

Priority Forests for Conservation in Fiji: landscapes, hotspots and ecological processes

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Appendix 1 Justification for the decision rules for identification of Priority Forests for Conservation (Table 1)

Maintaining viable populations

Minimum area requirements

An important conservation goal is to protect blocks of natural forest that are of sufficient size to maintain viable populations of species with larger area requirements. We used a decision rule that each of the major islands should have an intact forest block of at least 100 km², a rule-of-thumb minimum area used elsewhere for conservation planning for some tropical forest vertebrates, although perhaps less relevant for island species with small population sizes. Preliminary data suggest Fijian masked shining parrots *Prosopaea personata* require c. 50 km² to maintain 1,000 breeding pairs (this parrot generally occurs in forests at < 500 m in altitude; Masibalavu & Dutton, 2006), 30 km² for 1,000 calling giant forest honeyeaters *Gymnomyza viridis* (this density is reduced in logged forest and plantations; Kretzschmar, 2000) and 71 km² for 1,000 calling golden doves *Chrysoenas luteovirens* (Jackson & Jit, 2007).

The natural history and distribution of several other species suggests they may require even larger tracts of intact forest for long-term persistence but no data are available. The Critically Endangered red-throated lorikeet *Charmosyna amibilis* ranges nomadically across whole islands in search of flowering vuga *Metrosideros* spp. and other trees, although the requirements of these birds are still poorly known (Watling, 2001; Swinnerton & Maljkovic, 2002). Area requirements for far-ranging colonies of Fiji's flying foxes (*Pteropus* spp., *Mirimiri* spp.) are also unknown (Palmeirim et al., 2007). The metapopulation dynamics of highly patchy trees, such as dakua *Agathis vitiensis* and *Acmopyle sahaniana*, may depend on large blocks of forest to support viable populations in the long-term.

Refuge from alien predators

Fiji has no native terrestrial mammals. Introduced rats, mongoose, cats and dogs all prey heavily on Fiji's naïve native wildlife (Morley, 2004). Predation rates by introduced predators are lowest in natural forests > 4.5 km from the edge of the forest or road (Olson et al., 2006). Such areas may act as partial refugia from predation by alien mammals for a wide range of Fijian native species. Only a few sufficiently remote forests still exist and all should be protected, along with their forest buffers, as they represent one of the most cost-effective strategies for protecting Fiji's endangered species. Furthermore, preventing unnecessary road development into these areas would be viewed as a desirable conservation outcome (Olson et al., 2006).

Representation

Habitat types

We first assessed the degree of protection for major habitat types on each of the major islands (Viti Levu, Vanua Levu, Taveuni, Kadavu and Gau) and island groups (Mamanuca, Yasawa, Lau and Lomaiviti Groups, and Rotuma). The habitat types are cloud forests found on top of higher mountains and ridges (Ash, 1992), montane rainforests that start at 600–800 m, lowland moist forests (0–600 m), transition forests between the wet and dry sides of the larger islands, and tropical dry forests (Smith, 1951; Ash, 1982; Mueller-Dombois & Fosberg, 1998; Evenhuis & Bickel, 2006). Wetlands (e.g. reed beds, lakes and marshes), littoral, mangrove and karst forests were not explicitly considered in this analysis (Ash & Ash, 1984; Woodroffe, 1987; Heads, 2006).

Biotic (biogeographical) provinces

The goal of protecting each major habitat type on each of the major islands and in each island group helps ensure that the full range of species and distinct assemblages of species are conserved. Using major habitats as a proxy for representation of taxa is a valid precautionary approach as many Fijian species are restricted to single islands. However, local endemism within islands is pronounced in some taxa, such as plants and invertebrates (Duffels, 1988; Heads, 2006). This means that smaller areas within larger islands, or single islands within island groups, may also require protection to ensure a full representation of species and distinct species assemblages.

