TECHNICAL/AGENCY DRAFT

REVISED RECOVERY PLAN

FOR THE

PUERTO RICAN PARROT
(*Amazona vittata*)

April 1999

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(First Revision Approved: April 8, 1987)

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for

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By approving this recovery plan, the Regional Director certifies that the data used in its development represent the best scientific and commercial information available at the time its was written. Copies of all documents reviewed in the development of the plan are available in the administrative record, located at the Río Grande, Puerto Rico, Field Office.

Literature citations should read as follows:

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EXECUTIVE SUMMARY OF THE PUERTO RICAN PARROT REVISED RECOVERY PLAN

Current Status: The Puerto Rican parrot (*Amazona vittata)* is listed as endangered. This species, endemic to Puerto Rico, is the only native parrot in the United States and it is considered one of the ten most endangered birds in the world. Presently, only about 36 to 40 individuals survive in the wild and are restricted to the Caribbean National Forest in eastern Puerto Rico. In addition, 105 individuals exist in two captive propagation facilities, the Luquillo Aviary and the José L. Vivaldi Memorial Aviary in eastern and west-central Puerto Rico, respectively.

Habitat Requirements and Limiting Factors: The Puerto Rican parrot is a secondary cavity nester; therefore, it depends on mature forests with large cavity forming trees for nesting. Presently, the only habitat with such characteristics is found in the Caribbean National Forest, where the relic wild Puerto Rican parrot population survives. Historically, the major threats to the species were habitat loss, nest competition and predation of eggs and chicks by pearly-eyed thrashers (*Margarops fuscatus)*, predation of fledglings and adults by red-tailed hawks (*Buteo jamaicensis*), predation by rats (*Rattus rattus and R. norvegicus),* parasitism by warble flies (*Philornis pici*), and the impact of hurricanes. Other threats include competition for cavities with European and Africanized honeybees (*Apis mellifera)*, predation by Puerto Rican boas (*Epicrates inornatus*), and a variety of human activities affecting the remaining habitat. Many of the major historical threats have been controlled by the development of effective management strategies, principally nest guarding and fostering aviary produced chicks into wild nests.

A large proportion of the Puerto Rican landscape is covered by secondary forests. Some of those forests are mature enough to sustain Puerto Rican parrot populations if adequate management strategies are used. Nevertheless, the species is threatened by undetermined mortality factors affecting fledgling survival (perhaps predation by red-tailed hawks), the possibility of hurricanes, the increased introduction of exotic psittacines, and the ever-increasing demand of lands for development in Puerto Rico. Furthermore, the Puerto Rican parrot population has remained below 45 individuals for more than 30 years, augmenting the possibility of genetic erosion.

Recovery Objective: Downlisting to threatened status.

Recovery Criteria: We will consider downlisting when the following actions have been accomplished: two separate wild populations are established in Puerto Rico, the two populations become self-sustained, the effective population size is 500 birds (5-year average) in each area, and the habitat for those two populations is protected.

Actions Needed:

1. Protect the Puerto Rican parrot wild population.
2. Protect and enhance of Puerto Rican parrot habitat.
3. Investigate mortality factors reducing recovery rate.
4. Control predators, competitors, and parasites of the Puerto Rican parrots.
5. Monitor first year survival of wild fledglings.
6. Expedite development of captive release methodology.
7. Optimize the production of captive parrots.
8. Continue outreach efforts and develop a more comprehensive public awareness program.

Date of Recovery: We will initiate downlisting in 2020, if recovery criteria are met.

Recovery Cost: We have estimated recovery costs for the Puerto Rican parrot at $5,200,000.00 for the first 3 years of implementation of this plan. Subsequent expenditures will depend on the results of preliminary studies and activities and, therefore, we cannot estimate them at this time.

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I. INTRODUCTION

Once abundant and widespread throughout the Puerto Rican archipelago, the endemic Puerto Rican parrot (*Amazona vittata*) is presently one of the 10 most endangered birds in the world. Habitat loss to deforestation together with natural enemies and hurricanes are considered among the major causes for the precipitous decline of the species during the 20th century. Currently, a single wild population of 36 to 40 individuals survives in the Caribbean National Forest (CNF)[1].

The Puerto Rican parrot was determined to be an endangered species by the Secretary of the Interior in 1967 (32 FR 4001). Intensive efforts to protect the species started a year later, eventually evolving into the present conservation program. In 1973, a captive flock was established in the Luquillo Mountains[2] to ensure survival of the species, should a catastrophic event affect the wild population. A second captive flock was established in 1993, when a group of Puerto Rican parrots was transferred from the Luquillo Aviary to the José L. Vivaldi Memorial Aviary, administered by the Puerto Rico Department of Natural and Environmental Resources (DNER), in the Río Abajo Commonwealth Forest, in western Puerto Rico. Presently, the two aviaries shelter about 105 Puerto Rican parrots.

Description

The Puerto Rican parrot, largely green with a red forehead and blue flight feathers, is one of nine extant *Amazona* parrots occurring in the West Indies. Measuring about 29 centimeters (11 inches) in length and weighing about 270 grams (10 ounces), this species is one of the smallest in its genus, although it is similar in size to other *Amazona* in the Greater Antilles. Aspects of coloration suggest that it is most closely related to either the Jamaican black-billed parrot (*A. agilis*) or the Hispaniolan parrot (*A. ventralis*).

Historical Range and Status

Snyder *et al.* (1987) described in detail all aspects of the reproductive biology, historical range, population decline, and recovery efforts of the Puerto Rican parrots. The descriptions and summaries in the following sections are largely based on their work and the previous versions of the Puerto Rican Parrot Recovery Plan (U.S. Fish and Wildlife Service 1982, 1986). Although some management aspects of both the captive and the wild population have changed, most of the cited pioneer work, particularly the one related to the biology of the species, remains relevant today.

All indications suggest that the parrot was once abundant and widespread on the entire Puerto Rican Archipelago's major islands. Former numbers are highly speculative, but may have exceeded a million individuals. The parrot population probably remained reasonably stable until about 1650, when major increases in the human population began.

[1] In this plan, Caribbean National Forest refers to the land unit, within the Luquillo Mountains, owned and managed by the U.S. Forest Service.

[2] Luquillo Mountains refers to the entire geographic region comprising the CNF and adjacent lands.

The decline assumed catastrophic proportions in the latter half of the 19th century when most deforestation of the island took place. By the early 20th century, the species had disappeared from all of the offshore islands and was restricted to five known areas on the mainland. By about 1940, the only remaining population was in the Luquillo Mountains of eastern Puerto Rico, the largest area of native vegetation left on the island. Within the Luquillo Mountains, the population decline continued until recent years (Table 1).

Since 1968, the number of wild Puerto Rican parrots has been below 45 birds, with only three to six breeding pairs. Increases in the number of wild parrots have not been followed by proportional increases in the number of breeding pairs (Figure 1). Genetic problems, although suspected, have not been definitively documented in the wild population. The chronic prevalence of low numbers of individuals over a long period of time may eventually manifest in problems associated with genetic depression (Franklin 1980). Snyder *et al.* (1987) observed a gradual increase of in the incidence of non-developing, (probably infertile), eggs in the wild starting with 18 percent (%) in 1982 , 37% in 1983, and 56% in 1984, suggesting the possibility of genetic problems. However, for the most part the same pairs produced fertile clutches in previous years and again produced fertile clutches in 1985 (all eggs were fertile in 1985 and 1986). The recent reproductive history of the wild flock is summarized in Table 2 . Fertility fluctuations were observed again in the years after hurricane Hugo. Fertility of nesting pairs ranged from 65% to 100% from 1990 to 1998.

A new pair, discovered nesting in 1995, has laid infertile eggs in four consecutive nesting seasons. The specific reasons for this pair's infertility are unknown. Possibly, the Puerto Rican parrot wild population still is genetically robust and the fluctuations on fertility are not related to genetic problems. Nevertheless, the threat of genetic depression remains present.

Reproductive Biology

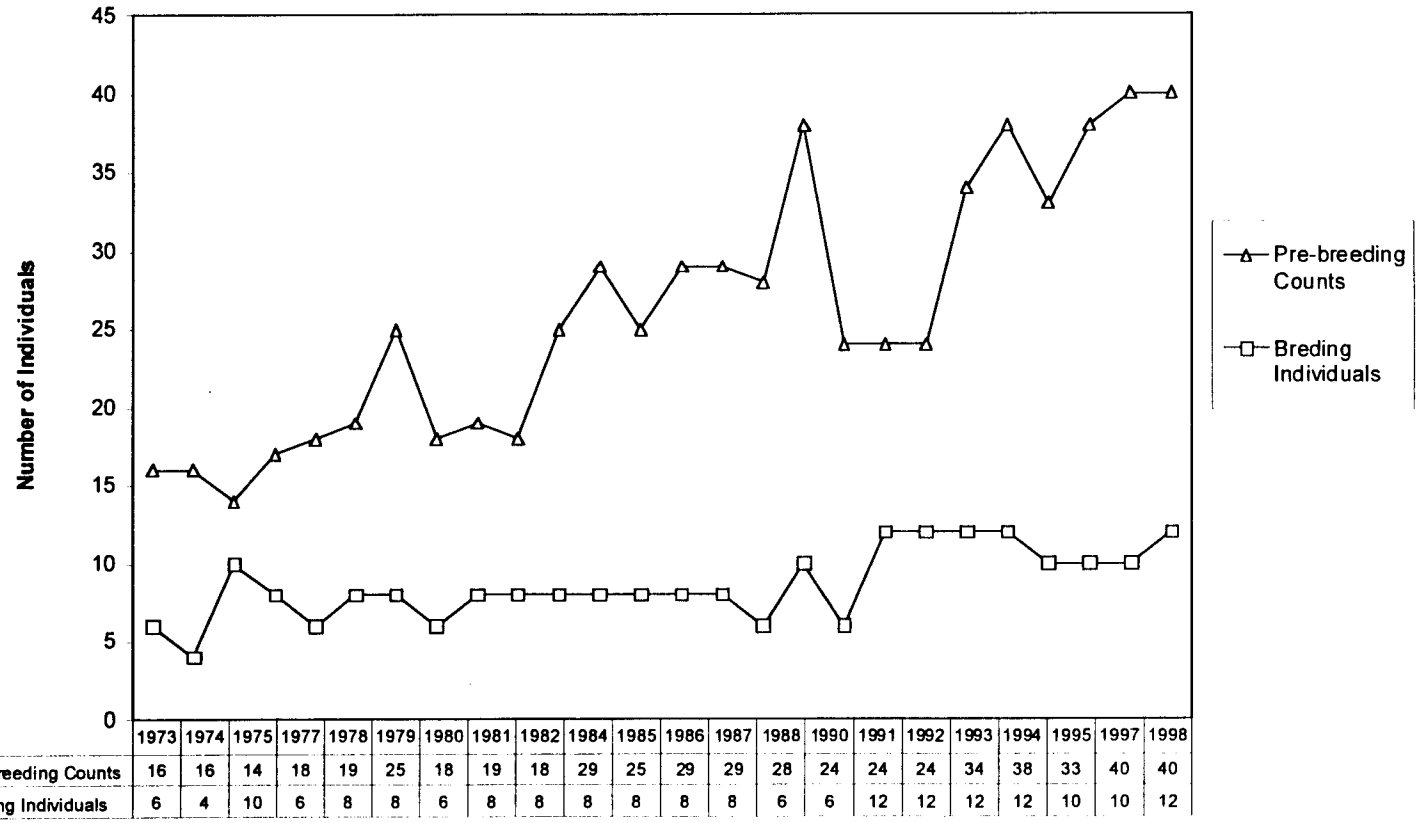
Puerto Rican parrots mature at 3 to 5 years of age. Pair bonds between adult parrots are normally stable over the years, and pair members stay together at all times of the year, except when the female remains in the nest during incubation and early nestling stages. The male assumes full foraging responsibilities for the pair during this time. Pair formation in the wild has not been observed in great detail, but has involved bowing displays, in at least some cases. Puerto Rican parrot pairs are vigorously territorial, commonly engaging in vicious combat with other pairs. Territories are defended to some extent year round and are extremely variable in size, sometimes consisting of only part of the nest tree, other times extending many meters away from it. Non-breeding pairs, at least some of which are sub-adults have established some territories. In all cases observed, newly territorial pairs have settled immediately adjacent to established pairs, a tendency that appears to explain the long-term stability of parrot nesting areas.

Table 1. Representative minimum counts of Puerto Rican parrots.

	Minimum number of parrots	
Year (month)	In the wild	In captivity
1954 (October)	200	-
1963 (May)	130	3 (2 at Mayagüez Zoo)
1966 (December)	70	3 (2 at Mayagüez Zoo)
1968 (November)	24	3 (2 at Mayagüez Zoo)
1971 (January)	16*	3 (2 transferred to Patuxent Wildlife Research Center in May 1971)
1975 (March)	14*	12
1975 (May)	13*	
1980 (January)	19	15
1982 (July)	29	
1985 (July)	35-37*	29
1986 (April)	29	32
1986 (August)	31*	38
1986 (November)	31	37
1989 (August [bH])	47	
1989 (September [aH])	23	41
1990 (January)	24	
1990 (September)	21	59
1991 (April)	24	
1991 (September)	30	61
1992 (February)	24	
1992 (October)	28	57
1993 (January)	34	
1993 (September)	42	64 [a]
1994 (March)	38	
1994 (August)	40	70 [b]
1995 (February)	33	
1995 (September)	44	81
1996 (January)	38	
1996 (August)	42-44	77
1997 (July)	40	91
1998 (March)	40	
1998 (September [aG])	36	104

* by reasonable inference.
[bH] before hurricane Hugo.
[aH] after hurricane Hugo.
[a] 12 birds were transferred to the José L. Vivaldi Aviary in the Río Abajo Forest.
[b] 13 birds transferred to the José L. Vivaldi Aviary.
[aG] After hurricane Georges.

Figure 1. Wild Puerto Rican Parrot breeding Population (1973-1998)



	1973	1974	1975	1977	1978	1979	1980	1981	1982	1984	1985	1986	1987	1988	1990	1991	1992	1993	1994	1995	1997	1998
Pre-breeding Counts	16	16	14	18	19	25	18	19	18	29	25	29	29	28	24	24	24	34	38	33	40	40
Breding Individuals	6	4	10	6	8	8	6	8	8	8	8	8	8	6	6	12	12	12	12	10	10	12

TABLE 2. SUMMARY OF WILD PUERTO RICAN PARROT(Amazona vittata) BREEDING SEASONS 1990-1998

Year	No. Breeding Pairs	Total No. Eggs	No. Fertile Eggs (%)	No. Fertile Eggs Hatched (%)	Fertile Egg Mortality (%)	Chick Mortality (%)	No. Chicks Fledged (%)
1998	6	18	14 (77.8)	12 or more[c]	?	2 or more	9
1997	5	15	9(60.0)	8(88.9)	1(11.1)	1(12.5)	7(87.5)
1996	5	15	12(80.0)	10(83.3)	2(16.7)	3(30.0)	7(70)+1[a]
1995	5	15	15(100)	15(100)	0(0.0)	2 (13.3)	11(73.3)+4[b]
1994	6	18	18(100)	16(88.9)	2(11.1)	4(25.0)	12(75)+2[b]
1993	6	26	26(100)	19(73.1)	7(26.9)	5(26.3)	11(57.9)+4[b]
1992	6	19	17 (89.5)	16(94.1)	1(5.9)	7(43.7)	9(56.3)+2[b]
1991	6	20	13(65.0)	10(76.9)	3(23.1)	3(30.0)	7(70.0)
1990	3	8	7(87.5)	5(71.4)	2(28.6)	2(60.0)	2(40.0)
Total	48	154	131(85.1)	111(84.7)	18(16.2)	29(26.1)	75(67.6)+1[a]+12[b]

[a] Nestling fostered from the José L. Vivaldi aviary into a wild nest.
[b] Nestlings fostered from the Luquillo aviary into wild nests.
[c] Nest contents predated before the number of chicks could be determined.

When pairs are prospecting for nest sites, the males commonly take the lead. Once a cavity is selected, the parrots continue inspections and spend some time inside chewing the cavity interior. At about the time of egg-laying, females begin to roost in the nest hole overnight, a pattern they usually follow until the young fledge.

Copulations are commonly preceded by the male feeding the female, but this is variable. Copulations follow the usual New World parrot pattern; the male perches beside his mate, rests one foot on her back while gripping the perch with his other foot, and bending his tail under that of the female from the side. Cloacal contact is frequently accompanied by the male fanning one wing over the back of the female.

Incubation, performed solely by females, begins with or shortly after the laying of the first egg. Clutch size ranges from two to four eggs, but averages three. The incubation period lasts about 26 days. Eggs hatch asynchronously, generally spaced about 2 days apart. Nesting is highly synchronized seasonally, with almost all clutches produced in late February or early March, the driest part of the year and also the time of peak fruiting of sierra palms (*Prestoea montana)*, the primary food of the species in the breeding season. Replacement clutches for eggs lost early in the breeding season were observed three times and induced six times (Snyder *et al.* 1987).

Young parrots hatch nearly naked with their eyes closed and take food almost immediately after hatching. Feeding is accomplished by regurgitation. After about the first week of the nestling period, the females begin to forage with their mates for part of the day. Time away from the nest increases to a maximum after 2 to 4 weeks. Most foraging takes place outside the nesting territory, with some pairs regularly flying as far as 1.6 kilometers (1 mile) to feeding areas. In general, chicks fledged at about 9 weeks of age, but some have taken as little as 8 weeks, and some as long as 11 weeks.

Causes of Decline

The decline of the Puerto Rican parrot has been characterized by high rates of mortality and low rates of reproduction at least during certain periods. From 1966 to 1968, the population declined an average of 42 percent each year. Clearly, even if there had been no reproduction at all during those years, mortality must have been much higher than it is at present. During the period from 1972 to 1989, with the parrot population relatively stable, the average annual rate of mortality of free-flying birds was about 25 percent. As discussed below, recent hurricanes have impacted the conservation efforts of both captive and wild Puerto Rican parrot populations. So far, hurricane Hugo has been the most deleterious in the history of the Puerto Rican parrot recovery program. The impact of hurricane Hugo in 1989 reduced the population from a minimum of 47 to about 23 individuals for a 49 percent mortality in one year. Pre and post-breeding counts indicate that since the impact of hurricane Hugo, mortality, including juvenile parrots, has

remained at 20 to 30 percent. The number of individuals in the wild population increased from 23 to 40 individuals during the period from 1989 to 1998.

