Chapter 3. Mining in Environmentally Vulnerable Areas

Protected areas, areas of ecological value, and stressed watersheds are considered vulnerable.

Habitat destruction is the most important cause of biodiversity loss, especially in the humid tropics (McNeely et al., 1995:751). The most obvious impact on biodiversity from mining is the removal of vegetation, which in turn alters the availability of food and shelter for wildlife. At a broader scale, mining may affect biodiversity by changing species composition and structure. To identify areas that might be especially vulnerable from an ecological perspective, we developed three global indicators: protected areas, ecological value, and watershed stress. A comparative analysis of these indicators with the InfoMine database revealed the following:

- More than one quarter of active mines and exploration sites overlap with or are within a 10-kilometer radius of a strictly protected area (IUCN I-IV).
- Nearly one third of all active mines and exploration sites are located within intact areas of high conservation value.
- Nearly one third of all active mines are located in stressed watersheds.
- Nearly three quarters of active mines and exploration sites are located in areas deemed by conservation organizations to be of high ecological value.

Unprotected, high value ecosystems are most vulnerable to the impacts from mining.

Mining in strictly protected areas has received considerable attention to date and the issue will likely remain contentious in countries where legislators are considering opening protected areas to mining, such as Ghana and Indonesia. However, the results of this analysis suggest that at the global level the overlap between mines and areas of high ecological value will likely present even greater challenges in the future, especially in areas that are not yet formally protected or where protected area boundaries are poorly defined.

Overlap between mining areas and important ecosystems is apparent in Papua New Guinea and the Philippines.

Such challenges are particularly apparent when considering the results of the two country case studies examined in this study. In Papua New Guinea, more than one third of the country's forests and nearly half of the country's mangroves have already been allocated in oil, gas, or mining concessions. More than one quarter of forests classified as "fragile" in Papua New Guinea government data overlap oil, gas, and mining concessions. In the Philippines, more than half of all exploratory and mining concessions overlap with areas of high ecological vulnerability. Although mining is prohibited in intact forests and protected areas, approximately one third of concessions overlap with these areas. Lack of clarity regarding protected area boundaries and uncertainty regarding the definition of intact forests provides an opportunity for land use conflicts between mining and conservation objectives. The remainder of this chapter examines in detail each of the ecological value indicators.

MINING AND PROTECTED AREAS

Protected areas reflect natural and cultural values held by societies.

Societies routinely seek to formally protect areas of high cultural and natural value by establishing protected areas, such as wildlife refuges, national parks, natural monuments, and biosphere reserves. Some areas are considered protected for conservation purposes while others may be considered valuable for their scenic or landscape values. The World Conservation Union (IUCN), an international, quasi-governmental body consisting of governments and conservation NGOs has developed a system for categorizing protected areas according to the degree of protection. Categories I-IV are protected for conservation purposes, while categories V and VI are considered "mixed use" areas. Although all categories are considered equally important, a gradation of human intervention is implied, such that Categories Ia and Ib are the least influenced by human activity and Categories V and VI are often modified landscapes. Strictly protected areas (IUCN I-IV) represent approximately 10 percent of the world's land surface while World Heritage sites represent only 1 percent.

In addition, the United Nations Educational, Scientific and Cultural Organization (UNESCO) maintains a list of designated "World Heritage Sites" and "Ramsar Sites." Both designations are subject to international conventions that establish listed sites as worthy of special attention due to their global natural or cultural significance. Of the 138 natural World Heritage sites, more than one quarter are threatened by mining or oil and gas development (UNESCO, 2003). Two of the natural areas listed as World Heritage in Danger sites are currently threatened by mining.

A key goal for biodiversity conservation is ensuring representation of ecosystems and the species that live within them. Although the total area under protection has increased ninefold in the last 40 years, many regions and ecosystems remain poorly represented. The Pacific region has the fewest number of protected areas globally. In addition, grasslands, coastal, and marine ecosystems are poorly represented in protected areas (Chape et al., 2003).

