

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

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Abstract Fiji's National Biodiversity Strategy and Action Plan encourages refinements to conservation priorities based on analyses of new information. Here we propose a network of Priority Forests for Conservation based on a synthesis of new studies and data that have become available since legislation of the Action Plan in 2001. For selection of Priority Forests we considered minimum-area requirements for some native species, representation goals for Fiji's habitats and species assemblages, key ecological processes and the practical realities of conservation areas in Fiji. Forty Priority Forests that cover 23% of Fiji's total land area and 58% of Fiji's remaining native forest were identified. The analysis confirms the majority of conservation priority areas previously identified, recommends several new areas, and supports the Government of Fiji's policy

goal of protecting 40% of remaining natural forests to achieve the goals of the National Biodiversity Strategy and Action Plan and sustain ecosystem services for Fijian communities and economies.

Keywords Conservation priorities, ecosystem services, Fiji, forest conservation, national biodiversity strategy, Oceania, protected area network, representation

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Introduction

The biodiversity of Fiji is increasingly being recognized as a global conservation priority (Davis et al., 1996; Stattersfield et al., 1998; Myers et al., 2000; Government of Fiji, 2001; Ryan, 2001; Olson & Dinerstein, 2002; Masibalavu & Dutson, 2006). Fiji's unusual biogeographical history (Van Balgooy, 1971; Green & Cullen, 1973; Kroenke, 1996; Hall, 2002; Evenhuis & Bickel, 2006; Heads, 2006) has imparted an exceptionally diverse forest biota characterized by pronounced endemism at the level of species and higher taxa (Ash, 1982; Gibbons, 1984, 1985; Ash & Vodonivalu, 1989; Davis et al., 1996; Heads, 2006) and the presence of numerous basal and primitive lineages (Ash, 1992; Miller, 1989; Hollingsworth, 2004), unusual radiations (*Camponotus* and *Pheidole* ants; Sarnat, 2006, 2008) and Gondwanan elements (Bickel, 2006; Davis et al., 1996).

The Government of Fiji, landowners, NGOs and the private sector have committed to protecting Fiji's natural forest heritage through the enactment of Fiji's National Biodiversity Strategy and Action Plan (Government of Fiji, 2001), the Fiji Departments of Forestry and Environment's forestry certification programmes (Fiji Department of Forestry, 2007), and the ongoing establishment and recognition of a number of national and community-based forest protected areas (e.g. community-declared protected areas of Waisali, Bouma, Koroyanitu, Kilaka and Naicuvalevu). The conservation priorities for Fiji's forests identified in the Action Plan were based on a synthesis of existing conservation analyses (Lees, 1989; Paine, 1989; Tabunakawai &

Chang, 1991; Watling & Chape, 1992; Government of Fiji, 1993; Wright & Lees, 1996) and consultations with biodiversity specialists (Government of Fiji, 1998a,b,c,d; Kretzschmar, 2000).

The Action Plan promotes the ongoing refinement of conservation priorities as new data and analyses become available (Government of Fiji, 2001). As a contribution to this process we have synthesized biodiversity information and conservation analyses (Fiji Important Bird Areas, Masibalavu & Dutson, 2006; Critical Ecosystem Partnership Fund's Fiji Profile, Olson & Farley, 2004; Key Biodiversity Areas, Conservation International, 2005) that have become available since 2001 and re-evaluated Priority Forests for Conservation. The Fiji Department of Forestry's (2007) policy goal of 40% of all extant natural forest (corresponding to 20% of Fiji's original natural forests) to remain forested provided a percentage target. Given this target, we asked which specific forests should be designated as Protection Forests (i.e. forests where the protection of native forest cover in a relatively undisturbed state is the primary management goal; Tabunakawai & Chang, 1991; Watling, 1994) to achieve conservation and ecosystem service goals based on existing knowledge, principles of regional conservation strategies that have been evolving through similar efforts elsewhere (e.g. representation of distinct assemblages and habitats, maintaining ecological processes and ecosystem services, minimum-area requirements; Noss & Cooperrider, 1994; Dinerstein et al., 2000; Groves, 2003; Jennings et al., 2003; Forest Stewardship Council PNG, 2006), and practical consideration of development trends and goals, and land use.

Methods

We employed a four-step approach to arrive at our recommended network of Priority Forests for Conservation:

(1) Information used in the preparation of the Biodiversity Strategy and Action Plan was reviewed. Data layers, such as existing protected areas, priority areas, natural forest cover and watersheds, were mapped. Using the geographical information systems *MapInfo v. 8.5* (Pitney Bowes, Troy, USA) and *ArcView v. 9.3* (ESRI, Redlands, USA) we overlaid watershed (Atherton et al., 2006) and topographic features with a map of remaining natural forests (Olson, 2006) based on Landsat Thematic Mapper imagery (1991–1995) and Fiji Department of Forestry (1996) vegetation maps.

(2) Studies published or otherwise available after the Action Plan was prepared were evaluated for relevant information (Keppel, 2002; Olson et al., 2002; Barker, 2003; Tuiwawa & Naikatini, 2003a,b; Watling, 2003; WCS, 2003; Farley et al., 2004; Olson & Farley, 2004; Yanega et al., 2004; Atherton, 2005; Conservation International, 2005; Keppel, 2005a,b,c; Keppel et al., 2005, 2006; Atherton et al., 2006; Chape, 2006; Evenhuis, 2006; Evenhuis & Bickel,

2006; Heads, 2006; Masibalavu & Dutson, 2006; Monaghan et al., 2006; Sarnat, 2006, 2008; Savu, 2006; Jackson & Jit, 2007; Keppel & Tuiwawa, 2007; Palmeirim et al., 2007; Rounds, 2007).

