Chapter III

The Affected Environment: Before and After the Alternatives

Introduction

The purpose of Chapter III is to present before-and-after views of the Caribbean National Forest (the Forest) environment: to discuss the environment as it is currently, and as it would be if the alternatives were implemented.

Discussion of the affected environment is organized as follows:

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NEPA Requirement Addressed

This chapter combines the discussions of the "Affected Environment" and "Environmental Consequences" that are required by National Environmental Policy Act (NEPA) implementing regulations (40 CFR 1500). Each resource is first described by its current condition. The descriptions are limited to providing the background information necessary for understanding how forest plan alternatives may affect the resource. The resources listed are designed to address the issues raised during the planning process.

After each resource description, the potential effects (environmental consequences) to the resource associated with implementation of each alternative are discussed. All significant or potentially significant effects, including direct, indirect and cumulative effects are disclosed. Where possible the effects are quantified. Where this is not possible, a qualitative discussion is presented. The effects of each alternative are disclosed with the mitigating measures in place. Chapter II includes a discussion of the mitigating measures to be applied to each alternative.

Environmental Effects: Direct, Indirect, Cumulative

Environmental consequences are the effects of implementing an alternative on the physical, biological, social, and economic environment. Direct environmental effects are defined as those occurring at the same time and place as the initial cause or action. Indirect effects are those that occur later in time, or spatially removed from the activity, but would be significant in the foreseeable future. Cumulative effects result from the incremental effects of actions when added to other past, present and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative effects can result from individually minor, but collectively significant actions, taking place over a period of time.

Potential adverse environmental effects which cannot be avoided are discussed. Unavoidable adverse effects result from managing the land for one resource at the expense of the use or condition of other resources. Many adverse effects can be reduced or mitigated by limiting the extent or duration of effects. Mitigation measures within standards and guidelines are specified for project activities to be implemented under the Revised Forest Plan. These are discussed throughout the chapter.

Short-term uses (effects) are those that occur annually, or within the first ten years of Forest Plan implementation. Long-term productivity refers to the capability of the land and resources to continue producing goods and services for 50 years and beyond.

Irreversible/ Irretrievable Commitments

Irreversible and irretrievable resource commitments are not made by the Forest Plan. Irreversible commitments are decisions affecting non-renewable resources such as minerals, the extinction of animal or plant species, and cultural resources. Such commitments are considered irreversible when the resource has been consumed or damaged to the point that renewal is impossible, or can only occur over a long period of time or at great expense. While a Forest Plan can indicate the potential for such commitments, the actual commitment to develop, use, or affect non-renewable resources is normally made at the the project level.

Irretrievable commitments are resource uses or production opportunities which are foregone during the planning period. These decisions are reversible, but the production opportunities foregone are irretrievable.

Irreversible and irretrievable commitments are not specifically identified as such in the discussions contained in this chapter.

Programmatic Versus Site Specific

For estimating the effects of alternatives at the programmatic Forest Plan level, the assumption has been made that the kinds of activities allowed under the management prescriptions will in fact occur to the extent necessary to achieve the goals and objectives of each alternative. However, the actual location, design and extent of such activities is not prescribed at this time; those will be site-specific project-by-project decisions. Thus, the discussions in this chapter refer to the potential for effects to occur, realizing that in many cases these are only estimates. The effects analyses are useful in comparing and evaluating alternatives on a Forest-wide basis, but are not intended to be applied to specific locations within the Forest.

Physical Setting

The Forest is located in the rugged Sierra of Luquillo Mountains, 25 miles southeast of San Juan, Puerto Rico. It is the only tropical forest administered by the USDA Forest Service. The tropics are frost free areas lying between the latitudes of Cancer and Capricorn.

Puerto Rico is located between 17° 55' and 18° 31' N latitude and 65° 39' and 67° 15' W longitude, or about 1,000 miles southeast of Miami, Florida. Lying between the Atlantic Ocean and the Caribbean Sea, it is the easternmost island of the Greater Antilles. Total land area is 3,421 square miles.

The Forest contains 27,890 acres. Elevation ranges from 100 to 3,533 feet above sea level. The climate is tropical. Average annual rainfall over the Forest is 120 inches per year. Topography is rugged, with 24% of the Forest exhibiting 60% slope or steeper.

Geology and Soils

Elevations on the Forest range from 100 feet at the northern boundary, to 3,533 feet at El Toro Peak. Terrain ranges from gentle slopes in lower elevations to rugged side slopes exceeding 60% in higher elevations, where vertical rock-faced cliffs are numerous. On the Forest's north slopes, water courses drop rapidly at high elevations, and then more gradually below. The reverse is true on south slopes, where most streams are less steep near their headwaters than further downstream.

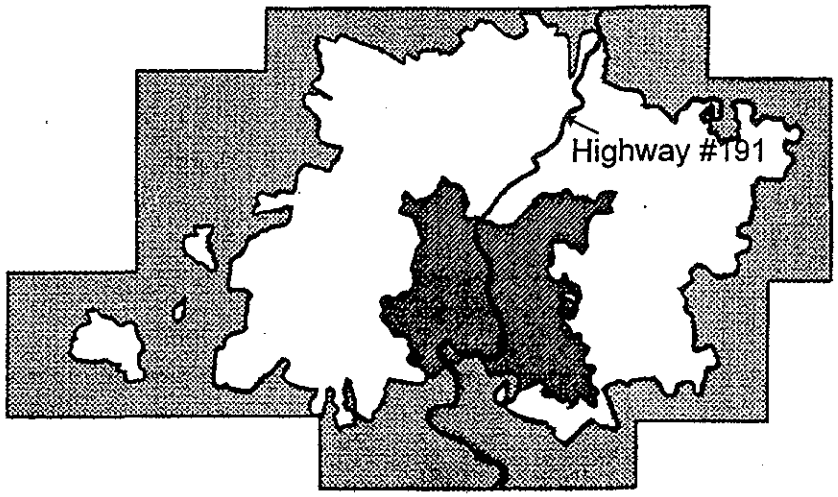
Geologic parent materials are of three basic types:

- Marine-deposited Cretaceous volcanic rocks, which are the most widespread
- Tertiary intrusive quartz diorites, which occur on the south side of the Forest
- Quaternary unconsolidated alluvial deposits (sands, gravels, silts and clays) occurring along major water courses.

Most nutrients necessary for plant growth are in the top 10 centimeters of the Forest's soils, as is typical of we tropical forests. Most Forest soils are comprised of high percentages of clay (45-80%). Sandy textured soils are associated with the area of quartz diorite parent rock on the Forest's south side (Figure III-1). Intense rains and steep slopes make the Forest's soils highly erodible when vegetative cover is removed. The sandy diorite-derived soils lack cohesion, so they are particularly susceptible to erosion.

Montane wetlands occur on slopes where soils are shallow and poorly drained. Rainfall is high and can be supplemented by cloud water interception (Weaver 1971). Evapotranspiration is low, and water does not drain rapidly. As a result, soils above 2,000 feet (600 meters) elevation are generally saturated with water, even on exposed slopes. Water frequently stands on the surface, which is covered by a slimy algal growth in some places. The extreme wetness of the soils gives rise to bog conditions, including growth of sphagnum moss, superficial plant roots, and accumulation of incompletely decomposed organic matter.

Figure III-1. Forest Soils.



Legend

- Non-National Forest Land
- Soils Derived from Quartz Diorites
- Other Forest Soils
- Highway #191

Soils derived from quartz diorites are associated with most of the landslides that occur on the Forest.

