Long-Term Frog Monitoring by Local People in Papua New Guinea and the 1997–98 El Niño Southern Oscillation

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During the 44 months I spent in Papua New Guinea doing fieldwork and training local people as parabiologists to conduct a long-term frog-monitoring project, I gained many insights that fall into two distinct categories. The first has to do with the social and logistical aspects of training and fieldwork. The initial mandate of my work was to train local people in standard biological monitoring methods. As parabiologists, the local participants would be highly trained individuals who could competently complete tasks, but they would be without formal, time-consuming, expensive education—comparable in some ways to paramedics. In this regard, I was fortunate to work with many of the Pawaia people of the southern parts of Chimbu Province, Papua New Guinea, and they provided the basis for the first category of lessons learned. The second category of lessons learned had to do with counterintuitive changes in the relative abundance of frog species during the 1997–98 El Niño Southern Oscillation event, which caused a catastrophic drought throughout much of Australasia.

I include in this chapter both the social aspects of working with local people as well as the scientific results of the survey in order to bridge the gap that normally exists between conservation biology and "the real world." Conservation biologists often operate in complex local socioeconomic conditions and need to incorporate local perspectives so that they can modify their approaches. This chapter demonstrates one approach that attempted to honor local perspectives during the long-term project. I document the lessons learned and provide recommendations based on those lessons.
The Problem: Declining Amphibian Populations

Amphibian populations around the world have received much attention in the last decade because of their declines (Blaustein and Wake 1990; Wake 1991b; Trenerry et al. 1994; Alford and Richards 1999; Lips 1999), disappearances (Pounds and Crump 1994), or deformities (Johnson et al. 1999). Disappearances are the endpoints of declining populations, whereas deformities may or may not be part of declines. Nonetheless, these phenomena occur simultaneously and in geographically distant locations. Animals in decline or with deformities are often limited in number, difficult to find, or protected by law, making investigations and experiments designed to find causes difficult or impossible at most sites. Two fungal species have been implicated recently as the cause of declines and/or disappearances (Kiesecker and Blaustein 1997; Berger et al. 1998), trematode infestation has been associated with deformities (Johnson et al. 1999), and global warming has been implicated as a factor contributing to declines (Kiesecker et al. 2001). No single cause, however, can explain anuran population dysfunctions across all sites. Whatever the reasons for these phenomena, natural population fluctuations and reactions at the population level to environmental degradation, contamination, weather perturbations, or other periods of stress remain virtually unknown (Pechmann et al. 1991). The lack of data on baseline population dynamics makes it difficult to differentiate human impacts on amphibians from natural disturbances or natural fluctuations in population size.

Habitat destruction and modification are the principal factors in most declines and extinctions, but amphibians are declining and disappearing from seemingly pristine and protected sites. For many reasons, amphibians are good biological indicators of their environment and may be more sensitive to environmental changes than are other organisms (Wake 1991b; Blaustein et al. 1994; see Pechmann and Wilbur 1994 for counterpoints). Understanding amphibian population dynamics is an important and feasible research priority for most ecosystems. Before we understand declines, we must investigate natural populations and describe baseline conditions in order to compare recent declines and disappearances to what may be natural population fluctuations, natural extinctions, or periods of dormancy. The only way to procure these data for comparison is to have long-term monitoring projects under way during periods of natural stresses, weather perturbations, or low-recruitment seasons. Only then can we make a serious attempt at understanding the differences between anthropogenic population declines and the natural variability in populations through time, including extinction events.
Long-Term Monitoring by Local People

I began a long-term frog-monitoring project and training program for local people under the auspices of an Integrated Conservation and Development Project (hereafter ICAD, but known in some literature as ICDP) in Papua New Guinea in September 1995. Integrated conservation and development projects attempt to meet the reality of human needs and desires for development with benefits and revenues based on the conservation of biological diversity. The conservation and development link of the ICAD project is summarized by Pearl (1994). Within the larger ICAD project, the frog-monitoring project is an example of scientific research as a local business. Frog-monitoring provides direct local economic and development benefits through the maintenance of biological diversity because it is only viable if the forest remains intact. The frog-monitoring project's aims were twofold: first, provide data on frog populations from a relatively pristine site; and second, reach the goal of the ICAD project by training local people as parabiologists. Employment as a parabiologist provides cash income for the stakeholders and may serve to promote protection and conservation of biodiversity.

STUDY SITE

The Crater Mountain Wildlife Management Area (CMWMA) is on the southern escarpment of the central cordillera of New Guinea. It includes parts of three provinces (Gulf, Chimbu, and Eastern Highlands provinces) and two local language groups (Pawaia to the south and Gimi to the north). The CMWMA is 270,000 ha and ranges from almost 50 m to more than 3,100 m above sea level (fig. 13.1).

The Crater Mountain Biological Research Station at Wara Sera is located in the center of the CMWMA and is named for its location on the Sera River. The protected study area extends from 850 to 1,350 m above sea level (fig. 13.1). The station lands are owned by one of the local groups in the Pawaia cultural/language group of the Pio-Tura area. Fieldwork by local people has always been a part of the station's purposes and strengths, and in 1995 I initiated a project designed to be fully executed in the field by Pawaia people over a long-term period.