(3) Using a set of decision rules that considered natural habitats and ecological processes, representation of the full set of habitats and distinct species assemblages, and the realities of conservation (Table 1, Appendix 1), we assessed if there were any major gaps in how existing protected areas, priority areas and recently proposed priority areas (Olson & Farley, 2004; Conservation International, 2005; Masibalavu & Dutson, 2006) addressed these guidelines and decision rules. Generalized boundaries around Priority Forest blocks were then drawn using forest edges and watershed boundaries (Atherton et al., 2006) within contiguous forest if they corresponded to *mataqali* (i.e. traditional land ownership) and provincial boundaries. The emphasis on watershed boundaries is a practical consideration as landowners and logging companies can readily identify watershed boundaries when they are on the land. In some cases provincial and *mataqali* boundaries were used where they differed markedly from watershed boundaries.

(4) Priority areas not identified in previous analyses were highlighted and existing priorities confirmed, where appropriate.

We recognize that achieving agreement on the boundaries and management of protected areas often requires considerable negotiation with a variety of stakeholders, a process that will be influenced by many factors. Therefore, the generalized forest blocks delineated on our maps (Figs 1–3), and their biological justification, are more relevant to this process than the exact boundaries proposed.

The forest cover data we used date from 1991–1995 and there has been considerable logging activity since. We therefore assume that the current area, boundaries and distribution of forest cover are not exactly the same as those depicted on our maps but our collective field experience suggests that these changes are not of sufficient scale to alter our Priority Forest list. However, mapping of forest cover at a greater resolution, along with the distribution of major habitat types such as dry, transition and moist forest, is required. Current biogeographical knowledge is most comprehensive for birds and herpetofauna. Certain groups of plants, such as palms, are relatively well-studied, but the majority of taxa have not been the subject of extensive biogeographical study. Similarly, some genera and families of invertebrates and freshwater fish have recently been the subject of archipelagic-wide surveys (Sarnat 2006, 2008) but the majority of groups are understudied (Jenkins & Boseto, 2003; Evenhuis & Bickel, 2006). The second largest island of Vanua Levu, in particular, is poorly surveyed for a wide range of taxa. Koro, Gau, Yasayasamoala and the southern Lau Group are also inadequately surveyed.

TABLE 1 Guiding principles and decision-rules for selection of Priority Forests for Conservation in Fiji. Appendix 1 provides the justification for the decision-rules.

Habitat & ecological processes

A majority of the larger blocks of remaining natural forest (> 100 km²)

Forest refugia remote from alien predators (Olson et al., 2006)

Intact watersheds & those forests that have a wide altitudinal range, particularly those with intact lowland forest (Atherton et al., 2006; Olson, 2005)

Forested watersheds adjacent to high conservation value reefs (WWF, 2005; Atherton et al., 2006)

Representation

All major islands & island groups (Viti Levu, Vanua Levu & Taveuni, Kadavu, Lomaiviti, Yasayasa Moala, Lau Group, Mamanuca Group, Yasawa Group, Rotuma)

All major habitat types within the four major islands: moist dry, transition & montane forest. Small island forests are represented but not mangroves.

All major biotic provinces (Fig. 4), & as many as possible of the biotic sub-provinces (Fig. 4) & province/sub-provinces for individual taxa (Appendix 2: Figs 5–8)

Known archipelagic-scale hotspots for endemism & richness

Known sites of special conservation concern, such as the last large populations of Critically Endangered or endemic species

(Forest corridors that are critical for maintaining connectivity across larger forested landscapes were not identified)

Conservation realities

Larger blocks of forest where logging & road-building are currently intense & future logging is predicted were generally avoided (Atherton et al., 2006)

Watershed boundaries & traditional ownership (*mataqali*) boundaries delineate larger forest blocks (Atherton et al., 2006) in most cases

The target for protection was c. 50% of the remaining natural forest

Results

Habitats and ecological processes

Forty areas (Table 2; Figs 1–3) were identified as Priority Forests for Conservation where protection should be the major management emphasis to achieve national-level conservation and ecosystem services goals. Together these areas cover 23% of the total land area and c. 58% of the remaining natural forest. Twenty-two large blocks (> 100 km²) of remaining natural forest were identified for protection. Two of the largest blocks of natural forest, western Serua and Wainimala, both remote areas (Olson et al., 2006), were not selected as they are experiencing intensive logging and may lose much of their conservation value in the near future. These areas should be re-evaluated if this situation changes.

We highlight as a priority two forested corridors that presently connect increasingly isolated Priority Forest blocks.

These are: (1) the threatened Vunitirilau Corridor, which is the last undisturbed forest connection between the wider Sovi-Waimanu forests and the upland forests of Monasavu/Tomanivi, as well as the Serua forest blocks; and (2) the corridor between Monasavu and Tomanivi, which is disappearing rapidly. Forests of the Nakauvadra Range and Mt Evans Ranges on Viti Levu are increasingly isolated from the main forest block. Forest corridors linking the larger forests blocks of the dividing range of Vanua Levu are also of critical importance.