Aside from periodic high mortality rates, there is strong evidence that reproduction has been low for many years, both in the sense of relatively few pairs attempting breeding and of low reproductive success of pairs that laid eggs (Snyder *et al.* 1987). Only 2 to 6, Puerto Rican parrot pairs have attempted breeding each year during the history of the recovery program.

Habitat destruction

Descriptive accounts of the history of habitat destruction as related to the Puerto Rican parrot decline are found in Snyder *et al.* (1987). A frugivorous cavity nester, the Puerto Rican parrot has seldom been seen far from forests. The destruction of the native forests of the island was unquestionably a major factor in the decline of the species. By 1912, the island was more than 80% deforested, and, of the forests left, only about 45,000 acres (18,220 hectares [ha]) remained in virgin condition (Murphy 1916). By 1922, only about 20,000 acres (8,097 ha) in the Luquillo Mountains remained forested, and nearly all of this had been cut over for its best timber trees (Wadsworth 1949, 1951). The parrots are critically dependent on large diameter trees for nesting cavities (although one former population is known to have also used cliff pot-holes on occasion; Snyder *et al.* 1987, Wiley 1980). Despite the fact that the tree-covered area of Puerto Rico has increased to more than 40 percent in recent decades, and has doubled in the Luquillo Mountains since 1940, the parrots have not followed suit. This is very likely due in part to the many decades needed before most trees grow large enough to provide acceptable natural cavities. However, this problem continues to puzzle biologists. Management strategies have been implemented to increase the availability of optimal nest cavities with negligible increases in the breeding population.

Present habitat of the parrot is centered deep within the largest remaining area of essentially unmodified forest in Puerto Rico. Most current nesting areas have been in use for decades. Recent new nests are all located within or near traditional nesting areas. In fact, the birds generally use the same nest cavities year after year. After hurricane Hugo, most of the remaining wild individuals concentrated in deep valleys near the southern part of CNF. Up until 1994, there were two pairs nesting in the eastern part of the forest. Just before the 1995 breeding season, two incidents of low altitude helicopter and fix-wing aircraft overflights occurred and no parrot activity has been observed in the eastern valleys. Direct relationship between the overflights and the abandonment of the areas is suspected although it is difficult to establish it beyond doubt.

Presently, the entire wild population is using the southern valleys of CNF and parrots are seldom seem in other areas. Whereas daily movements of the Luquillo Mountains population commonly took the birds into lowland areas in past decades, such movements

have been rare in recent times. Some observations suggest that the parrots are using private areas bordering the southern part of CNF, but the specific areas have not yet been identified.

Regulated timber cutting has occurred since 1931 within CNF in the Luquillo Mountains. Most of the timber removed has been of four tree species, tabonuco (*Dacryodes excelsa*), laurel sabino (*Magnolia splendens*), ausubo (*Manilkara bidentata*), and nuez moscada (*Ocotea moschata*). Aside from providing nest cavities, tabonuco is a seasonal food source for the parrots. It grows mainly at elevations under 2,000 feet (600 meters), as does ausubo. Although the abandonment of the lower forests as nesting habitat may be due in part to timber removal, 2,000 acres (800 ha) of old growth stands remain in this zone. For a long time the parrots did not use the tabonuco zone for nesting. Quite possibly these remnant stands lost their parrots because of their accessibility to human pressures such as nest robbing. However, in 1986, parrot activity was observed in a tabonuco area at the eastern part of CNF. Monitoring of the activity lead to the discovery of a nest in a tabonuco cavity in 1991. The nesting pair remained and used 2 tabonuco cavities in the area until 1994. No birds have nested on the eastern part of CNF since 1995, after the incident with the unauthorized overflight.

Laurel sabino and nuez moscada also grow in the upper forests now used by the parrots for nesting. A cavity in a laurel sabino, in fact, was used by nesting parrots in 1974, and in 1981 through 1983. However, the primary nest tree of the parrots in recent decades has been the palo colorado (*Cyrilla racemiflora*) (Snyder *et al.* 1987). Whereas this species is not a valuable timber tree, it too suffered from cutting over the years, primarily for charcoal production. Between 1945 and 1950, about 1,000 acres (405 ha) of palo colorado forest, representing about 12% of this forest type in the area, were cut selectively. This included a number of areas within, or close to, presently active parrot nesting areas. In addition to resulting in a direct loss of potential nest trees, the charcoal operations enabled a number of charcoal makers to find nesting parrots and facilitated the widespread harvest and sale of nestlings (Snyder *et al.* 1987). Trees and nest cavities were also destroyed for honey harvesting (Snyder *et al.* 1987).

A direct evaluation of the abundance of natural cavities suitable for nesting in the traditional parrot nesting areas, conducted between 1973 and 1982, revealed that suitable sites were rare (Snyder and Taapken 1977, Wiley 1985). Apparently, nest scarcity was a factor contributing to the following: the failure of some pairs to attempt breeding, low nesting success of pairs that have initiated reproduction, and high rates of physical injury resulting from aggressive competition for nest sites among parrot pairs. Wiley (1985) observed many parrot pairs that included members bearing conspicuous external injuries, many of which may have resulted from competition for nest sites. Many artificial and improved natural cavities have been provided in current parrot nesting areas since 1974. After hurricane Hugo, habitat modification efforts to create suitable nest sites for the

parrots were intensified. Parrots have accepted some of the modified cavities and physical damage produced by fighting has not been observed in recent years.

Habitat quality

There are some indications that habitat presently occupied by Puerto Rican parrots in the CNF may be suboptimal and that the parrots retreated to this area because preferred lowland habitat was destroyed. It is also possible that parrots always occupied this area and that the remaining parrots originated from this stock. Habitat characteristics that may be stressing the parrots are food quality and weather conditions.

Although parrots previously migrated seasonally to lowland forests, the remaining flock's movements and utilization of the environment appear to be conservative (Kepler and Kepler 1970, Snyder *et al.* 1987). Parrots occasionally leave the western edge of the forest to forage in the lowlands (Rodriguez-Vidal 1959, Snyder *et al.* 1987), but they are largely restricted to the sierra palm and palo colorado zones of the CNF. Snyder *et al.* (1987), suggested that the parrot's close association with the palo colorado forest may be related to the availability of nest sites there, and that its present limited distribution should not be considered historically typical of the species. The forest zones currently used by parrots have a low plant species diversity compared to other areas traditionally used by parrots.

Parrots consume a large variety of fruits, seeds, and leaves. The most commonly eaten foods are dominant in the vegetation. These observations seem to indicate that food is not a limiting factor for the Puerto Rican parrot. However, nutrient composition of the diet of wild parrots and seasonal fluctuations of food supply have received little attention. In addition, the phenology of most plant species of importance to the parrot has not been rigorously studied within the bird's current range.

The weather of the present parrot range in the Luquillo Mountains is extremely wet when compared to average conditions for the historical range of the parrot. Exposure to rain is apparently a primary limiting factor in the adequacy of nesting cavities (Snyder *et al.* 1987). Both chicks and eggs have been lost to rainwater entering nest cavities. Recent management techniques have adequately reduced the incidence of such events.

Direct human impacts:

Nest-robbing

Nest robbing has unquestionably been one of the most severe stresses on the parrot population in this century. It continued in the Luquillo mountains until the late 1960's. There is good evidence that, during the 1930's, 1940's, and 1950's, parrots were taken from at least four of the five traditional nesting areas, apparently resulting in a major

impact on the number of fledglings produced (Snyder *et al.* 1987). Irrespective of the loss of nest trees to timbering and charcoal production, the robbing of nests was probably adequate in itself to have caused a steep decline of the species. There is evidence that some nest cavities were cut open and nest trees were cut down to obtain nestling parrots. Moreover, the popularity of *Amazon* parrots as pets maintain the nest robbing threat.

Crop protection and hunting for food

Until early in this century, parrots were considered crop pests and were persecuted as such in some areas. However, shooting of the birds was regionally spotty, and there is little evidence of widespread shooting in the Luquillo Mountains region. In northwestern Puerto Rico, the parrots were once commonly shot as table items and were considered excellent fare. The same was true of the parrot populations that once existed on Culebra and Vieques. The species is a noisy, slow-flying bird, extremely vulnerable to shooting, as is true of most parrots. There can be little doubt that shooting has been a major cause of decline of a number of West Indian species now close to extinction.

Other disturbance factors:

Several other activities and changes in the CNF may have impacted the parrot. Hard data verifying these impacts are scarce.

Increased recreation

Construction of the El Yunque Recreation Area in the 1930's and subsequent construction of additional facilities resulted in dramatic increases in recreational use of the CNF. By 1955, the CNF received 65,000 visitors annually. Presently, this has increased to more than 1 million visitors annually. Although most visitor use is concentrated along the roads and in developed picnic areas, dispersed activities along hiking trails have increased. Whereas these dispersed activities near nest sites are known to adversely impact parrots, the effects of centralized recreation on parrots is unknown.

Road construction

Highway PR-191 was completed in 1937 and bisects parrot range at CNF from north to south. The 3-mile (5-km) East Peak road was constructed during the period of 1960 to 1966. It follows a ridge over which daily parrot migrations occurred seasonally, and is adjacent to a previous nesting area no longer used by parrots. Although construction occurred concurrently with a major decline of the parrot population, there is no evidence of a causal relationship.

Guerrilla warfare maneuvers

Military personnel moved through and camped in areas used by parrots during Vietnam War-related exercises between 1966 and 1971. One eyewitness account of a 10-day

operation in 1966 reported that helicopters temporarily evicted what may have been the entire parrot flock from one part of the forest (Victor Marquez, pers. comm.).

Radiation experiment

A 10,000 Curie Cesium source was exposed in the Quebrada Sonadora watershed, El Verde, in the CNF from January 19 to April 27, 1965. This w as part of an Atomic Energy Commission experiment to determine the effects of high intensity radiation on rain forest vegetation. After this radiation exposure, low activity radioisotope solutions were directly applied and injected into various compartments of the forest in the same area (Odum 1970). A radiation dose of 5,000 roentgens accumulated in the perimeter 30 m from the Csl37 source (Odum 1970), and isotopes were detected in the foliage of injected trees (J. Colon, pers comm.). Parrot food trees, including *Dacryodes excelsa* and *Prestoea montana*, were present in the radiation and tracer study areas.

Two active parrot nests were located 0.5 km (0.3 miles) of the radiation area during these experiments. Additionally, parrots were regularly seen flying over and foraging in the vicinity of the radiation source. It is possible that foraging parrots received radiation contamination by direct exposure and/or ingestion of contaminated *D. excelsa* fruits, and that this could have resulted in direct mortality or impeded reproductive ability. It cannot be determined if the sharp parrot population decline during the mid-1960's is related to this experiment.

Microwave radiation

There is public speculation that microwave radiation being emitted from El Yunque and East Peaks might have affected the parrot. Impacts of microwave radiation are unknown.

Natural Enemies:

Competitors

Honeybees (*Apis mellifera*) and pearly-eyed thrashers (*Margarops fuscatus*) compete with parrots for nest sites. Although there is no record of honeybees evicting nesting parrots, they take over nest cavities after the parrot breeding season. Late nesters may be particularly vulnerable to honeybees. In 1994, one bee swarm temporally took over a nest with two chicks. Rapid intervention of a nest guardian and subsequent cleaning actions saved the nest. The chicks were taken to the aviary and replaced with Hispaniolan parrot chicks after the nest was cleaned. Eventually the original Puerto Rican parrot chicks were returned and subsequently fledged from the nest. Nevertheless, bees can exclude parrots from potential nest sites and, therefore, are an important factor limiting nest site availability (Wiley 1980, Wiley 1985, Snyder *et al.* 1987, Lindsey *et al.* 1994). As indicated above, present management techniques enable managers to create

adequate nest cavities for the Puerto Rican parrots. Unfortunately, most of these modified cavities are taken by honeybees each year. Often it has been difficult to maintain each of the modified or natural cavities available for nest prospecting parrots. The threats associated with bees in parrot areas are believed to be even more serious since the arrival of Africanized honeybees.

Pearly-eyed thrashers, which were not present in notable numbers in the CNF until the 1950's, harass breeding parrots to obtain nest cavities. Prior to 1973, when efforts were initiated to counter thrasher attacks, parrots were known to be ousted by thrashers at least five times. Thrashers will also attack parrot eggs and nestlings while exploring unattended nests (Snyder and Taapken 1977). Since 1976, modifying nest sites for parrots and installing thrasher-preferred nest boxes close to parrot nests have controlled thrasher depredations. However, the thrasher management policy has not been consistent over the years. Thrasher incidents have been responsible for the lost of some eggs and chicks in recent years. Consistent management protocols need to be developed and implemented to reduce the impact of thrashers on the reproductive success of wild parrots.

Predators

Rodriguez-Vidal (1959) noted parrot nest predation by the roof rat (*Rattus rattus*) and cat (*Felis catus*). Strong evidence suggests that red-tailed hawks (*Buteo jamaicensis*) will also enter nest cavities to kill parrots (Wiley 1980) and probably prey on free-flying Puerto Rican parrots (Santana and Temple 1984, Snyder *et al.* 1987). Two recent red-tailed hawk conceivable depredations indicate that this species may pose a serious threat to the parrot.

Other possible predators that occur in the CNF are a Puerto Rican subespecies of broad-winged hawk (*Buteo platypterus brunnuscens*), peregrine falcons (*Falco peregrinus*), and Puerto Rican boas (*Epicrates inornatus*). Predation of parrots by these species is speculative. There is no evidence suggesting significant impact by these species at this time. The Puerto Rican broad-winged hawk, itself endangered, is relatively small, as compared to the red-tailed hawk, and may not be a significant threat to the parrots. Puerto Rican boas are not very abundant in CNF, but their densities are higher in the lowlands. Some observations suggests that they may be capable of predating both nestlings and incubating females (Snyder *et al.* 1987). Boas are major predators of parrot nestlings in Jamaica and Dominica (J. Wunderle, U.S. Forest Service, pers. comm.). Thus, Puerto Rican boas may become an important factor once parrots are reintroduced in lowland forests.

Parasites

Parrot nests sometimes become infested with parasites such as the botfly (*Philornis pici*) and the soldier fly (*Hermetia illucens*). Philornis ectoparasitic larvae significantly retard development and can result in death of parrot nestlings (Arendt 1985, Snyder *et al.* 1987). Soldier fly larvae are implicated in the death of at least one, and possibly two, nestlings. Philornis parasites have affected both nestling and adult parrots at the Vivaldi Aviary.

Exotic avian species

The introduction of exotic avian species to Puerto Rico increases the risk of disease spreading into the Puerto Rican parrot population. Exotic *Amazona* species pose the additional threats of interbreeding and competition.

Hurricanes:

The Association for Tropical Biology (1991) dedicated a special issue of *Biotropica* to the effects of severe hurricanes on tropical forest ecosystems. The dependence of parrots on natural vegetation for food, shelter, and nest sites makes them particularly vulnerable to hurricane impacts (Wiley and Wunderle 1993). A single, strong hurricane can potentially wipe out the entire wild population. Hurricanes that occasionally sweep over Puerto Rico cause severe parrot population reductions, not only because of the physical battering such storms cause, but also because of the destruction of habitat and food supplies and perhaps increased predation rates.

Hurricane Hugo demonstrated that severe tropical storms are, perhaps, the most dangerous natural enemy of the wild Puerto Rican parrots. Major hurricanes that hit the Luquillo Mountains earlier in this century caused extensive defoliation and loss of fruit within the forest, forcing surviving parrots into the lowlands to search for food. Given the frequency of hurricanes in Puerto Rico, most of the recent population decline of the Puerto Rican parrot cannot be attributed their impact. Nevertheless, hurricane Hugo had severe implications on the wild Puerto Rican parrot population.

Impact of recent hurricanes

Hurricane Hugo

On September 18, 1989, Hugo, a category 4 hurricane, struck the northeastern part of the CNF with sustained winds of 166 km/hr (100 mi/hr) and occasional wind gusts of up to 230 km/hr (138 mi/hr) (Scatena and Larsen 1991, Khadga *et al.* 1992, Walker *et al.* 1992). No hurricane of that magnitude had passed over CNF since 1932. Wind damage to vegetation in some areas reduced tree species from 31 to 8 (i.e., standing individuals of only eight species were found after the hurricane) (Khadga *et al.* 1992).

Damage to vegetation caused steep declines of nectarivorous and frugivorous bird populations (Waide 1991), although most species showed rapid recovery (Wunderle 1996).

Although the Luquillo Aviary suffered structural damages, not a single captive bird was lost to the hurricane. The wild population, however, suffered heavy losses. Intensive large scale efforts to estimate the number of surviving wild parrots indicated the wild population was reduced to roughly half (23) the number of individuals counted before the hurricane. The remaining individuals suffered from the effects of reduced food availability and cover, which augmented the risk of predation by red-tailed hawks. The nesting habitat and cavities also suffered substantial damage.

