Landscape and Urban Planning 110 (2013) 155–163

Contents lists available at SciVerse ScienceDirect

Landscape and Urban Planning

journal homepage: www.elsevier.com/locate/landurbplan

Research Paper

Effect of catchment urbanization on ant diversity in remnant riparian corridors

Christopher D. Ives[a,*], Mark Patrick Taylor[b], David A. Nipperess[c], Grant C. Hose[b,c]

[a] School of Global, Urban and Social Studies, RMIT University, GPO Box 2476, Melbourne 3001, Australia
[b] Department of Environment and Geography, Macquarie University, Sydney 2109, Australia
[c] Department of Biological Sciences, Macquarie University, Sydney 2109, Australia

HIGHLIGHTS

- ▶ Riparian ant communities did not differ between urban and rural land uses.
- ▶ Dominance of exotic plants influences ant communities more than catchment land use.
- ▶ An ecological threshold may have been crossed following initial deforestation.

ARTICLE INFO

Article history:
Received 14 May 2012
Received in revised form 5 November 2012
Accepted 11 November 2012
Available online 8 December 2012

Keywords:
Urbanization
Catchment land use
Riparian corridors
Biodiversity
Ants
Weed invasion

ABSTRACT

The conversion of rural land to residential use is occurring rapidly as the global trend of city expansion continues. The impact of this land use change on riparian biodiversity was investigated by examining ant communities from 12 remnant riparian corridors in northwest Sydney, Australia. Ants were sampled from rural and urban catchments using pitfall traps. Data on vegetation floristics, habitat structure and stream water quality were also collected. No significant differences in ant diversity metrics or assemblage structure were found between urban and rural sites. Similarly, very few environmental variables revealed significant differences between land use types. One exception, however, was the percentage cover of exotic plants, which was related to ant assemblage structure. Small-leaved and broad-leaved privet (*Ligustrum* spp.) were highly correlated with total weed cover. The results suggest that ants respond mostly to small-scale habitat characteristics, especially those related to the dominance of exotic plants. As all sites had experienced some level of human impact, it is possible that all the sites have already transgressed an ecological threshold due to the earlier catchment land use change from natural to agricultural use. This apparent sensitivity may explain the failure to observe any significant differences between the urban and rural catchments examined in this study. It is recommended that managers looking to protect the integrity of riparian invertebrate communities should focus on addressing local habitat pressures in human-modified catchments.

1. Introduction

Urbanization is one of the most significant processes currently transforming landscapes around the world. As human populations become increasingly urbanized (United Nations, 2008), urban sprawl is leading to the replacement of greenfield sites with low/medium density housing. Indeed, this ‘exurban’ development (6–25 homes per km^2) is the fastest growing land use in the USA (Brown, Johnson, Loveland, & Theobald, 2005) and is one of the dominant threats to biodiversity and ecosystem processes in Australian coastal regions (State of the Environment 2011 Committee, 2011). Increases in the proportion of sealed surfaces diminish infiltration and evapotranspiration and lead to greater conveyance of runoff to natural waterways. This results in a reduction in baseflow and more frequent, short duration, high volume stream discharges (Paul & Meyer, 2001). These hydrological changes are known to impair aquatic ecosystems (Allan, 2004; Walsh, Roy, et al., 2005) and riparian ecological processes (Groffman et al., 2003). However, despite the expansive knowledge of aquatic impacts from urbanization, there is a relative paucity of research into the effects on riparian invertebrate communities. One recent study in northern Sydney Australia, however, found that communities of ants in riparian corridors were influenced by adjacent land use (Ives, Hose, Nipperess, & Taylor, 2011a).

As the footprint of human-altered landscapes expands, it is becoming clear that remnant riparian corridors are important reserves for the conservation of biodiversity (Ives, Hose, Nipperess, & Taylor, 2011b; Lees & Peres, 2008; Naiman, Decamps, & Pollock,

* Corresponding author. Tel.: +61 3 9925 9945; fax: +61 3 9925 3088.
E-mail addresses: christopher.ives@rmit.edu.au, christopher.d.ives@gmail.com (C.D. Ives), mark.taylor@mq.edu.au (M.P. Taylor), david.nipperess@mq.edu.au (D.A. Nipperess), grant.hose@mq.edu.au (G.C. Hose).

0169-2046/$ – see front matter
http://dx.doi.org/10.1016/j.landurbplan.2012.11.005

1993), the maintenance of river geomorphic integrity (Simon & Collison, 2002), and for buffering waterways from non-point source pollutants and eroded soil material (Dosskey et al., 2010). Recognition of their value is evidenced by advances in the policy and legislative protection offered to riparian corridors (Davies, Ives, Findlay, & Taylor, 2011; Lee, Smyth, & Boutin, 2004; Wenger & Fowler, 2000). As a result, this has established urban riparian corridors as important environmental assets that deserve protection as well as further study to understand more fully their role in biodiversity protection and maintenance.

The majority of studies investigating arthropod responses to urbanization have described significant but variable responses in biodiversity or assemblage structure with anthropogenic disturbance (Hochuli, Christie, & Lomov, 2009 and references therein). For example, Sadler, Small, Fiszpan, Telfer, and Niemela (2006) identified greater species richness of carabid beetles in rural areas than in urban landscapes, while Sanford, Manley, and Murphy (2009) found species richness and abundance of ants to peak at intermediate levels of development. Interestingly, Lessard and Buddle (2005) found a higher richness of ant species in urban backyards than in remnant forest interiors, albeit with the addition of more aggressive and dominant species at urban sites. However, no studies have specifically examined responses in riparian invertebrate assemblages as a result of catchment urbanization, which is a consistent pattern of land use change across all global cities.