To assess representation of species, particularly range-restricted species, we developed provisional maps of biotic provinces and sub-provinces for five major taxa: plants (based on an analysis of island and intra-island endemism derived from Smith, 1951, 1979–1996; Whittier, 1975; Brownlie, 1977; Watkins, 1994; Mueller-Dombois & Fosberg, 1998; Kretzschmar, 2000; Heads 2006); terrestrial arthropods and gastropods (Tilyard, 1924; Robinson, 1975; Parkinson et al., 1987; Duffels, 1988; Haynes, 1998a,b; Barker, 2003; Evenhuis & Bickel, 2006; Sarnat, 2006, 2008; S. Prasad et al., unpubl. data); reptiles and amphibians (Pernetta & Watling, 1979; Zug et al., 1988; Zug, 1991; Watling & Zug, 1998; Morrison, 2003a,b, 2005); birds (Watling, 1998, 2001; Masibalavu & Dutton, 2006); and freshwater fish (Jenkins & Boseto, 2003; Appendix 2: Figs 5–8). Where available, mapped distributions of species and higher taxa informed biotic province delineation.

Biotic province boundaries were delineated based on our estimate of the distinctness of the entire biota (Fig. 4) and of different taxa (Appendix 2: Figs 5–8) across the archipelago. For each, we distinguished distinct areas at the province and sub-province level in the following order: (1) major islands and major island groups (Viti Levu, Vanua Levu, Taveuni, Kadavu, Lomaiviti, Lau Group and Yasayasa Moala Groups, Rotuma); some island groups were lumped with major islands (Mamanuca and Yasawa Groups with Viti Levu) if warranted by the distribution of the taxon in question; (2) dry versus wet forests on the larger islands; (3) larger mountains or mountain ranges within the larger islands, especially if notable for clusters of local endemic species; (4) single islands within major island groups notable for clusters of island-endemic species. Some important sites were also identified for several taxa.

We synthesized the maps for individual taxa (Appendix 2: Figs 5–8) to develop the overall biota regionalization (Fig. 4). We first looked for biogeographical divisions that were common among them and then emphasized the divisions of plants and invertebrates, as these constitute the vast majority of Fijian species and generally have smaller distribution ranges. All of the major islands are sufficiently distinct to warrant a major biotic division and, in some cases, groups of smaller islands were also distinguished. Biotic sub-provinces within islands or island groups were based either on zones of pronounced local endemism or on gross ecological shifts across major habitat types (e.g. dry forest versus wet forest) or biophysical gradients or barriers (e.g. isolated mountain ranges). These proposed biotic provinces and sub-provinces for the entire biota and various taxa represent a first attempt at biotic regionalization within Fiji and will, undoubtedly, benefit from further biogeographical analyses, scrutiny and data. More work is needed to refine the maps for plants, invertebrates and freshwater fish as there are many highly localized endemics.

Special elements

The distribution of some species is so restricted that single sites may become the goal for protection rather than larger blocks of forest. Such species may have naturally small ranges, such as the Ogea monarch flycatcher *Mayrornis versicolor* found on two smaller islands of the southern Lau Group (Watling, 1988). Some species, such as the Fijian crested iguana, were once more widespread but the remaining populations are now restricted to a few small areas or islands. Other kinds of special elements for conservation include caves and karst (Heads, 2006), other habitats on unusual soil such as ultramafics, offshore islands for breeding shorebirds and sea snakes, freshwater lakes and springs, and sago *Metroxylon vitiense* swamps (Rounds, 2007). Not all species can be accommodated in a priority-setting analysis. Therefore, proxies such as major habitat types, biotic provinces and sub-provinces, and endemic patterns for well-evaluated taxa are employed to help maximize the representation of as many distinct assemblages and species as possible.

Hotspots of richness and endemism

Hotspots for species richness and endemism have not been comprehensively evaluated but several islands and areas within islands have been highlighted by specialists for these features (Government of Fiji, 1993, 1994; Thaman, 1996;

Kretzschmar, 2000; Tuiwawa & Naikatini, 2003a,b; Keppel, 2004; Keppel et al., 2005a,b,c, 2006; Heads, 2006; Masibalavu & Dutson, 2006; E. Sarnat, pers. comm.).

