

Chapter 13

Sensitivity and Threat in High-Elevation Rainforests: Outcomes and Consequences of the IBISCA-Queensland Project

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Summary

Multiple taxon surveys of plant and animal diversity along a subtropical altitudinal gradient in rainforest in South-east Queensland identify a distinct assemblage for every focal taxon investigated in the *Nothofagus*-dominated cloud forest above

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1,000 m altitude. These high-elevation forests are not only biotically unique but they represent an endangered community under even moderate levels of predicted global warming. Although assemblages associated with lower elevations may adapt to a warmer world by moving upwards, these high-elevation sets of species have nowhere to go. At the continental scale, these forest types are rare. Some species or their near-analogues may persist in more southerly locations, but those at the northern ecosystemic limits appear doomed.

1 Introduction

The IBISCA¹ approach to biodiversity assessment in forests was, initially, the brain-child of Yves Basset, Bruno Corbara and Hector Barrios (Basset et al. 2007). The four IBISCA projects carried out to date have examined selected aspects of beta-diversity in tropical, subtropical and temperate forests. In each case a set of research questions were defined and a sampling design executed. Researchers with interests in particular taxa or ecological processes were invited to join one or more of the proposed field expeditions to carry out sub-projects of their choice within the general experimental design. When successful, this approach not only provides individual researchers or groups of researchers with analyzable and publishable data sets in their specific areas of interest but it also facilitates comparative and other meta-analyses with homogeneous criteria.

The first IBISCA project examined canopy-ground comparisons in the low-land tropical rainforest of Panama (Basset et al. 2007). This was followed by two projects which examined altitudinal changes in arthropod and plant diversity: IBISCA-Queensland, in the subtropical rainforest of South-east Queensland (Kitching et al. 2011), and IBISCA Santo, in tropical insular forest on Santo Island, Vanuatu (Bouchet et al. 2011). The fourth project, IBISCA Auvergne, examined the interaction between arthropod biodiversity and woodland structure in a managed forest in Central France.

The IBISCA-Queensland Project was carried out between 2006 and 2008 in Lamington National Park in South-east Queensland. Within a single wholly forested catchment, 20 sampling sites were established, four at each of five altitudes (300, 500, 700, 900, and 1,100 m asl). The lowest elevations were characterised by warm subtropical rainforest (notophyll vine forest *sensu* Webb 1959) with higher elevations grading into 'cool subtropical rainforest' through to 'cool temperate rainforest' at the highest elevations (i.e. grading from 'notophyll vine forest' to 'microphyll fern forest' in the terminology of Webb 1959). McDonald and Hunter (2010) discuss the detailed composition of the rainforest vegetation of the region, and Laidlaw et al. (2011a, b) describe and analyse in detail the vegetation of the IBISCA sites.

¹The IBISCA designation was originally the acronym for 'Investigating the Biodiversity of Soil and Canopy Arthropods' but has evolved into a general description of multidimensional, multi-researcher, multinational projects examining forest diversity.

The rationale for this project is based on the logic that studying adjacent altitudes in a continuously forested catchment (with sampling sites standardised for substrate and aspect) will provide insights as to how biodiversity responds under various scenarios of future climate change. Strong et al. (2011) discuss the physics and meteorology behind this logic as well as presenting results on the actual altitudinally related lapse rates encountered.

Results are now catalogued for a range of taxa including plants, springtails, moths, ants, flies, beetles and bugs. In this chapter we present a comparative summary of some of these results and discuss emergent conservation issues. Detailed methodologies and analyses have already been documented (see Ashton et al. 2011; Burwell and Nakamura 2011; Boulter et al. 2011; Greenslade and Kitching 2011; Lambkin et al. 2011; Laidlaw et al. 2011a, b; Kitching et al. 2011; Ødegaard and Diserud 2011). In some instances, data have been reanalyzed and re-presented in slightly different form for visual comparability.

2 The Uniqueness of the High-Elevation Forests: Results from Disparate Taxa

Figure 13.1 compares overall patterns of assemblage composition across six taxa, using nonmetric multidimensional scaling ordination based on presence/absence data. Samples were collected from four independent locations at each of five elevations along our Lamington altitudinal gradient. Figure 13.1a is derived from surveys of woody plants with stem diameters at 1.3 m height (dbh) of 5 cm or greater (see Laidlaw et al. 2011a). Figure 13.1b summarises Collembola sampled using pitfall traps (Greenslade and Kitching 2011). Figure 13.1c shows the distribution of moth species trapped using light traps (Ashton et al. 2011). Figure 13.1d reflects a similar analysis of beetles collected by sweeping (Ødegaard and Diserud 2011). Figure 13.1e is an ordination of the ant species sampled by a variety of methods (primarily hand collecting, litter extraction and bark spraying) (Burwell and Nakamura 2011). Finally, Fig. 13.1f presents an ordination of samples of higher flies (i.e. Diptera minus the Nematocera) collected in Malaise traps, sorted and analyzed at the family level (Lambkin et al. 2011).