Landslides

Landslides occur commonly, constantly reshaping the dynamic topography of the Forest. Landslides usually occur during periods of high rainfall (Larsen and Torres-Sánchez, 1990). Most landslides occur on the south side of the Forest, and are most common between 600 and 800 meters elevation. Commonly the failure surface for landslides, particularly the larger ones, is in the diorite derived soils (Río Blanco soils complex), along the contact with the surrounding soils derived from Cretaceous volcanic rocks. The largest recent landslides on the Forest are located in the Icacos Valley on the south side of the Forest, along Highway 191. (Guariguata and Larsen, 1990; Larsen and Simon, 1990).

Effects of Hurricane Hugo

Hurricane Hugo deposited large amounts of woody debris into stream channels and road drainage structures. Much of the woody debris which fell into smaller streams lodged in debris jams. Most of the woody material which entered the larger streams, flushed through quickly, carried by the normal high flow events common to the rain forest.

The initial defoliation had a short-term impact on watersheds. The loss of vegetative cover resulted in increases in water yield and runoff due to reduced transpiration and rainfall interception. However, these effects diminished rapidly, as the revegetation process ensued.

Recovery After Hugo

Emergency watershed protection funds enabled the Forest to remove debris jams at water intakes, bridges and culverts within 2 months after the storm. Other watershed recovery work focused on landslide stabilization and prevention. This included re-vegetation of bare slopes, maintenance and repair of road drainage structures, and stabilization of natural and slide affected drainages.

None of the alternatives propose road construction in the Rio Blanco soils most prone to landslides. Alternative B would include 4.7 miles of trail construction, and Alternatives A, C and C-mod would include 2.5 miles of trail re-construction in these soils, and so would cause a slight increases in the probability of small landslides. Alternatives D would not include trail construction in these soils.

Effects of Alternatives

Alternative A would include 25 miles of new road construction. Although only the parking area for the Río Blanco/Río Sabana Picnic Area would be on Río Blanco soils, this road construction would increase the potential for small landslides to a small degree. This new road construction would directly affect 0.4% of the area of the Forest. Of the 25 miles of new road construction, 22 miles would be for timber production demonstration, on the Forest's north side at lower elevations and on generally flatter terrain--the area of the Forest least prone to landslides.

Alternatives C, C-mod and D would include 3 miles of new road construction. Alternative B would include only about 1 mile of road construction. As with Alternative A, only a minor amount of parking area construction would occur on Río Blanco soils.

Effects on stream sedimentation are discussed in Water section of this chapter.

Minerals

Mineral rights on the 12,384 acres of the Forest that are former Spanish Crown Lands, are held by the Federal Government, and are not subject to U.S. mining laws. Opening these lands to mineral entry would require an act of Congress or a presidential decision (USDI, Bureau of Mines, 1991).

Ownership of mineral rights on the remainder of the Forest is more complicated. These rights were transferred from the Commonwealth of Puerto Rico to the Federal Government by Puerto Rican Law of February 16, 1903 (Puerto Rico Department of Natural Resources, 1976). However, U.S. law states that acceptance of jurisdiction by the Federal Government is not automatic for lands acquired after 1940. Rights on such lands may be claimed by the Commonwealth of Puerto Rico through the U.S. Secretary of Interior. Puerto Rican law does not recognize private mineral rights, except for "non-commercial minerals" (equivalent to salable minerals under U.S. regulations--sand, clay, gravel, etc.) on private land.

Small amounts of gold and copper have been mined on the Forest in the past. Currently, there is no mineral related activity on the Forest, and no activity is anticipated in the near future.

Effects of Alternatives

Mineral management would not vary by alternative. The only salable mineral extraction that would be permitted, would be incidental amounts for administrative uses.

Water

Water Supply in Puerto Rico

Puerto Rico has an abundant water supply, receiving an island-wide average of approximately 70 inches of rain annually, or 11,600 million gallons per day (MGD). Total withdrawals of surface and ground water were estimated to be approximately 600 MGD in 1987 (Torres-Sierra, Rodriguez-Alonso, and Aponte, 1988). Despite this apparent surplus of supply to demand, Puerto Rico faces a water supply situation that is frequently described as a crisis.

A recent manifestation of the water supply problems was the severe water rationing that had to be implemented over most of Puerto Rico during the summer of 1994. Below average rainfall, particularly over eastern Puerto Rico during much of 1994, was the immediate reason for the water shortage. Similar periods of "drought" and resulting water supply shortfalls, are virtually certain to be repeated.

The more general reasons for the water supply crisis are extensively documented by Hunter and Arbona (1995):

- Declining demand for water for irrigation because of the decline of agriculture, is being more than offset by increasing demand from an increasingly urbanized and industrialized society and growing population.
- Storage capacity is rapidly being lost in existing reservoirs because of sediment deposition (estimated at 1.8% per year of original capacity in Carraizo Reservoir, which supplies much of the San Juan Metro Area). There is limited opportunity for additional reservoir construction, as the best hydrological sites are already occupied.
- The water distribution system is inefficient, losing an estimated 43% between treatment plant and consumer.
- Pollution is seriously affecting both ground and surface water quality. Ground water production declined by 17% between 1980 and 1987 because many wells on the north coast limestone aquifer had to be abandoned because of contamination. Approximately 50% of Puerto Rico's river miles are considered moderately to severely contaminated (inadvisable for fishing or swimming).

- Puerto Rico's landfill crisis is a significant aspect of the pollution threat: the Chair of the Environmental Quality Board reports that only two landfills are well operated, 6 to 9 are marginal, and the remainder (80-90%) are a "disaster". Toxic wastes have been improperly disposed of in many of these landfills, contributing significantly to the groundwater pollution problem. Additionally, as much as 14-21% of solid waste generated in Puerto Rico may be dumped illegally outside any municipal landfill, ending up scattered over the countryside and in water bodies.

Water on the Forest

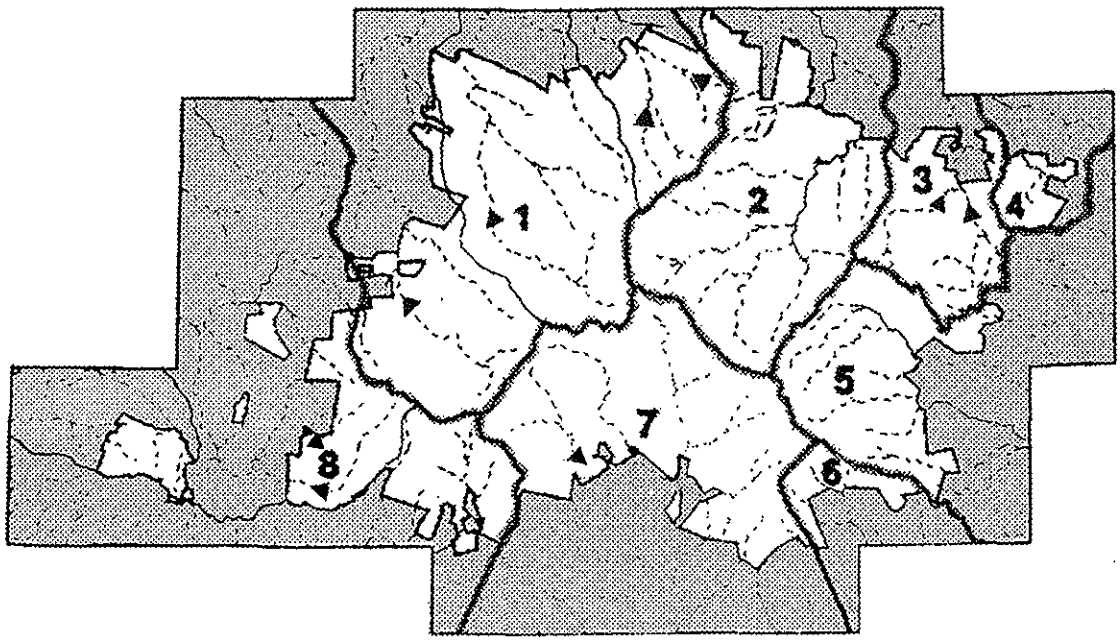
Water flowing from the Forest is abundant and of high quality, and provides many benefits. The Forest furnishes water for municipal and domestic uses, electrical power generation, and recreation. Water provides fish and wildlife habitat, and supports a lush tropical forest. Water leaves the Forest as surface water in streams, and as subsurface groundwater. Almost all current use is of surface water.