Sustaining ecological processes, resiliency to disturbance and ecosystem services

Forested watersheds

Protecting natural forest cover in watersheds is critical for biodiversity as well as for the well-being of Fiji's coastal communities who depend on freshwater resources and coastal fisheries (Balmford et al., 2002; Atherton et al., 2006). Maintaining forest cover in upper watersheds and buffering streams and rivers is particularly important for sustaining fisheries. Watersheds with at least two-thirds natural forest cover were identified for protection, with an added emphasis on those adjacent to high conservation value reefs (WWF, 2005) identified by Atherton et al. (2006).

Connectivity

We identify several medium-size blocks of forest that could function as corridors among major forest blocks within the larger islands and highlight these for protection. Specific forest corridors among forest blocks are not comprehensively highlighted here as many options usually exist and selection of the optimal route requires a detailed analysis of the local biophysical conditions, habitats, and socio-economic and political situation. Forests that span a range of elevations are also important for birds, insects and bats that move up and down mountains in response to the seasonal availability of food or to stressful weather conditions. Intact lowland forests are becoming particularly scarce, especially those with an unbroken connection to higher-elevation forests. Both of these situations were targeted for protection.

Appendix 2 Figs 5–8

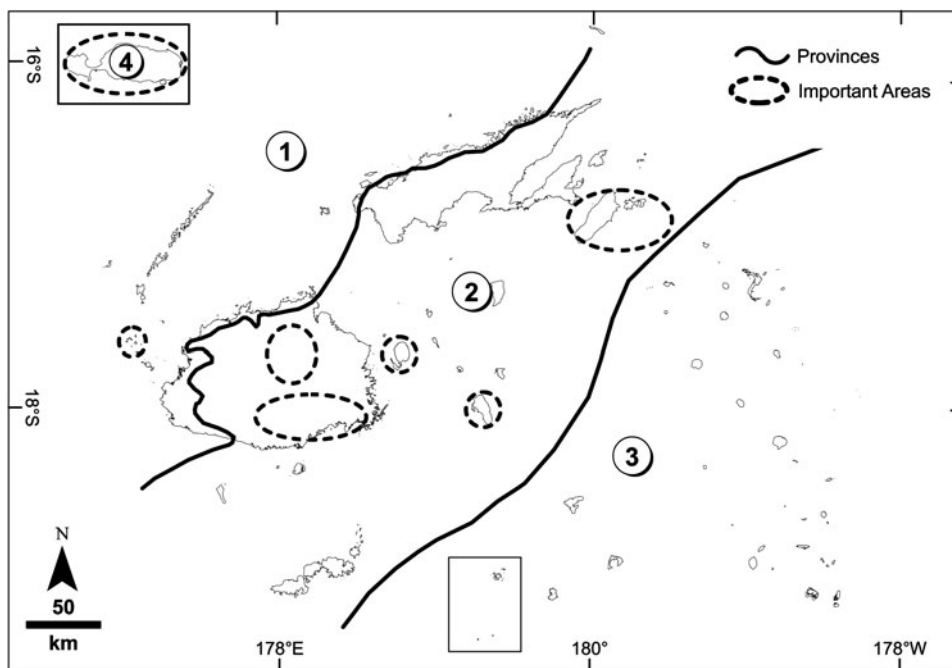


Fig. 5 Preliminary biotic provinces and sub-provinces for the terrestrial herpetofauna of Fiji. 1, Fiji Dry Forest; 2, Fiji Moist Forest; 3, Lau Group; 4, Rotuma (based on a synthesis of Pernetta & Watling, 1979; Zug et al., 1988; Zug, 1991; Watling & Zug, 1998; Morrison, 2003a,b, 2005).

