Application of a greenspace model to Auckland City, New Zealand

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Abstract

The urban forest, with a focus on percentage tree cover, can provide multiple ecosystem services. In comparison, one Greenspace Model for fragmented urban ecosystems suggests that indigenous biodiversity can be better accommodated by a network of intersecting forest patches across the landscape, with potentially a transformative effect on the local cultural sustainability. This study attempts to apply this idealised model to the Auckland City Infraspace. Network patch interconnectivities and gaps have been identified which appear to be associated with unhealthy and deprived areas respectively. There is an opportunity for local body policy and local community action to integrate social, cultural and environmental goals to strengthen the ecological networks, local ecosystem services and social cohesion.

Keywords: Urban biodiversity, Greenspace Model, urban forests, social cohesion

Introduction

In the urban ecology of the human environment, indigenous biodiversity is inevitably in a fragmented state. The patchwork-reality model (Forman and Godron, 1986) applied to fragmented landscapes may allow species to survive in the urban environment where patches that are large enough to accommodate breeding subpopulations of species, within movement and dispersal distances of similar habitat patches, function as viable metapopulations. McAlpine and Wotton (2009) suggest that ‘scenarios that enhance biodiversity also enhance the production of ecosystem services’. As well, the emergent ecosystem services (ecoservices) result in health and well-being to residential communities (Wardhaugh et al., 2010).

Many cities have goals for an urban forest to provide a minimum percentage tree cover up to 35% (American Forests, 2007; ACC 2008) in order to adequately meet some ecosystem service needs. In New Zealand, urban forests are most commonly defined as all vegetation native and exotic planted or naturalised on public and private land (Jones Grey, 1998; Knowles 2000) and this distinguishes it from the concept confined to mixed-use trees on public land (Brauch et al., 1995), or the more limited view as only the indigenous naturalised urban forest. This can be the basis for a connected network of patches for indigenous forest (O’Donohue et al., 2003) if the diversity and heterogeneity of the urban forest offers food, nesting and breeding opportunities for a range of species. Hence the urban forest would provide biodiversity, aesthetic, amenity, recreational and ecoservices values for the city.
Auckland City, the site of this study, is situated on an isthmus; the narrowest part of New Zealand, covering an area of approximately 15,000ha with a population of 1.3 million. The subtropical climate supports large native and exotic species diversity and is variable topographically with numerous ridges, gulleys and coastal cliffs, with 16 volcanoes and some more gently undulating areas. New opportunities for increasing tree cover occur with the current development of brown-fields (e.g. cleared quarries), where incremental loss of trees is occurring with infill housing and the associated loss of natural vegetation (ACC 2008). Along with urbanisation, the removal of the ability for local bodies to have general tree protection rules (effective from January 2012) is the largest threat to the urban forest and connectivity. Trees not scheduled for protection on urban private land will be able to be removed with significant detrimental effect on tree cover, and an associated loss of amenity values, biodiversity and ecosystem services. Currently, Auckland City has an urban forest plan (ACC 2010) with a vision to enhance the urban forests to 35% tree cover.

Greenspace Model

Rather than percentage tree cover per se, the Monck & Hall (2006) Greenspace Model is an ‘idealised, nested forest patch configuration’ forming a network of equilateral triangles and is based upon the ecological processes of species movement and dispersal, and the availability of food, nesting and roosting resources for a range of indigenous species and is specifically focused on urban biodiversity. The survival of metapopulations of indigenous birds such as kereru (Hemiphaga novaezelandiae Temminck) and tui (Prosthemadera novaeseelandiae Sclater) are not reliant on extensive intact habitats, commonly moving across the landscape from patch to patch, nesting in large patches, especially where pest mammals are managed and supplementing their diet with exotic species. The kereru is a particularly critical component of podocarp-broadleaf forests, being the only animal with a gap large enough to function as a disperser of large-seeded indigenous canopy tree species such as kahikatea (Fusodium taxoides Blak. et Hook). Based on movement and dispersal of such birds, the model has a large patch maximum of 625ha but provides core habitat of 2.25ha with a 5km edge effect (Young & Mitchell 1994), foraging patches of 1.56ha and ‘stepping-stone’ patches of 0.16ha (Figure 3). Those smaller patches are 15m, 45m and 0.2km respectively. Scattered vegetation in gardens, pocket parks and street trees of the matrix provide supplementary resources. The question then is: how does the Monck & Hall (2006) Greenspace Model synthesise with the Auckland City isthmus urban forest?

