CHAPTER 2

SCOPE AND DESIGN OF PABITRA

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Underlying Theories

The Island Biogeography Theory

MacArthur and Wilson’s (1963, 1967) theory of island biogeography provides an underlying scientific inspiration for PABITRA (Figure 2.1). It predicts that a large archipelago far removed from a biotic source area arrives at a lower species equilibrium than a similarly large archipelago closer to a biotic source area. While the concept of species equilibria is highly debatable, it is generally accepted that there is a gradient of indigenous colonizer plants from enriched to impoverished as one travels from the species rich continental islands in tropical Asia into the oceanic archipelagoes of Polynesia. The Marquesas in Eastern Polynesia and the Hawaiian Islands in Northern Polynesia are recognized as the outlier landmasses of the Paleotropics (Barthlott et al. 1996). This west to east gradient of impoverishment of colonizer plants is well documented for mangrove species by Woodroffe (1987). It also becomes apparent from the canopy tree guilds comprising the inland and upland forests of the volcanic high islands. Inclusion of the ecological concepts of biome and succession will improve the theory of island biogeography (Mueller-Dombois 2001).

Island Vegetation in a Biogeographic Context

A recent book synthesizing the vegetation of the tropical Pacific Islands by Mueller-Dombois and Fosberg (1998) can be used as a baseline document. This book treats the Pacific Island vegetation in a landscape perspective as ecosystem builders in the sense of the well-known British vegetation ecologist Tansley (1935). He stated that one cannot understand the plant community without its environmental context. Tansley declared the community together with its habitat as an “ecological system.” For this combined unit, he coined the abbreviated term “ecosystem.” Tansley’s term, launched in 1935, is now widely used and understood even by the non-specialist.

Mueller-Dombois and Fosberg (1998) consider the term “landscape” to be the geographic equivalent of the term “ecosystem.” In this sense, they developed a formula for defining and describing vegetation as a function of six factors:

Vegetation = \( f(g, cl, d, fl, ac, e) \)

where

- \( f = \) function
- \( g = \) geoposition (referring to geography, geology, geomorphology, and ground=soil)
- \( cl = \) climate
- \( d = \) disturbance regimes
- \( fl = \) flora of the island area
- \( ac = \) access potential of plants to become part of an ecosystem
- \( e = \) ecological characteristics of plants and their role in the ecosystem

Overriding these six factors are the scales of space and time. Scaling is an essential element in understanding vegetation. But scaling does not affect the above formula, which can be applied at any scale from broad to detailed. A landscape may also be considered a geographically broader unit that consists of several interacting ecosystems, such as the ahupua’a discussed in Chapter 1.
If one substitutes the factor \( f_l \) (=flora) with \( b \) (=biota) in the formula, the whole community would need to be synthesized. This is a task for the future that, however, can hardly be done in one book on a Pacific-wide scale. Instead, it would require about 10 books, one for each island region.

Based on this formula, the vegetation of the Pacific Islands was described in 10 regions as outlined by the section index maps on Figure 2.2. Their sequential numbers follow the general trend of biogeographic regionalization of the Pacific Island area as reviewed by Stoddart (1992).

**Geoecology: Focus on Two Kinds of Ecological Gradients**

The term geoecology derives from geographical ecology, a book written by MacArthur (1972). He emphasized research into the patterns of diversity, species and community distributions over wider areas as well as more local ones, such as the distribution of species and communities on mountain slopes. MacArthur wrote, “… to do science is to search for repeated patterns, not simply accumulate facts, and to do the science of geographical ecology is to search for patterns of plants and animal life that can be put on a map.”

**Biogeographic Gradients**

Pielou (1979) in her book on biogeography defined geoecology *sensu* MacArthur as the “study of the recurrence of similar communities in similar habitats occupied by different sets of species.” In other words, Pilou’s understanding of geoecology is the study of similar communities, members of the same biome, which grow in similar environmental settings but in biogeographically different areas. Geoecology in this sense is exactly the first approach of PABITRA, namely to focus on a comparative study of the indigenous upland/inland forests of the Pacific high islands as ocean-fragmented members of the same biome and
to study them structurally and functionally as communities harboring most of the indigenous and endemic biodiversity and then also for their ecosystem services as watershed covers.

**Environmental Gradients**

These, instead, focus on the changes in biodiversity as related to changing environmental control factors. These may be temperature, rainfall, seasonality, substrate age, disturbance regime, or other factors. Here, the sampling attempt is to place the study plots along the spatially changing “factor of interest” (control factor) by holding all other factors as constant as possible. For example, to study the effect of spatially changing temperature on biodiversity, the major environmental control factor correlated with latitude along DIWPA’s “Green Belt,” the forest plots should ideally be selected in such a way that soil age, elevation, water balance, and disturbance regime are kept closely comparable or equivalent. Similarly, island mountain slopes can be sampled to analyze patterns of biodiversity in relation to altitudinally changing control factors.

