SECTION 1

NATURAL FORESTS: SCIENTIFIC CONTRIBUTIONS

GROWTH AND MORTALITY OF KNYSNA FORESTS OVER THE 1990's: NO SIGNS YET OF NEGATIVE IMPACTS OF GLOBAL CHANGE

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Abstract

Global change has been suggested to drastically reduce the extent of the Knysna Forest. To evaluate this hypothesis, we analysed the dynamics of all trees > 10cm dbh in 108 plots each 0.04 ha in an undisturbed area (Lilyvlei Nature Reserve) in the Knysna Forest for the period 1991-2001. Gross growth rates (ingrowth plus growth of survivors) of trees was extremely slow (< 1%). Thus the forest biomass is extremely sensitive to any mortality of large trees because it may take centuries to replace the lost biomass. Because climate change is likely to increase mortality rates, the forest is likely to be sensitive to global change. Despite this, over the 10 year study period total basal area and biomass increased by 2%, in part because overall stem density increased by 1.2%. Rainfall was slightly below the long-term mean for the study period. At this stage the Knysna Forest biomass is not showing a negative response to global change.

1. Introduction

The present, and predicted future impacts, of global change on intact forests are both alarming and contentious. For example locally, Midgley *et al.* (2001) have predicted the demise of South Africas only significant extent of forest, the Knysna forest, by 2050. This model did not take into account the positive impacts of globally increasing CO_2 levels on forest growth. However, there is support for a positive influence of CO_2 on forest growth and biomass in tropical forests (Lewis *et al*., 2006). There is thus a need for a local perspective on this debate, which we aim to provide by an analysis of a decade of growth of the Knysna Forest. In particular we ask, is the Knysna forest biomass declining?

2. Methods

In the Lilyvlei Nature Reserve (33.56° S, 23.02° E), an unharvested section of the Knysna forest, 108 plots each 0.04 ha were laid using a grid system which provided a 5% sample area. Midgley *et al.* (1990, 1995) indicated that the Knysna Forest is a fine-grained forest comprised mainly of shade-tolerant species with a benign disturbance regime. Therefore the Lilyvlei Nature Reserve can be considered old-growth forest and changes in growth and biomass are not a result of successional responses. All trees > 10 cm diameter at breast height (dbh) and rooted in the plots were individually tagged and painted with at white circle at 1.3 m height where their diameter was measured in 1991 and remeasured in 2001. To convert dbh to Above Ground Biomass (AGB) we used equation 2.1 from Baker *et al.* (2004) where:

$$AGB=sum(exp[0.33(\ln dbh)+0.933(\ln dbh)^2-0.122(\ln dbh)^3-0.37])$$

This allometric equation has not been verified for the Knysna Forest and therefore these are preliminary analyses, because wood density significantly affects AGB estimates (Baker *et al.* 2004). Using data in von Breitenbach (1965) we obtained a mean relative wood density of 0.78 g cm^3 for the 10 most abundant species in Knysna Forest (>95 % of basal area in our plots) and a weighted mean of 0.71 g cm^3. This is greater than from 55 of the 56 plot averages reported by Baker *et al.* (2004), suggesting our estimate of AGB is probably an under-estimate. Because many analyses of forests are for practical purposes undertaken at the level of basal area (BA), we have analysed patterns at both the AGB and BA levels.

3. Results

There is a high mean stem density (613 stems > 10 cm dbh ha^{-1}) with relatively many large stems (11.6 or 1.9% > 70cm dbh ha^{-1}, Table 1). Net BA and AGB increased over the 10 year study period by 2% and there was a 1.2% increase in stem numbers (Table 2), spread almost equally amongst all size-classes. Largest changes in stems per species were generally small in total numbers, with only *Ocotea bullata* (9 stems, 11.4 % increase) and *Cassine papillosa* (14 stems. 16.3% increase) showing greater than 10% in relative changes.

Table 1. Demographic changes over 10 year study period. Percentage mortality is the number of trees that died divided by the original number of stems; expressed as a percentage

Size-class (dbh)	Mortality % (n)	Original:Final number of stems
10-20	7.1 (106)	1494:1495
20-30	5.9 (30)	512:533
30-40	6.5 (17)	261:263
40-50	6.8 (11)	162:168
50-60	3.0 (3)	101:107
60-70	17.3 (9)	52:43
70-80	7.1 (2)	28:32
80-90	11.8 (2)	17:18

Table 2. Estimates of growth and biomass for the Knysna Forest for period 1991 - 2001

	Initial	Final	Gross Growth yr^{-1} (%)	Net Growth yr^{-1} (%)
AGB (Mg ha^{-1})	489.5	498.7	4.7 (1)	0.92 (0.2)
BA (m^2 ha^{-1})	41.4	42.1	0.4 (1)	0.07 (0.2)

4. Discussion

Growth rates of individual trees is extremely low such that total growth $ha^{-1}yr^{-1}$, despite high stem numbers, amounts to the basal area of only a single tree of dbh 71.5 cm (=0.4 m^2). In other words, the annual mortality of a single tree this large per hectare would result in zero net growth. This means that over relatively short study periods such as our decade, this forest is more sensitive to negative/stressful conditions which would increase mortality, than to positive factors which may increase growth. Despite this, net biomass increased slightly. This may be the due to the impact of the global CO_2 increase, rather than increased local precipitation. According to rainfall data provided by South African Weather Office, precipitation over the period 1991-2001 was some 5 % less than long-term average. At nearby Knysna (34.05° S and 23.05° E.) mean rainfall was 735.7 mm compared to the long-term average of 778 mm. The 0.9 Mg ha^{-1} yr^{-1} net increase in biomass we have recorded in the Knysna forest is fairly close to the Amazon mean of 1.22 Mg ha^{-1} yr^{-1} noted by Lewis *et al*. (2006). At this stage therefore, there is no negative sign of global change on the AGB of the Knysna Forest (see also Midgley & Seydack, 2006).

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