Topography of the area is extreme, with sharp ridges and steep valleys dissected by several rivers and streams. Annual average rainfall is 6.4 m for the Crater Mountain Biological Research Station at Wara Sera (Wright et al. 1997), and there is no dry season (fig. 13.2). A severe El Niño Southern Oscillation (ENSO) event in 1997 and early 1998 dramatically reduced the rainfall received from September to December 1997 (see fig. 13.3 below). The rainfall during this period was not only the lowest ever recorded for those months, but it was also
Figure 13.1  Map of the Crater Mountain Wildlife Management Area (CMWMA) and its location in Papua New Guinea. The CMWMA, which straddles the Eastern Highlands, Gulf, and Chimbu provinces, is indicated by the shaded area on the map of Papua New Guinea.
below the 20-cm threshold, what most authors typically define as “dry” for a rainforest environment (Lincoln et al. 1982).

**Part One: Parabiologist Training**

Establishing a project to be wholly run in the field by the Pawaia was a difficult and lengthy process of trial and error. I learned many lessons during fieldwork and training that have heuristic value for other projects. The cultural, linguistic, and political contexts of working with local people are extremely important and need to be understood and specifically addressed.

Papua New Guinea is unique among developing tropical countries because of traditional land tenure regimes. More than 99% of land in New Guinea is managed privately, with almost no government ownership of land outside of urban areas (Crocombe and Hide 1987). Each group of people (e.g., language group, extended family group) owns its lands in various hierarchies of tenure and usufruct rights, and land is often managed by a group (Brookfield and Brown 1963; Brookfield and Hart 1971). Papua New Guinea has very little rural infrastructure. Many isolated villages in the interior have no road access and little government support for schools and first aid posts. The CMWMA-ICAD project is operated in a remote rural area about 75 km away from the nearest commercial center. The only access to the CMWMA is by small aircraft and/or foot.
THE PAWAIA

Until roughly 25 years ago, the Pawaia were principally a highly mobile population, moving through the forest in small family groups. The Pawaia had intimate and active contact with the forest in which they lived. They had few government services but moved around, lived in, and managed large holdings of land near the southern coast in Gulf Province to the foothills of the dividing range in Chimbu and Eastern Highlands provinces. The Pawaia were illiterate with a rich tradition of storytelling and chanting.

Local conditions for the Pawaia involved in the ICAD currently focus around a central airstrip in the village of Haia (fig 13.1). The first permanent missionary post in the area was in Haia, and a government school was established there in 1991. The Pawaia have been transformed from a largely mobile and rainforest-dwelling people to a sedentary and largely village-based people who do not move through their lands as they once did. Not surprisingly, the Pawaia mirror changes typical of those of indigenous peoples around the world. As the Pawaia have become more connected and influenced by the outside world and different standards of living, they have shown a tendency to replace their forest-based knowledge with new external-based knowledge.

PARABIOLOGIST TRAINING

To ensure data quality and to train and employ as many Pawaia as possible, I used methods that required two to four assistants. During the training period for these assistants, I attempted to provide employment and instructional opportunities regardless of gender or social group. Unfortunately, the Pawaian cultural context made it extremely difficult to include women in the training program. I was not able to hire unmarried women because of cultural taboos, and married women almost always had high demands of motherhood that started immediately after marriage. Although I tried to include married women with children in the training program, it was not feasible for women to simultaneously attend to their children and perform fieldwork. I included two recently married women in the training program, but they soon became pregnant and had to focus on domestic duties. Thus, training was implemented mainly for men, despite my efforts to include women.

I began training the assistants by teaching a series of fundamentals—reading, writing, and basic numeracy skills—and then moved on to techniques more specific to biological fieldwork.

Training Methods—Basic Skills

Because most Pawaia do not have much formal education (the median educational level was less than equivalent to third grade), my priority was to get the
basics across—reading, writing, and numeracy—in the context of the monitoring methods I planned to use. Training included small group discussions, workshops, and practice sessions. A few assistants had some formal education, so I trained them to teach their peers. An example of the exercises used by trained assistants to teach their peers was to copy the scientific names of each frog species in the study area and write in the local language the names for each frog species. This often precipitated other learning activities. Other exercises and workshops included introduction of the metric system and standard measuring units. We incorporated independent thinking by estimating the sizes of familiar objects as well as frogs in millimeters and meters to familiarize the Pawaia with the units of the metric system.

By using a variety of training techniques and involving the Pawaia as trainees, we tested the numeracy, literacy, natural history knowledge, and language skills of each assistant. These exercises also provided a medium whereby different generations could teach each other. Often older men had a better grasp of different frog species’ names, habitats, and natural history, whereas younger men and boys had better numeracy and written skills. Thus, an exchange was initiated that bridged generations, and sharing of forest-based cultural knowledge was rewarded. The assistants improved their abilities at frog identification, literacy, and numeracy.

To make these exercises less tedious, I incorporated games and exercises found in English-language grade school books and popular magazines. These were helpful and often captured the assistants’ attention. Discussions were initiated by the Pawaia assistants on the basis of articles they had read or pictures they had seen in conservation magazines (e.g., National Geographic, Wildlife Conservation, Nature Conservancy). I provided the assistants with environmental education articles or pamphlets in Melanesian Pidgin that were produced by the former Christensen Research Institute (based in Madang, Papua New Guinea). These were popular because they were picture-based and provided real-life stories from places the assistants knew within Papua New Guinea. Although not directly related to the frog-monitoring project, these media provided valuable tools to disseminate information about conservation, were helpful in literacy training, and indirectly proved to be valuable for the ICAD project as a whole.