The Forest is the wettest area in Puerto Rico, receiving an average of 120 inches of rainfall annually. Heavy rain may occur throughout the year, but on average May is the wettest month and March the driest. Higher elevations have about 250 rainy days annually. About 1,700 showers occur annually producing about 0.1 inch/shower. Precipitation is less on the south and west sides of the Forest than on the north and east.

The Forest is headwaters for 8 watersheds (Figure III-2), which produce an estimated 226,000 acre feet (73.5 billion gallons) of water per year. Monthly flows fluctuate from about 3,400 acre feet to 30,000 acre feet. Low flows occur in February and March and high flows occur in September and October.

The demand for consumptive use of water from the Forest's rivers, both on the Forest and below the Forest, is substantial and increasing. It can be expected that this pressure can only intensify, given the water supply situation in Puerto Rico described above.

Figure III-2. Forest Watersheds.



Legend

- National Forest Land
- Non-National Forest Land
- Watershed Boundary
- Major Streams
- Municipal Water Intakes

Watersheds

1. Río Espíritu Santo
2. Río Mameyes
3. Río Sabana
4. Río Pitahaya
5. Río Fajardo
6. Río Santiago
7. Rio Blanco
8. Rio Grande de Loíza

Of the 8 major watersheds with headwaters on the Forest, 4 have municipal water intakes within the Forest boundary. All the others have intakes downstream of the Forest except for the Río Mameyes and the Rio Pitahaya. The Mameyes has no currently functioning municipal water intakes, but a major new facility is under construction 2 miles north of the Forest.

Stream flows are highly variable--running very high during heavy rains, and much lower during periods of low rainfall (Figure III-3). Stream water is generally clear, with low accumulations of dissolved nutrients at low flows, and muddy with sediment during high flows.

The Forest's streams are considered high quality waters that constitute an exceptional resource (Environmental Quality Board, 1990). Generally, the water meets or exceeds Commonwealth water quality standards. Fecal coliform limits are being exceeded at heavily used undeveloped water play sites, such as Puente Roto.

Total annual sediment yield from the Forest is estimated to be between 25,000 and 75,000 tons. (See Appendix B for a discussion of the variability of different methods to produce this estimate.) Landslides are the main contributors of sediment to the Forest's streams. No restoration work is done on interior slides (slides located more than 100 feet away from roads or trails). Landslides are sources of nonpoint pollution (section 319 of the Clean Water Act). Increased stream sediments can pose hazards to public health, increase purification costs at municipal water treatment plants, increase maintenance at hydroelectric plants, and affect marine ecosystems. Stream water is generally clear, with low accumulations of dissolved nutrients at low flows, and muddy with sediment during high flows.

The Puerto Rico Aqueduct and Sewer Authority (PRASA) operates 12 dams on the Forest, diverting stream water to treatment plants to provide municipal water. These systems consist of low concrete dams (less than 6 feet in height), simple passive intake structures, and buried pipelines carrying the water to off-Forest treatment plants, where sediments are removed and the water is chlorinated.

In addition to public use of Forest water through PRASA's facilities, 36 private families obtain their domestic water from the Forest. These families use smaller dams (no more than 3 feet height) combined with 1 to 2 inch pipes. A total of about 250,000 people depend on water from the Forest. An estimated 14% of the Forest's water yield is used for consumptive purposes. If the historically experienced rate of increase in water use were to continue, nearly 50% of the Forest's stream flow would be removed for consumptive use by the year 2030. There are currently no formally designated municipal supply watersheds on the Forest.

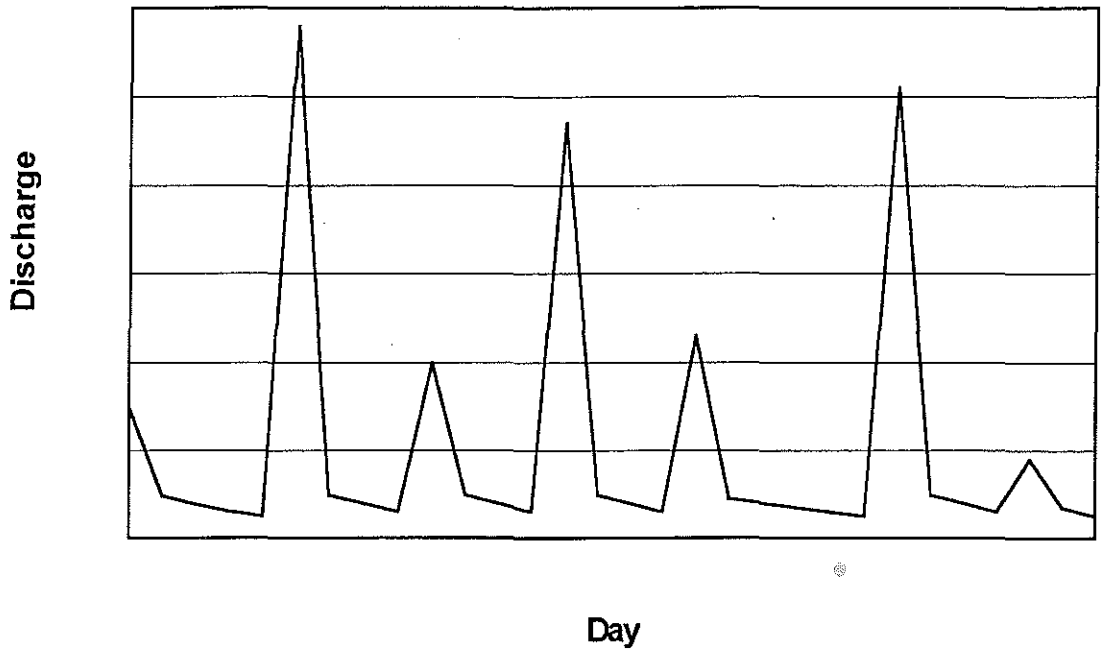


Figure III-3. Typical Monthly Flow of Forest Streams.
(After Lugo,1986)

Highly variable flows are characteristics of the Forest's streams. Streams approach some minimum flow between rains. High flows during significant rains are 10 to 20 times greater than minimum flows.

Existing water intakes are generally designed to take portions of minimum flows. Adverse impacts to aquatic ecosystems can be reduced by modifying intakes to avoid reducing streamflows below natural minimums.

