Plant Endemism, Rarity, and Threat in Palau, Micronesia: A Geographical Checklist and Preliminary Red List Assessment

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Plant Endemism, Rarity, and Threat in Palau, Micronesia: A Geographical Checklist and Preliminary Red List Assessment

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Abstract—An official checklist of the endemic plant species of Palau has been long awaited, and is presented here for the first time. For each species a substrate limitation, growth form, and relative abundance is listed. In addition an IUCN red list assessment was conducted using all available data. For over half of the endemic species there is insufficient data to provide a red listing status however an expected minimum number of threatened plants out of the total is inferred. Approximately 15% of Palau's endemic plants are believed to be only known from the type collection and many more only known from a few collections. These taxa however may now be prioritized and targeted for future inventory and research. The taxonomic robustness of several of these taxa is questionable and it is expected that more endemic species will be lost to synonymy in the future. Previous estimations have significantly over-estimated the rate of plant endemism in Palau (e.g., 194). Here, 130 plants are recognized for Palau, making its level of plant endemism comparable to some of its neighboring Micronesian islands to the east, notably Guam and Pohnpei. Several species are known to be restricted to isolated disjunct populations however the causes for their rarity are poorly known and have never been intensively studied. Palau although notable for its high percentage of remaining primary forest compared to other oceanic islands faces increasing threat from development making these small populations highly vulnerable. Nothing is known about how these rare species will respond to the imminent threat of climate change. There is no current legislation protecting specific plant species as their rarity has never been systematically quantified. This paper represents a step towards plant conservation in Micronesia and it aims to stimulate further studies to address the data deficiencies documented here.

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Introduction

The islands of Palau, lying roughly north of Papua New Guinea and East of the Philippines, contain a unique and rich flora that is shared with it's neighboring islands to the east, the Caroline Islands, and the Marianna Islands to the northeast. This geographic region, known as Micronesia, comprises the northwestern part one of the 34 recognized biodiversity hotspots on earth (Myers et al. 2000). The Polynesia-Micronesia hotspot has been quoted as the "epicenter" of the current global extinction crisis. Palau at the western most boundary of this region is at a pivotal location. This tiny island nation, which is one of the newest countries in the world, as well as one of the smallest, has been noted for years by various authors in environmental evaluation reports for containing the highest rates of plant endemism out of all its neighboring island states in Micronesia.

This should be expected considering Palau by far contains the highest number of native plant species in Micronesia. Palau with a native vascular plant species count of approximately 724 species, rivals its neighboring islands significantly. The numbers drop by over half traveling to the first island east with 376 in Yap (Fosberg et. al. 1979, 1982, 1987), then 328 in Guam (Stone 1970) and 357 in Pohnpei (Balick unpubl.). The numbers continue to drop rapidly traveling east to the Marshall islands before reaching a vast blue expanse of ocean that stretches eastward to Hawaii. The flora of Micronesia is an attenuated flora deriving largely from the Indo-Malesian region to the west. Conservation International (2007) declares a total of 3,074 endemic plant species in the region from western Micronesia across to southeastern Polynesia. The Office of Environmental Response and Coordination in Palau (2002) reported a total of 194 of these to be endemic to Palau, emphasizing that experts believe there to be more than this.

Where these statistics have been taken from and how they have been calculated has been one of the questions that has driven the author for the past several years. There has never been a checklist of endemic plants published for Micronesia. Throughout the course of the research presented in this paper, not only has the expected number of endemic species significantly dropped, but the original assumption that Palau takes the limelight for plant endemism rates in Micronesia has been critically re-evaluated. The results presented here suggest that Palau may actually have the second highest rate of plant endemism in Micronesia, Guam being the first and that the neighboring islands have comparable rates to that of Palau.

Although the endemic statistics have remained obscure over time, the flora of the region is very well known in comparison to many other parts of the tropics. The prospect of finding new species, though clearly present, is relatively low compared to places such as Southeast Asia and the Neotropics. Progress on the flora of Micronesia began during the Japanese occupation of the region. Notable collectors included Hosokawa, Kanehirae, and Tuyama. Many of the current names accepted for Palau's endemic plants were described by these pioneer botanists. Another early notable collector was Schlecter, a German botanist and orchidologist, who named many of Palau's recognized orchid species. During the American occupation, work was continued mostly by Raymond Fosberg and his collaborators who described several new taxa, new combinations, and most of Palau's endemic varieties. Although their geographical checklists (Fosberg et al. 1979, 1982, 1987) have proved to be an indispensable resource, it has also been a source of some confusion regarding which plants are endemic. In the Flora of Micronesia (Fosberg & Sachet 1975a, 1975b, 1977, 1980b; Fosberg et al. 1993), and other occasional publications on the flora of the region, endemic status is usually established. However these accounts are nowhere near a complete representation of the flora.

What the geographical checklists lacked was a clear indication of which plants were actually endemic to the region. In the abstracts it is clearly stated how many of the plants listed are endemic to the Carolines, the Marianas, and endemic to the entire region but there is no further mention of endemism outside the abstract. The taxa presented in the checklist are not distinguished by these categories. The users have been left to determine this for themselves. This has lead to a great degree of error in calculating figures of plant endemism for some of the respective island states. For example, if a plant's distribution within Micronesia is restricted to Palau, its distribution is listed as only occurring in Palau. This naturally has lead to assumptions that the taxa in question is endemic, when more often than not, its native distribution extends further west into Malesia. Many of these plants are at the eastern most limits of their native range in Palau.

An additional significant factor has contributed to this problem. Over time, a significant number of the names published during the Japanese era and even recent times have become basionyms or synonyms for species with a wider geographical range. This trend continues today and demonstrates how the determination of species as endemic to the region has been obscured by the slow simultaneous progress on the flora of Malesiana where as noted above, the vast majority of Micronesia's plants are derived. In addition to this, there is even slower progress towards published monographs of families and genera from the region.

These floristic problems came to the attention of the authors while inventorying collections from Palau at overseas herbaria and revising the checklist of vascular plants for the country, and stimulated the beginning of an effort extended over several years, amidst other projects, to compile an accurate list of endemic plants for Palau. Simultaneous work has been carried out by other Pacific researchers for the islands of Pohnpei and Kosrae and plans are underway to update the checklist of plants for the entire Micronesia region. The discussion here is limited to the islands of the Republic of Palau, geographically defined as the western Caroline islands, excluding the island state of Yap of the Federated States of Micronesia.

In addition to contributing to the taxonomic progress of the endemic plants it has been decided to do so within the context of conservation. The link between biodiversity conservation and endemism is indeed, as stated previously, at the "epicenter" of current discussion in the field of biology. This is especially so for small island nations where the threat of losing an endemic species is much greater due to very small population sizes and vulnerable ecosystems with unoccupied niches. These uneven island biotas, often without predators, can be easily exploited by invasive species. The link is put even more into the context of taxonomy when it is considered how limited funds and resources could be misspent on taxa believed to be endemic that are actually widespread.

For these reasons a preliminary assessment for the taxa represented here has been done using the IUCN Red List criteria (IUCN 2001). For the majority, data has not been sufficient for establishing even preliminary status. It is hoped that this will not detract from the value of this checklist but instead stimulate effort and funding for a complete and thorough study to produce a complete red list assessment of Palau's endemic plants.

Lastly, it is expected that as new taxonomic treatments are published, this list, and naturally the statistics of endemic species for Palau, will continue to change. Many of Palau's endemic plants are poorly known and in some cases only by the type specimens or a few additional collections. Critiques on the taxonomy and endemic status of taxa listed here are welcomed and encouraged.

Methods

Primary sources of information utilized include the working database in Palau referred to as the Palau Vascular Plants Database (PVPD 2006), the Provisional Checklist of the Plants of Palau (Kitalong et al. 2008), and Fosberg et al.'s checklists (1979, 1982, 1987). All species previously listed as endemic in any of the above checklists were critically assessed to verify their status. In addition, Fosberg et al.'s lists were reviewed systematically to check for any possible endemic taxa excluded from the former lists. The task of assessing endemic status began during herbarium inventories at the Bishop Museum. Any taxa listed as endemic with specimen records found in other countries were simply crossed off the list. This effort was later continued with a thorough literature review and inventory of digital herbaria and taxonomic databases world-wide.