**Site Selection Criteria**

In the literature, islands are often treated as single ecosystems. For example, in the classical theory of island biogeography, MacArthur and Wilson (1967) attempt to predict species richness on islands by only two parameters, distance from a biotic source area and island size. This generalization is adequate for certain purposes but inadequate for the goals of PABITRA. Instead, we consider islands a complex of interrelated ecosystems, such as shown on Figure 2.3.

On this diagram of a tropical “high island”, we see on the left side under “Natural Ecosystems” an upland or montane rain forest with cloud forest near the summit. Below is some open area with a patch of lowland rain forest and freshwater swamp, a wetland with trees. Near the coast is beach or strand vegetation with coconuts. Mangroves are at the mouth of a river where it enters the sheltered bay of a lagoon. Near shore marine ecosystems include the lagoon with a sea-grass meadow and fringing reef. On the right and drier side of the

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Figure 2.2. The biogeographic island regions in the tropical/subtropical Pacific as outlined by Mueller-Dombois and Fosberg (1998).
island are human-modified ecosystems: a reduced montane vegetation, a grass and fern savanna, two types of agro-ecosystems, one with trees, the other without trees. Near the coast is the principal human settlement with a managed coconut plantation. Two stream ecosystems, a permanently flowing river and an intermittent one as well as a bamboo grove complete the spectrum of island ecosystems on this diagram.

There are at least twelve ecosystems displayed in typical positions on these two island landscapes (natural and human-modified), and all ecosystems occupy relatively small areas which are topographically related to each other and by other environmental factors, such as precipitation, temperature, freshwater stream flow and type of soil-substrate.

Our initial focus was on the comparative study of indigenous upland forests for two good reasons, their function as ecological reserves of native species and their value as watershed covers. But the human dimension of biodiversity as a research subject requires a focus on the upland/lowland and coastal zone relationships as well as the human interaction with such broader landscape units.

With this view in mind, we formulated a set of site selection criteria for PABITRA at the second workshop in Taipei during the 9th PSA Inter-Congress (Mueller-Dombois et al. 1999). They are as follows:

1. The site should have relatively intact upland or montane forest with preferably some cloud or moss forest. Because upland forest is generally still the best preserved native ecosystem on most Pacific high islands, it has been selected as the priority ecosystem for study during the first phase of PABITRA.

2. The site should also extend downward altitudinally into a range of other ecosystems (e.g. lowland forest, agricultural ecosystems, freshwater wetlands, coastal and mangrove forest, intertidal zones, lagoons and reef ecosystems), and preferably have a major river or stream system that links these ecosystems along a vertical transect or gradient.

3. Each site must be accessible to researchers in terms of logistics or practicability and cost-
effectiveness of conducting multiple multi-
disciplinary studies at the site.

4. Sites must be connected to an institution or
group of institutions that could serve as the
lead agency in coordinating and facilitating
the PABITRA initiative at the site.

5. Preferably, sites should have ongoing re-
search, or a body of existing data from past
studies to allow for economies of scale in
terms of the cost and research effort required
for comparison over time.

6. The site should be under some form of pro-
tected status so that permanent study plots
can be maintained and long-term ecological
research (LTER) are continued on the site in
the future.

7. There should be scope for collaboration be-
tween a number of research organizations,
government and non-government organiza-
tions and local communities.

8. There must be government support for the
designation of the area as a PABITRA site for
long-term ecological research.

9. There must be local support, based on the
principle of “informed prior consent,” of
the landowners and resident support com-
munities for the designation of the area as a
PABITRA site.

Criterion 2 above outlines a mountain-to-coast land-
scape segment of an island as the ideal PABITRA site.
This is what we are striving for, a continuous moun-
tain gradient in form of broad belt transects. Howev-
er, where circumstances don’t allow analysis of whole
mountain-to-coast landscapes, PABITRA sites can
also be landscape fragments, such as upland forests
with cloud forest scrub and fern/grass savanna form-
ing a functionally related ecosystem complex, or mang-
rove vegetation with stream ecosystems and lagoons
forming another. Forests, intermittent tree gardens,
open crop fields, pastures, and tree plantations, may
be similarly analyzed as agro-ecosystem complexes,
but their relationship to the more natural forest and
coastal ecosystems is an important research concern
of PABITRA.

Proposed PABITRA Sites

In addition to the nine site selection criteria, we de-
veloped a list of two kinds of PABITRA sites, “transect
sites” and “peripheral sites.” Transect sites are simi-
lar biome areas across those archipelagoes whose geo-
graphic position is in the Paleotropics along the inva-
sion trend of the indigenous biota from west to east.
This is the PABITRA transect system as shown on Fig-
ure 2.4.

