Informal trails fragment the landscape in a high conservation area in the Andes

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Introduction

Areas of high use with free access often end up dissected by networks of trails. As a result, large areas of intact communities can be converted into numerous smaller subpatches (Leung et al., 2011). This type of internal fragmentation has a range of detrimental effects, including those directly due to damage from the trails, but also due to the edge effects of trails. In addition trails can restrict movement among subpatches for species with short dispersal distances, while enhancing the movement of other species along the trails. As a result the total area of intact vegetation is reduced along the trails, and on the verges, but also within subpatches. Changes in vegetation can include reductions in the cover, height, biomass of native plants, changes in species composition, and the introduction and spread of weeds (Monz et al. 2010; Wimpey and Marion, 2011). This multitude of impacts associated with fragmentation due to trail networks is of particular concern in high altitude parks that support rare and fragile ecosystems characterized by slow rates of recovery from disturbance (Körner, 2003). We assessed how trail networks have fragmented two high conservation value plant communities close to the entrance to the highest altitude protected area in the Southern Hemisphere, Aconcagua Provincial Park.

Study area

Aconcagua protects 70,000 ha of glaciers, watersheds and alpine ecosystems in the dry Andes in Argentina (DRNR, 2009). It is a popular mountaineering destination as it contains the highest summit outside the Himalayas, Mt. Aconcagua (6962 m a.s.l) (Barros, 2004). Each summer around 30,000 visitors, including >4,000 hikers along with 3,000 mules and horses traverse the intensive use area at the start of the Horcones Valley (2700-3000 a.s.l.), which is the main access route for the Park. As a result a network of formal and informal trails has fragmented this area, including alpine steppe vegetation and alpine meadows. These two communities are of high conservation value, contain most of the biodiversity in the Park and are the main habitat for over 44 native ground nesting birds (DRNR, 2009).

Methods

The effects of fragmentation from a network of formal, informal trails roads and infrastructure were assessed in the Horcones Valley intensive use area. First, the 223 ha area intensively used by tourists between the highway, river and cliffs on the sides of the valley was mapped using a hand held GPS. Then spatial and attribute data were collected for all trails, roads and infrastructure within this area. The area occupied by roads and all formal and informal trails was calculated by recording their length and average width measured every 100 meters. Also the natural boundaries of all meadow and alpine steppe vegetation were mapped. The data was converted to ESRI ArcMap 9.3 shapefiles for edition and analysis. To analyse landscape fragmentation, a similar methodology to that of Leung et al. (2011) was used. The high use area was used as a base layer from which all trails, roads and infrastructure were removed. This was accomplished by intersecting these features with the high use area to create shape files representing all the fragmented areas. These shape files were used to calculate the total area affected by visitors, and the number and size of subpatches per vegetation type. In addition, vegetation condition and level of disturbance were assessed in 102 plots (20 m^2) which were randomly located in the area using the Hawth´s Analysis Tools extension for ArcGIS. Vegetation parameters recorded in plots included the cover of native plants and weeds, species richness and plant composition. The presence of horse/mule dung, grazing damage, soil movement, and trampling damage was estimated in each plot using a four point scale ranging from zero (none) to 3 (extensive). A single measure of disturbance per plot was then calculated by averaging the four variables. The distance to the nearest trail and/or infrastructure from a plot was measured. All data were entered into SPSS (version 20) and descriptive analyses performed.

Results

The 223 ha intensive use area is extensively fragmented by trails, with 25 trails, 8 roads, and 6 sites with infrastructure recorded (Fig. 1). The combined length of the 2 formal trails was 2 km, and they were 3 m wide. The combined length of the 23 informal trails was >12 km with an average width of >2 m. This resulted in 16 ha directly affected by visitor use, fragmenting 9 ha of alpine meadows and 198 ha of steppe vegetation. Two patches of alpine meadow were fragmented into 10 subpatches, 6 of which were less >0.06 ha. Steppe vegetation was fragmented into 52 patches averaging 3.7 ha (Fig. 1). For the 102 plots surveyed, 11 were in alpine meadow and 91 in steppe vegetation. Over half of the plots had medium to high levels of disturbance. Vegetation cover was 40% in alpine steppe and 77% in alpine meadows, resulting in a 30% reduction in cover for alpine steppe and 10% reduction in alpine meadows compared to undisturbed sites (Barros, 2004). All plots in meadows had weeds as did 58 plots in steppe vegetation. The proportion of weeds (36%) and weeds species richness (5) was higher for plots closer to trails (Fig. 1). In alpine steppe vegetation, the exotic herb *Convolvulus arvensis* had the highest cover (22%) while in the alpine meadows the dominant weed was the herb *Taraxacum* officinale (16%).

