# 2nd MC Terrestrial Measures Workshop

# WORKSHOP REPORT

## June 18 – 21, 2012
## Koror, Palau

**Co-organized by MCRO, MCT, PCS & TNC**

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## Suggested Citation

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## Acronyms

| | |
|---|---|
| BNM | Belau National Museum |
| BWA | Belau Watershed Alliance |
| CNMI | Commonwealth of the Northern Mariana Islands |
| DAWR | Division of Aquatic and Wildlife Resources |
| DBH | Diameter at Breast Height |
| DO | Dissolved Oxygen |
| EPA | Environmental Protection Agency |
| EQPB | Environmental Quality Protection Board |
| IWRM | Integrated Water Resource Management |
| Island-SEAS | Island-Social & Ecological Applied Sciences |
| KIRMA | Kosrae Island Resources Management Authority |
| MC | Micronesia Challenge |
| MCRO | Micronesia Challenge Regional Office |
| MCT | Micronesia Conservation Trust |
| MICS | Marshall Islands Conservation Society |
| MNRET | Ministry of Natural Resources, Environment and Tourism |
| MRMD | Yap State Marine Resources Management Division |
| NRCS | Natural Resources Conservation Service |
| PAN | Protected Areas Network |
| PCS | Palau Conservation Society |
| PNI | Pohnpei |
| PICRC | Palau International Coral Reef Center |
| R&D | Yap Department of Resources and Development |
| RMI | Republic of the Marshall Islands |
| ROP | Republic of Palau |
| SD | Sustainable Decisions |
| SET | Sediment Elevation Tables |
| TNC | The Nature Conservancy |
| TEI | The Environment Inc. |
| VCP | Variable Circular Plot |

# Executive Summary

The ambitious goals of the Micronesia Challenge (MC) position the Micronesian region as an international leader in conservation. In order to assess whether these goals are being effectively achieved, the MC aims to create a set of regional monitoring measures that can be used to evaluate the health of managed areas protected under the MC. A series of conservation measures workshops have been held to create these regional monitoring frameworks. These workshops involved participants from across all jurisdictions, and have sought to utilize regional expertise in order to understand what is both needed and practical for the Micronesia region.

This 2nd Terrestrial Methods Workshop was held in Palau, from June 18-21, 2012. The purpose of the workshop was to come to an agreement on indicators and methods to be used for monitoring terrestrial targets of the MC: freshwater systems, native forests and mangroves. The workshop was created to build on the discussions of these terrestrial protocols from the 1st workshop in 2011 dedicated to the terrestrial component. The workshop was also designed to bring in expertise on monitoring methods for freshwater systems, which was recognized as a limitation during the last workshop.

The workshop was a balance between the presentation of essential and informative knowledge by regional and international experts, and discussion sessions designed to include all participants and all MC jurisdictions. The workshop was opened with background discussions and presentations on the MC, management objectives to address threats affecting protected areas across the jurisdictions, and effective sampling and methods for monitoring of protected areas. The latter half of the first day of the workshop was primarily dedicated to presentations and discussions of biological indicators for freshwater systems. On the second day, participants received in-field training on these bioassessment methods, which also helped all jurisdictions consider the practicality of monitoring protocols. Based on this extra knowledge gathered throughout those first days, participants were able to agree on the MC regional indicators and methods for freshwater systems on the morning of day three. That afternoon was dedicated to presentations on monitoring protocols for the last two terrestrial targets, native forests and mangroves. On the fourth day of the workshop, the group discussed and finalized the MC indicators and methods for those targets. The workshop was closed by discussions on capacity needs, and next steps.

Major outputs from this workshop include the agreement on MC terrestrial monitoring indicators and proposed methods, an enhancement of knowledge and capacity regarding different methods and designs for monitoring terrestrial targets, and the creation of a MC Terrestrial Technical Working Group to continue dialogue and momentum for the terrestrial component. Following this workshop, the jurisdictions agreed to complete trial implementations of the terrestrial protocols for all targets, over approximately one year. Another meeting will be held after this time, to discuss successes and challenges, and finalize standard monitoring designs for the region.

# Background

The Micronesia Challenge is a commitment, signed in 2006, by five Micronesian Governments to *"preserve the natural resources that are crucial to the survival of Pacific traditions, cultures and livelihoods."* The Federated States of Micronesia, the Republic of the Marshall Islands, the Republic of Palau, the Territory of Guam, and the Commonwealth of the Northern Mariana Islands agreed to "*effectively conserve 30% of the near shore marine resources and 20% of the terrestrial resources across Micronesia by 2020*". This ambitious goal well surpasses current international goals to conserve 10% of terrestrial and marine resources, making the Micronesia region a leader in conservation.

The Micronesia Challenge was initiated with its first regional meeting in Palau, in 2006. This 1st MC Planning Meeting was focused on the institutionalization of the MC, including the establishment of a regional co-ordination body, regional financial mechanisms, and institutional support and outreach. The meeting also focused on *"effective conservation"*, working to develop the definitions and indicator categories that would help guide all future work done under the MC.

In 2008, the 2nd MC Regional Meeting was held in Pohnpei, known as the 1st MC Measures Meeting. The meeting included a technical workshop, which focused on developing measures of success for the Micronesia Challenge. The meeting discussed regional indicators for the MC. One of the major outputs of the workshop was a consensus on the proposed set of categories of MC measures, and a possible set of corresponding indicators.

The 2nd MC Measures Meeting was held in 2010, to further develop a regional monitoring program for the managed areas protected under the Micronesia Challenge. This workshop focused on the marine component, developing regional monitoring protocols to be used in all MC jurisdictions for near-shore resources. The terrestrial component of the MC was not included in this workshop, due to time constraints.

In 2011, participants from across the five jurisdictions met in Chuuk, for the 3rd MC Measures Meeting. This meeting was the 1st MC Terrestrial Measures Workshop, which focused on developing regional terrestrial monitoring protocols for the MC. Outcomes of the workshop included the refinement of the regional terrestrial targets for monitoring, a set of regional indicators to measure and assess the management effectiveness for terrestrial protected areas under the MC, and a list of monitoring methods to measure those indicators. The workshop also helped identify management issues for terrestrial protected areas across the region, including strengths, weaknesses and capacity needs, and increased understanding of different terrestrial survey methods.

This regional meeting, the 2nd MC Terrestrial Measures Workshop, was called to build upon the work of that 1st MC Terrestrial Measures Workshop. The major objectives of this workshop were to review the proposed terrestrial indicators and methods, and arrive at a consensus on these regional protocols. One issue identified in the 1st Terrestrial Measures Workshop was a lack of expertise in the room regarding one of the identified terrestrial targets, freshwater ecosystems. Filling this knowledge gap was also one of the key reasons for this 2nd workshop dedicated to the terrestrial component. A regional expert in this field was asked to lead discussions during this workshop, to help build capacity in this area, and develop more effective regional monitoring protocols for this target.

# Workshop Purpose, Objectives and Agenda

## Purpose

The purpose of this workshop was to build on the outcomes of the previous MC Terrestrial Measures Workshop and arrive at a consensus on the proposed terrestrial monitoring indicators and methods, which will be used to assess the progress towards achieving the goals of terrestrial conservation under the Micronesia Challenge. The workshop was also designed to fill the gaps in knowledge relating to monitoring of freshwater ecosystems identified in the first workshop, and bring in the expertise to refine the indicators and methods for this particular target.

## Meeting Objectives

1. *Review proposed monitoring indicators and methods from the last workshop.*
2. *Review status of terrestrial technical working group focused on developing the process for the periodic measurement of progress made toward achieving the goals of the MC.*
3. *Develop a biomonitoring protocol including a pictorial guide to freshwater invertebrates and train local/regional personnel in this process:*
   - A. *Provide the conceptual scientific rationale for the approach taken to begin developing a biomonitoring program for Palau/MC jurisdictions.*
   - B. *Synthesize and present the background and summary results of nearly 10 years of baseline data gathering for Babeldaob streams, including a field guide and protocol.*
   - C. *Conduct both field and laboratory training for local and regional personnel and representatives on sample and data collection, processing and analysis.*
   - D. *Discuss future goals and directions for Palau and tropical Pacific watershed biomonitoring.*
4. *Participants arrive at a consensus on the proposed terrestrial monitoring indicators & methods.*
5. *Participants identify current capacity need (e.g. resources capacity, policy, etc.) to implement agreed monitoring methods.*
6. *Identify specific capacity needs and strategies to fill these needs to implement the protocol in each MC jurisdiction.*
7. *Enjoy ourselves in the company of the finest, most committed and most dedicated conservation colleagues we could ever hope for (that's us!)*

## Workshop Agenda

| **DAY 1: Monday June 18** | | |
|---|---|---|
| 8:30 | Registration | |
| 9:00 | Welcome Address | TBD |
| 9:30 | Introductions of participants, Objectives of the Workshop and Overview of the agenda | Lead Facilitator |
| 10:00 | Review the results of 1st Terrestrial Measures Meeting in Chuuk and status of technical working group | TBD |
| 10:30 | *Morning Tea Break* | |
| 11:00 | Sampling Design | Dr. Yimnang Golbuu |
| 12:00 | Discussion on objectives of monitoring for terrestrial protected areas throughout Micronesia | Facilitated by Charlene Mersai |
| 12:45 | *Lunch* | |
| 13:30 | Presentation of 10 years bio-monitoring research of Babeldaob Watersheds | Dr. Eric Benbow |

| | | |
|---|---|---|
| 15:00 | *Afternoon Tea Break* | |
| 15:30 | Discussion of indicators and methods of bio-monitoring work | Dr. Eric Benbow |
| 17:00 | Wrap up for the day | Facilitators |
| 18:00 | *Welcoming Reception* | TBA |
| **DAY 2: Tuesday, June 19** | | |
| 8:30 | Fieldwork | Dr. Eric Benbow |
| 4:30 | Return to Koror | |
| **DAY 3: Wednesday, June 20** | | |
| 8:30 | Overview of the day | Facilitator |
| 9:00 | Watershed bio-monitoring protocol | Dr. Eric Benbow |
| 10:30 | *Morning Tea Break* | |
| 11:00 | Discussion of bio-monitoring protocol (cont.) | Dr. Eric Benbow |
| 12:30 | *Lunch* | |
| 13:30 | Presentation by Belau National Museum on Forest Health using Bird as indicator – case study | Dr. Alan Olsen |
| 14:30 | Mangrove Resilience Research Project – case study<br>PICRC and U.S. Forest Service | Lukes Isechal |
| 15:30 | *Afternoon Tea Break* | |
| 16:00 | Terrestrial PA monitoring protocol for Palau's PAN | Dr. Alan Olsen and Pua Michael |
| 17:00 | Wrap up for the day | |
| **DAY 4: Thursday, June 21** | | |
| 8:30 | Overview of the day | Facilitator |
| 9:00 | Discussion of MC terrestrial monitoring protocol | Steven Victor |
| 10:30 | *Morning Tea Break* | |
| 11:00 | Discussion on capacity to implement monitoring | Facilitator |
| 12:00 | *Lunch* | |
| 13:00 | Wrap up of the workshop and next steps | |
| 15:00 | Closing Remarks | |
| 18:00 | *Closing Reception* | |
| **DAY 5: Friday, June 22** | | |
| | Departure for participants | |

## Workshop Outputs

1. Increased understanding of terrestrial management objectives and threats for the five MC jurisdictions.
2. Enhanced knowledge regarding bio-assessment methods and biological indicators for monitoring freshwater systems, including awareness of practical requirements.
3. Increased understanding of different monitoring protocols for native forests and mangroves.
4. Agreement on regional terrestrial indicators for the MC, for the three terrestrial targets: freshwater systems, native forest and mangroves.
5. Agreement on proposed monitoring methods for the identified terrestrial indicators.
6. Creation of a MC Terrestrial Technical Working Group, and identification of proposed members.
7. Identified next steps:
    - Formalization and first meeting of MC Terrestrial Technical Working Group, on August 1st, 2012.

- By 31st October 2012, each jurisdiction will have developed plans for the implementation of monitoring protocols. The plans can include budgets, and any identified gaps in capacity that jurisdictions need help with.
- Implementation trials of terrestrial monitoring protocols to have been conducted in each jurisdiction, for each of the three targets, within approximately one year.
- Meeting in ~ one year to discuss the monitoring methods implemented by the jurisdictions, and finalize standard monitoring designs.

8. Summary report of the workshop.

MC terrestrial monitoring protocols

## Native Forest

| Indicator | Methods |
|---|---|
| • **% Forest Cover** | **GIS-Remote Sensing** |
| • **Flora** | |
| • **Stand Structure – Species Representation and Abundance** | **FIA modified/Point Count** |
| • **Others** | |
| • **Fauna** | |
| • **Birds & Bats** | **Point Count/Variable Circular Plot** |
| • **Others** | |

## Mangroves

| Indicator | Methods |
|---|---|
| • **% Forest Cover** | **GIS-Remote Sensing** |
| • **Flora** | |
| • **Stand Structure – Species Representation and Abundance** | **FIA modified** |
| • **Fauna** | |
| • **Birds & Bats** | **Standard Point Count/Variable Circular Plot** |
| • **Crab (Sesarmids & Mangrove)** | **CPUE/Standard Plot** |
| • **Water quality** | **EPA** |

## Freshwater Ecosystems (rivers, streams and water lenses)

| Indicator | Methods |
|---|---|
| **Physical-chemical indicators:** | |
| • **Turbidity** | **Secchi Disc** |
| • **Salinity** | **EPA method** |
| • **Water discharge (stream size, flow rates, level)** | **Discretionary** |
| **Biological indicators** | |
| • **Aquatic invertebrates (shrimp, snail, moths/insects)** | **Rapid bio-assessment** |
| • **Aquatic vertebrates** | **Rapid bio-assessment** |
| • **Coliform** | **EPA method** |

# Workshop Report

## DAY 1

### Opening address

Carol Emaurois, Chairperson of the MC Communication Committee and Education and Outreach Program Manager at the Palau International Coral Reef Centre, opened the 2nd Terrestrial Measures Workshop by welcoming members to Palau, and expressing her delight in opening the workshop on behalf of the MC steering committee. Ms. Emaurois hoped that the meeting would result in outputs that can be adopted by all the participating countries. Ms. Emaurois further discussed the strength of the Micronesia community in leading conservation, with the goals of the Micronesia Challenge surpassing international standards: "We have the baton, and are out in front. Everyone is looking to us to guide the way". Ms. Emaurois spoke of the development and national adoption by Palau of the marine protocols, and hoped that this meeting would achieve a similar output for terrestrial conservation, and ascribe what is important for terrestrial conservation. She stated that everyone at the meeting was here for a very important purpose, not only for individual countries, but for the region, and internationally. On that note, Ms. Emaurois urged participants to work hard, but also to enjoy their time in Palau.

### Introductions of participants, objectives of the workshop and overview of the agenda

The workshop facilitator, Umiich Sengebau, asked members to introduce themselves and a bit about their background, to allow members to get to know each other, and to give an overview of the range of expertise that could be called on throughout the workshop. Steven Victor then went through the objectives and the agenda for the workshop, calling for any input or proposed changes from the workshop participants. No concerns or changes were raised at this stage or at any stage throughout the workshop, and as such the draft agenda and draft objectives were adopted.

### Presentation: Review of the results of the 1st Terrestrial Measures Meeting

### By Umiich Sengebau, TNC

Umiich Sengebau delivered the first of the presentations, which gave background context to this workshop, including the goals and definitions of the Micronesia Challenge, and the outcomes of the 1st Terrestrial Measures Meeting in Chuuk. This allowed for the group to refresh their understanding about the focus of this workshop, and the previous work done that this workshop was intended to build upon. The summary of this presentation is provided below.