Peripheral sites are “high islands” in the tropical/sub-
tropical belt which are not intercepted by the PABITRA
transect system, but are also of great ecological inter-
est. They also include several selected “raised lime-
stone islands” and three major chains of “atoll islands”
along precipitation gradients (Mueller-Dombois and
Fosberg 1998).

The following list of proposed transect sites includes
seven continental tropical island areas and one con-
tinental coastal area (North Queensland) where
PABITRA intersects with the north-south “Green” and
“Blue” Belt Transects of our sister network DIWPA.
Most of these may be included in the DIWPA research
design.

The focus of PABITRA is on landscapes in the high
islands in the archipelagoes of Micronesia, Melanesia,
and Polynesia. These thirteen islands areas are of pri-
ority in the PABITRA program.

Table 2.1 lists 20 proposed transect and 17 proposed
peripheral sites, each with contact persons. Names of
contact persons are in flux and will be updated with
the progress of PABITRA network activities.

PABITRA Phase 1
Core and Satellite Sites

In conjunction with our sister network DIWPA, we
have decided to concentrate PABITRA field research
activity, initially on only a few areas, on so-called
“core” and “satellite” sites.

Core sites are those near universities or research cen-
ters where already a considerable biological data base
exists. Such core sites may include new focus areas,
but they should be comprehensively investigated. This
means, in addition to biological inventories made in
an ecosystem context, there should also be a plan for investigating environmental variables in detail and for assessing short and long-term changes in selected populations and communities.

*Satellite sites* are those where biological inventories should be done by the same methods as used for the core sites, but where the short and long-term monitoring of environmental and biological parameters may not yet be practical. The primary reasons are financial. They refer to lack of appropriate infrastructure, lack of equipment and trained personnel.

In this sense, PABITRA will concentrate in phase I of its networking and fieldwork activity on two oceanic island core areas, Fiji and Hawai‘i, and two continental ones, Borneo and Taiwan. As satellite sites, PABITRA will focus on five island areas, namely Pohnpei, Samoa, the Marquesas, and Solomon Islands (Figure 2.4). Belau is also under consideration.

Fiji has been designated as the Gateway Site and as Protocol Test Site. A broad belt transect was established in 2002 from the Wabu watershed forest near Mt. Tomanivi, downslope to the Rewa River delta and coastal habitats near Suva. A 69 page technical report has been issued by the USP Institute of Applied Sciences (2002) entitled: APN/PABITRA Field Biology Techniques, Training and Joint Analysis Workshop. This report discusses in detail the establishment of the PABITRA wet-zone transect on Viti Levu and its target sites with initial data.

![Figure 2.4. The PABITRA transects and sites.](image-url)
Table 2.1. Proposed PABITRA sites. In the following list, “book” refers to Mueller-Dombois and Fosberg (1998).

**Transect Sites**

### Continental Islands in Tropical Asia and Western Pacific

- **Indonesia:** Papua, West New Guinea, Timika Pt Freeport Concession and Lorentz National Park  
  **Contact:** M. Kilmaskossu, Dr. Husin, Yahyn Aikatiri

- **Malaysia:** Mt. Kinabalu and Lambir  
  **Contact:** T. Yumoto (DIWPA), K. Kitayama, G. Ismail

- **Papua New Guinea:** Mt. Wilhelm and/or Mt. Giluwe  
  **Contact:** Wayne Takeuchi, Karol Kisokau, Earl Saxon, Gai Kovina, R. Kula, Harry Sakulas, Simon Sauler, Osia Gideon, R. Kiapranis

- **Philippines:** Mt. Makiling and/or Mt. Apo  
  **Contact:** Miguel de Fortes, Josef Settele, Norma Orlido-Aguilar, Perry Ong

- **North Queensland, Tropical Australia (continental source area)**  
  **Contact:** Nigel Stork, Roger Kitching, Jiro Kikkawa

- **New Caledonia:** Mt. Mou 1211 m, basalt mountain near Noumea  
  **Contact:** Tanguy Jaffre, IRD Center (formerly ORSTOM) Noumea

- **Taiwan:** Mts.  
  **Contact:** Chang-Hung Chou, Han-Bian King

### Oceanic High Islands of Micronesia

- **Republic of Belau, Babeldaoop**  
  **Contact:** Harley Manner, Noah Idechong, M. Falanruw, T. Cole, Kathy Ewel

- **Yap State, Federal States of Micronesia**  
  **Contact:** Margie Falanruw

- **Pohnpei, FSM, Mt. Nahaland**  
  **Contact:** Bill Raynor, Michael Balick, J. Juvik, M. Merlin, Harley Manner, Earl Saxon, Dageo Jano, Thomas Keene, Bismark Sebastian