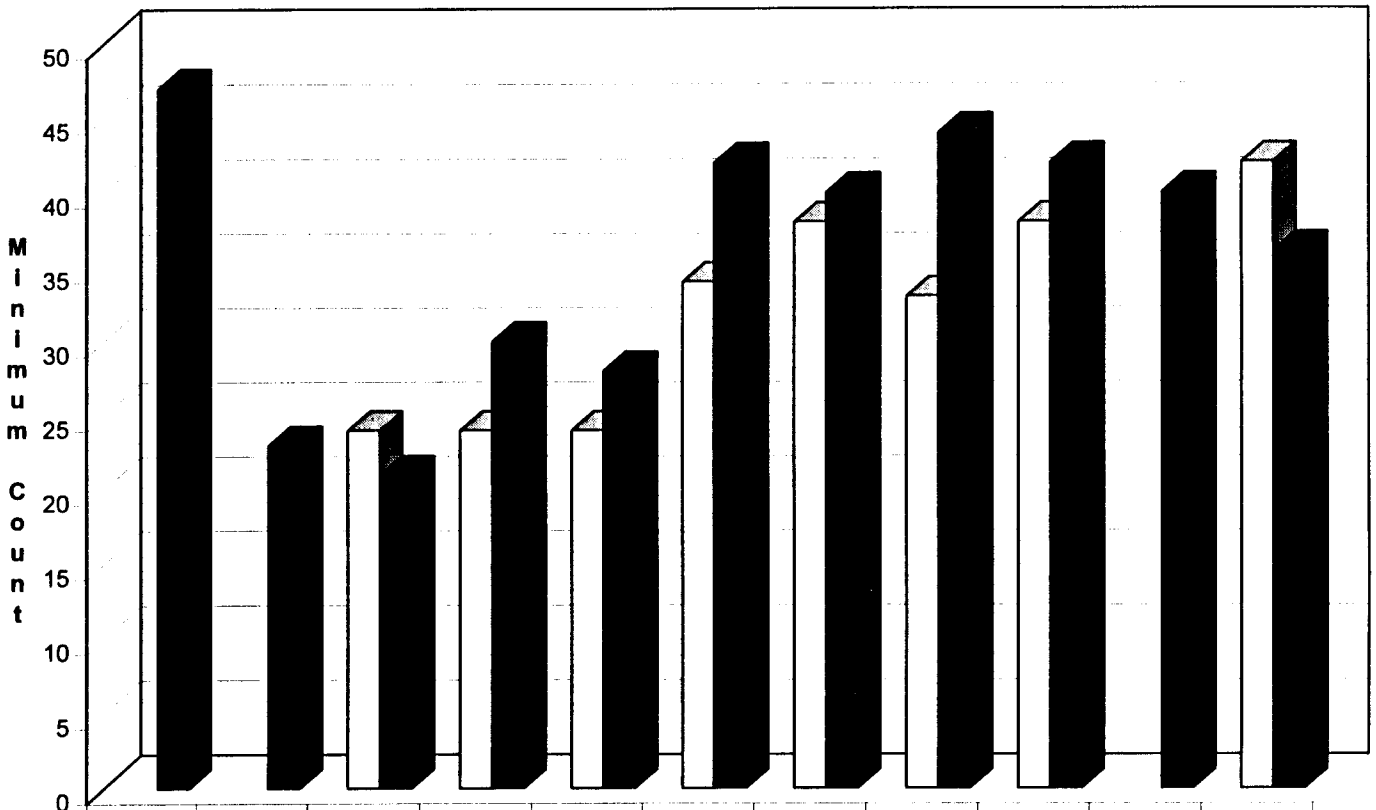
In 1990, the first nesting season after the hurricane, three parrot pairs nested, producing only two fledglings. Details of the wild population nesting seasons after hurricane Hugo are provided in Appendix A. In 1991, the number of nesting pairs increased, producing a total of 7 fledglings. In the following years, the largest number of Puerto Rican parrot chicks in the history of the recovery program fledged in the wild. The largest numbers of fledglings so far were produced in 1993 (15), 1994 (14) and 1995 (15). These numbers included four chicks fostered from the Luquillo aviary in 1993, two fostered in 1994, and three fostered in 1995.

Recovery of the wild population has been relatively quick. In 1993, the number of individuals in the wild population was 42 (89.4% of the population before Hugo; Figure 2). Some biologists attribute the quick recovery to positive changes in the forest triggered by the hurricane (Meyers *et al.* 1993). Managers credit the recovery to the intensive management efforts undertaken after the hurricane (Vilella and Arnizaut 1994). Critics of the recovery program have indicated that the population increase is actually slower after the hurricane given the number of chicks fledging every year (Figure 3). Still others have pointed out that quick recovery after natural catastrophes is a normal phenomenon in wild bird populations. These explanations are not mutually exclusive. Positive effects of hurricane Hugo, combined with effective intensive management may have been responsible for the increase in the number of nests and fledglings during the recent years. Other unknown negative effects may be responsible for the increased mortality of fledglings, thus increasing the number of young necessary for a smaller population increase. Nevertheless, the high degree of resiliency demonstrated by the wild Puerto Rican parrot population is the most encouraging indication of recovery potential. Perhaps as important is the fact that the Puerto Rican wild population has retained the ability to recover quickly from a natural disaster after going through such a severe bottleneck.

Despite the quick recovery after a natural catastrophic event, the overall recovery of the species has been extremely slow. The number of individuals has remained below 45 for more than 35 years. Since 1995, the number of individuals in the wild

population stabilized to around 40 and no substantial increase in population has been detected since then. The factors precluding continued increase in the number of wild Puerto Rican parrots, even when excellent reproductive potential is evident, remain unknown.

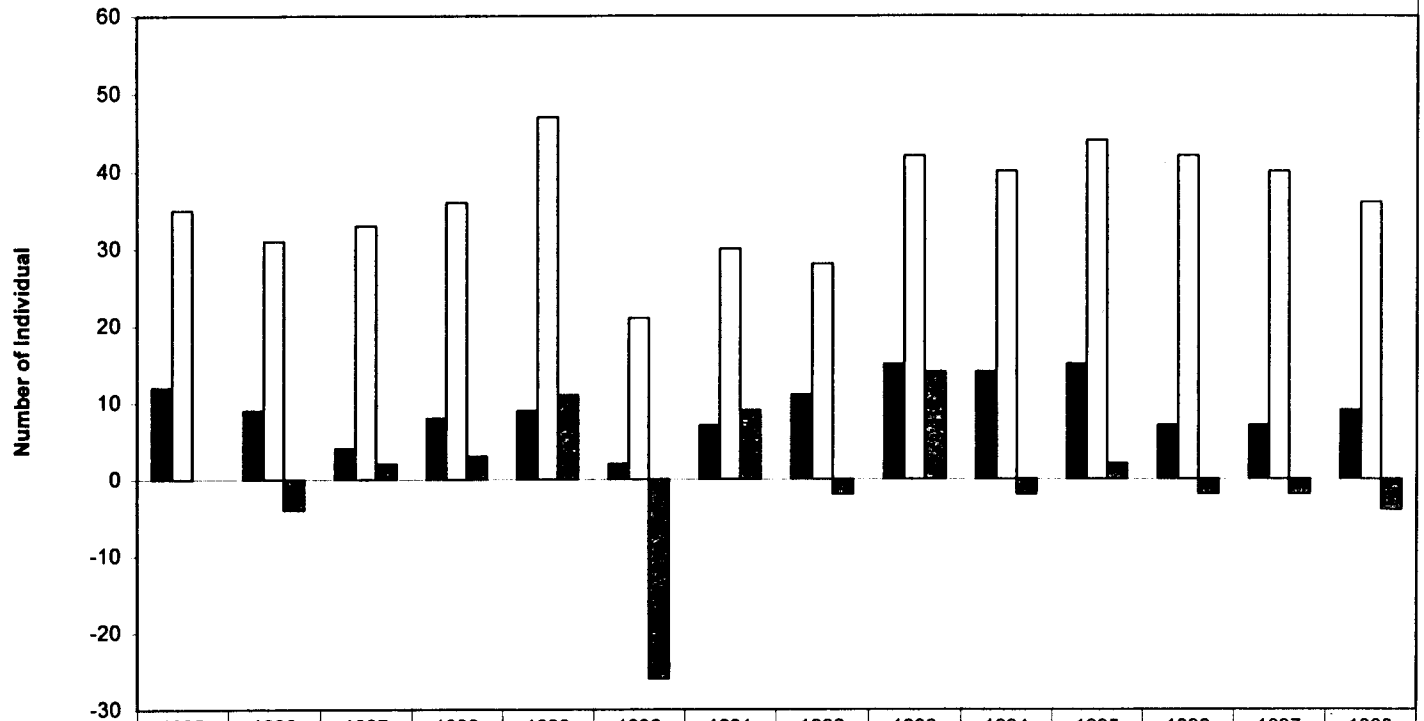
Figure 2- Puerto Rican Parrot Wild Population Counts (1989-1998)



	1989	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Pre-Breeding			24	24	24	34	38	33	38		42
Post-Breed	47	23	21	30	28	42	40	44	42	40	36

Year

Figure 3- Puerto Rican Parrot Population Changes (1985-1998)



	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
■ Number of Fledgelings	12	9	4	8	9	2	7	11	15	14	15	7	7	9
□ Minimum Counts	35	31	33	36	47	21	30	28	42	40	44	42	40	36
■ Population Change	0	-4	2	3	11	-26	9	-2	14	-2	2	-2	-2	-4

Hurricane Hortense

Early in the 1996 hurricane season, hurricane Hortense passed to the south of Puerto Rico with heavy rains that caused numerous landslides in CNF. No impact on the Puerto Rican parrot wild population was detected after the hurricane. The Luquillo Aviary, however, was isolated by the landslides and the parrot cages suffered significant structural damages. One female Hispaniolan parrot was killed by the winds and rains. The Vivaldi Aviary had minimal damage and no parrots lost. The actual impact on both wild and captive flocks was minimal. Nevertheless, rehabilitation and reconstruction activities tied up most of our Río Grande Field Office and U.S. Forest Service resources during the following months.

Hurricane Georges

On September 21, 1998, hurricane Georges inflicted substantial damage to the CNF. This hurricane struck the entire Puerto Rican archipelago and the eye passed to the south of CNF with sustained winds of up to 180 km/hr (112 mi/hr). Immediate effects of hurricane Georges in the wild Puerto Rican parrot population were not apparent, at least in terms of numbers of individuals. A minimum of 40 wild individuals were counted before the hurricane, and 36 wild parrots were detected 1 week after the hurricane. The deep valleys in which the wild population has been concentrating during recent years were not hit as severely as the eastern and southern slopes of CNF. However, as observed after hurricane Hugo, more chronic effects may be produced by the reduction of foraging habitat and, perhaps, increased predation rates impacting the wild population during the 1999 breeding season. Nevertheless, as of the beginning of January 1999, the numbers of wild Puerto Rican parrots counted during population surveys remained at 35 to 36 individuals (Pablo Torres, U.S. Fish and Wildlife Service, pers. comm. 1999). No mortalities at either aviary were recorded.

Summary

The major adverse forces thought to have brought about the dramatic decline of the Puerto Rican parrot are the following:

1. Habitat destruction: deforestation and selective cutting of mature, cavity-bearing trees.

2. Habitat quality, possibly inadequate diet, and wet environmental stresses.

3. Direct human impacts, especially nest robbing, honey harvesting, and shooting for food and to protect crops.

4. Natural enemies: competition, predation, and parasitism by various natural enemies, especially honeybees, pearly-eyed thrashers, red-tailed hawks, and warble flies.

5. Random catastrophic events such as hurricanes.

The decline is not due to any one factor but is a result of many factors acting together, some tending to depress reproduction in the species and others tending to increase mortality. Nevertheless, the wild population has shown tremendous resiliency and potential for recovery.

Conservation efforts

The Puerto Rican parrot received indirect benefits from land ownership and land management policies before direct efforts were expended on its behalf. More recently, increasingly intense efforts have been taken to protect and recover this species. Conservation efforts have been and continue to be a complex blend of research and management tasks. These efforts started with surveys that discovered the critical status of the species, proceeded to research projects that identified impacting factors, and continued to management actions to counter these impacting factors. They can be summarized in the following categories.

Land Ownership and Land Management

Most of the presently occupied parrot habitats remained largely uncut and in Spanish Crown hands until the United States occupation of Puerto Rico in 1898. These lands (12,394 acres [5,010 ha]) were transferred directly to the United States government and, in 1903, were proclaimed the Luquillo Forest Reserve, administered by the U.S. Forest Service. Between 1931 and 1954, land acquisition, predominantly of cut-over farmlands, doubled the size of the Reserve. The Puerto Rican government declared this area, renamed the Caribbean National Forest in 1935 (Figure 4), a Wildlife Refuge in 1946. The CNF is currently 27,846 acres (11,274 ha) in size, and the Luquillo Mountains encompass 48,550 acres (19,656 ha).

During the past several decades, those parts of the Luquillo Mountains outside the CNF have generally become more forested, due to a decline in agricultural practices on former pastures and farmlands. This has also occurred at lower elevations within the CNF through natural regeneration and reforestation practices. Since the mid-1950's, when the parrot population was determined to number only 200 birds, U.S. Forest Service land management activities have concentrated on plantation management, facility

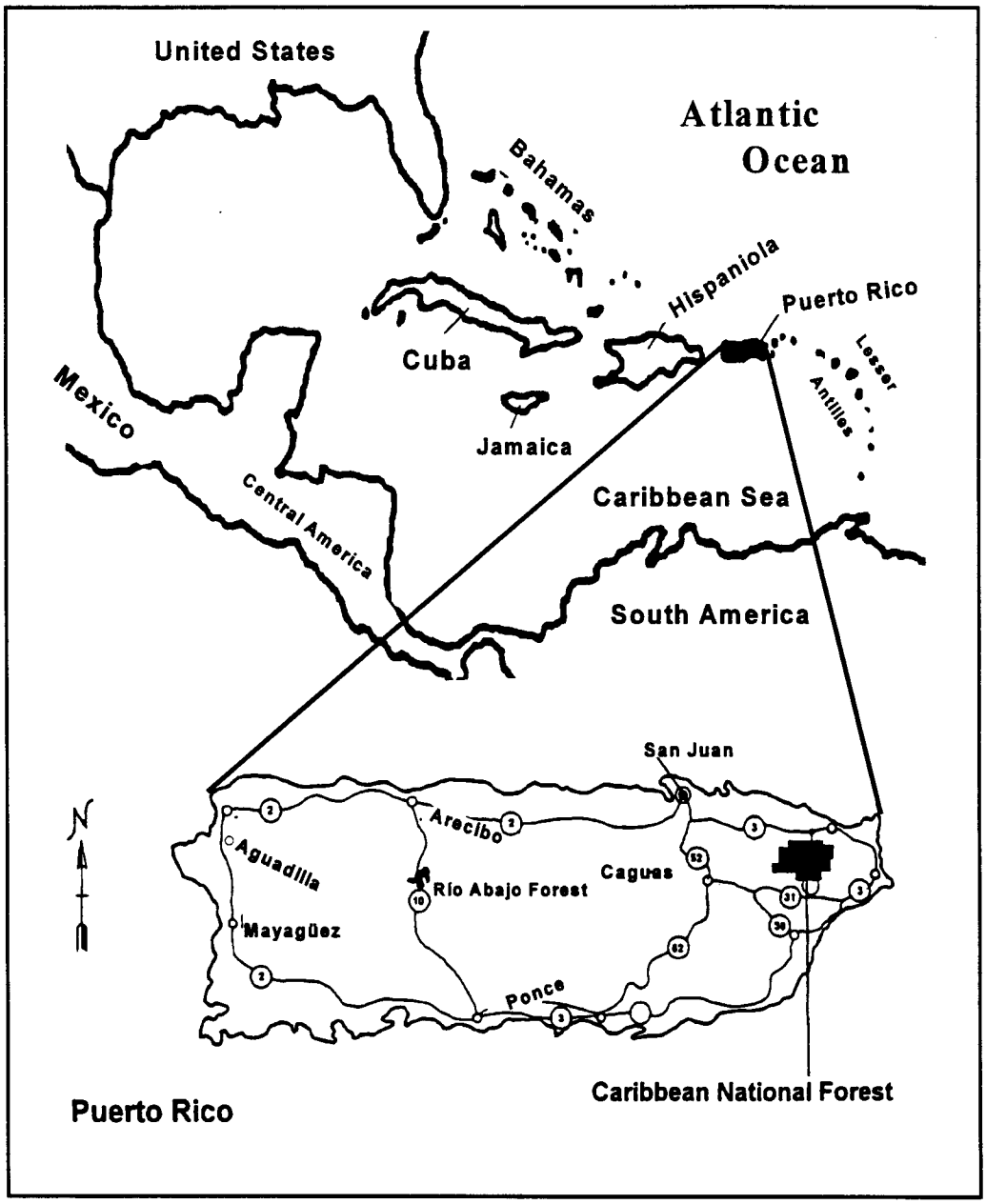


Figure 4. Map of the Caribbean Showing the Location of the Caribbean National Forest (CNF) and the Río Abajo Commonwealth Forest in Puerto Rico.

development, recreation management, and Puerto Rican parrot recovery activities. The latter include locating parrot nest sites, nest improvements, parrot range determination, and ensuring that other future forest management actions do not adversely affect parrots or parrot habitats. In 1986, a Caribbean National Forest Land and Resource Management Plan was approved, which gives direction for long-term parrot habitat maintenance and improvement, and places high emphasis on Puerto Rican parrot recovery (Figure 5).

The Río Abajo Commonwealth Forest is the proposed site for establishing the second wild Puerto Rican parrot population (Figure 4). The Reconstruction Administration established the forest in 1935. The DNER currently administers these lands (5,780 acres [2,340 ha]). Approximately 6,720 acres (2,720 ha) of forested lands surround the forest and have been recommended for acquisition. Scientists conducted nest cavity availability and phenology studies during the early 1980's (Cardona *et al.* 1986). Recently, construction of highway PR-10 bisected the Río Abajo Commonwealth Forest. Habitat deterioration and the implications of the construction of PR-10 on Río Abajo as a site to establish a second wild population still need to be evaluated.

Ongoing studies are investigating bird/habitat associations on private and public lands, including suitability for the reintroduction of Puerto Rican parrots. The results and conclusions of these studies will help develop criteria for the selection of areas and elaborate strategies for the conservation of optimal habitat. Land acquisition, partnerships with government and non-government organizations, and private lands initiatives can be promoted to maintain adequate parrot habitat in those areas.