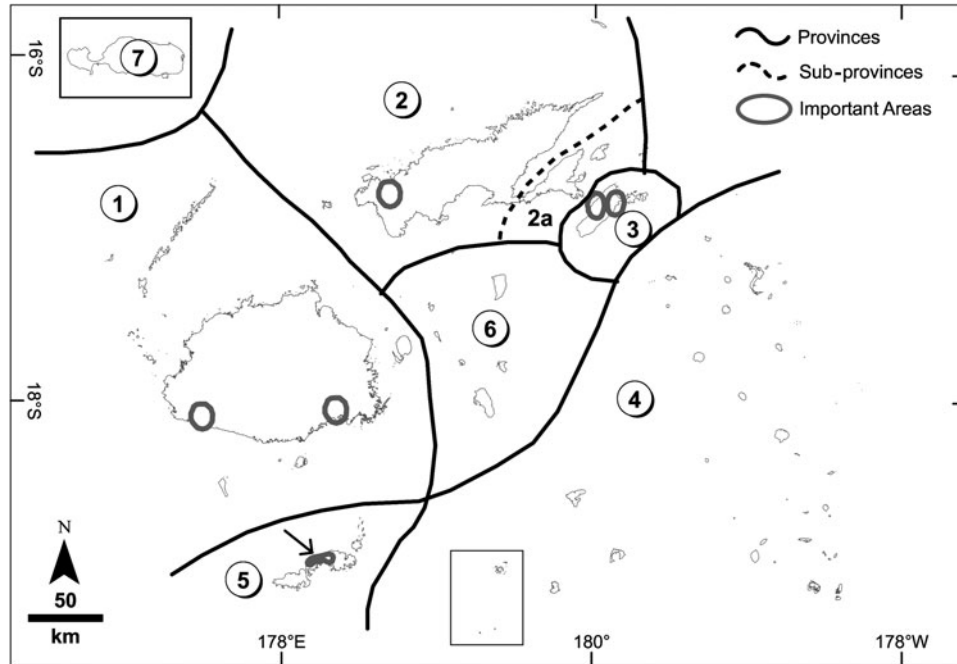


Fig. 6 Preliminary biotic provinces and sub-provinces for freshwater fish of Fiji. 1, Viti Levu; 2, Vanua Levu; 2a, Natewa; 3, Taveuni; 4, Lau Group; 5, Kadavu; 6, Lomaiviti Group; 7, Rotuma (after Jenkins & Boseto, 2003).

