# 3C.4 Tradeoffs Between Timber Management and Fire Vulnerability

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## Introduction

Fire in most tropical forests is considered a major disturbance because the scale of its impacts is usually at the community to landscape levels. After biogeography, community-wide disturbances – whether natural (e.g., fire, hurricanes, and disease outbreaks) or anthropogenic (e.g., fire and forest conversion) are the most important determinants of ecosystem structure and composition (Whitmore and Burslem 1998). Because of its large-scale and potentially devastating impacts, fire constitutes a threat to forest managers seeking to obtain sustained yields of commercial timber species. The tradeoffs between timber management objectives and fire vulnerability may be particularly great in seasonally deciduous forests in which intensive silviculture is required to secure sustained yields of the currently commercial timber species. We tested this hypothesis in a seasonally deciduous Bolivian timber concession (Figure 1).

The potential tradeoffs between timber management and fire vulnerability in the forests we study in Bolivia derive from (i) the disturbances shaping them, (ii) landscape phenomena, (iii) their current structure and composition, and (iv) the impacts of intensive silviculture. Aside from fires and logging, southern fronts accompanied by high winds are known to disturb these forests. In addition to toppling trees, these winds spread the fires set on established farms and ranches or to clear the slash in areas being converted from forest to agricultural lands. Although archeological evidence indicates that fires did occur historically in the Bolivian Amazon, land-use change and increasing fragmentation have increased their prevalence in the past few decades (Figure 2). The strong dry season facilitates the use of fire by farmers and causes about half of the canopy trees to shed their leaves, thus rendering the forest fire prone even in the absence of logging.

Our rationale for intensive silviculture in Bolivia is based on three observations. First, the forest is relatively open compared to wetter, evergreen forests and is dominated by light-demanding tree species, most of which lack adequate regeneration in the forest. Second, the trees must contend with one of the highest vine densities in the world (Figure 3). In addition to exacerbating wind and logging damage, the vines impede regeneration and slow tree growth rates. Silvicultural treatments are required to speed tree growth and to promote regeneration of the harvested tree species. We presumed that intensive silvicultural treatments – including soil scarification (Figure 4), extensive vine cutting, and the opening of large canopy gaps –increase fuel loads and speed dry-down rates of fuels compared with less intensive management regimes.

Given the situation described above, the tradeoffs between timber management and fire vulnerability in seasonally deciduous forests can be viewed as two alternative scenarios. Without silviculture, achieving sustained timber yields is impossible; timber harvesting alone, no matter how carefully done, results in a degraded, devalued forest. It may be possible to achieve sustained timber yields if silvicultural treatments are applied, but their cost may be substantial increases in fire vulnerability. Our study aimed to determine whether intensifying forest management for timber appreciably increases fire vulnerability in a seasonally dry, deciduous forest that is already prone to burn.

## Methods

We assessed fire vulnerability in a Bolivian seasonally dry forest subjected to four management regimes of increasing intensity: a no logging control, a selective harvest treatment with no additional silviculture, and 2 treatments consisting of logging of increasing intensity coupled with additional silviculture (Figure 5). To evaluate the impact of intensifying management on fire vulnerability, we first assessed the treatment impacts on vegetative cover using point sampling along 4 transects in each treatment plot.

Second, we quantified the treatment effects on fuel loads using planar transects randomly located in each treatment plot. Third, we measured the dry-down rates of 10-hr fuels across the range of microsites created by the different management treatments. Fourth, we set test fires in 4 $m^2$ plots established over the same range of microsites to determine whether cover influenced the ability of fires to carry. We also set test fires in forest logged a few months previously, 1 year previously, and 3 years previously. Finally, we developed a simple model to estimate the number of fire prone days during each dry season associated with each treatment. The model was based on the number of rainless days each month, the number of days necessary for fuels to dry enough to ignite under different cover conditions, and the proportion of each management treatment in the different cover classes.

**Results and Discussion**

The treatment impacts on forest structure and cover were modest. The minor changes observed in structure and cover are exemplified by the small increase in the proportion of gap and building phase forest with increasing management intensity (Figure 6). The most striking result here was the observation that about a third of the forest was disturbed even before logging. Consequently, although percent cover diminished with increasing treatment intensity, the differences were not as great as might have been expected (Figure 7).

Fuel loads increased after logging, as predicted, mostly due to increases in sound coarse woody debris (Figure 8). Somewhat surprisingly, however, fuel loads did not differ among the three harvest treatments.