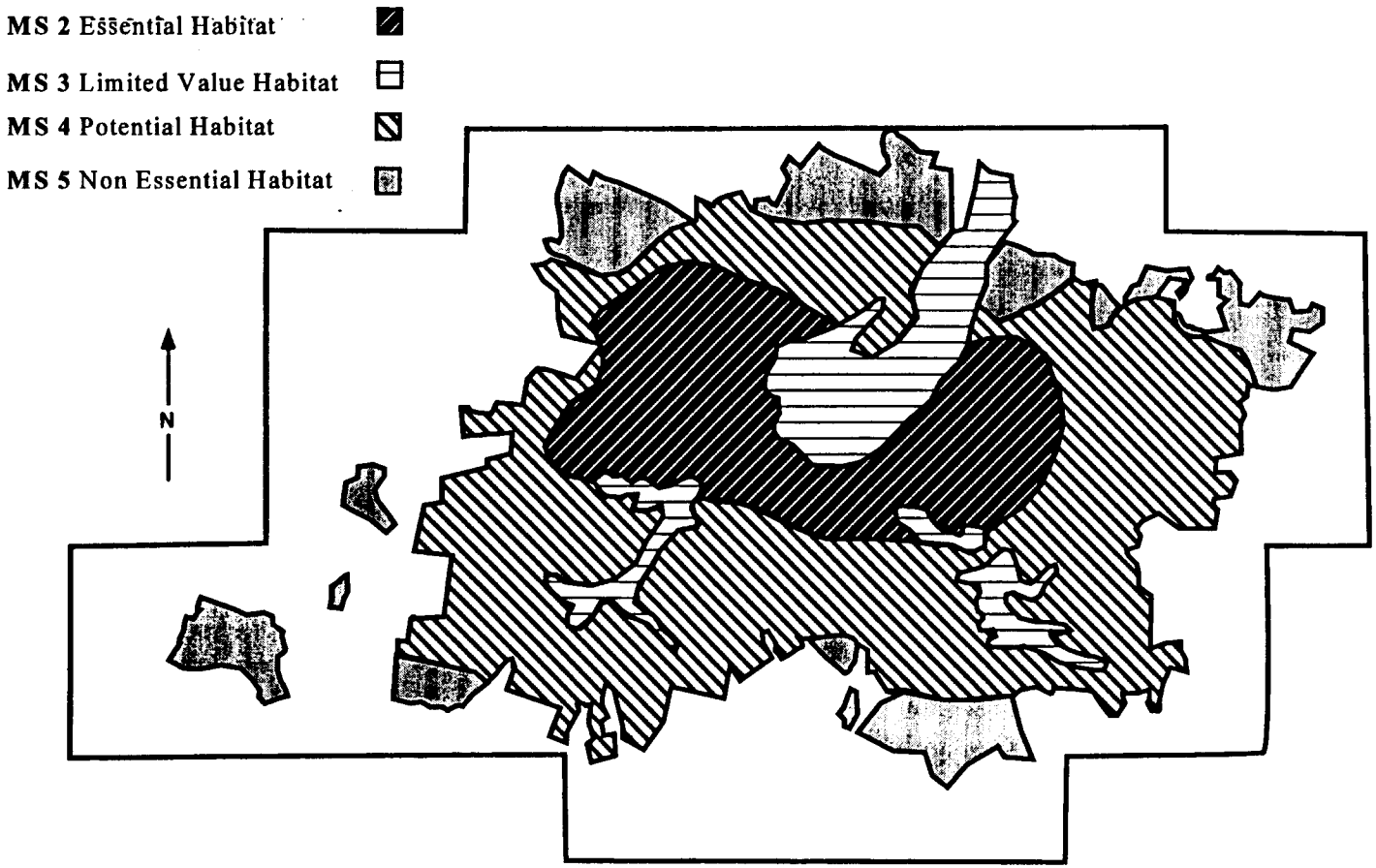
Legal Protection

The Puerto Rican parrot has been protected by law throughout the island for probably more than a century. In 1946, Puerto Rico Commonwealth regulations (see Snyder *et al.* 1987) prohibited nest robbing and hunting in the CNF. The parrot was afforded further legal protection in 1967, when the Secretary of the Interior declared it to be an endangered species. The Wildlife Law of 1970 and the Regulation to Govern the Management of Threatened and Endangered Species in the Commonwealth of Puerto Rico of 1985, both Commonwealth regulations, also provided legal protection for the parrot. Effective enforcement of laws and regulations was not achieved until 1970, shortly after the Federal and Commonwealth governments began a continuous recovery program of management and research. Since 1974, regular law enforcement patrols, along with surveillance by parrot program workers, have practically put an end to poaching.

Research

The Puerto Rico Department of Agriculture, with U.S. Forest Service and U.S. Fish and Wildlife Service support (Rodriguez-Vidal 1959), conducted the first efforts to census

Figure 5. Puerto Rican Parrot Management Situations (MS) in the Caribbean National Forest



wild flocks, locate nest sites, and study nesting success from 1953 to 1956, and in 1966. More intensive and continuous research efforts began in 1968, one year after the parrot was classified as endangered. The Puerto Rico Department of Natural Resources (which replaced the Puerto Rico Department of Agriculture on the project in 1972), U.S. Forest Service, and U.S. Fish and Wildlife Service, with 3-year support from the World Wildlife Fund-U.S., began systematic censuses and dawn-to-dark observations of nesting activities from blinds. These efforts produced important information, including identification of many stress factors affecting the population and development of effective measures to counter them. Research provided data on nest and nest site requirements, mortality factors, and reproductive biology. The dramatic increase in nesting success and the establishment of a reproducing captive population are a direct result of research efforts.

Efforts to Increase Nesting Success

Before 1973, nesting success of the wild population ranged from 11 to 26%. Research efforts identifying the primary stress factors led to intensive management activities that, since 1973, increased the average nesting success rate to 81%. Egg production and success of both wild and captive populations from 1979 to 1989 are summarized in Figures 6a and 6b, and from 1990 to 1998 in Figures 7a and 7b.

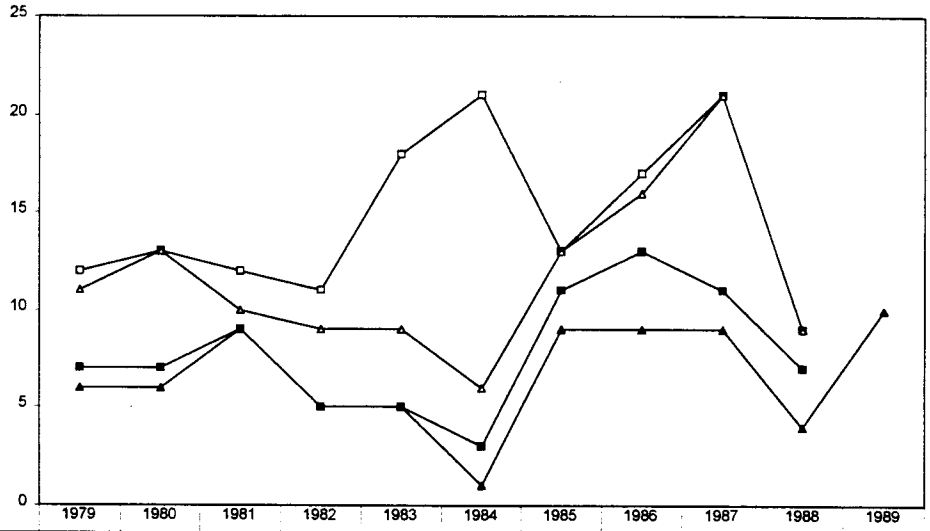
An apparent increase resulted from improving the quantity and quality of available nest sites and controlling enemies. Since 1976, all pairs of parrots have utilized either created or rehabilitated nest sites. These nests were designed or modified to prevent entry of water and to discourage entry of predators and competitors.

Control of Enemies

Routine maintenance of nest cavities, habitat improvements, and nest guarding were and still are the primary techniques utilized to counter parrot enemies. The problem of pearly-eyed thrasher takeovers of parrot nests was successfully resolved by converting nests into deep, dark structures with bottoms not visible from the entrances, characteristics repellent to thrashers, but not to parrots. Also, thrashers were provided nest boxes attractive to them, adjacent to parrot nest sites. By virtue of their aggressive territoriality, the thrasher pairs that occupy the alternative sites serve as parrot nest guards, excluding other thrashers prospecting for nest sites from the vicinity of parrot nests.

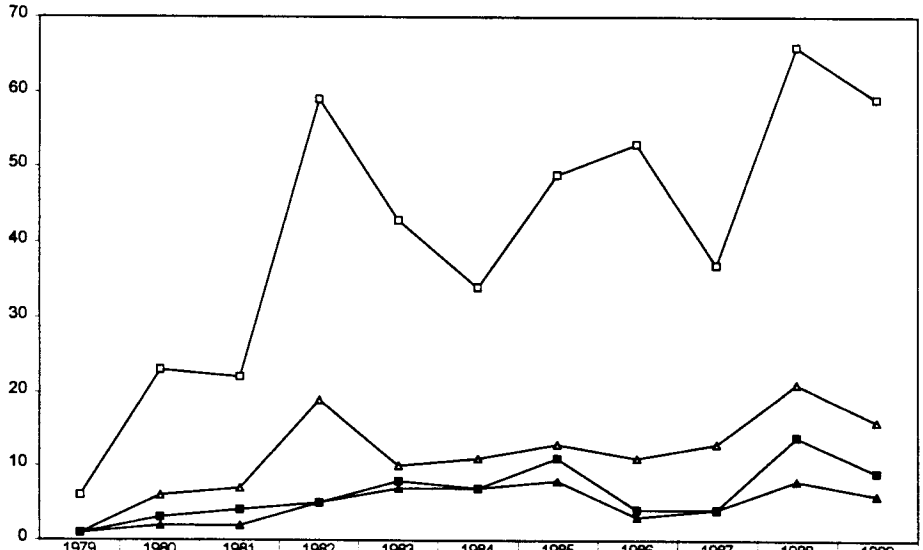
Intensive swarm trapping efforts in breeding areas and covering nest entrances during summer, after the parrot breeding season, when most honeybee swarming takes place, reduce honeybee occupation of traditional and potential parrot nest sites. Hives, which become established in parrot nests, are routinely removed during the non-breeding season. Temporary closure of nest entrances has proved to be an effective method with no known adverse effects on the parrots. After the impact of hurricanes, both bee

Figure 6a. Egg Production and Success of Wild Puerto Rican Parrots (1979-1989)



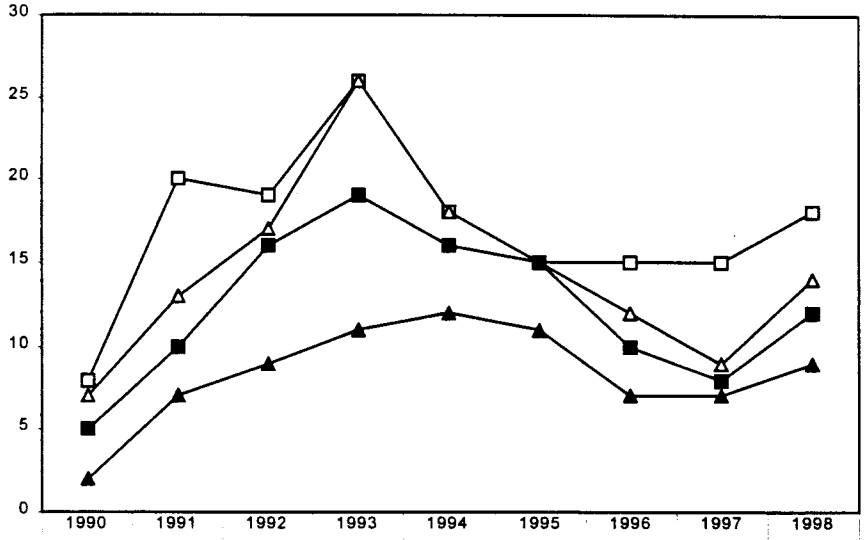
	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
No. Eggs	12	13	12	11	18	21	13	17	21	9	
No. Fertile	11	13	10	9	9	6	13	16	21	9	
No. Hatched	7	7	9	5	5	3	11	13	11	7	
No. Survive to Fledge	6	6	9	5	5	1	9	9	9	4	10

Figure 6b. Egg Production and Success of Captive Puerto Rican Parrots (1979-1989)



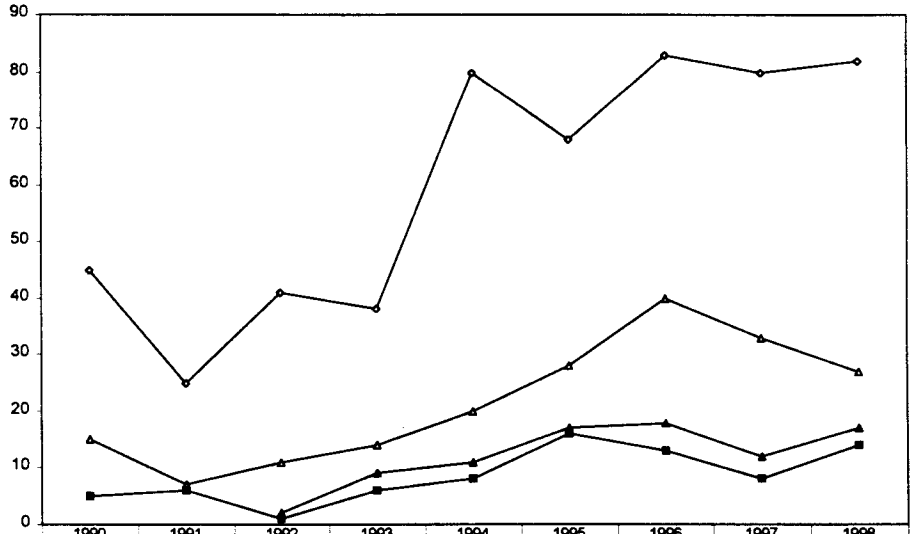
	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
No. Eggs	6	23	22	59	43	34	49	53	37	66	59
No. Fertile	1	6	7	19	10	11	13	11	13	21	16
No. Hatched	1	3	4	5	8	7	11	4	4	14	9
No. Survive to Fledge	1	2	2	5	7	7	8	3	4	8	6

Figure 7a. Egg Production and Success of the Wild Puerto Rican Parrot Population (1990-98)



	1990	1991	1992	1993	1994	1995	1996	1997	1998
No. Eggs	8	20	19	26	18	15	15	15	18
No. Fertile	7	13	17	26	18	15	12	9	14
No. Hatched	5	10	16	19	16	15	10	8	12
No. Survive to Fledge	2	7	9	11	12	11	7	7	9

Figure 7b. Egg Production and Success of the Captive Puerto Rican Parrot Flock (1990-1998)



	1990	1991	1992	1993	1994	1995	1996	1997	1998
No. Eggs	45	25	41	38	80	68	83	80	82
No. Fertile	15	7	11	14	20	28	40	33	27
No. Hatched			2	9	11	17	18	12	17
No. Survive to Fledge	5	6	1	6	8	16	13	8	14

swarming and parrot nesting behavior may by disrupted, thus increasing the need for close monitoring to avoid deleterious encounters.

The primary method of combating the warble fly threats has been frequent inspections of parrot chicks to determine severity of parasitism and the need for medical treatment (primarily surgical removal of maggots) of affected chicks. Although labor intensive and not an optimal means of reducing this problem, these efforts have saved a number of parrot chicks from certain death. Currently, there are some substances that could be injected to eliminate warble flies from infected chicks. However, more information is needed before they can be used as a regular measure to protect nestlings.

Constriction of nest entrances and nest guarding have reduced raptor threats. The use of poison baits has discouraged rat depredation.

Establishment of Captive Stocks

The Luquillo Aviary captive breeding program was established in 1973. Initially, researchers took eggs from the wild and hand-reared them in the aviary, but since 1976, most acquisitions have been chicks salvaged from a variety of mishaps in the wild. Project personnel salvaged 10 birds in the captive flock that would not have survived in the wild. Sometimes, birds produced in the Luquillo Aviary were swapped with wild chicks to ensure representation of possible new genotypes in the aviary. Historically, all sexually mature captive females had laid eggs, but only a small proportion of the heterosexually-paired females had laid fertile eggs. The recent numbers of both birds and fertile pairs in captivity have increased thanks, in part, to the establishment of a second captive flock (see figures 6b and 7b).

After many years of planning, the DNER finished construction of the José L. Vivaldi Memorial Aviary in Río Abajo in 1989, achieving major advances to establish a second captive flock. The DNER staff refined their skills and demonstrated their ability to manage a captive flock using Hispaniolan parrots during the first 4 years. In 1993, twelve Puerto Rican parrots were transferred from Luquillo to the Vivaldi Aviary. In 1995, a second group of 13 parrots was transferred. By then, the Vivaldi Aviary had already produced two Puerto Rican parrot fledglings. Since then, the Vivaldi Aviary has contributed to the recent high numbers of birds produced in captivity. In 1996, for the first time, a chick born in the Vivaldi Aviary was fostered and subsequently fledged from a wild nest in CNF. That event definitively established the versatility and importance of the Vivaldi Aviary. Further, the chick was fathered by a 27 year-old male, the only existing captive wild caught parrot in the aviaries. This aggressive male had been extremely difficult to breed at the Luquillo Aviary.

As of November 1998, the captive flock consisted of 105 Puerto Rican parrots (53 in the Vivaldi Aviary and 52 in the Luquillo Aviary). The current captive flock composition is

42 adult males (23 Luquillo and 19 Vivaldi), 49 adult females (25 Luquillo and 24 Vivaldi), and 14 young of the year (4 Luquillo and 10 Vivaldi). A bird over a year old is considered an adult for the purposes of flock composition. In the 1998 breeding season, 9 pairs laid fertile eggs (4 Luquillo and 5 Vivaldi).

Since the beginning of the captive breeding projects, captive flocks of Hispaniolan parrots were established as part of both aviaries. This stock of surrogate animals is extremely important for testing potentially risky techniques being considered for use on the Puerto Rican parrot. These include techniques such as marking procedures, multiple clutching, sequential removal of eggs, and telemetry studies. Hispaniolan parrots have also been used as incubation surrogates and foster parents for Puerto Rican parrots. Their eggs and chicks have been used as emergency replacements for wild Puerto Rican parrot eggs and chicks threatened by various factors. Also, Hispaniolan parrot eggs and chicks are used to assess the Puerto Rican parrot new pairs' aptitude for incubating their eggs and raising their own young.

Genetic Management

Both captive flocks provide insurance against catastrophes and a vital means to bolster the existing wild population. Also, they will be used to initiate the second population. The two flocks will be managed to minimize loss of heterozygosity through open exchanges. The new pair bonding management scheme attempts to produce pairs of the most distantly related individuals. Any parrot targeted for reproduction is offered a choice of at least 3 individuals of equivalent kinship values. The choice individuals can have close genetic relationships, but all need to be as distantly related as possible to the target bird. This scheme increases the probability of producing genetically, as well as behaviorally, compatible pairs.

Information and Education

The Puerto Rican parrot and its plight continue to receive both local and national publicity in newspapers and popular magazines. A film on parrot conservation efforts (with both English and Spanish versions) has been completed, but needs updating. Snyder *et al.* (1987) published a monograph on the Puerto Rican parrot, covering the bird's natural history and conservation efforts between 1946 and 1985. The Puerto Rican parrot recovery program personnel are in the process of developing a more comprehensive public education plan.

Interagency Cooperation

Interagency cooperation has been, and remains, a crucial need, if parrot recovery is to be successful. Cooperation began in the 1950's, when Federal and Commonwealth agencies conducted the first parrot surveys. Agreements between the U.S. Forest Service and U.S.

Fish and Wildlife Service, signed in 1968 and 1973, provided for cooperation in research efforts and construction of the captive propagation aviary. These memoranda, updated in 1983 to include the participation of the Puerto Rico Department of Natural Resources, and the Puerto Rican Parrot Recovery Plan (approved in 1982), provided the direction for coordinated recovery efforts. Representatives from the three agencies met in 1984 and revised the Memorandum of Understanding, which created the Puerto Rican Parrot Working Group. This group met bi-annually to review progress, plan future research and management, resolve problems, decide overall research and management goals, and to agree on future contributions to the cooperative effort by each agency. The active participation of the Working Group in determining recovery priorities was beneficial to the overall program. Presently the functions of the Working Group are carried out by the Puerto Rican Parrot Technical Committee, a subcommittee of the Puerto Rican Parrot Interagency Committee. This committee is composed of members representing the DNER, the U.S. Forest Service, and the U.S. Fish and Wildlife Service.

