CHAPTER 1
ECOLOGY IN PALAU

Christopher Kitalong, David Mason

Settings

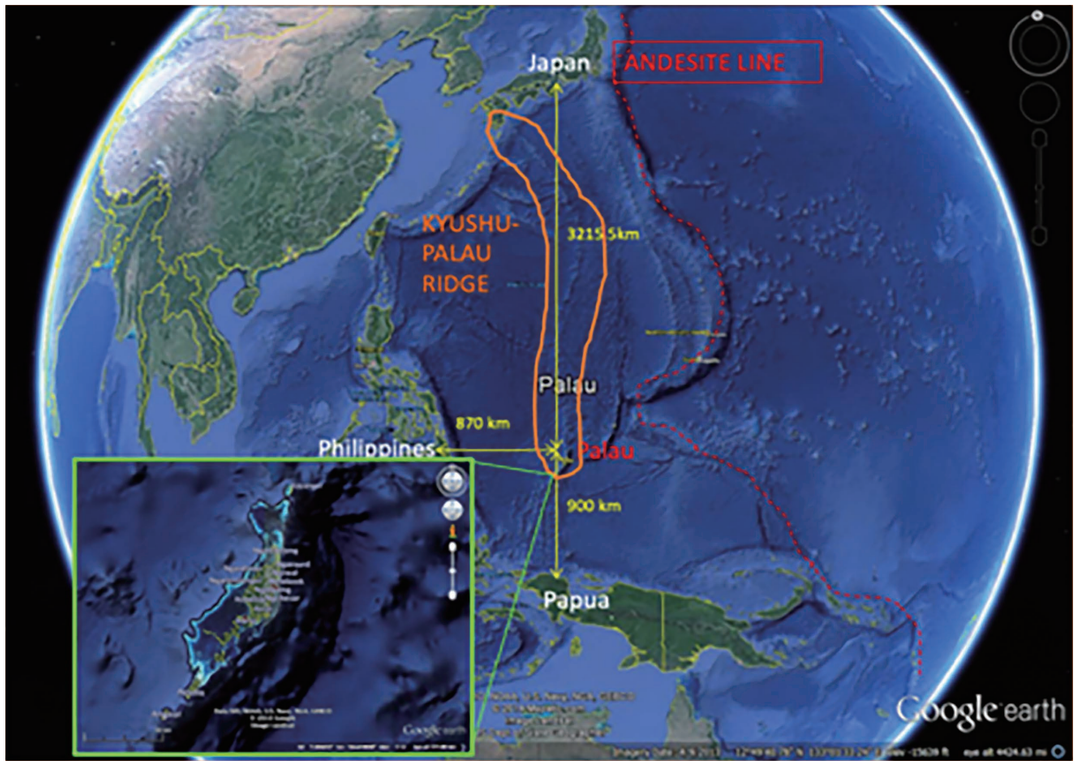

Fig. 1. Map of Palau, directly south of Japan and east of the Philippines.

The Republic of Palau is the westernmost archipelago of the Caroline Islands in Micronesia with approximately 586 islands covering a land area of 535 km^2. The archipelago extends 700 km northeast to southwest, from latitudes 8°12' to 2°48' North/South and longitudes 131°07' to 134°44' East/West, lying 900 km north of Irian Jaya, West Papua and 870 km east of the Philippines (PALARIS, 2012, Fig.1). Palau has a diverse assemblage of over 1,389 plants of which 802 are native and 571 are introduced; at least 135 of the native plants are endemic and has the highest species endemism per area in Micronesia(Costion and Lorence, 2012). Palau also has the largest tract of tropical lowland forest in the Pacific (Kitalong, 2014). In 1979, nearly 218 km^2 or 52% of Palau's land was covered with lowland forests. Yet, slowly, forests are being cut for homesteads, development and roads. Forest trees and plants are valued as sources of timber, food, medicine, habitat for other species, and for their cultural and aesthetic value (Kitalong, 2008).

