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An assessment of habitat diversity and transformation on La Réunion Island (Mascarene Islands, Indian Ocean) as a basis for identifying broad-scale conservation priorities

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Abstract. Most natural habitat in the Mascarene Islands (Mauritius, La Réunion and Rodrigues) has been transformed. Although urbanisation, agriculture and alien plant invasions have transformed large areas in La Réunion, the island has by far the greatest area of intact habitats in the Mascarenes, but remaining natural areas are under threat. We propose a protocol for defining a system of habitat types and for using these to provide a preliminary assessment of conservation priorities for La Réunion. The protocol draws on existing data and expert knowledge to map habitat types, assesses the extent of habitat transformation, and quantifies heterogeneity between habitat types based on climate, topography and geology. The pattern of habitat transformation was uneven among the nineteen habitat types identified. While three habitats have lost > 95% of their original area, four still retain > 80% of their original extent. Habitat types could be grouped into the following categories: (i) transformed habitats with low levels of plant endemism, (ii) habitats confined to homogenous geology with high levels of plantendemism, and (iii) species-rich heterogeneous habitats on diverse geological types. Priority habitats were also identified using municipalities as a basis for implementation. Urgent action is required for several habitat types where a large part of the original extent has been transformed. Three municipalities which contain more than 10 habitat types should receive conservation priority. The analysis provides the basis for setting conservation priorities in La Réunion at the regional and local scale. Implications of the results are discussed with reference to requirements for finer-scale conservation planning.

Introduction

La Réunion Island, together with the Malagasy region, has been recognised as a global biodiversity hotspot (Myers et al. 2000). As with all islands, La

Réunion faces many threats, including severe and rapidly escalating impacts due to invasive alien species (Macdonald et al. 1991). For example, 30 out of 45 native terrestrial vertebrates have gone extinct since European occupation of the island (in the year 1665) (Cheke, 1987; Probst, 1997; Mourer-Chauviré et al. 1999). Seventy-six vertebrate species have been introduced of which 42 are naturalised at present, mainly in highly modified habitats (Simberloff, 1992; Probst, 1997). The negative impact of alien vertebrates as habitat transformers is documented for rats over large areas and for deers in some montane forests (Cheke, 1987). The flora, initially comprising 500 native species, is now dominated by 2000 introduced species of which about 628 are naturalised and 62 highly invasive (invasive status defined according to Richardson et al. 2000) (Macdonald et al. 1991; Lavergne et al. 1999). The five most invasive and widespread alien plants are: *Psidium cattleianum, Rubus alceifolius, Lantana camara, Ligustrum robustum, Hedychium gardnerianum* (Macdonald et al. 1991; Baret et al. 2004). Although La Réunion has few formal conservation areas, it has by far the largest area of relatively intact habitat of the three Mascarene islands. This is because of its rugged topography which has precluded agriculture and other forms of land use in many habitats. The opportunities for preserving representative tracts of Mascarene ecosystems on La Réunion are good. With a proper network of conserved areas, La Réunion could also serve as benchmark for restoration of habitats on other southwestern Indian Ocean islands.

Several factors currently hinder the establishment of an adequate conservation network on La Réunion: the lack of stakeholder commitment, the lack of maps of island-wide biodiversity features (e.g., species records, vegetation), and pressures from other forms of land use. Invasion by introduced species is increasing, as is the clearing of native forest for small-scale agriculture and cattle breeding. Urbanisation pressure is also extremely high on both cultivated and natural areas, with the population predicted to reach 1,000,000 in 2020 (IEDOM, 2000). There is an urgent need to define and implement conservation actions. Decision makers on La Réunion are planning the creation of a national park to conserve native habitat remnants while also contributing to sustainable development in the face of changing priorities and dynamics of factors such as urbanisation, agriculture, nature conservation, and tourism. The national park is scheduled for implementation in 2006. The first phase of the project has involved consultation with all stakeholders. The preliminary plan for the national park proposes a configuration with a central protected area in the highlands and a peripheral area for sustaining socio-economic activities. In the next phase of the project, decision makers in municipalities will play an important role in determining the boundaries and in developing management priorities.

How does one set priorities for conservation actions under these circumstances? Here we propose a protocol for the rapid assessment of spatial components of biodiversity based on existing information and expert knowledge. Our aim is to derive a system of habitat types that can act as surrogates for biodiversity patterns and processes, and which serve as a sound basis for defining priorities for conservation at an island-wide scale.

In areas where available biological data are poor or limited, a coarse-filter approach to mapping biodiversity is recommended (Cowling and Heijnis, 2001; Ferrier, 2002). Previous studies have shown that such broad habitat types concord with patterns in the distribution of biodiversity as a whole (especially plant biodiversity) and can be used as biodiversity surrogates for regional planning (Ferrier, 2002; Lombard et al. 2003). Our approach involves five steps. First, we identified habitat types and mapped biodiversity patterns based on existing non-spatial data. Second, we quantified the spatial pattern of habitat transformation based on land use and patterns of alien plant invasions. Third, we analysed habitat transformation pattern in relation to habitat types. Fourth, we analysed heterogeneity of habitat types based on environmental and land use factors. Finally, we identified broad-scale conservation priorities for implementation at the municipality level based on habitat heterogeneity and transformation.