Method

High resolution aerial photographs (Auckland Regional Council 2010) were used to delineate areas of vegetation 0.5ha or greater and ArcGIS GIS software was used to draw polygons according to the three patch sizes (Monck & Hall 2006): large patches >625ha, medium patches 15.6-6.5ha, and small patches 0.01-1.4ha. The high resolution photographs allowed groups of trees to be distinguished from scrubs and shrubs (<15m) and many trees could be identified to species level at this resolution. Ground-truthing field surveys of a sample of areas allowed verification of this distinction.

In order to show the existing patch network, patches polygons were converted to points (the centres of the mass of the polygon) and NetLogo (Wilensky 1999) was used to model connections by creating three types of links between patches within the distance designated by the Greenspace Model (Monck & Hall 2006), e.g. all medium patches are linked to medium and larger patches within 1km.

Results

The total area covered by patches is 1,350ha, which is 8.7% of the total isthmus area. Thirty-one large patches providing 625ha of habitat for subpopulations of breeding birds, have an average size of 18.3ha. All large patches are connected at least one other large patch, with an average of 10 other large patches within 5km. Indigenous forest with intact understorey is predominant in around half of the large patches, while the remainder have a component of indigenous forest and/or dense large tree plantings of native/exotic mix. Medium patches cover approximately 2.75ha with 95 patches of 2.9ha (average) and 88% of these have some connection to another patch with an average of 3 connections. One third of the patches are predominantly indigenous forest with an intact understorey, while the majority are a mix of planted native and exotic large trees on public open space and private land. There are 1,629 small patches with a total area of 369ha, an average size of 0.3ha, and 25% are connected to other patches within 0.3km. Small patches are groups of predominantly planted exotic trees in a combination of public (e.g. streets) and residential properties.

Table 2. Map of patch connectivity for the Auckland Isthmus

Large patch distribution is not uniform across the isthmus, with the strongest connections in the northern area of the isthmus and the weakest connections in the west, southwest and southeast. Although no large patch is totally isolated, for part of the isthmus the density of large patches (up to 17 connections to other patches) is far greater than the model (6 connections), there are three gaps where the distribution of large patches limits the full coverage of the idealised model at this scale. The maximum number of connections for medium patches was six, while fourteen medium patches were totally isolated from connections to other medium or large patches. Three quarters of small patches are isolated and in those that are connected, only six small patches have or more connections to other small or medium patches and the average is 3 connections. Overall, at the small and medium patch scale, there is less connectedness resulting in a highly fragmented patch structure creating gaps especially in the north, southwest, northeast and southeast.
Movement and dispersal is facilitated by the number of trees in the matrix although predation may be high in some areas. Indigenous birds and insects are not impacted by roads and motorways generally and the matrix permeability of the isthmus is high with an average of 404 trees per hectare in residential gardens and 28.6% are indigenous (Morton et al. 2009).

Discussion

The Greenspace Model aligns with Opdam & Steingruber’s (2008) spatial cohesion guidelines for an ecological network design based on the carrying capacity (total area, and quality of patches) and connectivity (density, and matrix permeability). The actual carrying capacity of the isthmus is high in total area but may have some reduction in quality due to the ‘urban forest’ approach of this study in creating patches of trees, compared with the Greenspace Model which, especially for the large and medium patches, assumes indigenous forest quality in order to obtain effective ecological functioning of indigenous faunal species which prefer indigenous forest (Kuchel 1999, Williams & Karl 1999).