The archipelago of Palau was formed during the Eocene epoch, 40 million years ago by the subduction of the Pacific Plate beneath the Philippine Plate along the Kyushu-Palau Ridge (PALARIS, 2009). Palau lies on the east edge of the Andesite Line, which divides the deeper basalts of the Central Pacific Basin from the partially submerged continental areas of andesite. Volcanism ceased 20 million years ago and was succeeded by submergence of islands and formation of the barrier reef began. During this same period of submergence, uplift occurred and the limestone islands and raised atolls of southern Palau were formed. The limestone formed beneath the sea and became exposed through uplift that occurred in the last 3-4 million years. Subaerial erosion formed the karst landforms seen today in the limestone islands (Kayanne et al., 2002). Babeldaob, the largest volcanic island, covers an area of 365 km^2 (including 33 km^2 of mangroves) and extends 37 km in length and 6 to 13 km in width. The highest elevation for this old volcanic island is 213 m at Mount Ngerchelchuus in central Babeldaob with the volcanic islands of Ngarkebesang, Malakal and Koror to the south, and the atolls of Kayangel state to the north (Kitalong, 2014).

Ecology in Palau

The landscape of Palau is one of a medium to low volcanic island chain with large fringing and/or barrier reefs. The Palauan island chain has all three-island types: volcanic, limestone and atolls. Palau's proximity to the Asian continent, Philippines, and Indonesia results in increased radiation of plant taxa compared to other islands in Micronesia. Despite being the closest Micronesian island to larger land masses, Palau is still relatively isolated. Due to these factors, Palau has the greatest number of endemics and highest species richness in the Micronesian island chain (Canfield, 1981). However, the amount of arable soil is very limited and very prone to erosion. As suggested by the USDA report deposited at Forestry Service in Palau,

> *"The most fertile soils in this survey area are those that are under forest vegetation, mainly because of large amounts of organic matter, which provides nutrients for plants. As fallen leaves and branches rot, organic matter and nutrients are returned to the soil. Before these nutrients can be reached through the soil and lost, roots absorb them and the process begins again. In this way, forest soils retain their fertility. In addition, the forest canopy and layer of fallen and dead leaves (called litter) provide protection from erosion (United States Department of Agriculture, 2009)."*

Heavy, unmitigated development and agriculture causes sedimentation and loss of this thin, fertile layer soil. In general, the most favorable pH range for plant development is between 5.5 to 6.5 in mineral soil and 5.0 to 6.0 in organic soil, and the acidity of the mostly mineral soil on most of Palau (4.9-5.1) limits intense export-based agriculture (Foy, 1992). The majority of soil in Palau is highly ferrous saprolite that is very prone to landslides and therefore does not retain arable topsoil well (Hurst, 1977; United States Department of Agriculture, 2009). Increased development activity and agriculture without soil erosion mitigation has resulted in increased acidification of the soil and loss of arable topsoil. This activity will be addressed later in this chapter in section 1.5, which discusses land use by foreign occupancy in Palau. The areas in Palau that are used for plant cultivation are lowland and/or terraced upper forested areas, where heavy mulching, fertilizer or other soil treatment is necessary. Furthermore, the low-nutrient, hard and porous substrate of the limestone islands and sand substrate of the atolls are not suitable for large-scale agriculture. These factors make plant growth difficult, which from an evolutionary perspective may affect immigration rates and cause specific adaptive changes in original taxa to survive harsh circumstances leading to differentiation of species. Natural and human impact factors, discussed in the upcoming sections, leave Palau with vegetation types similar to other areas of the Pacific and Southeast Asia. Vegetative types are mainly dependent on substrate/soil (Donnegan et al., 2007).

Vegetation types

There are three main vegetation types on the limestone rock islands of Palau: *strand vegetation*, which found on atolls and coastal areas of the main volcanic island and rock islands; *limestone forests* that are restricted to the larger limestone "Rock Islands" and consist of a mixture of limestone-specific species and species shared with the large volcanic islands of Palau; and *mangrove forests* that occupy the brackish water zones, where salt and freshwater mix. The larger volcanic islands of Babeldaob and Koror are the most species rich with vegetative types include limestone forest, strand vegetation mangrove forest, as well as *lowland forests, swamp/wetland forests, riparian forests, interior forests* and *savannas* (Canfield, 1981; Costion and Lorence, 2012; Donnegan et al., 2007; Kitalong et al , 2013). A more detailed listing of vegetative types is found below.