In this paper, we specifically aim to: (a) derive a map of habitat types based on ground surveys and expert knowledge for the whole island, (b) assess the degree of transformation for each habitat type, and (c) identify broad priorities for conservation at the level of habitats and municipalities.

Methods

Study area

The oceanic island of La Réunion (2512 km^2) in the Mascarene Archipelago (see Figure 1) is of relatively recent volcanic origin (2–3 million years BP). Its steep relief reaches 3070 m in the centre (Piton des Neiges) and 2631 m in the southeast (Piton de la Fournaise, the only currently active volcano). The mean annual rainfall is high in the eastern (windward) part of the island, from at least 1.5 m on the coast to >8 m in the mountains and locally 12 m between 1300 and 1800 m (Barcelo, 1996). The rainfall is markedly lower on the western, leeward side, down to 500–1500 mm along the southwestern coast. The mean annual temperatures range from 24 °C on the coast to 12 °C around 2000 m.

More than 80% of the total population (750,000 in 2003) lives on the coastal lowlands where most of the economic activities are concentrated. La Réunion is administrated by 24 municipalities of relatively homogenous size (average size: 100 km^2, see Figure 1). The importance of municipalities for implementation of conservation actions is discussed later.

Quantifying and mapping habitat diversity

The vegetation of La Réunion Island is most clearly structured along a gradient of altitude and rainfall (Cadet, 1977). Based on phytosociological relevés,

Figure 1. Location of La Réunion Island and administrative boundaries. Municipalities range in size from 16 to 241 km^2. The inset shows the position of the island east of Africa and Madagascar in the Indian ocean.

Rivals, (1952) and Cadet, (1977) identified five natural communities within broad moisture and elevation zones:

A savanna-like vegetation dominated by palms (*Latania lontaroides*) described by the first settlers in the western coastal plain from the sea level to 200 m (annual rainfall 500–1000 mm).

A semi-dry forest comprising sclerophyllous tree species (annual rainfall 1000–1500 mm) formerly covered the leeward western side from 200–750 m.

A lowland rainforest with the greatest tree species diversity on Réunion (Strasberg, 1996), originally occurred all over the eastern lowlands from the coast to 800–900 m and, on the western side, from 750 to 1100 m with a canopy of tall trees up to 30 m high (annual rainfall 1500–6000 mm).

A mountain rainforest, from 800 to 1900 m in the east and 1100 to 2000 m in the west, richer in epiphytes, and emergent tree ferns and formerly palms (*Acanthophoenix rubra*) (annual rainfall 2000–10,000 mm). This dense cloud forest includes large areas of three mono-dominant plant communities: the

Acacia forest (*A. heterophylla*) very similar to *Acacia koa* forests in Hawaii, the *Philippia* thicket (*P. montana*) and the *Pandanus* wet thicket (*Pandanus montanus*).

Above the tree line (2000 m) is a shrubland dominated by endemic taxa of Ericaceae and Asteraceae (annual rainfall 2000–6000 mm). The summits of the volcanoes are alternatively covered by large mineral areas with sparse subalpine vegetation (lapilli), grasslands, ericoid vegetation or *Sophora* thicket (*Sophora denudata*), depending on the substrate texture.

Plant names refers here to the nomenclature of the Mascarene Flora (Bosser et al. 1976–2000).

Combining ground surveys and expert knowledge to map habitat types

The above mentioned major vegetation zones plus five particular habitats defined by Cadet were originally mapped at a scale of 1:200,000 (Cadet, 1977). No map of habitat types (land facets, environmental units, or vegetation types) was available at a finer scale for regional conservation planning. However, within each broad moisture and elevation zones, more habitat types, based largely on vegetation structure, have been described (Rivals, 1952; Cadet, 1974; Cadet, 1977; Dupouey and Cadet, 1986; Dupont et al. 1989), but these have never been mapped. Drawing mainly on insights from Cadet's classification, the unpublished work of J. Dupont, and discussions with many ecologists, managers and planners, we derived a system of 19 habitat types for use as biodiversity surrogates for identifying conservation priorities (see Appendix 1). These habitat types were mainly identified according to the following vegetation structure variation:

Height: vegetation either dominated by shrubs (< 4 m), low lying trees (4–8 m), or tall canopy trees (8–15 m).
Horizontal structure: dominant layer continuous or discontinuous (% cover < 80 %).
High density of a particular life form or of one species: in certain places canopy composed of one dominant species; or characterised by the abundance of one life form.