During the dry season, daily mean maximum temperature decreased and mean minimum relative humidity increased with increasing vegetative cover (Figure 9). Consistent with those results, the rate at which 10-hr fuels dried down to 12% moisture content increased with decreasing cover (Figure 10). Nevertheless, 10-hr fuels dried to this threshold in about 9-11 days even in sites with dense cover (Figure 10). Rainless periods of 20 days or more are common throughout the dry season indicating that fuels are dry enough to burn for long periods in this forest.

In forest logged 2-4 months previously, test plots burned most easily in sites with less vegetative cover (Figure 11), but some plots in areas with dense cover also burned. Plots located in recently logged forest burned more readily and more thoroughly than those located in forest logged 1 and 3 years previously (Figure 12). These results suggest that any elevation in fire vulnerability caused by logging and additional silviculture diminishes within 1 year.

Two major results were obtained from application of the model we developed for calculating fire prone days. First, the entire forest is very fire-prone during the peak of the dry season. Second, there are virtually no differences in the number of fire-prone days among the treatments.

**Conclusions**

Although a more elaborate model of fire-prone days might be justified for predicting the fire vulnerability of evergreen closed canopy forests in wetter areas in the tropics, the model seems adequate for the forest we studied because of its long dry season and relatively open and deciduous canopy. The tradeoffs between timber management and fire vulnerability are modest in this forest because it is already quite fire prone and because management regimes applied were of relatively low intensity compared to those typically used in Brazil, let alone in S.E. Asia. In other words, although forest managers in the seasonally dry forests in Bolivia need to actively prevent fires, they need not worry about elevating fire vulnerability with their silviculture, at least at the intensities currently applied. But considering that the species for which we are now managing in Bolivia are likely legacies of historical disturbances of much greater intensities, to sustain timber yields we probably need to apply silvicultural treatments even more severe than those with which we experimented.

Figure 1. Location map of Bolivia (red) and *La Chonta*, the logging concession (yellow square) in the Department of Santa Cruz (green), where the study was conducted.

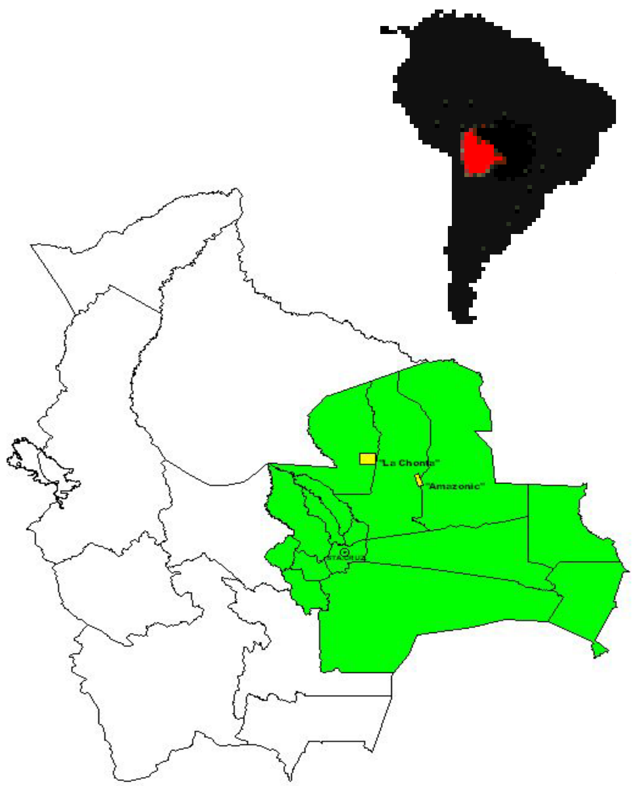


Figure 2. Fires escaping into forests from pastures, farms, or areas being converted from forest (photo) are becoming more common in the Amazon.  In 1999, 3 million ha of forest burned (red areas) in the Department of Santa Cruz (map).  See Figure 1 for location of Santa Cruz.