The following databases were consulted for distribution records and the most up to date taxonomy:

GBIF: Global Biodiversity Information Facility website: http://data.gbif.org/welcome.htm (accessed August 2007)

Kew World Checklist of Selected Plant Families. Royal Botanic Gardens Kew, online resource http://www.kew.org/wcsp/home.do (accessed August 2007)

ILDIS: International Legume Database Information Service. School of Plant Sciences, University of Reading. Website http://www.ildis.org/ (accessed August 2007)

IPNI: International Plant Names Index website: http://www.ipni.org/ index.html (accessed August 2007)

HUH: Harvard University Herbaria website: http://www.huh.harvard.edu/ (accessed August 2007)

If the name and its distribution information were not found in one of these databases, often by conducting an online search, publications or articles that mentioned the taxa were found, from which distribution records were often obtained. If the plant occurred in other countries, then usually several links were identified by the search engine. For most of Palau's confirmed endemics, there were very few if any links found. In addition, for each family and genus that occurs in Palau, a search was done for any published monographs using the library resources at the Royal Botanic Gardens Edinburgh. The Flora of Malesiana was also thoroughly reviewed which was relevant to many of Palau's taxa. In most cases, if a taxa recognized by Fosberg et al. (1979, 1982, 1987) was reduced to synonymy in the Flora Malesiana, the Flora Malesiana was followed. In some cases however, Fosberg et. al's treatment (1979, 1982, 1987) was retained.

Only species found to be endemic to Palau are listed. Anything not listed here has been found to have distributional records outside Palau. Geographic data within the Palau archipelago was obtained from two primary sources; Fosberg et al.'s (1979, 1982, 1987) checklists and the author's database of over 14,000 plant collection records from Palau. This database was compiled from all databased herbarium specimens collected in Palau that are held at the Smithsonian herbarium (US), the Bishop Museum herbarium (BISH), and the Belau National Musuem, in addition to presence/absence records obtained from the Babeldaob Forest Survey in 2005 (Costion & Kitalong 2006). Several cases proved that this supplementary data was worthwhile by extending the distributional ranges presented in Fosberg et al. (1979, 1982, 1987).

SYMBOLS

(*) A "*" is applied following the name to indicate the particular taxon was either insufficiently represented or not represented at all in the author's database and its substrate restriction data (volcanic, limestone, generalist) was determined solely from the literature. A complete list of the literature consulted for distribution data is as follows: Hartley (2001); Hassler et al. (unpublished world checklist of Orchidaceae); Holttum (1977); Huynh (1999); Fosberg & Raulerson (1990); Fosberg & Sachet (1979, 1980, 1981, 1987, 1991); Fosberg et al. (1979, 1982, 1987, 1993). The lack of specimens from inventoried herbaria suggests that these taxa are relatively poorly known, although it is known that un-databased material exists at the Smithsonian and the University of Guam, but was not seen by the authors. Until these records are databased, they remain unavailable for analysis.

(+) A "+" is listed after the name to indicate that the taxon is only known by the author from the type specimen or otherwise a single collection, or even in some cases where no specimen at all could be located. This serves to highlight taxa *very* poorly known and in need of further collections. Distributions of these taxa were determined from the checklists of Fosberg et al. (1979, 1982, 1987) and/or from the protologues or type specimen labels.

IUCN Red List status

All species listed have been assessed using the IUCN Red List categories and criteria (IUCN 2001). Taxa recognized as endemic only to the varietal rank, have not been assessed. Abbreviations used for the categories are as follows:

CR: Critically Endangered
EN: Endangered
VU: Vulnerable
NT: Near Threatened
LC: Least Concern
DD: Data Deficient

Categories that classify as threatened are highlighted in bold. If a taxa meets the criteria for one of the threatened categories, then the specific criteria that it qualifies under is listed in parenthesis following the IUCN red listing format (IUCN 2001). For example, *Cycas silvestris* K.D. Hill,**VU**(D2) is an Australian cycad that qualifies as **vulnerable** under criteria D2 which states that the area of occupancy must be less than 20 km^2 or the number of locations is less than or equal to five. This species is restricted to the Cape York peninsula, Queensland and only known from a few small stands that lack adequate protection (Hill, 1992). The specifications of the categories criteria are easily obtained from the IUCN website (www.iucnredlist.org) and will not be repeated here.

Forms

Eight growth forms were abbreviated as shown below. Some species have more than one form.

T = Tree
T(u) = understory tree
T(c) = canopy tree
S = shrub
L = liana
HP = hemi-parasite
H= herb
E = epiphyte

Relative Abundance Codes

This category was determined roughly from overall knowledge of the authors' field experience, data records, and review of the literature. It is included to help distinguish between different types of rarity. Plants that are uncommon to rare but across the island, plants that are locally abundant but restricted to small localities, and plants that are widespread. Code abbreviations are as follows:

R = Rare, very uncommon or very poorly known
RR = Range restricted, only known to specific localities
U = Uncommon, but found throughout the substrate type
C = Common, widespread in occurrence
A = Abundant, grows in abundance where found
D = Dominant, forms a dominant layer in the forest structure
DD = Data deficient, insufficiently known

Results

A total of 130 vascular plant species are listed here as restricted to Palau with an additional 23 endemic varieties. Well over 100 plants that were considered potentially endemic in the PVPD were found to have wider distributions outside Palau. Most of these had ranges extending into Malesia and some shared their distributions with other Micronesian island states. Plant distributions within the archipelago can be divided into three main categories. Plants restricted to volcanic islands, plants restricted to limestone islands, and generalist plants occurring on both substrates. A few taxa are restricted to specific islands within these categories. A total of 75 species were found to be restricted to volcanic islands including one restricted to the island of Malakal in Koror; 31 species are restricted to Limestone islands including one restricted to Peleliu and one restricted to Angaur; 24 species are considered generalists occurring on both volcanic and limestone islands.

Species Endemic to Volcanic Islands

It is believed that the volcanic islands of Palau were formed beneath the ocean's surface and were subsequently uplifted during the Miocene and Pliocene (Fig.1). Clay was formed from the erosion of upper exposed parts of the Island down into the swamps and coastal areas (Goldich et al. 1948). Today parts of the originally exposed basalt rock can be found scattered on the high ridges and hill tops of Babeldaob. Below these small areas it is mostly volcanic clay. Though the soils are acidic and nutrient poor, the total land mass of Babeldaob has produced high rates of plant diversity and endemism in comparison to other islands of Micronesia. Babeldaob is 331 km^2, making it the second largest island in Micronesia. The volcanic islands of Koror, Malakal, and Ngarekebesang although mostly urbanized, contain remnant patches of a similar flora to that of Babeldaob. The volcanic sections of Koror are virtually entirely deforested, though Malakal has some patches remaining. The island of Ngarekebesang

Figure 1. Volcanic islands, Palau

contains the largest area that has not been developed on the volcanic parts of Koror and has not been intensively surveyed.

A total of 75 vascular plant species and 12 endemic varieties are listed here as endemic to Palau's volcanic islands. The majority of these are expected to be found only on Babeldaob, however many do have ranges that extend to the volcanic islands of Koror state. Since it is difficult to presume exactly how similar the original vegetation of the Koror islands was to Babeldaob, prior to human habitation, it is most logical to treat all the volcanic islands as one floristic unit. There are a total of four endemic fern species, three *Sellaginella* species, and 68 endemic angiosperm species. Families most strongly represented are the Orchidaceae with a total of 21 species, Rubiaceae with eleven, and Pandanaceae with five.

Only one plant is known with a range restricted to a volcanic island in Koror. *Timonius salsedoi* is only known from the island of Malakal (Fig.2).

