Deforestation, Swidden Agriculture and Philippine Biodiversity

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It is thought that about 90% of Philippine land area was once forested. This has now been reduced to <20% and, if the current rate of deforestation is maintained, it is projected that no forest cover shall remain within the next decade. Forest destruction has occurred in two steps, beginning with logging, followed by various forms of swidden cultivation. We examined the literature in search of data with which to test the hypothesis that swidden cultivation is "not bad" for biodiversity in the Philippines. The great biodiversity and endemism of forest flora and fauna are such that, in most cases, number and kinds of species in the swidden do not adequately substitute for what is lost in the course of forest destruction. However, studies comparing forest and swidden biodiversity have been inadequate and have failed to consider ecosystem function and services. Because many indigenous and endemic species evolved as forest specialists, the continued deforestation of the Philippines shall likely lead to their extinction. The valuation of ecosystem services provided by Philippine forests may yet reveal that the benefits derived from their conservation would greatly exceed those currently derived from their destruction.

INTRODUCTION

The Philippines is considered to be a biodiversity "hotspot" of high species richness and endemism (Myers et al. 2000, Sodhi et al. 2004). Unfortunately, a common feature of biodiversity-related research conducted in the Philippines is that most of it goes unpublished. Alcala (2004), for example, states that of 131 funded studies conducted from 1998 to 2003, 17% yielded publications and only 7% resulted in submissions to peer-reviewed journals. Because scientific findings announced in the popular press often never make it into refereed scientific journals, the absence of expert peer-review and the lack of access to research methodology and results raise the issue of credibility. A recent article in a prominent, national newspaper entitled "Who says *kaingin* is bad?" (Fernandez 2009) asserts, based on a study sponsored by the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD), that swidden farming (also known as "shifting agriculture", "slash and burn farming" or "*kaingin*") is "not really that destructive" and "promotes plant diversity, preserves indigenous plant varieties, and provides organic fertilizer and food for some biotic components of the ecosystem". Such announcements and generalizations by the news media have the potential to influence public perception and behavior as well as to change government policy. Given how little forest cover remains in the Philippines, widespread acceptance of claims concerning the benign nature of *kaingin* can have potentially catastrophic consequences.

Here, we examine the process of deforestation and the context in which *kaingin* has been practiced in the Philippines. We then consider their impacts on biodiversity. Our intention is to determine whether there is empirical support for the *ecological hypothesis* that *kaingin* is "not bad" for biodiversity, while taking into account both the context in which biodiversity is defined as well as its importance. Although some may question the need to document what may seem obvious, we argue that a scientific, evidence-based approach to this issue is

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both timely and necessary, as well as of heuristic value.

History of Philippine Deforestation

According to a recent review (Bankoff 2007), about 90% of land area was covered with forest at the commencement of Spanish colonization of the Philippines in the 16th century. Logging during 3 centuries of Spanish rule reduced this to 70%, while half a century of American and Japanese occupation led to further reduction that left the newly independent Republic with about 50% forest cover by 1950. The decline in forest cover occurred while the human population increased from less than a million in the 1500s to about 20 million in 1950. Since then, the population has increased almost 5-fold and now exceeds 90 million (National Statistics Office, Republic of the Philippines, 2010). Recent journal articles quote estimates of remaining forest cover as low as 17-18% of total land area (Briones 2007; Moya and Malayang 2004, Posa and Sodhi 2006). Of the approximately 6 million hectares of forest remaining, less than 1 million consists of primary forest (Lasco et al. 2001). According to the FAO, the country has one of the highest rates of deforestation in the world and, if the current rate is maintained, no significant primary forest cover can be expected to remain within the next decade (Remollino 2004) (Figure 1).