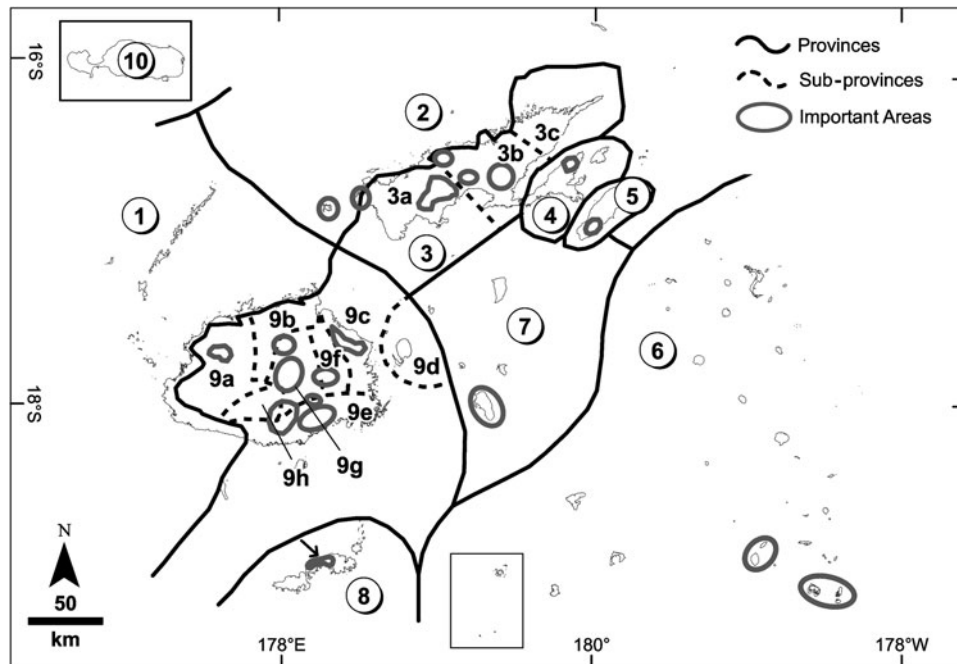


Fig. 7 Preliminary biotic provinces and sub-provinces for vascular plants of Fiji. 1, Viti Levu Dry Forest; 2, Vanua Levu Dry Forest; 3, Vanua Levu Moist Forest; 3a, Western Vanua Levu; 3b, Central Vanua Levu; 3c, Eastern Vanua Levu; 4, Natewa; 5, Taveuni; 6, Lau Group; 7, Lomaiviti Group; 8, Kadavu; 9, Viti Levu Moist Forest; 9a, Mt Evans-Nausori; 9b, Nakauvadra-Tuvuoa; 9c, Korotuba-Sawakasa; 9d, Ovalau; 9e, South-east Viti Levu; 9f, Wainimala; 9g, Tomaniivi-Nadrau; 9h, West Serua; 10, Rotuma (based on an initial synthesis of patterns of local endemism and distinct communities available in Smith, 1951, 1979–1996; Whittier, 1975; Brownlie, 1977; Watkins, 1994; Mueller-Dombois & Fosberg, 1998; Kretzschmar, 2000; Heads, 2006; M. Tuiwawa, unpubl. data).

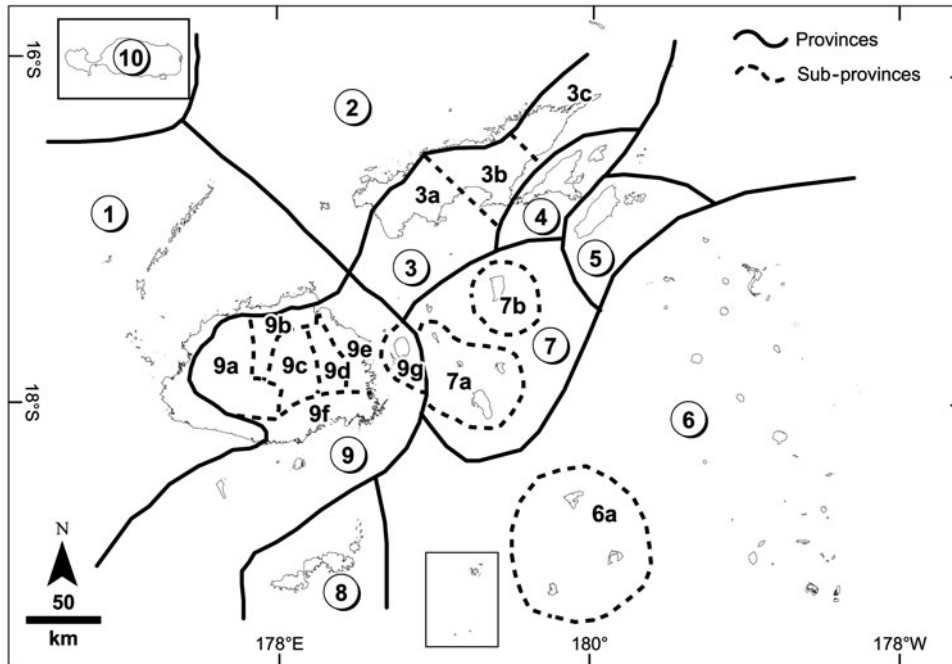


Fig. 8 Preliminary biotic provinces and sub-provinces for terrestrial arthropods and gastropods of Fiji. 1, Viti Levu Dry Forest; 2, Vanua Levu Dry Forest; 3, Vanua Levu Moist Forest; 3a, Western Vanua Levu; 3b, Central Vanua Levu; 3c, Eastern Vanua Levu; 4, Natewa; 5, Taveuni; 6, Lau Group; 6a, Yasayasa Moala; 7, Lomaiviti Group; 7a, Gau; 7b, Koro; 8, Kadavu; 9, Viti Levu Moist Forest; 9a, Mt Evans-Nausori; 9b, Nakauvadra-Tuvuoa; 9c, Tomaniivi-Nadrau; 9d, Wainimala; 9e, Korotuba-Sawakasa; 9f, South-east Viti Levu; 9g, Ovalau; 10, Rotuma (based on Tilyard, 1924; Robinson, 1975; Parkinson et al., 1987; Duffels, 1988; Haynes, 1998a,b; Barker, 2003; Evenhuis & Bickel, 2006; Sarnat, 2006, 2008; S. Prasad et al., unpubl. data).