SESSION 4B MONITORING AND MANAGEMENT OF MOUNTAIN BIKING

How formal and informal mountain biking trails result in the reduction, degradation and fragmentation of endangered urban forest remnants

Mark Ballantyne, Griffith University, Australia, m.ballantyne@griffith.edu.au;
Catherine Pickering, Griffith University, Australia;
Ori Gudes, Curtin University, Australia

Introduction

Forests provide important settings for a diversity of recreational activities, including urban forests. Where there are remnants of natural forest in urban areas, they often become hotspots for recreational use, including mountain biking. As a result, extensive networks of formal and informal trails can develop, causing an array of negative environmental impacts. Despite extensive research on trail impacts in forests, there is comparatively less research that compares the impacts of formal (management-designated) and informal (visitor-created) trails in terms of their effects on reducing, degrading and fragmenting multiple forest remnants. We compared the relative impacts of formal and informal mountain bike trails in remnants of an endangered urban forest, Tall Open Blackbutt Forest.

Study Region

This high conservation ecosystem exists as a highly fragmented network of isolated remnants spread over 937km2 along the rapidly urbanising lowland corridor linking the cities of Brisbane and Gold Coast in coastal Queensland, eastern Australia. Over 80% of this forest has been cleared since European settlement, with only 2,024ha remaining as small isolated patches often surrounded by urban residences. As a result, these forest remnants are popular destinations for mountain bikers due to their proximity to urban populations and varied topography (Pickering *et al.*, 2010).

Methods

We mapped the total area and all types of trails, including formal and informal mountain bike trails, within 17 publically-accessible forest remnants (829ha total) using a method similar to the condition class assessment. To assess the amount of forest lost to the trails including different structural components, we measured the maximum width, depth and slope of the trail and the distance from trail edges to the litter layer, understorey, midstorey and trees at 80 random sampling points; 40 each on formal and 40 on informal trails. We used a buffer analysis in ArcMap 10.1 to calculate the loss of the different structural components of the forest and ANOVA to assess differences in loss between formal and informal trails. To measure how the forest along trail edges has been degraded, we measured tree density, percentage canopy cover, litter depth and percentage of sapling, mid age, mature and dead trees adjacent to either side of the track at each of the points using 50m x 5m transects parallel to the trail, and at 20 random points within the forests (controls). To compare fragmentation between 5 remnants dominated by formal or informal trails (> 90% trails of either type), we calculated fragmentation indices for the 10 remnants as Weighted Mean Patch Index (WMPI) and Largest 5 Patches Index (L5PI) of Leung and Louie (2008) and then compared remnants using ANOVA.

Results

Mountain biking occurs on nearly all (95%) of the 46.1km of trails in these forest remnants, although 45% are also used for hiking. Most of the trails were informal (bare earth, 32.1km, 74%), while formal trails (all hardened) accounted for the rest. The maximum width did not differ between formal and informal trails, however soil loss was greater on informal trails which were also often on much steeper slopes (Table 1).

Mountain biking trails resulted in the loss of 47.2ha (5.7%) of forest with 17.1ha lost to the trails themselves, plus an additional 0.9ha of litter layer lost, 5.8ha of understorey, 18ha of midstorey and 30.1ha of trees along the trail edges. Due to the greater length of informal mountain biking trails, they accounted for 65% of the area lost. Per unit area of trail, however, there were no differences between the impact of formal and informal trails on the loss of each of the different structural components of the forest (Table 1).

The impacts of the trails extended into the forest along trail edges, with reduced canopy cover and fewer mature trees but more saplings compared to intact forest. There were also differences between the trail types with more saplings and fewer mature trees along the edge of formal trails compared to informal trails, but no differences in tree density, litter depth or percentage of mid and dead trees (Table 1).

Fragmentation as measured by WMPI was greater in forest remnants dominated by informal trails. However, there were no differences in fragmentation according to the L5PI index (Table 1).