- **Kosrae, FSM**  
  **Contact:** M. Falanruw, Kathy Ewel, M. Merlin, J. Juvik, Robert Taulung

### Oceanic High Islands of Melanesia

- **Bismarck Archipelago: New Britain and/or New Ireland**  
  **Contact:** Roger Kitching, Cyril Kondang, Wayne Takeuchi, Jiro Kikkawa

- **Solomon Islands: Kolombangara and Choiseul (= Lauru)**  
  **Contact:** David Burslem, Will McClatchey, MyKnee Sirikolo, Guna Pillay, Esau Tuza, Jon F. Kennedy, Takeshi Matsubara
Biodiversity Assessment of Tropical Island Ecosystems

Scope and Design of PABITRA

Vanuatu: Mt. Tabwemasana, Espiritu Santo
Contact: Ernest Bani, Randy Thaman, Chanel Sam, IRD

Fiji: Mt. Tomanivi, Mt. Koroyanitu, Viti Levu, Mt. Korobaba 422 m near Suva, Mt. Korouraga 1210 m, Taveuni
Contact: Randy Thaman, J. Ash, Marika Tuiwawa, E. Nasome, S. Tabua, D. Watling, Gunnar Keppel

Oceanic High Islands of Polynesia

Samoa: Ta’u Island, Am. Samoa, Mt. Silisili, Savai’i, Samoa
Contact: I. Reti, Paul Cox, J. Juvik, A.W. Whistler, C. Schuster, James Atherton, Orlo Steel, Nat Tuivavalagi, Siliko Siliko, Talie Foliga, Fiauu Faletoese, Mila Misa

Cook Islands: Rarotonga
Contact: M. Merlin, G. McCormack, A. Tira’a, M. Purea

Society Islands: Tahiti
Contact: Jean-Yves Meyer, Neil Davies

Marquesas: Nuku Hiwa
Contact: Jean-Yves Meyer

Hawai‘i: West Maui, East O‘ahu and Hawai‘i island
Contact: James D. Jacobi, J. Juvik, D. Mueller-Dombois, Curt Daehler, Lloyd Loope & colleagues

Peripheral Sites

Other High Islands

Lord Howe, Mt. Gower 875 m (book map: 166, profile: 180)
Contact: Ian Hutton, Peter Green, Judith Mortlock, John Pickard

Norfolk Island, Mt. Pitt 316 m, Mt. Bates 318 m (book map: 183, profile: 189)
Contact: Margaret Christian, Owen Evans, Naomi Gillet, Peter Bridgewater

The Bonin and Northern Mariana Islands (book map: 200, profile: 239, table 253)
Contact: Y. Shimizu, T. Ohba

Galapagos, Ecuador, Santa Cruz Island with Cerro Crocker 864 m (book map and profile: 589)
Contact: S. Itow, H. Adsersen

Juan Fernandez, Chile
Robinson Crusoe Island (Masatierra) with Cerro Yunque 915 m (book map: 611, profile: 617)
Contact: Josef Greimler, T. Stauss & Chilean Colleagues

Austral Islands, Rapa Island
Contact: J.-Y. Meyer, J. Florence


**Raised Limestone Islands**

Isle de Pines and/or Lifou New Caledonia (book map: 85, text: 149)
  Contact: IRD Colleagues

Kabara, Fiji: (book 135)
  Contact: Randy Thaman, M. Tuiwawa, D. Watling, E. Nasome

Nauru, Micronesia (book: 293)
  Contact: Randy Thaman, D. Hassall, Harley Manner

ʻEua Island, Southern Tonga (book map: 346), Gondwanic remnant: (book 19, forest types: 356)
  Contact: Don Drake, A. Whistler

Niue, Western Polynesia (book map: 343)
  Contact: Bill Sykes, A. Whistler, R. Thaman

Mangaia, Southern Cook Islands: (book 395)
  Contact: Mark Merlin, A. Tira’a

Makatea, Tuamotus
  Contact: IRD

Henderson Island, Eastern Polynesia, Pitcairn Island (map: 386, text: 441)
  Contact: J-Y. Meyer, G. Pauley, P. Spencer

**Atoll Islands (three environmental gradients)**

Micronesia: From Wake Island via northern Marshalls to southern Marshall Island Jaluit and through Gilberts to Tuvalu: a north-south environmental gradient across the equator (book: 312)

Central Polynesia: From Palmyra Island via Christmas, Howland and Baker Islands (Kiribati) to Puka Puka and Swains Island (northern Cook Islands, a more impoverished north-south environmental gradient (book: 338)

Eastern Polynesia: The Tuamotus, from Rangiroa via Mangareva to Ducie Atoll, a tropical-subtropical southern hemisphere gradient (book: 386)
Literature Cited