The Micronesia Challenge: Background Information

The MC is an agreement between 5 governments to "effectively conserve 30% of the near shore marine resources and 20% of the terrestrial resources across Micronesia by 2020". The extent of the Micronesia Challenge covers the size of continental US (see Figure 1). It is a huge area to work in, requiring a lot of resources, and a lot of people in order to achieve effective management.


Figure 1. Regional scope of the Micronesia Challenge

Table 1 (below) shows the progress, as of 2011, for each of the five jurisdictions in achieving the MC goals. This shows the percentage of marine and terrestrial areas designated as either a protected or managed area. The percentage of protected/managed marine area in Palau is noticeably high, well above the 30% target, because the whole area of the Rock Islands Southern Lagoon is considered a managed area.

Table 1. Size and percentage of protected or managed area, for each of the MC jurisdictions (figures for 2011).

| **Jurisdiction** | **Marine** | | **Terrestrial** | |
|---|---|---|---|---|
| | Hectares | Percentage | Hectares | Percentage |
| **Palau** | 167,117 | 58% | 8,047 | 19.6% |
| **Guam** | 2,967 | 13% | 12,404 | 23% |
| **CNMI** | 4,588 | 8% | 4,357 | 9% |
| **RMI** | 318,548 | 18% | 4,580 | 16% |
| **FSM** | 148,691 | 7% | 9,208 | 15% |
| Yap | 59,732 | 10% | 32 | 0.3% |
| Chuuk | 29,850 | 2% | 1,934 | 17% |
| Pohnpei | 58,556 | 29% | 6,481 | 20% |
| Kosrae | 553 | 4% | 761 | 8% |

MC definitions

To achieve the MC targets, it is key to also focus on and define *effective conservation*. Just setting aside areas does not necessarily yield the desired results for conservation. Conservation is more than just protected areas; we practice conservation because we need resources. Conservation activities also happen outside of protected areas, and surrounding areas can have huge impacts. For instance, in MPAs, sedimentation issues from the terrestrial environment have a huge impact.

Effective Conservation was defined during the MC Planning Meeting (2006):

**"Effective Conservation** entails the social, traditional, political, biological, financial, and legal aspects of sustainable use of at least 30% of our Marine Resources and 20% of our Terrestrial Resources, keeping in mind the overall management of surrounding areas, and finding a right balance between resource utilization by communities to sustain their cultural values, socioeconomic development, and prosperity."

The 1st MC Measures Meeting, in 2008, defined what was meant by **terrestrial resources**:

"Land areas composed of native forest and/or natural terrestrial communities, high biodiversity value or provide an especially high level of ecosystem services. As much as possible, the 20% should be distributed evenly among and within the jurisdictions."

It was also recommended that "as part of the MC, each jurisdiction aims to effectively conserve at least 20% of its total land area. This 20% must be composed of native forest AND/OR be natural terrestrial communities that have high biodiversity value or provide an especially high level of ecosystem services."

It is therefore very important to define what native forests are, for consideration of what to protect, and why. An area may not be considered native, but can still be an important habitat. The 1st Terrestrial Measures Workshop therefore defined **native forest** as:

"A functional forest with representation of indigenous and/or naturalized species of plants and wildlife, which include: Upland forest, Native Savannah, Freshwater Swamp, Marsh, Riparian Forest, Mangrove, Atoll Forest, Limestone Forest, Coastal beach strand, Secondary Forest, Agroforest and Rehabilitated Forest."

This is an all encompassing definition, which leaves it up to the jurisdictions to define. A comment was received from participants that forest should mean something to the community, and have some sort of value to them. This is then perhaps the way to define a "functional" forest.

In order for terrestrial indicators to be discussed productively during the workshop, it was important that participants were reminded of the MC criteria for selecting indicators.

**Criteria for selecting indicators:**

- **Importance –** *how critical is it to the MC that this indicator be measured regionally and communicated to target audiences?*
- **Practicality –** *how doable/realistic is it for all (or most) jurisdictions to measure this indicator at this point in time?*
- **Cost –** *what level of human and financial resources will be required to measure the indicator?*
- **Sensitivity –** *will the indicator respond to and detect changes through time?*

*"I urge you to develop measures according to what I call 'the grandmother test'. What would your grandmother, with her years of practical responsibility, be able to see and accept as a real measure of success?"*
His Excellency President Emanuel Mori.

The MC definition of an **indicator** is:

> "A measurable entity related to a specific information need such as the status of a target/ factor, change in a threat, or progress toward an objective."

During the 1st Measures Workshop, it was decided that indicators should focus on **targets** rather than threats. For instance, you could look to see if bird populations are increasing, or if a forest is growing, rather than measuring a threat such as invasive species. In this way, what is being measured should give a positive indication that goals are being met, rather than emphasizing the negative.

The MC definition of a target is:

> "An element of biodiversity, which can be a species, habitat/ecological system, or ecological process."

Previously identified terrestrial targets and indicators
1st MC Measures Workshop, Pohnpei

The first MC Measures Workshop, in 2008, proposed the following terrestrial targets and indicators.

**Targets**

- Freshwater ecosystems (rivers, streams)
- Native Forest
- Mangroves*
- Native forest birds

* Mangroves were left out of by MC Marine Measures Workshops, and so adopted by the terrestrial group.

**Indicators**

Freshwater Ecosystems (rivers, stream)

- Flow rates
- Density, size, diversity of fauna
- Water quality

Native Forest

- % native forest cover (including areal extent)
- Species Diversity and Abundance
- Forest Structure (Age Class)

Mangroves

- Water Quality
- Sediment Accretion
- Level of harvest/extraction
- % native forest cover (including areal extent)
- Species Diversity and Abundance
- Forest Structure (Age Class)

Native forest birds

- For specific important bird species: Population Density and abundance
- Age class structure (including # of breeding Pairs)
- Geographic distribution of Habitat and Nesting Areas

1st MC Terrestrial Measures Workshop, Chuuk

The MC workshop in 2011, dedicated to terrestrial measures, worked to redefine the terrestrial targets and indicators. One of the major changes was the removal of native forest birds as one of the targets. Birds were instead placed as an indicator for native forests. Methods for measuring these indicators were also suggested. It was an essential part of the development of these monitoring methods to have a group of people working in the terrestrial field to review these targets and indicators.

One of the challenges in coming up with the MC terrestrial monitoring protocols is that, compared to marine ecosystems, to date there has not been a lot of work in the region, particularly when it comes to long-term monitoring. So in many cases, a lot of this work will be starting from scratch. There has been some work done by the US Forest Service, but this has been limited to a 10 year cycle, which is on too broad a time scale. The date set for the Micronesia Challenge is 8 years away, so the region really needs something more frequent to show we are actually having some success on the ground.

**Targets**

- Freshwater ecosystems (rivers, streams)
- Native Forest
- Mangroves

Freshwater Ecosystems (rivers, streams and water lenses)

| Indicator: | Methods: |
|---|---|
| • Turbidity | Secchi Disc |
| • Coliform | EPA method |
| • Salinity | EPA method |
| • Fish/crustaceans | ??? |
| • Flow rates | ??? |
| • Size | ??? |

Native Forest

| Indicator: | Methods: |
|---|---|
| • % Forest Cover | Satellite imagery (remote sensing) |
| • Species Diversity | FIA modified |
| • Species Abundance | FIA modified |

- Bird Diversity — Standard Point Count
- Human Disturbance???
- Invasive species???

Mangroves

| Indicator: | Methods: |
|---|---|
| • % Forest cover | Satellite imagery (remote sensing) |
| • Species diversity | FIA modified |
| • Species abundance | FIA modified |
| • Water quality (turbidity)??? | Secchi disc |
| • Peat Depth??? | |

Indicators or methods with question marks associated are those that the 1st Terrestrial Measures Workshop suggested needed further work. One of the things that came out of that 1st workshop was the lack of expertise on freshwater ecosystems, which was a major reason for holding this 2nd Terrestrial Measures Workshop.

**Questions/Comments from participants on presentation**

Question: Why was harvest levels an indicator for mangroves, but not native forests?
Response: This is a minimum set of indicators. Scores were applied to indicators based on the criteria for selecting indicators. If indicators didn't score as high, they would have been cut.

Comment: Soils should be considered as an indicator for native forests.
Response: MC should help build capacity.
Response: We have limited capacity, and need to be realistic.

## Presentation: Sampling and Monitoring
## By Dr. Yimnang Golbuu, PICRC

Dr. Yimnang Golbuu, lead researcher at the Palau International Coral Reef Centre, gave an insightful presentation on the basic principles and considerations behind monitoring. Dr Golbuu stressed that the most important thing when designing monitoring methodology was to consider "What is the question?". The question then determines the monitoring and methodology. This was a very important reminder for participants, and was reflected during discussions throughout the workshop. The presentation is summarized below.

Sampling

The question is, why sample? We need to sample, because most of the time we are interested in large areas, which are too big to study everything in. For instance, we cannot monitor every single tree in a forest. It is impractical, with limitations in cost, time and resources. So from the whole population, you take a sample, which gives you an estimation of the population (see Figure 2).

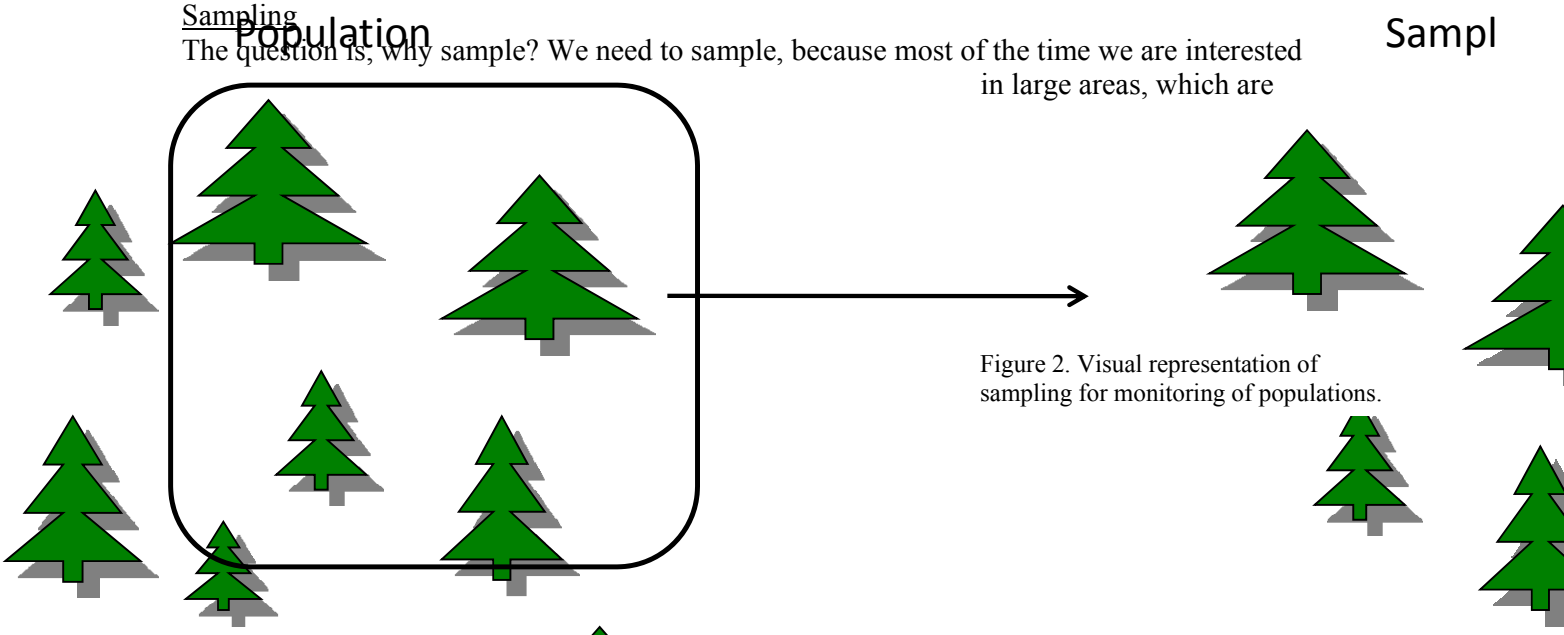



Figure 2. Visual representation of sampling for monitoring of populations.

It is important that samples are randomly selected from the population, so that it is not biased. If you sample randomly, you can then extrapolate it to the whole area. One way of randomly sampling is to divide the area into a grid, where every area is numbered and has a chance of being randomly picked as a study site. In some areas where there are changes in the community, for example in a mangrove, which is stratified, random sampling might miss some of those different areas. In this case, stratified random sampling is used, where the different areas are first separated, and then samples are randomly picked within those different areas. For example, in a study in 2010 of bleaching in Palau's reefs, stratified sampling was used. Palau has different types of reefs, such as outer barrier reefs, patch reefs and inshore reefs. Since most reefs are patch reefs, if you randomly selected sites, most sites would be patch reefs, and the important inner reefs would have been left out of the study.

Permanent Monitoring Sites

Once study sites have been randomly selected, you can choose sites to permanently monitor. The advantages of permanent monitoring sites are that they have high resolution, where you can examine changes over time, can examine key processes, and look at relationships. One of the limitations of permanent sites, though, is that it is harder to look at larger spatial scales; if you wanted to extrapolate to the whole area, you would need to randomize study sites again.

The differences between monitoring and assessments should also be considered. Assessments are one time studies. This gives an idea of where to conduct further efforts. If a study is conducted **consistently** over time, then it can be considered to be monitoring. Monitoring should be used to inform management, and is a key part of adaptive management.

Monitoring objectives

Monitoring is not just conducted in isolation, and for no firm purpose. Monitoring should be conducted to inform management. Therefore, monitoring should be guided by the management objectives: i.e. what is the reason for setting up your protected areas and what are you managing for? Monitoring should provide information to help us determine if we are meeting our management objectives.

The most important thing to remember is: What is the question? The question you want answered determines management and the methods. The question must be clear before you decide what you are going to monitor. For example, if the question was if there has been a detectable change over time in benthic community structure and benthic cover in managed vs. unmanaged sites, indicators to measure this could include percentage coral cover, percentage benthic cover, density of coral recruits and size of coral recruits. Monitoring methods could include photoquadrats and belt transects. If the question is whether key fisheries community structures have changed over time in managed compared to unmanaged sites, indicators to monitor would include species diversity and species biomass. Methods to assess this could include underwater visual census 5X50 m belt transects. So you start with the objectives for management, then the questions to consider, then pick indicators to measure for that, and finally the monitoring methods.

Monitoring Design

How many replicates do we need in a study? This is a very important part of the study design. When you measure more than one thing, you see variance and you get uncertainty in the measurement. It is very important to have a low Standard Deviation (measure of variance), as a high variation between samples results in the data having little credibility.

A pilot study can be used to estimate the number of replicates needed in a study, by looking at the variance and the number of samples. The Coefficient of Variation (CV= Standard Deviation/ mean) can be calculated from that information, and can be plotted against the number of replicates to find a number which results in an acceptably low variation (see Figure 3).

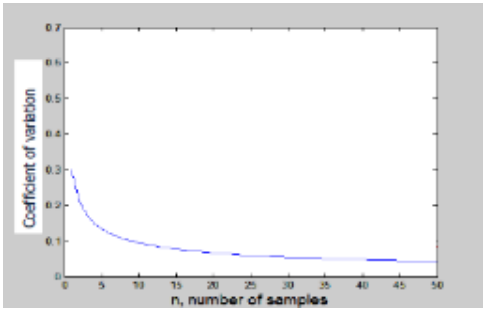



Figure 3. Graph of coefficient of variation against the number of samples, showing the lowering of variation with increased sampling effort.