In 1990, the Puerto Rican parrot recovery program was transferred from the research branch of the U.S. Fish and Wildlife Service to the management branch. This event lead to the eventual creation of the Puerto Rican Parrot Field Office, presently named Río Grande Field Office (RGFO). The RGFO is responsible for all aspects of the management of both the Luquillo captive flock and the wild population. Also, the RGFO is responsible for interagency coordination, and the coordination of all monitoring, management, and research efforts of the Puerto Rican parrot recovery program.

Population Viability Analysis

In June 1989, the Captive Breeding Specialist Group conducted a Puerto Rican parrot population viability analysis workshop. The workshop included most of the biologists, both managers and researchers, who had worked with the species. The workshop utilized the information and expert opinion of the parrot field biologists to construct and explore models of the population dynamics and population biology of the Puerto Rican parrot. The aviary personnel provided information on the captive flock, which proved key to development of a masterplan for the captive population. The final report provided recommendations and identified management needs of both the wild and captive Puerto Rican parrot populations (Appendix A). Among the most important recommendations, was the establishment of other captive and wild Puerto Rican parrot populations to reduce the risk of losing the species to the effects of catastrophic events.

Management after Hurricane Hugo

After the hurricane, our staff, together with cooperators, initiated intensive monitoring and management projects to restore breeding habitat for the parrots. These projects included repairs of existing nests and enhancement of suboptimal cavities to the dimensions of those used by nesting parrots. We installed metal visors to stop rainwater

and microphones to monitor nest activity all modified cavities. We camouflaged the nest cavity repairs with entrance vines and bromeliads. Also, we constructed new observation blinds and look-outs to monitor the wild population. The new blinds are larger structures raised at least 3m (10 ft) from the ground and 15 to 20 m (50 to 65 ft) from the parrot nests to reduce disturbances. In addition, we intensified efforts to control rats and honeybees around active nests.

The management of the captive flock also underwent modifications after hurricane Hugo. The hurricane tested some of the predictions of the Puerto Rican parrot population viability analysis (CBSG 1989). After the hurricane, the urgent need for the establishment of new captive and wild populations became more evident.

In the Luquillo Aviary, major modifications included the following: 1) structural repairs and improvements; 2) design and construction of new, larger breeding, flight, and pair bonding cages; and better nesting structures; 3) installation of close circuit cameras to monitor the activity of breeding pairs; and 4) the use of genetic and behavioral criteria to establish breeding pairs. Methods to produce and manage nest material for both the captive and wild pairs were also improved. The new nesting structures are constructed of polyvinyl carbonate (PVC). These structures have proved to be efficient in keeping the nests cleaner, dryer, and easier to disinfect, as compared to the wooden structures previously used.

The recent flock management of both the captive and the wild population have produced mixed results. As soon as the new pair bonding scheme was implemented, high numbers of fledglings were produced in the Luquillo Aviaries. Overall, the number of fledglings produced in captivity has been increasing thanks to the contribution of the second captive flock. Interestingly enough, the reproductive trends in the aviaries and in the wild during recent years have coincided (i.e., fluctuations in the number of chicks produced have occurred simultaneously). This suggests the possibility of environmental factors affecting the reproduction of both wild and captive populations. However, these trends are not well documented and any conclusion on their implications would be speculative.

Both egg fertility and the number of fertile eggs hatching each year in the captive population (Tables 2 and 5) are low compared to the wild population (Figures 2 and 3) and are the major reasons for the relatively low productivity of the captive flock. Increasing the production of fledglings in the aviaries is of paramount importance and can be a decisive factor in the establishment of new wild populations.

Recent Developments

In 1995, the International Institute of Tropical Forestry, in cooperation with the Río Grande Field Office and CNF, organized a Puerto Rican parrot workshop. The previous project leaders together with biologists, geneticists, aviculturists, and veterinarians

participated in the workshop. Several recommendations for research and management projects were produced as a result of the workshop (see Appendix B). Among the workshop highlights are recommendations to improve the management of the captive flocks and to establish new wild populations as soon as possible.

Presently, the Río Grande Field Office, in cooperation with the North Carolina State University and Mississippi State University, is involved in the refinement of methods to release captive raised parrots into the wild. The release project is being conducted in the Dominican Republic using Hispaniolan parrots produced in the Luquillo and Vivaldi aviaries. The project involves a training program to promote flying skills and learning processes in the captive birds and evaluation of survival using telemetry techniques. The project also includes training components for our staff biologists and technicians as well as those of the DNER and government and non-government organizations of the Dominican Republic. Preliminary results are encouraging and the final products will help design effective training and release strategies for the Puerto Rican parrots. Also, preliminary information is providing insights on the necessary monitoring and research projects needed to address biological interactions that could affect chances of survival of released birds.

The DNER, in cooperation with the North Carolina State University, U.S. Fish and Wildlife Service, Virginia Polytechnic Institute and State University, and Mississippi State University, is conducting research studies on bird habitat relationships in the karst region of Puerto Rico. Expected results will provide insights and recommendations for the management and enhancement of DNER forests reserves. In addition, those research studies will provide information on abundance and population dynamics of Puerto Rican parrot predators and competitors, incidence and prevalence of ectoparasitism, food availability, availability of nest sites, and management recommendations to deal with potentially limiting factors for the establishment a second parrot population in the karst region.

Outlook/Recovery Strategy

The conservation of the Puerto Rican parrot has special importance in that most other *Amazona* species of the West Indies are likewise threatened with extinction, and what can be learned in the process of saving the Puerto Rican species may be to some extent applicable to the conservation of these other species. Additionally, the Puerto Rican parrot merits special concern as the last native species of parrot left in United States territory. Finally, there appears to be a high probability for recovery of the species. The remaining habitat of the parrot is almost entirely publicly-owned land administered to conserve its natural resources. Additional publicly owned lands that were deforested early in the century have now recovered to the point where they may once again be capable of supporting the species. The prospects for recovery of the existing population of Puerto Rican parrots and establishment of new populations appear favorable. After the

49% reduction in the number of individuals in the wild population caused by hurricane Hugo, the Puerto Rican parrot has shown remarkable resilience.

In 1998, wild population counts indicated 87% recovery to pre-Hugo levels. However, the status of the species is still precarious and success will be unlikely without a willingness to make more efforts on its behalf. The process, which requires captive propagation, habitat protection, and wild flock protection, is expected to continue, and will require the commitment of considerable financial resources in the near term. Intensive management and research will continue to be essential for the recovery of the species.

Figure 8a represents the present management philosophy and relationships between Puerto Rican parrot populations. The arrows represent the direction of bird movements in the management of both the captive and the wild populations. For this and all other diagrams, solid lines represent activities that must be conducted on a consistent (yearly) basis, broken lines include activities conducted sporadically, as dictated by availability of individuals and recovery goals. Exchange of individuals between aviaries has been limited to transfer of birds from the Luquillo Aviary to the Vivaldi Aviary for founding purposes. Presently, both aviaries function independently of each other and captive Puerto Rican parrots are not managed as a single population. Regular movement of birds occurs during the breeding season between the Luquillo Aviary and wild nests. These include the temporary transfer of chicks from the wild to the aviary in case of developmental problems, ectoparasites, nestling competition, or other medical conditions. Though not always the case, displaced chicks are returned to wild nests, either to biological or foster wild parents. This helps to achieve brood stabilization. In the event displaced chicks can not be returned, they fledge in captivity and are retained. In most years (not always), captive produced chicks are placed in wild nests to be raised by wild parents. This has normally been limited to a small number of chicks (1 to 3) every year.

Figure 8b shows the management components needed to enhance recovery of the present wild population in the Luquillo mountains. The suggested management concept emphasizes dynamic relationships presently achievable among Puerto Rican parrot populations. This scenario is primarily designed to maximize the yearly number of parrots added to the wild and capabilities of captive population management. With the development of standardized release methodologies, yearling parrots can be added to the wild from two main sources. During the breeding season, chicks produced in captivity/displaced can be fostered into wild nests to maximize the fledging success of wild breeding pairs. Shortly after the conclusion of nesting in the wild, juvenile Puerto Rican parrots (i.e., age 0, age 1) can be released as free-flying birds into the Luquillo Mountains. These release groups can consist of both birds born to captive pairs as well as birds born in the wild but displaced to the aviary and retained due to treatment or phenology of wild nests. Exchange of birds between aviaries could be enhanced, in full compliance with aviary protocols, to assist in the management of genetic diversity and

Figure 8a. Diagram of the present management of the Puerto Rican parrot wild and captive flocks (developed by Dr. Francisco Vilella, Mississippi State University).

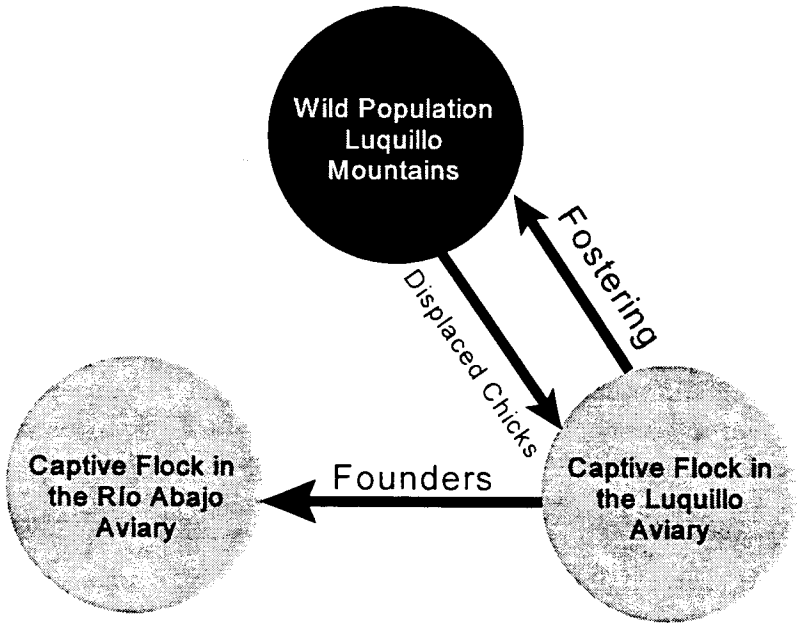
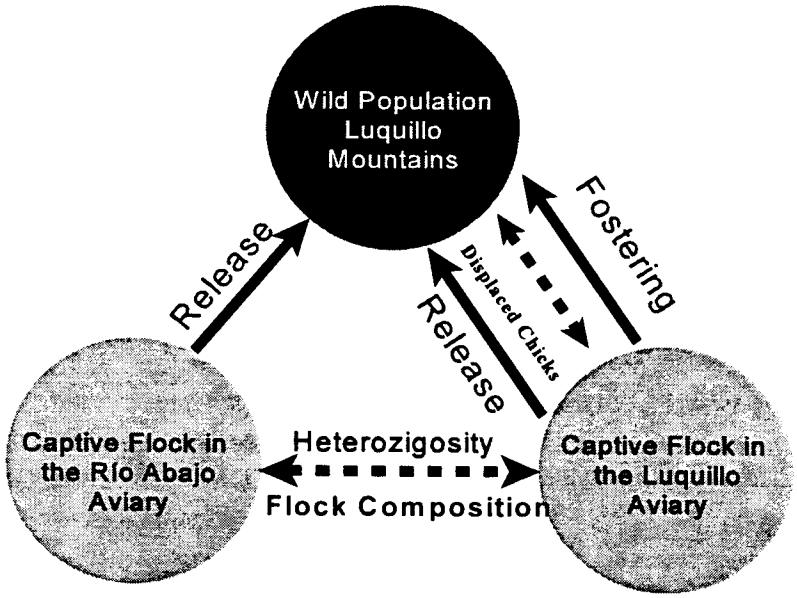


Figure 8b. Diagram of the management actions required to accelerate increase of the Puerto Rican parrot wild population in the Luquillo Mountains (developed by Dr. Francisco Vilella, Mississippi State University).



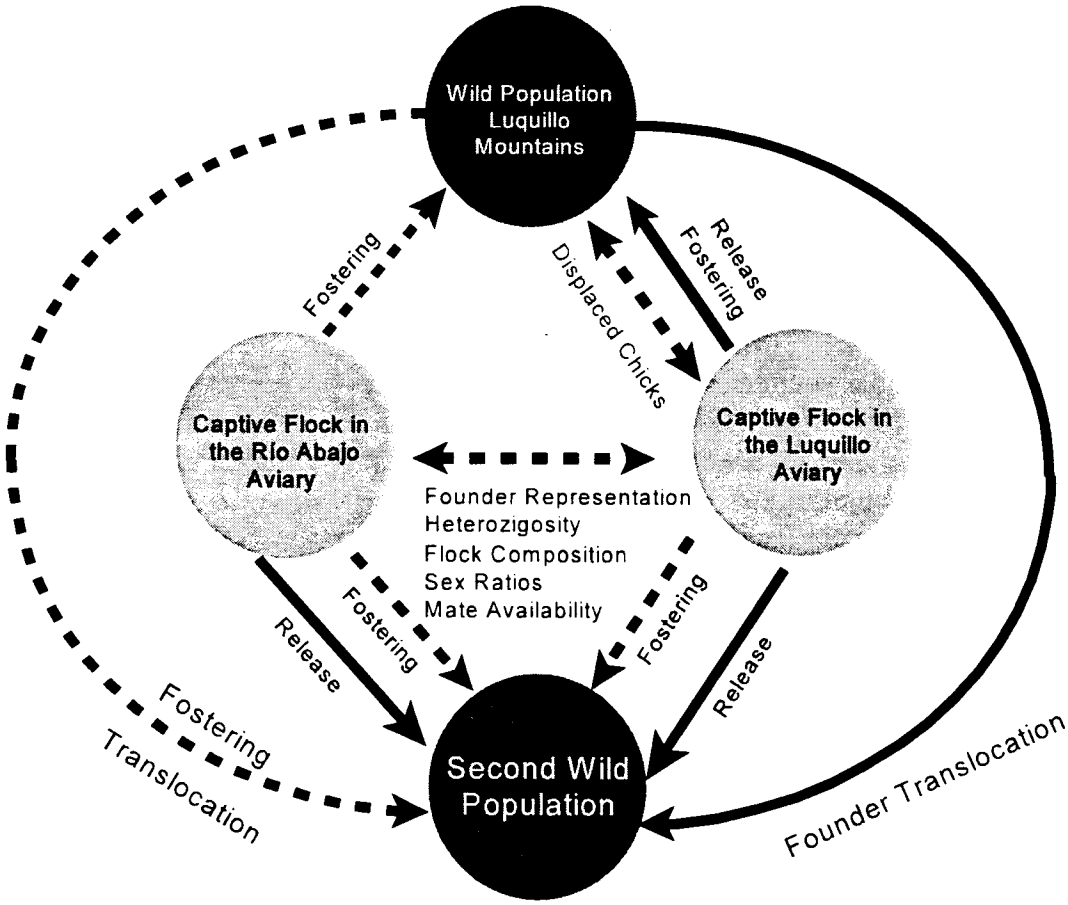
individuals (balance off sex ratios, mate availability for new/replacement breeding pairs). This would provide individual aviary managers with greater options of individuals for captive breeding purposes, while retaining the advantage of separate physical locations.

Figure 9 is a conceptual diagram of a strategy consolidating several management tools to achieve increases of the Luquillo wild population and to help establish other wild populations. This integrated management concept highlights the need for establishing and maintaining interactions among all recovery program components.

Both aviaries will play key roles and must be managed as a single population, in terms of maintenance of genetic representation and husbandry practices, to maximize the output of individuals into the wild. The wild population at Luquillo will play a prominent role in providing a template of wild non-breeding individuals for the establishment of a second wild population. Once breeding starts at a second site, the contribution from the wild population at Luquillo can be reduced to providing chicks for new breeders to foster.

The present management scheme contemplates the first releases of captive raised Puerto Rican parrots into the wild by the year 2001. The first releases will be conducted in CNF. Before the releases, various studies on the survival of wild chicks and predation by red-tailed hawks will be undertaken. The captive flocks must be managed to increase the reproduction of Puerto Rican parrots to the maximum extent possible. Meanwhile, habitat suitability studies are being conducted in areas of the karst region. This studies will help determine the optimal sites for the establishment of other wild populations.

Figure 9. Conceptual diagram for the management of both captive and wild Puerto Rican parrot populations to include the establishment of new wild populations (developed by Dr. Francisco Vilella, Mississippi State University).



II. Recovery

Recovery Objective

The objective of this recovery plan is to downlist the species to threatened status. The immediate goal of this revised recovery plan is to restore and ensure the long term viability of the Puerto Rican parrot in the wild, thereby preventing its extinction, with the eventual potential for reclassification to threatened status. The critical status and restricted range of the Puerto Rican parrot wild population precludes the consideration of delisting in the foreseeable future.

Recovery Criteria

Recovery of the Puerto Rican parrot will require at least two separated self-sustaining wild populations with a minimum effective population size of 500 birds each (5-year average). These populations need to be established and suitable habitats protected concurrently, and as soon as possible.

There is evidence, however, that from a genetic standpoint, a population must contain a certain minimum effective number of individuals in order to maintain sufficient genetic variability to support long-term natural selection. Franklin (1980) recommended that, for long-term viability, total populations (*i.e.*, census population) should be maintained at a level necessary to have an effective breeding population of 500 animals. An effective breeding population of 500 animals is not equivalent to 250 breeding pairs. Due to mortality of young and other factors, the effective breeding population for a species is nearly always lower than the total number of breeders.

Narrative Outline

1 Protect and manage the Puerto Rican parrot wild population.
Increase viable wild population in Luquillo Mountains to attain a self-sustaining level of 500 birds to include a minimum of 100 breeding pairs (5-year average). Currently, there is only one extant population of the Puerto Rican parrot. If the species is to survive and expand its range, we must protect, monitor, and enhance the existing population.

The ultimate goal of any recovery program is to increase the number of individuals in the wild population to a level that would secure survival of species. The major mechanisms to achieve this goal in the Puerto Rican parrot recovery program are: 1) increasing the number of individuals by enhancing reproduction, fostering chicks into wild nests, or releasing captive raised birds; and 2) minimizing threats to the species and its habitat through nest guarding, control of predators and competitors, conducting habitat manipulations, and protecting essential habitat. The development of management techniques to release captive raised Puerto Rican parrot into the wild is still an ongoing process and will be discussed in Task 4 below.