Although governments have not explicitly prohibited mining in all IUCN I-IV protected areas, some countries, including the Philippines, have passed laws making it illegal to mine in these protected areas. In 2000, IUCN members passed Resolution 2.82, calling on all governments to prohibit mining, oil, and gas development in IUCN I-IV protected areas and recommending that any extractive activity in categories V and VI should take place only if it is compatible with the objectives for which the protected area was established (IUCN, 2000).

OTHER ECOLOGICALLY VULNERABLE AREAS

Many areas of high ecological value are not yet formally protected.

Officially designated protected areas are only one component of ecologically vulnerable ecosystems. Many conservationists argue that protected areas are insufficient to protect the world's biodiversity (Soule, 1986). On one hand, much of the world's biodiversity is found outside of designated protected areas (McNeely et al., 1990). On the other hand, many existing protected areas suffer from poor management, lack of funding, and isolation from other areas of high biodiversity (Miller et al., 1995).

In light of the challenges inherent in conserving the world's biodiversity through protected areas, conservation organizations such as Conservation International, World Wildlife Fund, Birdlife International, and The Nature Conservancy have identified important ecosystems for conservation purposes. Some approaches (e.g., Conservation International's "hotspots") focus on "the last of the best" places—that is, those critical remnants of habitat that could disappear within a few years absent aggressive, near-term intervention. The World Wildlife Fund has identified globally important ecoregions, some of which have been subsequently evaluated at a regional scale to identify conservation priority areas based on biological value, conservation status, and degree of threat.

Other approaches, such as WRI's intact forests assessments, focus on identifying large areas of relatively undisturbed habitat, which if managed carefully could sustain human livelihoods and provide basic natural resources for many years to come (Bryant et al., 1997; Aksenov et al., 2002). Although approaches to identifying areas of conservation value differ, they typically take into account several common themes (see Table 3). We aggregated these approaches and compared them with active mines and exploration sites. Nearly three quarters of active mines and exploration sites overlap with areas of high conservation value.

Conservation mapping approaches may be useful for establishing institutional priorities, but they provide little insight into which areas may be vulnerable to the potential impacts of mining. Depending on the methodologies used, high values are placed either on biologically important remnants that may disappear without immediate conservation interventions ("hotspots" approach) or large blocks of intact landscapes that should be conserved for future generations (wilderness and ecosystems approaches). However, none of these approaches adequately addresses whether and under what conditions development should occur. In fact, high-value, highly threatened remnants and intact, remote ecosystems could be equally vulnerable if development activities were to proceed in an unsustainable manner.

Our analysis identifies intact areas of high conservation value and classifies these areas by size.

Ideally, an assessment of areas ecologically vulnerable to mining would take into account many of the criteria listed in Table 3. However, data for most of these criteria are lacking at a global level. For this reason, we chose to use ecosystem intactness as a measure of ecological value because it is a necessary condition for maintaining key species and ecosystem function. Scientists at Columbia University and the Wildlife Conservation Society recently undertook a global mapping effort to assess the relative condition of the world's natural habitats and identify the degree of human influence on the Earth's surface. They estimated that less than 15 percent of the Earth's terrestrial habitats remain uninfluenced by human activities (Sanderson et al., 2002).

We combined this analysis of human influence with the aggregated conservation value layer to identify areas of high conservation value that are relatively undisturbed. These intact areas were further stratified by size (see Map 2). The smaller areas (< 1,000 km^2) may be especially vulnerable to mining if they are home to the last representative samples of a given community type or ecosystem that will not survive in smaller habitat patches. For example, many mammals may not survive in patches smaller than 100 km^2. The largest game mammals are more likely to require patches larger than 10,000 km^2 (Armbruster, 1993; Beier, 1993; Terborgh, 1992).

Table 3. Criteria Used to Define Biodiversity Conservation Priorities

Category	Criteria	Definition
Biological	Species richness	Number of species in a given area
	Rarity	Least common species or ecosystems
	Endemism	Degree of separation of a population, species, or ecosystem from its closest comparable analogue
	Representativeness	Degree to which a given area contains examples of all species or ecosystems
	Threat	Degree of imminent danger or harm from human activities
	Function	Role of species, communities, or ecosystems in determining survival of other species, communities, or ecosystems
	Condition	Relative condition of ecosystems or populations based on degree of intactness
Social/ Institutional	Utility	Importance of biodiversity elements known to have utilitarian value to humans
	Feasibility	Potential success of conservation efforts based on political, economic, and logistical factors
	Other	Ethnic, religious, and/or cultural values assigned by local cultures

Source: Adapted from Johnston, 1995.

