2016

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Published in Perry, M. C. , ed., The History of Patuxent –America's Wildlife Research Story (2016)
U. S. Geological Survey Circular 1422, 255 p. https://doi.org/10.3133/cir1422

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Although indigenous Amerindian populations adversely affected the biota of their island environments, it was not until the arrival of Europeans that populations of many plant and animal species in the Caribbean Islands declined dramatically (Snyder and others, 1987). Island species are particularly vulnerable to changes in the environment, which, in the extreme, can lead to their extinction. The small populations of many species that occupy islands have limited gene pools and typically show extremes of specialization, characteristics that place those species at high risk for decline and extinction with rapid environmental change. The most important factor in the decline of most Caribbean Island species has been the rapid increase in human population and the environmental changes related to that growth (Snyder and others, 1987).

Among the islands in the Caribbean, Puerto Rico has experienced arguably the most radical transformation of any pre-Columbian habitat. Puerto Rico formerly was covered in natural vegetation, but by 1912 fewer than 1 percent of the original forests were still virgin; all other areas were cut, plowed, grazed, burned, or otherwise degraded (Snyder and others, 1987). The extensive agriculture supported by Puerto Rico's fertile soils allowed the human population on this small (11,489 square kilometers [km^2] [4,436 square miles (mi^2)]—204 kilometers [km] [127 miles (mi)] east to west and 76 km [47 mi] north to south at the widest points) island to increase rapidly, to the point that in 2015, with 4 million residents (about 350/km^2 [900/mi^2]), it was one of the most densely populated islands in the world. Although agriculture is no longer of major importance in Puerto Rico, the human population has continued to grow, causing many plant and animal species to decline or disappear from the island (Snyder and others, 1987).

The endemic Puerto Rican parrot (*Amazona vittata*) is perhaps the most charismatic and emblematic of the species affected by the many environmental problems that have faced Puerto Rican wildlife in the past 500 years. Early accounts reported the parrot's presence throughout the island and on at least three of Puerto Rico's four major satellite islands. All indications are that the parrot was once abundant on the island, perhaps numbering more than 1 million individuals. As Europeans settled the land, parrot populations declined rapidly and disappeared from one after another part of the island (Snyder and others, 1987).

Development of an Endangered Species Research Program in Puerto Rico

In 1946, Ventura Barnés, a biologist with the Commonwealth of Puerto Rico Department of Agriculture and Commerce, expressed concern over the parrot's decline (Rodríguez-Vidal, 1959). From 1953 through 1956, José Rodríguez-Vidal, another Commonwealth biologist, supported by the Pittman-Robertson Program of the U.S. Fish and Wildlife Service (USFWS), conducted the first detailed study of the parrot. Rodríguez-Vidal found that the parrot population in the mid-1950s consisted of only about 200 individuals, and those birds were localized in one small area in eastern Puerto Rico—the Luquillo Forest (Rodríguez-Vidal, 1959). The evidence of the parrot's precariously low numbers and restricted range prompted further apprehension on the part of Commonwealth Department of Agriculture and Commerce biologists,

Puerto Rican parrot ready to fledge, 1975. Photo by Jim Wiley, U.S. Fish and Wildlife Service.

who attempted to reintroduce the parrot in western Puerto Rico, outside its remnant range. Unfortunately, those efforts failed. Early studies by Rodríguez-Vidal and others indicated that a broad array of environmental problems could have been responsible for the parrot's decline (Snyder and others, 1987).

At the urging of Frank Wadsworth, Director of the International Institute of Tropical Forestry (IITF), Río Piedras, Puerto Rico, and with similar efforts by Ray Erickson, assistant director in charge of endangered species research at Patuxent Wildlife Research Center in Laurel, MD (Patuxent), a cooperative program to rescue the parrot was begun in late 1968. The program was developed as a collaboration of the USFWS, U.S. Department of Agriculture, U.S. Forest Service (Forest Service), and the government of the Commonwealth of Puerto Rico, with support from the World Wildlife Fund. The initiation of the Puerto Rican parrot program closely followed passage of the Federal Endangered Species Preservation Act (1966) and inclusion of the parrot on the Federal Endangered Species List in 1967.

At the onset of the Patuxent program in Puerto Rico, all participants recognized that the parrot was in steep decline and extreme measures would probably be needed to save the species. To maximize the likelihood of determining the important factors affecting the parrot population, studies were not restricted to the parrot, but included efforts to understand the biological characteristics of important natural enemies of this species and the biology of other, closely related parrot species (Snyder and others, 1987).

History of Patuxent Biologists at the Puerto Rico Field Station

Cameron Kepler was the first biologist to lead the Caribbean research program. The Forest Service provided Cam and his wife, Angela ("Kay"), with a live-in field station in the heart of the parrot's remnant range in the protected Luquillo Forest, to allow them direct, daily access to the remaining population. The Keplers conducted research on the parrot and other species of conservation concern from 1968 to 1971. Cam Kepler's parrot work focused on determining population size and distribution within the Luquillo Forest, where he developed reliable censusing methods (Kepler, 1972b). Unfortunately, the accuracy of the counts did not show a hoped-for larger population of parrots than had previously been reported. Kepler gave special attention to parrots in the eastern half of the Luquillo Forest, where he documented daily and seasonal foraging behavior and sought to obtain information on recruitment and mortality. Cam left Puerto Rico in late 1971 to become Visiting Researcher at the Edward Grey Institute of Field Ornithology, Oxford University, after which he returned to Patuxent in 1973 to head the whooping crane (*Grus americana*) captive breeding program. He moved on to Hawaii to establish the Maui field station in 1977, but returned to Patuxent (Southeast Research Station, Athens, GA) in 1986 to conduct research on Kirtland's warbler (*Seteophaga kirtlandii*) and other species.