Deforestation and *Kaingin* in Context

The decline in Philippine forest cover is associated with an increase in the area devoted to agriculture, indicating that much of the deforested areas were converted to agricultural production (Dobson et al. 1997, Sajise et al. 1992). A landmark in studies of Philippine deforestation and *kaingin* is the work of Kummer (1992a) that documents how, during the postwar period, majority of Filipinos remained poor and did not benefit from economic growth. Wealth, political power and control of resources became increasingly concentrated in the hands of the minority elite. During this period, substantial areas of primary forests were rich in dipterocarp species that were highly valued and in great demand overseas. The Philippine government - the largest landowner in the country - granted legal permission to harvest logs to a limited number of wealthy concessionaires. However, there was so much corruption and inefficiency in the regulation of logging that this became a virtually unregulated activity. After concessionaires harvested dipterocarp trees from primary forest areas, they left logging roads and secondary forests behind. The poor, who lacked employment opportunities in the lowlands, migrated into the upland areas where they cut down secondary forests and practiced *kaingin*. There were periods during which such migration was encouraged by the

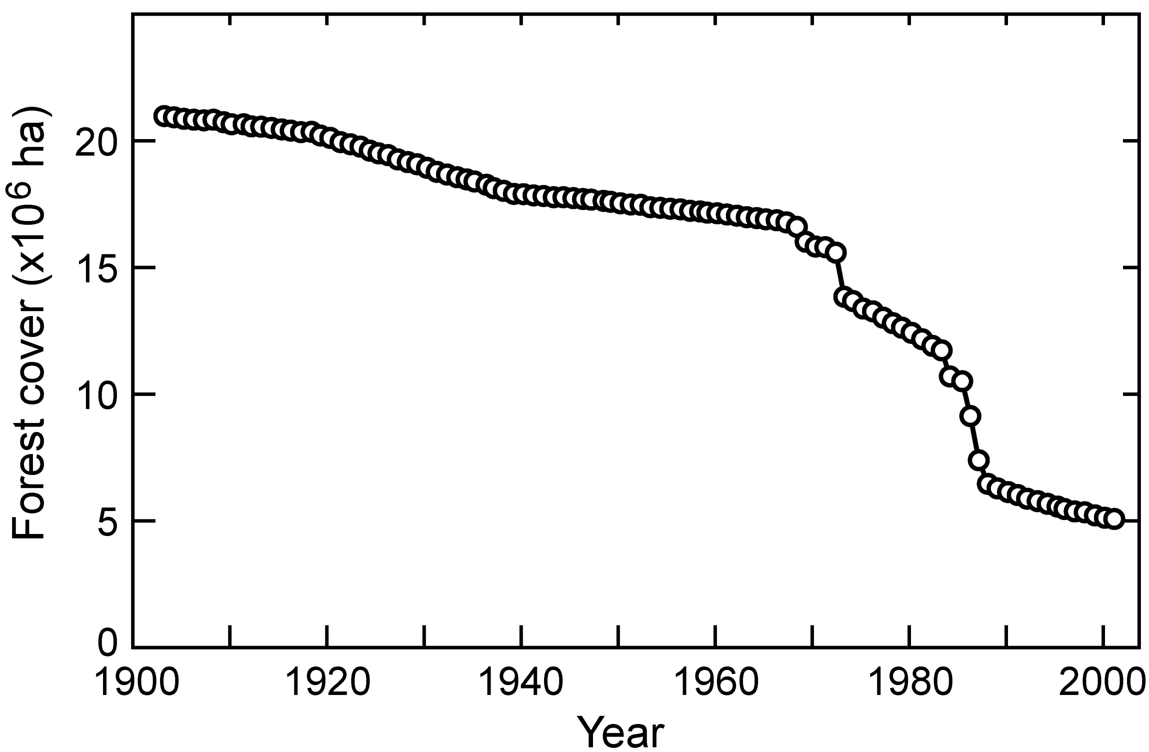

Figure 1. Philippine forest cover in hectares (ha) over time, redrawn from Moya and Malayang (2004) with permission from the publisher. The rate of forest loss greatly accelerated from about the late 1960s to the late 1980s, consistent with the hypothesis that political and socioeconomic factors account for much of postwar deforestation (Cuevas 1991; Kummer 1992a). A useful exercise is to determine which colonial power ruled and which president was in office as the deforestation rate varied.