Mining in areas of high conservation value should only proceed if these areas will retain their ecological values after development.

The existence of high conservation values does not automatically preclude mineral development. However, such industrial activities should proceed only if it can be demonstrated that these areas' ability to retain their wilderness values and ecosystem services will remain intact after development. Ultimately, decisions regarding which ecosystems may be too fragile to withstand the impact of mining development will largely depend on local species requirements, as well as the potential for conflict with restoration goals in ecosystems that have already been degraded.

Other parameters, such as uniqueness, should also be considered.

In addition to intactness, other parameters, such as uniqueness and representativeness, should also be considered. For example, the Asia-Pacific region is characterized by small islands, which are rich in endemic species. Uninhabited small islands in this region often serve as important refugia for critical species, warranting protection from human intervention. The coral reef and coastal ecosystems in the Asia-Pacific region harbor the highest degree of aquatic biodiversity in the world (Burke et al., 2002). Mining poses significant challenges on small islands due to the lack of safe and acceptable waste disposal sites, as well as the inherent ecological fragility of these unique terrestrial and aquatic ecosystems. Competing land uses and the high levels of biodiversity may justify a "no go" decision with regards to mining on the smaller islands in this region.

The intactness analysis also offers little guidance with respect to mining in areas that demonstrate high biological value but have suffered significant disturbance. Indeed, such areas often coincide with highly threatened ecosystems, especially in countries where human influence on natural habitats is high (e.g., the Philippines). The fact that some areas of high ecological value may already be significantly disturbed does not imply that mining is a compatible land use. Finer-scale analysis is required to determine whether potential mineral development will have a negative impact on these habitats.

ECOLOGICALLY VULNERABLE AREAS IN PAPUA NEW GUINEA

Papua New Guinea's forests are vulnerable to mining.

The island of New Guinea is considered a major tropical wilderness area, containing one of the world's largest tracts of intact tropical forest. These forests are home to unique plants and animals, including the world's largest butterfly (Queen Alexandra's Birdwing Butterfly) and 42 species of birds of paradise. Much of the wildlife found in New Guinean forests is highly dependent upon trees for its survival. Map 3 displays vulnerable ecosystems and mining, oil, and gas concessions in Papua New Guinea. Nearly 90 percent of the country is forested, with more than one third of all forests already allocated to oil, gas, or mining concessions. A significant proportion (30 percent) of remaining forests within concession boundaries is already fragmented, especially in the highlands region. These forests may be especially vulnerable to additional clearing from road building, land clearing, and human migration typically associated with mining in remote areas.

Papua New Guinea's mangroves may also be especially vulnerable to mining, oil, and gas development. Less than 1 percent of the country's forests is classified as mangroves, and 42 percent of mangrove forest areas have been allocated in mining, oil, and gas concessions. Located largely on the southern coast of the country, these large tracts of mangrove forests are considered to be internationally significant as spawning and nursery grounds for prawn and fin fisheries, and are a source of subsistence for a substantial artisanal fishery (Sekhran and Miller, 1994).

Establishing formal protected areas has posed unique challenges in Papua New Guinea, given that nearly all of the country's land is owned communally. Forty-seven protected areas have been established, more than half of which are community-controlled Wildlife Management Areas (WMAs). Although WMAs present a key conservation opportunity, management of such areas has been plagued by a lack of central government support, abuse of license fees and other management mechanisms, and a backlog in requests for new areas. Unfortunately, recent conservation efforts have focused mostly on the establishment of isolated, "pristine" wilderness areas rather than strengthening community-based approaches that are better suited to the cultural realities of Papua New Guinea (Hunnam, 2002).

Fragile forests are especially vulnerable to mining.