1. Mangrove

Mangroves are important buffer zones that reduce sedimentation along coastal areas. They also provide a nursery and habitat for marine, intertidal and terrestrial fauna. The mangroves of Palau are species-rich extending along tidal zones with reduced wave activity. The regularly occurring species found here include *Rhizophora mucronata* Lam., *Rhizophora apiculata* Blume, *Bruguiera gymnorrhiza* (L.) Lam., *Ceriops tagal* (Perr.) C. B. Rob., *Dolichandrone spathacea* (L.) Seem, *Sonneratia alba* J.E. Smith, *Avicennia marina* (Forssk.) Vierh., *Lumnitzera littorea* (Jack) Voigt, *Xylocarpus granatum* Koenig, *Scyphiphora hydrophylacea* C.F. Gaertn., *Dalbergia candenatensis* (Dennst.) Prain and *Nypa fruticans* Wurmb. Mangroves are very dense forest types and when left undisturbed, can expand quite rapidly in Palau (Canfield, 1981; Costion and Lorence, 2012; Donnegan et al., 2007; Kitalong, 2014).

2. Swamp forest

This forest type tends to buffer mangrove areas in slightly brackish water or exists around fresh water sources, mostly wetlands buffering riparian/ravine areas. *Horsfieldia irya* (Gaertn.) Warb., *H. palauensis* Kaneh., *Cynometra ramiflora* L., *Barringtonia racemosa* (L.) Spreng.,*Campnosperma brevipetiolata* Volk., and *Heritiera littoralis* Aiton, are often found in the intact freshwater swamps. *Hibiscus tiliaceus* L. is opportunistic and grows very well, and in dense clusters, in these areas(Canfield, 1981; Costion and Lorence, 2012; Donnegan et al., 2007; Kitalong, 2014).

3. Interior volcanic forest

Occurring primarily on volcanic substrates, interior volcanic forest encompasses distinct subtypes of forest in undisturbed ecosystems. Moving inland from the mangroves and swamps, the species include *Casuarina equisetifolia* L. in sparse, rocky and/or disturbed areas. Farther inland, the forest grades into a mixed-forest canopy that includes *Campnosperma brevipetiolata* Volk., *Horsfieldia irya* (Gaertn.) Warb., *H. palauensis*, *Myristica hypargyraea* A. Gray subsp. *insularis* (Kaneh.) W.J. de Wilde, *Atuna racemosa* Raff. subsp. *racemosa*, *Maranthes corymbosa* Blume, *Serianthes kanehirae* Fosberg var. *kanehirae*, *Phyllanthus microcephalus* Wagner & Lorence, *P. otobedii* Wagner & Lorence, *Alphitonia carolinensis* Hosok., *Calophyllum inophyllum* (L.) *var. wakamatsui* (Kaneh.) Fosberg & Sachet, *C. soulattri* Burm.f., *C. pelewense* P.F. Stevens, *Symplocos racemosa* Roxb. *var. palauensis* (Koidz.) Noot., *Manilkara udoido* Kaneh., and *Fagraea ksid* (Gilg & Bened). The forest is dense, multilayered, and structurally complex here and some species thrive in buffer zones between volcanic forests and grassland, like *Planchonella obovata* (R.Br.) Pierre, *Rhus taitensis* (Guillemin), *Cerbera floribunda* K. Schum. and *Cerbera manghas* L. (Canfield, 1981; Costion and Lorence, 2012; Donnegan et al., 2007; Kitalong et al., 2013).

4. Savannas/Grassland

Although most of these are a result of past agriculture the predominant trees are *Pandanus tectorius* Parkinson ex Du Roi, *Commersonia bartramia* (L.) Merr., and *Melastoma malabathricum* L. Some other important trees in these areas in include *Morinda citrifolia* L., *M. pedunculata* Valeton., and *Wikstroemia elliptica* Merr. on the borders of the forested areas (Canfield, 1981; Costion and Lorence, 2012; Donnegan et al., 2007; Kitalong et al. , 2013).