government, allowing *kaingin* to serve as a "safety valve" that relieved pressure to undertake much-needed socioeconomic reform. There is evidence of deliberate manipulation of forestry data concerning the extent and rate of deforestation (Kummer 1995). Such misinformation allowed blame to be shifted to the poor. In reality, logging, followed by agriculture, are inseparable as parts of a two-step process that resulted in postwar deforestation in the Philippines. While the concessionaires and their partners in government have been motivated primarily by financial gain, those who practice *kaingin* have done so just to survive. The human dimensions of *kaingin* in the Philippines are subjected to detailed analysis in a fine review by Cuevas (1991) who concludes, as Kummer (1992a) does, that Philippine deforestation and *kaingin* can be fully understood only in the context of socioeconomic and political conditions in the country (Figure 1). Among the outcomes of commercial logging and migration of lowlanders to upland areas is the socioeconomic marginalization and detribalization of indigenous groups (Cuevas 1991, Eder 1990).

Types of *Kaingin*

It is necessary to recognize that the term "swidden farming", often used by social scientists and commonly called "*kaingin*" in the Philippines, encompasses a variety of agricultural practices with differing environmental effects (Cuevas 1991, Kummer 1992a, Russell 1988). As *traditionally practiced* worldwide, swidden farming involves the cutting down and burning of plant growth, followed by the planting and harvesting of crops. Farming is conducted until soil fertility is exhausted and the swidden farmers move on to other areas. In this condition, the fields are left fallow for a sufficient period until soil fertility and vegetative growth return. This makes possible significant recovery to its original state and repetition of the cycle of "slash and burn" (Noble and Dirzo 1997, Russell 1988). Relatively benign forms of *kaingin* have been described as practiced by indigenous people in the Philippines, e.g., Igorot in the Cordillera (Kowal 1966), T'boli in Cotabato (Hyndman et al. 1994), and Hanunoo in Mindoro (Russell 1988). Regarding the latter, Russell (1988) states "The system is often practiced with great sophistication. The Hanunoo people, for instance, of Mindoro Island in the Philippines are expert botanists and ecologists (Conklin 1957). Their soil classification stands up to modern scientific analysis. They know all about slopes, erosion, and the value of litter as mulch. They can recognize 1600 different kinds of plants (including varieties as well as species) and treat them all differently and appropriately, and they cultivate more than 400 kinds of plants in the swidden, a veritable botanic garden." The Hanunoo are said to till a given plot for only 2-4 years, leaving it fallow for 8-10 years to allow regeneration of soil and forest vegetation. Performed in this way, *kaingin* can be regarded as superior to traditional agriculture because, despite low yield per unit area, it protects the soil and requires no fossil energy-based inputs such as commercial fertilizer, herbicide or insecticide. However, *kaingin* is only sustainable at low population density because of the need for free access to large areas of land. Beyond the critical population density, it becomes necessary to increase the period of cultivation and to decrease the period of fallow. This initiates a vicious cycle because of the resulting progressive declines in soil quality and crop yield. More land is cultivated in an attempt to maintain total yield, leading to the degradation of even more land. Thus, when large numbers of lowlanders are forced by adverse socioeconomic conditions to migrate to the uplands to practice *kaingin*, negative environmental impacts are not unexpected. Even among various indigenous groups, the pressure to increase productivity in response to increased population size results in the low sustainability of their *kaingin* (Cuevas 1991).

Kummer (1992b) summarizes empirical evidence supporting the view that most forms of upland agriculture practiced in the postwar period, referred to loosely as *kaingin*, actually involve sedentary agriculture. Now that the primary forests are mostly gone, what little forest remains is considered as mostly secondary growth and this is where most *kaingin* is currently practiced (Lasco et al. 2001, Viloria et al. 2005). The view that most migrants to the uplands actually practice sedentary (rather than shifting) agriculture is supported by the work of other researchers, e.g., Viloria et al. (2005) in Mindanao and Lawrence (1997) in Leyte and Bohol. The latter conducted a detailed examination of the agricultural practices of 6 communities. Depending on the site, there may have been commercial logging or the cutting down of trees for local use preceding agricultural activity. There may have been crop rotation, short periods of fallow or the burning of fallow. However, the practices at these sites differ significantly from the shifting agriculture characteristic of the traditional, more environmentally-benign forms of *kaingin*, as traditionally practiced by indigenous people at low population density.