Specific field training required construction of a dichotomous key to identify frogs to species. Because some of the frogs were difficult to identify, we focused on unambiguous characters to distinguish between similar species. Many frogs in the Wara Sera study area did not have common local names (see the section titled “Language and Vernacular”) so we invented names. Because I was introducing new names to the Pawaia, I used abbreviated scientific names instead of a “local name—scientific name” mix to alleviate confusion. The first few letters of the genus and species were used as a code name for each frog species. For example, Sphenophryne schlaginhaufeni became “Speno slag” and Hy-
Iphorbus rufescens became “Hylo ruf.” The assistants were able to recognize these names and use the codes effectively to identify frogs.

**Field Training: Long-Term Monitoring Methods**

Rather than document all trials and errors, I focus on the methods that worked and discuss reasons why they worked to facilitate their generality for other projects.

**Nonrandom Teams**

As the project grew and I was employing 6–10 Pawaia at a time, I realized that there were two general groups of assistants. These were by and large the young group and the old group. The main difference between groups was the amount of formal education in the village school (or more precisely, the amount of time spent in the village). I found that the younger Pawaia who had stayed around the village as youngsters to attend school were generally less knowledgeable about natural history and frog names. The younger group, however, had much better numeracy and literacy skills, and young Pawaia were better at recording data and measuring frogs. The older assistants, on the other hand, were better at identifying frog species and distinguishing between similar frog species. Initially, my random teams sometimes were made up of excellent parabiologists who could read and write extremely well but had problems identifying frogs to species. Likewise, some teams were made up of men who were able to identify all of the frogs found in the area but could not accurately record data. Hence, I paired older and younger Pawaia to balance these different skills. Members of these teams worked together and exchanged knowledge, and proved to be efficient and reliable.

The other nonrandom quality of the assistants that worked with me reflected the ever-present political complications among Pawaia family groups. During each hiring cycle, I included members of different family groups. Although there are ten extended family groups in the village of Haia, not all were included in the beginning years of the station’s history. The lack of total group involvement, coupled with the Pawaia history of jealousy and fighting among extended family groups, resulted in a complex situation. To try to give uniform opportunity to all extended family groups, the project sponsored training workshops in which each extended family group elected two members to be fully trained as assistants at the research station. Many of these elected Pawaia were not good assistants or parabiologists, but the project gave the opportunity for training to all extended family groups in an attempt to be fair. After the initial trials of all extended family groups, it became apparent that it was in the project’s best interest to keep hiring in a cycle to ensure full inclusion of all extended family groups. If this affected assistant quality, I hired one or two additional highly qualified and experienced assistants to work with the underqualified assistants.
Benefits of Employment

The landholder committee of the ICAD project decides on researcher responsibilities and what researchers must provide for their assistants. In the case of our project, assistants hired as employees were expected to receive wages, rain gear, flashlights, blankets, candles, food, and medical aid. In this part of Papua New Guinea, jobs are in demand and cash is limited, so there is competition for employment, and the people want the benefits accrued through the CMWMA-ICAD and biological field research. Moreover, the assistants earn respect by being a part of the project because they receive wages and other benefits.

Equal Opportunity to Work

Two-week trial periods (fortnights) were the standard contract for employment. This made wages and turnover of assistants evenly spaced, and equal opportunity was afforded to each lineage or family group. To provide stability, I tried to avoid a complete turnover of assistants at any single hiring period. I trained the more experienced assistants to be trainers of the less experienced assistants. This management strategy was effective for the frog-monitoring project. Other important repercussions of the employment protocol were the prevention of new jealousies among family groups and the amelioration of clashes among lineages of the Pawaia and with their neighbors to the north, the Cimi speakers in the village of Herowana (see Gillison 1993 for historic relations between these groups).

Training of Local Trainers

Training the skilled Pawaia assistants to be trainers was important to the success of the project. Pawaian trainers shared their experience as parabiologists during the training of less experienced assistants. Employing Pawaian teachers eliminated many of the constraints imposed by translating among three different languages. In New Guinea, where there are approximately 750 local languages, the lingua franca is Neo-Melanesian Pidgin, and in most urban centers classes are taught in English. The frog-monitoring project involved the many levels of translation that occur between English, Neo-Melanesian Pidgin, and Tehoe (the local Pawaia language). One of the most rewarding aspects of the project was seeing the Pawaia train each other in field methods in Tehoe and watching older assistants teaching younger ones the Tehoe names for the different frog species.

Daily Meetings

After about 12 months of fieldwork, I found it difficult to stay on top of all the various things that could go awry with 6–10 field assistants working in two teams. I initiated daily meetings to improve morale and to stay abreast of problems or errors as they occurred. Simply reminding the assistants of principal
points they had learned during training (especially frog identification and measuring protocols) was sufficient and appreciated. These meetings also improved intragroup cohesion. I typically managed two teams of four assistants who would not see each other all morning, so daily meetings ensured a unified working field team for the evening's fieldwork. As the teams became used to these meetings, I allowed opportunities for discussion on other topics. Thus the daily meetings became an avenue for assistants to voice opinions and ask questions, and with experienced teams the meetings were regular social gatherings.