5. Limestone forest type

On the limestone substrate throughout Palau, organic matter from the vegetation and fauna droppings forms a thin layer in places over the coral rock. The limestone substrate is naturally steep, porous, and extremely rugged, unless altered by constant natural or human based activities. Limestone uplifts border the ocean

and are typically undercut by waves and bio-erosion are typically quite difficult to access. Dominant species are *Eugenia reinwardtiana* (Blume) A. Cunn ex DC., *Rinorea bengalensis* (Wall.) Kuntze, *Ficus microcarpa* L.f. Hornem, *Canarium sp.*, *Intsia bijuga* (Colebr.) Kuntze, *Planchonella obovata* (R.Br.) Pierre, *Psychotria cheathamiana* Fosb., *Guettarda speciosa* L., *Syzygium mesekerrak* Lorence & Byng, *Syzygium palauensis* (Kaneh.) Hosok., *Calophyllum soulattri* Burm.f., and *Horsfieldia palauensis* Kaneh. Other notable species include *Casearia hirtella* Hosok., *Garcinia matsudai* Kaneh., *G. rumiyo* Kaneh., *Cycas micronesica* Hill, *Pandanus dubius* Spreng., *Phyllanthus macrosepalum* (Hosokawa) W.L.Wagner and Lorence, *Flacourtia rukam* Zoll. & Moritzi var. *micronesica* Fosberg & Sachet., *Aidia racemosa* (Cav.) Tiring., *Meryta senff tiana* Volkens, *Polyscias macgillivrayi* (Benth,) Harms, *Cleidion sessile* (Kaneh. & Hatus.), *Premna serratifolia* L., *Cyrtandra todaiensis* Kaneh., *Badusa palauensis* Valeton, *Psychotria hombroniana* variants and *Wikstroemia elliptica* Merr. The largest trees include *Trema orientalis* L. Blume and *Artocarpus mariannensis* Trecul. (Canfield, 1981; Costion and Lorence, 2012; Donnegan et al., 2007; Kitalong et al , 2013)..

6. Strand

Strand communities are found on the atolls of Palau, the low coral limestone rock islands, and on both coasts of the big volcanic island, Babeldaob, inside the fringing reef, depending on substrate. Strand species common to Palau include *Cordia subcordata* Lam., *Scaevola taccada* (Gaertn.) Roxb., *Badusa palauensis* Valeton and, *Bikkia palauensis* Valenton. Furthermore, *Casuarina equisetifolia* L. is an opportunistic, large tree that thrives in these areas.

7. Ravine and riparian forest

Palau's ravines and riparian areas have the densest populations of primary and secondary forest. The plant species in these ravines and riparian areas disperse into disturbed areas and savannas, and are the main compositional vegetative element of secondary forests in Palau. *Inocarpus fagifer* (Parkinson) Fosberg, *Quassia indica* (Gaertn.) Noot., *Colona scabra* (Sm.) Burret, *Cynometra ramiflora* L., *Dolichandrone spathacea* (L.) Schum., and *Semecarpus venenosus* Volkens. are common plant species in these areas.

Other than the typical types of vegetation mentioned above, in order to understand real changes in landscape it is important to include two other vegetative types. The first is *homestead/mesei vegetation*, important not only to traditional Palauan villages, but to the current Palauan homes as well. The second is *farm/sers vegetation,* which would include cultivated lands further away from homes as well as those lands cultivated by non-Palauan colonizers. These two vegetation types are important to the livelihood of the people. Farming practices either alter the landscape or are managed natural landscape, which utilizes natural vegetation areas for sustainable harvest.

8. Homestead/mesei vegetation

This human-influenced vegetation consists of economically important plants used daily for medicines and flavoring that include many native and endemic plants for which local people found uses. Examples of these plants are *Phaleria nisidai* Kaneh., *Premna serratifolia* L., *Syzygium samarangense* Blume. as well as other species used by habitants for medicine and food and planted within the homestead. Furthermore, in Palau these homestead plants would include various taros such as *Cyrtosperma merkusii* (Hassk.) Schott., *Colocasia esculenta* (L.) Schott. and *Alocasia macrorrhizos* (L.) G. Don, as well as plants found in the taro patches within the villages (Olsudong, 2002; Wickler, 2002).

9. Farm/sers vegetation

This human-influenced vegetation includes plants that are left loosely cultivated and harvested as needed. These areas may be interlaced within normal vegetation areas in the understory, or cultivated heavily and harvested for economic purposes. Some plants, such as *Nypa fruticans* Wurmb. And other mangrove plants were harvested as needed for traditional construction. These managed natural landscapes, within the mangrove forests, were maintained through harvest of naturally occurring species from their natural habitat (Kitalong and Tadao, 2010). On the other hand, plantations of *Manihot esculenta* Crantz. and *Ananas comosus* (L.) Merr. were introduced and harvested for economic purposes. These commercial farms commanded the alteration of vegetation in large areas throughout Palau (Iida et al., 2010; Iida et al., 2011).