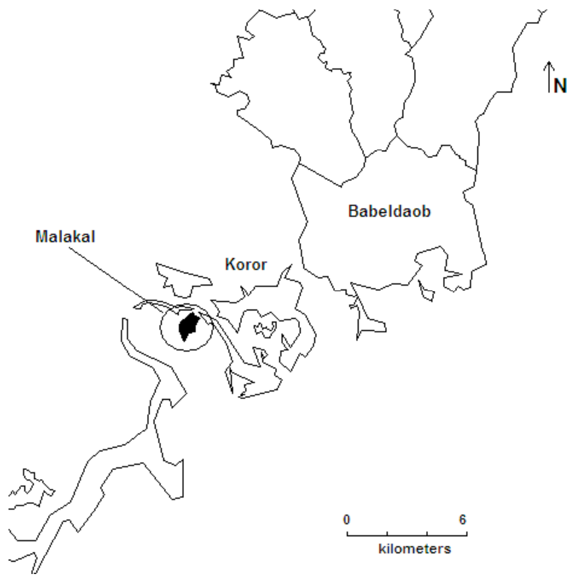

Figure 2. Malakal Island

Described by Fosberg & Sachet (1987) this plant is only known from the type specimens and is poorly known. No information has been recorded regarding the population size or ecology. However, the amount of suitable habitat on this island qualifies this species under the class of Critically Endangered, under the IUCN red list guidelines. Malakal is a very small island with less than half of its land area providing suitable habitat for native vegetation. This small area is restricted to patches on top of the island's hill and fragmented from subsistence farming. The island is heavily developed along the coast at the bottom of the hill and the vegetation at the urban boundary is occupied by introduced and invasive species. Currently there is no known legislation to protect the remaining areas of vegetation on the hill. The occurrence of this threatened species warrants protection of all remaining forest on the island until further studies can be undertaken. Collection of population data on the island of Malakal for this species is highly recommended. A phylogenetic study of the genus *Timonius* in Palau would be beneficial to confirm it is a distinct species and not merely a regional variant of another more widespread species. To date, no other species have been described as restricted to any islands as small as this one in Palau.

SPECIES RESTRICTED TO LIMESTONE FOREST

The limestone islands are derived from lime-secreting organisms that flourished in tropical seas that became shallow from the volcanic eruptions forming Babeldaob and Koror. These deposits have likely been continuous since the Miocene. Parts of southern Babeldaob are actually limestone formed from these deposits (Fig. 3). The high limestone islands known today as the Rock Islands are older, formed from the Miocene to the Pleistocene and were also subject to significant uplift (Goldich et al. 1948). There are between 250 and 300 islands with a total area of 47 km². They are composed of karst limestone which is jagged and sharp making it dangerous to traverse. Early Palauan settlers were

Figure 3. Limestone Islands

known to inhabit these islands but they have long since been abandoned and are now virtually all undisturbed virgin forest. The vegetation here is distinct with virtually no topsoil. The plants often literally cling to shear rock. Some of the endemic plants are restricted to the karst Rock islands, but many also occur on the low platform islands to the south. The low platform islands and reef atolls such as Peleliu, Angaur, and Kayangel, are younger, believed to be formed from deposits from the Pleistocene to recent times (Goldich et al. 1948). Peleliu and Angaur are lower and generally flat islands that have undergone heavy disturbance particularly in the 20th century, and are currently inhabited.

A total of 31 endemic species and seven endemic varieties were found to be restricted to the limestone islands of Palau including four ferns, two palms, three orchids, and four members of the Rubiaceae family. The remaining families are represented by only one to two species. Families that occur here, but are not represented on the volcanic islands by any endemic species, include Lomariopsidaceae, Arecaceae, Caparidaceae, Cucurbitaceae, Elaeocarpaceae, and Vitaceae.

Due to its inaccessibility the Rock Islands are relatively undisturbed, however they are also poorly studied. It is expected that most of the taxa listed here are distributed throughout the limestone islands though with some restricted to the Rock Islands. Further studies are needed to determine the degree of abundance or rarity and assess the degree of threat proposed to many of these plants. One endemic palm, *Ponapea palauensis* is considered critically threatened as it is restricted to a few Rock islands and of the three areas where it has been found only one has a healthy stand of trees (Lewis 2008). A second endemic palm species, *Hydriastele palauensis*, is more common than the former, though only occurring in scattered patches throughout the Rock Islands. Both palms are considered threatened by two species of introduced parrots (Mueller-

Dombois & Fosberg 1998). Manner and Raulerson (1989) documented the continued plight of *Hydriastele* in the Seventy Islands reserve, which was once believed to provide a refuge for the palm, emphasizing its continuing decline. Follow up studies have been limited.

SPECIES RESTRICTED TO PELELIU

Peleliu is one of the largest limestone islands in Palau, with a total land area of 13 km^2, and is the most populated with approximately 700 inhabitants (Fig.3). The island is most notable for being the site of a major WWII battle, the Battle of Peleliu. From what is currently known, there were not many endemic plants on the island to begin with. Local lore asserts that after the battle, only one coconut tree was left standing. Today the untrained eye would never be able to tell, as it is quite heavily forested. However the majority of the vegetation is secondary re-growth and has become dominated by the non-native *Timonius timon*. One endemic species, *Pandanus peliliuensis* Kaneh., is recognized as being restricted to Peleliu (Fosberg & Sachet 1987). This taxa is only known from isotype specimens (HUH, NY), and these are only fragments. Further collections are needed to verify to what extent it occurs on the island and quantify its population size.

SPECIES RESTRICTED TO ANGAUR

Angaur is positioned further south from Peleliu and across an ocean channel (Fig. 3). Unlike the rest of the archipelago discussed here, which occurs within a sheltered coral lagoon, Angaur is surrounded by open ocean. It has a land area of 8 km^2 and a small population of less than 200. The island was also a WWII battle site, and was mined for phosphate from 1909 to 1954. It is likely to have experienced much disturbance in the past century but today is mostly forest. One endemic plant is currently recognized as being restricted to Angaur; *Maesa canfieldiae*. The authors of this species (Fosberg & Sachet 1979) however note that the plant has only been known to the local inhabitants after WWII and could have possibly been introduced from elsewhere. They further document that the plant is closely related to *Maesa tetrandra* (Roxb.) A. DC. and *Maesa papuana* Warb., which occur in Papua New Guinea and the Malesian region, though it doesn't match either of them exactly. It has tetramerous flowers like the latter two, unlike all the other Micronesian species which have pentamerous flowers. The Myrsinaceae family has to date not been treated in the Flora Malesiana. Until this has been done, or other studies indicate otherwise, the name *M. canfieldiae* will be retained.

GENERALIST ENDEMICS

The following 24 endemic species occur on both volcanic and limestone islands of Palau. They are all angiosperms. Families not represented by species in the volcanic and limestone restricted categories include; Anacardiaceae, Celastraceae, Flacourtiaceae, Myristicaceae, Myrtaceae, Olacaceae, Piperaceae, and Putranjivaceae, suggesting that the taxa represented by these families may have better dispersal capabilities and/or less habitat specificity within the archipelago. Most of them are widespread, common species and unlike the former categories, few are poorly known.

CANDIDATE ENDEMICS

Two species are listed as candidate endemics due to considerable doubt over their taxonomic status as separate species. A brief summary of the known information regarding them is provided.

Limnophila palauensis T. Yamaz.

Possibly same as *L. indica* var. *raymundii* which also occurs on Guam. The author of the former did not view the type of the latter when describing the new taxon (Yamazaki 1993), and some of the characters used to distinguish them are questionable. If it is distinct however, then it is endemic to Palau. Further study is required.

Decaspermum raymundii Diels

Both Fosberg et al. (1979) and Stone (1970) doubted that this was distinct enough from *D. parviflorum* (Lamarck) A. J. Scott to validate the application of a separate species name. However, Scott (1979) accepts the name and lists it as endemic to Babeldaob. The former authors were the most experienced in the flora of the region, however the later author specialized in this genus. Further study will enable its delimitation with confidence.

ENDEMIC VARIETIES

A total of 23 endemic varieties are recognized here from 12 different angiosperm families. In all families except the Rubiaceae, there are only one to two endemic varieties. The Rubiaceae has nine recognized endemic varieties with four represented by the genus *Psychotria* and four represented by the genus *Timonius*. A total of 17 of the 23 varieties were described by Fosberg and Sachet. All the names presented here are recognized in the current literature. However, it is reasonable to expect that some will become synonyms after monographs of the respective genera are completed. The regional variation that Fosberg and his colleagues often used as a basis for splitting taxa is sometimes viewed differently by authors of monographs that study genera across a larger distribution.