As indicated in Figure III-3, the flow regime of the Forest's streams is highly variable. Any removal of water for human use alters these natural regimes. The effects of such water "harvest" can be kept within acceptable levels by establishing instream flow needs for ecosystem maintenance, and allocating water to those needs first, with the balance available for human use. Instream flow needs have yet to be established quantitatively for the Forest's streams, but they can be qualitatively described in terms of four parameters:

- **Minimum flows** - water use would not reduce flows below naturally occurring low flows.
- **Periodic high flows** - water harvest would reduce high flows to some extent, but would not eliminate the periodic peaks or "spikes" shown in Figure III-3.
- **Total flows** - depicted in Figure III-3 as the total area under the peaks and valleys of the flow line.
- **Timing** - when water harvest occurs could also be important, particularly to aquatic organisms that may need certain flows to accomplish migration to or from the ocean at specific times of the year.

Effects of Alternatives

Water Quantity

No alternative would have any measurable effect on the amount of water produced by the Forest.

Under all alternatives, withdrawal of the Forest's water, through construction or modifications of intake systems, would be allowed only after instream flow needs for ecosystem maintenance, research, and recreation are met. Instream flows needs would be characterized in terms of four parameters: minimum flows, peak flows, total flows, and timing.

The Forest would be designated a municipal supply watershed under Alternatives B, C and D, but not under Alternatives A or C-mod. Response to the Proposed Revised Plan and Draft EIS indicated virtually no public or agency support or understanding for municipal supply watershed designation. Alternative C-mod drops the proposal for such designation, but keeps the emphasis on maintenance of instream flows.

Water Quality

All alternatives would improve water quality by providing recreation developments at two key heavily used undeveloped sites: Puente Roto on PR 988 at the Quebrada La Máquina (Rio Mameyes Watershed), and the Rio Cubuy Bridge on PR 191 (Rio Blanco Watershed). The construction of toilets at these sites would reduce water pollution from human waste. The construction of parking areas, surfaced trails and picnic areas, would reduce sedimentation.

Table III-1 summarizes estimates of maximum annual sediment delivery caused by timber harvest and road, trail and recreation site construction, proposed by alternative. To give a worst case scenario, these estimates assume that all construction would occur in the first decade. It is assumed that all recreation site construction could occur in one year, but that road and trail construction would be evenly spread over the decade. The estimates for the fifth decade assume that the only sediment cause would be timber harvest.

Table III-1. Maximum Annual Sediment Delivery.

Alternative A would cause the greatest amount of sedimentation because it would have the most timber harvest and road construction.

			Alternative				
Sediment Cause	**Decade**	**Unit**	**A**	**B**	**C**	**C-mod**	**D**
Timber Harvest	1	Acres/Year	257	0	22	22	22
	5	Acres/Year	410	0	100	64	100
Sediment Delivery	1	Tons/Year	417	0	36	36	36
	5	Tons/Year	664	0	162	104	162
Road Construction	1	Acres/Year	11.0	0.4	1.3	1.3	1.3
Sediment Delivery	1	Tons/Year	147	5	17	17	17
Trail Construction/Reconstruction	1	Acres/Year	1.6	1.7	1.0	1.2	0.8
Sediment Delivery	1	Tons/Year	21	23	13	16	11
Recreation Site Construction	1	Acres/Year	49	46	46	46	46
Sediment Delivery	1	Tons/Year	63	59	59	59	59
Total Sediment Delivery	**1**	**Tons/Year**	**648**	**87**	**125**	**128**	**123**
	5		**664**	**0**	**162**	**104**	**162**

Alternative A would produce as much as 640 tons per year sediment delivered to the Forest's streams, over current levels. This approximately 5 times the sediment produced by Alternatives C, C-mod and D, and 6 times Alternative B. This is due to the greater amount of road construction and timber harvest in Alternative A. Sediment delivered would increase somewhat in all alternatives, except B, in the fifth decade, as more timber harvest occurs. (This is because more of the area allocated to the demonstration of sustainable timber production would have mature trees by that time.)

However, the added sediment, even for Alternative A, is only about 1% of the median of estimates of current sediment delivery (50,000 tons per year). An increase in sedimentation of 1% could be locally important (e.g. in a stream reach directly adjacent road construction), but would be undetectable Forest-wide.

Climate and Air

The climate of northeastern Puerto Rico is wet-tropical. Puerto Rico lies in the path of the easterly trade winds. Located at the east end of the island, the Sierra of Luquillo is the first uplifted land mass over which these winds pass. As a result, the Forest is the wettest place on the island. Mean annual rainfall ranges from 96 inches at lower elevations to 157 inches at higher elevations, averaging about 120 inches (Brown and others, 1983). Maximum rainfall occurs from May to November, although intense rainfall may occur throughout the year, commonly associated with tropical depressions or hurricanes. A 2-day storm with a 5-year recurrence can produce as much as 11 inches of rain (Miller, 1965).

Mean annual temperatures range from 80°F at lower elevations to 64°F at the higher elevations. Forest temperatures average 8-10°F cooler than nearby on the coast. Average monthly temperature is 70°F, with a mean annual range of about 12°F. Maximum and minimum temperatures are 90°F and 52°F, respectively.

Hurricanes occur annually in the West Indies. Major hurricanes affect Puerto Rico on the average every 20-30 years, usually during the months of July through September. The most recent major hurricane to affect the Forest was Hugo in 1989. The center of Hugo hit the northeastern tip of Puerto Rico with sustained winds of over 125 MPH and gusts of 140 MPH. The 3-day rainfall total associated with the storm ranged from 6.5-13.5 inches. It was the largest hurricane to directly impact the Forest since San Ciprián in 1932.

Air directly affects plants, animal and fish habitat, and contributes to the scenic and recreational attributes of the Forest and nearby communities. Air is an essential component of the Forest. In addition to being a physical resource, air is also an esthetic resource. The Forest's relatively cool clean air attracts many forest visitors, and is valued by local residents as well.

The goal of air quality management program is to protect public health by assuring that all activities on the Caribbean National Forest conform to the State Implementation Plan. This means assuring that the National Ambient Air Quality Standards (NAAQS) for public health and welfare are not violated or significantly deteriorated from existing pollution levels. The Clean Air Act; as amended in 1990, directs Federal agencies to comply with state and local regulations directed at preventing and controlling air pollution. The 1990 Amendment includes provisions to prevent significant deterioration of air quality. There are no NAAQS non-attainment areas within or upwind of the Forest. The Forest has been designated as Class II for air quality (designated for moderate protection).

The factors that influence the chemical composition of clouds and rain in the Forest include wind direction, time of year, and land use in the lowlands. Northern winter winds are associated with storms rich in marine salts (Odum 1970), which affect forest stands on northern exposures. During the dry season, southern winds cause similar events over forests on south-facing slopes. The prevailing easterly trade winds may transport dust from the African continent. Burning of lowland agricultural fields on the eastern and southern boundaries of the forest also influences the quality of clouds passing over the Forest (Lugo 1986).

Effects of Alternatives

Expected air quality effects from planned development and use of the Forest are temporary and limited in nature. Effects include dust and vehicular emissions from facilities construction and maintenance, public travel on Forest roads, and smoke from picnic and camping activities. The alternatives would not vary in their effects on air quality.

Biological Setting

Biodiversity has been defined as "the variety of life in an area, including the variety of genes, species, plant and animal communities, ecosystems, and the interactions of these elements."

Puerto Rico's tropical moist forests are characterized by a great diversity of plants, although somewhat less so than in continental tropical forests. More tree species occur on the Caribbean than in all the other 155 National Forests combined; and none of these species occur on any other National Forest.