**Hands-on Learning**
I minimized the amount of formal or classroom learning and maximized hands-on learning by using selected field methods as training tools. This "on-the-job" learning was efficient, and assistants learned quickly while doing the fieldwork. I also used question-and-answer sessions and problem-solving exercises in the field, sometimes employing transit time between sites (e.g., while walking from one leaf-litter plot to the next) or time spent in preparation for fieldwork before the sampling began (e.g., while walking—frog in hand—to the beginning of the visual encounter survey [VES] transect). In the field, assistants appeared to be at ease and were not worried about making mistakes. Informal teaching in the field was more effective than direct questioning typical of classroom situations.

**Low-Pressure Tests**
Formal teaching and field evaluations were often hindered by performance anxiety. To avoid this, I conducted less formal evaluations for each assistant on a regular basis. I maintained rigor by testing each assistant in the field, either one-on-one or as part of a group. I performed evaluations as part of the field method (e.g., asking an assistant to measure leaf-litter depth at each corner of the plot and then checking his measurements). Sometimes, as part of an evaluation, I would allow the team to work on a problem together (e.g., identification of a particularly difficult or rare frog species). If an assistant was unable to complete a task or made a mistake, instead of calling him out and making an example of him, I simply asked another, more experienced assistant to check his answer. This type of evaluation did not appear to be formal, and the assistants were not anxious about failure when they were corrected by one of their peers. I never attempted classroom written tests because I felt they were not appropriate and would only heighten an already high level of performance anxiety for the Pawaia.

**Never “Lose Face”**
After inadvertently embarrassing assistants by directly correcting them when they made mistakes, I learned that avoiding embarrassment or humiliation was very important in cross-cultural exchanges with assistants. To provide a work-
ing environment in which humiliation was prevented, I used every error as an instructional tool. Instead of telling an assistant that he was wrong and explaining why, I would ask him in a nonthreatening way why he thought his answer was correct. Many times, I never had to specifically mention that his initial answer was incorrect because he would correct himself during a question-answer exchange. For example, if an assistant misidentified a frog, I would ask him why he thought it was that particular species. He would list the attributes or characteristics, which would allow me to ask more specific questions and simultaneously hone his identification skills. If one characteristic was incorrect, I would ask him about it and the range of possible character states in the frog species. By comparing different frog species and characteristics, we could almost always correct a misidentification without causing the assistant to feel humiliated or ashamed.

LIMITATIONS

Many sociocultural limitations affected the field methods on numerous occasions. Because the frog-monitoring project is part of the ICAD project and local people are the primary beneficiaries, cultural acceptance is paramount to success. This means that sacrifices are made and limits are established to both maximize information gathering and minimize cultural disruption or disrespect.

Flexibility is a key factor to any field project that involves working with local people. Project leaders must listen and react to local needs. Becoming intimately familiar with the local perspective is necessary to understand how to be flexible and get the research done. During my work in the CMWMA I was asked for favors that included making personal loans, allowing early termination of a work period to attend a funeral, and buying items in town. Requests like these can be considered but need to be taken care of as they arise so they do not become limiting problems during critical periods of fieldwork. In most cases, there is no tangible effect of cultural beliefs or social customs on methods used in the field. In some cases, however, specific field methods are affected by pre-existing beliefs or cultural perspectives that may not be obvious to an outsider.

Legends and Myths: The Masalai

A cultural constraint of fieldwork with the Pawaia became apparent during nocturnal visual encounter surveys (VES) conducted along fixed transects. Many folk tales and legends exist about the pseudomythical masalai (or poison-man), who comes out at night and kills people. Although there seems to be a great deal of variability in the strength of belief in these stories, they are perpetuated, and there are instances in which these stories become reality when they elicit violent behavior that is explained without blame or punishment. Because
these stories related to murders at night, and we sampled VES transects almost every night. I realized that the unease and lack of morale were not the result of inexperience or arduous conditions. Because of the constant “looking-over-the-shoulder” anxiety related to fear of masalai, reliability of data collected at night by local parabiologists was not high initially. However, after the Pawaia told me the stories and I realized the variability of the strength of belief about the myth, we were able to avoid many negative aspects of the masalai myth on the monitoring methods. I selected men whose belief in the masalai was not strong and worked exclusively with them at night for many months. Because these assistants were never killed by the masalai, they would explain to the other assistants that the scientific night work we were doing must be exempt from the actions of the masalai, or that the study area was somehow protected from the masalai. After grooming a few Pawaia assistants and trainers who effectively addressed the fears of their fellow Pawaia, we were able to overcome this constraint completely.

**Legends and Myths: The Singing Worm**

One way of tracking frogs—the audio strip transect (AST) method—relies on knowledge of frog calls, so the person recording the data needs to know all the frog calls in the area. As a result of the large number of calls that had to be learned, I found this method impractical, but in any case use of the method was affected by a myth about the singing worm. Frogs of the microhydrid genus *Xenobatrachus* are considered to be mythical singing worms by many cultural groups in New Guinea (see Bulmer and Tyler 1968). The perpetuation of this myth stems from the natural history of the frogs. *Xenobatrachus* frogs are fossorial and rarely encountered by humans. They are typically active and calling during or immediately after rain. Their calls are extremely quiet, high pitched, and infrequent “poopoop” emitted from under the soil surface. Worms in New Guinea can be enormous and are also seen during or after rains. Because of the rarity of the frogs, their unusual calls, and their shared fossorial microhabitat with worms, these frogs have become known as the singing worms. I believe, however, that asking local people to disregard myths and stories in their cultural context is not in the best interests of the ICAD project nor the frog-monitoring project and may lead to loss of cultural knowledge over time. Also, in this case the identification method was inappropriate because of the diversity of calling frogs and the difficulty in training, so it was not included.