Most management is done at the site level, and so the monitoring design will be focused on information at that local scale. However, managers also want information on a national scale. In the case of the Micronesia Challenge, monitoring will be designed to look at informational on a regional scale. So the design and level of replication will depend on what you are looking at. Ultimately, monitoring methods need to be designed to be able to inform managers about whether their objectives are being met, and if management activities are

resulting in the desired changes. In this way, monitoring can be used to inform adaptive management.

**Questions/Comments from participants on presentation**

Unless indicated, questions and comments are from workshop participants, and responses are from the presenter, Dr. Yimnang Golbuu.

Question: How do you choose permanent monitoring sites?
Response: You can initially randomize to select sites. Or if you are interested in something at a specific site, you can just select that site. So it depends on what you are trying to do.

Comment: The points from the presentation are very important. Sometimes you monitor but forget what the objective is, and you need to clarify that.

Question: Sometimes countries are overwhelmed with so many protocols for what to measure. So how does PICRC standardize this?
Response: Marine monitoring protocols for the MC were standardized in February. The objectives for management were uniform in all MPAs – fisheries and corals.

Question: One challenge is to find a good periodicity to detect changes. How often would you suggest you should be conducting surveys?
Response: For PAN monitoring of fish, we initially surveyed every quarter, for a year and a half. We found two major patterns of difference- summer and winter. So now we sample twice a year. So you look at your data to decide on the frequency.

Question: Are reference sites inherent in monitoring of managed sites?
Response: If you are monitoring a managed area, then you need reference sites. You find sites that closely resemble your managed site, hoping that the only difference between the two are the management actions. Sometimes it can be hard to find a reference site. For example, in Kayangel, there isn't a reference site, because there are no other atolls close by.

Comment: What ultimately drives a monitoring program is the resources available, and to that extent what you can answer.
Response: If you don't have the resources to do a study properly, you should wait until you have it.

Question: Have you looked at indicator species for climate change?
Response: Yes, corals.

Question: If you collect something specific and decide to collect additional measurements, could that be a problem if it is the wrong design?
Response: If it doesn't cost too much and the design of the monitoring program lets you do it, it is ok, but you have to be careful.
Comment: Clarifying comment – Eg. if you are comparing MPAs and non-MPAs, and then decide to estimate the population of parrot fish.

Response: You can say if parrot fish went up or down within the sites, but you can't extrapolate that to the whole country. You would need to randomly select more sites to specifically look at parrot fish.

## Discussion: objectives of monitoring for terrestrial protected areas throughout Micronesia
## Facilitated by Charlene Mersai, Island- SEAS/ SD

What was missing in the 1st MC Terrestrial Measures Meeting was a discussion on what is important to each jurisdiction at the site level. What is the question being asked at the site level? There are different scales for consideration: site, national and regional. When the terrestrial measures were being revised to look at what is relevant to us, the fundamental reasons for why Protected Areas were created was missed. So the protocols might be ok at a regional scale, but is it ok at the national and site levels? So in this session, we will take a step back, and have look at the major objectives and threats for each area. Then we can look at what indicators are relevant and important at the site and national levels, and which indicators are overarching and can be used across the region.

Each jurisdiction was asked identify the major objectives and threats for their protected areas. These are summarized below.

| **RMI** | |
|---|---|
| Objectives<br>• Functionality (ecosystem services): is the area functional, is it working, providing the community what they need? Eg. Functionality of forest, intact ecosystem services= food (taro, breadfruit etc.); medicine | Threats<br>• Solid waste<br>• Climate change |
| **Kosrae** | |
| Objectives<br>• Species diversity<br>• Ecosystem services | Threats<br>• Road development and activities |
| **Pohnpei** | |
| Objectives<br>• Watershed management: maintain integrity of area; monitor and control threats; water quality<br>• Biodiversity | Threats<br>• Farming (destructive methods)<br>• Invasive species |
| **Chuuk** | |
| Objectives<br>• Ensure quality and quantity of water to sustain communities | Threats<br>• Invasive species<br>• Pollution<br>• Climate change<br>• Human development |
| **Yap** | |
| Objectives | Threats |

| | |
|---|---|
| • Sustainability of terrestrial developments and sustainable resource use<br>• Important habitats: mangroves, savannah, agro-forests | • Development |
| **CNMI** | |
| Objectives<br>• Species diversity<br>• Ecosystem functions | Threats<br>• Invasive species<br>• Development |
| **Guam** | |
| Objectives<br>• Watershed management perspective: connection between coral reefs and terrestrial<br>• Looking specifically at species diversity | Threats<br>• Invasive species (ungulates)<br>• Development- increasing<br>• Wildland fires |
| **Palau** | |
| Objectives<br>• Birds: endangered species, eg. Micronesian Megapode, and culturally important species<br>• Traditional and cultural significance, eg. sacred trees<br>• Ecosystem services<br>• Resources, eg. medicine, food, building materials<br>• Watersheds: water quality and quantity<br>• Ecotourism<br>• Species diversity<br>• Mangroves- mitigation sites<br>• Community education | Threats<br>• Tourism<br>• Urbanization/development<br>• Pollution<br>• Climate change<br>• Fires<br>• Poaching |

**Discussions/ participant comments**

Comments: The Micronesia Challenge needs to follow what is happening in all of the jurisdictions, and be aware of what the major concerns and interests are. The MC protocols are designed to look at the broad level, but are not adequate for individual sites or jurisdictions. So just following MC protocols might not be enough for managing specific sites.

Comment: Watersheds came up again and again across the jurisdictions, so they are important to focus on.

Question: For the jurisdictions that didn't mention harvested resources, are there important harvested resources you wanted to include?

Response: Species diversity will determine to what you can harvest; so for resource harvesting, species diversity is important.

Comment: Indicators for the local level will vary depending on the question; but if certain indicators can be found for regional common regional objectives, that is important.

Comment: We need to step back, see if management objectives were covered in Chuuk (1st MC Terrestrial Measures Workshop), and discuss throughout the workshop. Terrestrial objectives will vary, but we want to capture things in common so we can use that for the MC. Indicators should be about the targets itself, not the threats, so as to keep a positive focus.

Comment: The regional efforts set up by the MC don't limit us nationally to go further.

## Presentation: 10 years bio-monitoring research of Babeldaob Watersheds By Dr. Eric Benbow

Dr Eric Benbow, from Dayton University, is an expert in freshwater invertebrates who has been studying Palau's rivers and streams for over 10 years. He has been working to create a freshwater bioassessment method for the region, using macro-invertebrates as indicators. Dr. Benbow was asked to attend this workshop, to present information on this work, to lead in-field training on the rapid bioassessment methods, and to guide discussions on the MC regional indicators for freshwater ecosystems. Below is a summary of the presentation: *An approach to rapid biological stream assessments for island watersheds.*

Ridge to Reef Connections

The local economy depends on marine and terrestrial habitats, particularly in Palau. In the terrestrial environment, the streams are highly dynamic. Rivers and streams can act as a liaison between the terrestrial and marine environments, because they are highly dynamic and fluid in nature. They connect upstream landscapes to marine environments out from shore. Perhaps these systems can therefore be used as a type of "canary in the coal mine". Ultimately, if we are monitoring, these freshwater systems could be used to identify problems earlier.

In Hawaii, work was done early on in tropical inland systems to show how watersheds affect entire ecosystems. This clearly showed a connection between the mountains and the reefs. We know that connection is true, but do not know all of the dynamics. For instance, what happens when we break that system? There has been a lot of work done recently on coral reefs, recognizing the importance of watersheds, and their maintenance, for coral reef health. For instance, a recent paper (Richmond *et al*. 2007. *Watersheds and coral reefs: conservation, science, policy, and implementation*. BioScience 57(7): 598-607) recognized runoff and sedimentation from the terrestrial environment as one of the greatest threats to coral reefs. This paper showed that sediment, accumulated over decades, can continue to be an issue long after it has been deposited, and be re-suspended during storm surges. The paper urges that integrated watershed management is needed for coral reef protection.

However, freshwater resources are very rarely properly managed. Usually freshwater systems are studied in connection to the terrestrial land environments, but very rarely just for themselves. Scientifically data is lacking, and more studies are needed on freshwater resources.

How we got started

The project initially started out as a university course, when we brought students over in 2001, teaching about biological integrity and sustainability. A colleague had been working in Brazil, attempting to develop a rapid bio-monitoring protocol, a bioassessment method, for streams. We thought this might be usable in Micronesia.

We developed a study around an initial question: what impact would the construction of the new capital and the compact road in Babeldaob, and the associated runoff and sedimentation, have on the aquatic ecosystems? These extensive constructions were a major concern for the community, who wanted to understand how the run-off would affect mangroves and coral reefs. A bioassessment method, using macro-invertebrates, was chosen to begin looking at these questions. Baseline data for aquatic ecosystems in Palau was collected in 2003, 2004, 2007, 2009, 2010, 2011 and 2012.

Figure 4. River Babeldaob affected by heavy sedimentation.

Bioassessment approach

There are a lot of different indicators and metrics used to assess water quality, including different bio-indicators, such as fish. So why use invertebrates for water quality assessments?

1) They are ubiquitous in nature, i.e. they are found everywhere.
2) The diverse taxa provide a range of response to environmental stressors.
3) They are relatively stationary (except the migratory stages of amphidromous fauna). This means that they can be used as an indicator for changes over time, and for a range of interactions.
4) They have relatively long life cycles.
5) They are usually easy to collect and identify at coarse taxonomic levels.

What you want to know with an indicator is the point at which, in a disturbed ecosystem, more disturbance will result in an ecosystem collapse (see Figure 5). You want a measurable attribute to show when things are going wrong in an ecosystem. Invertebrates are thought to be a good indicator for this kind of pollutant gradient. If you can identify species responses to disturbance, you can develop a ranking system based on species, or on ratios of species. You can then use these bio-indicators as a more practical measure, rather than looking at the entire gradient of disturbance.

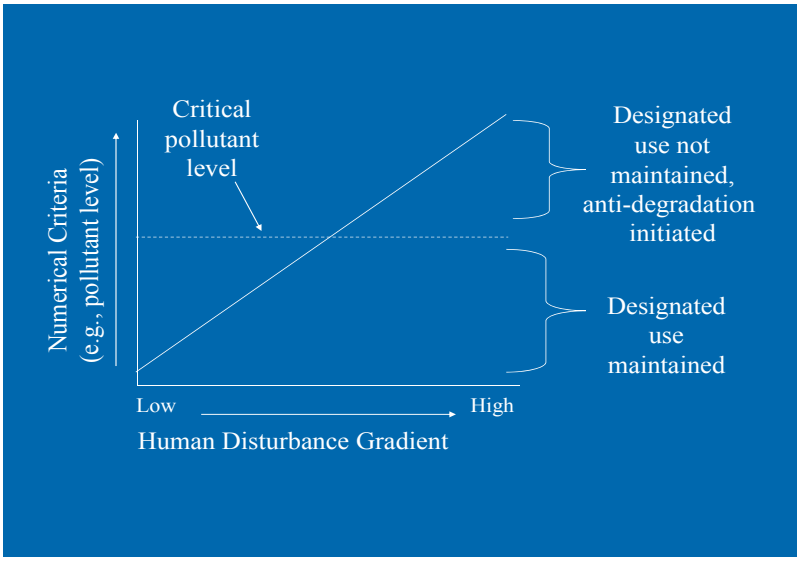



Figure 5. Graphical representation of the critical tipping point in a disturbed ecosystem, at which point more disturbance can result in ecosystem collapse.

In this study, we used a macro-invertebrate functional feeding group approach to bioassessment. Advantages to this approach include: it is economical, and therefore good for agencies with limited funding; taxonomic expertise is minimized, as invertebrates do not need to be identified to a high resolution; it can be combined with teaching; and it is relatively quick and easy. However, a baseline database is necessary.

In this method, macro-invertebrates are classified into their functional groups, which are categories based on types of feeding. Taking a functional approach takes away the need for taxonomic expertise. The major responses of these groups are also simplified. For example, if there was a lack of vegetation, the group directly eating vegetation would be the first to respond to this change. Macro-invertebrates can be classified into the following functional groups:

- Scrapers – eat biofilm off of organic matter (OM).
- Shredders - break OM into smaller pieces.
- Gathering-Collectors - collect pieces and continue to break down into smaller pieces.
- Filtering-Collectors - collect smallest pieces by filtering from water.
- Predators - eat all of the above.

In Palau, the major invertebrate scrapers include *Petrophila sp.* The Filtering collectors here include the blackfly *Simulium palauense*. The gathering collectors include the shrimp *Pycnopsyche lepida*. Predators in Palau waterways include macrobrachium.

The classification of invertebrates to functional groups is determined by mouth parts, habit and habitat. In an aquatic ecosystem, you generally have similar interactions among functional groups (see Figure 6). There has been a lot of work done in US streams to look at how different functional groups use particulate foods across a size range. This might be different in Micronesia, but we could develop similar information for the region.

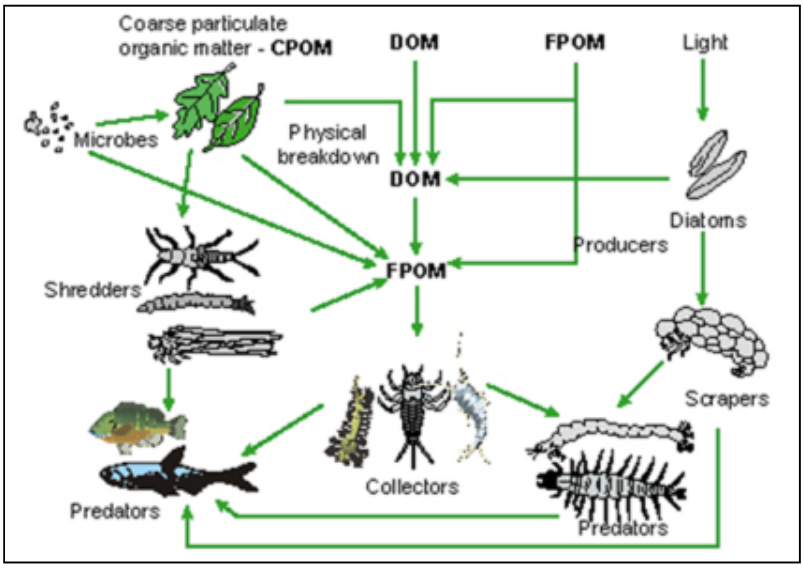



Figure 6. A simplified view of a food web in a woodland stream. Energy inputs include fallen leaves, subsequently colonized by microbes; small autotrophs, primarily diatoms; and DOM and FPOM, originating from external sources and upstream.

The bioassessment method looks at the ratios of the different functioning groups to estimate different stream ecosystem attributes (see Table 2). For example, if you wanted to assess the ratio of course particulate organic matter to fine particulate organic matter, you would look at the ration of shredders (which deal with course material) to other collectors. For each of these attributes, there are expected ratios (general criteria ratios) that the ratios from the collected data can be compared against. These values will need to be changed for the Micronesian region.