RATE OF ENDEMISM

Figure 4 shows three different trends. Each data point represents one of the families represented in the checklist of endemic species. The vast majority of families are low in both numbers of native species and endemic species, with no obvious reciprocal relationship between the number of species and number of

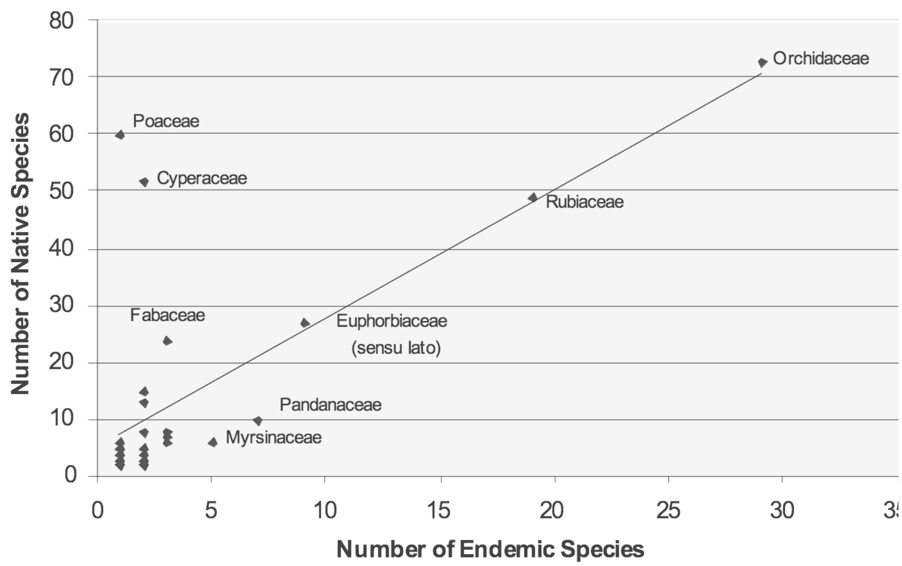

Figure 4. Number of endemic species in proportion to number of native species

endemics (Fig.4). These families often have high rates of endemism at the family level (see Table 1). This is likely the result of few representative species being dispersed to Palau in addition to relatively low rates of species radiation. The Orchidaceae, Rubiaceae, and Euphorbiaceae (*sensu lato*) however demonstrate a trend of endemism being directly proportionate to an increase in the number of native species. These families are notable worldwide for high rates of species diversity (Judd et al. 2002). The percentage endemism for these families in Palau (Table 1) is significantly lower than families such as Annonaceae and Myrsinaceae, the high relative endemic species richness in these later three families is likely a combination of higher rates of successful dispersion of native taxa to the islands and high rates of insular speciation.

Wind dispersed taxa, including the Poaceae and Cyperaceae, although high in species richness, have the lowest rates of endemism. The same is true for Asteraceae, which has no endemic species in Palau. Wind dispersal, allowing propagule movement between Pacific islands, is likely a significant factor contributing to this. There is also palaeoenvironmental evidence to suggest that the abundance of these groups, particularly the Poaceae and Cyperaceae, is a recent occurrence in Palau. Athens & Ward (2002) showed from sediment core analysis that savannas and pollen from savanna indicator plants either do not appear in the sediment record at all or are very limited prior to the colonization of humans and forest clearing. The sudden appearance of Graminoid pollen suggests that many or some Graminoid and even Asteraceae taxa may have dispersed to the islands more recently after the expansion of suitable habitat following human disturbance.

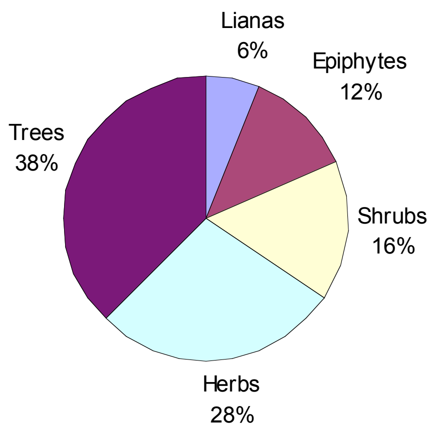

Figure 5: Growth forms of all endemic species

Figure 4 appears to provide some support for the recent theory of "diversity begets diversity" (Emerson & Kolm 2005a, b), which suggests high rates of species diversity foster higher rates of speciation and endemism, particularly on islands. However, clearly for wind-dispersed taxa this model does not apply. There are also additional outliers evident in Figure 4, notably the Myrsinaceae, Pandanaceae, and Fabaceae that don't strongly support this model. The skewness of biodiversity has been well documented for both taxonomic groups and geographical locations (Pimm et al. 1995; Purvis et al. 2000; Sechrest et al. 2002). The data presented here seems to support the "diversity begets diversity" theory primarily for taxonomically skewed families, i.e. those prone to high rates of speciation. The remaining families do not appear to follow any obvious trends on the whole.

The majority of endemic plants in Palau are trees, comprising 38% of the total, followed by herbaceous terrestrial plants with 28%. Shrubs and lianas together comprise 22% and epiphytes total to 12% (Fig. 5). These figures were compared to all native plants using the growth form categories from the Provisional Checklist of the Plants of Palau (Kitalong et al. 2008) in Table 2. Trees and shrubs have higher representation in the endemic species count compared to native plant tallies. This demonstrates a stronger trend towards endemism with arborous habit. However, epiphytes were not distinguished from herbs in the Provisional Checklist, thus they could not be compared. Due to the high rate of endemism in the orchids, epiphytes are also expected to have a high tendency towards endemism whereas terrestrial herbs, abundant with graminoid species, are likely to have a lower percentage.

Plant endemism on limestone islands, when calculated per square kilometer (34%), is significantly higher than on the volcanic islands (21%), where the majority of endemics occur (Table 3). To explore the reasons for this thoroughly and adequately, requires further investigation and comparison with other islands across the region which shall be left for subsequent publications. This data may however suggest support for the general dynamic theory and speciation pulse model for island biogeography of Whittaker et al. (2007, 2008). This model considers island age to have primary importance in species diversity and endemism on islands. New islands increase in diversity and endemism with time but only to a certain point at which opportunities and niches for evolution and radiation diminish through time. The karst limestone islands are notably younger than the volcanic islands.

Table 1: Percent Endemism of Selected Families

Family	Native Species	Endemic Species	Percent Endemism
Annonaceae	2	2	100%
Gesnariaceae	2	2	100%
Myrsinaceae	6	5	83%
Pandanaceae	10	7	70%
Melastomataceae	3	2	67%
Sapotaceae	3	2	67%
Orchidaceae	73	29	40%
Euphorbiaceae	27	9	33%
Fabaceae	24	3	13%
Cyperaceae	52	2	4%
Poaceae	60	1	2%

Table 2: Comparison of the distribution of different growth forms for native and endemic angiosperm species.

Flowering Plants	Trees		Shrubs		Lianas/ Vines		Herbs & Epiphytes	
Native	177	29%	71	12%	56	9%	301	50%
Endemic	49	41%	21	18%	8	7%	41	34%

Table 3: Percent endemism (E/km²) for each island type (km² data for substrate types provided by USDA Natural Resources Conservation Service).

	Endemic Species (E)	Total Area (km²)	% Endemism (E/km²)
Restricted to Volcanic	75	363	21%
Restricted to Limestone	31	90	34%
Generalists	24	453	5%
Total for Palau	130	453	29%

IUCN Red List

There is insufficient data for 61% of Palau's endemic species thus these species cannot be adequately assessed under the IUCN criteria (Fig. 7). These will remain as data deficient, "DD," until further studies are done. There is sufficient data for the remaining 39%, of which 30% of these, or 39 species, were of "Least Concern" because they were either common or widespread. Five endemic species (4%) are considered near threatened, three species (2%) are considered vulnerable, and the last two categories, critically endangered and endangered are each represented by two species (1.5%). If this 39% is considered a representative sample of all Palaun species, we can make an estimate of the IUCN categories for the 61% of data deficient taxa and the entire endemic flora.

