The present work considers what area of forest plantations would be required to supply the present demand for firewood. These plantations would be established on land which has been cleared and would avoid completely the need for harvests from the native forests of the Basin.

Two factors are likely to restrict the feasibility of plantation establishment in the Basin. First, firewood is a product of

*Corresponding author. Tel.: +61 2 6242 1628; fax: +61 2 6242 1688.
E-mail address: margaret.cawsey@csiro.au (E.M. Cawsey).
0961-9534/$ - see front matter © 2008 Published by Elsevier Ltd.
doi:10.1016/j.biombioe.2008.02.018

relatively low commercial value; it is often difficult to encourage land owners to grow plantations even for high-value wood products [e.g. 2,3] and would be even more difficult for a low-value product such as firewood. Second, the productivity of plantations in the Basin will be relatively low. In the past, plantations have been established in regions of Australia where the annual rainfall is at least 800 mm yr^{-1} and, to achieve the highest productivity, often above 1000 mm yr^{-1} [4]. Small areas in the easterly and southerly parts of the Basin have an annual rainfall as high as 1000 mm yr^{-1}. However, its rainfall declines progressively to less than 300 mm yr^{-1} towards the arid interior of Australia; about 75% of the Basin has a rainfall of less than 750 mm yr^{-1}, sufficiently low to reduce plantation productivity appreciably.

However, there is increasing appreciation that plantations may offer environmental benefits in addition to their ability to supply wood. Particularly important is their role in ameliorating the environmental damage that has occurred, in some regions of Australia, through increasing salinity of the surface soil. This damage has resulted from rising soil water tables, after native forests have been cleared and replaced with shallow-rooted, agricultural crops [5]; parts of the Basin suffer from this problem. The establishment of deeper-rooted, plantation forest crops may assist in rehabilitation of the damaged soil by lowering the water table [5,6]. Other social, economic and environmental benefits of plantation forests include the possibility of crop diversification for struggling agricultural enterprises, enhancement of regional biodiversity and contributions to regional development [7].

Considerable research remains to be done to establish the practicalities of plantation development in the drier regions of Australia in general and the Basin in particular. There have been a number of trials undertaken, often in the context of rehabilitation of saline soils, to investigate the growth rates and/or the physiological attributes of various species, which might be appropriate for plantation development in these regions, including the Basin [e.g. 8–16]. Other work has examined the processing of wood from plantations in the Basin, although only in the context of sawn wood products and paper pulp, not firewood [17–20]. Some work has investigated the economic feasibility of plantations in the Basin, although only in the context of irrigated plantations for sawn wood or paper pulp [18,21]. Irrigation can be expected to increase plantation productivity substantially and has been considered also in the context of the disposal of sewage waste water in the Basin [22,23]. Much work remains to be done for the drier regions of Australia, to determine definitively which species will be most appropriate for plantations and what silvicultural practices will be necessary (see [5, Chapter 8]) to provide satisfactory growth, appropriate products and adequate environmental benefits.

The present work does not consider in any detail these practical issues, which will need to be addressed before forest plantations could become major suppliers of firewood from the Basin. Rather, it attempts simply to establish a benchmark, by estimating the minimum plantation area, which would be required to supply the amount of firewood, which is taken presently from the Basin. This should quantify the magnitude of the task of replacing, with plantation grown wood, the supply of firewood obtained presently from the native forests of the Basin.

2. Identification of land areas suitable for plantation forestry

The first step in this work was to identify where land suitable for plantation forestry occurs in the Murray-Darling Basin. GIS surfaces of the Basin were obtained, showing forest cover, forest type and land tenure (National Forest Inventory, Bureau of Rural Sciences, Australia), digital elevations, urban areas, rainfall and water courses (Geosciences Australia), areas at risk of site degradation by salinisation (National Land and Water Resources Audit, Bureau of Rural Sciences, Australia) and land productive capacity (Dr D. Barrett, CSIRO Plant Industry, Australia). The measure of productive capacity was the maximum annual rate of net primary production of vegetation at a site, referred to here as 'NPP index'; this index is described in more detail in [1] and was determined using methods described in [24].

Land areas considered suitable for plantation forestry were assumed to

- be both cleared and privately owned (or leased). It was assumed that plantation forests would be established by private investors and environmental benefits would arise from planting previously cleared land,
- be less than 500 km from a capital city; the main market for firewood is in the capital cities and it was considered economically unfeasible to transport firewood further than this,
- have a slope no greater than 15° and to be more than 50 m from streams or rivers; this should minimise the risks of environmental damage from soil disturbance during plantation operations,
- have an altitude above sea level of no more than 650 m, an altitude considered generally in Australia above which temperatures are too low for successful plantation forestry, and
- have an NPP index of at least 5 t ha^{-1} yr^{-1}; as discussed in Section 3.2, a productive capacity below this was considered impractically low for plantation forestry.

Using the GIS surfaces, there was found to be 15.8 M ha of such land. Its distribution across the Basin is shown in Fig. 1(a) and represents what was termed here Option 1 for land areas suitable for plantation forestry. Three other options were considered also, each reflecting different environmental considerations, which might be appropriate when undertaking a plantation programme in the Basin. Each of these other options involved putting an additional restriction on the land area determined for Option 1.

Option 2 included only areas where the annual average rainfall was less than 900 mm yr^{-1}. This option reflected a desire that water lost from the Basin through evapotranspiration from plantations should not come from the higher rainfall, most productive regions of the Basin. Generally, there seems to be little risk presently of environmental degradation through soil salinisation of land cleared for agriculture in