Table 2. Functional feeding group ratios as indicators of stream ecosystem attributes. General ratio of ranges given are for numerical or biomass taken when most taxa are in mid-late larval instars or are in the adult stage.

| ECOSYSTEM ATTRIBUTES | SYMBOLS FOR ECOSYSTEM ATTRIBUTES | FUNCTIONAL FEEDING GROUP RATIOS FOR ATTRIBUTES | GENERAL CRITERIA RATIO LEVELS |
|---|---|---|---|
| AUTROPHY TO HETEROTROPHY INDEX | P/R | SCRAPERS TO SHREDDERS + TOTAL COLLECTORS | AUTROPHIC > 0.75 |
| COARSE PARTICULATE ORGANIC MATTER (CPOM) TO FINE PARTICULATE ORGANIC MATTER (FPOM) INDEX | CPOM/FPOM | SHREDDERS TO TOTAL COLLECTORS | NORMAL SHREDDER ASSOCIATION LINKED TO FUNCTIONING RIPARIAN ZONE > 0.25 |
| FPOM IN TRANSPORT (SUSPENDED) TO FPOM STORAGE IN SEDIMENTS (DEPOSITED IN BENTHOS) | TFPOM/BFPOM | FILTERING COLLECTORS TO GATHERING COLLECTORS | FPOM TRANSPORT (IN SUSPENSION) GREATER THAN NORMAL PARTICULATE LOADING IN SUSPENSION > 0. 50 |
| SUBSTRATE (CHANNEL) STABILITY | STABLE CHANNEL | SCRAPERS + FILTERING COLLECTORS TO SHREDDERS + GATHERING COLLECTORS | STABLE SUBSTRATES (E.G., COBBLES, BOULDERS, LARGE WOODY DEBRIS, ROOTED VASCULAR PLANTS) PLENTIFUL > 0. 50 |

The Design

The data needs to be gathered in a manner that is repeatable and standardized. This includes the use of at least one control site. The habitat should be examined, with recorded data including:

- Visual estimation of canopy;
- Visual estimate of flow habitats (cascade vs. riffles vs. pools);
- Water clarity.

Transects measures should be taken, including:

- Flow velocity
- Depth
- Temperature, Conductivity, DO
- Transect Width

It is good to take at least three transects, and the associated measurements, at each site.

Macro-invertebrate samples are collected from both fast habitat (fast flowing water) and slow habitat (pools and bank edges). For slow habitat, sampling involves sweeping a net along the bank for 30 seconds. 2-3 samples are collected, and combined. For fast habitat, the net is held

on the bottom of the stream while the bottom is scoured. 2-6 samples are collected, for 30 seconds each, and the replicates combined. Samples are sorted to remove excess debris, and then preserved in ethanol.

Sorting of the samples is then done in the lab. Sorting into functional groups can be relatively easy, and does not require taxonomic expertise. Students with no expertise, and sometimes with no scientific background, can learn quickly to identify the different groups. A quality control was used, which showed students were accurate. The data sheet used in the lab, the Palau Stream Macroinvertebrates Metrics Data sheet, is used to input the numbers different taxonomic groups, and the numbers for functional groups. From this, percentages and ratios of functional groups are easy to calculate.

Preliminary Results

From the samples collected, we have a preliminary species list, with the major families identified. In Palau, there are few insect taxa. Common aquatic insects include some coleopteran, mayflies, dragonflies, *Pyralidae* sp. (moth), and the blackfly *Simulium palauense*. A lot of snails were found, and a key for snails could help people easily ID species. There is also a diversity of shrimp and prawns, and we are working on building a key. Overall, the systems here are not incredibly diverse. However, we were only sampling once a year, so this might be missing quite a lot of groups, particularly families which have a sharp peak and then disappear. The important invertebrates that could be used as indicators include the *Pyralidae* moth, the blackfly *Simulium palauense*, shrimps, and neritid snails. The moth, because it has filters, could be a particularly sensitive indicator.

The ratios of the functional groups were compared between slow and fast habitats. In fast habitats, the majority of macro-invertebrates were filtering-collectors, whereas scrapers were the most common functional groups in slow habitats (see Table 3). Filtering-collectors would obviously be suited to areas of faster flowing water. We are still analyzing what the actual values mean, and how they can be applied as indicators of stream health.

Table 3. Total number of invertebrates and relative percent composition of each functional feeding group for all sites combined, for 2004.

| | Functional Feeding Group | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Habitat Sampled | Shredders | | Filtering-Collectors | | Gathering-Collectors | | Scrapers | | Predators | | Total |
| High Velocity | 0 | 0.0% | 511 | 37.7% | 387 | 28.5% | 458 | 33.8% | 0 | 0.0% | 1356 |
| Low Velocity | 0 | 0.0% | 4 | 1.7% | 0 | 0.0% | 223 | 97.4% | 2 | 0.9% | 229 |

These ratios of the functional groups can be used to compare the different streams. For instance, in 2004, there was a much higher number of insects from the family Simulidae (blackflies) at Ngardmau compared to Ngermeskang and Ngatpang, where this taxa was poorly represented (see Figure 7). In that same year, it was found that the number of filtering-collectors were extremely low at Ngermeskang. The loss of these filterers from the stream could have been an indication that the ecosystem was being affected by sedimentation from the construction of the road. In 2007, the number of filterers was found to have increased, which could indicate that the system is recovering. By 2009, predators were found at Ngardmau, where they had previously been extremely low in abundance. This could also be an indicator of ecosystem recovery. Predators could be a really good indicator, as you need enough biomass in the system to sustain a population big enough to collect.

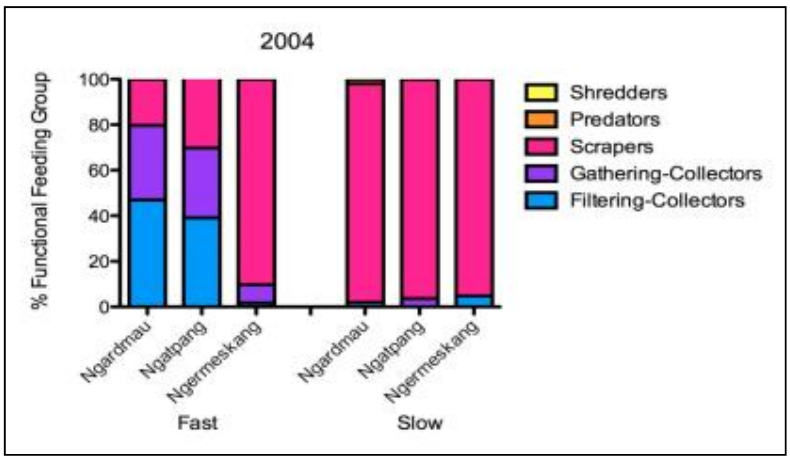



Figure 7. Proportions of functional feeding groups in Babeldaob streams, in 2004.

Additional on-going research/ Other Approaches

We also wanted to get a picture of what was happening down in the slow moving streams closer to the coast. We wanted to look at the post-larval migration of species, which move from the coast upstream. Migrating organisms, including fish, shrimps and neritid snails, are a biological connection between ridges and reefs. We used migratory traps to collect organisms, but found that these traps were often collecting the adults, rather than the migratory juveniles. We also used large PVC traps and Minnow Traps to look at organisms present, and compared catch rates. Taxa caught included snails, anguila, fish, shrimp and prawns. For the Minnow Traps, snails were not caught in 2010, whereas the anguila, fish, shrimp and prawns were abundant, but in 2011, snails were high in number but the other taxa were low or absent.

We also started work on bio-film, looking at how it develops, and the changes in microbial species. We used tiles as a growing medium, but found that in the shade algae could not grow properly, due to a lack of sunlight for photosynthesis, leaving mostly fungae.

We also looked at the levels of organic and inorganic matter in streams, to see if we could detect changes. This is very time intensive, and is a work in progress. We also began to look at the locations of sites, relative to surrounding stresses and other streams, to be able to better interpret the data from streams.

Conclusions and recommendations

The functional feeding group approach has promise. Additional years of data still needs to be analyzed, and more work needs to be done. Other indices that are needed include a better understanding of taxonomy, to relate to functional groups, and taxa richness/diversity. More frequent sampling is needed, preferably quarterly each year. We need to continue to work on understanding the location of the sampling sites relative to disturbance. This bioassessment method could also be considered for future collaborative efforts, and could work in conjunction with other indicators of ecosystem health.

**Questions/Comments from participants on presentation**
Unless indicated, questions and comments are from workshop participants, and responses are from the presenter, Dr. Eric Benbow.

Question: If you had to choose one simple indicator, what would it be?
Response: The ratios of scrapers and filterers in fast cascade bedrock outcrops, as fast habitat will respond to changes more quickly.

Question: Would the monsoon affect sampling?
Response: Possible, sampling has always been done in the summer.

Question: Can you share your thoughts about how monitoring indicators guide management actions?
Response: You can look at ecosystems, based on baseline changes and dynamics, and understand if an action or development is going to have impact. Then you can also monitor the impacts and see if there are any changes. You can show what kind of changes were due to certain activities.

Question: How about some of the physical metrics as indicators?
Response: Physical metrics are going to be point measurements. When you get a full data set, when you have chemical and physical results, you can calibrate and correlate those with biological data.

Comment: With physical data, how to handle standalone data points is a big issue.
Response: Bioassessment is important because it is an integrative measure, and not just a point measure. We have a set of baseline data.

Question: It is helpful to include in monitoring protocols something that people want to catch, such as fish. It gives people motivation to see what's in the stream. So can you expand on the potential for vertebrates to be used as indicators, as top predators?
Response: Yes, that is a very positive aspect, and it could be built in. I don't know enough about fish data or species ID. It could be very promising, and it could be a sell to local communities who are interested in what's there. I just don't know enough about fish bioassessment surveys here, except for visual surveys.

## Discussion: Indicators and methods of bio-monitoring work
## Led by R. Eric Benbow

After the presentation on the freshwater bio-assessment approaches, Dr. Benbow led the afternoon discussion on these indicators and methods, which is summarized below.

This type of biomonitoring is longer-term. The approach doesn't require taxonomic expertise. Keys can be built that act as an easy guide. Biological indicators get hit by a whole lot of issues, so this shows long-term perturbations, and you can integrate all information. These are not high resolution metrics, but it shows if something big is happening, something you really need to worry about. It can show long-term perturbations, and show more than some of the other water quality metrics. It can be used to assess overall system quality, and that can be connected back to the "ridges to reefs" continuum. The method can also be used as a learning mechanism for students, who learned quickly. Scientists can educate the community about the impacts of activities, and this can also help teach younger generations. In the field, we will see how to do it, how it is quick and fun. Processing is done after the field work. You can use community colleges, or conservation groups, to sort the samples.

**Questions/Comments from participants on presentation**
Unless indicated, questions and comments are from workshop participants, and responses are from the facilitator of this discussion, Dr. Eric Benbow.

Question: How can States look at the terrestrial and marine environments together, and how these systems are connected? Can indicators be used as a 'red flag' to understand all of these systems? Could you use an indicator with a lifecycle that is linked to both the terrestrial and marine systems?

Response: It is ideal to look at everything at once, but it is not going to be easy. If you establish a biomonitoring program in streams, that clearly shows something is going on, it can be a predictor of impacts to mangroves and near-shore communities. You can study these changes from one year to the next. For indicators, they could be simple, such as monitoring the recruitment of migratory species, which shows a link between mangroves and streams. For instance, in Hawaiian streams, snails were eliminated because of a reduction in water the nursing habitats.

Comment: We need to take a long-term monitoring approach, looking at control sites and changes, looking at indicators for protected terrestrial areas. We need to take a watershed approach.

Comment: We need to remember Yim's presentation, and consider "what is the question". So for indicators, what are we looking at: are we looking at stream health, or changes in stream function? We need to measure physical conditions in the stream. In terms of the MC, we are interested in looking at different jurisdictions, and looking at the current status of its target. For the marine protected areas, it was simple, as the areas were set up for fish. But for terrestrial areas, there were different objectives for setting up protected areas. One overriding reason is to protect watersheds.

Response: Most objectives were ecosystem attributes. This bioassessment method is looking at the functional part of ecosystems, measuring things assets such as species diversity. If we were looking at watersheds as a link between marine and terrestrial

changes, what should we be measuring? Freshwater systems have a good potential to show larger scale major degradation.

Comment: So if freshwater is a target, we need to take a watershed approach to management.

Response: In an integrative watershed approach, you have tiers. The upper part of the watershed shows intermediary changes, whereas in the mangroves, there will be a lag in response. Perturbations in the watershed can be linked to changes in the marine. The trouble is developing an entire system of metrics, weighted for time, that can show changes in the linked systems.

Comment: The state of the science, in stream and watershed research, shows that if just 12% of a stream is developed, it can have a large irreversible impact. This has implications for management. So we need to look for opportunities to tie in management goals, monitoring goals, and monitoring questions.

Comment: Protected areas aren't going to address all problems, they are not the end goal. We need to take an integrated management tier approach that looks at the 3 tiers (upland, middle and mangrove systems). Unless this approach is undertaken, we are lying to ourselves to say we have protected 20%.

Comment: Palau's national vision is sustainable development. The challenge is how you implement this.

Question: If the measures group does adopt these bioassessment measures, how soon can we expect to get training?

Response: Within the year. We first need to analyze the last 2 years of data, to be more confident in how well the indicators can be used. The actual implementation and sustaining the monitoring will be the harder part.

Question: It took 10 years to develop this method in Palau – how long would it take in other places?

Response: If we had better funding, five years would be ok. We are fairly confident that the big indicators found here should be in most of the islands. It would be a matter of doing an initial survey to confirm that there are similar taxa, and that the functional feeding group designation is similar. So the first thing is to develop a pictorial key. We need to look at each specimen and develop morphological characteristics that give a clear indication of the functional groups. Once that is done, if the same functional groups are in the other islands, it could be rapidly developed.

# DAY 2

## Fieldwork training on freshwater invertebrate biomonitoring protocols

The second day of the workshop was devoted to in-field training in the invertebrate bioassessment methods, led by Dr. Eric Benbow. The Terrestrial Measures group were able to directly try out the methods discussed by Dr. Benbow on the first day of the workshop, including transect measurements of water velocity and depth, and the collection of invertebrates from fast and slow habitats.

The stream site was located in upper Ngermeskang. Participants were able to appreciate some of the logistical challenges involved in reaching monitoring sites, including a long "45" minute trek, and a fear-inducing crossing fondly referred to as the "bridge of emasculation".

On arrival, Dr. Benbow led a briefing to discuss the day's work. Smaller groups were able to take turns in collecting samples. Samples were taken in the fast habitat by holding a net against the substrate for 30 seconds, while the bottom of the stream was scrubbed. The width of the stream was used to determine the number of replicates. Samples were combined into a sieve, and then transferred to a jar of ethanol. Three samples were collected from the slow habitat, in the pools and against the stream banks. The group was able to look at the organisms caught, which included many shrimp for both types of habitat.

The field trip was able to demonstrate that the field work for this type of study is relatively quick and easy. It was a good opportunity for the group to be able to see the realities of the concepts discussed on the first day, and for members from each of the jurisdictions to be able to understand how the methods could be implemented in their sites.

Figure 8.The high beam crossing on the trek to the Ngermeskang stream site.

Figure 9. Dr. Benbow demonstrating to the group the diversity of taxa to be found in Palauan streams.

# DAY 3

## Opening discussion

The workshop facilitator, Umiich Sengebau, opened the third day of the workshop with a discussion about innovative work being done in Latin America to do with water funds and monitoring methods for freshwater systems.