We mapped these 19 habitat types using the most up-to-date survey of natural habitats. Between 1985 and 2000, an extensive ground survey was conducted in all untransformed areas (defined by agriculture and urbanisation) to identify zones of ecological interest (*Zones Naturelles d'Interêt Ecologique Faunistique et Floristique*; hereafter "ZNIEFF", Dupont, 1985–2001). Two types of ZNIEFF were recognised based on the extent of habitat degradation: "ZNIEFF type 1" areas correspond to areas relatively untransformed (native canopy still pristine and not invaded); "ZNIEFF type 2" areas are moderately degraded (native biota dominated by alien plants) but representing habitats of ecological interest. After many altitudinal transects Dupont (2000) mapped the boundaries between ZNIEFF and transformed areas on 1:25,000 topographical sheets. Nevertheless, the boundaries between each ZNIEFF remained somewhat arbitrary: they roughly followed topographical features with no delineation of specific habitats. Available records for each ZNIEFF included a written description of the major habitats (based on Cadet's classification), an estimate of the extent of habitat degradation (mostly by invasive species), and possible future threats (such as spread of recently introduced alien species). A list of plant and vertebrate species (native and alien) was also available for each ZNIEFF. Over 250 ZNIEFF were identified of which 238 are considered of "type 1".

We used digitised ZNIEFF at 1:25,000 (Dupont, 2000) to map boundaries between untransformed areas and land used for agriculture and urbanisation. Several habitat types could occur within a ZNIEFF and, as these were not mapped; we used topography, aerial colour orthophotos (scale 1:10,000) as well as expert knowledge from local botanists, foresters and conservation authorities to identify boundaries between habitats. In most cases, it was possible to visually identify and digitise the boundaries between two habitat types using the orthophotos. In cases where this was not possible, boundaries were defined using altitudinal limits (determined by expert knowledge). The resultant habitat map was verified using an independent data set of 744 plant relevés (average size: 400 m^2), and through consultation with local botanists and foresters. The map thus derived placed more than 75% of the plant relevés into the correct habitat type. Errors are attributable to two main factors: some patchy habitats like subalpine grasslands (patches often $<0,1$ ha in size) were not always mappable from aerial photographs; – many fragments of native vegetation (size of 1–5 ha) when embedded in a matrix of secondary vegetation, could not be mapped at the scale used for ZNIEFF survey. We considered the derived map to be suitable for analysis of the distribution patterns of main habitats at the scale of 1:50,000. This habitat map is not designed to identify fine-scale conservation areas. Beyond the ZNIEFF boundaries, communities are dominated by alien species but contain remnant populations of native species. As landuse conflicts escalate in such areas, spatial data will be needed at a cadastral scale (1:5000). For this purpose, detailed field work will be needed along the boundaries of those ZNIEFF occurring on private land that are at highest risk of transformation. This is particularly important at the lower-elevation boundary of lowland dry forest, lowland and submountain rainforests, and *Pandanus* wet thicket.

Mapping habitat transformation

Spatial information of land cover (including current land-use practices) was not available in La Réunion Island until the recent development of remote-sensing techniques. Areas transformed by urbanisation and agriculture (including forestry plantations of exotic species) were mapped from a

Table 1. Categories of habitat transformation recognised for La Réunion.

Category	Description	Source	% area
Extant			
Pristine	Canopy and understorey not invaded	ZNIEFF 1, expert knowledge	25.6
Lightly invaded	Canopy intact (native species cover >90%) but understorey invaded (10–90%)	ZNIEFF 1, expert knowledge	8.3
Invaded			
Moderately invaded	Canopy and understorey invaded (native species cover between 10 and 90% in the canopy)	ZNIEFF 2, expert knowledge	7.0
Highly invaded	Native species cover < 10% in the canopy	ZNIEFF 2, expert knowledge	11.0
Transformed			
Secondary vegetation	No native species	Land cover	14.4
Cultivated	Includes forestry	Land cover	22.0
Urban		Land cover	11.7

land-cover map derived from satellite-image interpretation (IGN, 1997). Even in those habitats that are relatively pristine in the highlands (over 1000 m), invasion by introduced plant species is a major threat in the long term (Macdonald et al. 1991). Alien plant invasions could not be adequately mapped from the land-cover map. We used information on habitat degradation from the ZNIEFF and expert knowledge from local botanists and foresters to identify the extent and the degree of plant invasions (see below).

We distinguished three broad types of habitat transformation: extant (areas not transformed by urbanisation, agriculture or high-density stands of alien plants), invaded (areas of native vegetation invaded to a limited extent), and transformed (urban or cultivated areas, and alien secondary vegetation). Based on land-cover data (IGN, 1997), ZNIEFF and expert knowledge of J. Dupont and D. Strasberg, we subdivided these three broad types into seven categories, representing a gradient of habitat transformation (see Table 1). All type-1 ZNIEFF were considered to be extant, while type-2 ZNIEFF were considered to be invaded. The extent and the degree of invasion was estimated using information contained in each ZNIEFF and expert knowledge. For each habitat type, we calculated the area occupied by the seven land-use categories mentioned above.