In this article, we accept a loose definition wherein the term *kaingin* is applied to a broad spectrum of agricultural practices that are part of (or follow) the process of forest destruction. Despite variation in the manner in which it is practiced, *kaingin* has been and remains an integral part of the process of forest destruction in the Philippines.

Effects on Floral Biodiversity

The Philippines is endowed with many plant species, majority of which are endemic (Sodhi et al. 2004) (Figure 2). An excellent starting point in attempting to appreciate tree biodiversity in Philippine forests is the recent work of Co et al. (2006) on a 16 hectare plot in a mixed dipterocarp forest in Palanan, Isabela. 78,205 trees were counted; 323 species belonging to 160 genera and 67 families were identified. The family Dipterocarpaceae, represented by 10 species, accounted for 50% of basal area. Biodiversity is usually measured as species richness in a community or ecosystem. Recognizing the confounding effects of statistical artifacts, e.g., resulting from variation in sample size, ecologists have developed various metrics for species richness. One metric is Fisher's α (Fisher et al. 1943), computed from S, the total number of species and N,

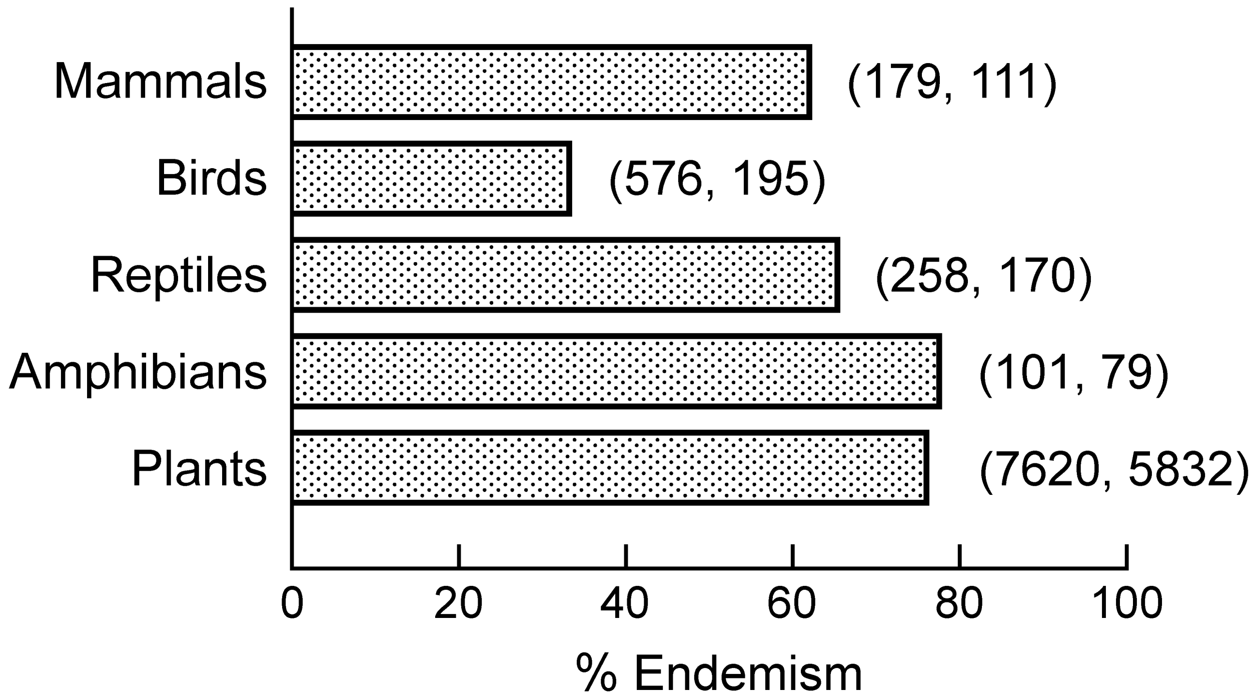

Figure 2. Number of plant, amphibian, reptile, bird, mammal species, and number of endemics, redrawn from Sodhi et al. (2004) with permission from the publisher. Bars indicate % of species that are endemic to the Philippines. At the right of each bar, the first number in parenthesis is the total number of species; the second is the number of endemics. Many species evolved as forest specialists, given that about 90% Philippine land area was once forested. Because many of these species are endemic, i.e., found nowhere else in the world, loss of forest cover is considered likely to lead to their global extinction.

the total number of individuals, according to the equation $S = \alpha \log [1+N/\alpha]$. Co et al. (2006) estimate Fisher's α = 43.19 in their plot which, although lower than the values for other equatorial tropical forests in Southeast Asia, is the highest reported in the Philippines. In contrast, a study of a 1 hectare submontane tropical rainforest plot in Negros (Hamann et al. 1999) yielded 92 species, 54 genera and 39 families. Species richness was high (metrics other than Fisher's α were used); no species or family dominated over others in relative abundance, and numerous rare species populated the Negros plot. Given the dominance of secondary growth in what remains of Philippine forest cover, it is instructive to examine results obtained from Mt. Makiling, Laguna. Using data from Brown (1919), who studied a 0.25 hectare plot of primary forest, Luna et al. (1999) estimate that dipterocarp species accounted for 8.6% of basal area and Fisher's α = 28.2. For comparison, Luna et al. (1999) studied a 4 hectare site that had recovered for 50 years after having been logged. They counted 179 species of trees, 4 dipterocarp species that accounted for 2% of basal area, and estimated Fisher's α = 39.5, a value close to that reported by Co et al. (2006) in Palanan. While the results from Palanan and Negros illustrate that Philippine primary forests have high species richness, those from Mt. Makiling demonstrate how, given enough time, secondary forests can recover to levels of species richness similar to those of primary forests, accompanied by regeneration of at least some dipterocarp species. However, these results as well as data from other Southeast Asian countries demonstrate that the return to pristine conditions is a slow process (Sodhi et al. 2004). The primary forests described above represent productive, protective and sustainable ecosystems where the interactions of different components are manifested as biodiversity. By virtue of the interactions among components, desirable characteristics and ecosystem services are manifested.