TNC has been working in the Latin American region to develop a water fund strategy, which involves downstream water users paying for clean and consistent water supplies. In these areas, where there are a lot of indigenous communities dependent on freshwater ecosystems, farming cattle and other issues have led to negative impacts in stream quality. TNC worked to develop water funds, where water users invest money into a trust fund, including water bottling companies, hydropower companies and farmers. The revenues are used for conservation projects in the area designed to increase stream health, such as helping the community use better farming techniques.

As part of these projects, managers need to be able to assess if these actions are having a positive impact. Bio-physical and socio-economic indicators were created to monitor and measure impacts and management effectiveness. These indicators are effective, and simple enough to be applied to Micronesia. These indicators are actually very similar to what we came up with in the 1st MC Terrestrial Measures Workshop.

For Protected Areas in Micronesia, we want to maintain what is there, such as biodiversity and stream flow, and see if there are any changes that indicate there is a problem. We can look at the work done in other places, and adopt it to the region, without needing to use all of it. This water funds document is very interesting, and we should look into it further. The monitoring protocols also include socio-economic indicators. For Palau as well as the rest of Micronesia, eco-tourism is an important part of Protected Areas, with benefits to the community. So these kind of socio-economic questions can be really useful to make the case for what we are doing.

## Discussion: Watershed bio-monitoring protocols Led by Dr. Eric Benbow

To follow on from the presentations, discussions and training on bio-monitoring protocols for freshwater ecosystems, Dr. Eric Benbow led another discussion group on this topic. The discussion was designed to recap the invertebrate bioassessment methods, and use that as a starting point for discussions on the MC monitoring protocols for the freshwater ecosystems target. The discussion is summarized below.

The field trip should have shown people that the monitoring methods are really not very difficult. To clarify, the site we went to was hard to access, and was very overgrown. We have been trying to develop a baseline, but you can choose sites that are more accessible for future monitoring. You can also choose sites that include more impacts.

In the field, we set up transects to conduct habitat surveys. We measured depth, channel width and velocity, from which you can calculate the volume. We used a velocity flow meter to measure velocity. You can get volume measurements at a more crude level with simpler methods. For example, you can get an estimate of surface velocity by simply measuring the time something takes to move a certain distance, and from there you can calculate mid-column velocity.

This type of data about the site you can set up initially, and don't have to do every time. You could measure this type of information every other time, or even once a year for some data. Most of the time you can just collect the samples, and you don't need to do all of the measurements. If you are just sampling, the equipment needed is very simple: you need a net, a sieve, a brush, containers, forceps and ethanol.

The sampling methods are not difficult. In the fast flow habitat, someone holds a net, and then someone scrubs in front, for 30 seconds at a time. If you sample 6 times, that's a total of 180 seconds. In the slow habitat, you do three 30 second sweeps around the vegetation and along the bank. So it can be very quick. Haphazard sampling is fine to select where you sample. Once you have the sample, you can put the contents into a sieve to quickly get rid of some excess matter, or directly into the container of ethanol. Isopropyl will be fine to preserve to use for ID. However, if you want to preserve the DNA or store in a museum, better quality ethanol should be used. So the methods can be very quick. We did a second site on the field trip at Ngatpang, which took only a few minutes to hike in and an hour to complete.

**Questions/Comments from participants**

Unless indicated otherwise, comments or questions refer to comments from workshop participants, and the response is from the discussion leader.

Question: There are a lot of rapids along a river – so what is the criterion for selecting a particular site?

Response: We were trying to get up as high as possible upstream, to get more pristine conditions, and get away as far as possible from perturbations. We have also been looking at slow habitats, and have been starting to analyze slow and fast habitats separately. Many eco-tourism sites are at cascades, so they will be easier to get to. So yes, you can do any of the habitats below, depending on the question and the landscape.

Question: Taking into account complex food webs, if you counted eels and fish, could you assume that if there are ok numbers then there are enough invertebrates to sustain them? Could you just measure that?

Response: Theoretically. But sometimes there is a departure. Eels and fish can survive fairly stressful conditions. So yes, you can probably see longer term and slower responses, but you might have to wait for everything to collapse.

Question: What other ways of monitoring are there? For example, the monitoring in Hawaii?

Response: Most work is done by State Government agencies, and is much more complex. What we are doing is much more streamlined. The major question in Hawaii is when you reduce water flow, what happens to the ecosystem? So the question that was used was what happens to moths as an indication of what is happening to the entire ecosystem. It got to the point where you could just look at the density of species, and predict changes. For the functional groups, you are basically just looking at categories and assigning ratios. This is good because you don't have to have taxonomic expertise, and it is much more economically feasible.

Question: Where do people bring the samples for ID? And where is the data stored?

Response: Someone trained can help pass those skills on. Once organisms have been ID'd for countries, it only takes a little bit of experience to catch on quickly. It can be one person's job to pick though and ID samples, and they don't need a scientific background. The data can be entered into and stored in an excel file, which can give out ecosystem values. The report for this method will have a section on how to interpret the data.

Question: Is it easy to train people to analyze the data?

Response: Yes, analysis and interpretation is the hardest part, but that's what we hope to streamline in the next year.

Question: Will the slow downstream areas be the same sort of habitat?

Response: Shrimp will be there, and the traps should offer additional information.

Question: You sometimes see snails up on the banks. How could this information be used?

Response: During a flood event, snails can attach on the bank and move up. This could be used as another coarse assessment. They may be trying to find new food recourses they don't get when the river is more stable.

Comment: You can walk around a stream and do a visual assessment, to understand different conditions.

Response: In the US, part of wetland monitoring involves community monitoring of dragonflies, which involves just counting and visually assessing these populations. This can be used as a reasonably coarse indicator. If you start losing dragonflies and damselflies, then it means everything else is gone. In Palau, we think we know what the adult moths look like for the moth larvae found in the streams. If you can make that connection, you could have a terrestrial indicator of the aquatic habitat. You could do visual surveys of these moths, and then just assess more scientifically annually. So yes, something like a walk though assessment could be used, and then more often you use a more complicated study.

Question: What type of taxa can you use for very basic monitoring?

Response: Snails and moths. Both can be seen when you walk into a stream. We don't know enough about snails, and some species may be more tolerant or more susceptible to changes. The data from the last few years should give an indication of what should be there in the streams, and in what proportions. So snails and moths would be the recommendation, but how you develop those as indicators is a more complex process.

Question: Do we need to identify more sites down the stream as well?
Response: Yes, you should have three sites on each stream to look at for monitoring: upper, mid, and lower sites. This is logistically hard, but it gives you an idea of the conditions at different elevations.

Question: Are there different species of snails in different areas?
Response: Yes, there are different species, but we are not sure what the species are yet. In the banks of streams, snails are not in high abundance. In Hawaii, you don't see any snails, because the streams are so trashed. That is where you don't want to be in 20 years. Palauan and Micronesian streams are in much better health, and are really high quality streams. But I do wonder if some rare species here used to be more abundant.

Question: What is the significance of flow rate?
Response: It's so that you know every time you sample what some of the conditions are, and if they will affect what you are collecting. If a stream is deep and full, it will change what organisms you are getting. So it is about trying to understand other variables.

Question: Do you sample for water quality?
Response: Yes: pH, dissolved oxygen etc. It would be nice to also take samples of nitrogen and phosphorous.

Question: Do you know what is affecting organisms?
Response: Not yet. We are trying to look at what's happening, and identify the variables. We are looking at a complex suite of perturbations. But maybe one is the biggest impact, such as sedimentation from development. So we want to look at the surrounding conditions with GIS. We think moths might be incredibly good indicators of flow volume. If velocity and the depth change, and there is not enough water, this will affect the population.

Question: Is there an indicator species that responds to turbidity?
Response: The tiny blackflies could be an indicator for this. They are filterers, so the ratio of organic particles to sediment will affect them. Probably also moths. Sediment will clog the houses the larvae build. Sediment can affect the food quality for moths, by affecting algae.

Comment: Yesterday, we saw a lot of green algae.
Response: This might be natural. Or it could be a sign of something like wild pigs. We need GIS information to know what's going on up there, such as if there is major agriculture that could be affecting the system.

Question: The sites sampled were very exposed to direct sunlight. Does canopy cover affect species?

Response: It does, you get a whole different suite of algal and bacterial species. Under the canopy, you still see moths but they are much more reduced. In that case, blackfly populations would be a better indicator, as they are not as dependent on sunlight.

Question: It would be great to involve schools in the monitoring. How can you involve students and still ensure that data is reliable for science and monitoring? Is that possible and feasible to get good reliable data and sampling from schools?

Response: Yes, but you need a well planned quality control and assurance. For example, a teacher could be trained by experts, and that teacher could maintain quality assurance. If the quality of the data is poor, there is no credibility. So engaging the right teacher to become the gatekeeper is very important. The students sort in the lab or count in the field, but the teacher records the data. As long as the right person is engaged and has investment in the project, there are ways to do it.

## Discussion: MC freshwater monitoring protocols
## Led by Umiich Sengebau

To follow on from the discussions on freshwater monitoring methods conducted throughout the workshop, participants discussed freshwater monitoring indicators and methods that could be adopted regionally for the MC. This involved reviewing the monitoring protocols identified in the 1st MC Terrestrial Measures Workshop (see below).The output of the discussion was the agreement on these protocols. Below is a summary of discussions and the key outputs.

**Freshwater Ecosystems monitoring protocols identified in the 1st MC Terrestrial Measures Workshop**

| **Indicator:** | **Methods:** |
|---|---|
| • **Turbidity** | **Secchi Disc** |
| • **Coliform** | **EPA method** |
| • **Salinity** | **EPA method** |
| • **Fish/crustaceans** | **???** |
| • **Flow rates** | **???** |
| • **Size** | **???** |

Participant discussions

Comment: In the last MC Terrestrial Measures Workshop, we didn't have any experts present for the freshwater systems, and didn't have much to go on. We need to utilize Eric's expertise, and the expertise of the people from EPA, who do most of the sampling. We can use this to come up with freshwater indicators and methods, and for defining what we want to measure to ensure that protected areas are improved. So what do we think of the identified indicators?

Question: In the 1st measures meeting, we weren't aware of macro-invertebrates as indicators. Would we be willing to add this?

Comment: We could have two sets of sites – pristine streams, and areas that are trashed, closer to communities.

Comment: We need to shoot for a minimum set of indicators that we think we can do for the MC.

Comment: We could just say aquatic bio-indicators, rather than aquatic invertebrates. There may be different species in different areas.

Comment: In terms of stream health, Coliform could be an indicator for ungulates, that they are in the area.

Comment: In Monday's discussion, we identified direct services, such as drinking water, as an important objective.

Comment: There are different things you look at for drinking water and ecosystem health. Maybe there is a commonality though, and you could start from there. We could break indicators down into human use and ecosystem quality. Turbidity would fit into both.

Question: What are the capabilities of the organizations we would be relying on for monitoring, such as EQPB? What are you testing?
Response (from EQPB): What you measure depends on the question. For instance, specific ways of testing turbidity depends on the question. Measuring fish, flow rates and size are all feasible.

Comment: Salinity is a major threat under climate change. Salinity is an indicator showing increased saltwater intrusion.

Question: Flow rates are important, particularly for climate change. What is an indicator that could give us that?
Question: How many streams have USGS gauges?
Response: Gauges are all not functional. We have gauges, but we need someone to do the measuring. We are trying to rebuild that system of collection.
Comment: So there could be an opportunity to take existing infrastructure and modify that, instead of reinventing anything.

Comment: The last few comments seem to have been getting at what the priorities are for sites. This might help us hone in on where to go from here. Quantity is number one, the top priority. So then monitoring that might be a top priority.

Question: So what are we measuring: water level?

Response: The indicator will be water discharge, which includes water levels, stream size, and flow rates.

Question: For physical and chemical indicators, do we have the capacity to test turbidity, coliform, salinity, and water discharge?
Consensus agreement.

Question: What biological indicators can we use?
Response: Everyone can look at aquatic insects.
Response: Measuring species levels could be done, like in Hawaii, where you just look for the presence of what's supposed to be there.
Response: It is better to say invertebrates, rather than just insects.

Question: Would it be an issue if you chose one type of invertebrate indicator, such as snails over insects?
Response: That is more of a jurisdictional issue.

Question: What would respond to stressors – fish or invertebrates?
Response: Invertebrates, especially for complex, unknown stressors.

Comment: You could use a nested approach for looking at the priority indicators.

Comment: You look at the functional groups. For instance, if you were worried about turbidity, you would look at the filterers.
Comment: You don't need to look at what species are there, just the major groups: shrimps, snails, and moths, representing 3 major classes. So you don't need to worry about taxonomy.

Comment: Some bio-indicator species might be harvested. So if you lose shrimps, this might be a harvesting issue, and not an indication of something else.
Response: That is the benefit of insects.

Comment: You could monitor something at a very basic level, i.e. presence/ absence, scales of 1-4 for abundance.

Comment: We want to be realistic when we go back do the work in our jurisdictions, that we have included enough indicators.
Response: These are the minimum set of indicators. It doesn't limit the jurisdictions, which can look at others.

Question: Do we need to do baseline surveys when we are doing monitoring?
Response: Yes, you would need to do baseline surveys, and you need reference sites to compare.

Comment: Stream bank erosion could be used as a proxy for stream flow, as bank erosion integrates long-term stream flow. In an intact watershed, there will not be much erosion, but there will be erosion in highly impacted watersheds.
Response: Bank erosion shouldn't be included as one of the major indicators. It is more background information. Even if not in the MC protocols, you can still do it.

Comment: Invasive species are very important problem in Guam. Guam is the hub for Micronesia, so even if it is not a problem in other jurisdictions, it will be. It will come to the other islands, and it needs to be monitored.
Response: The MC measures are all about the targets, and the indicators should be about the health of the targets. We want to emphasize the positive part. We don't want to be monitoring the threats. So invasives monitoring is something that can be done by each of the jurisdictions on their own.
Response: We should emphasize the positives. But with invasives, by the time you see a change, it is too late to take action.
Response: We should make sure that we are not missing out on critical issues for countries which already have invasives.

Question: Wouldn't salinity and turbidity also be threats?
Response: Those measure variables which indicate a threat, but invasive species are the threat.

Comment: We want to emphasize the native target. If the native numbers going down due to invasives, when you reduce the threat you want that target to come back. For example, you want to show that native fish are coming back because of action to limit tilapia. The indicators are not about management, and reporting on management. They are reporting on ecosystem health and quality.

Comment: For the MC, at the regional level, we want to look at what's there, and why an area is protected. At the local level, you can measure other things.

Comment: It is not always the case that the primary goal of protected areas is to protect a target. In Guam, conservation areas have been set up to kill invasives, and to restore that ecosystem from threats.
Comment: Areas were set up to manage the threats within them, and to look at why native species are declining, such as the wild pigs which are eating coconut crabs.
Response: You wouldn't be reporting pig numbers went down, you would report on the increase in crabs. The reason you are setting up a reserve is to protect something precious, not to kill the invasives.
Response: In Guam, it's both. Guam's dedication of protected areas that are counted towards the MC numbers might be misrepresented.

Comment: Back to the indicators: what specific methods should be used for measuring water discharge?

Response: It will depend on what infrastructure is there, so it should be up to the jurisdiction's discretion. We can leave it as discretionary indicator.

Question: Are wetlands included in freshwater systems?
Response: Wetlands are counted as native forest. Swamps are included in the definition of native forests.

Question: What methods for aquatic invertebrates?
Response: A rapid bioassessment approach. This could include functional groups, or simply looking at presence or absence of taxa.

Comment: Aquatic plants aren't mentioned.
Response: Invertebrates should encompass that, and show when there are stressors to aquatic plants.

Question: Are pH levels, dissolved oxygen (DO) etc. important to measure?