Pico el Yunque, El Yunque National Forest (formerly Luquillo Forest), Puerto Rico, mid-1970s. Photo by Helen Snyder, U.S. Fish and Wildlife Service.

Cam and Kay Kepler, U.S. Fish and Wildlife Service, at field station, Luquillo Forest, Puerto Rico, 1970. Photo by Noel F.R. Snyder, U.S. Fish and Wildlife Service.

Noel Snyder (left) and John Taapken, U.S. Fish and Wildlife Service, prepare for a day in the field, Puerto Rico, mid-1970s. Photo by Helen Snyder, U.S. Fish and Wildlife Service.

Noel Snyder was the second scientist to head the Puerto Rico field station. Noel and his wife, Helen, conducted detailed studies of parrot biology from 1972 through 1976, concentrating on the population's breeding biology. Constant daylight observations of all known nests (2–5) were conducted from blinds throughout breeding seasons. The Snyders made critical advances in the understanding of the parrot's challenges and, as each bit of knowledge was obtained, immediate efforts were made to correct identified problems. For the first time, the decline of the parrot population was reversed, and the wild population began to increase slowly in number. Further, a captive parrot program was established in Puerto Rico under the watch of the Snyders, who developed fundamental husbandry techniques for captives (Snyder and others, 1987).

Jim and Beth Wiley's work overlapped with that of the Snyders; they came to the program as Forest Service employees in 1975, replacing Noel when he transferred to Patuxent in 1976. After a writing stint at Patuxent, Noel headed back to the field to study snail kites (*Rostrhamus sociabilis*) in 1978, before leading the California condor (*Gymnogyps californianus*) research program beginning in 1980. Noel left the Patuxent program in 1987, when he retired, but continued writing scientific papers as a private researcher. The Wileys continued the work initiated by the Keplers and Snyders, with emphasis on improving reproductive success in the wild population and developing techniques for releasing captive-produced birds into the wild. The aviary flock increased in number, produced the first captive-bred Puerto Rican parrots, and provided a vital resource for managing the wild flock. During this period, the first releases of captive-produced parrots were made in the Luquillo Forest, and radiotelemetry was used to track post-fledging parrots (Lindsey and Arendt, 1991). The Wileys left Puerto Rico in late 1986, following Noel Snyder to California, where Jim studied the California condor through 1991, when he entered the U.S. Geological Survey (USGS) Cooperative Research Units program.

Gerald Lindsey joined the Puerto Rico program in 1985. After the Wileys' departure, he led the program, conducting additional work on parrot movements by using telemetry. Gerald overlapped with Marcia Wilson, who assumed leadership of the program in 1989, after which time Gerald followed Wiley out to California, where the two worked together again—this time on the condor project—before Gerald transferred to Hawaii in 1991.

Marcia Wilson (1989–91) continued to oversee nesting investigations, the captive program, and tracking of free-flying parrots. In her first year at the station, Marcia was faced with a major hurricane, which damaged much of the Luquillo Forest. Under the challenging post-hurricane conditions, her team documented the greatly reduced population size and distribution of the parrot (Wilson and others, 1994). Marcia left the Puerto Rico field station in 1991 to assume an administrative post at Patuxent in Maryland.

Wylie Barrow (1990–92) and J. Michael ("Joe") Meyers (1990–95) joined Marcia in Puerto Rico as Patuxent staff members before she went to Laurel. Barrow and Meyers continued the telemetry work and developed refined parrot-marking techniques. Meyers was the last of the Patuxent scientists to lead the parrot project, which was abandoned in 1995. Barrow and Meyers continued as USGS wildlife research biologists—Wylie at the National Wetlands Research Center and Joe at Patuxent, stationed at the University of Georgia in Athens.

Even before Marcia Wilson left the Puerto Rico field station, a transition of agency roles had begun. In 1990, the USFWS (Region 4) assumed the lead in management aspects of the parrot conservation program, including operation of the aviary, in cooperation with the Puerto Rico Department of Natural Resources (PRDNR) and the Forest Service. Patuxent

Puerto Rican field crew at East Fork, Puerto Rico, 1989. Photo by Jim Wiley, U.S. Fish and Wildlife Service.

closed the Puerto Rico field station in 1995. Francisco ("Tito") and Ana Vilella, the first biologists involved in the USFWS program (1989–95), were followed by Augustín Valido (1991–2001), Fernando Nuñez (2000–06), and Tom White (1999–present [2016]), among others.

Challenges and Accomplishments of Patuxent's Program for Conservation of the Puerto Rican Parrot

At the outset, Patuxent biologists were faced with a staggering, diverse array of environmental problems affecting the parrot (Snyder and others, 1987). Foremost among these was the near-complete, island-wide habitat destruction and alteration. Although parrots formerly were found through all of the island's habitats ranging from woodland to forest, the species requires habitat that includes trees large enough to harbor cavities for nesting. By the mid-1950s, the Luquillo Forest was the only location in Puerto Rico that supported a parrot population, mainly because it was the only sizable habitat that provided nesting cavities. Early studies by Barnés, Rodríguez-Vidal, and others had provided few clues about the parrot's problems (Rodríguez-Vidal, 1959). Rodríguez-Vidal and others suggested that poor nest success, apparently due mainly to rat (*Rattus rattus*) and pearly-eyed thrasher (*Margarops fuscatus*) predation, was responsible, but a comprehensive appreciation of nesting and other difficulties was still lacking.