Although Fisher's α values of *kaingin* plots in the Philippines are unavailable, the cultivation of "400 kinds of plants in the swidden" by the Hanunoo (Russell, 1988) suggests that this indigenous group had evolved an agricultural practice that promoted a high degree of biodiversity. But this was a sustainable form of *kaingin*, practiced at low population density. When *kaingin* is practiced at high population density with short periods of fallow, or when it is practiced as sedentary agriculture, the outcomes would be expected to be different. Indeed, Briones (2007) lists biodiversity loss, along with accelerated soil erosion and river sedimentation, among the negative impacts of *kaingin*. The process of biodiversity loss is described by Russell (1988) as follows: when periods of cultivation last only 10-20% of the total cycle in sustainable swidden agriculture (in some cases, fallow periods last 30 years), forest vegetation has sufficient time to regenerate and the soil recovers before farmers return to slash, burn and cultivate again. However, prolonged periods of cultivation and insufficient periods of fallow result in soil erosion and depletion of nutrients so severe that when the site is abandoned (for lack of productivity), forest regeneration does not occur. Instead, a common scenario involves invasion by grasses. Two tough grasses of the genera *Imperata* and *Hyparrhenia* already covered 40% of the Philippines in 1966 (Russell, 1988). Because grasses are inferior to forests in holding the soil and restoring fertility, further soil degeneration occurs and the traditional, sustainable *kaingin* cycle stops. This process is illustrated by the following example: based on studies of communities engaged in *kaingin* in Northern Luzon, Wallace (1996) estimated an average per capita consumption of 1.53% of a hectare of secondary forest per year. Deforestation was followed by invasion of *Imperata cylindrica* (commonly known as *cogon*). He states that if *kaingin* is practiced in secondary forest and sufficient period of fallow is allowed, the forest can regenerate. However, if *cogon* moves in, it renders the land "useless", a process he observed in many parts of the Cagayan Valley over a 30-year period. *Cogon* produces a phenolic compound that may be allelopathic (Koger and Bryson 2004, Sajise and Lales 1975). Together with competition for space, soil nutrients and light, allelopathy could play a role in preventing forest vegetation from becoming reestablished. Sajise et al. (1976) also showed that *Imperata*-dominated areas become fire-prone and that fire promotes the competitive dominance of this grass species. If fire becomes a dominant and regular disturbance factor, *Imperata cylindrica* becomes a "disclimax species", promoting the establishment of an *Imperata*-fire-*Imperata* cycle. This cycle prevents forest regeneration and has made reforestation efforts with weak fire prevention measures ineffective.