Response: DO and pH can the overall health of systems. Changes in the physical indicators can be a first alarm. If you get longer term changes and responses in the biological indicators, then you start to worry, and could be on the brink of collapse.

Comment: These indicators are not about finding ultimate causes, or specific problems. This is about big picture. Then if there is a problem, you can go and find out what it is.

**Key outcomes: MC monitoring protocols for freshwater systems**

Participants reached a consensus on the following monitoring indicators and methods for freshwater systems.

**Freshwater Ecosystems (rivers, streams and water lenses)**

| Indicator | Methods |
|---|---|
| Physical-chemical indicators: | |
| • Turbidity | Secchi Disc |
| • Salinity | EPA method |
| • Water discharge (stream size, flow rates, level) | Discretionary |
| Biological indicators | |
| • Aquatic invertebrates (shrimp, snail, moths/insects) | Rapid bio-assessment |
| • Aquatic vertebrates | Rapid bio-assessment |
| • Coliform | EPA method |

From the list of indicators proposed during 1st MC Terrestrial Measures Workshop in Chuuk, turbidity, salinity and coliform were kept. Flow rates were expanded to water discharge, to also include stream size and water levels. Fish/crustaceans were replaced with both invertebrate and vertebrate biological indicators.

## Presentation: Birds as indicators of Forest Health
## By Dr. Alan Olsen, Belau National Museum

Dr. Alan Olsen has been studying birds in Palau for many years, and is a firm advocate of using birds as indicators of forest health. Dr. Olsen gave a presentation on the long-term monitoring program being conducted in Palau, which is summarized below.

The holy grail of science is that whenever you can, you count. Without counting, it is just stories. Stories and anecdotes are ok, but the plural of anecdote is data. The message here is to remember to listen to the birds, because they have something to tell us. Birds are superlative ambassadors for conservation programs such as the Protected Areas Network, because people universally relate to birds on many levels, in ways that are favorable to creating awareness of the need to conserve a shared natural heritage.

National monitoring program for birds

Since 2006, we have been involved in a long-term national program to monitor forest and coastal birds. This has involved the collection of an inventory of species for sites, and the monitoring of that inventory over time. If you are managing a system, you need to know what is there. Species counts were taken every month for 20 sentinel sites, located in Babeldaob, and in the Rock Islands Southern Lagoon. Those inventories can then be compared across the different sites, to show areas of high species diversity.

Species accumulation curves were developed for the sites, which allows you to be confident, given enough data has been collected, that you have an accurate inventory of species (see Figure 10). Some species will be rare or shy, and so you need to keep collecting data until you are confident you have got all species. First-order Jackknife statistics were also run to validate these inventories, by comparing the estimated total species richness for sites with the observed data.

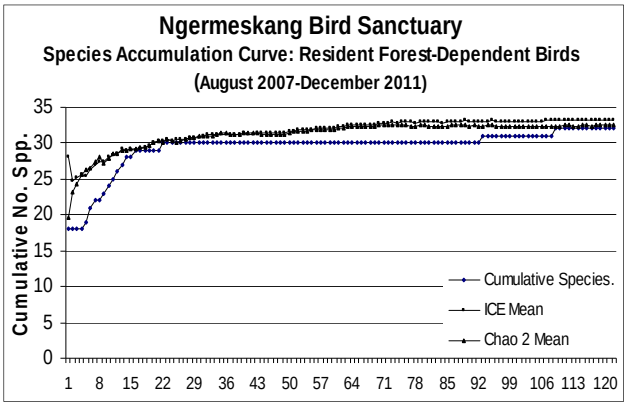



Figure 10. Species accumulation curve of birds at Ngermeskang.

Inventory monitoring

Species inventories at the study sites were monitored over the years, looking at major trends and changes. Birds can be used as good preliminary indicators of ecosystem health. Because birds are mobile, they are absent if something has gone wrong with in an ecosystem, and abundant if the area is rich enough to be attractive.

***"Birds undeniably contribute to our pleasure and quality of life. But they are also sensitive indicators of the environment, a sort of 'ecological litmus paper,' and hence more meaningful than just chickadees and cardinals that brighten the suburban garden, grouse and ducks that fill the sportsman's bag, or rare warblers and shorebirds that excite the field birder. The observation and recording of bird populations over time lead inevitably to environmental awareness and can signal impending changes."***

***~Roger Tory Peterson***

Trends were tracked at the sites, using yearly averages of bird species. For example, at Ngardok, the numbers were down in 2010 and 2011. This could have been due to the disturbance from the construction of the quarry.

Indicator species monitoring

We also monitored the abundance of keystone species which could be used as indicators. For forests, canopy frugivores are keystone species, as they spread fruit throughout the forest, and understory omnivores, which eat seeds and insects, are also important. For Palau, we chose to monitor the Palau fruit dove, the Palau bush warbler, and the Micronesian imperial pigeon. For coastal ecosystems, apex predators are good indicators. We used three birds which use the environment in different ways: the Rufous night heron, which is a shallow wader; the reef heron, which is a rock climber; and the cormorant, which dives in the channel.

The abundance of these different species was counted monthly at each of the monitoring sites. We looked at the variation not only over time, but also comparing the sites. For instance, for the Micronesian imperial pigeon, when some sites had a high abundance, other sites were low, and so it was obvious that the populations are going back and forth to different areas (see Figure 11). The inclusion of more sites should help complete the picture about where these birds are going. The point is that it is very important to look at trends in context. If you just monitor one station, you can't understand why something is happening. You want a national context, with an idea of the flow of life throughout the islands.

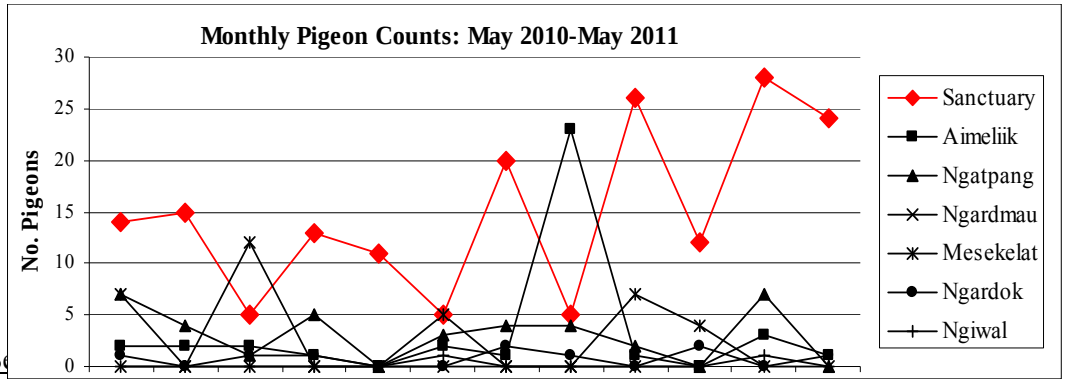



Figure 11. Monthly counts of Micronesian imperial pigeon at Babeldaob monitoring sites, 2010-2011.

The data can be used to help set priorities, and prioritize areas. For the Micronesian Challenge, which 20% do you want to protect? Listen to the birds, and look at the species richness inventories. A study of bird diversity was conducted in 2005by PCS and the US Fish and Wildlife Service in Babeldaob, that found that Ngermeskang Sanctuary had the highest diversity. However, this was only a once off study. The species richness data collected by the Belau National Museum, from 2006-2012, was a longer term study which should be a more reliable data set. Ngardok was shown to have the highest bird species diversity.

However, the problem is that there were a lot of places with very high diversity, but not necessarily the same species present. A better way of setting priorities is the formula used by BirdLife International. An analysis was conducted which looked at data from all the IBAs across the world, and ranked important forests, using bird diversity as a reliable indicator of overall biodiversity. From this scoring system, Palau was ranked number 2 among the top forest eco-regions for conservation. The scoring system incorporated information aside from species diversity, and was biased towards rare and unusual species. Scores were calculated for $5km^2$ cells.

For Babeldaob, we divided the area up into $5km^2$ cells, and analyzed the data from the national monitoring program, using the BirdLife International formula to compute scores for each area. Ngermeskang, Lake Ngardok and Ngerikill had the top ranking impact scores. Just looking at species richness across Babeldaob for the same $5km^2$ areas, there were a lot of areas that were very similar. The BirdLife International score was able to separate out these sites, as the score includes rare and unusual species. The bias towards uncommon species was able to pick up the areas which included species such as the Micronesian megapode, the Palau ground-dove, and the Giant white-eye.

These priority bird areas can be overlaid with other information. Floristic surveys recently completed in Palau prioritized areas by flora. The top three areas for birds all included priority floristic areas. The areas with the top scores for birds were also overlaid with current IBAs. Not all areas were matching up, and this can show you where to prioritize local IBAs.

## Conclusions

That is the type of work you can do with bird monitoring programs, looking from ridge to reef. Whenever you can, count birds. They are a clue to overall biodiversity. The next step is to expand the national program into Angaur, Kayangel and the south-west. We have begun work in the RISL, looking at species diversity. We are also conducting megapode surveys, locating and counting megapode nests.

**Questions/Comments from participants on presentation**

Unless indicated, questions and comments are from workshop participants, and responses are from the presenter, Dr. Alan Olsen.

Question: So is the concern the number of species?
Response: Species diversity is the primary measure. Then there are the indicator species, where you count the numbers. You have to be selective in what you count, otherwise you'd be overwhelmed.

Question: Does counting need to be done by experts?
Response: Yes, for consistency.

Question: Is there a way to tag the birds?
Response: We are looking into what kind of tagging could and should be done.

Question: Interpretations of data needs to be done carefully. Just because bird numbers go up and down, this might be natural variation, and they might be going somewhere.
Response: Caution is important. You count everything you can as often as you can. When there are changes, you don't push the panic button, it may only be a temporary change. You have to keep collecting numbers.

Comment: The RISL data should help complete some of the picture of where the birds migrate to.
Response: Yes, they seem to be moving to these areas, and tagging could show that.

Comment: At the 1st Terrestrial Measures meeting in Chuuk, the decision was made to address birds as an indicator and not a target. Major species are hunted, so they might not be a good indicator of forest health. If the pigeon declines, this could be due to hunting, and not forest health. So it is very problematic to use a single species as bio-indicators of forest health.
Response: If the question is, is the population increasing because of PAN, you can use that as an indication that numbers are going up at that sites, and not at other areas. Pigeons are a keystone species. So in areas they are hunted out, biodiversity will also go down, so they are still an indicator in decline in forest health. Zero is still a data point. Even if this is like this for a few years, you still want to know if the numbers go up.

Question: Are you keeping track of when trees are fruiting, and which areas have more diverse food to eat?
Response: No, we need to switch databases with vegetation studies.

Question: So prioritizing sites in Palau picks sites with rare species?

Response: Yes, it tells you where the rare species are. It's up to people if they want to use the methods for future sites. Ideally, you'd have a combined ranking system for PAN, which incorporates bird scores, tree scores, and insect scores. Then you can make a rational decision based on the data.

Question: Is there going to be a meeting to bring all of these metrics together, and look and see if they are all saying the same things?

Response (from Umiich): The indicators and methods haven't been refined, so they have to be refined even before a protocol is decided. Maybe this could happen at a national level in Palau, to help redesign PAN. But at the MC level that is a big challenge.

Comment: The 2005 survey done by PCS with Fish and Wildlife Services was a replication of surveys conducted in 2001. It is important that permanent monitoring sites use that information, as it gives comparable data across the region.

Response: It gives information, but it is comparing things slightly differently, and the studies do not completely mesh. You need to be sure you are not comparing apples and oranges.

Question: Should we really be discounting birds as targets, and just using them as an indicator?

Response (from Umiich): We will discuss this later.

Comment: The program will involve counting within and out of Protected Areas, as the targets are mobile.

## Presentation: Mangrove Resilience Research Project
## By Lukes Isechal, PICRC

Lukes Isechal, from the Palau International Coral Reef Center, gave a presentation about the work being done in Palau looking at human impacts on mangroves, and their potential response to sea-level rise. The presentation was designed to get participants thinking about the monitoring protocols for the MC mangroves target, and is summarized below.

The driving question

The question driving this study was: How do human activities impact mangrove ecosystem functions and services, especially those associated with mangrove resilience to sea-level rise (e.g. below ground biomass)?

Objectives

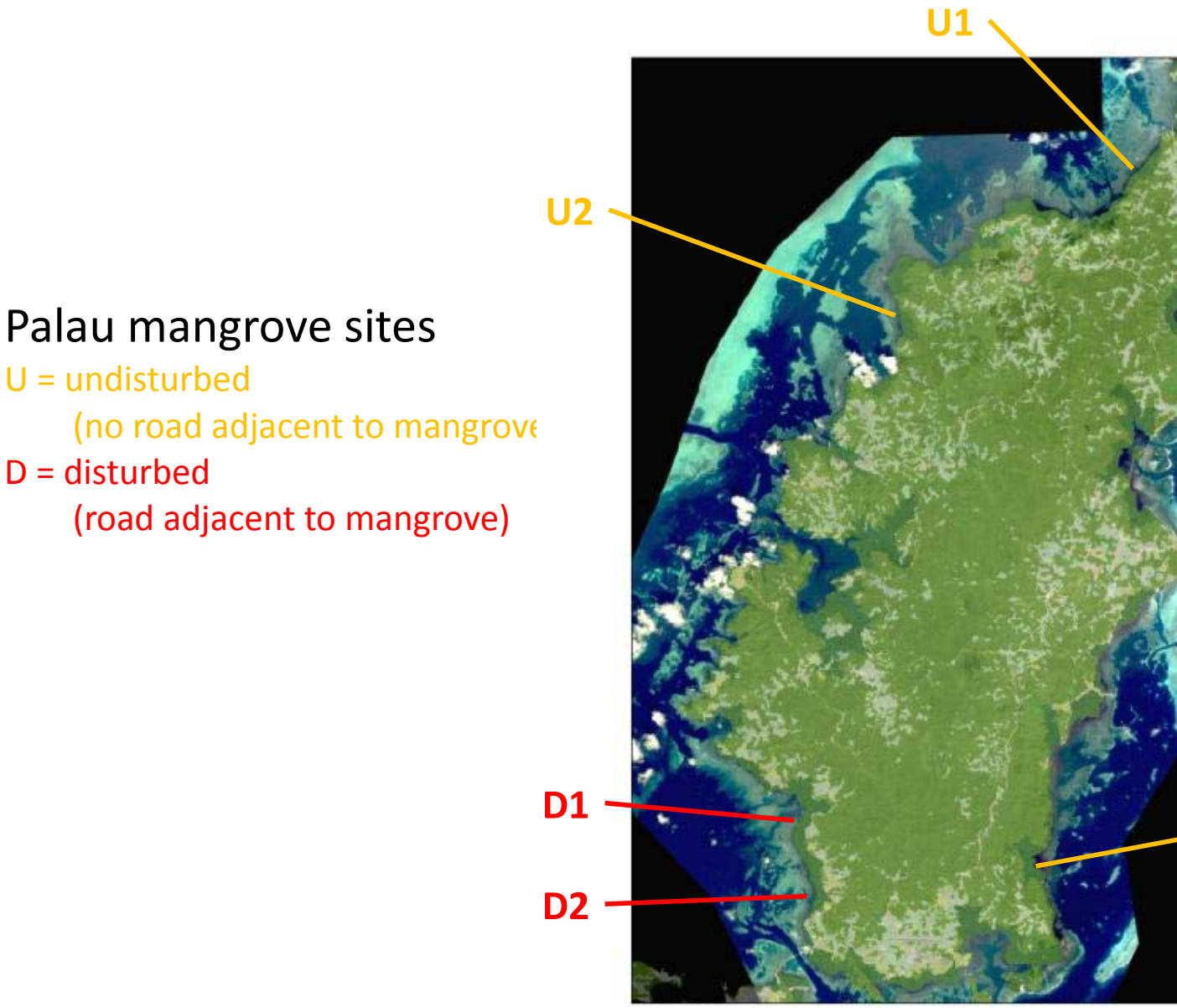
Based on that question, we had the following objectives:

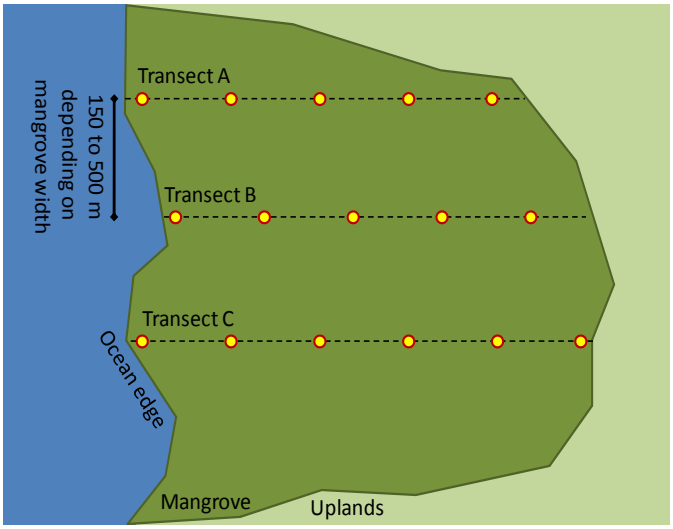
- Quantify key ecosystem services mangroves provide (fishery habitat, carbon sequestration, sediment regulation).
- Examine how human activities affect those services and functions.
- Identify mangrove forests that may be more resilient to sea-level rise, suggesting high conservation priority.