Glossary

Atolls: A roughly circular coral reef surmounted by a chain of closely spaced., low coral islets that encircle or nearly encircle a shallow lagoon in which there is no land or islands of non-coral origin; the reef is surrounded by open sea

Karst: (topography):. The relief an area underlain by limestone that dissolves in differing degrees, thus forming numerous depressions or small basins

Sand: As a soil separate., individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class. A soil that is 85 percent or more sand and not more than 10 percent clay

Saprolite: Soft, friable, weathered bedrock that retains the fabric and structure of the parent rock and exhibits extensive intercrystal and intercrystal weathering. In pedology, the term "saprolite" has been used to refer to any unconsolidated residual material that underline the soil and grades had to bedrock bellow

Swamp: An area of low , saturated ground., intermittently or permanently covered with water and vegetated dominantly by shrubs and trees, with or without the accumulation of peat

Terrace (geologic): An old alluvial plain., ordinally flat or undulating, bordering a river, a lake, or the sea

Topsoil: The upper part of the soil., which is the most favorable material for plant growth. It is ordinally rich in organic matter and is used to top dress road banks, lawns and land affected mines

Index of Genera and Species

Scientific	Common	Palauan
Aidia racemosa (Cav.) Tirveng.		kerumes
Alocasia macrorrhizos (L.) G.Don		bisechrabelau
Alphitonia carolinensis Hosok.		chelebiob
Ananas comosus (L.) Merr.	pineapple	ongorngebard
Artocarpus mariannensis Trecul	wild breadfruit	chebiei, meduuliou
Atuna racemosa Raff. subsp. *racemosa*	parinarium nut	cheritem
Avicennia marina (Forssk.) Vierh.		dadaiit
Badusa palauensis Valeton		ralm
Barringtonia racemosa (L.) Spreng.		koranges
Bikkia palauensis Valeton		rur
Bruguiera gymnorrhiza (L.) Lam.	black mangrove	kodenges, denges
Calophyllum inophyllum L. var. *wakamatsui* (Kaneh.) Fosberg & Sachet	linneaus	btaches
Calophyllum soulattri Burm. f.		olebtaches
Calophyllum pelewense P.F. Stevens		chesemolech
Commersonia bartramia (L.) Merr.		bebechelut
Campnosperma brevipetiolata Volk.		kiu, kelelacharm
Canarium sp.		mesecheues
Casearia hirtella Hosok.		kesengelngolm
Casuarina equisetifolia L	beefwood, ironwood	ngas
Cerbera floribunda K. Schum.		chemeridech
Cerbera manghas L.		chemeridech
Ceriops tagal (Perr.) C. B. Rob.		biut

Scientific	Common	Palauan
Colona scabra (Sm.) Burret,		chuchab
Cleidion sessile Kaneh. & Hatus.		
Colocasia esculenta (L.) Schott.	taro	dait, kukau
Cordia subcordata Lam.		baderirt
Cycas micronesica Hill	cycad	ocheall
Cyrtandra todaiensis Kaneh.		melkii
Cyrtosperma merkusii (Hassk.) Schott.	giant taro	brak
Cynometra ramiflora L.		ketenguit
Dalbergia candenatensis (Dennst.) Prain		
Dolichandrone spathacea (L.) Seem.		riu
Eugenia reinwardtiana (Blume) A. Cunn ex DC.		kesiil
Fagraea ksid Gilg & Bened.		ksid
Ficus microcarpa L.f. var. microcarpa		lulk
Flacourtia rukam Zoll. & Moritzi var. *micronesica* Fosberg & Sachet		chemechong
Garcinia matudai Kaneh.		tilol
Garcinia rumiyo Kaneh.		tilol
Guettarda speciosa L.		blau
Horsfieldia palauensis Kaneh.		chersachel
Heritiera littoralis Aiton	saltwater chestnut	chebichech
Hibiscus tiliaceus L.	corkwood	chermall, eremall
Horsfieldia irya (Gaertn.) Warb.		chemeklachel
Horsfieldia palauensis Kaneh.		chersachel
Inocarpus fagifer (Parkinson) Fosberg		keam
Intsia bijuga (Colebr.) Kuntze		dort
Lumnitzera littorea (Jack) Voigt		mekekad (ngemoel)
Manihot esculenta Crantz	tapioca, cassava	diokang
Maranthes corymbosa Blume		bkau
Manilkara udoido Kaneh.		udeuid