The government of Papua New Guinea has identified "fragile forests" that experience slow regeneration as a result of human-induced change. Occurring predominantly in the highlands region, these forests are likely to be especially vulnerable to mining, as the highlands contain a disproportionate share of the country's biodiversity and are subject to high population pressures. Slightly more than one quarter of the country's forests can be classified as fragile, with 26 percent of fragile forests occurring within oil, gas, and mining concessions.

ECOLOGICALLY VULNERABLE AREAS IN THE PHILIPPINES

High value ecosystems in the Philippines are critically threatened.

The Philippines has been designated by scientists as one of the world's top 20 "megadiversity" countries. The country is richly endowed with marine biodiversity; the archipelago boasts 500 of more than 800 known coral species, more than 2,000 fish species, and over 40 species of mangrove plants (Ong, 2002). However, only 5 percent of the country's coral reefs remain in excellent condition and mangroves and sea grasses have shrunk to less than one quarter of their original extent (Ong, 2002). Mining has been identified as a threat to the marine environment due to impacts from releases of mine waste, resulting in fish kills and coastal pollution (ESSC, 2003). Philippine terrestrial ecosystems are also critically threatened. More than 93 percent of Philippine forests have been lost in the last 500 years and 418 species are already listed as threatened.

Protected areas constitute the main legal mechanism through which the Philippine government has sought to conserve the nation's biodiversity. Approximately 8 percent of the country's total land area has been designated as protected areas, and is consequently off-limits to mineral development. Mining also is not allowed in the country's remaining intact forests, due to the highly fragmented state of these ecosystems. However, more than two thirds of existing protected areas have not been ratified by law and forest cover estimates are subject to large uncertainties due to lack of data. Moreover, according to the Philippine Biodiversity Priority Setting Program (PBCPP), only 41 percent of protected areas retain original vegetation and the protected areas system does not include some areas of high biodiversity (Mackinnon in Ong, 2002).

Lack of clarity can exacerbate conflicts between mining and conservation uses.

For this study we identified areas of high ecological value according to the location of existing protected areas and intact forests (see Map 4). These areas also correlate well with high-priority areas identified by the PBCPP. More than half (56 percent) of all exploration areas and mining leases overlap with areas of high ecological vulnerability shown on Map 4. Six percent of mining leases and exploration areas overlap with protected areas (see Table 4). More than one quarter of approved mining leases and 8 percent of exploration areas overlap with intact forests, covering an area of approximately 60,000 hectares. According to the terms of mineral agreements, protected areas and intact forests are excised from mineral contracts. In practice, however, the lack of clear delineation of protected area boundaries and uncertainty regarding the definition of intact forests provides the opportunity for land use conflicts between mining and conservation uses.

WATERSHED STRESS

Access to clean water poses a significant challenge in some parts of the world.

Mining is most likely to compete with other water users in places where water resources are already scarce and demand is high. According to some estimates, global industrial demand for water is projected to supersede that of agriculture by 2075 (Alcamo et al., 1997). At the same time, the availability of clean water for human consumption is declining due to industrial discharges and urban and agricultural runoff. This problem is especially serious in developing countries, where pollution regulations and water conservation technologies are less well developed (Revenga et al., 2000). Certain parts of the world, such as Africa, face considerable challenges in ensuring equitable and sustainable access to water resources, which can only be addressed through judicious management of water resources (Ashton et al., 2001).

Table 4. Overlaps Between Approved Mines And Protected Areas

License #	Contractor	Location	Area Affected	Overlap (%)	Date Granted
156-00-CAR	Philex Mining Corp.	Tuba & Itogon, Benguet	Lower Agno Watershed Forest Reserve	57	April 2000
157-00-CAR	Philex Mining Corp.	Tuba & Itogon, Benguet	Lower Agno Watershed Forest Reserve	31	April 2000
012-92-VIII	Hinatuan Mining Corp.	Manicani Island, Eastern Samar	Guiuan Protected Landscape and Seascape	98	October 1992
063-97-IX	Philex Gold Phil., Inc.	Sibutad, Zamboanga del Norte	Jose Rizal Memorial Protected Landscape	3	April 1997
094-97-XI	Alsons Development & Investment Co., Inc.	Nabunturan, Davao del Norte	Mainit Hotspring Protected Landscape	12	November 1997
EP-006-97VII	Philippine National Oil Company – Energy Development Corporation	Amlan to Valencia in Negros Oriental	Balinsasayao Twin Lakes National Park	47	November 1999
EP-007-00VII	Altai Phils. Mining Corporation	Amlan to Pamplona in Negros Oriental	Balinsasayao Twin Lakes National Park	6	July 1997

Source: ESSC, Case Study Analysis, 2003.