**Language and Vernacular: Frog Identification**

Loss of forest-based indigenous knowledge (i.e., loss of the accumulated experience of thousands of generations of people living in the forest) is a tragic reality for most indigenous cultures.
The local Pawaia language, Tehoe, is a complex and rich language, with stories and ecological designations that can be intricate and detailed. Partly because young boys attend school in a central village, many are not learning forest-based knowledge that is gained mainly by living and traveling by foot through the forest. Instead, the centralized village is changing the cultural knowledge of the Pawaia. Older men and women are the caretakers of knowledge that is not being passed down.

Although not generally correlated with Latin binomials, the Pawaia Tehoe names are useful. The Pawaia sort frogs into two categories: sian, frogs you can eat (generally ranids); and eria, frogs you cannot eat (they are too small or have toxic skin secretions). In Tehoe there are descriptors of color, size, and habitat that modify names in some cases. For example, *pulambo sion n'hoela hō'ō* is the name for the small edible frog with a short snout (*Nyctimystes cheesmani*). Few frogs have a Pawaian common name that corresponds directly to a Latin binomial. The frogs that do have specific names are the largest, most colorful, most common, have the loudest calls, or are used in local magic potions. Frogs that are eaten, for example, have one-word names such as *so'ā* (the Tehoe name for *Rana grisea*). Because so many frogs did not have names, and because of the generalized and inconsistent Pawaia naming scheme, it was difficult to teach frog identification in local terminology. I used the aforementioned code based on the Latin binomial, which enabled us to name frogs and collect data accurately.

RESULTS AND CONCLUSIONS

Training local people as parabiologists can be a powerful mechanism for including local perspectives in field research and conservation. I recommend that local people be included in all aspects of conservation projects, thereby enabling their participation through education and access to information. Table 13.1 contrasts the field methods I found most useful in Papua New Guinea with typical field protocols.

After nearly four years of training assistants (1995–99), the frog-monitoring project was run for three years by locals in the field at the Crater Mountain Biological Research Station at Wara Sera. It was terminated in 2002, however, until more training could take place because systematic errors were accumulating during data collection. As part of a larger ICAD project, the frog-monitoring program has had many positive results. It provided local cash income for the parabiologists hired to conduct the monitoring. Training local people as parabiologists instilled or augmented an existing stewardship ethic and spent conservation dollars locally where they are needed. Training local people to conduct a long-term frog-monitoring project involves local people in biodiversity conservation. This situation is stable and feasible for long-term conservation
Table 13.1  Contrasting approaches used in field projects

<table>
<thead>
<tr>
<th>Subject</th>
<th>Traditional approach</th>
<th>Approach used in Papua New Guinea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training Style</td>
<td>Classroom /lecture with fieldwork</td>
<td>Hands-on fieldwork with discussions</td>
</tr>
<tr>
<td>Mistakes</td>
<td>Correct mistakes/heuristic display of errors</td>
<td>Use mistakes as learning tools/avoid humiliation</td>
</tr>
<tr>
<td>Corrections</td>
<td>Correction from authority figure</td>
<td>Correction from peers</td>
</tr>
<tr>
<td>Communication</td>
<td>Translate</td>
<td>Use senior assistants for training in local language</td>
</tr>
<tr>
<td>Assessing progress</td>
<td>Formal written and/or oral tests with grades, often in large groups</td>
<td>Informal evaluations with no grades—best in small groups or individually</td>
</tr>
<tr>
<td>Working in the field</td>
<td>Random or select the best workers</td>
<td>Select teams to maximize diversity of skills or knowledge</td>
</tr>
<tr>
<td>Team constituents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Choosing workers</td>
<td>Only the best or most productive or reliable</td>
<td>Political representation of all concerned stakeholders</td>
</tr>
<tr>
<td>Group meetings</td>
<td>Ranges from often to only when needed</td>
<td>Daily</td>
</tr>
</tbody>
</table>

and may be more effective than forcing local people to uphold lofty conservation ideals that they do not fully understand.

The reality of ensuring success in a long-term monitoring project requires a serious investment of time. In the case of the Pawaia in Papua New Guinea, it took nearly four years of training to produce field teams that can complete monitoring methods by themselves. Even after this lengthy training period, intermittent training needs to be carried out to keep the field teams working effectively. The time investment for other projects may not be as lengthy, but it must be made on the ground with local people. Special attention must be paid to the cultural context and/or the perspectives of local people. Training projects and conservation education programs like the one I have described cannot be administered remotely.

Although it may not be a new paradigm, turning the focus from working with local people to working for local people is powerful. In a monitoring project that can employ local people as parabiologists, conservation education and training should be priorities. Research projects can flow smoothly, reliable data can be procured, and conservation dollars can be saved by including local people. Inclusion of local people in conservation projects also ensures the project's long-term feasibility.
Part Two: Biological and Scientific Aspects

Long-Term Frog Monitoring

I collected baseline data from a pristine site in Papua New Guinea to understand variation in the size of frog populations. New Guinea, the world’s largest tropical island, has vast tracks of undisturbed primary forest and is geographically proximate to Australia, where there have been numerous declines and hypothesized extinctions of frogs.