Effects on Faunal Biodiversity

Philippine forests are renowned for having among the world's highest levels of faunal biodiversity and endemism (see reviews by Persoon and van Weerd 2006, Sodhi et al. 2004). Taking into account vertebrate animals only, there are as many as 176 mammal, 576 bird, 258 reptile, and 101 amphibian species, large fractions of which are endemic (Figure 2). The country's 5.7 endemic vertebrate species per 100 km^2 of forest is surpassed only by endemism in the coastal forests of Tanzania and Kenya; but, along with high levels of endemism, the Philippines has the greatest number of threatened vertebrate species per unit area in the world (Myers et al. 2000, Persoon and van Weerd 2006).

Given that most species of animals evolved and became adapted to the islands when 90% of total land area was covered by forest, habitat loss through deforestation is easily seen as one of the major drivers of biodiversity loss. If the relation between species number and habitat size is known, it should, in principle, be possible to predict the effect of reduced habitat size on the number of species. Applying this approach, Brooks et al. (1997) found that degree of deforestation can be used to predict the number of threatened endemic birds throughout Southeast Asia. In the Philippines, however, the number of species listed as threatened exceed the estimate based on the species-area relationship by 2-fold; thus, loss of forest area alone is not a sufficient mechanistic explanation. An additional explanation offered is that majority (78%) of endemic bird species in the Philippines inhabit lowland forests where most deforestation has occurred and these are highly fragmented and degraded. As a result, more species are threatened than declining habitat area alone would predict.

Tropical forests are complex habitats that offer many ecological niches to which various species have become adapted over evolutionary time. Habitat complexity and the specialized niches available to animals are lost due to deforestation. In a study on 9 forest fragments in Southwestern Negros, Alcala et al. (2004) estimate a 16-25% loss (local extinction) of reptile and amphibian species over the past 50 years. Loss of canopy cover, loss of epiphytes that provide microhabitats for some species, lower relative humidity and elevated substrate temperature were identified as proximate contributors to biodiversity loss, along with forest fragmentation and edge effects.

A study of 21 species of Philippine raptors (Gamauf et al. 1998) revealed that 13 preferred forest cover of > 50% and 8 preferred open habitats. Morphological traits were analyzed in relation to habitat and foraging mode. Among the forest dwellers, 4 species hunted below while 9 hunted within and above the forest canopy. Below-canopy forest hunters tended to have smaller bodies, low aspect ratio (*length*^{2}/*area*) wings, high wing-loading (*body mass*/*wing area*) and were adapted for "sit and wait" hunting modes in dense vegetation. High wing loading tends to increase the energetic cost of flight, so this mode of hunting involves much sitting and waiting, with sporadic bursts of high-speed pursuit for short durations. The open area species tend to have larger bodies, higher aspect ratios, lower wing loading, and are adapted for long-distance flight and active searching. The above-canopy hunters possess features that represent a compromise between the need to perch high and soar above the canopy versus the need to dive into the forest in pursuit of prey. Thus, although they tend to have larger bodies than the below-canopy hunters, their wings tend not to be as long as those of open area species. The authors point out that as forest cover declines, the specialized forest dwellers are constrained by the suite of traits that make them effective forest hunters; i.e., these features make them ineffective at making a living in open habitat.