Kepler studied three nests from blinds and determined that many of the birds in the population were not breeding. He also found that the population had declined precipitously since the mid-1950s and, with only about 24 wild birds in existence in 1968, the species was perilously close to extinction in the wild.

Pearly-eyed thrasher—a parrot predator, 1970s. Photo by John Taapken, U.S. Fish and Wildlife Service.

Noel Snyder intensified observations at nests, and initiated comprehensive studies of the ecology of the parrot. Through extensive searches and tree climbing, it was determined that although many large trees and cavities existed within the protection of the Luquillo Forest, only a few existing cavities were actually suitable for parrot nesting. Many of the most amenable cavity-bearing trees had been removed through historic logging and timber-stand improvement practices in the forest. Further, a tradition of felling nest trees or hacking into cavities to harvest chicks for pets selectively destroyed the most suitable (that is, parrot-occupied) nesting habitat. Snyder's finding that few good cavities were available for nesting parrots led to an effort to improve existing

suboptimal cavities as well as provide suitable artificial cavities for parrots.

Detailed studies of parrot breeding biology were initiated in 1973 with constant daylight observations from blinds of as many nests as possible given constraints of personnel and their energy limitations. Those were days of pressing urgency, as the wild population continued its decline toward extinction and the time remaining to find solutions to slow and reverse the rapid loss of birds grew increasingly limited. In fact, when the low point of only 13 birds known in the wild was reached in mid-1975, the goal had to be nothing less than a rapid turnaround in the plummeting population to prevent genetic collapse of the species. This pressure led scientists to conduct intensive trials of innovative methods to protect the parrot and reverse the decline in reproductive output.

Intensive observations revealed the relative unimportance of some natural and exotic predators, including Puerto Rican boa (*Epicrates inornatus*) and introduced Javan mongoose (*Herpestes javanicus*). Although both are known predators of parrots, their role in the decline of the species was evaluated to be less significant than that of other threats. Exotic rats and pearly-eyed thrashers were determined to be important predators and competitors of the parrot. The now-ubiquitous thrasher is evidently a recent invader of the forest and may not have threatened historical populations of parrots. Both thrashers and rats use tree cavities for nesting, with thrashers being particularly aggressive cavity competitors with parrots. Rats were found to be more important as scavengers of abandoned parrot eggs or chicks, but nevertheless remained a threat to nest contents and were controlled within key nesting areas. The thrasher menace was addressed first through direct elimination of birds that demonstrated a threat at parrot nests. That labor-intensive strategy was not sustainable, however, and other control mechanisms were explored. Experimental trials using various alternatives of cavity size and dimension revealed that thrashers and parrots differed with respect to preferred nest-cavity characteristics, thereby indicating a potential option for thrasher management (Snyder and others, 1987). Nest boxes of various configurations and sizes were placed in the forest and their acceptance by thrashers was monitored to determine that species' preferences. Comparing those data with data collected from successful parrot nests revealed that parrots preferred deeper cavities than thrashers. A program of deepening existing parrot nesting cavities was begun, along with provisioning thrashers occupying the parrots' nesting areas with one or more optimal thrasher-sized nest boxes. That strategy greatly reduced thrasher-parrot competition and resulted in improved parrot nest success.

European honeybee (*Apis mellifera*), another exotic species, also proved to be an important cavity competitor with parrots. Honeybees seek cavities with characteristics attractive to parrots. Once established in a parrot nest cavity, honeybees may occupy that site for years, excluding the parrot and further diminishing the overall availability of parrot nest sites. Provisioning of additional nearby artificial boxes was not feasible in controlling honeybee invasions of parrot nests. Fortunately, honeybees typically do not swarm and seek new cavities until after the parrot nesting season. A practice of physically removing honeybee colonies that invaded parrot nests was used successfully for bee control.

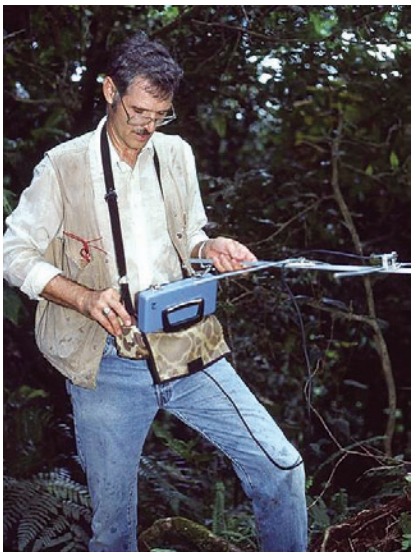
Most natural cavities in the Luquillo Forest, where annual rainfall averages 500 centimeters (nearly 200 inches), were found to have wet bottoms, a characteristic that was determined to lower the chances of parrot egg and chick survival. Therefore, in addition to fortifying natural cavities against predators and competitors, all existing cavities were modified to eliminate problems caused by entry of water.