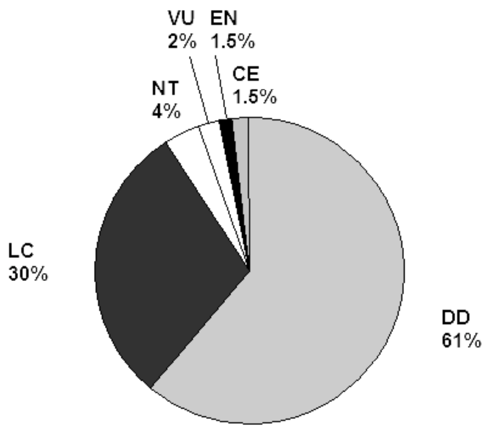

Figure 6: Percentages of all plants assessed for each IUCN red list category

The percentages of the species with sufficient data are shown in Figure 6. If we assume that the data deficient taxa follow a similar proportion of rareness then it can be estimated that there would be approximately 99 species of least concern, 13 species of near threatened, eight vulnerable species, five endangered, and five critically endangered endemic species for Palau. This is a very conservative estimate, as many of the species considered of least concern are taxa that are well known. It is more likely that there will be a higher proportion of threatened species represented from the Data Deficient category listed here. Many of Palau's poorly known taxa may be rare or have restricted ranges. Indeed a total of 19 (15%) are only known from the type collections. An estimated minimum number of endemic plants expected to be threatened in Palau is inferred as shown in Figure 7. This was calculated by excluding the data deficient taxa then recalculating percentages for all known taxa. The 39 (30%) LC taxa becomes 76% which is then multiplied by 130, the total number of endemic species equaling 99. The minimum expectation is the sum of 8, 5 and 5 (VU + EN + CE in Figure 7), 18 species (14%). An additional 1% is added to give the greater benefit of doubt considering this is a conservative estimate. This produces an estimation of 20 (15%) out of the total of Palau's endemic plants. It is stressed that this is the estimated minimum that may be considered threatened following more thorough studies. By the time these studies are done, there may very likely be additional or increased threats.

Previous results produced by the author (Costion 2007) demonstrate that this may be a relatively accurate expectation. Turnover, or β diversity, for the island of Babeldaob was calculated using DIVA-GIS. The results clearly suggested that most of Palau's endemics are widely distributed across the island, with a small percentage that have small restricted ranges or disjunct distributions.

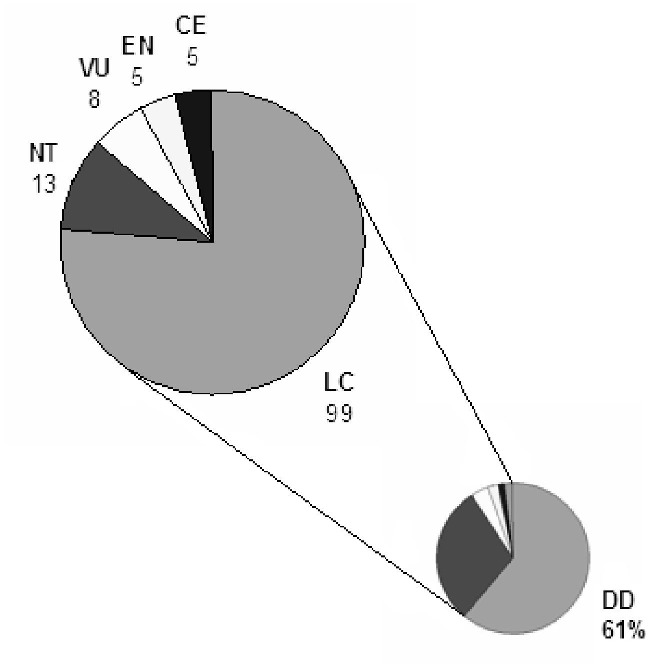

Figure 7: Percentages inferred from the total of assessed taxa with sufficient data. The lower pie is the same as that in Figure 6.

The results showed a significant difference in β diversity for all native species compared to the β diversity for endemic species only. Clearly, the endemic species formed a more consistent component of the vegetation across the island as a whole, with a small turnover rate, whereas the same analysis for native species showed a higher turnover rate.

Six endemic trees are known to have rare and restricted populations including *Ponapea palauensis*, mentioned above. *Parkia parvifoliola* is only known from one healthy population with two scattered individuals adjacent to this area and three disjunct individuals recorded further south. *Terminalia crassipes* is a riparian tree only known to occur along two of Babeldaob's river systems. *Rauvolfia insularis* occurs in very small numbers with a scattered distribution. *Goniothalmus carolinensis* is a poorly known species that has only been recorded from a few collections on Babeldoab. Kitalong (2008) documented the occurrence of G. carolinensis on the limestone islands. This data however could not be sourced or verified so it remains listed as restricted to the volcanic islands. *Manilkara udoido* is abundant and can form a dominant understory canopy where it occurs, but its range is restricted to the southern portion of Babeldaob with the exception of a few disjunct individuals. The causes of population disjunctions for all of these trees are unknown.

BIOGEOGRAPHIC COMPARISON

A total of 724 plants are listed as native or endemic in Palau's latest checklist (Kitalong et al. 2008). If the total number of endemic species, 130, are divided by this figure then Palau has a rate of endemism calculated by no. of endemic spp. (E/N), of 18%. Calculated per sq. km for the total land area, 458 km^2, the rate is 29%. These new figures are important in that is has been traditionally assumed that Palau has the highest plant endemism rates in Micronesia. Based on the revised data presented here Palau appears to not be significantly different from other Micronesian islands. Guam has a plant endemism rate of 21% (calculated by E/N) based on statistics from the Flora of Guam (Stone, 1970). This percentage exceeds that of Palau's. The list of endemic species for Guam however, may need to be updated as recent work in the Caroline Islands has clearly demonstrated. The number of accepted native and endemic species has significantly changed since 1970. Recent estimates for the eastern Caroline Islands (Balick unpubl.) indicate that Pohnpei's flora is only 1% lower than Palau (calculated by E/N) and Kosrae's flora is also only 1% lower (calculated by E/km^2) showing comparable rates of endemism to that of Palau's.

Distance from continental sources have clearly effected the richness of plant species in the islands of Micronesia, but does not appear to have affected equally the rates of plant endemism. Similar results are shown by (Keppel 2008, Keppel et al. 2009) where isolation is highlighted as a more significant factor contributing to plant endemism rates on oceanic islands in the Southwest Pacifc. What factors then, are most significant in determining rates of plant endemism in the region; distance from source, island size, elevation gradients, or island age? A comprehensive biogeographical analysis and comparison of floristic data for each of the respective islands in the Micronesian region is now needed to explore these questions further. This should include updated checklists for native and endemic species for each island. Palau, Pohnpei, and Kosrae have all been recently updated and checklists are currently being finalized for publication. Updates are needed for Guam, Yap, and Chuuk.

THREATS

Palau boasts 70% of its land mass covered by intact forest. On Babeldaob, it is difficult to discern areas that are actually pristine primary forest from forests regenerated from early Palauan disturbance however the limestone Rock Islands are the least impacted and contain areas virtually untouched. Their inaccessibility renders a comforting protection to them and they are one of the only areas remaining as such in all of Micronesia (Mueller-Dombois & Fosberg 1998). As a whole, Palau may be considered a "good news area" for Micronesia (Myers et al. 2000), with its high percentage of intact forest. For this to remain true prompt action must be taken as the island of Babeldaob, approximately 70 % of the total land mass of the archipelago, faces increasing imminent threat from development.

Islands have historically been exceptionally vulnerable to extinctions. The IUCN determined that of all recorded extinctions for mammals, birds, amphibians, reptiles, and molluscs; 72% were island species (Baillie et al. 2004). This has been especially true for birds. Ricketts et al. (2005) document 245 extinctions from mammals, birds, selected reptiles, amphibians, and conifers that have occurred since 1500. Of these, 80% occurred on islands and more than one half were from tropical moist forests. The current percentage is now more balanced, but not due to a reduced threat on islands, rather an increased threat in continental areas (Ricketts et al. 2005; Baillie et al. 2004). Islands are still arguably at greatest risk. Of all the recorded extinctions that occurred after 1983, over half were from islands, the bulk of which were from Hawaii and Guam (Baillie et al. 2004). These extinctions render the Pacific as having more recorded extinctions over the last 25 years than any other biogeographic realm. This suggests that the Pacific islands may be one of the most threatened of all of Myers et al. (2000) biodiversity hotspot regions, or at least the most vulnerable to extinction.