The relatively intact watersheds of Taveuni, southern Vanua Levu, eastern Kadavu (Koronibanuve), and southwest Viti Levu (Waimanu) were all selected. These areas, along with Gau, Tunuloa/Natewa and Nakorotubu, support some of Fiji's last forests that range from lowland to montane habitats. Several smaller islands are largely covered in native forest, including Sawa-i-Lau, western Macuata Island, Yaduataba, Namenalilai, Makodroga, Vatuvava, Vuaqava, Ogea Levu and Ogea Driki. Several larger forested watersheds that are adjacent to Fiji's high conservation value reefs (WWF, 2005; Atherton et al., 2006) were also selected (Nakauvadra, Nakorotubu, Navotuvotu, Kubulau, Vatuvonu, Delaikoro, Dogutuki, and Ovalau) to help protect these marine ecosystems.

Representation of distinct assemblages and habitats

The 40 areas represent all of the major islands and island groups, and major forest habitat types within the major islands. Mangroves, wetlands, *Pandanus* savannahs and littoral forests were not analysed. Most of the remaining fragments of tropical dry forest are encompassed. Tropical dry forest was formerly widespread on the leeward side of the larger islands but now occurs only in small remnant patches (Mueller-Dombois & Fosberg, 1998).

All proposed biotic provinces and sub-provinces (see Appendix 1 for a description of identification and delineation; Fig. 4), except for Wainimala and western Serua, are represented. The four larger islands with notable bird endemism (Viti Levu, Vanua Levu, Taveuni and Kadavu) are represented, as are the majority of Important Bird Areas (Masibalavu & Dutson, 2006). All biotic provinces for reptiles and amphibians are represented but the important site of Yanuya Island, Ono-i-Lau (the only known locality for *Leiolopisma alazon*) is not captured (Morrison, 2003a,b, 2005; Appendix 2: Fig. 5; biotic subdivisions may be less relevant for the relatively widespread Fijian herpetofauna; Morrison, 2005). Provisional biogeographic subdivisions for freshwater fish (Jenkins & Boseto, 2003; Appendix 2: Fig. 6) are all represented but two sites of special importance, the lower Sigatoka River and the Upper Lekutu River are not captured. All of the biotic provinces and sub-provinces for invertebrates (Appendix 2: Fig. 7) are represented except for the Wainimala Sub-province.

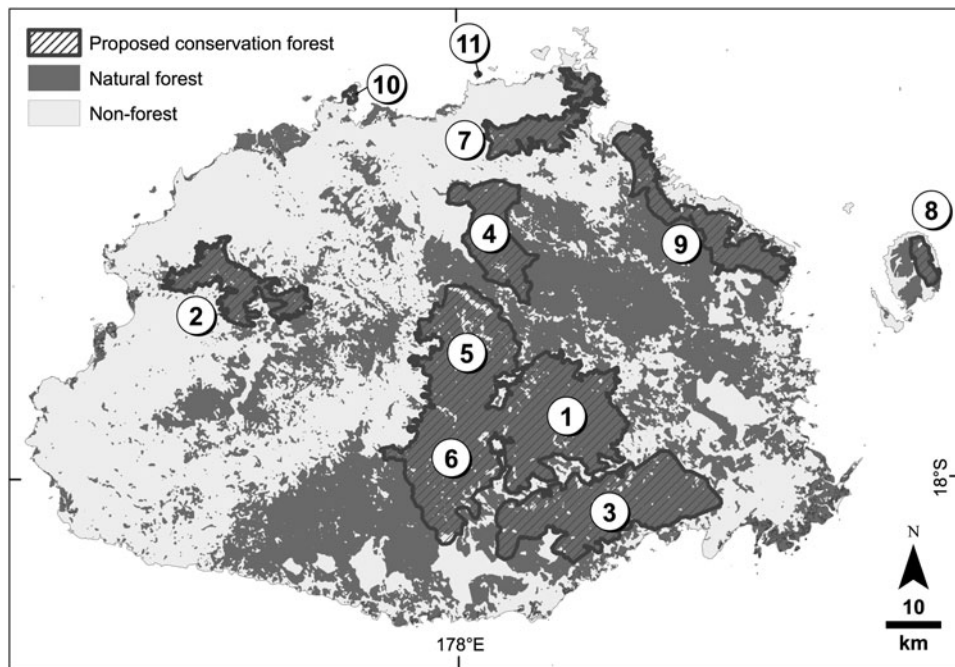


FIG. 1 Priority Forests for Conservation proposed for Viti Levu. 1, Sovi Basin & Korobasabasaga; 2, Mt Evans/Koroyanitu/Abaca (Batilamu); 3, Waimanu (Nakobalevu to Nakoro); 4, Tomanivi/Wabu; 5, Nadrau Plateau; 6, Eastern Serua; 7, Nakauvadra; 8, Ovalau; 9, Nakorotubu; 10, Vatia; 11, Macuata Island.

Proposed biotic provinces for plants are all represented but the Wainimala Sub-province is not captured and two sites of special importance, central Kadavu and several sites with restricted-range palm species along the southern coast of Viti Levu and the southern Rewa River valley, are not captured (Fuller, 1997; Doyle & Fuller, 1998; Zona & Fuller, 1999; Watling, 2005; Appendix 2: Fig. 8).