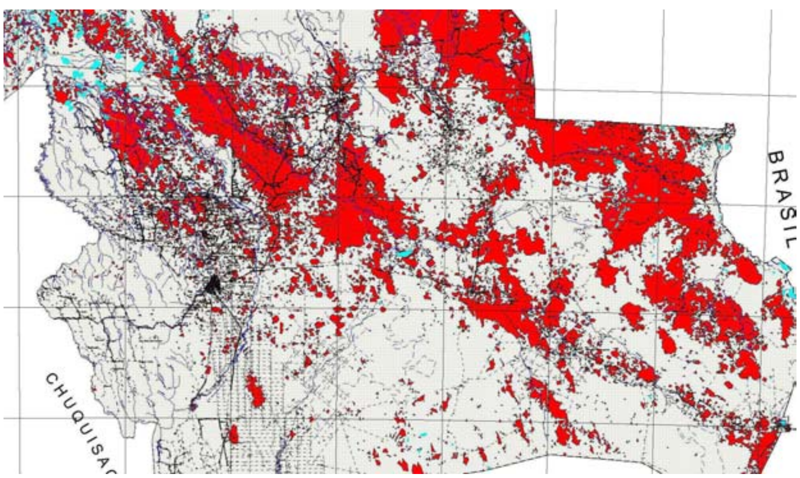


Figure 3.  La Chonta, and other timber concessions in this part of Santa Cruz, Bolivia have some of the highest vine densities recorded in the tropics.

Figure 4. Scarifying soil in select logging gaps increases the abundance of commercial regeneration.

Figure 5. Four management treatments were applied in 3 harvest blocks (B1, B2 & B3) in La Chonta, which encompasses 100,000 ha. Each treatment plot was about 27 ha. No trees were cut in the control. Two to four trees were cut in the normal logging treatment; twice as many were cut in the intensive treatment. In addition, future crop trees were liberated from vines and nearby competitors and the soil was scarified in the intensive treatment. The fourth treatment was intermediate in intensity between the normal treatment and the intensive treatment. Areas circumscribed by rectangles in the figure refer to annual harvest units that cover ca. 2,000 ha.

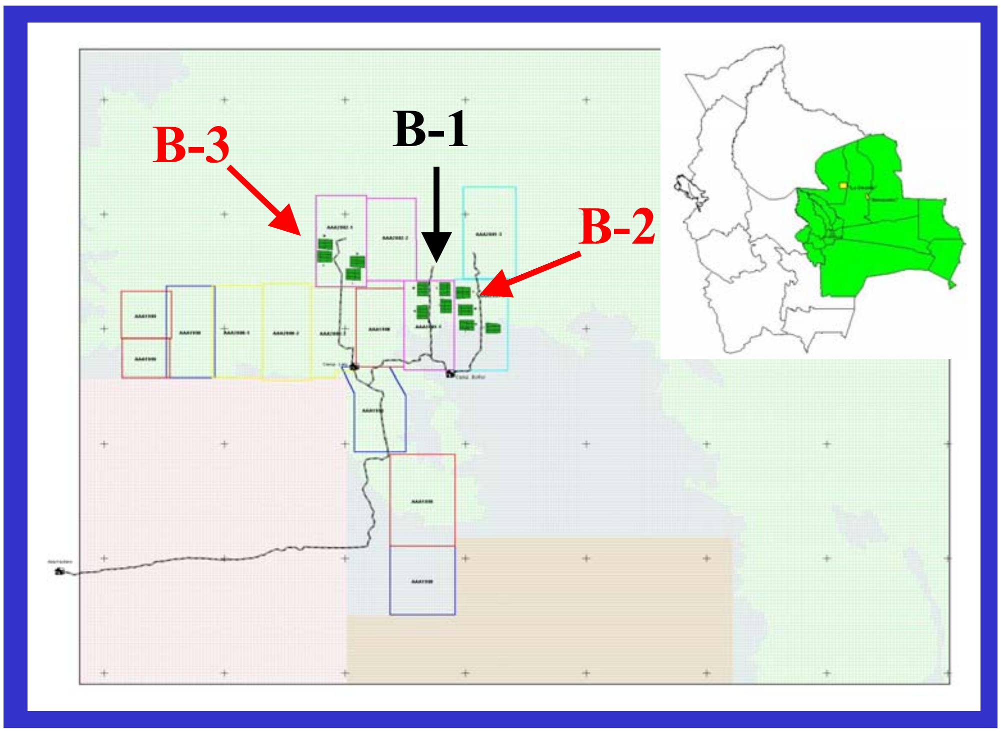


Figure 6. Treatment impacts on vegetative structure assessed in 4 transects per treatment 6 months post-harvest in La Chonta. Cover was assessed in 6 vertical strata (0-1, 1-2, 2-4, 4-8, 8-16, and > 16 m) every 5 m along the transects. The figure shows the proportion of treatment plots with vegetative cover at different maximum heights.