Of the recent extinctions, 85% of species had restricted ranges. Commonly cited causes of extinction are habitat loss, invasive alien species, and over-exploitation. Of the recent extinctions post-1983, the most commonly recorded cause was habitat loss, followed by introduced species. Over-exploitation was not a significant factor in these recent extinctions (Baillie et al. 2004). This trend is similar historically and highly relevant in Palau.

The primary threat to native vegetation historically in Palau has been forest degradation as a result of human activities. Palaeoenvironmental investigations conducted in Palau (Athens & Ward, 2002, 2005) provide convincing evidence that the island of Babeldaob was entirely forested prior to human colonization. After the first evidence of humans occurs in the pollen records, charcoal deposits as well as pollen from savanna indicator species; Poaceae, Pandanaceae, and Cyperaceae, rise significantly. These pollen types are absent or minimal prior to this. In addition, several unknown pollen types recorded from pre-human times rapidly decrease after human settlement. Some of them completely disappear and are no longer present in contemporary pollen profiles.

Similar results have been shown for other Pacific islands. On the island of Kosrae, the entire lowland vegetation was replaced by agroforest within 500 years of human colonization (Athens et al. 1996). On the island of O'ahu, Hawaii a similar scenario has been shown although the causes are less likely to be due to direct clearing for agriculture and possibly related to the introduction of the pacific rat or other causes (Athens 1997, Athens et al. 2002). On the island of Guam, indicators of disturbance arise around the same time as Palau at 4500 to 4300 cal. BP. Ample evidence from additional islands throughout the Pacific support a similar scenario occurring at different times, all independent of climate change (Athens & Ward 2005).

This implies that not only has the extent of native forest been significantly reduced, but many current areas of seemingly "pristine" forest may actually be re-growth. Studies in Palau have shown (Endress & Chinea 2001) that the edges of forest do expand back into savanna areas if the savannas are left alone and not burnt. Further more, the evidence of "unknown" pollen types suggests the likelihood that some species may have either been significantly reduced in their area of occurrence or even gone extinct. This evidence raises many questions regarding the rare and disjunct distribution patterns of several of Babeldaob's endemic species discussed above.

Endemic plants that are rare or with very small restricted natural ranges, often restricted only to one hilltop or valley, are not uncommon in the tropics (Myers 1988, 1990). These localized endemics with very small ranges are well documented in the Neotropics and on islands (Gentry 1986; Cody 1986). These can be neoendemics that have evolved more recently such as the case in Amazonia with the result of Andean uplift creating many new isolated habitats (Gentry 1982), or relict or palaeo-endemics which are often rare due to the loss of a former more widespread habitat such as has been suggested for many monotypic genera in the Australian wet tropics of Queensland (Bowman 2000, Kershaw et al. 2005, Greenwood & D. C. Christophel 2005). Alternatively they may be localized as a result of human activities and habitat loss.

The neoendemic model proposed by Gentry (1982) implies habitat specialization. Although *Ponapea palauensis* is only found near depressions that are damp or near lakes in the Rock Islands and *Terminalia crassipes* is restricted to streams and rivers, their distributions are disjunct and restricted. Although not a complete explanation, as not all of the known rare endemics occur in specialized habitats, recent molecular work strongly supports the notion that much of the Pacific biota has evolved recently (Price & Clague 2002; Keast 1996; Keppel et al. 2008a, 2009, unpubl.).

The palaeo-endemic model is unlikely due to the relatively young age of the islands. In any case, there is insufficient palaeoenvironmental data but the studies that have been done (Athens 1997; Athens & Ward 2002, 2005; Athens et al. 2002) do not indicate significant vegetation turnover prior to human settlement in the Pacific.

The relationship between the increase in charcoal and savanna indicators, as well as the loss of "unknown" pollen types at the time of human colonization, is suggestive of an anthropogenic cause of rarity. However, the mystery is far from solved. More data and studies are needed to support any of the above hypotheses for Palau. The causes of rarity in the tropics are a poorly understood and are an understudied topic. In any case it is indisputable that these plants are significantly threatened. Their habitats need only be destabilized or disturbed to put them at risk of "summary extinction" or secondary causes of extinction (MacArther & Wilson 1967, Myers 1988, MacKinnon 2005).

Historically fire has clearly been the most effective method of forest clearing for Palauans, but this has become an increasingly pertinent issue today. Traditional systems of government that regulated the use of fire have eroded. Every year careless fires are lit and occasionally some get out of control and destroy patches of forest. Today however, fire is not the only threat to Babeldaob's remaining forest. The construction of the 53 mile Compact Road, which encircles the island, has opened Babeldaob up for development. Building the road was part of the Compact Free Association Agreement with the US, which granted Palau independence. In return for allowing the US military access to the island at anytime in the future Palau was granted the funding for the Compact Road, additional funding, and other benefits. There has been much written about this elsewhere. It is mentioned here only to highlight a potentially significant future threat. The construction of a US military base on Babeldaob would undoubtedly result in massive forest clearance and pose a serious threat to some of Palau's rare trees among other environmental problems. This has certainly been the case in Guam.

A national highway, which has very much been needed and appreciated by the island's inhabitants, has now for the first time made development on the island of Babeldaob possible. The majority of the country's population resides on the island of Koror but many have plans to build and resettle on Babeldaob after the road is completed. Others have plans to lease land to foreign developers for building vacation homes for Asian tourists, building resorts and some even propose building golf courses. The impact of such development on such a tiny island ecosystem will be severe.

Invasive species are playing an increasingly significant role in Palau though this has not to date been as extreme as has happened on other Pacific islands such as Hawaii. Much on this topic has been treated elsewhere. Notable invasive plants include the interestingly native but invasive vine *Merremia peltata, Clidemia hirta* in the understory, and *Falcataria moluccana* which towers over the native canopy layer out-competing native trees. On a whole however, invasive species appear to be a secondary or lesser threat to that of habitat loss. Areas of Babeldaob harboring major invasions of non-native plants tend to be previously disturbed areas. The primary forest remains very much intact and native. From the pollen record, Athens & Ward (2002) documented that Palau's native forests displayed a resilience to introduced species brought by early Palauans giving the island a "non-insular" character. This curious documentation is worthy of further investigation.

Climate change has been documented as a significant threat to existing rare plant populations across the globe (Harte et al. 2004; Thomas et al. 2004; Hannah et al. 2005;). Modeling techniques have been developed that can predict the amount of change that particular ecosystems are expected to undergo given current global warming trends (Li & Hilbert 2008; Beaumont et al. 2005, 2008; Hijmans & Graham 2006). Whilst modeling methods are still developing, it is well established that native ranges of many plant species are expected to change significantly as global temperatures rise and rainfall patterns change (Bartlein et al. 1997; Matsui et al. 2008; Tylianakis et al. 2008; Wirth et al. 2008). This can, and is likely to, lead to many extinctions where species' ranges are restricted. Habitat fragmentation, which is occurring everywhere on earth at alarming rates, has been acknowledged as a serious exacerbant of the problem presenting additional barriers to plant and animal migration corridors. As a whole, knowledge on this topic is very limited for the tropics (Stork et al. 2007; Colwell et al. 2008). However analyses have been conducted for the Queensland Wet Tropics (Hilbert et al. 2001; Williams et al. 2003), and in other montane areas of the tropics (Colwell et al. 2008; Raxworthy et al. 2008), which stress a significant proportion of species that will be pushed to extinction as their habitable ranges shrink, or even vanish completely leaving them with nowhere to migrate to.

Virtually no comparable studies have been conducted for tropical Pacific Islands. However, both the Queensland wet tropics and the montane tropics are comparable to that of Micronesia. Both mountain tops and islands serve to isolate gene pools which can promote speciation events, but are particularly vulnerable to extinction. The Queensland Wet Tropics region has also been regarded as having an insular character, being a rainforest pocket within an arid continent. It also shares many genera with Palau. Given this, it is reasonable to expect similar future climate change induced species extinctions on islands of the Pacific. Further information and study on this issue is urgently needed, as vegetation turnover in response to past climate change in the Pacific palaeoenvironmental record is a hotly debated topic.