Several areas known to have high alpha richness of plants (south-eastern Viti Levu: Tuiwawa & Doyle, 1998; Tuiwawa & Naikatini, 2003b; Vatuvonu and Kubulau, Vanua Levu: Government of Fiji, 1994; Kretzschmar, 2000) and invertebrates (Mt Evans/Koroyanitu/Abaca, Kubulau, Tomanivi/Wabu and Waimanu; Sarnat, 2006; S. Prasad et al., unpubl. data) are priorities. Areas notable

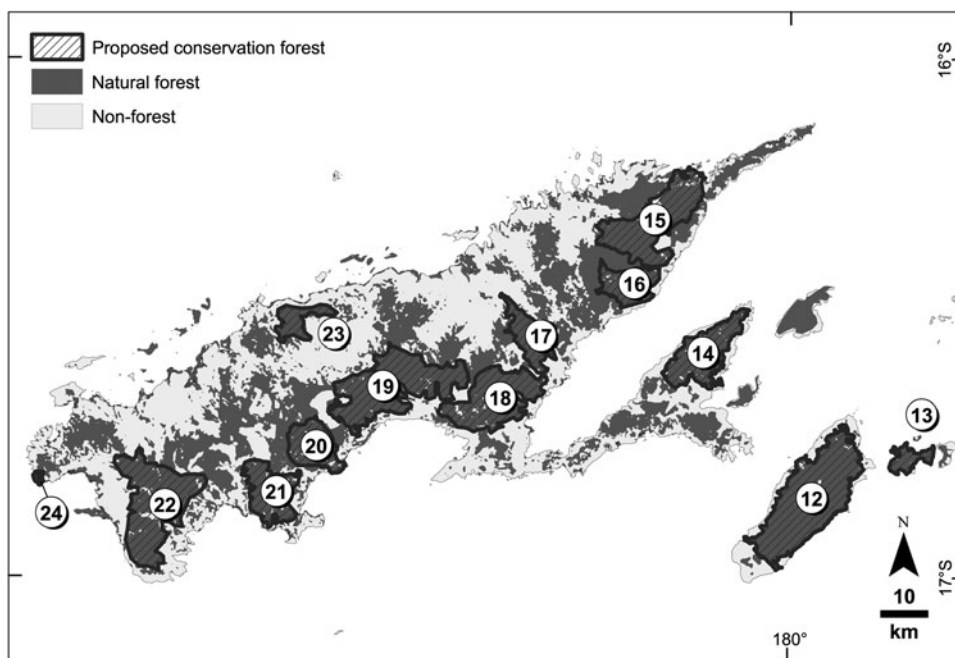


FIG. 2 Priority Forests for Conservation proposed for Vanua Levu and Taveuni. 12, Taveuni Forest Reserve & Bouma National Heritage Park; 13, Qamea & Laucala; 14, Tunuloa/Natewa; 15, Dogutuki; 16, Saqani; 17, Dikeva; 18, Koroalau; 19, Delaikoro; 20, Vatuvonu (Tavea-Valili); 21, Kubulau; 22, Navotuvotu; 23, Rokosalase; 24, Naicobocobo.

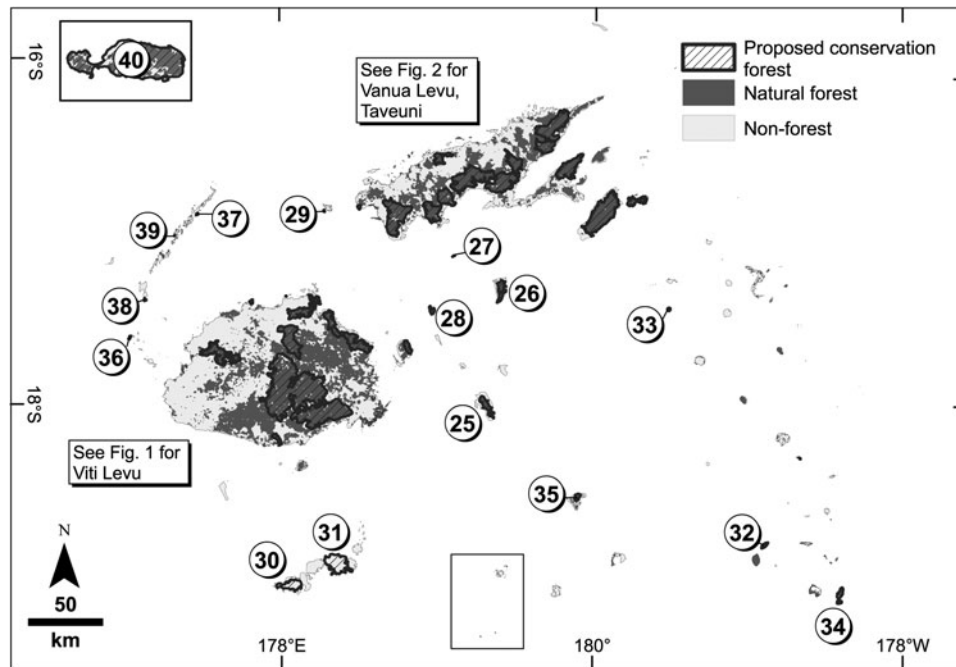


Fig. 3 Priority Forests for Conservation proposed for Outer Islands of Fiji. 25, Gau; 26, Kuitarua, Koro; 27, Namenalailai; 28, Makodroga; 29, Yaduataba; 30, Delaiuviivi (Nabukelevu or Mt Washington); 31, Koronibanuve; 32, Vuaqava; 33, Vatu Vara; 34, Ogea Levu & Ogea Driki; 35, Moala; 36, Monuriki & Mono; 37, Sawa-i-Lau; 38, Kuata; 39, Devuilau; 40, Rotuma.