The Forest's animal diversity is significantly less than in similar continental forests. This is primarily because Puerto Rico is located a long way and upwind from the closest continental land masses, which has made it difficult for new species of animals to arrive. Nevertheless, some 134 vertebrate species are known to occur within the Forest's 27,890 acres.

Biodiversity generally is threatened by factors such as human-caused habitat change, toxins and pollution, overuse of plant and animal populations, habitat fragmentation, climate change, simplification of ecosystems, reduction in genetic variation, and the spread of exotic species. Puerto Rico and the Forest is being, or has been, influenced by many of these same factors.

These factors can often have greater impacts on the animals and plants of small islands. (The study of the relationships between the size and isolation of islands, and their native plants and animals, is called island biogeography). Many species of plants and animals are endemic to Puerto Rico. These small isolated populations, which cannot be re-established from elsewhere, are inherently more prone to extinction than more common widespread continental species.

Vegetation

The Forest contains 5 ecological life zones: subtropical wet forest, subtropical rain forest, lower montane wet forest, lower montane rain forest, and a small area of subtropical moist forest. Its vegetation includes four major forest types: tabonuco, colorado, palm and dwarf.

The four major forest types have their nearest allies in the Lesser Antilles. Nearly one-third of the Forest's tree species are endemic to Puerto Rico and the Virgin Islands, and 10% are endemic to the Forest itself.

The tabonuco forest type, associated with sub-tropical wet and sub-tropical rain forest life zones, occurs on foot hills and slopes below 2,000 feet elevation. Tabonuco is the most extensive type, covering about 13,800 acres or 49% of the Forest. It also has the richest flora, containing at least 175 tree species; 115 of these species occur less commonly than one tree per hectare. Significant human impact, such as farming and pasturing, has occurred on probably 80% of this type, leading to a variety of successional stages.

The colorado forest type, associated with the lower montane wet life zone, occurs above 2,000 feet on gentle slopes and in valleys. This type borders the tabonuco forest with an overlapping vegetative transition. The colorado type provides nesting habitat for the endangered Puerto Rican Parrot. The abundant moisture in this type supports a host of herbaceous plants, including epiphytes representing many plant families. Over 50 tree species occur in the colorado type, with 15 species occurring less commonly than one tree per hectare. The type covers 8,200 acres or about 30% of the Forest. At least 80% of it is essentially unmodified by human activities.

The palm forest type, dominated by Sierra Palm, is associated with all five life zones occurring on the Forest. Palm forest occurs chiefly on steep slopes and stream beds above 1,500 feet. This type indicates unstable soils. The Palm Type covers about 4,800 acres or 17% of the Forest. It is essentially unmodified by human activities, with exception of small areas in recreation sites.

The Dwarf Forest Type or "elfin woodland" is associated with the lower montane rain forest life zone. This type occurs only on higher peaks and ridges above 2,500 feet that are subject to extreme exposure. Trees here are stunted and twisted. The largest trees are about 15 feet tall and 12 inches in diameter. Average diameter is about 2-4 inches. Its exposed environment supports a smaller number of species per unit area than the other types. However, a higher percentage of these species are endemic to Puerto Rico. Some species are confined to just the Forest. Dwarf Forest covers only about 1,000 acres or 4% of the Forest. Most of this type is unmodified by human activities, apart from areas on the peaks which have been developed for electronic sites and their access roads.

Zones of riparian vegetation roughly 200 feet wide occur along perennial streams, totaling approximately 2200 acres.

Primary Forest

The core of the Forest remains in primary condition--without significant human modification. This primary forest is the largest remnant of the original forest that covered virtually the entire island at the time of Columbus' arrival 500 years ago. At least 85% of Puerto Rico was cleared for agriculture, resulting in the disappearance of nearly all the forests that were once similar.

The primary forest presents a unique window to the past, and a natural control against which past, and ongoing changes, in Puerto Rico's and other tropical forests, can be measured. It provides the only currently suitable habitat for many endemic plant species, as well as the endangered Puerto Rican parrot. Its biological values remain incompletely known, but are certainly unique.

Construction of PR Highway 191 through Forest, and access roads to electronic sites on El Yunque Peak and East Peak, opened up the primary forest to vehicular traffic. El Toro-Tradewinds Trail traverses primary forest for about 5 miles, providing the main walking access into the primary forest. Tree harvesting for charcoal during World War II in the colorado type also impacted some primary forest. Timber sales begun in 1931 never entered the dwarf and palm types, and were discontinued in the colorado type 40 years ago. Despite these impacts, nearly 50% of the Forest, some 13,700 acres, remains in primary condition today.

Timber Management

The first users of the Forest's wood resources were Puerto Rico's pre-Columbian inhabitants. With their limited technologies and the passage of time, virtually no trace of these first wood users is apparent.

During the Spanish colonial period durable timbers such as ausubo were extracted from the forest for shipbuilding and construction. These timbers were considered so valuable for warships that for a time the Spanish government prohibited their exportation to any foreign power.

About 10 years after the Luquillo National Forest had been proclaimed in 1914, unauthorized harvest by charcoal-makers prompted the Puerto Rican government to petition the Forest Service to appoint the first forest supervisor. Sales of timber were authorized in 1931. More than 10,000 small sales of fuelwood sawtimber, poles, posts, vines, moss, and fruits have been made on the Forest. Most of these were for fuelwood for the production of charcoal during World War II, which was Puerto Rico's primary cooking fuel during that time.

Timber production was the legal objective for land acquisition that more than doubled the area of the Forest. Over 4,000 acres were reforested and another 1,200 were underplanted by the Forest Service with tree species valued for their wood. Seven thousand acres of forests at low elevation, particularly the plantations, have been treated silviculturally to encourage growth on the best potential timber producing trees. Despite the impacts of Hurricane Hugo, this area of the Forest which was once largely cleared for agriculture, now supports dense stands of native secondary forest and plantations.

Proposed, Endangered, Threatened, and Sensitive Plants Species

There are 8 federally-listed endangered plant species known to occur on the Forest; these 8 species are also listed by the Commonwealth of Puerto Rico, as endangered. (see Appendix E). One Forest species is currently proposed for listing as threatened.

Thirty species of sensitive plants are known to occur on the Forest. Special consideration is given to these plant species to help ensure that their populations do not decline to a point where they become threatened or endangered.

Management Indicator Species

To help determine the effects of Forest management activities and natural habitat-altering processes on biological communities, several animal and plant species have been chosen as management indicators. A management indicator species (MIS) can represent a number of other species that depend on similar habitats. Considerations in the selection of MIS include population status and vulnerability, monitoring feasibility, migratory habits, and habitat versatility (see Appendix G).

A total of 11 MIS plant species have been identified for the Forest:

Lepanthes eltorensis
Coccoloba rugosa
Eugenia haematocarpa
Ternstroemia subsessilis
Ternstroemia luquillensis
Styrax portoricensis
Callicarpa ampla
Ilex sintenisii
Pleodendrum macranthum
Solanum woodburyi
Miconia foviolata

Effects of Hurricane Hugo

The initial visual impact of Hurricane Hugo on the Forest's vegetation was dramatic. Impressive damage in the plantations and bamboos near the principal entrance to the Forest was widely photographed and led to a general impression that such effects were typical. Most of the Forest was defoliated. Much of the public was convinced that the Forest would need to be re-planted.