In this study, ants were selected to assess ecological changes associated with urbanization because they are ubiquitous in the Australian landscape (Andersen & Majer, 2004), have high levels of species diversity (Andersen, 1995b), are easily sampled (Andersen, Fisher, Hoffmann, Read, & Richards, 2004) and respond rapidly to changes in environmental conditions (Andersen et al., 2004; McIntyre, 2000; Pik, Dangerfield, Bramble, Angus, & Nipperess, 2002). Ants have been found to respond to both landscape scale pressures such as reserve size (Gibb & Hochuli, 2002; Yamaguchi, 2004) and small-scale microhabitat features such as soil moisture, leaf litter and tree cover (Lassau & Hochuli, 2004; Vepsalainen, Ikonen, & Koivula, 2008). Ants also play an important role in the function of ecosystems through their role in nutrient cycling (Folgarait, 1998), soil development (Richards, 2009), aiding runoff infiltration (Sanford et al., 2009), seed dispersal (Rico-Gray & Oliveira, 2007), and via predation on other insects as well as being food for other species (Folgarait, 1998; Hölldobler & Wilson, 1990). Consequently, ants have been used widely as indicators of ecological condition and ecosystem restoration and function across a range of environments (Hoffmann & Andersen, 2003; Lomov, Keith, & Hochuli, 2009; Sanford et al., 2009).

In this study, we selected multiple sites from the urban-rural fringe in north-west Sydney, Australia to evaluate differences in riparian ant assemblages following the transformation of low-density rural/residential land to higher density residential housing. Such landscape transformation is commonly associated with increased physical and chemical disturbance of the riparian zone as a function of altered hydrological regimes and higher levels of anthropogenic pollutants in urban catchments (Walsh, Roy, et al., 2005). We hypothesized therefore that catchment urbanization would be reflected in the diversity and composition of the riparian ant fauna as a result of these environmental changes to the river and riparian zone. This study follows that by Ives et al. (2011a), where relationships were identified between the diversity of riparian ant communities and characteristics of the surrounding landscape within the suburban Ku-ring-gai local government area (LGA), 15 km north of Sydney city. The selection of riparian sites in north-west Sydney provided an opportunity to assess these trends more rigorously, through studying the ant diversity of remnant riparian corridors situated intentionally in proximal catchments of contrasting urban and rural land uses.

2. Methods

2.1. Survey design

Sites were located in the north-west of Sydney within The Hills, Hornsby and Ku-ring-gai LGAs (Latitude = 33°37′32″S–33°44′40″S; Longitude = 151°08′39″E–150°57′55″E) (Fig. 1). Prior to the 1960s the majority of this area was rural in character and dominated by grazing and horticulture, but urban development began in earnest after this time within restricted land use zones. To test for differences in ant assemblages in response to land use, six riparian sites were selected from within rural-dominated catchments and six from urban-dominated catchments. Rural and urban catchments differed markedly in a number of quantitative measures of urbanization such as road density (Rural = 18–55 m/ha; Urban = 153–186 m/ha), property density (Rural = 0.72–1.43 lots/ha; Urban = 9.25–12.75 lots/ha) and average lot size (Rural = 13,335–17,617 m^2; Urban = 1133–1484 m^2). We were careful to match as many landscape variables as possible across the two land uses because anthropogenic and natural landscape features often co-vary (Allan, 2004). Sites were located on public and private land within contiguous areas of riparian bushland of widths between 60 m and 200 m. They were adjacent to low to mid order streams (Strahler, 1952) with upstream catchment areas of between 72 ha and 363 ha. All sites were on Hawkesbury Sandstone and were part of the Sydney Sandstone Gully Forest vegetation unit (Benson & Howell, 1994). Land use of the surrounding sub-catchment was relatively homogeneous, with the majority of land in the rural catchments zoned as "Rural" land and the urban catchments as "Residential" land under respective Local Environment Plans, which are the New South Wales (NSW) legislated provisions for specific land use (e.g. The Hills Shire Council, 2011). Areas of active bushland restoration were avoided to avoid unnecessary confounding effects, as were any other obvious visible signs of physical disturbance.

At each site, ants were collected along with data on vegetation floristics and structure, physical habitat characteristics, water chemistry and geomorphology of the adjacent stream (Table 1).

2.2. Field sampling and invertebrate processing

Field sampling was undertaken between the 17th and 24th March 2010. Ten 250 mL pitfall traps (diameter 70 mm) were installed at each of the six urban and rural sites, resulting in a total of 120 traps. These were arranged at each site along a 50 m linear transect positioned ~5 m from the top of bank, parallel to the stream. Traps were filled with a mixture of 70:30 ethanol:water to kill and preserve specimens as well as a small amount of detergent to break surface tension. Pitfall traps have been found to capture a good representation of invertebrate diversity compared with other sampling techniques, and as such are used widely in field sampling of ants (Andersen, 1991). Traps were left open for 7 days.

The structure of the vegetation 5 m either side of the transect was recorded at each site, and for each stratum the following measurements were taken: (i) average height, (ii) growth form (i.e. tree, shrub, herb, etc.), (iii) total foliage cover, (iv) dominant vascular plant species and their cover, (v) the proportional cover of weeds and (vi) the proportion of weed species to the total number of species at a site. A seven-class Braun–Blanquet cover abundance scale was used to quantify species cover. Weed proportions were derived from visual estimates to the nearest 5% (Hill, 2005). All field information was collected by the lead author to maintain consistency of data.

Techniques for measuring local habitat characteristics were adapted from Lassau and Hochuli (2004) and involved assigning a score for the percent cover of rocks/logs/debris and leaf litter