The 60 or so known species of endemic Philippine rodents are hypothesized to have descended from only a handful of ancestral species that underwent adaptive radiation as they spread to other islands (Rickart et al. 2005, Steppan et al. 2003). As in the case of frogs, reptiles and birds, mammalian forest specialists are threatened by deforestation in various areas of the Philippines, e.g., Palawan (Esselstyn et al. 2004) and Mt. Katinglad in Bukidnon (Heaney et al. 2006).

In Bohol and Leyte, farmers in low-income communities practicing *kaingin* (mainly sedentary) showed recognition of some of the problems brought about by their agricultural practices; a survey revealed that they planted 24-35 species and protected 39-62 native tree species per village (Lawrence 1997). Whether (and to what extent) the replanting of trees might be beneficial is an empirical question. A study conducted at Subic Bay (Posa and Sodhi 2006) where 26 bird species occur revealed that 100% forest cover is required for all 26 species to be present; 24 of 26 species of birds require 60% of forest cover, while none remain when cover is less than 35%. In the Cagayan Valley, a study of 11 sites (Van Weerd and Snelder 2008) showed the presence of 58 species of birds and 16 species of bats. However, these represent "only 13 percent of lowland forest birds, 15 percent of endemic lowland birds and eight percent of threatened lowland birds known to occur in the region" and "44 percent of all lowland bats, 42 percent of endemic bats and 29 percent of forest bats in the region". Most species were found to occur only in areas bordering the forest. The authors conclude that "the human-altered landscape fails to serve as an alternative for closed-canopy forest habitat".

Measuring and Comparing Biodiversity

Given the global mass-extinction event that humans are currently causing (Pimm et al. 1995) as well as the imminent disappearance of Philippine forests and the consequent extinctions likely to result, number and kinds of species, as well as population sizes are appropriate metrics with which to measure biodiversity as well as to test ecological hypotheses concerning the effects of deforestation and *kaingin* on Philippine biodiversity. Such data have led to widespread recognition that the Philippines is a center of great biodiversity and endemism. Much less abundant and often much less quantitative are studies of biodiversity at sites where various forms of *kaingin* are practiced. Thus, when newspaper (e.g., Fernandez 2009) or journal articles report high biodiversity, a number of issues arise. High, compared with what? In a study conducted by Caringal and Panganiban (2008), secondary forest, consisting of "27 tree species belonging to 22 genera and 15 families" was cleared to make way for the cultivation of "53 species in 52 genera distributed to 30 families". Further breakdown reveals that these consisted of "at least 10 species and 6 families of vegetables, 7 species and 6 families of root crops, 13 fruit trees by 10 families, 5 species of legumes and pulses under 2 families, 7 spices under 4 genera and 3 families, 4 forage and pasture species belonging to 3 families and 7 species of valuable crops". Taking into account both the *number* and *kinds* of species, it is reasonable to ask whether *kaingin*, in this example, is truly as benign as claimed with respect to biodiversity. First, the comparison is between cultivated sites and secondary forest with only 27 tree species (no other diversity metric is reported). Second, many of the cultivated species are exotic plants, raising the issue of whether, for example, tomatoes originating from South America (Jenkins 1948) are ecologically equivalent to the indigenous or endemic forest species displaced. Third, comparisons must associate biodiversity levels with ecosystem attributes including ecosystem function and properties providing for sustainability and ecosystem services. Simply counting species and estimating population sizes does not consider these.

In the Mount Makiling area, biodiversity was compared between primary and mid-montane forest, *Imperata-Saccharum* grasslands, and shifting upland cultivation (Sajise et al. 2005). The shifting cultivation area is characterized as a combination of perennial fruit trees and annual crops where the annual crops are shifted on a cyclical basis while the perennials are more or less left in place. The study indicated that plant biodiversity values of this type of shifting cultivation area were as high as the primary mid-montane forest (Sajise et al. 2005). The combination of natural dispersal of surrounding forest vegetation and the species of crops introduced by farmers resulted in high plant diversity. However, this type of biodiversity in swidden cultivation and in a forest differ significantly in terms of functional attributes for carbon sequestration, soil and water conservation and many other ecological services. Biodiversity, measured in terms of its specific components does not take into account the totality of interactions among various ecosystem components. These interactions should be understood in the context of the ecosystem's interactions with the social system and its components (Dove et al. 2005).