At present, there is no wild parrot population in Río Abajo Forest or Central Highland Region and it is not anticipated that one will be initiated for about 5 to 10 years. Tasks 21 and 22 will result in stock production and bird release, necessary precedents to task 23. Once the Río Abajo Forest project reaches this stage, DNER and U.S. Fish and Wildlife Service must be prepared to conduct direct management activities associated with protection and enhancement of that flock.

The management of the second wild parrot population will begin before birds are released. Initial management activities will consist of nest augmentation, pest abatement, and placement of a preliminary monitoring infrastructure. Protection and further enhancement of the flock and its new habitats will follow. The experience and participation of all cooperators presently involved in the recovery program will be essential for the establishment of the second wild population.

11. Manage the wild population.
Research has resulted in development of management techniques leading to increased wild nesting success of the wild parrots in recent years. The two most important techniques are the provision of improved natural or artificial nest sites and refinement of nest guarding techniques. We should continue improvement and maintenance of active sites on a regular basis.

12. Maximize parrot reproduction in the wild.
To maximize parrot reproduction in the wild, we must obtain additional information to determine why, at present, breeding parrots in the CNF are

so strongly attached to traditional nesting areas. Understanding the mechanisms involved in this strong association to traditional nesting areas will be valuable for the establishment of new wild populations and nesting sites in Rio Abajo or other areas.

One frustrating aspect in the recovery efforts has been the slow recruitment of new breeding pairs in the wild population. Every year, several pairs have shown territorial behavior near apparently appropriate nest sites. However, the number of parrots actually breeding has remained at 3 to 6 pairs for the last 9 years. To maximize reproduction in the wild, it is necessary to investigate the mechanisms involved in nest selection and fidelity and to find ways of recruiting new pairs into the breeding cohort.

Clutch manipulations (double clutching) have been conducted with some success in the past. However, handling eggs and transporting them to the aviary means increasing risk of mortality. Moreover, double clutching will not necessarily increase the number of chicks fledgling in the wild although it may increase the number of birds in the aviary. When a clutch is removed, opportunities to foster the eggs into another wild nests are not always present. Therefore, the eggs need to be moved to the aviary to be incubated. Double clutching, however, can be a valuable tool to maximize the number of young available for captive releases.

Wild Puerto Rican parrots have clutches ranging up to four eggs, but, by far, the most common clutch size is 3. Whether or not foster chicks can be successfully added to wild nests to increase the average brood size to four, or possibly even five, will require additional study.

13. Foster captive-produced chicks into wild parrot nests.
The first fostering of a captive-reared chick into a wild nest was accomplished in 1974, and this method has been used successfully and regularly since. Before that time, it was determined through experimentation with chicks produced in the wild, that young could be exchanged among nests: (l) to keep nests active while nestlings in need of care were removed to the aviary for treatment, and (2) to allow for redistribution of young for protective reasons. In 1979, the technique of fostering chicks was taken a step further by the use of captive-produced Hispaniolan parrot chicks as "stand-ins" for Puerto Rican parrot chicks at nests in danger of failing. This has proven valuable for keeping such nests active and available to receive chicks from other sources, especially captive-produced chicks. By manipulation of photoperiod in the aviary, synchrony between aviary and wild nests generally has been acceptable, although there have been occasional problems.

For the most part, fostering manipulations have caused no serious disruption of adult nesting behavior. Substitutions have mostly been made while the adults were absent, and neither changes in the identity of chicks nor the number present seems to evoke suspicion in the adults. However, one substitution in 1977 of a chick close to fledgling was not initially accepted. Apparently the chick had reached an age where individual recognition had become possible. In the case of small chicks, adults evidently do not recognize them as individuals, probably because the appearance, begging behavior, and vocal repertoire of young nestlings show little variation.

Until now, fostering has been the most successful and practical way of releasing chick produced in captivity into the wild. The ongoing process of developing releasing techniques of captive raised parrots has produced promising preliminary results. Doubtless, fostering will continue to be an important management tool in the recovery of the Puerto Rican parrot even after release techniques are refined.

14. Implement mechanisms to reduce loss of parrot eggs, nestlings, fledglings, and adults from enemies.

Active nests have been monitored and guarded for the past 30 years. On many occasions, intervention saved chicks or nests that otherwise would have been lost (Wiley 1986). However, successful interventions depend on experience and skill of the nest guardian. Often, it is difficult to get adequate guardians for each nest.

Although there are several problems associated with intensive nest guarding, it must be continued until a viable alternative is developed or the wild population attains a size where it can absorb losses from natural predation and competition. Presently, nest guarding efforts are concentrated on egg laying, hatching, and fledgling periods. Efforts are also concentrated on nests with potential problems (i.e., bees, pearly-eyed thrashers). Some level of continued nest guarding is anticipated for a considerable number of years. Nest guarding, although important, will have to be decreased as more breeding pairs are recruited. Therefore, instead of increasing it, nest guarding should be optimized and refined each year by identifying critical periods when the nests need more coverage and problem nests are in need of attention.

141. Minimize losses to pearly-eyed thrashers.

This combination of parrot nest modifications and thrasher nest box placement should continue and be carefully monitored. If parrot nest destruction or takeover by thrashers appears imminent,

then intervention and artificial incubation of parrot eggs should be initiated.

142. Minimize warble fly parasitism.
Placement of a listening device in each nest has greatly improved the rate of warble fly detection. However, nestlings should be checked for maggots at least once every five days. When an infestation is detected, chicks should be closely monitored. Only in cases where the infestation is determined to be life threatening, maggots should be removed from infected chicks in the aviary under quarantine, using the appropriate protocols. More information is needed on the possibility of using pharmaceutical products as preventive measures to avoid warble fly parasitism. Apparently, some products can increase chicks' capacity to resist fly infestations, but the secondary effects of such treatments are unknown.

Although inconclusive, it is believed that a damp nest cavity promotes the occurrence of warble flies. Efforts should continue towards the maintenance of dry nest conditions as a prophylaxis against warble fly infestation.

143. Minimize losses to rats.
The incidence of rat depredations, albeit low, can reduce chick production or result in complete nest failure. Such cases had occurred at least twice in the past ten years. Effective rat control is thus warranted to promote parrot recovery.

Control measures should be applied in the vicinity of active parrot nests before and during the parrot breeding season. In late winter and early spring, rat densities in parrot nesting areas are at their annual low and most rats present at this time are mature adults capable of breeding (Layton 1986). Rat control measures implemented during this time can depress the number of rats of breeding age and subsequently lower peak rat numbers that occur in late summer. A reduced peak number of rats would likely lower parrot-rat interactions (Layton 1986).

In past years, rat control has consisted of the use of metal rat guards on nesting trees, zinc phosphide, and anticoagulant baits. To date, the use of baits, placed before nest selection, followed by additional applications one week after hatching, and one week before fledgling if needed, appear to be the most effective means of

reducing potential depredations. The total amount of bait used annually has been decreased substantially as methods for bait placement have become more effective (100 lb were needed to cover 5 active nests in 1988, versus 52 lb to cover 5 nests in 1995). Alternatives to baiting, such as trapping, are currently being explored. Effectiveness and environmental impact of all potential control measures should be evaluated.

144. Minimize losses to honeybees.
Intensive efforts are currently underway to intercept bee swarms and discourage bee occupation of parrot nests and cavities. Protocols for bee interception and eradication have been developed.

145. Minimize losses to raptors.
There are four breeding raptor species in the CNF: the Puerto Rican screech-owl, the Puerto Rican sharp-shined hawk, the Puerto Rican broad-winged hawk, and the red-tailed hawk. Two additional raptor species, the merlin and the peregrine falcon, occur as transients or winter residents in the forest. All present potential threats to parrots, but red-tailed hawks are thought to be the most important predator of nesting parrots. Since 1994, two probable red-tail depredations have occurred at nest sites during the nest selection period. Efforts to quantify red-tailed hawk densities on the forest, assess raptor impacts to the parrot, and develop strategies for effectively reducing the threat of raptor predation are needed.

146. Minimize losses to other predators (Puerto Rican boas, cats, others).
The influence that any other potential predator has on the parrot should be assessed and mitigated. Feral cats and other predators introduced to the CNF should be controlled or eliminated to the degree feasible.

147. Minimize losses to humans and human activities.
Human impacts should be minimized by controlling unauthorized entry into nest areas, maintaining confidentiality of nesting locations, concealing trails leading into nesting areas, placing parrot management structures (blinds, lookout platforms, improved nest cavities, and access trails) as inconspicuously as possible, limiting parrot management and research activities in sensitive areas and confining them to the hours of darkness, monitoring

parrot exportation from Puerto Rico, monitoring breeding areas to ensure lack of disturbance, and reducing overall potential for human disturbance by employing the Puerto Rican Parrot Management Situation Guidelines.

Parrots are exceedingly vulnerable to human disturbance in the vicinity of their nests, and therefore require the greatest protection in these sensitive areas (1 km minimum radius). As the number of nests increases with time, the tolerance of the birds should be re-evaluated, and protective restrictions adjusted accordingly.

All research and management activities proposed within the influence zone of occupied parrot habitats must be evaluated for their potential effects on the parrot and its habitat, and undergo appropriate coordination before implementation. Opportunities to use research or management to enhance recovery efforts, should be maximized. Roads and trails that abut or access parrot habitats should be controlled as needed, and should be patrolled periodically to ensure effective protection, especially during the pigeon hunting season. The CNF and its buffer zone should be maintained as a no shooting area and "no hunting" signs should be posted.

148. Minimize potential threat from exotic fauna, especially exotic psittacines.
Introduced psittacine species that are apparently reproducing in lowland Puerto Rico currently are not known to affect the Puerto Rican parrot in CNF. However, exotic psittacines have been reported within the perimeter of the Vivaldi Aviary and elsewhere in the Río Abajo Commonwealth Forest. The central highlands area has been suggested as the secondary location, besides CNF, for the future release of Puerto Rican parrots. With such populations of exotics, competition, hybridization, and diseases may be problems in the future. *Amazona* species should not be allowed to be imported to Puerto Rico. Importation of other members of the psittacine family should be banned or strongly controlled. If importation is allowed, each application should go through a peer review by DNER. Further introductions or escapes into the wild of exotic psittacine and other species must be prevented. Control of feral exotic fauna is strongly recommended.

Adequate monitoring of exotic species reproducing in the wild is necessary. Some management actions may be necessary to reduce

or preclude population increases of exotic species. Populations of feral exotic birds from the Psittacine family should be monitored. Should exotic species of this family present a problem, control techniques should be developed and implemented. These could include trapping, shooting, and harassing exotic birds, or habitat modification.

15. Monitor wild population trends.

It is difficult to obtain accurate parrot counts from under the forest canopy. In flight, however, the birds generally vocalize loudly, giving the observer ample time to locate and count them from unobstructed viewpoints at or above treetop level. Population counts are made by simultaneously monitoring a series of treetop look-outs in the CNF. Recent observations question the accuracy of the population counts. Inaccuracies may come from changes in parrot behavior after hurricane Hugo opened the canopy and inability of observers to count birds flying close to the canopy.

Whereas censussing from look-outs has been adequate for total population counts, a means of identifying individual birds is needed to evaluate age-specific mortality, movement, and the fate of reintroduced parrots. No attempt has yet been made to mark wild adult birds, because the risk of trapping may result in injuries and disruption of established behavior patterns. Fortunately, it has been possible to gather mortality information, at least for breeding adults, through careful observation of minor differences in coloration, external injuries, and behavioral idiosyncrasies (including vocalizations). Juveniles are now being marked at the nests each year to facilitate identification. Marking techniques currently include the use of radio telemetry equipment and leg bands. Some of the banded birds have been identified as members of nesting pairs. However, the present banding methods are still inadequate for individual recognition.

The existence of non-breeding territorial (NBT) pairs was recognized almost from the beginning of the recovery efforts. Factors precluding these pairs from breeding are unknown. Whether the problem of NBT pairs can be solved is unknown. Efforts to gather information on NBT pairs need to be increased. Also, present knowledge should be used to manage sites used by NBT pairs to make them as similar as possible to active nest sites.

2. Protect and improve parrot habitat.

To recover the Puerto Rican parrot, it is critically important that suitable habitat be retained and managed for the species. This habitat consists of the forested lands in the Luquillo Mountains and the forested lands in and around the Río Abajo Forest and Central Highland Region (Figure 6). An estimated total of

18,219 ha (45,000 acres) of forested land remains in the Luquillo Mountains, of which about 10,931 ha (27,000 acres) are in the CNF. The CNF forest consists of 3,343 ha (8,257 acres) of palo colorado forest, 1,866 ha (4,609 acres) of sierra palm forest, and 5,711 ha (14,106 acres) of tabonuco forest (predominantly advanced secondary growth, but also including plantation areas, and early secondary growth). Every effort should be made by the Federal government and the government of Puerto Rico to protect these areas. All decisions regarding proposed land uses in these areas should give priority consideration to impacts and benefits to long-term parrot recovery goals.

21. Develop, maintain, monitor, protect and augment parrot nesting habitats; expand occupied habitats.

Nests used by the Puerto Rican parrot must be managed intensively to ensure their suitability and availability during the nest selection and breeding seasons. Nests and alternative cavities must remain closed outside of the nesting season to discourage their deterioration and occupation by enemies or competing species. They must be opened and serviced promptly just before the nest selection period, be actively maintained throughout the breeding season, and closed soon after fledgling.

The areas used by the Puerto Rican parrot for nesting are presently very limited, and because parrots display a high degree of site fidelity, their rate of expansion into new parts of the forest is extremely low. However, to effect recovery, the current breeding population must expand. To induce parrots to move into new areas, adequate nesting habitat must be made available. This is achieved either by improving existing natural cavities, or by constructing and erecting artificial nesting structures.

The criteria used for selecting sites for nest improvement activities are: (1) active breeding areas with inadequate numbers of suitable cavities; (2) non-breeding areas with inadequate numbers of cavities and where parrots have been observed during the nest selection period; (3) non-breeding areas with inadequate numbers of cavities and where parrots have been observed outside of the nest selection period; and (4) unused areas lacking adequate numbers of cavities, and that are good candidates for expansion because they are known to have been used by parrots historically, or lie adjacent to currently occupied habitats.

Habitat suitability studies in Río Abajo indicate a paucity of natural tree cavities due to the young age structure of its secondary forests. It will be necessary to provide artificial nest sites until natural cavities become more abundant. The methods used in the CNF for developing nest sites should

be adopted in Río Abajo or Central Highland Region and where appropriate, modified to meet the conditions found there. Parrots historically nested in cavities in the limestone cliffs that are abundant in Río Abajo. Efforts should be made to promote parrot use of this abundant source of cavities. Characteristics that make these cavities suitable for parrot nesting should be identified and cavities improved, if necessary. Versatile nest monitoring and protection efforts will be vital initially, as parrots explore their new habitats and establish reproductive sites.

22. Delineate occupied range, and assess habitat use.
The Puerto Rican Parrot Management Situation Concept (Appendix C) provides a means of defining and delineating specific parrot habitats, both current and potential. The determination of use-areas (such as breeding, feeding, and movement areas) and their characteristics provide information needed to better understand parrot-habitat relationships, and define management needs and opportunities. Information on parrot use-areas and dispersal is acquired through continued monitoring using periodic population counts and surveillance of parrot activities.

Habitat suitability studies indicate that Río Abajo and Central Highland Region should provide suitable parrot habitat. Re-establishment of a population of such a highly mobile species entails some risks and unknowns. It is essential that released birds be monitored to define and plot occupied range. As the population becomes established and increases in numbers of individuals, the area occupied by parrots is expected to expand. It is critical that their range be monitored to allow project objectives and methods to be modified as range use indicates its necessity. Results of monitoring may indicate a strong need to protect areas not presently within the Río Abajo Forest. Monitoring will be accomplished using radio-telemetry, periodic population counts, and surveillance from lookout platforms or posts.

23. Explore means to protect, improve, and acquire habitat outside, but adjacent to, the CNF and the Central Highland Region.
Habitats outside of the CNF/LEF are sometimes used by parrots, and these lands may eventually be important to parrot recovery. The U.S. Forest Service should pursue every opportunity to acquire such lands or to develop conservation easements.

Since most of these lands are in private ownership, landowners should be encouraged to develop and protect secondary forests on them. This could be greatly facilitated through the designation of conservation buffer adjacent to the CNF. Within this buffer, supportive zoning by the

Commonwealth of Puerto Rico would ensure that decisions regarding proposed land uses consider effects to long-term parrot recovery goals.

The high mobility of the parrots together with the small area and the existence of similar habitats outside of the Río Abajo Forest, suggest the possibility that the re-established population will use areas outside the forest. Approximately 2,720 ha (6,720 acres) of potential habitat surround the Río Abajo Forest. The extent and details of parrot use of these areas will be determined by recovery tasks 21 and 22. Efforts should be made to protect areas outside the forest that are used extensively by parrots. These efforts could include voluntary or paid conservation easements, zoning regulations, voluntary cooperation, or land acquisition. Other management efforts described in this recovery plan may also need to be implemented in these areas.

3. Maintain and manage the captive flocks.

31. Maximize production of Puerto Rican parrots in captivity.
Since 1973, the general policy had been to continue to build up the captive stock with eggs from the wild, but to allow each nest to fledge at least part of its brood in the wild, except where emergency situations existed and nests would clearly have been lost.

This approach had its benefits and disadvantages, as the hand-raised parrots will certainly imprint on their human caretakers, consequently preventing these young parrots to acquire the behavioral traits that could only be learned from the adults. Use of Hispaniolan parrots to incubate and raise Puerto Rican parrot chicks should be maximized to avoid imprinting problems associated with hand rearing.

The José L. Vivaldi Memorial Aviary initiated operations in 1990, with a group of 30 Hispaniolan parrots that served as disease sentinels for 3 consecutive years, before the arrival of the first group of Puerto Rican parrots from the Luquillo Aviary in 1993. This group of Hispaniolans served also to select dependable surrogate pairs that could be used to incubate and raise Puerto Rican parrots eggs and chicks.

Several problems within the captive stocks, however, have resulted in low productivity through the years. A number of factors may have contributed to the low number of fertile pairs, including unbalanced sex ratios within the captive populations (more females that males), inaccurate sexing techniques, possible genetic problems, physiological causes, lack of species-specific behavioral traits, disregard of species barriers and other

behavioral problems within pairs and group.

These behavior problems may be a direct result of parrots having been hand raised by humans or that interacted mainly with humans during their juvenile years, with little or no interaction with members of their species. In addition, some productivity problems may have been related to sub-optimal housing conditions or inadequate nutrition.