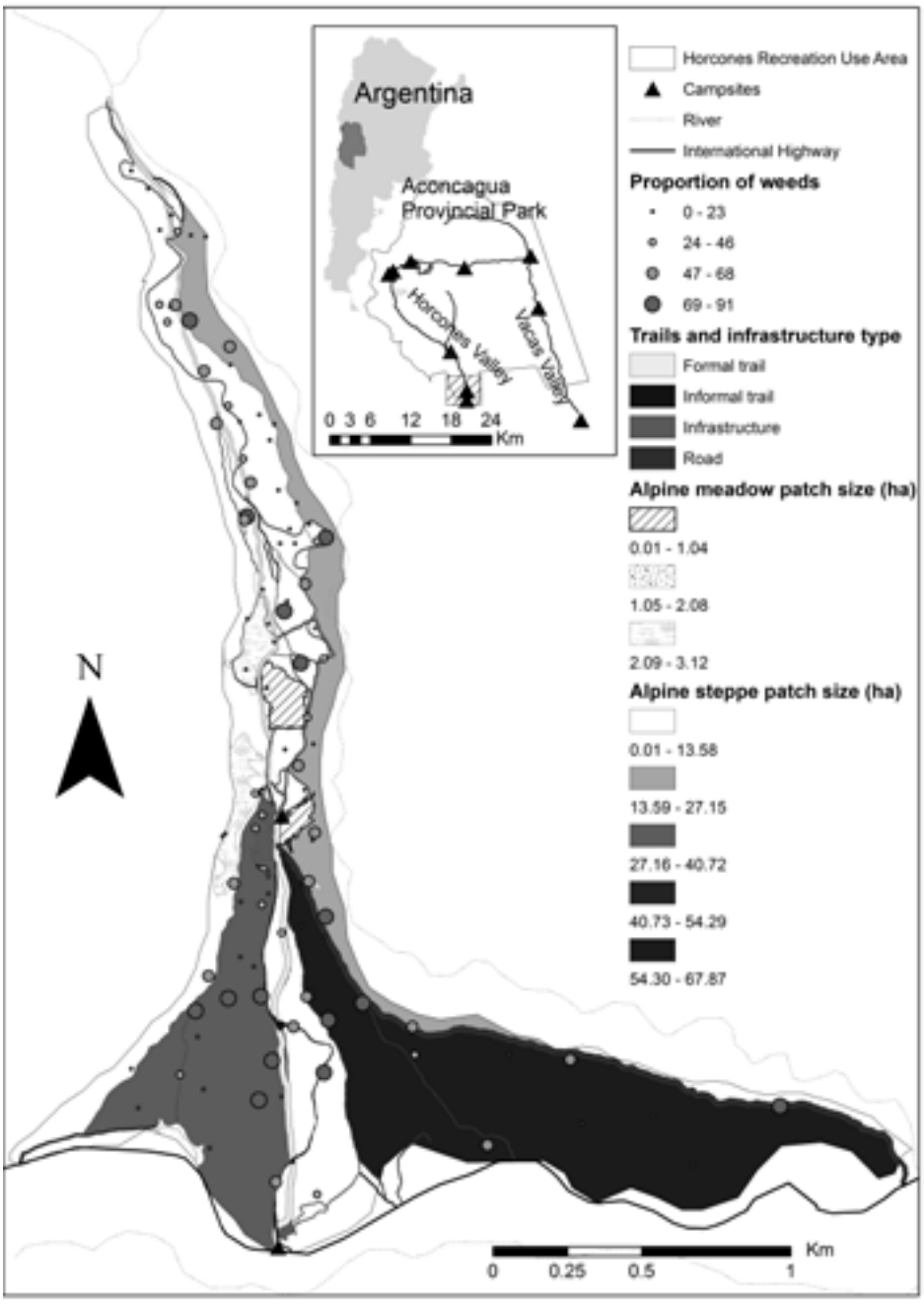

Figure 1. Type of trails and infrastructure, patch size per vegetation type and proportion of weeds in the high use area of the Horcones Valley (69° 56' West, 32° 48' South) in Aconcagua Provincial Park, Mendoza, Argentina.

Implications

Tourism use including the >12 km network of informal trail has extensively damaged alpine meadows and steppe vegetation at the entrance to the Horcones Valley. As a result 7% of the area is occupied by trails and infrastructure, while vegetation away from trails had lower native cover and higher weed diversity and cover than undisturbed sites. In this, and other high conservation areas, where such informal trail networks form effective management is required to concentrate use on a limited set of trails, and remediate areas already damaged including controlling the proliferation of weeds.

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