The Greenspace Model ‘fitted’ over the isthmus would create 1.12 large patches, minimum size of 6.25ha, at 5km spacings and total area of 0.72ha. Compared with the Greenspace Model there are nearly three times the number of actual large patches, of three times the average size. Therefore the density of patches is greater, which facilitates metapopulation functioning. However, the distribution of all patches is clustered, intensifying the density and efficacy in some areas, while creating gaps in the network. They are clustered in the north of the isthmus and associated with high household income sectors of the city. The major gaps in the network of large patches are in the lowest household income sectors of the city.

Large patches are associated particularly with public open space, with only two predominantly on private land. These patches tend to occur on steeper land, especially south-facing, cooler, steeper slopes or gullies which are less suitable for housing. As well, they occur in the vicinity of the volcanic cones which are preserved as open space. The areas where there are gaps in the large patch configuration, the topography tends to be flatter. Medium and small patches cover an area considerably larger than the minimum prescribed by the Model, but are clustered (mostly in the northern areas) or poorly connected (especially in the southern deprived sectors).

Opdam and Steingruber (2008) include in their model the contribution made by a ‘key patch’ that is able to support a subpopulation relatively long-term, suggesting this could compensate for up to a 20% reduction in the network. The isthmus’ southern coastal forest could be considered a ‘key patch’ as it is of considerable size (c.50ha) and capable of supporting a subpopulation of birds for a considerable time. In addition, this patch is relatively well connected to a ‘stronghold’ that is situated outside the network, thus with a strong influence on the network sustainability because it has long-term self-sustaining populations (Opdam and Steingruber, 2008).

Comparison of two socio-economically contrasting suburbs

Remuera is an area of the city which has high household income, high percentage of post graduate education, is zoned Built/Flora to protect significant bush clad areas and the landscape quality of trees, Low Density to maintain open space on large lots allowing room for trees (ACC 1993). It contains medium and small patches and has a large patch within 2km. This suburb is one of three wealthy areas where all patches are connected to other patches within 200m, with no gaps.

Table 3. Remuera (left) with well connected patches and Pt England (right) as a gap in the network.

Within the Auckland City Isthmus, Pt England has the lowest household income, the lowest percentage of postgraduate education and the highest percentage of residents with no qualification, the highest rental housing of which the majority are state rental, and is zoned Medium Density to High Density with no specific tree protection (ACC 1999). Pt England has ten small, but no medium or large patches, and is 2km from the nearest large patch. It has the capacity for two medium and 36 small patches according to the Greenspace Model. The extent open space and housing density indicate capacity for a more dense urban forest, so if it is not clear why it is a ‘determinate’ it has a large open space (c.47ha) which is currently grazed, with 30% as cricket sports fields, and it lies between the low decile primary and secondary schools and the coast. A large patch equivalent to the current average large patch size in Auckland (c.1814) could be created by extending an existing small riparian patch at the margin of the Lзнаком open space. In order to perform the Greenspace Model configuration it would also require two medium-sized medium patches distributed evenly over the area, with 19 small patches and amongst these, and another large patch approximately 4km south within the adjacent suburb. Minimum-sized medium patches could be accommodated within existing smaller open space within this suburb. Small patches could be a combination of strategic street tree plantings and pocket park enrichments, but would also require residential plantings. These could be achieved with groups of 10 trees across four to six cojoining properties in cooperation with Housing NZ.
A focus for the Auckland Urban Forest Plan (ACC 2008) on a community project in Pt England to fill the gaps for biodiversity functioning and a range of environmental ecosystem services, could provide an opportunity for cultural ecosystem services of aesthetics, education, and recreation. Social cohesion can be enhanced through the participation in conservation activities which increase experience and knowledge and empower communities to affect the quality of their environment through changing peoples’ perception of biodiversity (New et al. 2009) and increasing their self-esteem (Baron & Panter-Brick 2010). Here is a spatial opportunity for a large patch of indigenous forest, designed with the community using ecological aesthetic principles (Nassauer 1997, Guetter et al. 2007) appropriate to local needs while integrating with the schools’ co-education and enriching on the ecosystem services provided by the recently revegetated riparian strip.