for concentrations of endemic plants and invertebrates are also represented, including Kadavu, the cloud and montane forests of central Viti Levu, Mt Evans Range (Thaman, 1996; Thaman et al., 1999), and south-eastern Viti Levu; hotspots within this area include Waimanu, Mt Voma, Korobasabasaga, Mt Naitaradamu, and eastern Serua (Watkins, 1994; Tuiwawa, 1999). Other endemism hotspots include Taveuni, Gau and Koro. The latter two may have the most distinctive invertebrate fauna, in terms of percentage single-island endemism, of all the Fijian islands (Barker, 2003; E. Sarnat, pers. comm.; S. Prasad et al., unpubl. data).

The largest known populations of the Critically Endangered Fijian crested iguana *Brachylophus vitiensis* are selected, representing the Viti Levu (Macuata Island), Mamanuca (Monuriki and Mono), Yasawa (Devuilau), and the presumptive Vanua Levu (Yaduataba) forms (Gibbons, 1981; Laurie et al., 1987; Harlow & Biciloa, 1999, 2000; Olson et al., 2002; Olson & Keppel, 2004; Harlow et al., 2007). The broad distribution of the Priority Forests may also capture some of the poorly known geographical variation of the banded iguana *Brachylophus fasciatus*.

The unusual karst habitats of Sawa-i-Lau are represented but known karst habitats of Wailotua and several of the Lau Group islands are not (Heads, 2006). The Priority Forests within the Lau and Yasayasamoala Groups are probably underrepresented in this analysis. Two of the largest extant sago palm *Metroxylon vitiense* swamps, Maratu and Wainikevu (Rounds, 2007), are included in the Serua and Waimanu forest blocks, respectively. Sago

swamps on Vanua Levu are not represented, and the few documented swamps near Savusavu are small and threatened. Fiji's tropical dry forests are represented on Macuata Island, Yadua Taba, Rokosalase and Naicobocobo. Mangroves and seabird and sea-snake islands (Government of Fiji, 2001; Masibalavu & Dutson, 2006) were not analysed.

Comparisons to previous priority-setting analyses

This analysis confirms existing priorities identified in the Fiji National Biodiversity Strategy and Action Plan (i.e. the Department of Environment's List of Sites of National Significance and Nature Reserves) and highlights several new areas of conservation importance, namely the Nakauvadra Range, the Waimanu region (south-east Viti Levu), eastern Serua, Macuata Island, Koro, Sawa-i-Lau, Nakorotubu, Yasayasamoala Group, Vatuvara, Kuata, Devuilau, Aiwa Levu and Aiwa Lailai, Vuaqava, and much of the remaining forest of southern Vanua Levu including Navotuvotu, Kubulau, Vatuvonu, Korolau (the larger forested landscape around Waisali Reserve), Dikeva and Sagani. Several of these new areas were previously identified in the Critical Ecosystem Partnership Fund's Fiji assessment (Olson & Farley, 2003; Conservation International, 2005), Important Bird Areas (IBAs would cover 39% of the remaining natural forest if implemented; Masibalavu & Dutson, 2006) and Conservation International's (2005) Key Biodiversity Areas (KBA) draft analysis. The western and central portions of Serua (Serua Forest Wilderness and Upper Navua Gorge KBAs) and the Nausori Highlands

TABLE 2 The 40 identified priority forests for conservation (Figs 1–3), with description and justification, whether a Fiji Biodiversity Strategy and Action Plan Site of Biological Significance (FBSAP; Government of Fiji, 2001), Important Bird Area (IBA; Masibalavu & Dutson, 2006) or Key Biodiversity Area (KBA; Conservation International, 2005), and any site-specific references. The Critical Ecosystem Partnership Fund Profile Priority Areas for Fiji (Olson & Farley, 2005) informed the development of the Key Biodiversity Areas. Alternate names given by different priority-setting efforts are provided where needed.