Design

The study design was developed based on the objectives. Study sites selected included disturbed forest, which had been hydrologically altered by the Compact Road, and intact, less disturbed forest. We wanted to compare forests with a similar geomorphological and hydrological character. A total of six sites were used: three disturbed sites, which were adjacent to the compact road; and three undisturbed sites, which were picked arbitrarily, but happened to fall into Protected Areas (see Figure 12).

At each sites, 3 transects were places perpendicular to the ocean face. The centre was placed in a randomly selected point, and the other two transects were placed 100m apart. Along each transect, study plots were spaced at 75m, starting at 15m into the mangrove seaward edge (see Figure 13).






angrove study in

Figure 13. Transect design for mangrove study in Babeldaob.

## Methods

At each of the study plots, the diameter and species of all trees ≥5cm was recorded, in a 10m radius. In a 3m radius, seedlings were counted, and the diameter and species of all saplings <5cm DBH recorded (see Figure 14). Soil cores were taken near the center of the plot using an open-faced auger, to look at the peat profile. Soils probes were taken to measure peat depth. Sediment accretion was measured using sediment elevation tables (SET). Rods are hammered into the mangrove peat, and set in concrete, with measured increases in height of the peat being used to show the accretion of not only sediment, but also organic materials.

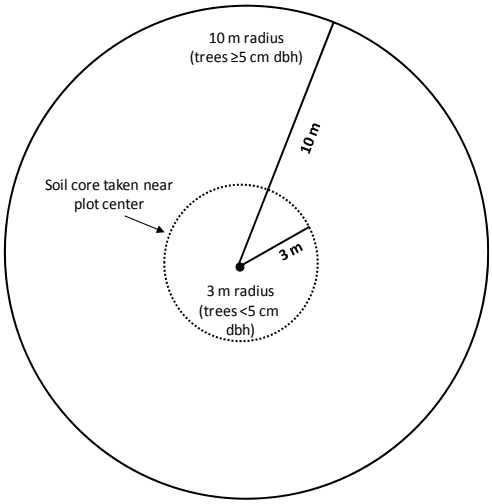



Figure 14. Graphical representation of sampling methods for a mangrove study in Babeldaob.

Sesarmid crabs were counted in quadrats at the plot edge. We also tried trapping crabs. Adults and juveniles from the nekton community were caught using jar traps and fyke nets, and ID'd and counted.

## Results

A lot of different data was collected. From the tree surveys, we were able to look at stand density, composition, basal area, above and below-ground biomass, and tree regeneration. The soil cores showed bulk density, peat carbon content, and peat depth. We were able to look at fish and crab abundance, which are important species in mangroves. Crabs are a good indicator for mangrove health. If there is a big impact, crabs will leave before the mangroves start to die.

## Implications for long-term monitoring

This study has implications for how the terrestrial group can include mangroves in long-term Protected Areas monitoring. Typical forest plots will work for mangroves. The accretion rate needs to be measured. It doesn't have to be hard. The method could just involve using baby powder on the surface, and then coring to see the level of accretion above that. Crabs should be counted, or their burrows, as crabs are a good indicator of short term change.

It is important in studies to distinguish between a research question, and a status monitoring question. For status monitoring, you are looking at measures of the overall health, rather than something a more specific and detailed analysis. It is a fine balance of what you count, and how much. You need to balance between measuring enough to understand the health of the protected area, and not going into overkill. Once you detect a change, you can then call in people to look at that change in more detail.

The protocols developed need to be tested in the field, and refined, and they are not always perfect. Some things didn't work out so well in the field. It is very ambitious to try to look at everything, and so you need to test if it is doable. The logistics is half the work. Working with the conditions, such as the tide, greatly restricts field work. We learned a lot of lessons during this study.

**Questions/Comments from participants on presentation**

Unless indicated, questions and comments are from workshop participants, and responses are from the presenter, Lukes Isechal.

Question: Did you tag trees at plots?
Response: Yes.

Comment: There have been other studies of mangroves in Palau, which could be continued. In one study, crab boroughs were counted, rather than the crabs.
Question: Why did you want to count crab holes and not crabs? How can you differentiate crab and rat holes?
Response: Ideally you would count crabs, but it is harder to see and count crabs than the holes.

Question: What would you suggest are basic indicators for mangrove health, that can be feasibly used for monitoring over the long term?
Response: Basic forest plots, measuring the number of trees over an area; crabs, which are mobile, and will leave before the trees die; peat depth; and levels of sedimentation.

Question: Did you do any assessments of the health of trees? How can you assess that?
Response: We recorded dead trees, but other than that, no. Trees are hard to assess, they can look healthy when you walk through.
Comment: Mangroves are tough forests. During the bad drought in 97/98, they were still green.

Comment: Fishermen are saying mangroves are expanding, due to sediment.

Comment: Accretion can be measured using talc powder or white sand that will not decompose, and coming back and cutting a section out to see how much is above that.

Comment: With accretion, you are measuring two things; sedimentation, and the decomposition of roots.
Response: Sediment Elevation Tables looks at the net accretion. In some areas, there a lot of sediment. In others, root growth is a big part of it. Then you have the natural decomposition of peat.

Comment: The research question is, can we see if mangroves can survive sea level rise by slowly retreating, and if this is related to ecosystem health.

Comment: Do you take any measurements of canopy cover?
Response: We wanted to know the biomass of trees, above and below ground. There is an allometric equation to calculate that, and you don't need canopy cover.

## Presentation: Terrestrial PA monitoring protocol for Palau's PAN

## By Dr. Alan Olsen, BNM and Pua Michael, Palau Forestry

Terrestrial monitoring work being conducted in Palau was discussed by Dr. Alan Olsen, from the Belau National Museum, and Pua Michael, from Palau Forestry. This session was designed to help further define what terrestrial monitoring protocols and indicators could be adopted by other islands throughout the Micronesia region.

**Comments from Pua Michael**
Once the protocol is decided, we will then test it out in Palau's Protected Areas. We will see how it works out in Palau, and then will endorse it nationally.

**Presentation: Bio-monitoring protocol for the Protected Areas Network**
**By Dr. Alan Olsen**

Bird Monitoring Protocol

A lot of work has been done in Palau to develop a bird monitoring protocol for Protected Areas. It is a two step process. First, a snapshot transect is conducted, which is a brief survey that gives an indication of what birds are present at sites. Along the transect, every 150-250m, you have stations, and take species counts. If more than 10 species are counted, you can then proceed onto a longer 6 month baseline survey of sites. If less than 10 species are counted, it generally means it is not a very diverse area, and so you wouldn't proceed with further studies. You pick the sites with a higher diversity for these baseline surveys.

The 6 month survey involves regular counts to collect an inventory of species, according to the developed methods. A cumulative number of species will be built up over this time. It is recommended at this stage to vary the monitoring time, to pick up birds that will not be active all of the time. For example, owls will not be seen during the day, whereas others will only be active at that time.

After 6 months, Jackknife statistics can be run, to estimate the species diversity for the sites. The diversity of sites can then be ranked, and this can help decide which sites to continue monitoring in the long-term. You can decide which PAN sites are worth the effort of continuous monthly monitoring, including counting numbers of indicator species.

Ant surveys

Ants can also be used as an indicator for terrestrial Protected Areas. The protocol is currently in development. Ant monitoring will be done according to functional groups, which are partly based on diet, and partly on the social organization. Standard monitoring methods for studying ants have been well established, and so we will be following those (Agosti D, Majer JD, Alonso LE and Schultz TR. (eds.). 2000. *Ants: Standard Methods for Measuring and Monitoring Biodiversity.* Smithsonian Institution Press, Washington DC). Work has also been done on ants in Micronesia, and we have keys to identify some native ants (Clouse RM. 2007. The Ants of Micronesia. *Micronesica* 39: 171-295).

Ant functional groups include:

- Generalized Myrmicinae
- Subordinate Camponitini
- Opportunists
- Tropical Climate Specialists
- Cryptic Species
- Specialist Predators

Generalized Myrmicinae and subordinate Camponitini have large, highly organized colonies, whereas the rest have less organized colonies. Generalized Myrmicinae are found in high abundance in leaf litter, and have two major classes: majors, with big heads; and minors, which are seed eaters. Subordinate Camponitini are generally carpenters. Opportunists inhabit specific niches, wherever the other groups aren't present. Tropical Climate Specialists are defined by the climate zone they inhabit, as they live only in the tropics. Cryptic species are

found in low numbers and have special diets, but they are largely unknown. Specialist predators hunt specific prey, such as springtails and bugs. They also hunt other ants, and stage attack raids on other tunnels.

In Palau, specialist predators include those in the genus Odontomachus. *Odontomachus simillimus* is known as the huntress ant, and inhabits leaf litter. *Odontomachus malignus*, known as the Marine Littoral Ant, is a very interesting species, which inhabits the intertidal zone in the Rock Islands. Not many insects live in this area. Their nests in the Rock Island shelves are below the high tide level, and are exposed during low tide. The nest is probably built upwards into the limestone to avoid flooding. When the tide is out, the ants are very active hunters. They hunt both by day and by night, which is unusual for an ant to do. They have a jaw which opens out to 180 degrees, and which have trigger hairs that close when hit. They drag their prey back to the nest, but pass it to another nest mate when they meet, and the hunter goes back. This is probably to maximise the efficiency in getting food during low tide, as they only have a certain amount of time to hunt.

**Questions/Comments from participants on presentation**

Unless indicated, questions and comments are from workshop participants, and responses are from the presenter, Dr. Alan Olsen.

Question: Ant functional groups are needed in the leaf litter, so could they be an indicator of healthy forests?
Response: Definitely, you need them there, so they are an indication of a healthy system. In disturbed, exposed areas, yellow crazy ants are found, but they are not found in healthy systems. They can be a good indicator of disturbance.

Question: Are there any riparian functional groups?
Response: Not that I know of.

# DAY 4

## Discussion: MC terrestrial monitoring protocols for native forests and mangroves.
## Led by Steven Victor

This session was designed to allow the workshop participants to discuss and finalize the monitoring protocols for the last two MC terrestrial targets, native forests and mangroves. Participants discussed and revised the indicators and methods discussed during the 1st MC Terrestrial Measures Workshop (see below). The discussions and the key outputs are summarized below. The discussion was open, with comments and responses from workshop participants.

**Native Forest monitoring protocols from the 1st MC Terrestrial Measures Workshop**

| Indicator | Methods |
|---|---|
| • % Forest Cover | Satellite imagery (remote sensing) |
| • Species Diversity | FIA modified |
| • Species Abundance | FIA modified |
| • Bird Diversity | Standard Point Count |
| • Human Disturbance??? | |
| • Invasive species??? | |

**Mangrove monitoring protocols from the 1st MC Terrestrial Measures Workshop**

| Indicator | Methods |
|---|---|
| • % Forest cover | Satellite imagery (remote sensing) |
| • Species diversity | FIA modified |
| • Species abundance | FIA modified |
| • Water quality (turbidity)??? | Secchi disc |
| • Peat Depth??? | |

Discussion opening by Steven Victor

When this workshop was put together, the hope was to have developed terrestrial protocols for the MC. In the last few days, we have realized there hasn't been enough terrestrial work done to come up with monitoring methods. So we need to test those methods decided upon in this workshop, and see how they can be implemented. Then we will meet again to further discuss the protocols.

In this workshop it is time to agree once and for all what the terrestrial indicators are to assess the effectiveness of the Micronesia Challenge. We need to be looking at indicators that can be achieved across the Micronesian level, so that we can compare 'oranges to oranges' in the region. Indicators that are site specific, such as invasive species, can be left to be done at a jurisdictional level. So the whole purpose of this discussion is to come up with the most common and relevant indicators across the region.

Discussion of native forest indicators

Comment: We shouldn't be restricted to just using birds as indicators. There is more wildlife in a forest that could be more useful in determining the health of a system. Every forester here would agree that there are other wildlife that helps make a native forest healthy, such as insects and fruit bats. You can get a lot of information from birds, but there are other things to look into. We all have insects in our jurisdictions, which can help us look at the status of native forests, as well as soil, which is the foundation of forests. Could we change the indicator from birds to just biodiversity, that can include other things, such as insects and fruit bats.

Response: We already talked about other indicators, such as ants, and bird monitoring does include bats.

Response: We are looking for a minimum data set. So it depends on what is easy to do. Birds are visible and easy to do. I'm not saying insects aren't important, but we need to keep in mind what indicators are easy to do to look at forest health.
Response: Not sure about the capacity for studying insects. Maybe we could do it qualitatively.
Response: It would be a lot of work to encompass everything.
Response: We should have birds as an indicator. But let's not just use birds, let's say species diversity. Birds can be put as a specific indicator under diversity.
Response: What if you change the wording to flora and fauna abundance, and then jurisdictions can decide what to measure.

Comment: We are not saying don't monitor other things that are important. We need to try to come to an agreement about what we can compare across the region, to see how we are achieving the goals of MC.

Comment: Species diversity is not an indicator. Species diversity is the thing you measure. For example, if trees are the indicator, species diversity is what you are measuring.
Comment: The indicators and measures are all getting confused and combined.

Comment: Everyone needs to think about the core activities you are doing, and how the indicators can fall into your plan. You need to ask yourselves what you can do, what is practical, and not get ambitious.

Comment: We are doing a disservice to Guam if we just use birds.

Comment: Is measuring for birds something realistic?
Response: Birds are important, and so are important to measure.

