CRITICAL ISSUES IN QUANTIFYING LAND-USE CHANGE EFFECTS ON NEW ZEALAND’S TERRESTRIAL CARBON BUDGET:
DEFORESTATION, AFFORESTATION, AND REFORESTATION

Deforestation with human settlement

Polynesian settlement led to clearing and burning of about 9.6 Mha of forest (1200–1800). European settlement (1800–present) resulted in large areas of forest converted mainly to grazing land (7.1 Mha).

Vegetation Carbon Change

First, we used average forest class information (Table below; Hall et al. 2001) to estimate mean forest biomass, and then multiplied this by the area of deforestation. Two cases were examined: (a) mean biomass for all classes (163 Mg C/ha), and (b) mean biomass for podocarp/broadleaf forest types (201 Mg C/ha), as these were the forests most heavily impacted by human settlement.

Vegetation C

Between 1990–2000 planted forests accumulated on average 4.8–6.5 Tg C y⁻¹ (Kyoto forests) (Marshall et al. 2001).

Soil C

Little is known about changes in soil C with afforestation – this includes the effects of forest harvest. We compared soil C storage under grazing land and plantation forest using 1) paired sites where soil C is measured under pasture and plantation forests established on pastures, and 2) nationally distributed (but non-random) soil pedon data.

Critical issues

- Spatial patterns of both biomass and deforestation are important for accurate estimates of total deforestation C losses of ca. 2.5 Pg C
- Conversion of forest to grazing land increased soil C storage, which offsets about 20% of the vegetation C lost through deforestation
- Potential for re-accumulation of C through reforestation or afforestation large compared with current CO₂ emissions of 8.3 Tg C y⁻¹
- European settlement led to deforestation of more C-rich forests than did Polynesian settlement

References


Tate, K.R.; Scott, N.A.; Parshotam, A.; Brown, L.; Wilde, R.H.; Giltrap, D.J.; Trustrum, N.A.; Gomez, B.; Ross, D.J. 2000: A multi-scale analysis of soil carbon. Spatial patterns of both biomass and deforestation are important for accurate estimates of total deforestation C losses of ca. 2.5 Pg C.

Critical issues

- Paired site data below 0.1 m needed to reduce uncertainty in national-scale results
- Long-term management may influence soil C storage with afforestation
- Current knowledge integration limits accurate simulation of soil C changes

Deforestation with human settlement

Afforestation with grazing land (1990–present)

Planting of exotic forests (mainly Pinus radiata) began in the 1930s on land unsuitable for agriculture but, since 1960, most new forests have been planted on former grazing land.

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Paired sites

- Mineral soil C declines with afforestation - uncertainty is high, especially in secondary and subsequent rotations, and for depths below 0.1 m
- Results from paired sites and national soil pedon data suggest small changes in mineral soil C with afforestation
- Accumulation of forest floor C may offset loss of mineral soil C, but current accounting of forest C accumulation includes forest floor only

Critical issues

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References


Newsome, P.F. 1987: The Vegetative Cover Map of New Zealand.


Tate, K.R.; Scott, N.A.; Saggar, S.; Giltrap, D.J.; Baisden, W.T.; Newsome, P.F.; Davis, M.R.; Wilde, R.H.; Parshotam, A. 2002b: A multi-scale analysis of soil carbon. Spatial patterns of both biomass and deforestation are important for accurate estimates of total deforestation C losses of ca. 2.5 Pg C.

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Throughout New Zealand, areas of marginal agricultural land are reverting back to native woody vegetation. In some areas, native woody species, e.g., manuka (Leptospermum scoparium) and kanuka (Kunzea ericoides), establish first, while in other areas bracken (Pteridium esculentum) and gorse (Ulex europaeus) establish first. The decrease in shrubland since 1990 is highly uncertain and may be attributed to clearing for exotic forests.

### Critical issues

- **Definition of shrubland**
- **Area change estimates**
- **Reducing uncertainty in model prediction of C sequestration (above- and below-ground)**
- **Scaling site measurements to the national scale**
- **Changes in soil C with reforestation uncertain**

### National C accumulation in shrublands

- **Estimate based on fractional-cover of shrub vegetation and variable growth rates for all shrublands (2.7 Mha) (1.2–2.8 Tg C y⁻¹ age-class variable)**
- **Simulated (RHESISys, Band et al., 1991) estimate for manuka/kanuka shrublands (1 Mha) (1.8 Tg C y⁻¹)**
- **Small mineral soil C losses have limited impact on large C storage by vegetation, in contrast to recent US study (Jackson et al., 2002).**

### Carbon losses from soil erosion

Deforestation and establishment of pastures led to increased soil erosion, particularly in areas with highly erodible soils.

- **Shrublands dominated by manuka and kanuka establish quickly in some parts of New Zealand, and can accumulate C almost as fast as plantation forests.**
- **Small mineral soil C losses of ca.7 Mg C ha⁻¹ are offset by litter accumulation.**
- **Other shrublands can establish quickly, but accumulate C at a slower rate.**

### Biomass accumulation in manuka/kanuka shrublands

- **Age (years)**

#### Current shrubland vegetation biomass estimates

- **Regional**
  - Mg C ha⁻¹: 53 ± 14 (Gonnea et al., 2004)
  - Mg C ha⁻¹: 65 (Hill et al., 2001)

### Problems associated with converting between the two maps

- **Large areas of bare ground in the LCDB contain vegetation in the VCM.**
- **The VCM resolved many shrub types, whereas the (current) LCDB resolves one with some uncertainty.**
- **The VCM divides native forests into several “classes”, whereas the LCDB has only one native forest class.**

### Land-cover changes during the 1990s obtained by merging the VCM and the LCDB

- **Post-1990 land cover changes are highly uncertain.**