Quantifying heterogeneity among habitat types based on environment and land use

Cadet (1977) classified broad habitats according to altitudinal zonation but identified among each zone specific habitats determined by rainfall, topography and geology like *Pandanus* wet thicket. To cluster habitats with similar characteristics we quantified environmental and land-use variation among the 19 habitat types. Environmental factors, from the Environmental Atlas of La Réunion (DIREN, 2001), comprised climatic variables, topography and geology. Surface roughness was calculated as the ratio of actual area and planimetric area.

We used biplots to display the relationships between habitat types, environmental factors and land use categories. Biplots are very useful for depicting multivariate data (Gabriel, 1971; Underhill, 1990). They show a scatter of *n* points, representing the *n* samples, and superimpose information on the original variables, represented by vectors starting from the origin. Due to multidimensional scaling, some degree of approximation must be accepted to display the information in two dimensions (Gower and Hand, 1996). We used correlation biplots which are best for displaying correlation between variables. We analysed each habitat type in relation to five variables: (1) the mean altitude value; (2) the geological diversity (number of geological types present in the original distribution of the habitat type); (3) the mean surface roughness; (4) the % of habitat currently transformed; and (5) the % of the habitat type currently invaded. We did not include mean annual rainfall, as this factor was not accurately displayed in two dimensions. Correlation biplots were used to identify cluster of habitat types sharing similar environmental characteristic.

Setting broad priorities for conservation

This study does not aim to establish a reserve network that achieves all biodiversity targets, but rather to guide the region's efforts in retaining the most valuable habitats of the island. We have proposed a protocol, using all available data, to rapidly identify priorities for conservation actions at the scale of municipalities. The identification of conservation priorities is currently limited by the lack of vulnerability data (such as urbanisation, agriculture and invasions expansion) and native biota distribution maps. A full systematic conservation plan is envisaged in the future to establish a representative conservation area network.

We decided to use municipalities as the spatial units for allocating conservation priorities for several reasons. First, municipalities are responsible for decision-making regarding landuse, especially urban expansion. Second, municipalities in La Réunion Island are relatively homogenous in size and represent broad subdivisions of the island (each municipality contains a coastal and a montane section). Third, their boundaries follow on major topographic features (such as water catchment, geological discontinuities, cirques, cliffs).

We used two criteria for assessing the importance of habitat types for conservation action. We first considered the percentage of intact habitat per habitat type. We propose that heavily transformed habitats should be prioritised as there are fewer options for preserving and restoring them.

We also considered the frequency and extent of each habitat type among the 24 municipal zones. This allowed us to identify those municipalities that still containing a large proportion of intact habitats and/or many different habitats.

Results

Habitat diversity and transformation

The 19 habitat types in La Réunion originally covered between 500 ha (wetland) and over 50,000 ha (lowland rainforest) (Figure 2; see Appendix 1 for descriptions of each habitat). Almost 50% of the island has been transformed by crops and urban areas or is now covered by secondary vegetation. Urban areas cover 29,380 ha (11.7% of the island); agriculture – including forestry, 55,045 ha (22%); and secondary vegetation, 36,094 ha (14.4%). One third of the island still contains intact habitats where invasion by introduced species is still localised (habitats not irreversibly transformed). The remaining (44,925 ha) is moderately (7% of the island) or highly invaded (11%).

The conversion of natural habitats to agriculture and urban areas has been most severe on the lowlands and in the west (Figure 2). In the west, most native habitats have been converted to agriculture between sea level and 2000 m. In the southeast, habitats have remained untransformed due to the constant volcanic activity.

The extent of some habitat types has been severely reduced by transformation (Figure 3). Seven habitats, of which six occur in the lowlands (< 1000 m), have lost more than 50% of their original extent in the early colonisation by Europeans: the coastal habitat, the savanna, the dry forest, the lowland, and leeward submountain rainforest. Upland habitats (i.e., subalpine *Sophora* and *Philippia* thicket) have been more recently transformed for logging and cattle breeding in the 20th century. All habitat types except two have been affected by invasion or transformation. The *Pandanus* mountain wet thicket and the subalpine shrubland on lapillis still have 100% of their original distribution intact due to harsh environmental conditions. The relationship between percentage of invaded area and percentage transformed varies among habitat types. Some habitat types, such as subalpine herbland and shrubland, are sparsely disturbed and subsequently invaded but not transformed as they have been used for erratic grazing for 100 years. In wetlands the vegetation structure seems unchanged but the composition is almost totally dominated by alien or pantropical species.

Some habitats, such as *Philippia* mountain thicket, were recently transformed (in grasslands) and remnants have not yet been heavily invaded.