Comment: So between birds and insects, what should we measure?
Comment: Birds are rapid dispersers, because they have wings, so have a quick response to impacts. Aquatic invertebrates are also hypersensitive. There are a whole lot of insects on every single island, and so we need to pick out one group. All islands have ants, and they are more sensitive to local soil disturbance than other communities. Forest bugs aren't as exposed to as much impact as aquatic insects. So the recommendation would be to use birds and aquatic invertebrates. The rest would be slow and a lot of work.

Comment (from facilitator): We need to get back to the four criteria for selecting indicators: how important is to measure regionally; how practical is it for all to do; and what is the cost, in terms of the level of human activity, and finances. We need to get back to the purposes of the MC.

Comment: We can break indicators down into those for flora and fauna.

Comment: The indicators are getting very broad, which makes it harder to compare across the region.

Comment: Species, genera etc. can be left open to the jurisdiction.

Comment: So for flora, the indicator can be trees, measuring cover, and diversity and abundance.
Response: Diversity is not always a good indicator.
Response: We should change that to species representation and abundance (species representation refers to the presence of species you expect to find in the system).

Comment: Indicators for fauna? What are the indicators that will respond first?
Response: Invertebrates in the stream and birds are both sensitive to impacts. Birds will respond first to the clearing of forest.
Comment: Birds and bats should be used.
Comment: Ants are a little more problematic, but are can be used to look at soil.
Comment: We need to stick to the bare minimum, and agree on what's feasible.
Comment: Monitoring ants would need more training. It is easier to recognize birds.

Comment (from Alan): For birds, the way we designed the protocol was to develop a snapshot, then a baseline, which you can use to decide if you want to monitor birds. In some places, you may not want to count them.

Comment: We do not want to be limited, and too specific. We should leave it open as to what fauna we use as indicators.

Comment: What we are trying to do is find something comparable, so we can see if we are achieving goals in areas.

Comment: Guam only has four native species, because of the brown tree snake. Only 1 in 10 vessels are inspected before they depart Guam, so they will bring it to other islands. So back to the indicators, birds are very important, they tell a story. But you have to look at other things too. For the MC, the importance is the target audience, the community, and what they want us to do. We need to look at what is important to the people, and take it back to the audience. It needs to be a little bit broad, and then back in the home stats you can dissect it and be more specific.

Comment: The best focus of the MC is on communication and funding. So we want something we can compare within the next 24 months, and report that. Is it too broad to leave it open to flora and fauna? Can we choose on indicator that we can all begin to implement in the next 10 months?
Response: Birds are easy. You don't even need funding, just a truck. The number one for do-ability if birds.

Question (from facilitator): So that is an agreement on birds?
Consensus agreement from participants.

Question (from facilitator): Agreement on percent forest cover?
Consensus agreement from participants.

Question (from facilitator): Agreement for flora, to use trees- species representation and abundance?
Response: The definition of trees doesn't include other vegetation. We should use a broader definition of stand structure (meaning all trees, sizes and the composition of a forest).
Response: Include "others" to keep it broad.
Consensus agreement from participants.

Comment: Methods for measuring forest cover should be changed from just satellite imagery to include GIS.
Consensus agreement from participants.

Question: What methods for stand structure?
Response: Modified FIA.
Response: Also add Point Count.
Consensus agreement from participants.

Question: What indicators do we use for fauna: birds and bats?
Response: Also include "others" to keep it broad.
Consensus agreement from participants.

Question: Methods for measuring birds and bats?
Response: There are several methods out there. A point count will suffice.
Response: Also add VCP (Variable Circular Plot method).
Consensus agreement from participants.

Question: Do we want to remove invasive species and human disturbance as indicators?
Response: Yes. Invasive species are not necessarily an indicator. They can be captured under the flora and fauna indicators.
Consensus agreement from participants.

<u>Discussion of mangrove indicators</u>

Comment: Are mangroves a separate target to forests?
Response: The reason why they were separated in Chuuk was that there are different species and different indicators that you need to look at for mangroves than for native forests.
Comment: It was left out by the marine group in the MC, so the terrestrial group adopted it.
Consensus agreement from participants on mangroves as an MC terrestrial target.

Comment: To adequately monitor mangroves, you need to monitor the marine components of it as well.
Comment: Mangroves are a forest. Marine people will look at marine issues, but not so much the forest.

Comment: Can we focus just on the terrestrial part of it and not worry about the marine side of it, and the marine group focus on the rest?
Comment: For the target to focus on simply using flora as an indicator, and not looking at the mud and water, is limited.
Comment: If we just look at the forest, it doesn't mean it is healthy even if it is extending. It could be extending in area because of sedimentation, but still not be healthy.
Comment: The MC marine group left mangroves out of their monitoring protocols. So the indicators do need to encompass the marine component.
Comment: In reality, will it be the marine resources people or forestry that will be doing the work? For eg. would mangrove crabs be marine?
Comment: Maybe this group can communicate with the marine group, and they can include some of the things needing to be monitored for mangroves in their monitoring protocols.
Comment: As units, the people are divided - but mangroves are not, it's a unit. Crabs are important indicator and easy to sample.
Comment: Mangroves are part of the terrestrial protocols now, so we need to include everything.
Comment: We can create the methods, and then determine who needs to do the monitoring.

Comment: So, would mangroves be covered by the indicators agreed upon in Chuuk?

Consensus agreement on % forest cover.

Comment: Instead of species diversity, we should have indicators for flora and fauna.
Consensus agreement to change species diversity to flora and fauna indicators.

Comment: For flora, we can have the same indicator as for native forests: trees – species representation and abundance.
Comment: Change trees to stand structure.
Consensus agreement on stand structure – species representation and abundance as an indicator.

Question: Indicator for fauna?
Response: Birds and bats.
Response: Marine invertebrates.

Question: What invertebrates are harvested?
Response: Mangrove crabs, clams etc.

Question: Should we just leave it as marine invertebrates or specify just mangrove crabs?
Response: Just specify crabs, they are keystone species.
Response: Then other invertebrates can be done if jurisdictions want to.

Comment: Lukes' presentation mentioned small crabs with holes, the fiddler crabs. It would be easier to measure those. They are a good indicator of stresses. Mangrove crabs are harder to see because they bury.
Comment: So we could just say crabs, which could include both sesarmids and mangrove crabs?
Response: It depends on the objective. You can count sesarmids if you want to know if you are effectively managing Protected Areas.
Comment: If you cut down trees, you can't see an impact with mangrove crabs, so they are not a good indicator.
Comment: Regardless of the health of mangroves, the number and size of crabs is not really affected, so they are not a good indicator of the health of forests.
Comment: Mangrove crabs don't indicate health, they indicate threats from harvesting. Sesarmid crabs are a measure of the health of forests. So you can use both, to look at social and forest aspects.
Comment: MC is also about resources, and what is being used. Crabs are a resource, and so they are a good indicator of the use of ecosystems.

Consensus agreement on crabs (Sesarmids and Mangrove) as an indicator.
Consensus agreement to include birds and bats as an indicator.

Question: What about the water quality indicator?
Comment: Salinity could be an indicator.
Comment: Some water quality indicators change very quickly. Unless you can measure salinity in the longer-term, with more permanent sampling, you shouldn't do it. Salinity will fluctuate depending on the rain, and the ingoing and outgoing tides.
Comment: Turbidity will change that way too.
Question: Are you using turbidity to measure sedimentation?
Comment: Turbidity is good in a mangrove. It all depends what the turbidity is composed of. You need to quantify what it is, and sample to see if it is terrestrial sediment or organic matter.
Comment: During a mangrove study, the community was most concerned about pollution. So we can link that to water quality, the health of the water.
Comment: We can leave water quality open, and not define it. The jurisdictions can decide on the different parameters to measure.
Consensus agreement on water quality as an indicator.

Question: What about peat depth – in or out?
Comment: We could measure accretion rates, if we are concerned about sedimentation.
Comment: Peat depth is important to mangroves.
Comment: We should make it up to the jurisdiction as to whether they measure peat depth, based on their resources. So yes, leave it out.
Consensus agreement to remove peat depth as an indicator.

Question: What methods for crabs?

Response: Sesarmid crabs can be counted in plots. Mangrove crabs are hard to survey. You could use visual surveys.
Response: For Mangrove crabs you could do trap and release, and use the CPUE.
Consensus agreement on CPUE/Standard Plot measures for crabs.

Question: For water quality, can we use EPA methods?
Consensus agreement.

Comment: Standard Point Count and VCP can be used as measures for birds and bats.
Consensus agreement.

Comment: Modified FIA can be used to measure stand structure.
Consensus agreement.

Comment: GIS-Remote Sensing can be used to measure % forest cover.
Consensus agreement.

**Key outcomes: MC monitoring protocols for native forests and mangroves.**
Participants reached a consensus on the following monitoring indicators and methods for native forests and for mangroves.

**Native Forest**

| Indicator | Methods |
|---|---|
| • % Forest Cover | GIS-Remote Sensing |
| • Flora | |
| ◦ Stand Structure – Species Representation and Abundance | FIA modified/Point Count |
| ◦ Others | |
| • Fauna | |
| ◦ Birds & Bats | Point Count/ Variable Circular Plot (VCP) |
| ◦ Others | |

**Mangroves**

| Indicator | Methods |
|---|---|
| • % Forest Cover | GIS-Remote Sensing |
| • Flora | |
| ◦ Stand Structure – Species Representation and Abundance | FIA modified |
| • Fauna | |
| ◦ Birds & Bats | Standard Point Count/ Variable Circular Plot (VCP) |
| ◦ Crab (Sesarmids & Mangrove) | CPUE/Standard Plot |
| • Water quality | EPA |

For native forests, % forest cover was unmodified from the list of indicators proposed during 1st MC Terrestrial Measures Workshop in Chuuk. Species diversity and species abundance were expanded to include indicators for flora and for fauna. For flora, species presentation and abundance of stand structure was chosen as the indicator. Species representation, which is a measure of presence of species expected in the area, was chosen in place of species diversity. Stand structure was chosen as a broader term than trees, which was initially proposed. For a faunal indicator, there was a lot of discussion around concerns that only focusing on birds would be too limited. The indicator "bird diversity" was therefore extended to include bats, and an open indicator of "others" was included for fauna, to allow jurisdictions greater flexibility.

Human disturbance and invasive species were removed as indicators, in line with earlier discussions during this workshop regarding the need to focus on positive indicators for the targets, rather than on the threats. Participants felt that invasive species could be captured under monitoring of flora and fauna.

For mangroves, % forest cover and water quality were kept as indicators from the 1st MC Terrestrial Measures Workshop. Water quality was left as a broad indicator, so that jurisdictions could decide on what were feasible measures. Peat depth was removed as an indicator. Species diversity was replaced with flora and fauna indicators. For flora, stand structure was again chosen as the indicator, specifically looking at species representation and abundance. For faunal indicators crabs, and birds and bats were chosen, to represent both marine based and forest based organisms. Crab indicators include both sesarmids, which are indicators of ecosystem health, and mangrove crabs, which can be used as indicators of resource use.

**Facilitator comments on monitoring protocols**

During this workshop, we have come to an agreement on the indictors for the three terrestrial targets. These will be the indicators for the score charts for the MC. We have come to an agreement on the bare minimum of what we want to measure. This is 10 steps forward.

Each jurisdiction will need to take these decisions back home, and begin implementing assessments with the suggested methods. We will need to work out the detailed methods and designs. By implementing these assessments, we should be able to then discuss minimum designs. We can start analyzing things like, for an FIA, how many plots do we need, to statistically detect changes. For Palau, we can work with people such as Dr. Olsen, and Forestry to modify the FIA. We can meet again in a year, to agree on these protocols. In the

future discussions, we can decide on the standard designs to be implemented, so that we have comparable data that can be used to measure the three terrestrial targets across the region.

**Outcome: Jurisdictions have ~ one year to trial the monitoring methods. A meeting will follow to finalize the protocols and agree on minimum standard monitoring designs.**

## Discussion on capacity to implement monitoring
## Led by Umiich Sengebau

The workshop facilitator led a discussion on the capacity needs of jurisdictions, designed to identify what help is needed in order to begin implementing the MC terrestrial monitoring protocols. This also involved a discussion on next steps to take for the MC terrestrial measures. The key discussion points are summarized below.

Opening Comment (from facilitator): The MCT is here to help jurisdictions with their needs and build capacity. What financial and human resources are needed? Is there anything to discuss now, or do you want to come back and discuss capacity needs in a year at the next meeting?

Comment (from facilitator): We are shooting for trying out the protocols in one protected area.
Comment: So this is just a pilot, focusing on one specific site.
Comment: We need one site for each of the targets.

Question: Is there any way to get assistance from US Forestry to modify the FIA?
Response: We are looking at State foresters to take the lead, and they will have connections to US Forestry. They can ask for assistance.
Comment: We shouldn't make US Forestry do the work. We need to report on all of this, and we don't want to depend on them.

Comment: We need to be strategic about fundraising. We need to look to powerful summits, and ask for the needed support.

Comment: If we apply for competitive grants, but we need to do the work within a year, the grants won't be fast enough to get for that time.

Comment: We are looking at capacity bridges – what funding and equipment is needed to implement the work.

Comment (from facilitator): We need to agree that within 2 months, each jurisdiction will have developed a plan to start implementing the protocols for the three targets. So we can submit the plans by October the 1st, which is the start of the fiscal year.

This gives you time to coast out the budget to do the work, and figure out what resources you need.

**Consensus agreement to develop implementation plans for monitoring protocols by October 1st.**

Comment: Each jurisdiction needs to figure out what out what they are going to do, and what they need.

Comment: The methods are not going to be limited, but we just need the same units so we can compare across the region.

Comment: We already have methods for some things, such as circular plots for mangroves; we just need to implement it.

Comment: For Palau, in reality on the ground, we can't expect Pua (Palau Forestry) and her small team to go out to every area. In reality conservation officers will be doing this on the ground.
Comment: This can be discussed internally.

Comment: In Palau, there are also not a lot of people who can analyze the data.
Response: We can take baby steps. We can start collecting data, and then refine the methods, before we start analyzing.
Comment: We still need data analysis to see if we are asking the right questions.
Response: We can work on that as an objective for the next workshop.

## Discussion: Creation of an MC terrestrial technical working group
## Led by Umiich Sengebau

In the 1st MC Terrestrial Measures workshop, it was suggested that a terrestrial technical measures working group should be created, which would focus on the periodic measurement of progress in achieving MC goals related to the terrestrial component. This discussion was designed to allow participants to decide if that group should be created. This discussion was also part of identifying next steps for the MC terrestrial measures.

Participants asked for the facilitator to explain the role of this group. The facilitator explained that the technical group can help monitor progress in each jurisdiction. It can keep communication going, and help jurisdictions work with each other to keep on the same page. It can help assess if members are falling behind in the MC goals and objectives, and provide support. The group could include State foresters State foresters from the jurisdictions, the MCT, and regional supporting partners.

**Participants reached a consensus agreement on the creation of a terrestrial technical working group**. Participants nominated group members (see below). It was agreed that the

first meeting of this group would be held via a phone conference on August 1st, 2012. TNC offered to sponsor phone meetings for the technical group.

**Proposed MC Terrestrial Technical Working Group members (15 initial members):**

1. CNMI
    - Victor Camacho
2. Guam
    - Jeff Quitigua
    - Joe Mafnas
3. FSM
    - National- Gibson Susumu
    - PNI- Saimon Lipai
    - Kosrae- Eric Waguk
    - Chuuk- Julian Sipas/Pacente
    - Yap- Francis Ruegoron
4. RMI
    - Karness Kusto
5. ROP
    - Lynna Thomas
    - Pua Michael
6. MCT
7. TNC
8. MCRO

******CLOSE OF WORKSHOP******