Island/island group	Priority Forest for Conservation (PFC)	Description & justification	FBSAP	IBA	KBA	References
Viti Levu	1, Sovi Basin & Korobasabasaga	The largest block of extant lowland forest, surrounded by steep ranges, remote forest, endemism foci along ridges, landowner negotiations for conservation advanced, conservation funding prospects good	Yes	Sovi Basin	Yes	Tuiwawa & Doyle (1998), Tuiwawa (1999), Tuiwawa & Naikatini (2003a), Watling (2003, 2006)
Viti Levu	2, Mt Evans/Koroyanitu/Abaca (Batilamu)	High local endemism in plants & invertebrates (possibly the most pronounced invertebrate endemism locality; D. Bickel, pers. comm.), scenic landscape & steep terrain, good existing protection & landowner interest	Yes	Koroyanitu/Vaturu	Yes	Thaman (1996), Thaman et al. (1999)
Viti Levu	3, Waimanu (Nakobalevu to Nakoro)	High local endemism & richness, highest richness for leaf litter invertebrate samples (S. Prasad et al., unpubl. data), relatively intact watersheds, scenic ranges, close to capital, Waimanu Forest Reserve established by landowners	Yes	Viti Levu southern highlands	Korobaba	Bush (1997), Watling (2003), Keppel et al. (2005)
Viti Levu	4, Tomanivi/Wabu	Highest forests, high local endemism & concentrations of endemic taxa, Nadarivatu has highest alpha native ant diversity (E. Sarnat, pers. comm.), critical watershed for Sigatoka & Wainimala Rivers	Yes	Greater Tomanivi	Yes	Keppel (2005b)
Viti Levu	5, Nadrau Plateau	Plateau of highland forest, many endemics	Yes	Rairaimatuku highlands	Yes	
Viti Levu	6, Eastern Serua	Largest block of remaining forest, likely foci for endemism, logging & degradation increasing, landownership issues complex, critical watershed for Navua River	No	Possible additional IBA	E portion of Serua Forest Wilderness	Bush (1997)
Viti Levu	7, Nakauvadra	Large block of wet-dry transitional forest, intact altitudinal transect on southern slope, important watershed for Vatu-i-Ra coral reefs	No	No	Yes	
Viti Levu	8, Ovalau	Highland block of forest represents the only Viti Levu forests without mongoose <i>Herpestes</i> spp. impact	Yes	Possible additional IBA	Yes	
Viti Levu	9, Nakorotubu	Unusual transition forests, poorly known biologically, some karst habitats, important watersheds adjacent to high conservation value coral reefs of the Vatu-i-Ra	No	No	Yes	
Viti Levu	10, Vatia	Largest remaining block of Viti Levu dry forest with good restoration potential & community interest	No	No	Yes	Keppel & Tuiwawa (2007)
Viti Levu	11, Macuata Island	Driest form of highly threatened Fijian dry forest, without alien predators (except rats <i>Rattus</i> spp.) or grazers, last known population of Viti Levu form of Critically Endangered Fijian crested iguana <i>Brachylophus vitiensis</i>	No	No	No	Olson & Keppel (2004), Keppel (2005a)
Taveuni	12, Taveuni Forest Reserve & Bouma National Heritage Park	One of two remaining large forested landscapes in the Oceanic Pacific that extends from the mountains to the sea, one of three largest islands with no mongoose in oceanic Pacific, high single-island & archipelagic endemism, scenic coastline, Taveuni Highlands IBA, FBSAP Site of Biological Significance, KBA	Yes	Taveuni highlands	Yes	Ash (1988)

TABLE 2 (Continued)

Taveuni	13, Qamea & Laucala	Well-forested islands next to Taveuni with distinct populations of several bird species	No	No	Laucala is a KBA	
Vanua Levu	14, Tunuloa/Natewa	Relatively distinct biota from the rest of Vanua Levu, unusual affinities with Taveuni & Waimanu forests of Viti Levu based on plants & invertebrates, distinct races of endemic birds	Yes	Natewa/ Tunuloa	Natewa	
Vanua Levu	15, Dogutuki	Largest relatively intact watershed in Vanua Levu adjacent to high conservation value Cakau Levu Reef, distinct forest types	Yes	No	Vunivia	Lees (1989), Bogiva (1993), Keppel et al. (2006)
Vanua Levu	16, Saqani	Rugged mountains with interesting plant endemism	No	No	No	
Vanua Levu	17, Dikeva	Rugged mountains, representative moist forest with local plant endemism	No	No	No	
Vanua Levu	18, Koroalau	Large block of forest acting as a corridor between Dikeva & Delaikoro, important watershed for Savusavu Bay & Natewa Bay, local plant endemism	No	No	No	
Vanua Levu	19, Delaikoro	Large block of forest in mountainous terrain, very high richness of plant & invertebrates, good populations of Vanua Levu birds including long-legged thicketbird <i>Trichocichla rufa</i> , important watershed for Savusavu Bay, Waisali Reserve of National Trust for Fiji	No	Wailevu-Dreketi Highlands	Waisali KBA site	
Vanua Levu	20, Vatuvonu (Tavea-Valili)	Highest known single-site tree richness (alpha diversity) for Vanua Levu, rugged peaks, important watersheds for coastal reefs & Namena Reef, one of Fiji's highest priority reef complexes	No	No	Mt Kasi is a KBA site within this site	Government of Fiji (1994), Kretzschmar (2000)
Vanua Levu	21, Kubulau	Highest invertebrate richness for Vanua Levu based on malaise trap surveys of Fiji Arthropod Survey, rich plant communities, important watershed for high conservation value reefs of Namena & Wainunu	No	No	No	Keppel (2005c)
Vanua Levu	22, Navotuvotu	High montane forest in Bua, poorly known, important watersheds for high conservation value reefs of western Vanua Levu & Vatu-i-Ra Channel	No	No	Mt Navotuvotu is a KBA site	
Vanua Levu	23, Rokosalase	Good example of Vanua Levu dry/transition forest, last relatively intact <i>buabua</i> (<i>Fragraea</i> spp.), high conservation interest of landowners	Yes	No	No	
Vanua Levu	24, Naicobocobo	Largest & most intact block of Vanua Levu form of Fijian dry forest	No	No	Naicobocobo	Keppel & Tuiwawa (2007)
Lomaiviti Group	25, Gau	Large, single block of moist forest with a wide altitudinal range, high % single-island endemism, island-endemic Fiji petrel <i>Pterodroma macgillivrayi</i> breeds here	Yes	Gau highlands	Gau	
Lomaiviti Group	26, Kuitarua, Koro	Faunal similarity analyses of leaf litter invertebrate taxa suggest Koro & Gau's fauna is among the most distinctive in Fiji (S. Prasad et al., unpubl. data), important for protection of local reefs & fisheries	No	No	No	