This evidence presented above justifies the application of IUCN red list criteria B (b(iii)) for several of Palau's endemic plants. This criterion refers to a continuing decline in area/extent or quality of habitat. Clearly Palau's forests as a whole have been in decline since early human occupation. There has likely been some regeneration at particular intervals, but the current trend with the opening of Babeldaob for development is certainly continuing decline. Since very few population-based studies have been conducted in Palau, this criterion, in addition to cases where species qualify as fragmented and very small in population size, have been the primary criteria used for establishing threatened status in this report. It is hoped that a comprehensive study can be funded and conducted to assess all of Palau's endemic plants. This will not only improve the data presented here by conducting population studies but also fill the huge data deficiency gap for Palau's poorly known taxa.

Although the rate of data deficiency for Palau is exceptionally high, this is not surprising. In one of their recent global assessments, the IUCN (Baillie et al. 2004) determined that only 4% of the worlds described plant species have been evaluated under the IUCN Red List Criteria (IUCN 2001). Since 3% of these are listed as threatened it is evident that assessments have been biased towards selected taxa that are known to be threatened. Considering the known threats, and the vulnerability of island endemics to extinction, it is imperative that Palau's 61% data deficient endemic plants be assessed. If a threatened species does not have formal recognition of its rarity, it is very difficult to justify its protection and prevent the loss of crucial habitat. In 2001, the Conservation International established a goal to increase the number of plants on the IUCN Red List to meet the 2010 CBD target of obtaining preliminary assessments of all the world's described plant species (Baillie et al. 2004). Since Palau is a member of the CBD this need is even more relevant. Focusing efforts of the assessment first on the endemics is an obvious priority. This has been successfully achieved in much larger tropical regions including the island of Socotra, Ecuador (Baillie et al. 2004) and is a realistic goal for Palau.

Conclusion

A total of 130 endemic plants are listed here as endemic to the Palau archipelago, 75 restricted to volcanic islands, 31 restricted to limestone, and 24 occurring widespread. Several of these are known to have small, restricted ranges and a total of 7 qualify for threatened status under the IUCN red list criteria. Although there is a considerable paucity of data for over half of Palau's endemic plants it can be expected that at least 15% are threatened. It is clear that the plants with restricted ranges on the volcanic islands are the most threatened due to human activities, primarily forest clearance. Evidence suggests that this is not a recent trend but has continued from the very first early Palauan settlers. Recent development however has accelerated this trend significantly making the need for a complete understanding of the distribution of Palau's endemic plants more pertinent then ever. A full scale IUCN red list assessment for all of Palau's endemic plants, especially those listed as data deficient in this paper, is urgently needed along with studies investigating the degree of threat posed by climate change.

The results presented here are by no means a final product. It is expected that the number of endemic species cited here will actually decrease as further taxonomic studies are conducted, not increase as has been previously suggested. The discovery of a few new species is also likely. However the likelihood of several species listed here as endemic being reduced to synonymy in the future is much higher. Furthermore, as additional collections are made and studies are conducted, current understandings of plant distributions may change.

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Checklist of Endemic Species

Taxon Name	Substrate	Form	Abundance	Status
Lycophyta				
SELLAGINELLACEAE				
Selaginella dorsicola Hosok.	V	H	U	DD
Selaginella palauensis Hosok.	V	H	U	DD
Selaginella pseudo-volkensii Hosok.	V	H	U	DD
Pteridophyta				
LOMARIOPSIDACEAE				
Cyclopeltis kingii (Hance) Hosok.	L	H-E	DD	DD
PTERIDACEAE				
Adiantum palaoense C. Chr. *	V	H	DD	DD
Pteris tapeinidiifolia H. Itô *	L	H-E	DD	DD
POLYPODIACEAE				
Grammitis palauensis Hosok. +	V	E	DD	DD
Prosaptia palauensis Hosok.	V	H	DD	DD
THELYPTERIDACEAE				
Thelypteris carolinensis (Hosok.) Fosberg +	L	H	DD	DD
Thelypteris pseudarfakiana (Hosok.) C.F. Reed *	V	H	DD	DD
Thelypteris rupi-insularis Fosberg +	L	H	DD	DD
Basal Angiosperms				
ANNONACEAE				
Goniothalamus carolinensis Kaneh.	V	T	U-R	NT
Polyalthia merrillii Kaneh. *	L	T	DD	DD
MYRISTICACEAE				
Horsfieldia palauensis Kaneh.	G	T	C	LC
PIPERACEAE				
Peperomia kraemeri C.DC.	G	H	DD	LC
Peperomia palauensis C.DC.	G	H	C	LC
Piper hosokawae Fosberg	G	L	C	LC
Monocots				
ARECACEAE				
Ponapea palauensis Kaneh.	L	T	U-R	**CE** (B2abc)
Hydriastele palauensis (Becc.) W.J.Baker & Loo	L	T	U-R	NT
CYPERACEAE				
Hypolytrum flavinux (T.Koyama) D.A. Simpson *	V	H	DD	DD
Fimbristylis palauensis Ohwi *	V	H	DD	DD
ORCHIDACEAE				
Bulbophyllum desmanthum Tuyama *	V	E	DD	DD
Bulbophyllum hatusimanum Tuyama	V	E	DD	DD
Chiloschista loheri Schltr.	G	E	C	LC
Cleisostoma porrigens (Fukuy.) Garay	V	E	U	DD
Crepidium calcarea (Schltr.) D. L. Szlachetko	L	H	DD	DD
Crepidium kerstingiana (Schltr.) D.L. Szlachetko *	G	H	U	DD

Taxon Name	Substrate	Form	Abundance	Status
Crepidium palawensis (Schltr.) D. L. Szlachetko	V	H	U	LC
Crepidium setipes (Schltr.) D. L. Szlachetko	V	H	A	LC
Cystorchis ogurae (Tuyama) Ormerod & P.J.Cribb	V	H	DD	DD
Dendrobium brachyanthum Schltr.	V	E	C	LC
Dendrobium implicatum Fukuy.	V	E	DD	DD
Dendrobium kerstingianum Schltr. *	V	E	DD	DD
Dendrobium palawense Schltr. *	L	E	DD	DD
Dendrobium patentifiliforme Hosok. +	V	E	DD	DD
Dipodium freycinetioides Fukuy.	V	E	C	DD
Liparis dolichostachya Fukuy. +	V	H-E	DD	DD
Liparis palawensis Tuyama *	V	H-E	DD	DD
Liparis yamadae (Tuyama) Fosberg & Sachet *	V	H-E	DD	DD
Micropera draco (Tuyama) P.J. Cribb & P. Ormerod +	V	E	DD	DD
Moerenhoutia laxa Schltr.	V	H	U	DD
Nervilia trichophylla Fukuy. +	V	H	R	NT
Oberonia palawensis Schltr.	G	E-H	DD	LC
Peristylus palawensis (Tuyama) Tuyama	V	H	R	NT
Phreatia kanehirae Fukuy.	V	E	DD	DD
Phreatia palawensis (Schltr.) Tuayama	L	E	DD	DD
Robiquetia palawensis Tuyama	G	E	DD	DD
Taeniophyllum palawense Schltr.	V	E	U	DD
Zeuxine palawensis Tuyama	V	H	C	LC
PANDANACEAE				
Freycinetia villalobosii Martelli	V	L	C-A	LC
Pandanus aimiriikensis Martelli	V	T(u)	C-A	LC
Pandanus kanehirae Martelli	V	T	U	NT
Pandanus lorencei Huynh +	L	T	DD	DD
Pandanus macrojeanneretia Martelli	V	T	U	DD
Pandanus palawensis Martelli	V	T	DD	DD
Pandanus peliliuensis Kaneh. +	L	T-S	DD	**VU** (D2)
POACEAE				
Panicum palauense Ohwi *	V	H	DD	DD
Eudicots				
ACANTHACEAE				
Hemigraphis palauana Hosok. +	V	H	DD	DD
Pseuderanthemum inclusum Hosok.	V	H	DD	DD
ANACARDIACEAE				
Buchanania palawensis Lauterb.	G	T	C	LC
APOCYNACEAE				
Melodinus insularis (Markgr.) Fosberg *	V	L	DD	DD
Rauvolfia insularis Markgr.	V	T	U,RR	**VU** (D1,2)
ARALIACEAE				
Osmoxylon oliveri Fosberg & Sachet	G	T(u)	A	LC
Osmoxylon pachyphyllum (Kaneh.) Fosberg & Sachet	G	T(u)	U	LC