When I designed the monitoring project, I had to balance several factors. I was aware of and concerned with problems of data accuracy. Because of the variation in the quality of data collected by different people, I had to decide which methods would be most rigorous and repeatable. The local people had little formal education, and methods had to be technically simple, effective, and repeatable by different teams at different times.

Methods

During a trial period, I tested several methods to assess their suitability for training of and long-term use by local people in a tropical, developing country. Some methods (e.g., leaf-litter plots and breeding site surveys) sampled specific microhabitats effectively, whereas others (e.g., VES transects, AST censuses, and general collecting) were more general. A number of methods can be used to measure density (e.g., leaf-litter plots) and others used for indices of density or relative abundances (e.g., VES transects). The methods I used are presented in Table 13.2 and are contrasted with other techniques.

Leaf-litter plots were one of the best methods because (a) they sampled a subset of the total frog fauna, which simplified species identification; (b) they incorporated simple but important measures of habitat variables (e.g., temperature, vegetation type, canopy cover); and (c) they involved a team of four assistants, which ensured high morale and an internally consistent way to check data. The AST method (Zimmerman 1994) was the worst method for training because of high frog species diversity (> 40 species) at the study site.

Standard Methods: Part I

Drift Fences and Pitfalls

Drift fencing and pitfall traps are logistically difficult to deploy in a remote site. Moreover, the method is too expensive in terms of materials, transportation, and labor for a grassroots conservation project. Because of financial and logistical constraints, I did not include this method in the monitoring project.
Table 13.2  Standard methods for training local people for long-term frog monitoring

<table>
<thead>
<tr>
<th>Method</th>
<th>Suitability for training</th>
<th>Data utility for monitoring</th>
<th>Tried (yes or no) and final outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf-litter plots</td>
<td>High</td>
<td>Good</td>
<td>Yes—best method</td>
</tr>
<tr>
<td>Visual encounter surveys (VES)</td>
<td>High</td>
<td>Good</td>
<td>Yes—problems with species identifications</td>
</tr>
<tr>
<td>Audio strip (AST)</td>
<td>Low</td>
<td>Moderate</td>
<td>Yes—impractical in areas with high species richness</td>
</tr>
<tr>
<td>Drift fences with pitfall traps</td>
<td>Low</td>
<td>Moderate</td>
<td>No—expensive</td>
</tr>
<tr>
<td>Breeding-site surveys</td>
<td>Medium</td>
<td>Moderate</td>
<td>Yes—not suitable in PNG</td>
</tr>
<tr>
<td>Tadpole sampling</td>
<td>Medium</td>
<td>Poor</td>
<td>Yes—not suitable</td>
</tr>
<tr>
<td>General collecting</td>
<td>Medium</td>
<td>Poor</td>
<td>No—not suitable</td>
</tr>
</tbody>
</table>

Tadpole Sampling and Breeding-Site Surveys
Because less than half of the species at most sites in Papua New Guinea have a free-swimming larval stage, and because most of those that do typically breed in fast-flowing or torrential streams, I did not include tadpole sampling methods in the training program for frog monitoring. Most frogs in Papua New Guinea do not form large aggregations around breeding sites, so surveys at breeding sites are not feasible for a monitoring project.

General Collecting
The method of general collecting is one of the best ways to approach a complete species inventory over a number of years at a single site. General collecting can be one of the only ways to find rare species, but it is not highly suitable for long-term monitoring because it is not quantitative. I did not use general collecting as a frog-monitoring method.

Audio Strip Transects
AST is a form of transect sampling that relies on the ability of an observer to differentiate and identify all frog calls within the study area. It is a powerful method that is useful across a wide range of variables and habitats. Unfortunately, in tropical forests there may be 40–70 frog species in an area, and differentiating and identifying all calls unambiguously is a talent gained only through many hours in the field. Once expertise has been achieved, it is a rapid and useful method to estimate frog relative abundances. I conducted these transects between 1900 and 2100 h, when most frogs were active and calling. To avoid biases (see Zimmerman 1994), I used AST on six preexisting trails that crossed streams, valleys, and ridges but did not follow any waterway or topo-
graphic contour for an extended length. For an hour during each AST, I recorded all calling individuals I heard from the trail along with their species name and time I heard them. I also recorded date, time started and finished, approximate length of transect (10 m), and weather conditions, as was recorded in the VES transects (see appendix 13.2). I compared the same repeatedly measured transects, as in the VES, across the three time periods. Because of the high species diversity at this site (approximately 40 species), however, AST was not suitable for the training of and long-term monitoring by local people.

**Standard Methods: Part II**

**Leaf-Litter Plots**

Leaf-litter plots are a form of quadrat sampling (Scott 1976; Jaeger and Inger 1994) and are one of the best ways to estimate the density of frogs found on the forest floor. I used 5 x 5-m plots because there are many species of terrestrial and fossorial frogs at Wara Sera. Plots larger than 5 x 5 m are difficult to establish because of rugged terrain in the area. We used a random number table (Heyer et al. 1994) to select plot locations. After determining two random two-digit numbers, we paced off the first number along a preselected trail and then took a 90° bearing off that trail, pacing off the second random number perpendicular from the first trail. Unless topography (cliff faces, waterfalls, etc.) prevented it, we would head to the right side off trail for the even numbers and to the left side for odd numbers. Once we located a plot, we delineated the boundaries with a tape measure or pre-measured rope. After the plot was laid out, one person recorded the time and we began to search for frogs (Scott 1976; Jaeger and Inger 1994). Appendix 13.1 has a facsimile of the data sheet we used for leaf-litter plots.