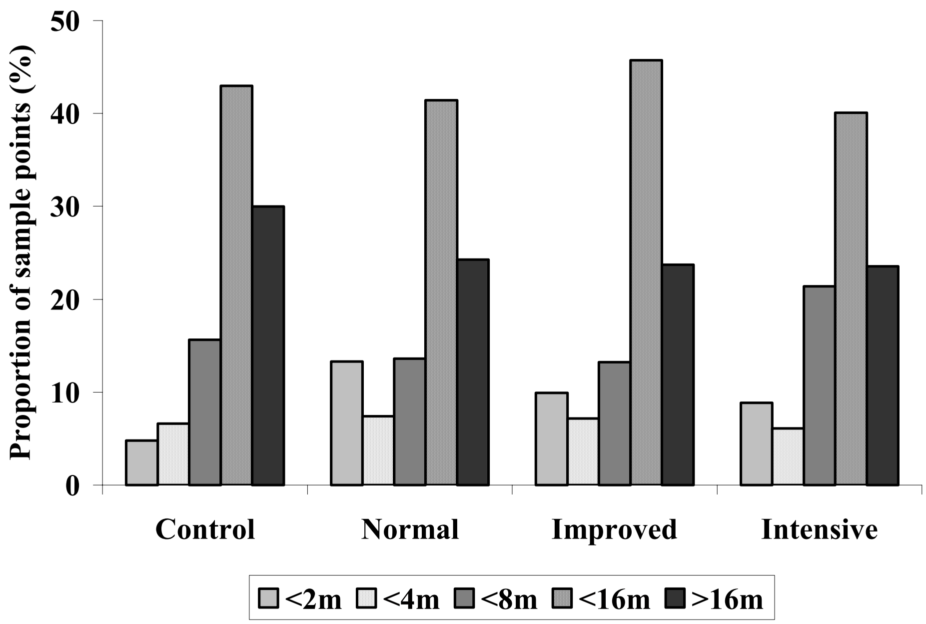



Figure 7. Treatment impacts on total vegetative cover (%) assessed in 4 transects per treatment 6 months post-harvest. Different letters indicate significant differences at p <0.05. Although the normal and intensive harvest treatments significantly reduced cover compared to the no logging control, the magnitude of these differences – and of the differences among the harvest treatments themselves – were not as great as expected.

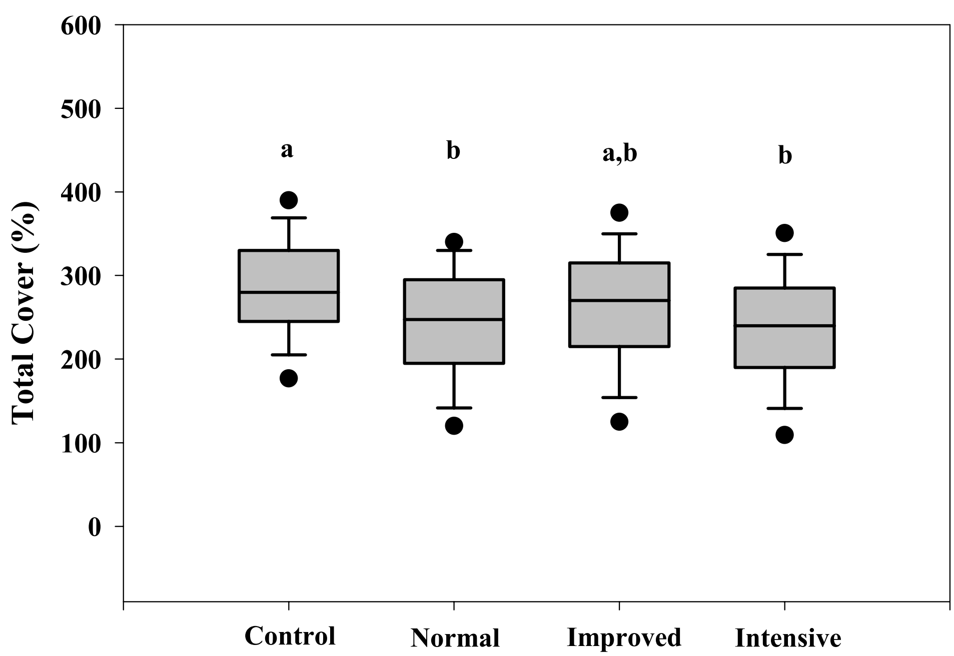


Figure 8. Treatment impacts on fuel loads, shown here as mass of dead and down woody debris, based on planar transect surveys of each treatment plot 6 months post-harvest. Different letters indicate significant differences among treatments at $p<0.05$. Note the broken scale in the y-axis to accommodate high values in the intensive treatment plot.