TABLE 2 (Continued)

Lomaiviti Group	27, Namenalailai	Intact small island forest	Yes	No	No	
Lomaiviti Group	28, Makodroga	Intact small island forest	Yes	No	No	
Lomaiviti Group	29, Yaduatava	Protected, good example of Fijian dry forest & home of largest remaining population of Fijian crested iguana, good degree of existing protection, restoration potential & landowner interest, National Trust for Fiji Yaduatava Reserve	Yes	No	Yes	Laurie et al. (1987), Olson et al. (2002)
Kadavu	30, Delaivuiivi (Nabukelevu or Mt Washington)	Montane forest with known endemics, under threat (Nabukelevu is a more recognizable geographical name for this area)	Nabukulevu	Yes		Nabukelevu/Mt Washington
Kadavu	31, Koronibanuve	Largest block of intact forest & watersheds on Kadavu with good populations of island endemics, important watersheds for reefs	Yes	East Kadavu	No	
Lau Group	32, Vuaqava	A relatively intact southern Lau Group forest with low threat	No	No	Yes	
Lau Group	33, Vatu Vara	Intact high island with good populations of Endangered banded iquanas <i>Brachylophus fasciatus</i> , one of the highest raised limestone islands in the world (300 m)	No	No	No	
Lau Group	34, Ogea Levu & Ogea Driki	Ogea monarch flycatcher <i>Mayrornis versicolor</i> restricted to these islands, relatively intact representative forests	Yes	Ogea	Only Ogea Levu is a KBA	Watling (1988)
Yasayasamoala Group	35, Moala	Representative forest block in central Moala, Yasayasamoala Group has locally endemic invertebrates (E. Sarnat, pers. comm.)	No	No	No	
Mamanuca-i-Cake Group	36, Monuriki & Mono	Last dry forest remnants of Mamanuca Group with dwindling populations of Mamanuca form of Fijian crested iguana	Yes	No	Monuriki is a KBA	Harlow & Biciloa (1999, 2000), Keppel (2004), Harlow et al. (2007)
Yasawa Group	37, Sawa-i-Lau	One of the best examples of threatened Fijian dry forest, best example of Yasawan dry forest, karst landscape, uplifted limestone island, high landowner interest in protection, possible translocation site for Yasawa Group race of Fijian crested iguanas, rugged terrain inhibits deforestation	No	No	No	
Yasawa Group	38, Kuata	Good example of threatened small island dry forest	No	No	No	Harlow et al. (2007)
Yasawa Group	39, Devuilau	Last good example of Yasawan dry forest with remnant population of Fijian crested iguana	No	No	No	Harlow et al. (2007)
Rotuma	40, Rotuma	Isolated island 465 km north of Fiji, several island-endemic species & populations of regionally threatened species	Yes	Rotuma	No	Robinson (1975), Zug et al. (1988), McClatchey et al. (2000), Rigamoto (2000), Masibalavu & Dutson (2006)

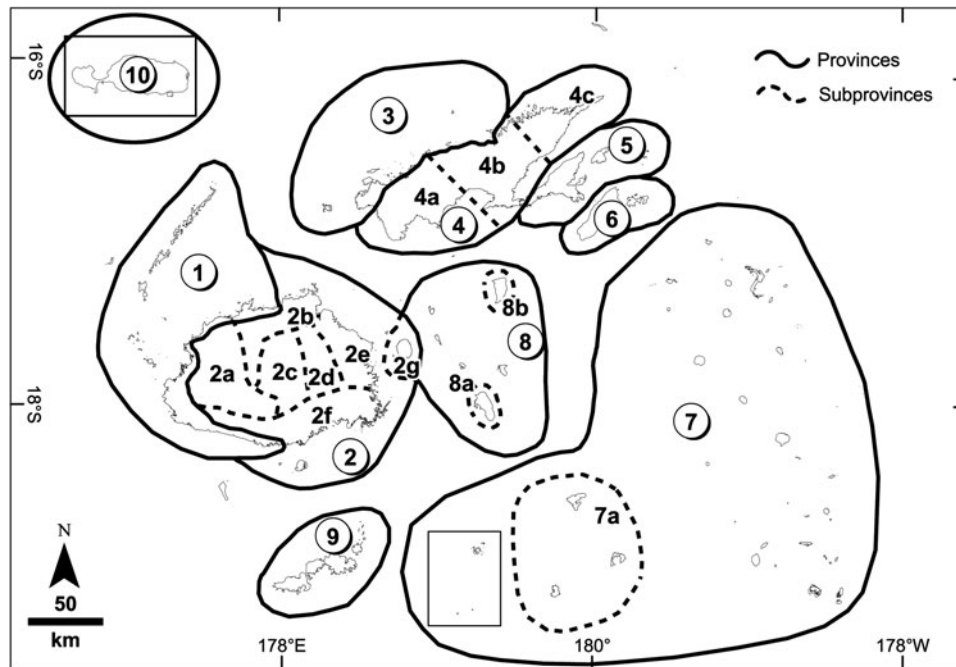


FIG. 4 Preliminary biotic provinces and sub-provinces for Fiji (see Appendix 2). 1, Viti Levu Dry Forest; 2, Viti Levu Moist Forest; 2a, Mt Evans-Nausori; 2b, Nakauvadra-Tuvuca; 2c, Tomaniivi-Nadrau; 2d, Wainimala; 2e, Korotuba-Sawakasa; 2f, South-east Viti Levu; 2g, Ovalau; 3, Vanua Levu Dry Forest; 4, Vanua Levu Moist Forest; 4a, Western Vanua Levu; 4b, Central Vanua Levu; 4c, Eastern Vanua Levu; 5, Natewa; 6, Taveuni; 7, Lau Group; 7a, Yasayasa Moala Group; 8, Lomaiviti Group; 8a, Gau; 8b, Koro; 9, Kadavu; 10, Rotuma.