During litter plot sampling, we found frogs and clutches of direct-developing microhylid frogs. Because microhylids dominate the frog fauna of New Guinea and have discrete egg clutches, they are a proxy of frog reproductive activity.

**Visual Encounter Surveys**

VES is a standard method that is useful across nearly all situations found in the field (Crump and Scott 1994). It has been widely used and remains a mainstay for field herpetologists. The method is standardized by unit effort in people/hours for our use, but it is versatile and can be standardized to time, distance, unit effort, people, or combinations of these. We incorporated nocturnal VES transects along six preselected trails in the study area. We rotated transects so that each transect was sampled approximately once per week. Each group of 3–5 parabiologists carried a flashlight and searched from ground level to approx-
imately 3 m above the forest floor along the trail for one hour (between 1900 and 2100 h). I optimized teams by having one assistant record data and the others search for and capture frogs. Once animals were captured, we recorded the substrate, time, sex, and age and measured snout-vent length (SVL; in mm). After processing the frog, we released the animal where it was found and continued sampling. Appendix 13.2 has a facsimile of the data sheet we used for VES.

Monitoring Methods in Use
Sampling methods that were technically simple, effective, and repeatable and generated direct estimates of density and/or relative abundances were the 5 × 5-m leaf-litter plots and the nocturnal VES transects. Both methods were rated highly among the Pawaia and remained effective throughout training and evaluation periods. Unfortunately, the accuracy of species identification during use of the VES method was not reliable once I left Papua New Guinea. Because of problems associated with species identification, the VES transects are not currently part of the monitoring project. The 5 × 5-m leaf-litter plots are not being used for long-term monitoring at Waba Sera because of a few problems with frog identification. With the institution of additional training and a photo-based identification key, I hope to boost species identification abilities; after the reevaluation of the VES transects and the 5 × 5-m plots, I anticipate reinstating the frog-monitoring project in the future.

Statistics
I analyzed the data from the 5 × 5-m plots, the VES transects, and the AST censuses for three discrete time periods: before, during, and after the ENSO drought. Because the rainfall during the period of September–December 1997 was consistently below the second standard deviation from the mean (except for a brief hiatus in November), I defined this four-month period as the ENSO drought period. I standardized sample sizes for the 5 × 5-m plots, VES, and AST in the three time periods. For example, I compare the 60 VES transects run immediately before the ENSO period, the 60 VES transects run during the ENSO drought, and the 60 VES transects run immediately after the ENSO time period to determine any differences that exist among time periods.

In the 5 × 5-m leaf-litter plot analyses, in which all plots were random and independent of each other, I used a Kruskal-Wallis test to compare frog density among the three time periods (pre-ENSO, ENSO, and post-ENSO; http://www.obg.cuhk.edu.hk/researchsupport/KruskalWallis). I used repeated measures analysis of variance (ANOVA; http://faculty.vassar.edu/lowry/cor3.htm) to compare relative abundance for the three time periods because I made repeated observations of the six transects. The null hypotheses for these analy-
ses were that there was no difference in density or relative abundance among time periods. If the differences among time periods were significant, I conducted post-hoc Tukey Honestly Significant Difference tests (http://www.graphpad.com/calculators/tosttest.cfm) to determine which periods differed from each other.

**RESULTS**

Because I have data from before, during, and after the ENSO drought of 1997, I can examine how frog populations reacted to a naturally occurring low-rainfall event that lasted nearly four months. I include both methods that were part of the long-term monitoring project (5 × 5-m leaf-litter plots and VES transects) as well as an AST census method that was included and evaluated during the training period but was not part of the long-term monitoring.

**Leaf-Litter Plots**

I analyzed 972 plots (324 per time period) to make sampling efforts equal in each time period (fig 13.3) and compared the number of clutches per plot across the three time periods. There were significant differences in the number of clutches among the three time periods ($p < .0001$, $H = 33.86$, $df = 80$). There were significantly fewer clutches per plot during the ENSO period than during the pre-ENSO period ($p < .05$) and the post-ENSO period ($p < .05$). There was no difference, however, in the number of clutches between the pre-ENSO and the post-ENSO periods.

**Nocturnal VES Transects**

I compared 180 VES transects (60 per time period) to standardize sampling among the pre-ENSO, the ENSO, and the post-ENSO periods (fig. 13.4) and found significant differences in the number of frogs seen during the three time periods ($p < .0001$, $F = 101.93$, $df = 2, 179$). More frogs were observed during the ENSO period than during either the pre-ENSO period ($p < .05$) or the post-ENSO period ($p < .05$). There was no significant difference in the number of frogs seen during the pre-ENSO and the post-ENSO periods.