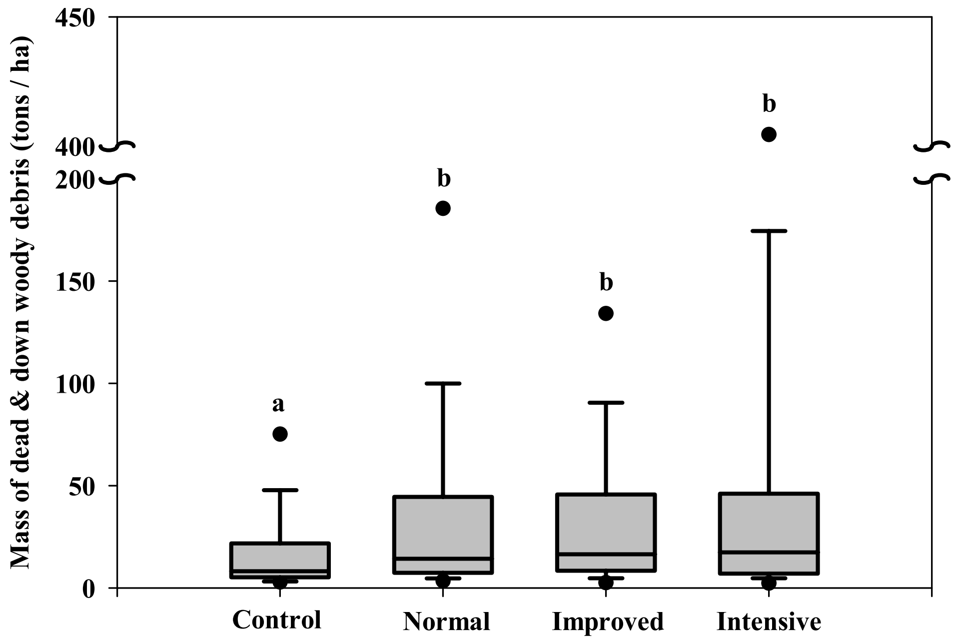
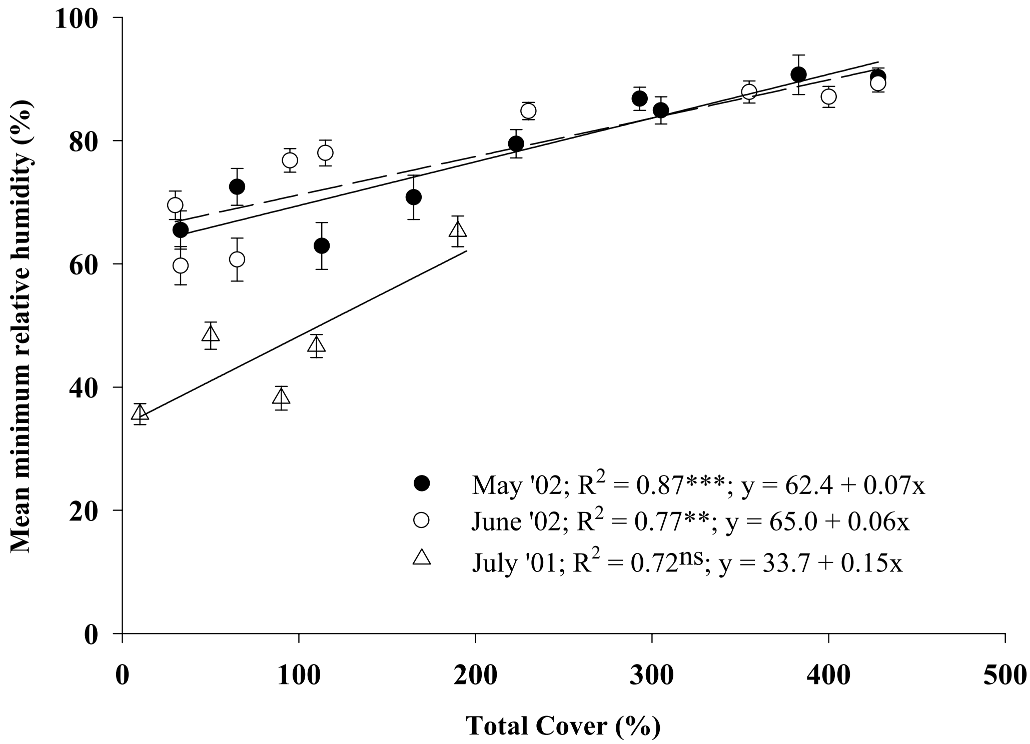