In each of these six examples, we performed permutational multivariate ANOVA (PERMANOVA, Anderson et al. 2008) to test for differences in assemblage composition among elevations (using 19999 unrestricted permutations of the raw data, with five elevations incorporated as a fixed factor). There is statistically significant evidence that the assemblages of organisms under study are far from random and that altitude is strongly associated with the patterns generated by the ordinations (see individual papers referenced above).

The flora and fauna associated with the samples from 1,100 m asl (called microphyll fern forest by Webb (1959) or 'cool temperate rainforest' as used by Floyd (1990)) were the best defined assemblages and more isolated from the lower forest sites. The results of post hoc pairwise comparisons were consistent with observed patterns,

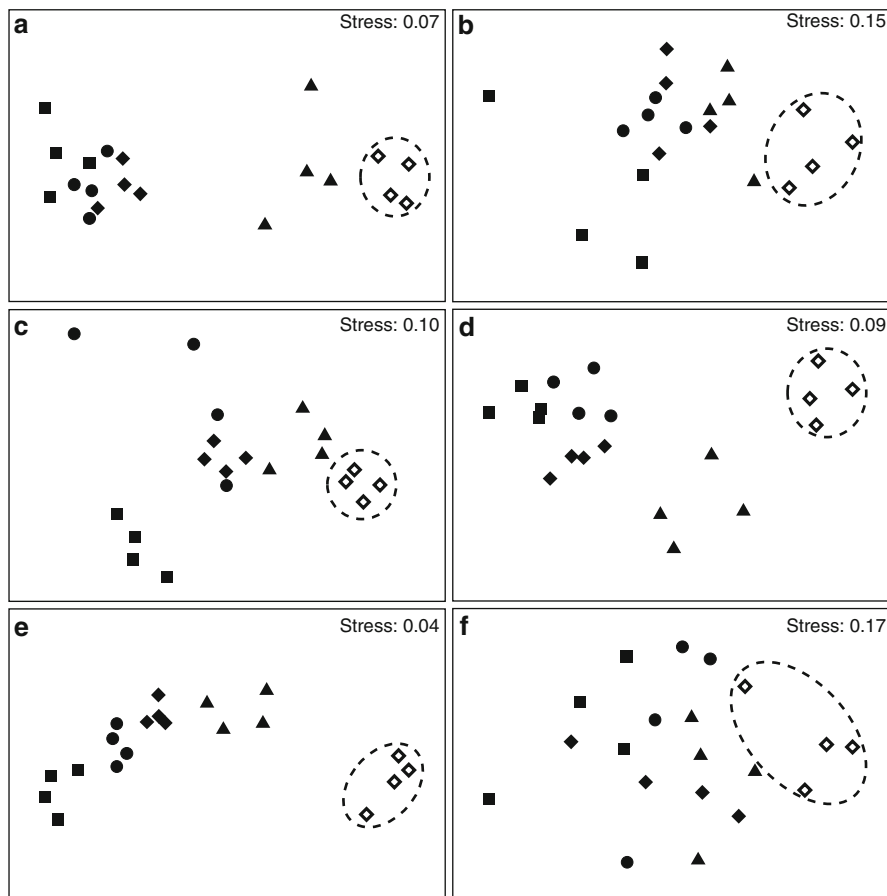


Fig. 13.1 Results of nonmetric multidimensional scaling ordinations on presence/absence data for taxa along an altitudinal gradient in subtropical rainforest in Lamington National Park, South-east Queensland, Australia: (a) trees with dbh greater than 5 cm; (b) Collembola from pitfall traps (October 2006); (c) night-flying Lepidoptera with forewing length >1cm, from light traps (October 2006 and March 2007); (d) Coleoptera collected by beating to head height (October 2006); (e) Formicidae based on a protocol including pitfall traps, bark spraying, litter extraction and hand collecting (October 2006, January 2007, March 2007, July 2007 and January 2008); (f) families of Diptera (excluding Nematocera) from ground zone Malaise traps (October 2006, January 2007 and July 2007) (For further details of methods used, see references in the chapter text)

with assemblages at 1,100 m significantly different from those from lower elevations. These unique higher-elevation assemblages have, embedded within them, species characteristic of, and restricted to, these cooler forests. Table 13.1 lists the characteristic taxa for each of the six examples illustrated in Fig. 13.1.