How ecosystem function should be measured, how many species are required for an ecosystem to be stable and resilient, and how ecosystem services should be assigned value are still developing, active areas of research (Balmford and Bond 2005). Ultimately, an issue Filipinos must confront is whether artificial communities, consisting of mostly exotic species, can be considered acceptable substitutes for forest ecosystems that have existed for millennia. The valuation of ecosystem services (Costanza et al. 1997) may prove to be a useful conservation tool, given the need to formulate policy, provide for human needs, and conserve what biodiversity remains. For example, recent application of this approach revealed that the conservation or selective utilization of a Sumatran forest would more greatly benefit a broad range of stakeholders than deforestation. The value of benefits derived from either scenario would exceed those derived from deforestation by more than $2 billion over a 30 year period (van Beukering et al. 2003).

CONCLUSIONS

Although we have not attempted an all-inclusive review of the existing literature, we have used published information from multiple disciplines to evaluate the combined effects of deforestation and *kaingin* on Philippine biodiversity. Based on the work of social scientists, deforestation and *kaingin* are seen as integral parts of the process of forest destruction, best understood in the context of socioeconomic conditions and politics in the country. Available scientific evidence concerning both number and kinds of species leads to our rejection of the null hypothesis that deforestation, accompanied by *kaingin*, is "not bad" for Philippine biodiversity.

Certainly, different forms of *kaingin* have been practiced. At the most benign end of the continuum of practices is the *kaingin* of indigenous people, sustainable at low population density. At the most destructive end are many of the current practices of lowland Filipinos who, as victims of social and economic inequities, have become an invasive species of the forests. At population densities higher than critical limits, they practice various forms of *kaingin* that cause severe erosion, loss of soil nutrients, damage to watersheds, loss of floral and faunal biodiversity. Between these two extremes are the more benign agricultural practices that are said to increase plant biodiversity, favor the growth of native trees, minimize erosion and protect watersheds. However, the ecosystem attributes of these types of agricultural practices have not been sufficiently or holistically studied.

From the perspective of conservation biology, the Philippines, because of its status as a hotspot of biodiversity and endemism, could soon become a major contributor to the currently unfolding global mass extinction event. It is reasonable to expect the extinction of many forest species within the next decade if the current rate of habitat loss through deforestation, followed by *kaingin*, continues. However, in considering biodiversity loss and its consequences, it is important to distinguish between the "global extinction" that the remaining Philippine endemic species have, thus far, avoided and "local extinctions" that have probably been widespread due to massive habitat loss throughout the country. Of great consequence is the phenomenon called "ecological extinction" (Estes et al. 1989), i.e., the idea that reduction in population size may render a species ineffective in its ecological interactions with other species in a community. The relation between population size and ecological function may be non-linear such that, as population size declines, function is largely lost before the species becomes rare (e.g., McConkey and Drake 2006). If so, it is entirely possible that the population sizes of many Philippine species have already declined below their respective thresholds to the point of ecological extinction.

The relationships among population growth, culture, socioeconomic factors, politics and biology are complex; this makes the prevention of biodiversity loss an extraordinarily difficult undertaking. Such efforts are not helped by reports, based on inadequate quantitative data, or based on incomplete pictures of the structure and function of ecosystems, alleging the ecologically-benign nature of *kaingin*. More holistic studies that relate "kind(s) of biodiversity" to productive, protective and other ecological service functions are urgently needed. Diamond (2005) uses the example of Easter Island to illustrate how deforestation can lead to societal collapse. Both within and beyond the realm of science is the question of whether allowing the total destruction of Philippine forests is in the national interest.

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