Figure 9. Mean minimum relative humidity (a) and mean maximum temperature (b) as a function of total cover during the early dry season of 2002 and mid dry season of 2001 in La Chonta.

a.




b)

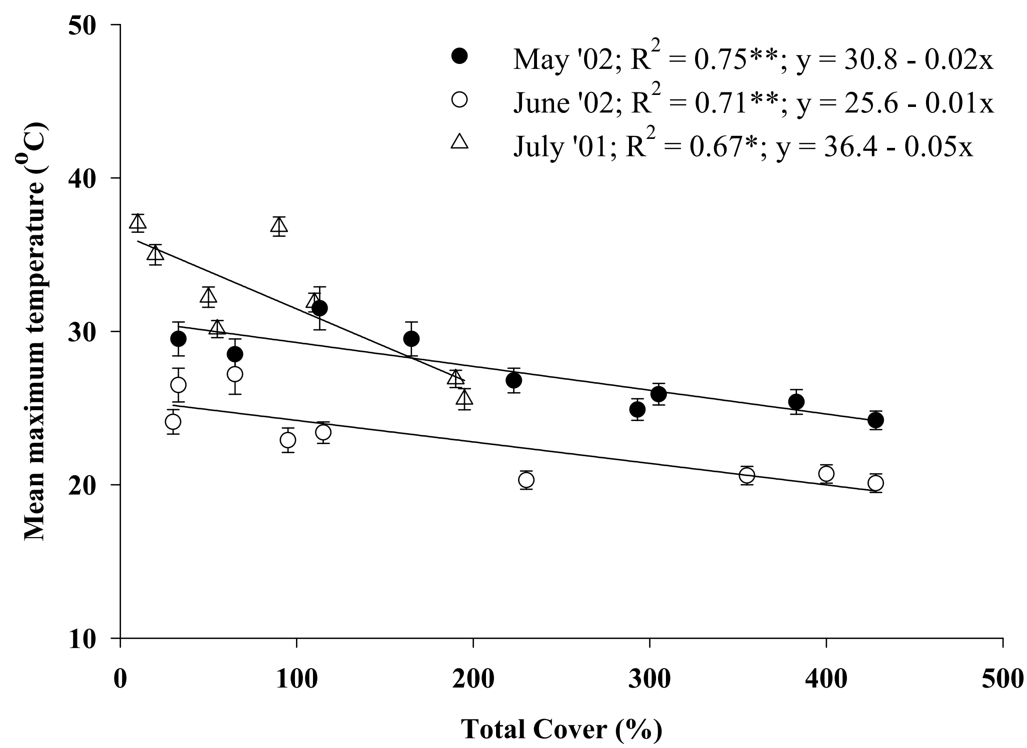


Figure 10. The influence of total cover (%) on the dry-down rates of 10-hr fuels during the mid dry season in La Chonta.