**Audio Strip Transects**

I compared 81 one-hour ASTs among the three time periods (27 repeated transects per time period). There were significant differences in the number of frogs heard calling during the three time periods ($p < .0001$, $F = 48.63$, $df = 2, 80$). Significantly fewer frogs called during the ENSO period than during the pre-
Figure 13.3  Average number of clutches per plot. The El Niño Southern Oscillation event lasted from September to December 1997.

Figure 13.4  Average number of frogs encountered during hour-long nocturnal visual encounter surveys. Error bars = one standard deviation. The El Niño Southern Oscillation event lasted from September to December 1997.

ENSO period ($p < .05$) or the post-ENSO period ($p < .05$). There were also significantly fewer frog calls heard during the post-ENSO period than during the pre-ENSO period ($p < .05$), probably because of the "lag time" of a few weeks after the actual drought had ended when frogs were still responding to the effects of the drought (fig. 13.5).
Conclusions

During training and long-term monitoring, I saw changes in frog calling, number of clutches, and frog density during the severe ENSO drought from September to December 1997. There were many fewer frogs calling, significantly fewer clutches, but higher densities of frogs (during nocturnal VES transects) during the 1997 ENSO. The significantly lower reproductive effort during the ENSO drought, measured both in terms of frog calling as an investment in reproduction and in actual number of clutches per plot, was not surprising. Because frogs are highly susceptible to evaporative water loss, they often change their behavior or activity patterns to avoid physiological stress caused by desiccation. The reduced reproductive effort during the ENSO drought is a typical response for amphibians that experience an extended drought. The higher density of frogs in the nocturnal VES transects, however, was counterintuitive. Although initially confusing, the result makes sense when the species composition and relative abundances are broken down into habitat-use guilds. The significant increase in frogs seen on VES transects during the 1997 ENSO drought is largely explained by a greater number of arboreal frogs encountered (almost 78% of total). I hypothesize that these frogs were simply seeking moisture-rich habitats and fleeing the relatively dry canopy, although I have no direct measures of moisture between the two microhabitats. Anecdotal measurements during (relative humidity = 85%) and after (> 98%) the ENSO drought indicated that it was drier even at ground level.

The other interesting aspect of the counterintuitive result from the VES transects is the implication for interpreting results from a long-term monitor-
ing project. Because we saw significantly more frogs in the VES transects during the drought and encountered fewer frogs after the drought, it superficially appeared that frog populations had crashed or species had disappeared as a result of the 1997–98 ENSO drought. This effect would be particularly notable if the monitoring project had been during the ENSO, and we could not compare time periods before the ENSO. Although our data from before the 1997–98 ENSO period show that this is not the case (no statistical differences between before and after the 1997–98 ENSO; also see fig. 13.4), it would be easy to make a false hypothesis or jump to the conclusion that there had been a severe population crash or a series of local species extirpations as a result of the low rainfall ENSO without the data collected before the ENSO drought. Cautionary tales such as this are extremely valuable when setting up monitoring projects and analyzing preliminary results.

Appendix 13.1  Sample Data Sheet for 5 × 5-m Leaf-Litter Plots

<table>
<thead>
<tr>
<th>5 × 5-m Plot</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Det (date):</td>
<td>San (amount of sun*):</td>
</tr>
<tr>
<td>Ples (location):</td>
<td>Ren (amount of rain*):</td>
</tr>
<tr>
<td>Taim stat (time begun):</td>
<td>Shed (canopy cover*):</td>
</tr>
<tr>
<td>Taim finis (time finished):</td>
<td>Wet (amount of soil saturation*):</td>
</tr>
<tr>
<td>Diwai (trees):</td>
<td>Ston (amount of bare ground*):</td>
</tr>
<tr>
<td>Bikpela (large, &gt; 50 cm dbh):</td>
<td>Klaut (amount of cloud*):</td>
</tr>
<tr>
<td>Namel (medium, 50−10 cm dbh):</td>
<td>Temp (temperature in °C):</td>
</tr>
<tr>
<td>Liklik (small, &lt; 10 cm dbh):</td>
<td>Stip: (degree of slope—to nearest 10°):</td>
</tr>
<tr>
<td>Dai diwai (logs on ground):</td>
<td></td>
</tr>
<tr>
<td>Hamas tip (leaf-litter depth in mm):</td>
<td>1) 2) 3) 4)</td>
</tr>
<tr>
<td>Rokrok Nem Siанс (frog species code)</td>
<td>mm Ples</td>
</tr>
<tr>
<td>(SVL in mm) (location found)</td>
<td></td>
</tr>
</tbody>
</table>

Wanem kain ples (general habitat description, e.g., near stream, on ridge with Pandanus sp.):
Husat wokim (names of field workers):
Sekim pinis (all categories double-checked):
* Four categories: 0 = no rain, new moon, etc.; 3 = hard rain, full moon, etc.
Appendix 13.2  Sample Data Sheet for Nocturnal VES

VES NAIT
Det (date):
Ples (location):
Taim stat (time begun):
Taim pinis (time finished):

Ren (amount of rain*):
Mun (amount of moonlight*):
Klaud (amount of cloud*):
Temp (temperature in °C):

Rokrok Nem Sians mm Ples Taim
(frog species code) (SVL in mm) (location found) (time found)

Yugo hamas mita long rot (length of transect in m):
Husat wokim (names of field workers):
Sekim pinis (all categories double-checked):
*Four categories: 0 = no rain, new moon, etc.; 3 = hard rain, full moon, etc.

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