KBA were not selected as Priority Forests because of the intensive logging in these areas.

Discussion

This Priority Forests for Conservation analysis confirms and complements previously identified priorities for the archipelago, including those of Fiji's National Biodiversity Strategy and Action Plan (Government of Fiji, 2001). There is strong consensus amongst Fiji's conservation community on important areas for protection, and the list and areas of proposed priorities continues to expand as knowledge of the archipelago's biodiversity increases and conservation strategies are refined. The Priority Forest map also addresses a broad range of conservation and ecosystem service goals. If all the Priority Forests and proposed marine priority areas (WWF, 2005) could be designated for protection, Fiji would have one of the most comprehensive and robust systems of protected areas (IUCN/UNEP, 1986; Rodrigues et al., 2004).

National development goals and the needs and aspirations of local people (Government of Fiji, 2004, 2005) may, however, preclude protection for the entire proposed Priority Forest network. However, our analysis suggests that the Government of Fiji's (Fiji Department of Forestry, 2007) policy goal of protecting 40% of Fiji's remaining forests may represent a minimum threshold, below which unacceptable losses of biodiversity may occur, both in

forests and coastal marine ecosystems. Levels of 10–20% for protected areas that are commonly discussed in conservation negotiations (Desmet & Cowling, 2004; Svancara et al., 2005) are inadequate to protect the full range of species in the archipelago. Recent biogeographical studies (Watling, 2005; Heads, 2006; Sarnat, 2008) suggest that patterns of local endemism in Fiji may be more complex than previously documented, especially for invertebrates and plants. Multiple and widespread protected forests will be needed to represent the biota adequately.

Protecting < 40% of Fiji's remaining natural forest may also compromise important ecosystem services. Almost every remaining native forest has communities living within it, downstream, or utilizing coastal resources influenced by run-off. At a minimum, upper watersheds should all be protected, as indicated in Fiji's Forest Function map (Watling, 1994), for their role in maintaining healthy freshwater and coastal fisheries, diminishing flood impacts, providing clean water, enhancing local rainfall and seasonal water availability, and as a source of non-timber forest products. Fiji's islands are sufficiently small that the effects of altering watersheds are immediately and dramatically felt in freshwater and coastal marine ecosystems, with cascading effects on subsistence and commercial fisheries and community health.

The current proliferation of high-impact logging operations in smaller coastal watersheds of Vanua Levu and Viti Levu is probably one of the major drivers of degradation in

Fiji's freshwater and coastal resources (Atherton et al., 2006). Greater weight should be given to the critical role of intact forests in providing ecosystem services to Fiji's people and economy, and the substantial economic value of these services needs to be recognized and integrated into cost/benefit analyses and planning (Cambie & Ash, 1994; Government of Fiji, 1998b; Balmford et al., 2002). Fiji's efforts to develop a certification programme for forestry operations reflects a growing recognition of the importance of ecosystem services provided by protected forests (Fiji Department of Forestry, 2007).

If a protected area system based on the Priority Forest network is put in place then the entire forest product industry in Fiji could potentially receive a national-level forestry certification (i.e. landscape-scale certification; Farley et al., 2004), as long as standards relating to logging practices, social values, and High Conservation Value Forests (i.e. a certification category of the Forestry Stewardship Council's widely-adopted certification programme that emphasizes a narrower range of conservation considerations; Forest Stewardship Council, 2003; Jennings et al., 2003) are upheld. While challenging to implement (Gullison, 2003; Lenoa, 2003; Sesega, 2003), the economic and societal benefits of landscape-scale forestry certification may, in the long-term, outweigh those from certifying single operations (Pierce & Ervin, 2003; Farley et al., 2004; Olson, 2006).

The Government of Fiji continues to work towards the commitment it made in 2007 to protect 40% of its remaining natural forest. Our analysis recommends 58% protection to achieve conservation and ecosystem service goals. We, collectively, are thinking at a similar scale of protection, a pre-condition for success in the task that lies ahead, working with landowners and the forest industry to turn protection goals into reality.

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Appendices 1–2

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Biographical sketches

The authors are naturalists, scientists, conservationists, natural resource managers, foresters, field researchers and conservation geographical information system specialists who share an interest in, and concern for, the future of Fiji's forests. They share a belief that a functional balance between conservation and sustainable development, livelihoods and quality of life for Fijians is attainable through science-based analyses, participatory planning and decision-making, respect for tradition, and partnerships and collaboration among all stakeholders. The decisions Fijians make today about preserving their natural wealth and heritage are critical because opportunities are likely to diminish in the coming decades if trajectories of forest loss continue. This analysis is a contribution from the authors' collective efforts to find the balance.