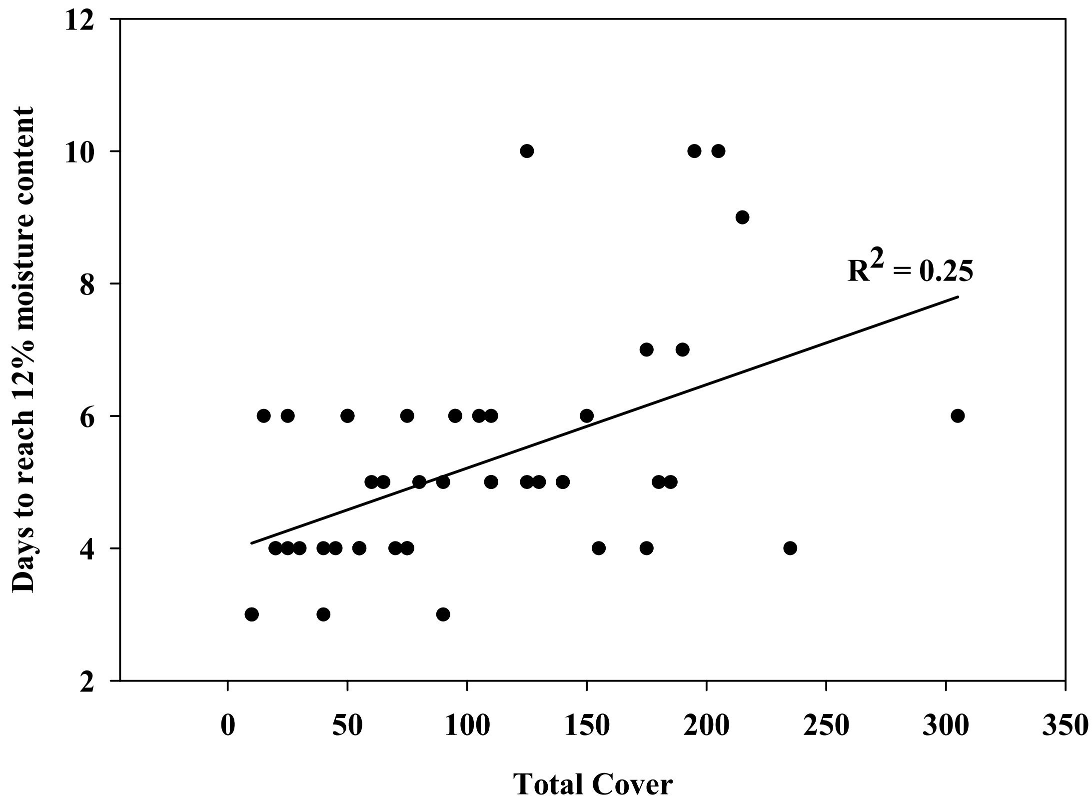


Figure 11. The area of test fire plots that burned was nearly the same regardless of total cover.

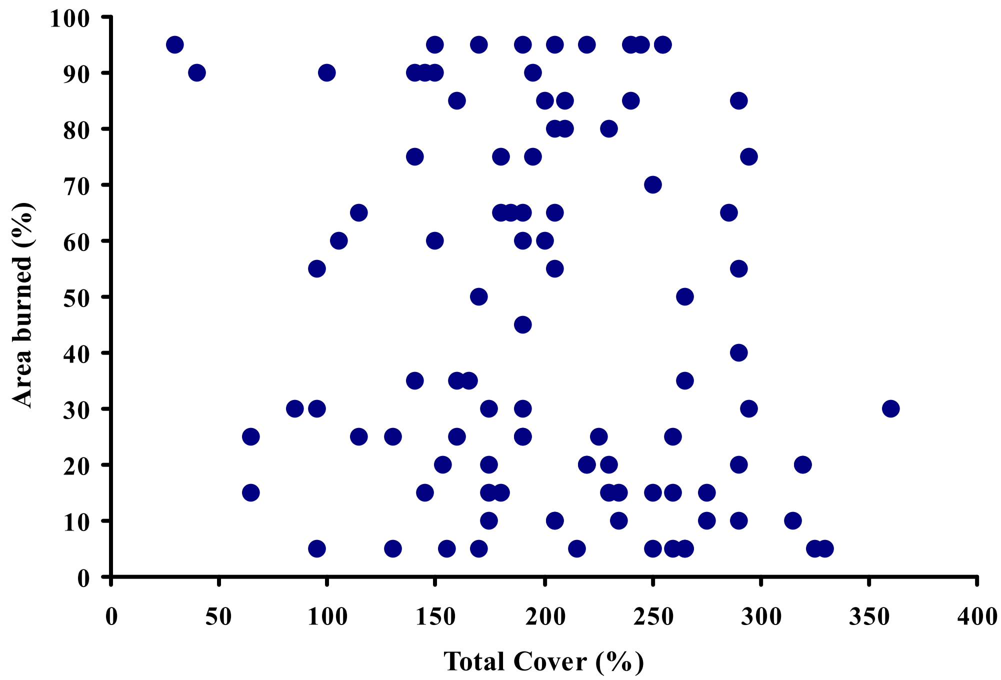



Figure 12. Test plots burned more readily in areas logged a few months prior to the fire trial compared to areas logged 1 and 3 years previously.