Scientific	Common	Palauan
Melastoma malabathricum L.		matakui
Morinda citrifolia L.	noni, Indian mulberry	ngel
Morinda pedunculata Valeton		kesengelngel
Meryta senfftiana Volkens		omechidel
Myristica hypargyraea A. Gray subsp. *insularis* (Kaneh.) W.J. de Wilde		
Nypa fruticans Wurmb.	nypa palm	teuechel
Quassia indica (Gaertn.) Noot.		cheskeam
Pandanus tectorius Parkinson ex Du Roi	screw pine, pandanus	ongorraked, ongor, Such
Pandanus kanehirae (Hosokawa) W.L.		buuk
Phyllanthus macrosepalus (Hosokawa) W.L.Wagner & Lorence		ngolm
Phyllanthus palauensis Hosok.		udoud, dudurs
Phyllanthus otobedii W.L. Wagner & Lorence		
Polyscias macgillivrayi (Benth.) Harms		bngei
Premna serratifolia L.		chosm
Psychotria cheathamiana Fosberg		
Psychotria hombroniana variants		
Planchonella obovata (R.Br.) Pierre		chelangel
Phaleria nisidai Kaneh		ongael, delal a kar
Rhizophora apiculata Blume		bngaol
Rinorea bengalensis(Wall.) Kuntze,		
Rhus taitensis Guil.		cheues
Scaevola taccada (Gaertn.) Roxb.,		korrai, kirrai, raelchol
Scyphiphora hydrophyllacea C.F. Gaertn.		kuat
Semecarpus venenosus Volkens		tonget
Serianthes kanehirae Fosberg var. *kanehirae*		kumer, ukall
Sonneratia alba Sm.	mangrove apple	urur
Syzygium mesekerrak Lorence & Byng		mesekerrak

Scientific	Common	Palauan
Syzygium samarangense Blume Merr. & L.M. Perry	rembu	rebotel
Symplocos racemosa Roxb. var. *palauensis* (Koidz.) Noot.		chebtui
Syzygium palauense (Kaneh.) Hosok.		orenged
Trema orientalis (L.) Blume	charcoal tree	chelodechoel
Wikstroemia elliptica Merr.		tebudel
Xylocarpus granatum Koenig		meduulokebong

References

Canfield, J. E. 1981. Palau: Diversity and Status of the Native Vegetation of a Unique Pacific Island Ecosystem. Newsletter of the Hawaiian Botanical Society 20: 14-21.

Costion, C. M. and D.H. Lorence 2012. The Endemic Plants of Micronesia: A Geographical Checklist and Commentary. Micronesica 43 : 51-100.

Donnegan, J. A., S.L.Butler, O. Kuegler, B. J. Stroud, B. A. Hiserote, and K.Rengulbai 2007. Palau's Forest Resources, 2003. US Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Foy, C. D. 1992. Soil Chemical Factors Limiting Plant Root Growth, Limitations to Plant Root Growth. Springer (New York) pp. 97-149.

Hurst, V. J. 1977. Visual Estimation of Iron in Saprolite. Geological Society of America Bulletin 88: 174-176.

Iida, A., M. Noguchi, S. Osawa and M. Ishikawa 2010. A Study on the Sustainable Land Use of Villages Based on Watershed Management; Babeldaob Island, Republic of Palau. Iida, A., S. Osawa, and M. Ishikawa, 2011. A Study on the Past and Present Conditions of the Development Sites of the Japanese Colony in Micronesia : A Case Study at the Plantations and the Bauxite Mining Lands on the Babeldaob Island, the Republic of Palau Papers on City Planning 46: 319-324.

Kayanne, H., H. Yamano, and R. H. Randall 2002. Holocene Sea-Level Changes and Barrier Reef Formation on an Oceanic Island, Palau Islands, Western Pacific. Sedimentary Geology 150: 47-60.

Kitalong, A. H. 2008. Forests of Palau: A Long Term Perspective. Micronesica 40: 8-30.

Kitalong, C. and V. R. Tadao 2010. The Use of Plants for Fishing and Building: *personal communication.*

Kitalong, A. H., R. A. DeMeo and T. Holm. 2013. Native Trees of Palau: A Field Guide, 2nd ed. The Environment, Inc, Koror, Palau. 239 p. The Environment, Inc.