Although capture of parrots, especially taking young from nests, was an important historical factor in the decline of the parrot, that practice had declined by the 1960s, in part because of greater legal protection of the species and its habitat, but also because the pet trade had changed. People who wanted pet parrots were more likely to purchase an exotic parrot from a pet store than to encounter an individual selling Puerto Rican parrots. Unfortunately, this shift from native to exotic birds being sought as pets introduced other threats to the Puerto Rican parrot. Exotic parrots that escaped or were intentionally released from captivity established populations in Puerto Rico, and those species threatened the native species as competitors for habitat. Even though most alien parrots characteristically remained near populated areas, these established exotics posed a far more insidious threat: imported birds might carry exotic diseases against which the native parrot likely would have no defense.

Harvesting of wild parrots was also deterred by program personnel who guarded all active nests throughout the day, while watching for signs of other problems that would affect nest success and productivity. Although manpower constraints did not allow for constant vigil at all nests every day, the number of nests monitored was maximized through the dedication of technicians and volunteers. A tabulation of Patuxent parrot program activities from 1973 to 1979 showed that scientists and assistants had logged more than 20,000 hours of observations from blinds and lookouts.

Radiotelemetry techniques for tracking parrots were developed and have proven invaluable in advancing the conservation of the species. In 1985, studies of parrot movements using telemetry were brought to the forefront of the research program in an effort to determine areas of vulnerability of parrots to predation. Telemetry of marked birds confirmed the conclusions reached from observations and tallies of parrots: post-fledging mortality in the wild flock was high. Known and suspected predators included resident red-tailed hawks (*Buteo jamaicensis*), which are found in extraordinarily high densities in the Luquillo Forest, and wintering peregrine falcons (*Falco peregrinus*) (Lindsey and others, 1994).

As Patuxent scientists tallied the many environmental problems faced by the parrot in the Luquillo Forest, they also examined the possibility of establishing flocks in other parts of Puerto Rico that might exhibit less challenging environmental conditions than those in the extremely wet rain forest at Luquillo and, therefore, might prove to be better suited for



Gerald Lindsey, U.S. Fish and Wildlife Service, tracking parrots with telemetry, Luquillo Forest, Puerto Rico, 1986. Photo by Jim Wiley, U.S. Fish and Wildlife Service.

Helen Snyder, U.S. Fish and Wildlife Service, with Hispaniolan parrots, Sierra de Baharuco, Dominican Republic, 1982. Photo by Noel F.R. Snyder, U.S. Fish and Wildlife Service.

Beth Wiley, U.S. Fish and Wildlife Service, feeding young parrots, Puerto Rican parrot aviary, Luquillo Forest, Puerto Rico, 1980s. Photo by Jim Wiley, U.S. Fish and Wildlife Service.

self-sustaining populations of the parrot. It became obvious that by using current (1985) techniques the parrot population at Luquillo could be sustained only through rigorous and extensive management. Although the Luquillo Forest offered substantial protection against poaching and habitat alteration, the parrot population there was facing more risk factors (especially the wetter environment and denser populations of predators and competitors) than existed in other areas in Puerto Rico. Several areas that might have been appropriate for potential reintroduction areas of the parrot were protected as Commonwealth forests and, with a shift of the island's human population away from an agrarian-based society, natural cover, albeit second growth, had increased dramatically to about 40 percent of land cover. Patuxent scientists believed it would be advantageous to maintain the Luquillo Forest population, which was an important source of behavioral memory, while establishing a second free-flying flock distant from the Luquillo population and supported by an on-site aviary at a second release area. Río Abajo Commonwealth Forest was judged to be a suitable site for this next phase of the recovery effort on the basis of its recent (1940s) history of parrot presence, habitat recovery, security, and lower densities of predators and competitors.

With intensive and extensive efforts by many dedicated people, the Luquillo Forest wild population began a slow recovery from the low of 13 individuals and only 2 breeding pairs in 1975 (Snyder and others, 1987). By 1989, the wild population had reached 47 individuals and as many as 5 (1975, 1984) breeding pairs in a year. In September 1989, however, the first major hurricane in 57 years devastated the Luquillo Forest. Despite an apparent loss of more than half the parrots in the wild, biologists subsequently located a new nesting area that may have been established as a consequence of the storm. In fact, an until-then program-high number of breeding pairs (six) nested in 1991. By 1995, when Patuxent discontinued the parrot program, the wild population had increased to 44 individuals (Snyder and others, 1987).

Captive Puerto Rican parrots were established at Patuxent in 1970, with two birds donated by the Mayagüez Zoo in western Puerto Rico. In early 1972, Paul Sykes (USFWS) and Mike Lennartz (Forest Service) were detailed temporarily to Puerto Rico, where they captured two wild birds despite tremendous odds and physical challenges. One parrot survived and was added to the Patuxent flock. At that time, however, an outbreak of Asiatic Newcastle disease in Puerto Rico led to rigorous quarantine for any birds entering the United States, making it impractical to continue developing the captive flock at Patuxent. The quarantine problem and the need to move parrot eggs and chicks to and from wild nests for protection and treatment led to the establishment of an aviary in the Luquillo Forest in 1973, at which time activities shifted from capture of wild, free-flying birds to harvesting eggs and chicks from the wild to build the captive flock. In fact, most new members of the captive flock were added when eggs or chicks could not be maintained safely in the wild because of potentially lethal threats to their health and safety. At the onset of developing an on-site captive flock, a primary goal was to obtain genetic representation of as many of the existing wild parrots as possible.