Some of the problems have been solved by modifying the aviary, improving cage designs, improving monitoring methods to reduce disturbance, and using different pair-bonding strategies to avoid producing homosexual and incompatible pairs.

Embryonic death continues to be an important source of mortality. Some of these deaths had reasonable explanations, as they may have been caused by external forces. However, others seem to occur without apparent reasons. Further research is needed to determine factors causing embryonic death. Bird breeders suggest that high humidity is a possible cause of embryonic death, and Rahn *et al.* (1979 both) found the optimum relative humidity for incubation for a number of bird species to be approximately 45%. However, embryonic death occurs as well in eggs under natural incubation at both aviaries.

Pedigree analysis should be conducted for both captive flocks. Information from pedigree analysis can help in pair bonding by enabling managers to optimize genetic combinations of individuals in breeding pairs.

The Luquillo Aviary is faced with a restricted availability of space, making it difficult to deal with aggressive or nervous pairs, that can not tolerate the presence of other pairs or birds near their cages. A minimum of 10 to 12 breeding Puerto Rican parrot pairs may be a suitable number to house at Luquillo in addition to a similar group of surrogate Hispaniolan parrot pairs to aid management. The Vivaldi Aviary, on the other hand, may comfortably house up to 30 pairs of each species, ensuring adequate distance between breeding pairs.

Egg and chick production by individuals within the captive stock have been increased over normal production in the wild through clutch manipulations. Artificially-induced replacement clutches and sequential removal of eggs as they are laid have resulted in grater increases in fertile egg production among Puerto Rican parrots and their surrogate species, the Hispaniolan parrot. Further refinement of these techniques should

improve captive production above current levels and yield more offspring that can be fostered or released into the wild.

Captive production might also be improved through experimental pairings of adults, transfers between aviaries, cage, and nest designs, and relocations of captive pairs within the aviaries. New mates should be provided to females laying infertile eggs to develop compatible (i.e., fertile egg-producing) pairs. Also, it is possible that some pair infertility might be due to intimidation of pairs by birds in adjacent pens. Therefore, relocations of these unproductive pairs or installation of visual barriers between pairs may help prevent this and other negative interactions and might trigger some of the pairs to lay fertile eggs.

Quality equipment, optimal temperature regimes for artificial incubation, and the selection of reliable surrogate brooding females can improve overall egg and chick survivability.

32. Maintain captive stock in good health.
Both aviaries should have staff with training and experience in bird health problems. Ideally, each aviary should have an aviculturist, a veterinary technician, and an "on call" veterinarian to deal with emergencies. At both aviaries, qualified veterinarians will perform yearly exams on at least a selected number of captive parrots representatives of each of the captive flocks. Cages will be properly designed to facilitate sanitation methods and must be cleaned as often as necessary to maintain proper sanitary conditions, yet reducing to a minimum human activities and other disturbances in their vicinity.

Standard operation protocols dealing with such operations as cleaning, health maintenance, prevention of diseases, dead birds, and emergencies need to be revised and updated periodically to adjust to new situations. Cooperators should be notified of specific protocols that could affect their activities (*e.g.*, research, visits to the aviary, volunteers, etc.).

Nest boxes will be cleaned, repaired, or discarded and new ones built at the end of each breeding season. New nesting material will be added as needed to the nests before the beginning of each breeding season.

Sick birds will be isolated from the rest of the flock in an appropriate enclosure, room, or building and a strict infectious disease protocol will be followed by all personnel in contact with the animal until the causes of illness are determined and controlled. Removal of birds for treatment outside of the aviaries must be avoided. If a bird is removed for treatment

elsewhere, such bird must not return to either aviary to avoid the possibility of diseases been transmitted to the captive flocks. Adequate protocols will be developed and implemented to manage unavoidable removal of birds outside of the aviaries for treatment.

As appropriate, newly introduced birds will also be quarantined for a minimum of 30 consecutive days. The Aviary Operations Coordinator and Project Leader will request veterinary assistance as necessary. Birds that die from disease or injury will be necropsied at recognized institutions on the bases of expertise and diligence in identifying cause of death. In the event of a hurricane, the captive flocks will be sheltered in a secure building.

Only limited research on psittacine nutritional requirements has been conducted. To date no definitive studies have yet been conducted on the nutritional requirements of *Amazona* parrots. The present commercial formulations used by both aviaries appear to be appropriate, but may not supply all the nutrients needed by the Puerto Rican parrot. Further research should be conducted using surrogates to obtain samples that may provide an accurate array of the food items fed by females to chicks in the wild. Exchange of research and management information between the Río Abajo and Luquillo aviaries is essential to obtain maximum benefits from the experiences of staff.

4. Release captive produced parrots.

Now that captive populations have been established in two aviaries, releases of free-flying captives can be initiated in the Luquillo Mountains to bolster the wild flock and refine release techniques. Initial releases of free-flying captives in Luquillo will have the advantage of an existing wild flock into which the captives can integrate. This will increase the likelihood of survival relative to sites lacking wild birds.

41. Refine release techniques used in other parrot releases.

Previous releases of Hispaniolan parrots in the Dominican Republic (Snyder *et al.* 1987, Wiley *et al.* 1992) and recent releases of other captive-reared parrots elsewhere (Snyder *et al.* 1994) provide adequate information to initiate releases of captive-reared Puerto Rican parrots in Luquillo. In addition, Wiley's release of 3 captive-reared Puerto Rican parrots in 1985 showed that one individual survived to breed. The most important proximate factor limiting the success of these captive releases was that released birds did not quickly integrate into the wild flock, which probably increased their risk of mortality to raptor predation.

Releases of captive-reared Puerto Rican parrots should be scientifically designed to facilitate identification of the factors influencing maximal survival in the Luquillo Mountains. Soft releases in which captives are held in a field aviary at the site before release, and provided with food, water, and cover after release, as well as conditioning programs for native foods and raptor recognition, show promise for maximizing survival of released captives (Snyder *et al.* 1987, Wiley *et al.* 1992). Releases with Puerto Rican parrots should be designed to identify the effects of sex, age, cohort size, conditioning, and season on survival. We must strive for survival of at least 33% of released individuals. Information may also be obtained from other captive release studies.

42. Assess feeding habits and determine nutritional needs.
Recent information suggests that direct observation of parrots feeding can result in misleading information about the birds diet. Some species of parrots use insects in their diet at a frequency higher than expected if ingestion was accidental. A detailed study of wild parrot feeding habits should be conducted to determine nutritional quality of their diet and the feasibility enhancing management of the natural diet. Reliable diet information is critical for the reintroduction of Puerto Rican parrot to presently unoccupied areas.

43. Release free-flying, captive-reared Puerto Rican parrots to bolster growth of the wild population in the Luquillo Forest using procedures developed to maximize survival.
Releases of free-flying captive-reared Puerto Rican parrots should be used to further maximize the growth of the wild population, thereby reducing the chance of extinction due to random, catastrophic events and adverse genetic effects that may result from the small breeding population. Releases of free-flying captive-reared parrots should be based on the results of experimental releases and should involve scientific monitoring to determine survival and enable identification of the causes of mortality of the released parrots.

44. Monitor releases of juvenile Puerto Rican parrots to identify mortality factors and to reduce impacts.
All captive-reared parrots should be marked to enable individual identification after release so that their fate may be determined. Only by tracking known individuals will it be possible to determine their ability to integrate into the wild flock, reproductive history, and sources of mortality. Radio telemetry is an invaluable tool for obtaining this information and should be used for at least half the released individuals until satisfactory release techniques have been established.

5. Establish a second viable wild population.
A second wild population of at least 500 birds, including a minimum of 100 breeding pairs (5-year average), must be established in the karst region. Establishment of a second viable wild population of Puerto Rican parrots will reduce the risk of catastrophic mortality.

51. Determine suitable release sites.
The Río Abajo Forest, part of the former range of the Puerto Rican parrot, was identified in the 1982 Recovery Plan as a candidate location for the establishment of the second wild population of the parrot. Habitat studies to determine the suitability of this forest for the establishment of this population included an assessment of cavity and food availability (Cardona *et al.* 1986). These results led to the decision to proceed with plans to establish a breeding facility and a wild population in Río Abajo. Specific sites for release of parrots in the forest need to be determined. Factors that should be considered are the distance to the forest boundary, adverse human activities, the abundance of suitable nesting cavities, and plans for timber harvesting in the release area. Other factors include the density of parrot predators, competitors, and parasites in the proposed release site, availability of food and foraging areas, and the distance of the release sites to the aviary compound. Densities of predators, competitors, and parasites in the release site should be monitored before parrots are released into the area to make certain that the parrots are not subjected to greater than average risks.

Studies in the Central Highland Region are being conducted to evaluate other suitable release sites.

52. Develop and implement a management plan for second release site to ensure favorable environment and protection for parrots.
Previous reviews of the parrot recovery effort (U.S. Fish and Wildlife Service 1986 and Seal *et. al* 1989) have indicated that the Río Abajo forest represents a reasonable future site for establishment of a second population of Puerto Rican parrots. These reviews have recommended that the Commonwealth government manage this forest to encourage parrot habitat and consider protecting appropriate habitat adjacent to this small reserve. This protection could be obtained through zoning regulations, voluntary or paid conservation easements, voluntary cooperation or land acquisition. Given the rate of development on the island, efforts should proceed immediately to protect a site for the second wild population. A management plan, ensuring the long-term survival of the parrot, is essential before a second site is selected for releases.

53. Release wild and captive-produced Puerto Rican parrots at a second site. Use translocated wild Puerto Rican parrots to establish a population at a second site, only after the existing population in CNF is sufficiently large to offer birds for translocation.

The difficulties of introducing captive-bred birds into an environment lacking wild conspecifics is well documented (*e.g.*,Wiley *et al.* 1992). Captive-reared birds are at greater risk to raptor predation and this is expected to be increased given the abundance of red-tailed hawks throughout Puerto Rico (Rivera-Milán 1995). This risk is particularly severe where no established flock exist for the captive-reared birds to join. However, the chances of success are much improved with the release of wild birds experienced in predator recognition and avoidance. Therefore some wild birds translocated from Luquillo to a second site could form the initial flock into which captive-reared birds might later be released.

Wild parrots should not be trapped in CNF until that population has attained an adequate size to withstand the loss of individuals and potential disruption associated with trapping. The exact size that the wild population in CNF must obtain before initiating this activity is largely conjectural and may occur at 60-70 birds (Wiley *et al.* 1992). However, this decision must be weighed against the risk of prolonging the period in which only one flock, rather than two, exists in the wild. Translocated birds captured in CNF should be held for a short period in a holding cage at the release site to acclimate them to the surroundings and local foods, and to encourage them to remain in the vicinity after release.

It is likely that only a few wild birds will be captured in CNF and therefore the initial release will need to include captive-reared parrots to obtain a group of sufficient size for release. The initial release should include a relatively large number of birds to assure establishment. Captive-reared parrots should be held with translocated wild birds to enable socialization before release. Release should be made at the appropriate season and cohort size to obtain maximum survival as determined by previous releases in CNF (tasks 141., 143.). Captive parrots held in the holding cage after the initial release may encourage released birds to remain in the vicinity of the release site.

54. Release captive-produced parrots using scientific procedures to progressively adapt release procedures to conditions in Central Highland Region.
Once a free flying flock is established in the Central Highland Region, additional releases of captive-reared parrots can be initiated based on the

procedures originally developed in CNF (task 124.). However, each Central Highland Region release should be scientifically designed to facilitate identification of the factors influencing maximal survival in the Río Abajo forest. Central Highland Region releases should be monitored (as in task 125.) to enable refinement of release procedure to the specific conditions of Central Highland Region.

55. Determine feasibility of fledgling Puerto Rican parrot chicks from nests attended by demobilized surrogate parents.
Because there are no parrots in Central Highland Region, release techniques that promote site fidelity should be developed. One such technique could be to allow parrots to fledge naturally from an artificial nest in the forest attended by sterilized or pinioned surrogate parents.

56. Monitor released parrots.
All captive-reared parrots should be marked to enable individual identification after release so that their fate may be determined (task 125.). Only by tracking known individuals will it be possible to determine their ability to integrate into the wild flock, reproductive history, and sources of mortality. The marking methods used in CNF (task 125) should also be used in Central Highland Region to increase the likelihood of survival of captive-reared parrots.

57. Foster captive produced chicks into active wild nests
After breeding pairs are established in the second wild population, foster appropriate-aged Puerto Rican parrot eggs and chicks into active wild parrot nests

Once breeding pairs are found in the Central Highland Region, the established methods from CNF (task 11) should be initiated including fostering of eggs and chicks of appropriate age to increase productivity of nesting pairs.

6. Develop support for the Puerto Rican parrot recovery project.
The future of the Puerto Rican parrot ultimately depends on the desire of the Puerto Rican people to protect and preserve the species. Therefore, conveying accurate information on the plight of the species, the factors leading to its endangerment, and the importance of protecting the Puerto Rican parrot to the general public, is essential for its recovery. Most Puerto Ricans can not distinguish the differences between the endemic parrot and several introduced species of psittaformes.

61. Develop public outreach program.
An effective culturally compatible public outreach program is necessary to assure public support and ultimately the fate of the Puerto Rican parrot. Teacher training workshops has been proposed to enhance our capability to convey our conservation message. The development and implementation of teacher training workshops will enable the Fish and Wildlife Service to reach larger audiences, and to incorporate conservation ethics and concepts in the education of children and young adults.

Another appropriate vehicle to promote the conservation of the Puerto Rican parrot would be a live display at the CNF El Portal Tropical Rain Forest Visitor Center. Public outreach should also include strategies to promote support for the program by government and non-government organizations.

Contacts should be established with business and the public education institutions to promote conservation of endangered species and the environment in general. It may be possible to use school teachers as liaisons disseminating conservation messages.

7. Refine recovery criteria.
As we gather additional information on the biology, ecology, and management of the Puerto Rican parrot, it will be necessary to better define the recovery criteria.

71. Determine number of individuals and populations necessary to ensure species stability, security, and self-perpetuation.
Population studies, together with the relative success of protection measures, will allow more precise and realistic recovery criteria to be established and met.

72. Determine what additional actions, if any, are required to achieve recovery criteria.
If any additional recovery actions become necessary for the species' survival and well-being, they must be incorporated into the plan.

III. Literature Cited

Arendt, W.J. 1985. Philornis ectoparasitism of pearly-eyed thrashers. I. Impact on growth and development of nestlings. Auk 102:270-280.

Cardona, J.E., M. Rivera, M. Vázquez-Otero, C.R. Laboy. 1986. Availability of food resources for the Puerto Rican parrot and the Puerto Rican plain pigeon in Río Abajo Forest. Puerto Rico Department of Natural Resources, Draft Report Project No. W-10(ES-1)

Franklin, R.I. 1980. Evolutionary changes in small populations. Pp . 135-149. In Soule, M. E . and B. A . Wilcox (eds.), Conservation Biology: An Evolutionary-Ecological Perspective. Sinauer Associates, Inc., Sunderland, Mass.

Khadga B., G.E. Likens, F.N. Scatena, and A.E. Lugo. 1992. Hurricane Hugo: Damage to a tropical forest. J. Tropical Ecology 8:47-55.

Kepler, C.B., and A.K. Kepler. 1970. Preliminary comparison of bird species diversity and density in Luquillo and Guanica Forests. Pp. E183-El91 In A Tropical Rain Forest, H. T. Odum (ed.), Division of Techn. Information, U.S. Atomic Energy Comm. Rept., Washington, D. C.

Layton, B. 1986. Reproduction chronology and habitat use by black rats in Puerto Rican parrot nesting habitat. A thesis submitted to the faculty of LSU School of Forestry, Wildlife and, Fisheries.

Lindsey, G.D., Arendt, W.J., and Kalina, J. (1994) Survival and causes of mortality in juvenile Puerto Rican Parrots. J. Field Ornithol. 65:76-82.

Mayers, J.M., F.J. Vilella, and W.C. Barrow, Jr. 1993. Positive effects of hurricane Hugo: Record years for the Puerto Rican parrots nesting in the wild. Endangered Species Technical Bulleting 18(1).

Murphy, L.S. 1916. Forests of Porto Rico, past, present and future, and their physical and economic environment. USDA Agricultural Bulletin No. 354, Washington, D.C.

Odum, H.T. (ed). 1970. A tropical rain forest. U.S. Atomic Energy Comm. Rept., Washington, D.C.

Rahn, H., A. Ar, and C.V. Paganelli. 1979. How bird eggs breathe. Sci. Am. 240(2) :208-217.

Rivera-Milan, F.F. 1995. Distribution and abundance of raptors in Puerto Rico. Wilson Bull. 107:452-462.

Rodriguez-Vidal, J.A. 1959. Puerto Rican parrot (*Amazona vittata vittata*) study. Commonwealth Puerto Rico, Monog. Dept. Agric. & Commerce, P.R. 1:1-15.

Santana, C., and S.A. Temple. 1984. Management recommendations for the endangered Puerto Rican parrot and the red-tailed hawk in the Luquillo Experimental Forest. Unpubl. report. Univ. Wisconsin and USDA.

Scatena, F.N., and M.C. Larsen. 1991. Physical aspects of hurricane Hugo. Biotropica 23(4a):317-323.

Snyder, N.F., S.E. Koenig, J. Koschmann, H.A. Snyder, T.B. Johnson. 1994. Thick-billed parrot releases in Arizona. Condor 96845-862.

Snyder, N.F.R., and J.D. Taapken. 1977. Puerto Rican parrots and nest predation by pearly-eyed thrashers. Pp. 113-121 In S. A. Temple (ed.), Endangered Birds. Univ. Wisconsin Press, Madison, Wisconsin.

Snyder, N.F.R., J.W. Wiley, and C.B. Kepler. 1987. The parrots of Luquillo. West. Found. Vert. Zool., Los Angeles.

The Association for Tropical Biology. 1991. Special Issue: Ecosystem, plant, and animal responses to hurricanes in the Caribbean. Biotropica 23(4a)

U.S. Fish and Wildlife Service. 1982. Puerto Rican Parrot Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia. 44 pp.

U.S. Fish and Wildlife Service. 1986. Puerto Rican Boa Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Geogia. 21 pp.

Vilella, F.J. and A. Arnizaut. 1994. Making the best of mother nature: Managing the Puerto Rican parrot after hurricane Hugo. Endangered Species Technical Bulleting 19(2).

Wadsworth, F.H. 1949. The development of the forest land resources of the Luquillo Mountains. Ph.D. Dissertation, Univ. Michigan, Ann Arbor. 481 pp.

Wadsworth, F.H. 1951. Forest management in the Luquillo Mountains, I. The setting. Caribbean Forests 12:92-114.