The northeastern half of the Forest, especially on slopes at mid and lower elevations, experienced considerable tree breakage and windthrow. Upper elevation dwarf forests suffered considerable tree damage from defoliation, breakage and root stress. In the northwestern quarter of the Forest the effects were spotty. The southern half of the Forest received little more than partial defoliation. No openings in the forest canopy larger than one-quarter acre resulted.

Recovery Since Hugo

The early succession species that need full sunlight have rapidly filled in canopy openings where trees were toppled. Virtually all the trees left standing after the storm, despite defoliation or breakage, remain alive today. Trees at lower elevations rapidly refoliated and are restoring their crowns. The process is occurring more slowly in the dwarf forest.

Effects of Alternatives

Secondary Forest Alternative A would demonstrate the sustainable production of timber on 5,833 acres of secondary forest. Alternatives C and D would allocate 1,500 acres to timber demonstration; Alternative C-mod 1,167 acres. Alternative B would not demonstrate sustainable timber production. Timber harvest demonstration would be conducted on 257 acres per year in Alternative A, and 22 acres per year in Alternatives C, C-mod and D, during the first decade. (See Table II-3.)

The effects of timber demonstration would be to periodically (every 15 years) open up the canopy of a small portion of secondary forest, by removing up to one-third of the overstory trees. Trees with greater potential for future growth and value would be given more growing room through selective cutting. Because only a relatively small part of the Forest would be affected, including no primary forest, it is not anticipated that timber demonstration would alter vegetative diversity.

Primary Forest The only proposed projects that would directly affect primary forest would be the construction of trails. Table II-5 summarizes the amount of trail construction and re-construction in primary forest by alternative. Existing trails in primary forest include approximately 5 miles of El Toro-Tradewinds Trail, and 0.3 miles of the Rio Sabana Trail (northeast part of the Forest). Alternatives A and B would include new trail construction in primary forest while Alternative C and C-mod would include only re-construction. Alternative D would not include either new construction or re-construction of trails in primary forest.

Use on all of these proposed trails would be expected to be light, as is the case for the existing El Toro-Tradewinds Trail. The effects of such use is a matter of scientific debate (Lugo, unpublished), but there are no studies demonstrating what the effects of existing trails are on primary forest here.

The acres actually in the trail tread (about 0.4 acres per mile) would be lost as primary forest. It could also be expected that some increase in plant collecting would occur as a result of the construction of new trails. Because recreation use is almost entirely limited to trails, with virtually no cross-country travel, effects on vegetation would be limited to a narrow band along trails. Assuming this trail effect band was 100 feet wide, about 1% of the primary forest would be affected under Alternative A, which has the greatest amount of trails in primary forest. (The potential disturbance effects on some wildlife species could be considerably greater--see wildlife section in this chapter.)

Management Indicator Species

It is not expected that any of the alternatives would affect these species. Alternative A would have a somewhat higher potential to impact plants because it includes more ground disturbing activity. However, surveys would be conducted for these and other rare plants, prior to any ground disturbing project implementation, and areas with rare plants would be avoided.

Wildlife and Fish

Tropical forests are usually characterized by their rich diversities of wildlife species. This is less true on the Caribbean National Forest, and in Puerto Rico generally, where animal diversity has been affected by island biogeography, and to a lesser extent, by man. Nevertheless, the vegetative diversity of this relatively small land area does support 134 species of wildlife and aquatic vertebrate, and 10 additional species of aquatic macroinvertebrate.

A total of 127 species of terrestrial vertebrate wildlife species are known to occur on the Forest (see Table III-2). Of the 16 mammals, only bats (11 species) are native. Two species of rat, the house mouse, cat and mongoose are introduced species. There are also 19 reptile species (14 lizards and 5 snakes), 15 amphibians (13 coquís, one other frog, and a toad), and 77 species of birds.

Table III-2. Summary of Animal and Plant Species Status.

Federally listed animals such as the Puerto Rican Parrot and Puerto Rican Boa are relatively well-known, but there are many more rare species on the Forest, the majority of which are plants.

Species Group	Total Number of Species	Federal T&E	Commonwealth T&E	Sensitive Species	MIS Species
Birds	77	5	4	1	5
Mammals	16	0	0	1	0
Reptiles	19	1	1	0	1
Amphibians	15	0	2	5	3
Fish	7	0	0	0	2
Shrimp and Crabs	10	0	0	0	1
Plants	unknown	8	8	30	11

Neotropical Migratory Birds

Neotropical migrant birds (NTMB's) are those species which breed in North America and migrate south for the winter. Approximately 35 species of NTMB's either winter or pass through the Forest. They contribute significantly to the bird and total animal diversity of the Forest. The status of NTMB's is of growing concern throughout North America, Mexico, Central America, and the Caribbean. Major causes of recent declines in the populations of many of these species are believed to be the fragmentation of North American breeding habitat, and the loss of wintering habitats in Mexico, Central and South America, and the Caribbean.

One of the Forest NTMB's, the Black-throated Blue Warbler, winters in the Tabonuco and Colorado forest zones, and has been designated a management indicator species (MIS) (see MIS section on page III-28.)

Aquatic Animals

Rivers and streams provide aquatic habitat for organisms that are important elements of the Forest's biological diversity. Most perennial streams, and many ephemeral streams on the Forest, support aquatic species, including 7 species of fish, 9 species of freshwater shrimp, and one species of freshwater crab. An estimated 1100 miles of Forest rivers and streams are occupied by such aquatic species.

For ecological as well as and recreational reasons, the Forest's aquatic resource values are very significant. Within and adjacent to the Forest boundary exist some of the most pristine and productive aquatic habitats remaining on the island.

All but one of the aquatic species present on the Forest must spend part of their life cycles in estuaries or in the ocean. These species are vulnerable to changes in off-Forest water quality, and to barriers (dams or sections of stream dried up by water use) in their migration corridors. Two of these migratory (or amphidromous) aquatic species, a fish and a shrimp, are included in the list of management indicator species.

No endangered, threatened, or sensitive aquatic species have as yet been designated or proposed.

Consumptive demand for aquatic animals is focused mostly on the larger shrimp species. They are fished most commonly with traps and spears, but occasionally illegally with liquid bleach or other toxic substances. Harvest of these species is as yet unregulated, both on and off the Forest. Monitoring surveys to determine their distribution, habitat needs, and population status and trend, are conducted regularly.

Management Indicator Species

To help determine the effects of Forest management activities and natural habitat-altering processes on biological communities, several animal and plant species have been chosen as management indicators. A management indicator species (MIS) can represent a number of other species that depend on similar habitats. Considerations in the selection of MIS include population status and vulnerability (MIS often include TES species), monitoring feasibility, migratory habits, and habitat versatility. See Appendix G for a discussion of the process to select MIS species.

A total of 12 animal MIS have been identified for the Forest:

Birds
- Puerto Rican Parrot (*Amazona vittata*)
- Sharp-shinned Hawk (*Accipiter striatus venator*)
- Broad-winged Hawk (*Buteo platypterus brunnescens*)
- Elfin Woods Warbler (*Dendroica angelae*)
- Black-throated Blue Warbler (*Dendroica caerulescens*)

Amphibians
- Tree-hole Coquí (*Eleutherodactylus hedricki*)
- Warty Coquí (*Eleutherodactylus locustus*)
- Burrow Coquí (*Eleutherodactylus unicolor*)

Reptiles
- Yellow-bearded Anole (*Anolis gundlachi*)

Fish
- (*Sicydium plumieri*)
- (*Agonostomus monticola*)

Crustaceans
- a river shrimp (*Marcrobrachium carcinus*)

A general summary of all MIS and other wildlife species on the Forest, identified by Federal, Commonwealth, or Forest Service status, is presented in Table III-2.