Kitalong, A. H. 2014. Native trees of Palau: A Field Guide, 2nd ed. The Environment, Inc, Koror, Palau.

Olsudong, R. 2002. Oral Traditions and Archaeology in Micronesia: An Attempt to Study Past Ideology in a Built Environment, The Melaka Papers: Proceedings of the 16th Congress of the Indo-Pacific Prehistory Association, Melaka, Malaysia 1 to 7 July 1998, pp.153-160.

PALARIS 2009. Executive Summary: Submission to the Commission on the Limits of the Continental Shelf, Pursuant to Article 76 of the UN Convention on the Law of the Seas, In: (Development, P. A. L. a. R. I. S. P. M. o. R. a. ed.) Republic of Palau (Koror, Palau)

PALARIS 2012. Republic of Palau Sustainable Land Management Policy. In: Sustainable Land Management Policies UNDP. Palau Automated Land and Resource Information System (PALARIS) (Ministry of Public Infrastructure, I. a. C. ed.): Ministry of Resources and Development, Republic of Palau (Koror, Palau) pp. 1-49.

United States Department of Agriculture (USDA), N.R.C.S. 2009. Soil Survey of the Island of Palau, Republic of Palau.

Wickler, S.2002. Oral Traditions and Archaeology: Modeling Village Settlement in Palau, Micronesia. Micronesian Journal of the Humanities and Social Sciences 1: 39-47.

CHAPTER 2
HISTORY OF LAND USE

Christopher Kitalong, David Mason

Initial Immigrants

Coastal settlements in Babeldaob date back more than 4000 years (Clark et al., 2006; Fitzpatrick, 2003), however due to acidity, sedimentation and intertidal changes, archaeological remains on the large island of Babeldaob are limited (Fitzpatrick, 2003; United States Department of Agriculture, 2009). Most archeological evidence is drawn from the Southern Lagoon from scattered limestone rock islands settlements, seen in Fig.2. These archeological features and the ecological significance of these limestone rock islands were the deciding factors in the Rock Islands Southern Lagoon's nomination as a UNESCO World Heritage site in 2012 (Reepmeyer et al., 2011, Fig. 2). Archeological studies provide evidence supporting early settlement in Palau dating back more than 3000 years (Liston, 2008). The origin of these settlers is not clear and Palauan settlement may have been through several waves of different immigration events (Clark, 2005).

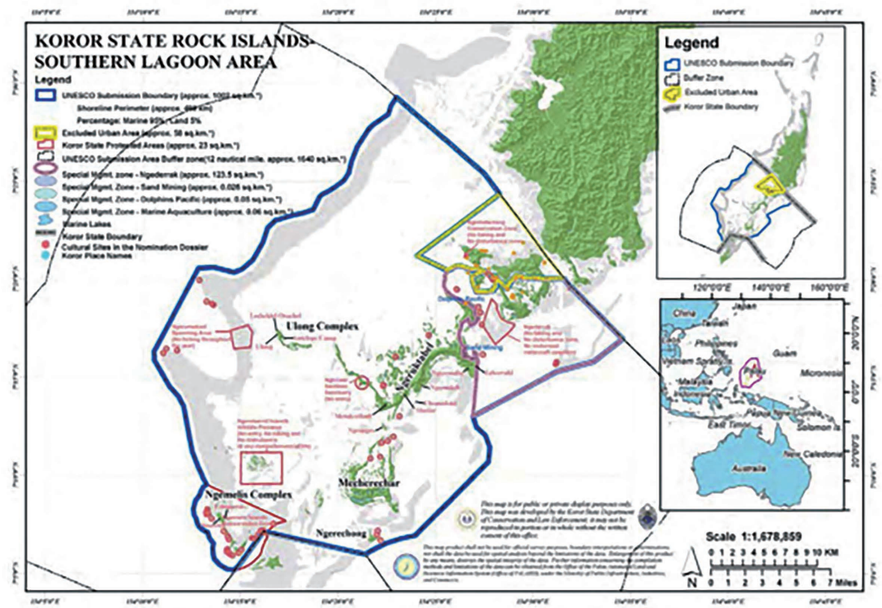

Fig. 2. UNESCO World Heritage Site delineation (blue line) (Reepmeyer et al. 2011).