Heterogeneity among habitat types

Figure 4 shows the relationships between the 19 habitat types and environmental and land-use factors. Three major clusters were identified (see labels 1–3 in Figure 4). The first cluster groups mostly high-altitude habitat types associated with one or a few geological types among 15 types. The second is mostly

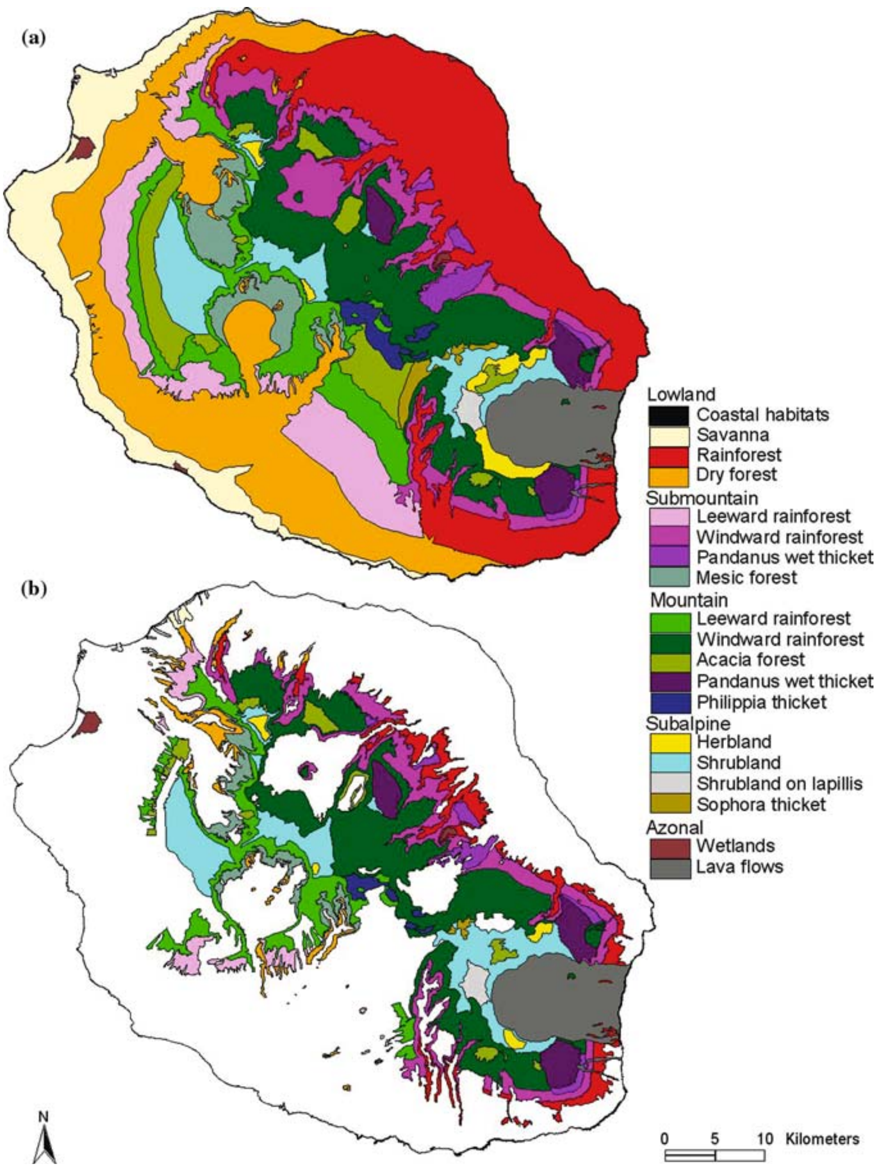

Figure 2. Habitat types in La Réunion Island: (a) original extent; (b) current extent (excluding areas transformed by agriculture and urbanisation or highly invaded areas).

characterised by low altitude and high levels of habitat transformation and invasion. The third cluster groups habitat types on heterogeneous topography and diverse geology (Figure 4).