Proposed Endangered, Threatened, and Sensitive Wildlife

Endangered Species

Appendix E lists all endangered, threatened and sensitive animal and plant species, and species proposed for listing. The Puerto Rican Parrot (*Amazona vittata*) is one of the rarest of these species and is endemic to the Caribbean National Forest. From an island-wide population which once numbered several thousands (and possibly well over a million at the time Columbus discovered the island), it dropped to an all-time low of 13 birds in 1975. The population climbed slowly after 1975 to a high of 47 birds in the wild, prior to Hurricane Hugo, but declined to about 23 following the storm. Currently, the wild flock is closely approaching its pre-hurricane population level. Another 79 adult birds are in captivity in the aviaries on the Forest and in Rio Abajo. Originally associated with forests throughout the island, the parrot occurs most frequently in the palo colorado zone. Its habitat is being managed under the guidance of the 1982 Puerto Rican Parrot Recovery Plan (revised in 1996), the 1984 Interagency Puerto Rican Parrot Memorandum of Understanding (revised in 1991), and the Puerto Rican Parrot Management Situation Concept guidelines (Appendix F).

The Puerto Rican Boa (*Epicrates inornatus*), found throughout the island, occurs infrequently throughout the Forest, but most often below 1200 feet in elevation. Although a recovery plan for the boa was prepared and approved in 1986, its ecology, habitat needs, distribution, and population status, are poorly understood.

The Puerto Rican Sharp-shinned Hawk (*Accipiter striatus venator*) is a year-round deep forest resident of the mid-elevation Colorado and lower-elevation Tabonuco forest zones. Although it has never been known to occur in great abundance, the lesser frequency of recent sightings suggests that its population levels are low. Monitoring efforts for this and all other birds of prey, are being conducted to locate and protect critical habitats, and to better determine their status.

The Puerto Rican Broad-winged Hawk (*Buteo platypterus brunnescens*) is also a year-round Forest resident. More common than the Sharp-shinned Hawk, it also occurs in the Tabonuco and Colorado forest zones.

The endangered White-necked Crow (*Corvus leucognaphalus*), extinct on the island of Puerto Rico, is known today only from the neighboring island of Hispaniola. Last seen here in 1963, the Caribbean National Forest will be the most probable site for re-introduction.

Threatened Species

The Peregrine Falcon (*Falco peregrinus tundrius*), the Forests' only threatened wildlife species, is a rare winter visitor to the Forest.

Sensitive Species

The Elfin Woods Warbler (*Dendroica angelae*), only discovered in 1972, is a rare year-round Forest resident, endemic to Puerto Rico. It is found primarily in high-elevation Dwarf forests.

The Red Fruit Bat (*Stenoderma rufum*) is an uncommon resident of Tabonuco forest. It is endemic to Puerto Rico and possibly the Virgin Islands. Little is known about this bat; its low abundance, spotty distribution and solitary habits, have hindered research and monitoring efforts.

The Mottled Coqui (*Eleutherodactylus eneidae*) is a ground-dwelling frog that was once found throughout the mountains of Puerto Rico above 2500 feet in elevation. Known from four historic Forest sites, this species has not been located in over 10 years.

The Web-footed Coqui (*Eleutherodactylus karlschmidti*), largest of the Puerto Rican tree frogs, is a semi-aquatic inhabitant of rocks and boulders along mountain streams and waterfalls. Despite numerous survey efforts, it has not been observed in over 20 years.

The Burrow Coqui (*Eleutherodactylus unicolor*), is one of the smallest of the coqui species. Although locally common, it is endemic to the Forest and one of the most limited in its distribution. It occurs in upper forest zones above 2000 feet, primarily in the Dwarf Forest Zone.

The Warty Coqui (*Eleutherodactylus locustus*), is a small, rare coqui encountered near the ground, but almost never on the ground. It has not been observed below 900 m in elevation. It is currently known from only five sites within the Forest.

The Ground Coqui (*Eleutherodactylus richmondi*), is another rare species always found near the ground. It had not been observed in the Forest since 1988, but was recently confirmed at one site.

Effects of Hurricane Hugo

Hurricanes occur regularly in the West Indies. Major hurricanes affect Puerto Rico about every 20 to 30 years. Hurricanes play a disturbance role in Caribbean ecosystems comparable to natural wildfires in western North America. The Forest and its organisms are adapted to such disturbances.

The Forest's streams are characterized by extremely variable flows-running very high after storms and very low during dry periods. The aquatic organisms in these streams are well adapted to the heavy rains and flooding caused by hurricanes. Hurricane Hugo was considered to be a relatively low-rainfall hurricane in Puerto Rico.

Initially food resources for aquatic organisms were sharply reduced as streams were scoured by high runoff. These resources quickly recovered, as fallen leaves and branches entered the streams. The decreased tree canopy allowed more sunlight to penetrate into the streams, encouraging increased aquatic plant growth.

The effects of Hurricane Hugo ranged from minor temporary changes of some species, to effects which threatened the continued existence of a few species with already low populations. Different species were affected differently depending on their mobility, food habits, adaptability, and tolerance to changed habitat conditions.

The endangered Puerto Rican Parrot was severely affected. Numbering 47 in the wild before Hurricane Hugo, its population was reduced by half by the storm. Foraging and nesting habitats suffered extensive damage, and the opened canopy is believed to have made the parrots more susceptible to predation by raptors. Several natural nest sites were damaged or destroyed. Most human-made structures for parrot recovery—lookout towers, blinds, artificial nest structures--were also destroyed or extensively damaged.

Recovery After Hugo

The effects of Hurricane Hugo on most wildlife species was hardly detectable 2 years after the storm. Studies and surveys undertaken immediately after the storm indicated changes in relative abundance of many species. But subsequent and ongoing studies have shown that with the exception of various sensitive and endangered species, whose population levels were low prior to the storm, the changes were mostly short-term.

Hurricane effects to sensitive coquis, and the rates of recovery for these species, appear to be variable. The Burrow Coqui, because of its occurrence in the dwarf forest, which was significantly damaged and remains the least recovered of the forest types, may have been one of the more heavily affected species initially, but appears to have stabilized. It is not known whether two other sensitive tree frog species, the Mottled Coqui and the Web-footed Coqui, were in existence before the storm. Surveys to confirm their presence on the Forest continue to yield negative results. The populations of two additional coqui species, the Warty Coqui (*Eleutherodactylus locustus*) and the Ground Coqui (*E. richmondi*) still appear to be depressed since Hugo, and as a consequence have been officially recommended for Federal listing.

The status of most species of Forest bat seems stable, with the exception of *Stenoderma rufum*, the Red Fruit Bat. This species appears to be seriously imperiled, and is being considered for endangered status.

The Puerto Rican Parrot is recovering from the dramatic decline following Hugo. Reproduction since the hurricane has been the most successful since 1952. The 1996 post-breeding season census estimated the wild population at 45 birds, 96% of its pre-hurricane level.

Effects of Alternatives

The effects of the alternatives are analyzed here in terms of their effects on wildlife habitat. Proposed activities which could affect habitat that were considered in this analysis include: timber demonstration, road construction, recreation and administrative site construction and use, trail construction and use, research, and electronic site use. Table III-3 summarizes the acres of habitat that would be physically altered by these activities, by alternative.