Conclusion

Biodiversity in urban areas, and in landscape design especially, is often reduced to planting native plants which may address indigenous species diversity but without regard for genetic or ecosystem diversity (Haines 2010). The Greenspace Model attempts to address the optimisation of indigenous biodiversity (genetic, ecosystem and species) within the human environment of cities. Meek & Hall (2006) state that the Greenspace Model’s spatial pattern may be an oversimplification of the relationship to processes such as dispersal, and that “the overall concept proposed should be treated cautiously”. However, models allow development of a concept which is then useful in allowing us to measure the existing conditions against an ideal (Pickett et al. 2004). Applied to the Auckland itahau it clearly indicates a clustering of biodiversity within a range of patch sizes, with threads of connectivity between the clusters, and indicating deprived areas where there are gaps in the patch network or poor connectivity to patches.

Although this is a preliminary study of the relationship between urban forests, biodiversity conservation and socio-economic deprivation, the general implication indicates as association. Meek and Swaffield (2007) describe the Greenspace Model as applying a “visitable deep landscape structure” to promote biodiversity conservation, as well as suggesting it potentially will have a transformative effect on the local cultural sustainability providing “social visibility and accessibility”. There is an increasing call to better integrate the biological, physical and socio-economic components of urban ecosystems (Pickett et al. 2009:25) and its intention to protect and enhance the city’s urban forest (ACC 2008) could focus on working with local communities in deprived areas. Wia (2008) suggests urban sustainability can be achieved by encouraging people as “ecosystem engineers” to integrate cultural, socio-economic and ecological elements. The rectification of urban forest gaps can provide for network cohesion as well as the integration with social cohesion and a just distribution of ecosystem services thus ‘protection of another ecosystem and human health, ensuring equal access and services’ (Wia 2010).

References

Landscape ecological mapping and rural land use change in Ekondo-Titi Sub-division, South West Region of Cameroon.

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Abstract

Land use dynamics and rural land use planning in most developing countries is often hampered by the lack of relevant data. This could be a consequence of the lack of expertise and financial resources required for integrative surveys. Landscape mapping was carried out with the help of the ecosystem approach which often consider broad ecological zones with the dominant land uses taken into consideration. The major land uses considered were agriculture, forestry and settlement of which land use maps were deduced from aerial photographs through the MapInfo GIS program. The agricultural land use draw more resources from the forest through provisioning ecosystem services thereby causing problems of deforestation of the forest and wadies/beds, less of biodiversity and land degradation. Development in this area has come with mixed blessings as human kind continues to eke out a living from the land. An integrated land use planning based on land use classification and suitability offers promising solutions to resource exploitation and sustainable management.

Key words: Non-Wood Forest Products (NWFPs), Ecosystem services, Landscape ecology, Plantation agriculture, Ekondo-Titi, sustainable management

Introduction

Landscape ecology is an interdisciplinary science that is widely heterogeneous thereby making the landscape perspective relevant to ecology at different organizational levels across a broad range of spatial scales (Heinemann, 2001; Wu, 2006). The real impact of landscape ecology on decision-making and sustainable land uses is still very limited (Nowak, 2007). This is because the changes that have taken place in the landscapes of most developing countries has not been able to sustain the ever-growing population. In areas where industrial agricultural practices are intensifying, the demand for high quality landscapes is on the increase (Jackson, 2008; Matsuoka and Kappes, 2008; Stephen, 2008).

Landscape ecology has been positioned as the scientific basis for sustainable landscape development (Perechini and Haines-Young, 2006; Wu, 2006; Wu and Hebb, 2007; Rennolls and Oxlade, 2009). Anthropogenic modifications to the landscape and the different types of land uses are necessary for understanding the dynamics of landscape.