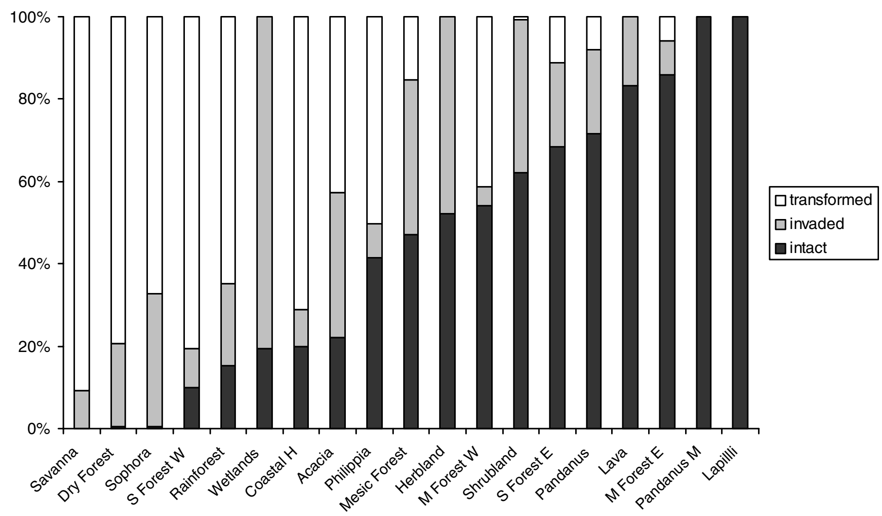

Figure 3. Extent of transformation on the 18 habitat types of La Réunion Island (see Table 2 for definition of the categories). White bars indicate the percentage of transformed areas; grey bars, the percentage of invaded areas; black bars, the percentage of intact areas.

Species diversity and endemism of each habitat type differed within these clusters (Table 2). Endemism level (per 1000 ha) was generally higher in cluster 1 than in others. Cluster 2 represents habitat types of low endemism level, while cluster 3 characterises habitats of high species richness (Table 2).

Identifying priority habitat types and municipalities

Priority habitats were defined based primarily on the percentage of intact habitat and to a lesser extent on the frequency of each habitat type among the 24 municipalities (Figure 5). Municipalities were prioritised based on the amount of remaining natural and the distribution of habitat types (especially those identify as priority) they contain.

Based on the percentage of intact habitat, all habitats belonging to cluster 2 should be prioritised for conservation action since less than 25% of their original habitat remains. The other habitat types are relatively secure as, for most of them, more than 60% of their original habitat remains (Figure 5).

The consideration of the other criterion, the number of municipal areas in which a habitat type is found, cannot be used to quantify vulnerability of habitats. It shows that habitat distribution in municipalities is very uneven. Nevertheless it may help decision makers in debating future land-use planning. Municipalities having unique habitat could be more prone to protect it.

Two municipalities, Sainte–Rose and Saint–Philippe, contain over 70% of the remaining natural habitat of habitats belonging to cluster 1. Four and

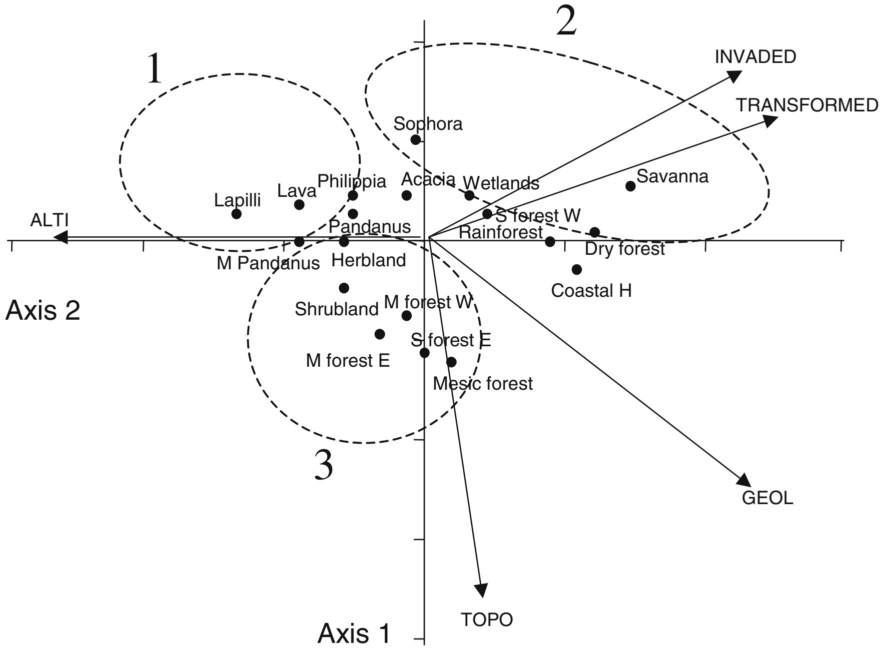

Figure 4. Biplot showing the relation between habitat types in La Réunion Island and environmental factors (mean altitude – ALTI, mean surface roughness – TOPO, and geological diversity – GEOL) and habitat transformation (% of habitat type transformed – TRANSFORMED, and % of habitat type invaded – INVADED).

five municipalities are required to represent 50% of cluster 2 and 3, respectively. Three municipalities, Sainte–Rose, Saint–Philippe, and La Possession, which contain more than 10 habitat types and the largest proportion of priority habitat types, should receive conservation priority. Moreover, they constitute the only areas in Réunion where the zonation of habitats along altitudinal gradient is uninterrupted from sea level to summits (>2000 m).

Discussion

This study is the first spatially-explicit assessment of habitat diversity and transformation in La Réunion. Until now, the lack of such information has hindered the objective identification of conservation priorities and the implementation of systematic conservation planning.