Conclusions

This study found that formal and informal mountain bike trails can differ in how they reduce, degrade and fragment urban forest remnants. These differences were, in part, a result of the much greater spatial proliferation, and therefore, fragmentation capacity of informal trails that formed dense, geometrically-complex networks that cumulatively resulted in a greater loss of forest than formal trails. We found remnants with numerous informal trails tended to be small (< 10ha), in more highly urbanised areas, had no legal protection and had numerous entry points, all of which likely contribute to high densities of informal trails. Such remnants likely experience a disproportionately large reduction in the undisturbed area of natural forest and, therefore, the habitat available to many disturbance-sensitive species. The level of fragmentation by informal trails was similar to that caused by local urban development (Ballantyne *et al.*, in review) as well as intense trail use in popular USA national parks (Leung *et al.*, 2011).

Interestingly however, in contrast, there was actually more degradation of remaining forest vegetation along the edges of formal trials with more saplings and fewer mature trees. These effects are likely related to the way such trails are constructed and maintained resulting in more initial damage to the forest, and hence early successional stage regeneration along forest edges. As such, these trails may have stronger per unit area effects on the structural integrity, and therefore biodiversity of these forests (Wolf *et al.*, 2013). Based on these relative impacts, we suggest that the use of narrow, unhardened formal trails with appropriate slope alignment be combined with methods to reduce the proliferation of informal trails such as trail-bordering to stop widening and centralising visitor flow. These management actions may help alleviate some of the threats mountain biking can pose to urban forest remnants.

Table 1: Means and standard deviations of trail variables, loss of forest structural components, vegetation degradation variables and fragmentation indices. Bold-values are those with significant differences at $p < 0.05$ with letters signifying post hoc differences. WMPI = Weighted Mean Patch Index, L5PI = Largest 5 Patches Index (Leung and Louie, 2008).

Variable	Formal (± SD)	Informal (± SD)	Control (± SD)
Length (km)	11.9	32.1	
Width (m)	2.8 ± 0.8	2.9 ± 1.8	
Soil loss (cm^2)	463.5 ± 411.9	2,486.9 ± 3,358.5	
Slope (°)	4.7 ± 2.5	7.4 ± 6.7	
Distance to (cm)			
Litter layer	10.6 ± 16.4	11.7 ± 19.3	
Understorey layer	77.2 ± 51.1	62.6 ± 36.7	
Midstorey layer	234.6 ± 86.5	224.9 ± 102.5	
Tree layer	406.7 ± 127.4	381.7 ± 154.9	
WMPI	1.2 ± 0.2	0.6 ± 0.3	
L5PI	97.9 ± 1.4	81.8 ± 18.8	
Tree density (trees m^{-2})	0.32 ± 0.24	0.31 ± 0.18	0.38 ± 0.20
% canopy cover	55.3 ± 16.2a	56.9 ± 20.0a	72.7 ± 11.3b
Litter depth (cm)	4.4 ± 1.4	4.8 ± 1.9	4.6 ± 1.2
% saplings	42.5 ± 19.1a	33.9 ± 15.1b	10.7± 10.4c
% mid	40.5 ± 19.2	34.2 ± 15.8	39.3 ± 9.6
% mature	16.9 ± 9.9a	31.9 ± 15.2b	49.7 ± 8.9c
% dead	16.1 ± 11.9	14.8 ± 10.9	19.8 ± 11.5

Ballantyne, M., Pickering, C.M. and Gudes, O., (in review) Visitor trails are an important cause of fragmentation in endangered urban forests.

Leung, Y.F., Newburger, T., Jones, M., Kuhn, B. and Woiderski, B., (2011) Developing a monitoring protocol for visitor-created informal trails in Yosemite National Park, USA. Environmental Management 47.1, 93-106.

Leung, Y.F. and Louie, J., (2008) Visitor experience and resource protection - data analysis protocol: social trails during 2007 field season. USDI National Park Service, Yosemite National Park.

Pickering, C.M., Castley, J.G., Hill, W., and Newsome, D., (2010) Environmental, safety and management issues of unauthorised trail technical features for mountain bicycling. Landscape and Urban Planning 97.1, 58-67.

Wolf , I.D., Hagenloh, G. and Croft, D.B., (2013) Vegetation moderates impacts of tourism usage on bird communities along roads and hiking trails. Journal of Environmental Management 129, 224-234.