With the establishment of the aviary in Puerto Rico, first in the Snyders' living room and later at a dedicated aviary field station building, salvaging and manipulation of wild nest contents became practical. Eggs and chicks threatened by problems such as predation, parasitism by warble (*Philornis pici*) and black soldier (*Hermetia illucens*) flies, or wet cavity floors

could be removed temporarily to the aviary, treated or guarded in a safe environment until the threat at the wild nest had been addressed, then returned in time to fledge in the wild (Snyder and others, 1987). The ability to salvage endangered eggs and chicks was further improved through the establishment of an on-site captive flock of the closely related Hispaniolan parrot (*Amazona ventralis*). Captive Hispaniolan parrots served as surrogates for the endangered species in many ways. During periods of high risk at wild Puerto Rican parrot nests, captive-produced Hispaniolan parrot eggs and chicks were fostered into wild nests to replace Puerto Rican parrot eggs and chicks until the danger had passed. Hispaniolan parrots were used as "guinea pigs" to test for suitability of various procedures before they were used on Puerto Rican parrots (Snyder and others, 1987). Furthermore, captive Hispaniolan parrots proved extremely useful and reliable in incubating eggs and brooding of captive- and wild-produced Puerto Rican parrot eggs and chicks. In fact, Hispaniolan parrots were far better at incubating eggs and brooding chicks than were mechanized incubators and brooders, and required far less intense interaction with humans—an important concern for avoiding parrot imprinting on humans and reliance on people as sources of food.

Although the wild population began to recover from its 1975 low, by mid-1979 only 25 or 26 birds were known to exist in the wild. The slow recovery made efforts to use the captive flock to augment the wild population even more important to the parrot's survival. Efforts to achieve captive reproduction involved developing techniques for sexing the captives and methods of artificial insemination. Experiments in the aviary revealed that replacement clutching was a valuable procedure to increase egg production of parrots; therefore, this practice was incorporated into the captive program to boost production. The first captive-bred Puerto Rican parrot chick was produced in 1979 and was fostered into an active nest, from which it successfully fledged. Thereafter, all fit chicks produced through 1986 were fostered into wild nests.

As part of the preparation for releases of free-flying, captive-produced Puerto Rican parrots, experimental releases of captive-produced Hispaniolan parrots were conducted in the Dominican Republic in 1982. Those releases of 36 birds resulted in an encouraging survival rate of 33 percent, which is approximately the rate the program had been able to achieve through efforts to manage the wild Puerto Rican parrot flock.

Mike Lennartz, U.S. Forest Service, carrying Puerto Rican parrots, Luquillo Forest, Puerto Rico, 1980s. Photo by Paul Sykes, U.S. Fish and Wildlife Service.

Additional advancements with radiotelemetry and other marking techniques gave biologists the confidence to release three free-flying, captive-produced Puerto Rican parrots into the Luquillo Forest in 1986. That release was preceded by aversion conditioning of release candidate parrots by using a trained red-tailed hawk. Again, the survival rate was one out of three, and, importantly, the surviving individual reached sexual maturity and bred in the wild.

After Ray Erickson retired from Patuxent in 1980, the program for the conservation of the Puerto Rican parrot was managed differently. Field work was delegated primarily to technicians and junior scientists, and active nests were monitored remotely. Senior scientists devoted more time to communicating with their superiors and writing scientifically defensible research proposals and manuscripts rather than making field observations and guarding nests, a function that had proven critical to the recovery effort (Lindsey, 1992). Therefore, although the junior scientists and technicians were very capable and dedicated to the success of the project, the knowledge, experience, and judgment of the senior scientists were no longer being applied directly to decision-making in the field.

Half-grown captive Puerto Rican parrot. Photo by Jim Wiley, U.S. Fish and Wildlife Service.

Patuxent administrators continued to work on parrot recovery progress after the USFWS and the PRDNR assumed expanded roles in the parrot program. The second wild population in Río Abajo, Puerto Rico, was not established in spite of strong evidence that the Luquillo Forest environment was not optimal for the survival of a viable, self-sustaining wild population (Snyder and others, 1987, p. 270). Over time, the USFWS strengthened its relations with PRDNR and the program's leadership shifted away from Patuxent. In 1990, the Puerto Rican government established and administered a second captive breeding site at the Río Abajo aviary in western Puerto Rico. Patuxent's parrot program ended in 1995.

Present Status of the Puerto Rican Parrot

The establishment of a disjunct western population of Puerto Rican parrots has been of pivotal importance in the recovery of the parrot. By 2012, the wild population at Río Abajo totaled 40 to 50 birds, after only 6 years of releases. Even more encouraging, 10 pairs in the western area were productive in the wild in 2012. The collective captive populations in the Luquillo Forest and Río Abajo aviaries, which support both of the wild populations, currently (2016) number more than 400 birds. A third wild population was established at a second western site (Maricao) in Puerto Rico in 2015 (U.S. Fish and Wildlife Service, 2016).

Unfortunately, however, after more than 40 years of intense efforts to establish a self-sustaining population of parrots in the Luquillo Forest, the flock still struggles to survive, with a 2016 wild population of only about 12 birds. If other areas of Puerto Rico are included, however, the wild population of the parrot is more than 100 birds (Breining, 2015).