This study confirms that one third of La Réunion is still covered by natural habitat but reveals some unexpected results concerning the spatial pattern of habitat transformation. First, the widely-held notion that all high-altitude areas are not transformed was refuted by our results. Two subalpine habitat

Table 2. Characteristics of habitat types on La Réunion, with details on species richness of flowering plants (Sp richness), number of species endemic to La Réunion (Endem sp), endemism rate (Endem rate – the percentage of species endemic to La Réunion occurring in this habitat), and number of endemic species per 1000 ha of original area (Endem/1000 ha). Clusters were identified based on land use and environmental factors (see Figure 4).

Habitat	Species richness	Endemic species	Endemism rate	Endemic/1000 ha
Cluster 1: homogenous habitats				
Pandanus submountain wet thicket	114	38	33	13.9
Pandanus mountain wet thicket	92	36	39	8.8
Philippia mountain thicket	90	38	42	17.7
Subalpine herbland	34	17	50	6.3
Subalpine shrubland on lapillis	6	5	83	6.3
Lava flows	53	19	36	1.9
Cluster 2: transformed habitats				
Acacia mountain forest	96	41	43	4.1
Coastal habitats	35	7	20	4.8
Lowland savanna	41	15	12	0.9
Lowland dry forest	126	30	24	0.6
Lowland rainforest	127	29	23	0.6
Leeward submountain rainforest	142	41	29	2.2
Subalpine *Sophora* thicket	11	7	64	5.4
Wetlands	26	2	8	1.8
Cluster 3: heterogeneous habitats				
Windward submountain rainforest	166	58	35	3.4
Submountain mesic forest	98	33	34	4.3
Leeward mountain rainforest	144	67	47	4.3
Windward mountain rainforest	165	81	49	2.8
Subalpine shrubland	30	25	83	2.2

types are heavily transformed (see Figure 3). Such results will generate new discussions for the design of the proposed national park that include most of intact mountain habitats and very few lowland invaded and fragmented habitats. Second, habitats occurring on the leeward coast have been more heavily transformed than those on the windward coast. Some municipalities on the west coast have no natural habitat left below 2000 m elevation. The first settlement and large-scale cultivation of coffee that early occurred on the west coast, and more recently harvesting for production of essential oils probably explains this rapid transformation. Several habitat types on the leeward coast mainly occur as small patches that are highly invaded and that occur outside any protection network.

This study indicates the high habitat diversity of La Réunion. Using habitat types as surrogates for biodiversity, broad-scale conservation priorities were identified based on the spatial pattern of habitat transformation and the representation of these habitats in municipalities. Although this confirms local

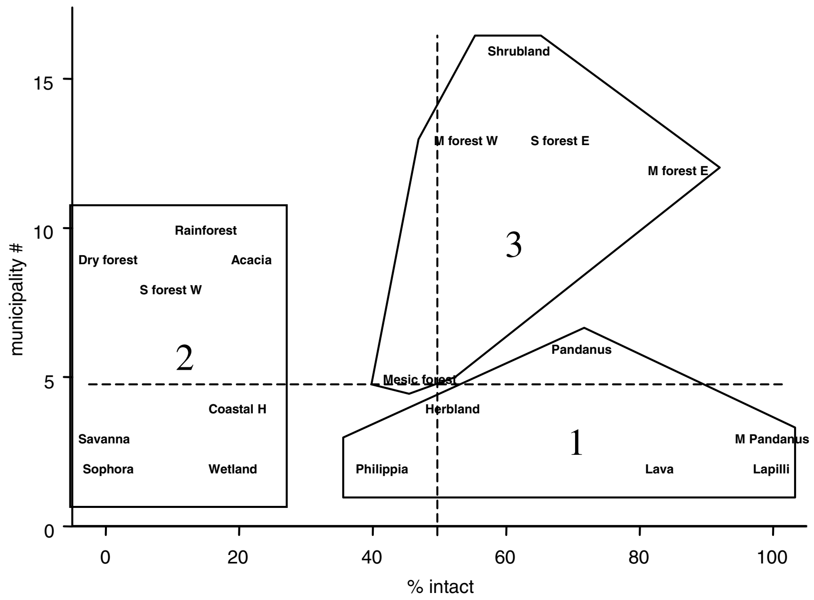

Figure 5. Classification of habitat types according to % intact and number of municipalities in which they occur.

expert knowledge, new priority habitats emerged. Regional (i.e., within the Mascarene islands) and local (in La Réunion) priorities can be distinguished.