The Pilot Analysis of Global Ecosystems (PAGE) estimated current (1995) and projected (2025) water scarcity for individual river basins around the world, identifying "water stress" in watersheds where less than 1,700 cubic meters (m^3) of water per capita per year is available (Falkenmark and Widstrand, 1992; Hinrichsen et al., 1998 in Revenga et al., 2000: 26).

Mining may be incompatible with other land uses in water-scarce areas.

We compared the PAGE dataset with active mines and exploration sites (see Map 5). According to this analysis, nearly 30 percent of active mines are currently located within stressed river basins. Of these 20 percent occur in highly stressed river basins. In stressed watersheds with competing demands for water, mining may prove to be incompatible with other land uses. Furthermore, absent strict water quality controls, water returned to river basins from mining operations may not be suitable for consumption, potentially reducing water availability in stressed watersheds. Watersheds near the cut-off for stress may also be especially vulnerable if a mine competes with other land uses.

WATERSHED STRESS IN THE PHILIPPINES

Watersheds in parts of the Philippines are stressed.

To understand the vulnerability of stressed watersheds to mining, we examined potential water stress in the Philippines, as defined by vulnerability to floods, water quality, and quantity. Papua New Guinea does not experience water scarcity; therefore watershed stress was not calculated for that country case study. As shown in Map 5, the Philippines is moderately vulnerable to water scarcity. Indeed, average annual precipitation is relatively high at approximately 2,300 millimeters per year. However, these generalized statistics mask important geographic and seasonal differences in rainfall across the country. Wide-scale alterations in the landscape and deforestation have increased the rate of erosion and flooding throughout the country, resulting in reduced dry-season stream flows (WRDP-WMIC, 1998:3). As a result, many areas experience water shortages during the dry season. Projections based on population growth indicate that water usage is expected to increase by 250 percent, leading to massive water deficits by 2030 (Haman, 1999). In addition, nearly half of the annual rainfall occurs as a result of intense storm events (PAGASA, 2000), which contribute to increased runoff and erosion, especially in highly degraded watersheds.

There is some overlap between mining and protected watersheds.

The disastrous El Niño event in 1997-98 spurred the Philippine government to begin considering water consumption in land-use management decisions. Two land-use management designations were developed to protect watersheds: critical watersheds and proclaimed watersheds. Critical watersheds are those that support agriculture and industry, but are known to be severely degraded. Proclaimed watersheds encompass forests that are protected in order to maintain water quality and yield. Mining is prohibited in both categories. Aquifer recharge zones and other important groundwater resource areas are considered “environmentally sensitive” and categorized by the Mines and Geosciences Bureau as low, medium, and high vulnerability. Map 6 provides a summary of environmentally sensitive water resource areas as defined by the Philippine government. According to this map, 8 percent of approved mining contracts and exploration areas overlap with proclaimed watersheds but no contracts or exploration areas have been approved in critical watersheds.

More overlap occurs between mining and unprotected, stressed watersheds.

Although water quality and yield were the primary factors leading to the designation of proclaimed and critical watersheds, these protected area designations do not fully encompass water scarcity. Some watersheds may be especially stressed with regard to water availability, but have not been designated as proclaimed or critical watersheds. To account for these unprotected, vulnerable watersheds, we evaluated water demand and availability at a national scale. Areas where the demand-to-availability ratio exceeded 40 percent were defined as “highly stressed” (see Map 7).

Although the resulting analysis cannot establish a cause-effect relationship between water use and degree of stress, it does identify areas where land-use decisions will be especially critical to ensuring future water supply. As indicated in Map 7, 14 percent of mining and exploratory concessions overlap with areas of high watershed stress.