Research on Other Parrot Species and Training of Caribbean Conservationists and Biologists

Comparative studies of the Puerto Rican parrot and parrot species on other islands were an important component of the research conducted by Patuxent biologists. Such studies provided insights into some of the ecological and behavioral aspects of Puerto Rican parrot biology, particularly when "healthy" populations were compared with the small remnant population surviving in Puerto Rico. In such comparisons, wild populations of Hispaniolan parrots were studied where they occurred in large numbers in unaltered ecosystems in the Dominican Republic. Among other species studied, to varying extents, were Bahama parrot (*Amazona leucocephala bahamensis*) in Great Abaco and Great Inagua Islands (Kepler, 1982); Grand Cayman (*A. l. caymanensis*) and Cayman Brac (*A. l. hesterna*) parrots in the Cayman Islands (Wiley, 1991); Cuban parrot (*A. l. leucocephala*) in Cuba and Isla de Pinos (now Isla de la Juventud) (Aguilera and others, 1999); black-billed (*A. agilis*) and yellow-billed (*A. collaria*) parrots in Jamaica; and St. Vincent parrot (*A. guildingii*), St. Lucia parrot (*A. versicolor*), and imperial (*A. imperialis*) and red-necked (*A. arausiaca*) parrots in Dominica (Beissinger and Snyder, 1992; Snyder and others, 1987). In addition to conducting studies of other parrot species and their ecosystems, Patuxent scientists trained many resident conservation officers and biologists on site or during their extended stays at the Puerto Rico field station. Parrot research and management techniques—for example, development of reliable censusing methodology and using artificial and improved natural nest structures to augment natural habitat—were transferred to other islands and incorporated into those countries' parrot conservation efforts.

Other Endangered Species Research by Patuxent Scientists in the Caribbean

Because of the urgency of reversing the population decline of the Puerto Rican parrot, Patuxent biologists focused their research on that species; however, many other Caribbean wildlife species were in need of conservation efforts. For several species, that need could only be speculated upon, because no reliable population numbers or trends were available. Island agencies often asked Patuxent scientists to participate in studies of species in addition to the parrot. Therefore, Patuxent biologists considered it important to explore the biology of other species identified as possibly threatened to provide baseline data on those populations as well as a biologically sound foundation upon which to base local and international conservation efforts.

Seabirds on several of Puerto Rico's offshore islands and cays were the focus of Kepler's extra-parrot research (Kepler, 1978). Cam also conducted the first study of Puerto Rican nightjar (*Caprimulgus noctitherus*), a species that was thought to have become extinct until its rediscovery in 1961. His work and subsequent surveys by other Patuxent biologists produced a basic understanding of the distribution of, status of, and threats to the nightjar. In addition, Cam and Kay Kepler surprised the ornithological world with their discovery of a new species of warbler (the elfin-woods warbler, *Setophaga angelae*) in Puerto Rico in 1970 (Kepler and Parkes, 1972).

Two pigeon species of international concern—plain pigeon (*Patagioenas inornata*) (Wiley and others, 1982) and white-crowned pigeon (*P. leucocephala*) (Wiley and Wiley, 1979)—were studied by Patuxent personnel. Both suffered from the extreme habitat modification seen in Puerto Rico and other Caribbean islands. Results of the studies were used by the PRDNR to manage the pigeon populations. The formerly endangered Puerto Rican plain pigeon (*P. i. wetmorei*) has

Male white-crowned pigeon brooding, Puerto Rico, early 1980s. Photo by Jim Wiley, U.S. Fish and Wildlife Service.

shown remarkable recovery since the 1970s, when only about 120 birds survived, to the several thousand pigeons that are currently (2016) spread over a large portion of Puerto Rico.

The endangered yellow-shouldered blackbird (*Agelaius xanthomus*) and several other native host species of a recently arrived brood parasite, shiny cowbird (*Molothrus bonariensis*), were the subject of extensive research that improved understanding of the ecological relations between the parasite and its hosts (Cruz and others, 1985, 1988; Wiley, 1985, 1988). Patuxent scientists and technicians developed techniques for controlling the effects of brood parasitism on host species, which resulted in improved reproductive success and productivity of hosts, including the yellow-shouldered blackbird (Post and Wiley, 1976, 1977; Wiley and others, 1991).

Several endangered or threatened species of raptors were the subject of in-depth research by Patuxent biologists. The threatened status of endemic races of sharp-shinned (*Accipiter striatus venator*) and broad-winged (*Buteo platypterus brunnescens*) hawks was determined, and Patuxent scientists initiated research on the ecology and behavior of these species. The restricted range of the endemic race of short-eared owl (*Asio flammeus portoricensis*) was determined and its status was identified as being of national concern.

White-necked crow (*Corvus leucognaphalus*), endemic to Hispaniola and Puerto Rico, was extirpated from Puerto Rico in the early 1960s. Patuxent scientists conducted a detailed study to determine the possible cause of that extirpation by studying populations of the crow in the Dominican Republic (Wiley, 2006). That study resulted in a recommendation to reintroduce the crow to Puerto Rico as part of a restoration of the island's original ecosystems and a hedge against extirpation in Hispaniola and, thereby, extinction. The data collected on the crow in the Dominican Republic serve as a baseline for reintroduction into Puerto Rico, although no action to do so has been undertaken.

A detailed study of the critically endangered St. Croix ground lizard (*Ameiva polops*) was conducted by Beth and Jim Wiley at Green and Protestant Cays at the request of the government of the U.S. Virgin Islands. That study provided baseline information on the population size, habitat requirements, and management needs of the lizard. The formerly endangered Puerto Rican boa (*Epicrates inornatus*) was the subject of a diet study by Jim Wiley (2006).