Taxon Name	**Substrate**	**Form**	**Abundance**	**Status**
Osmoxylon truncatum (Kaneh.) Fosberg & Sachet +	V	T(u)	DD	DD
BORAGINACEAE				
Cordia micronesica Kaneh. & Hatus.	V	T	U-R	DD
CAPARIDACEAE				
Capparis carolinensis Kaneh. *	L	S	DD	DD
CELASTRACEAE				
Maytenus palauica (Loes.) Fosberg	G	S	C	LC
CLUSIACEAE				
Calophyllum pelewense P.F. Stevens	V	T(c)	U	DD
Garcinia matsudai Kaneh.	V	T	C-A	LC
Kayea pacifica Hosok.	V	T	U, DD	DD
COMBRETACEAE				
Terminalia crassipes Kaneh. & Hatus.	V	T(c)	A, RR	**EN** (B1ab(iii) +2a,b(iii))
CUCURBITACEAE				
Trichosanthes hosokawae Fosberg *	L	L	DD	LC
ELAEOCARPACEAE				
Elaeocarpus rubidus Kaneh. +	L	T	DD	DD
EUPHORBIACEAE				
Claoxylon longiracemosum Hosok.	V	T	U	DD
Cleidion sessile Kaneh. & Hatus.	L	T	DD	DD
FABACEAE				
Crudia cynometroides Hosok.	V	T	U	DD
Dalbergia palauensis Hosok.	V	L	DD	DD
Parkia parvifoliola Hosok.	V	T(c)	R, RR	**EN** (B1ab(iii) +2ab(iii))
GENTIANACEAE				
Fagraea ksid Gilg & Benedict	V	T	C	LC
GESNARIACEAE				
Cyrtandra palawensis Schltr.	V	L	U-C	LC
Cyrtandra todaiensis Kaneh.	L	S	DD	LC
MALVACEAE				
Sterculia palauensis Kaneh.	L	T(c)	DD	DD
Trichospermum ledermannii Burret	V	S	A	LC
MELESTOMATACEAE				
Astronidium palauense (Kanehira) Markgr.	V	T(u)	C	LC
Medinilla blumeana Mansf.	V	L	DD	DD
MYRSINACEAE				
Discocalyx mezii Hosok. *	G	T(u)	U, DD	DD
Discocalyx palauensis Hosok. +	L	T	DD	DD
Maesa palauensis Mez *	L	S	DD	LC
Myrsine palauensis (Mez) Fosberg & Sachet	V	T(u)	C	LC
MYRTACEAE				
Syzygium palauensis (Kaneh.) Hosok. *	G	T		DD
OLACACEAE				
Anacolosa glochidiiformis Kaneh. & Hatus.	G	T	U	DD
PHYLLANTHACEAE				
Cleistanthus carolinianus Jabl.	G	T	U	LC
Cleistanthus insularis Kaneh. *	V	T	U	DD

Taxon Name	Substrate	Form	Abundance	Status
Glochidion macrosepalum Hosok.	G	S	DD	LC
Glochidion palauense Hosok. *	G	T	C	LC
Phyllanthus palauensis Hosok.	V	S	C-A	LC
Phyllanthus rupi-insularis Hosok.	L	S	DD	LC
PUTRANJIVACEAE				
Drypetes nitida Kaneh.	G	T	C	LC
RHAMNACEAE				
Ventilago nisidai Kaneh.	V	L-S	DD	DD
RUBIACEAE				
Badusa palauensis Valeton	G	T	C	LC
Bikkia palauensis Valeton	L	S	C	LC
Hedyotis aimiriikensis Kaneh. *	V	S	DD	DD
Hedyotis cornifolia Kaneh.	V	H	DD	DD
Hedyotis korrorensis (Valeton) Hosok	V	S	C-A	LC
Hedyotis sachetiana Fosberg *	V	S	DD	DD
Hedyotis suborthogona Hosok. +	V	H	DD	DD
Hedyotis tomentosa (Valeton) Hosok.	G	H	C	DD
Hedyotis tuyamae Hosok.	V	S	DD	DD
Maesa canfieldiae Fosberg & Sachet *	L	T-S	DD	**VU** (D2)
Morinda latibractea Valeton	L	T(u)	U	DD
Morinda pedunculata Valeton	V	S-T	C	LC
Ophiorrhiza palauensis Valeton	G	H	U	DD
Psychotria cheathamiana Kaneh. *	L	T(u)	DD	DD
Psychotria diospyrifolia Kaneh.	V	L-S	U	DD
Psychotria mycetoides Valeton +	V	S	DD	DD
Timonius corymbosus Valeton	G	T-S	DD	DD
Timonius korrensis Kaneh. +	L	T	DD	DD
Timonius mollis Valeton	V	T(u)	DD	DD
Timonius subauritus Valeton	V	S	C	LC
Timonius salsedoi Fosberg & Sachet +	V	T(u)	DD	**CE** (B1ab(iii) +2,ab(iii))
RUTACEAE				
Melicope palawensis (Lauterb.) T.G.Hartley	L	S	C	LC
Melicope trichantha (Lauterb.) T.G.Hartley *	V	S-T	DD	DD
SAPINDACEAE				
Elattostachys palauensis Hosok. +	L	T	DD	DD
SAPOTACEAE				
Manilkara udoido Kaneh.	V	T	C-D,RR	LC
Planchonella calcarea (Hosok.) P. Royen	L	T	DD	DD
SALICACEAE				
Casearia hirtella Hosok.	G	T	C	LC
URTICACEAE				
Elatostema stoloniforme Kaneh. *	V	H	DD	DD
Pipturus micronesicus Kaneh. *	L	S	DD	DD
VITACEAE				
Cayratia palauana (Hosok.) Suesseng. +	L	L	DD	DD

Checklist of Endemic Varieties

Taxon Name	**Substrate**	**Form**	**Abundance**
ARECACEAE			
Heterospathe elata Scheff. var. *palauensis* (Becc.) Becc.	G	T	C-D
CLUSIACEAE			
Calophyllum inophyllum var. *wakamatsui* (Kaneh.) Fosberg & Sachet	V	T	A
Garcinia rumiyo var. calcicola Fosberg	L	T	C
EBENACEAE			
Diospyros ferrea (Willd.) Bakh. *var. palauensis* (Kanehira) Fosberg	G	T(u)	C
EUPHORBIACEAE			
Acalypha amentacea Roxb. *var. heterotricha* Fosberg *	V	S	C
Acalypha amentacea Roxb. *var. palauensis* Fosberg +	L	S	R
FABACEAE			
Serianthes kanehirae var. *kanehirae* Fosberg	G	T	U-C
GENTIANACEAE			
Fagraea berteroana var. *galilai* (Gilg & Benedict) Fosberg	V	HP	U
ORCHIDACEAE			
Zeuxine palawensis var. variegata Tuyama *	V	H	U
PIPERACEAE			
Peperomia palauensis C.DC. var. *occidentalis* Fosberg	L	H	U-C
POACEAE			
Pschaemum polystachyum Presl var. *chordatum* (Trin.) Fosberg &Sachet	V	H	DD
Paspalum orbiculare G. Forst. var. *otobedii* Fosberg & Sachet	V	H	DD
RUBIACEAE			
Hedyotis divaricata (Valeton) Hosok. var. *divaricata*	V	H	R
Psychotria hombroniana var. *canfieldiae* Fosberg	L	T(u)	C
Psychotria hombroniana var. *peliliuensis* Fosberg +	L	T(u)	DD
Psychotria rotensis var. palauensis (Hosok.) Fosberg	L	T(u)	C
Timonius corymbosus Valeton *var. takamatsui* Fosberg & Sachet	L	S	DD
Timonius mollis Valeton *var. submollis* Fosberg & Sachet	V	T(u)	DD
Timonius mollis var. villosissimus (Kaneh.) Fosberg & Sachet	V	S	DD
Timonius subauritus var. strigosus Fosberg & Sachet	V	S	DD
Uncaria lanosa var. korrensis (Kaneh.) Ridsdale	V	S	C
SCROPHULARIACEAE			
Limnophila fragrans (G. Forst) Seem var. *brevis* Schltr.	?	H	DD
SYMPLOCACEAE			
Symplocos racemosa Roxb. *var. palauensis* (Koidz.) Nooteb.	V	T	A