Although we focused on the 1,100 m sites because of their special conservation significance, we noted that the ordinations (with the exception of fly families) showed clear, progressive changes from 300 to 900 m. For trees and beetles, 900 m also

Table 13.1 Species or morpho-species unique to 1,100 m sites surveyed during IBISCA-Queensland with their wider distribution where known (abbr.: *NSW*, New South Wales; *Qld*, Queensland)

Species or morpho-species	Known distribution
Angiospermae^a	
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<i>Acronychia octandra</i>	Regional endemic: South-east Qld, North-eastern NSW only
<i>Arthropteris beckeri</i>	Widespread: wet tropics of Qld to Southern NSW
<i>Blechnum watsii</i>	Widespread: Southern Qld to Tasmania
<i>Blechnum patersonii</i>	Widespread: Northern Qld to Southern NSW
<i>Berberidopsis beckeri</i>	At northern limit, spreads south to central, coastal NSW
<i>Callicoma serratifolia</i>	Widespread: Central Qld to Southern NSW
<i>Dendrobium falcorostrum</i>	Local endemic: border ranges only, <i>Nothofagus moorei</i> associated
<i>Cyperus disjunctus</i>	At northern limit, spreads south to central, coastal NSW
<i>Cyathea australis</i>	Widespread: Northern Qld to Tasmania
<i>Cryptocarya foveolata</i>	At northern limit, spreads south to central, coastal NSW
<i>Dockrillia pugioniformis</i>	Widespread: South-east Qld to South-eastern NSW only
<i>Dryophila moorei</i>	Regional endemic: South-east Qld, North-eastern NSW only
<i>Helmholtzia glaberrima</i>	Regional endemic: South-east Qld, North-eastern NSW only
<i>Marsdenia rostrata</i>	Widespread: Northern Qld to Victoria
<i>Melicope hayesii</i>	Regional endemic: South-east Qld, North-eastern NSW only
<i>Parsonia induplicata</i>	Regional endemic: South-east Qld, North-eastern NSW only
<i>Nothofagus moorei</i>	Regional endemic: South-east Qld, North-eastern NSW only
<i>Pennantia cunninghamii</i>	Widespread: Northern Qld to Southern NSW
<i>Parsonia tenuis</i>	Local endemic: Border ranges only
<i>Polyosma cunninghamii</i>	Widespread: South-east Qld to South-eastern NSW
<i>Ripogonum fawcettianum</i>	Regional endemic: South-east Qld, North-eastern NSW only
<i>Ripogonum discolor</i>	Widespread: Northern Qld to central NSW
<i>Quintinia sieberi</i>	At northern limit, spreads south to South-eastern NSW
Collembola	
<i>Acanthanura</i> sp. nov.	Local endemic to this site, under process of description
<i>Pseudachorutinae</i> gen.nov., sp. nov.1	Probably local endemic to this site—known only from this site
<i>Pseudachorutinae</i> gen.nov., sp. nov. 2	Probably local endemic to this site—known only from this site
<i>Lobellini</i> sp.	Probably local endemic to this site—known only from this site
<i>Folsomina</i> sp.	Probably or likely on other moist summits
<i>Proisotoma</i> sp.	Probably or likely on other moist summits
<i>Calvatomina pagoda</i>	Probably or likely on other moist summits, including Melanesia
<i>Acanthomurus</i> sp. 2	Unknown, insufficient information
<i>Rastriopes</i> sp.	Unknown, insufficient information
<i>Cryptopygus</i> sp.	Unknown, insufficient information
Coleoptera	
21 species of which >3 specimens were found (out of a grand total of 1,219 spp.) were restricted to the 1,100 m sites. These belonged to the families Carabidae (3 spp.), Ptiliidae (1 sp.), Scydmaenidae (2 spp.), Staphylinidae (8 spp.), Scaphiidae (1 sp.), Pselaphidae (1 sp.), Scirtidae (2 spp.), Buprestidae (1 sp.) and Byrrhidae (1 sp.). These have not been identified further at this stage	

(continued)

Table 13.1 (continued)