These potential agents of habitat change were analyzed in terms of their effects on wildlife habitat generally, and on Puerto Rican Parrot habitat. Effects on parrot habitat were specifically analyzed because the species is of special concern both to the public and several government agencies, and because it is believed to be one of the Forest's animals most sensitive to habitat change and disturbance. For these reasons, it has been designated a management indicator species.

Effects on general wildlife habitat and Puerto Rican Parrot habitat were analyzed in two ways: acres of habitat physically altered, and acres within one-half kilometer of existing and proposed new developments (roads, trails, and recreation, administrative and electronic sites). See Appendix B (page B-13) for a detailed explanation of these analysis techniques, and rationale for their use.

The Key Habitats maps display the locations of existing and proposed developments, Puerto Rican Parrot habitat, and primary forest (a key habitat for most of the rare plants and animals on the Forest).

Figures II-8a and II-8b summarize effects on general wildlife habitat by alternative. Figures II-9a and II-9b summarize effects on Puerto Rican Parrot habitat.

General Wildlife Habitat

Physical Change (Figure II-8a)

Alternative A would alter habitat on about 21% of the Forest, Alternatives B 4%, Alternatives C and D 6%, and Alternative C-mod 5%. In all alternatives, over 90% of this change is attributable to timber demonstration. (Alternative B has a very limited timber demonstration program, but would continue maintenance work on 1000 acres of existing plantations through the first decade.)

Table III-3. Physical Habitat Change by Management Activity.

		Additional Acres Proposed by Alternative				
Activity	**Existing**	**A**	**B***	**C**	**C-mod**	**D**
Timber Demonstration		5,833	1,000	1,500	1,167	1,500
Road Construction	121	61	2	7	7	7
Trail Construction	17	17	17	10	12	8
Recreation Sites	43	10	11	9	8	9
Administrative Sites	54	0	0	0	0	0
Electronic Sites	31	0	0	0	0	0

* *Alternative B does not demonstrate sustainable timber production, but does include 100 acres per year of maintenance of young plantations through the first decade.*

The effects of timber demonstration on wildlife habitat are expected to minor, given the small proportion of the Forest proposed for habitat alteration, and the protective Standards and Guidelines which apply to demonstration activities. No more than one-third of the canopy would be removed in any treatment, and only plantations and native secondary forest around the periphery of the Forest would be affected (areas already significantly altered by man). In addition, over 500 acres of plantations and secondary forest scattered over the northwest portions of the Forest were deducted from the timber demonstration base in Alternative C-mod. These acres will be managed in support of the Puerto Rican Parrot recovery effort, and for other endangered species such as the Broad-winged and Sharp-shinned Hawks which are associated with plantations and secondary forest habitats. No primary forest would be affected by timber demonstration.

Habitat change from activities other than timber demonstration would affect 0.3% of the Forest under Alternative A, and 0.1% in all other alternatives. Such changes would be significant only if they coincided with habitat for a rare and very localized animal or plant. Site specific analysis for all proposed projects will be implemented to ensure that such impacts do not occur.

Potential Human Disturbance (Figure II-8b)

Almost 50% of the Forest currently lies within one-half kilometer of existing developments. This is believed to be significant to disturbance-sensitive species. Under Alternative A, this would increase to 68% after all the developments planned over 50 years were completed. The percentage would be 70% for Alternative B, and 52% for Alternatives C, C-mod and D.

Most of this increase, in all alternatives, would be attributable to trail construction in areas of the Forest which currently lack trails. Other new developments and timber demonstration would occur near existing roads, trails and other facilities.

The significance of the potential additional disturbance caused by new trails, depends on the species of wildlife, the location of the trail, and the intensity of use. The Forest has few species that are known to be sensitive to human disturbance; these include the Puerto Rican Parrot (discussed below) and birds of prey such as the Sharp-shinned and Broad-winged Hawks during their reproductive periods. Efforts to avoid impacts from human disturbance include the development of protective management guidelines (see LRMP pages 4-13 to 4-15), population surveys, and project site assessment.

Puerto Rican Parrot Habitat

Physical Change (Figure II-9a)

Alternative A would alter about 11% of currently occupied Puerto Rican Parrot habitat, and 22% of currently unoccupied, potential habitat on the Forest. Alternative B would alter a small fraction of 1% of currently occupied and potential habitats. Alternative C would alter 1% of currently occupied habitat, and 3% of unoccupied but potential habitat. Alternative C-mod would alter no existing habitats and a small fraction of 1% of potential parrot habitats. Alternative D would alter no currently occupied habitat and 3% of unoccupied potential habitat.

Most of this change would be attributable to the demonstration of sustainable timber production. There is little potential for parrots to nest in natural cavities in such secondary stands, but they are known to feed in such areas. The effects of removing up to a third of the canopy on the production of fruits used by parrots is not known. However, given the tree species which would be removed through the timber demonstration program, and the direction to maintain habitat values (e.g., food-producing trees) in parrot habitats, it is unlikely that parrot foraging potential would be measurably affected, even under Alternative A. The effects of altering o% to 1% of non-nesting, occupied habitat and 0% to 3% of potential habitat, under Alternatives B, C, C-mod and D, would be even less likely to affect the course of recovery of the parrot.

Potential Human Disturbance (Figure II-9b)

About 47% of currently occupied Puerto Rican Parrot habitat is within 0.5 kilometer of existing developments. This would increase to 66% in Alternative A and 62% in Alternative B, because of new trail construction in the upper Rio Espíritu Santo watershed. It would decrease slightly in Alternatives C, C-mod, and D to 43% to 44%, as some trail segments within occupied parrot habitat would be closed.

About 36% of currently unoccupied potential habitat is within 0.5 kilometer of existing development. This would increase to 55% in Alternative A, 52% in Alternative B, and 45% to 46% in Alternatives C, C-mod, and D. These increases would be attributable to new trail construction. Other new developments would be near existing roads, trails and other facilities.

The new trails proposed within Puerto Rican Parrot habitat, in Alternatives A and B, could cause significant increases in disturbance. Use of these trails would be expected to be relatively light, but these trails would closely approach nesting habitat. Puerto Rican Parrots have been observed to be highly sensitive to human disturbance, particularly during the nest selection and breeding seasons. Any reduction in reproductive success would be a significant adverse effect. There were only five to six active nests in the wild over the last three years, and only about half that number during the 1970's and 1980's.

These proposed new trails represent a potential for increased disturbance of parrots in the future. The importance of this potential future disturbance is less clear than the effects of disturbance in currently occupied habitat. It is clear that if the recovery goal of two populations of 500 birds each is to be met, parrots will have to move, and/or be introduced, into currently unoccupied habitat. As this occurs, the probability of closer parrot/human interaction will increase.

Management Indicator Species

The population of Puerto Rican Parrots is projected to increase under all alternatives. This projection is based on continued intensive management efforts, and reproductive success since Hurricane Hugo. The probability of such population increase would be lower under Alternatives A and B because of the potential for increased human disturbance from new trails in occupied habitat, as is discussed above.

The populations of other animal indicator species are projected to be unaffected by management activities proposed under any of the alternatives. This projection is based on the small amount of habitat modifications proposed, the fact that most of these modifications would occur outside the most important habitats, and the fact that these indicator species are believed to be less sensitive to human disturbance than the Puerto Rican Parrot. It is possible that populations of several of these species may decline because of environmental factors occurring at scales much larger than the Forest. Examples include an apparent world-wide decline among most species of amphibians, and the Americas-wide decline of many species of Neotropical migrant birds.