La Réunion is the last of the Mascarene islands with large areas of untransformed forest; these forests (such as the windward mountain rainforest) thus represent regional conservation priorities. Although they are currently relatively well connected, there is an increasing risk of creating invasion window as road projects, tourism and urban development threaten these habitats. Moreover, these habitat types, corresponding to cluster 3, are generally species-rich, with many species endemic to La Réunion (Table 2). The need to conserve such habitat types has usually been ignored, as they are not currently transformed. However, they can rapidly be threatened by future transformation as agriculture may shift toward higher elevation in the next 10 years. These habitat types should be prioritised at the regional scale as they are unique to La Réunion.

At a local scale (i.e., in La Réunion), conservation actions should probably focus on habitat types where most of the original extent has been transformed. Only one habitat type, the lowland savanna, has been entirely transformed; La Réunion has thus the opportunity to preserve a representative sample of all habitat types once occurring. Nevertheless results can be tempered knowing that the scale we used is not accurate enough to take into account small fragments surrounded by transformed areas. It implies a different approach for mapping and different priority criteria when they occur outside the preliminary boundaries of the proposed national park. In order to fill the former gaps in the analysis, we are preparing a proposal to constitute a technical group on conservation planning for the future national park that could establish conservation targets, produce threat level maps, and ground survey checking at a cadastral scale when necessary.

The issue of setting conserving priorities in areas where limited spatially-explicit biodiversity information exists is common to many biodiversity-rich areas (Pressey et al. 2003). However, this study demonstrates that existing biodiversity information, even where this is not spatially explicit, can be used to map broad habitat types and for setting conservation priorities at a limited cost and over a relatively short period. The increasing availability of environmental and land-cover data in digital format now facilitates mapping of coarse-filter biodiversity surrogates and habitat transformation. Such a broad-scale approach highlights the conservation status of each habitat type in La Réunion. As similar level of information is available in other islands, this approach can form the basis of a conservation plan for the Mascarene islands (Margules and Pressey, 2000).

Given the broad-scale approach adopted here, municipalities appear to be an appropriate level for implementation of conservation actions. Since no regional conservation mechanisms are in place in La Réunion, decisions regarding land-use planning are taken at the municipal level. In many cases, conservation priorities failed to be implemented for practical reasons as either the biodiversity feature or the implementation unit cannot easily be identified on the ground. For example, conservation actions based on arbitrary grid cells have seldom been implemented. Here, we have identified priorities on the basis of habitat types (easily identifiable and objectively defined) and municipalities (practical governmental unit).

The spatial dimensions of ecological and evolutionary processes or future land-use pressures need to be addressed before conservation planning takes place (Rouget et al. 2003). For adequate planning, implementation units will also be required at a finer scale than municipalities. In La Réunion, upland–lowland gradients, recent lava flows, and riverine corridors would be important spatial components to consider as surrogates for ecological and evolutionary processes (Strasberg, 1996; Rouget et al. 2003). Urban and agriculture pressure, as well as invasion by alien plants should be mapped, and the factors that control the distribution of these factors need to be determined. The ecological units ZNIEFF, combined with the habitat types derived from this study could be used for subdividing the island into units of manageable size.

Acknowledgements

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Appendix 1. Description of Broad habitat types identified in this study. Present area of untransformed habitat is given in hectares.

Habitat	Description	Present area
Lowland		
Coastal habitats	Herblands and scrublands on rocky cliffs, stony and sandy shoreline	316
Lowland savanna	Dry discontinuous woodland with tall trees and palms (*Latania lontaroides*) on sandy soils	481
Lowland dry forest	Dry forest with a semi open canopy of sclerophyllous trees	3294
Lowland rainforest	Wet forest with a continuous canopy of tall trees rich in epiphytes	7626
Submountain		
Leeward submountain rainforest	Mixture of dry and wet forest trees in dense stands	4064
Windward submountain rainforest	Very wet dense forest with low-lying trees and shrubs	12127
Pandanus submountain wet thicket	Dense stands of *Pandanus montanus* mixed with rainforest trees	1815
Submountain mesic forest	Dry mountain forest with small trees and shrubs	3586
Mountain		
Leeward mountain rainforest	Cloud forest with tall trees and dense herbaceous layer	11614
Windward mountain rainforest	Cloud forest with stunted trees and dense epiphytic layer	26949
Acacia mountain forest	*Acacia heterophylla* mono-dominant forest with bulky trees and light canopy	2736
Pandanus mountain wet thicket	Dense stands of *Pandanus montanus* growing in marshes	2604
Philippia mountain thicket	Moorland with thick organic topsoil covered by the heath *Philippia montana*	889
Subalpine		
Subalpine herbland	Mosaic of grasses and sedges on waterlogged or dry high-altitude flat areas	850
Subalpine shrubland	Large tracts of high-altitude continuous heathlands	14744
Subalpine shrubland on lapilli	Dry discontinuous shrubland on recent volcanic deposits	802
Subalpine *Sophora* thicket	Wet thicket dominated by *Sophora denudata* trees	211
Azonal		
Lava flows	Recent lava flows	9765
Wetlands	Permanent msarshes or ponds	467

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