Waide, R.B. 1991. The effect of hurricane Hugo on bird populations in the Luquillo Experimental Forest, Puerto Rico. Biotropica 23(4a):475-480

Walker, R.L., J. Voltzow, J.D. Ackerman, P.S. Fernandes, and N. Fetcher. 1992. Immediate impact of hurricane Hugo on a Puerto Rican rain forest. Ecology 73(2):691-694.

Wiley, J.W. 1980. The Puerto Rican Amazon (Amazona vittata): Its decline and the program for its conservation. Pp. 133-15g In R. F. Pasquier, ed., Conservation of New World Parrots. International Council for Bird Preservation. Tech. Publ. No.1.

Wiley, J.W. 1985. The Puerto Rican parrot and competition for its nest sites. Pp. 213-223 In P. J. Moore (ed.), Conservation of Island Birds. ICBP Tech. Publ. No. 3.

Wiley, J.W. 1986. Evaluation of alternatives to parrot nest guarding. Unpubl. report. U.S. Fish and Wildlife Service.

Wiley, J.W., Snyder, N.F.R., and R.S. Gnam. 1992. Reintroduction as a conservation strategy for parrots. In: New world parrots in crisis. S. R. Beissinger and N. F. R. Snyder (Eds). Smithsonian Institution Press, Washington D.C. Pp. 165-200.

Wiley, J.W. and J. Wunderle 1993. Hurricane effects on bird populations in general. Bird Conservation International 3:319-349.

III. IMPLEMENTATION SCHEDULE

The following Implementation Schedule outlines actions and estimated costs for the recovery of the Puerto Rican parrot over the next 3 years.

Key to Implementation Schedule Column 1:

Priority 1: Those actions that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2: Those actions that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery of the species

Key to Agency Designations in Column 5 and Column 6:

FWS-	U.S. Fish and Wildlife Service
R4-	FWS Region 4
ES-	FWS Division of Ecological Services
LE-	FWS Division of Law Enforcement
DNER-	Puerto Rico Department of Natural and Environmental Resources
USFS-	U.S. Forest Service
UNIV-	Universities
Cons.Org.-	Conservation Organizations
Vol. -	Volunteers

IMPLEMENTATION SCHEDULE

Task Priority	Task Description	Task Number	Task Duration	Responsible Organization FWS	Other	Cost Estimates ($000) FY 1	FY 2	FY 3	Comments
1	Manage the wild population.	11	ongoing	R4		255	271	288	
1	Maximize parrot reproduction in the wild.	12	ongoing	R4		55	55	55	
1	Foster captive-produced chicks into wild parrot nests.	13	ongoing	R4	DNER				Cost included in task 11
1	Minimize losses to pearly-eyed thrashers.	141	ongoing	R4	USFS	5	5	5	
1	Minimize warble fly parasitism.	142	ongoing	R4		2	2	2	
1	Minimize losses for rats.	143	ongoing	R4	USFS	2	2	2	
1	Minimize losses to honeybees.	144	ongoing	R4	USFS	5	5	5	
1	Minimize losses to raptors.	145		R4	USFS	5	5	5	
1	Minimize losses to other predator (Puerto Rican boas, cats, others).	146	ongoing	R4	USFS	2	2	2	
1	Minimize losses to humans and human activities.	147	ongoing	R4	USFS, DNER	12	12	12	
1	Minimize potential threat from exotic fauna, especially exotic psittacines.	148	ongoing	LE	DNER	45	45	45	

Task Priority	Task Description	Task Number	Task Duration	Responsible Organization FWS	Other	Cost Estimates ($000) FY 1	FY 2	FY 3	Comments
1	Monitor wild population trends.	15	ongoing	R4		40	48	52	
1	Develop, maintain, monitor, protect and augment parrot nesting habitats; expand occupied habitats.	21	ongoing	R4	USFS	30	30	30	
1	Maximize production of Puerto Rican parrots in captivity.	31	ongoing	R4	DNER	569	591	613	
1	Maintain captive stock in good health.	32	ongoing	R4	DNER				Cost included in task 31
1	Release free-flying, captive-reared Puerto Rican parrots to bolster growth.	43		R4	DNER	100	60	60	
2	Delineate occupied range, and assess habitat use.	22	ongoing	R4	USFS	15	16	16	
2	Explore means to protect, improve, and acquire habitat outside, but adjacent to, the CNF and the Central Highland Karst Region.	23	ongoing	R4	USFS, DNER	75	75	75	
2	Refine release techniques used in other parrot releases.	41	ongoing	R4	DNER	20	20	20	
2	Assess feeding habits and determine nutritional needs.	42		R4	USFS	10	10	10	

Task Priority	Task Description	Task Number	Task Duration	Responsible Organization FWS	Other	Cost Estimates ($000) FY 1	FY 2	FY 3	Comments
2	Monitor releases of juvenile Puerto Rican parrots to identify mortality factors and to reduce impacts.	44		R4		60	60	60	
2	Determine suitable release sites.	51	ongoing	R4	DNER	50	50	50	
2	Develop and implement a management plan for second release site to ensure favorable environment and protection for parrots.	52		R4	DNER				
2	Release wild and captive-produced Puerto Rican parrots at a second site.	53		R4	DNER	100	60	60	
2	Release captive-produced parrots using scientific procedures to progressively adapt release procedures to conditions in the Central Highland Karst Region.	54		R4	DNER	40	40	40	
2	Determine feasibility of fledgling Puerto Rican parrot chicks from nests attended by demobilized surrogate parents.	55		R4	DNER	60	60	60	
2	Monitor released parrots.	56		R4	DNER	80	80	80	

Task Priority	Task Description	Task Number	Task Duration	Responsible Organization FWS	Other	Cost Estimates ($000) FY 1	FY 2	FY 3	Comments
2	Foster captive produced chicks into active wild nests.	57		R4	DNER				Cost included in task 53
2	Develop public outreach program.	61	ongoing	R4	USFS, DNER	100	100	100	
2	Determine number of individuals and populations necessary to ensure species stability, security, and self-perpetuation.	71		R4	USFS, DNER	10	10	10	
3	Determine what additional actions, if any, are required to achieve recovery criteria.	72		R4	USFS, DNER	10	10	10	

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Appendix A. SUMMARY OF WILD PUERTO RICAN PARROT (Amazona vittata) BREEDING SEASONS 1990-1998

Year	Nest	Clutch Size	No. Fertile Eggs (%)	No. Fertile Eggs Hatched (%)	Fertile Egg Mortality (%)	Reasons for Egg Mortality	Chick Mortality (%)	Reasons for Chick Mortality	No. Chicks Fledged
1998	SF-1	4	4	4	0	0	1	Poor development	3
	SF-2B	3	3	3	0	0	0		3
	Acostao	3	0	-	-	-	0		-
	QG	3	3	3	0	0	0		3
	Cacique	3	3	1 or more	Unknown	PET predation?	1 or more	PET predation	0
	Tubo	2	1	1	0	0	0		1 aviary
Total	6	18	14	11 or more	Unknown	Unknown	2 or more	-	9 (82) + 1[d]
1997	SF-1	4	3	3	0		1	Development Problems	2
	SF-2A	1	0	0	0		0		0
	SF-2B	2	2	2	0		0		2
	Acostao	3	0	0	0		0		0
	QG	2 first clutch 3 second clutch	1 3	0 3	1 0	Rain Water N/A	0 0		0 3
Total	5	15	9(60.0)	8(88.9)	1(11.1)		1(12.5)		7(87.5)

Appendix A. (CONTINUED)

Year	Nest	Clutch Size	No. Fertile Eggs (%)	No. Fertile Eggs Hatched (%)	Fertile Egg Mortality (%)	Reasons for Egg Mortality	Chick Mortality (%)	Reasons for Chick Mortality	No. Chicks Fledged
1996	SF-1	3	1	1	0		1	Development Problems	0
	SF-2A	3	3	3	0		1	Development Problems	3[a]
	SF-2B	3	3	3	0		0		3
	Acostao	3	3	1	2	Rats	1	Rats	0
	QG	3	2	2	0		0		2
Total	5	15	12	10(83.3)	2(16.7)		3(30)		7(70)+1[a]
1995	SF-1	3	3	3	0		1	Undetermined	2+1[b]
	SF-1A	3	3	3[d]	0		0		2+1[b]
	SF-2A	3	3	3	0		1	Undetermined	2+1[c]
	SF-2B	3	3	3	0		0		3
	QG	3	3	3[e]	0		0		2+1[b]
Total	5	15	15(100)	15(100)	0(0)		2 (13.3)		11(73.3)+4[b]

Appendix A. (CONTINUED)

Year	Nest	Clutch Size	No. Fertile Eggs (%)	No. Fertile Eggs Hatched (%)	Fertile Egg Mortality (%)	Reasons for Egg Mortality	Chick Mortality (%)	Reasons for Chick Mortality	No. Chicks Fledged
1994	SF-1A	3	3	2	1	Died in shell	0		2
	SF-2A	3	3	3	0		1	Undetermined	2+1c
	SF-2B	3	3	2	1	Died in shell	0		2
	EF-3	3	3	3	0		3	1-development problems 2-phillornis	2[b]
	EM-2	3	3	3	0		1	Development Problems	2
	QG	3	3	3	0		0		3
Total	6	18	18(100)	16(88.9 %)	2(11.1)		4(25.0)		12(75)+2[b]
1993	SF-1A	3 First Clutch 4 Second Clutch	3 4	1 3	2 1	PET Pred. PET pred.	1 1	PET Pred. PET Pred.	0 2+1[b]
	SF-2A	3 First Clutch 3 Second Clutch	3 3	1 3	2 0	Microbial Infec. N/A	1 0	Undetermined N/A	0 3
	SF-2B	3	3	3[e]	0		0		2
	EF-3	3	3	2[e]	1	Died in Shell	1	Undetermined	0+1[b]+1[c]
	EM-2	4	4	3[d]	1	Died in Shell	1	Development Problems	1+2[b]
	QG	3	3	3	0		1	Died at Aviary	2
Total	6	26	26(100)	19(73.1)	7(26.9)		5(26.3)		11(57.9)+4[b]

Appendix A. (CONTINUED)

Year	Nest	Clutch Size	No. Fertile Eggs (%)	No. Fertile Eggs Hatched (%)	Fertile Egg Mortality (%)	Reasons for Egg Mortality	Chick Mortality (%)	Reasons for Chick Mortality	No. Chicks Fledged
1992	SF-1A	3	3	3	0		2	Undetermined	1
	SF-2A	3	3	3	0		1	Undetermined	2
	SF-2B	3	2	2	0		0		2
	EF-3	3	2	1	1	Died in Shell	0		1+1[c]
	EM-1	4	4	4	0		4	1 Undetermined 3 Phyllornis	2[b]
	QG	3	3	3[e]	0		0		2
Total	6	19	17 (89.5)	16(94.1)	1(5.9)		7(43.7)		9(56.3)+2[b]
1991	SF-1	4	3	2	1	Died in Shell	2[h]	Phyllornis	0
	SF-2A	3	3	2	1	Died in Shell	0		2
	SF-2B	3	3	2	1	Died in shell	0		2
	EF	3	1	1	0		0		1
	EM	4	2[f]	2	Unknown [f]	Predated by Boa [f]	1	Undetermined	1
	QG	3	1	1	0		0		1
Total	6	20	13(65.0)	10(76.9)	3(23.1)		3(30.0)		7(70.0)

Appendix A. (CONTINUED)

Year	Nest	Clutch Size	No. Fertile Eggs (%)	No. Fertile Eggs Hatched (%)	Fertile Egg Mortality (%)	Reasons for Egg Mortality	Chick Mortality (%)	Reasons for Chick Mortality	No. Chicks Fledged
1990	SF-1	2	2	2	0		2	Undetermined	0
	SF-2TR	3	3	1	2	Rain Water Entered Nest	1	Rain Water Entered Nest	0
	EF	3	2	2	0		0		2
Total	3	8	7(87.5)	5(71.4)	2(28.6)		3(60.0)		2(40.0)

[a] Nestling fostered from the José L. Vivaldi aviary into a wild nest.
[B] Nestling fostered from the Luquillo aviary into a wild nest
[c] Fostered nestling received from another wild nest.
[d] Nestling moved to the Luquillo aviary
[e] Nestling removed and fostered into another wild nest
[f] eggs predated before fertility could be determined.

Appendix B. Recommendations from the Puerto Rican Parrot Workshop 1995

CATEGORY RANKS

Category 1. - A critical and essential task that must be undertaken immediately with adequate resources.

Category 2. - An essential task that should be initiated and completed as soon as resources can be secured.

Category 3. - An important task that would assist recovery, but either (1) has a lesser priority than other ongoing activities, or (2) requires completion of other actions before it can be initiated.

CATEGORY I RECOMMENDATIONS

Parrot census methods need to be re-evaluated to validate the assumptions on which the counts are based. Appropriate statistical methods should be applied to historical count data to develop confidence intervals and facilitate the estimation of population trends.

Determine demographic characteristics of the wild population, especially reproductive rates, age of first breeding, causes of non-breeding, and survival of various age classes through nest observation and individual marking techniques (especially banding, transponders, and radiotelemetry).

Enhance nest-guarding, nest monitoring, and chick fostering of captive-produced young in order to minimize losses to natural enemies *and other threats, maximize* productivity of the wild population, and to accurately determine fledging rates and causes of productivity losses.

Monitor Red-tailed Hawk populations and their effects on the parrot populations in Luquillo.

The captive flock must be managed to produce as many Puerto Rican parrots as possible to support the wild flock through fostering and release of captive-reared birds. The integrity of the captive flock must be ensured by sound genetic and demographic management.

Conduct a pedigree analysis of the captive flocks.

Contract an on-site data manager to organize and standardize existing aviary data sets, enter past data and design more efficient (e.g., daily) data entry and management procedures. Appropriate statistical analyses should be performed on these data. Make data sets available to appropriate personnel and agencies.

As soon as possible, experimental releases should be initiated of captive-reared Puerto Rican parrots into the wild Luquillo population. Further experiments with releases of captive-reared Hispaniolan parrots in the Dominican Republic are not recommended.

Implement double-clutching of wild and captive pairs of parrots to boost productivity and to provide birds for fostering and release.

Support the efforts of the Puerto Rican Department of Natural and Environmental Resources to limit the importation of exotic animals into Puerto Rico.

Develop standard necropsy protocols for eggs, embryos, chicks, sub-adults, and adults, and identify a common laboratory for postmortem analysis

Manage captive flocks to enhance creation of productive pairs. In particular, long-term non-breeders at the Luquillo aviary should be moved to the Rio Abajo aviary to test their reproductive potential *in a different* environment and/or with new mates.

Identify the best site(s) for the establishment of other wild populations of the Puerto Rican parrot, so that the Puerto Rican Department of Natural and Environmental Resources can protect these areas before they are developed.

CATEGORY 2 RECOMMENDATIONS

Conduct diet studies of nestling Puerto Rican parrots by crop sampling Hispaniolan parrots fostered into Puerto Rican parrot nests.

Conduct phenology studies in parrot habitat to facilitate understanding of parrot reproductive biology and movement patterns.

Incorporate the pertinent biological information from studies of parrots and studies of Puerto Rican birds (e.g., Pearly-eyed *Thrasher) to* revise nest management protocols.

Ensure that all personnel observe existing protocols prohibiting movements of birds out of the aviaries to other locations followed by return to the aviaries. The only exception to this rule will be movements between the aviaries and the wild population. In addition, there is a need to establish a protocol for people coming into the aviaries as well, especially those having contact with birds elsewhere.

Improve protocols for handling wild chicks and use existing management protocols for trapping exotic psittacines to test for diseases that could affect the Puerto Rican parrot and necessitate control measures.

Design and implement experiments to improve aviary management techniques (e.g., nest boxes, cage design) based on accepted experimental design procedures.

Enhance existing management systems for storage and retrieval of flock data.

CATEGORY 3 RECOMMENDATIONS

Establish a second Wild population by initially translocating adult birds from the wild Luquillo population to a second release site when the wild population in Luquillo reaches an appropriate size and reproductive status (e.g., the population viability analysis suggests the Luquillo Population has a relatively low risk of extinction when it exceeds 70 birds).

Re-analyze the DNA fingerprinting data of Brock and White (1992 Proc. Natl. Acad. Sol. 89:11121-11125) considering new statistical recommendations for all founders, captive PRP, wild PRP. Statistically consider alternative hypotheses to inbreeding depression.

Appendix C. Summary of the Puerto Rican Parrot Management Situation Concept in CNF

Management Situation	Description	Sensitivity to Disturbance		Standards and Guidelines	Coordination Requirements
		Physical	Human		
1	Breeding Habitat	Extremely High	Extremely High	3. No physical disturbances 4. Time projects outside of the nest selection period (12/1 - 4/15) 5. Time projects outside of breeding season (1/1 - 7/30)	1. Forest Biologist 2. PRP Technical Committee [1] 3. FWS[2] 4. ESA[3] 5. NEPA[4]
2	Non-Breeding habitat	High	Moderate-High	1. No physical disturbances 2. Time projects outside of the nest selection period (12/1 - 4/15) 3. No timing constraints for activities (except blasting, aircraft use, etc.) During breeding season (1/1 - 7/30) unless parrots enter the area.	1. Forest Biologist 2. FWS 3. ESA 4. NEPA
3	Limited Value Habitat	Moderate-Low	Low	1. Physical disturbances should retain feeding components 2. No activity timing constraints (except blasting, aircraft use, etc.) unless parrots enter the area during nest selection (12/1 - 4/15) or breeding season (1/1 - 7/30).	1 Forest Biologist 2 ESA 3. NEPA
4	Potential Habitat	Low	Low	1. Physical disturbances should retain habitat components 2. No activity timing constraints (except blasting, aircraft use, etc.) unless parrots enter the area during nest selection (12/1 - 4/15) or breeding season (1/1 - 7/30).	1 Forest Biologist 2 ESA 3. NEPA
5	Non-Essential Habitat	Extremely Low	Extremely Low	1. Physical disturbances should retain habitat components 2. No activity timing constraints (except blasting, aircraft use, etc.) unless parrots enter the area during nest selection (12/1 - 4/15) or breeding season (1/1 - 7/30).	1 Forest Biologist 2 ESA 3. NEPA

[1] **The Puerto Rican Parrot Technical Committee; consists of representatives from the U.S. fish and Wildlife Service (Management), U.S. Forest Service (Management and Research), and the Puerto Rico Department of Natural and Environmental Resources.**

[2] **U.S. Fish and Wildlife Service**

[3] **Endangered Species Act**

[4] **National Environmental Policy Act**