Species or morpho-species	Known distribution
Lepidoptera	
Geometridae, Ennominae	
<i>Dyscheralcis crinnodes</i>	A high-elevation species in tropical and subtropical Australia, close to its southern range limit here. Southern limit in Northern NSW
<i>Lychnographa heroica</i>	Restricted to South-east Queensland and northern half of NSW. Southern limit is near Barrington Tops National Park, NSW
<i>Middletonia hemichroma</i>	Restricted to South-east Queensland and northern half of NSW. Southern limit is near Barrington Tops National Park, NSW
Geometridae, Larentiinae	
<i>Heterochasta conglobata</i>	A high-elevation species in tropical and subtropical Australia, close to its southern range limit here. Southern limit in Northern NSW
Noctuidae, Amphipyriinae	
<i>Thalatha trichroma</i>	Restricted to South-east Queensland and northern half of NSW. Southern limit is in Blue Mountains National Park, NSW
Hymenoptera, Formicidae	
<i>Pachycondyla</i> IBISCA1	Uncertain—to date known only from this site
Diptera families	
Helosciomyzidae (124 of 130 specimens at 1,100 m) ^b	In Australia restricted to higher elevation rainforest from the tropics southward. Also in New Zealand and Chile

^aBased on an assessment of the entire vascular flora, not just the canopy trees used in Fig. 13.1a. List includes only taxa which could confidently be identified to species and excludes one widespread herbaceous species

^bThese were all *Helosciomyza ferruginea*—the same species identified by Wilson et al. (2007) as a potential indicator of future climate change within the wet tropics of far North Queensland

exhibited distinctively different assemblages. The lower degree of separation found in the fly assemblages is attributable to the family-level resolution of the data, yet assemblages at 1,100 m were different from those of lower elevations. In some instances better separation was achieved when relative abundances were included in the analyses. The results of such analyses are discussed elsewhere (Burwell et al. 2011).

3 Endemism and Options: Conservation Implications for a High-Elevation Specialist

In undisturbed tracts of natural vegetation such as the rainforests of Lamington National Park, fauna and flora characteristics of lower elevations have the option to move to higher elevations as the climate warms. Allowing for the 1.5 °C lapse rate per 200 m elevation and assuming nothing but temperature is involved (a big assumption), this means that the biota currently encountered below the 900 m elevation mark has at least the potential to adapt to the range of changes predicted over the coming century. In contrast, 1,100 m biotas are different because they have nowhere to go.

Cool temperate rainforest dominated by *Nothofagus* or *Eucryphia* spp. occurs in Australia from extreme South-east Queensland stretching south through New South Wales to Victoria and is the dominant wet forest type in Tasmania. In the north the canopy of these forests is generally dominated by *Nothofagus moorei*, in the central part of their distribution by *Eucryphia moorei* and in Victoria and Tasmania by *Nothofagus cunninghamii*. In all, Australia has about 820,000 ha of this forest type but only about 200,000 ha on continental Australia and 624,100 ha in Tasmania (Williams 1974). The 200,000 ha of cool temperate rainforest on mainland Australia is made up of isolated patches, few of which exceed more than a 1,000 ha in extent. These patches are separated from each other by warmer rainforest types, by wet and dry scleromorphic woodlands and by large areas of lowland developed for agriculture and settlement. Taxa that are strong fliers or sufficiently small to be wind assisted in their movements could, in principle, move south in the face of a warming climate. Many of the local endemics though are far from highly vagile and simply do not have that option. Bass Strait, separating Tasmania from mainland Australia, represents a significant barrier for species seeking cooler *Nothofagus* forests.

4 Future Work and Conservation Options

To assess the species-level conservation threat to high-elevation forests of Lamington National Park, we need to quantify the wider distributions of the species that make up these unique assemblages (Table 13.1). For the arthropods, many gaps exist in the database. Museum-based surveys of species of Lepidoptera and ants are underway. Other groups must wait.

Policymakers are faced with questions about management actions to insure stewardship of these high-elevation rainforests. Clearly, species of invertebrates cannot be systematically moved to more southerly habitat (although this is an option actively discussed for vertebrates). Even if this were possible, the unpredictable consequences concerning their impacts on the more southerly sites make it a risky option. For invertebrates, ex situ conservation is not practical. Steffen et al. (2009) have made it quite clear that reducing the impacts of ‘other stressors’ in environmental terms (such as clearing, inappropriate fire regimes and invasive weed impacts) will likely maximise the intrinsic resilience of natural ecosystems to change driven by global warming. We are not optimistic about the long-term survival of these unique mountain communities. In contrast, species in lower-elevation rainforests (see Burwell and Nakamura 2011; Ødegaard and Diserud 2011) have greater plasticity to shift up elevational gradients, even if their levels of local endemism are less than the cool temperate ecosystems.

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