In addition to studies of threatened wildlife species, Patuxent biologists led or were involved in research on several nonthreatened species that were important to the understanding of the ecology of the parrot and other species—for example, investigations of rat populations in the Luquillo Forest, pearly-eyed thrasher ecology and behavior (Snyder and Taapken, 1978), and warble and soldier fly biology.

Patuxent scientists served as members or consultants on Federal recovery teams for the Puerto Rican parrot, Puerto Rican plain pigeon, Puerto Rican nightjar, yellow-shouldered blackbird, and several other species in Puerto Rico and the U.S. Virgin Islands. The Patuxent scientists' research results provided baseline data critical to the development of recovery plans.

Contributions of Patuxent Wildlife Research Center to Caribbean Conservation Efforts

It may never be known whether the efforts of Patuxent scientists and the many other employees and volunteers to save the Puerto Rican parrot actually prevented the species' extinction. Certainly their efforts shifted the parrot's trajectory from a precipitous decline headed for extinction toward population growth, albeit slow growth beset by many setbacks over the years. Although confidence is not yet warranted, the parrot appears to have beaten the odds and recovered from an extremely small population consisting of few individuals and, consequently, a dangerously small gene pool. Of course, whether genetic problems will appear in the future is unknown.

Similarly, it is difficult to evaluate the importance of Patuxent's efforts to save other species from extinction. Certainly Patuxent scientists helped to recognize the problems faced by several species and to provide population estimates upon which the results of future recovery efforts could be assayed. Regardless of the effect of Patuxent on the recovery of individual species, the program had wide and lasting effects on conservation in the region. Importantly, the parrot program was one of the first conservation issues to attract the attention of the Puerto Rican public and helped to establish a foundation for the elevated conservation ethic seen on the island today.

Another of the most important byproducts of the Patuxent research program in the region has been the training of several conservationists and biologists from other islands while the Patuxent scientists were on site or during their extended stays in Puerto Rico. Patuxent scientists visited all islands having parrot populations and involved local conservationists in research and management efforts. Effective and experimental

technologies were thereby transferred to other islands and incorporated into those countries' parrot conservation efforts.

The many other people who sacrificed and worked under extremely difficult conditions as they participated in parrot recovery efforts also merit acknowledgment. Most were employed by the Forest Service, USFWS, and PRDNR, but many others generously donated their time as volunteers. Advances made through Patuxent and its collaborating agencies would not have been possible without their valuable contributions. Equally important as the conservation of individual species and their ecosystems are the effects of Patuxent's Caribbean program on the professional development of the many technicians, assistants, graduate students, and volunteers who went on to become influential contributors to conservation efforts in Puerto Rico and elsewhere (table 1). In fact, several of those program associates have become important decision makers in the parrot's recovery.

Table 1. Representative technicians, students, and volunteers who participated in Patuxent Wildlife Research Center's Endangered Species Program in the Caribbean, and highlights of their subsequent careers.

[AM, aviary manager; AT, aviary technician; F&AT, field and aviary technician; FT, field technician; GS, graduate student; T, trainee; US, undergraduate student; V, volunteer; BBS, North American Breeding Bird Survey; EYNF, El Yunque National Forest; GIS, Geographic Information Specialist; IITF, International Institute of Tropical Forestry; NGO, Nongovernment organization; NMEMNRD, New Mexico Energy, Minerals and Natural Resources Department; PRDNR, Puerto Rico Department of Natural Resources; PRP, Puerto Rican parrot; Patuxent, Patuxent Wildlife Research Center; TNWRA, Tennessee Wildlife Resources Agency; UPR, University of Puerto Rico; USDA-APHIS, U.S. Department of Agriculture-Animal and Plant Health Inspection Service; USFS, U.S. Department of Agriculture-Forest Service; USFWS, U.S. Fish and Wildlife Service; USGS, U.S. Geological Survey; USNPS, U.S. National Park Service]

Program participant	Status in program	Post-program contributions
Hernán Abreu	F&AT	Environmental Scientist, USNPS
Wayne Arendt	F&AT/GS	Wildlife Biologist, IITF
Bonnie Bell	F&AT	Enforcement Officer, USFWS
Kelly Brock	AM/GS	Endangered Species Specialist, U.S. Navy
Julio Cardona	V	Scientist and Director, Puerto Rican conservation NGO
Orlando Carrasquillo	F&AT	Supervisory Biological Technican, Ecosystem Team, EYNF, USFS
José Colón	F&AT	Sociedad Ornitología Puertorriqueña, environmental consultant, photographer
Victor Cuevas	F&AT	Visitor Information Service Leader, EYNF, USFS
Carlos Delannoy	F&AT	Professor and Department Chair of Biology, UPR-Mayagüez
Linda DeLay	V	GIS, NMEMNRD
Oscar Díaz-Marrero	F&AT	Refuge Manager, USFWS
Joe diTomaso	F&AT	Department Plant Science Chair and Professor, University of California at Davis
Sharon Dougherty	V/GS	Endangered Species Biologist and cofounder, Circle Mountain Biological Consultants, Inc.
Rosemarie Gnam	V/GS	Chief, Division Science Authority International Affairs Program, USFWS
Nelson Green	T/V	Manager, captive parrot program in Dominica
Quammie Greenaway	T/V	Conservation Officer, Dominica Forestry Department
Robin Knopp	F&AT	Veterinarian
Ed LaRue	F&AT/GS	Endangered Species Biologist and Chief Executive Officer, Circle Mountain Biological Consultants, Inc.
Benjamin ("Benji") Layton	F&AT/GS	Regional Big Game/Waterfowl Coordinator, TNWRA
Sebastian Lousada	V/US	Private aviculturalist
Aurea ("Puchi") Moragón	AT	Website Manager, EYNF, USFS
Fernando Nuñez	F&AT/GS	Leader of PRP Recovery Program, USFWS Region 4
Keith Pardieck	FT	Patuxent BBS Program Coordinator
José Rodríguez	AT	First comanager. of captive program at Río Abajo aviary, PRDNR
Ann Smith	AT	First comanager. of captive program at Río Abajo aviary, PRDNR
Dwight Smith	F&AT	Businessman
John Taapken	F&AT	Businessman and politician
Monica Tomosy	V/GS	Chief, U.S. Bird Banding Laboratory; USFS liaison to USGS
Edgar Vazquez Cabrera	F&AT	Biologist, PRDNR and USDA-APHIS
Michael Zamore	T/V	Wildlife Research officer, Dominica Forestry Department

Selected References

Aguilera, X.G., Alvarez, V.B., Wiley, J.W., and Rosales, J.R., 1999, Population size of Cuban parrots *Amazona leucocephala* and sandhill cranes *Grus canadensis* and community involvement in their conservation in northern Isla de la Juventud, Cuba: Bird Conservation International, v. 9, no. 2, p. 97–112. [Also available at https://doi.org/10.1017/S0959270900002227.]

Beissinger, S.R., and Snyder, N.F.R., 1992, New world parrots in crisis—Solutions from conservation biology: Washington, D.C., Smithsonian Institution Press, 288 p.

Breining, Greg, 2015, Puerto Rican parrot comeback: National Wildlife, accessed June 3, 2016, at https://www.nwf.org/News-and-Magazines/National-Wildlife/Birds/Archives/2015/Puerto-Rican-Parrot-Comeback.aspx.

Brock, M.K., and White, B.N., 1991, Multifragment alleles in DNA fingerprints of the parrot, *Amazona ventralis*: Journal of Heredity, v. 82, no. 3, p. 209–212. [Also available at http://jhered.oxfordjournals.org/cgi/content/abstract/82/3/209.]

Cruz, Alexander, Manolis, T., and Wiley, J.W., 1985, The shiny cowbird in the Caribbean: Ecology of an avian brood parasite undergoing range expansion, *in* Buckley, P.A., Foster, M.S., Morton, E.S., Ridgely, R.S., and Buckley, F.G., eds., Neotropical ornithology: Ornithological Monographs no. 36, p. 607–620. [Also available at http://www.jstor.org/stable/40168308.]

Cruz, Alexander, and Wiley, J.W., 1989, The decline of an adaptation in the absence of a presumed selection pressure: Evolution, v. 43, no. 1, p. 55–62. [Also available at http://dx.doi.org/10.2307/2409163.]

Cruz, Alexander, Wiley, J.W., Nakamura, T.K., and Post, W., 1988, The shiny cowbird, *Molothrus bonariensis,* in the West Indian region—Biogeographical and ecological implications, *in* Woods, C.A., ed., Biogeography of the West Indies—Past, present, and future: Gainesville, FL, Sandhill Crane Press, Inc., p. 519–540.

Derrickson, S.R., and Snyder, N.F.R., 1992, Potentials and limits of captive breeding in parrot conservation, *in* Beissinger, S.R., and Snyder, N.F.R., eds., New World parrots in crisis—Solutions from conservation biology: Washington, D.C., Smithsonian Institution Press, p. 133–163.

Enkerlin-Hoeflich, E.C., Snyder, N.F.R., and Wiley, J.W., 2006, Behavior of wild *Amazona* and *Rhynchopsitta* parrots, with comparative insights from other psittacines, *in* Luescher, A.U., ed., Manual of parrot behavior: Ames, IA, Blackwell Publishing, p. 13–25.

Kepler, A.K., 1977, Comparative study of todies (Todidae)—With emphasis on the Puerto Rican tody, *Todus mexicanus*: Publications of the Nuttall Ornithological Club, no. 16, 190 p.

Kepler, C.B., 1972a, Notes on the ecology of Puerto Rican swifts, including the first record of the white-collared swift *Streptoprocne zonaris*: Ibis, v. 114, no. 4, p. 541–543. [Also available at http://dx.doi.org/10.1111/j.1474-919X.1972.tb00856.x.]

Kepler, C.B., 1972b, The ecology of the Puerto Rican parrot, an endangered species: Ibis, v. 114, no. 3, p. 442–443. [Also available at http://dx.doi.org/10.1111/j.1474-919X.1972.tb00846.x.]

Kepler, C.B., 1978, The breeding ecology of sea birds on Monito Island, Puerto Rico: Condor, v. 80, no. 1, p. 72–87. [Also available at http://sora.unm.edu/node/102818.]

Kepler, C.B., and Kepler, A.K., 1973, The distribution and ecology of the Puerto Rican whip-poor-will, an endangered species: Living Bird, v. 11, p. 207–239.

Kepler, C.B., and Kepler, A.K., 1978, The sea-birds of Culebra and its adjacent islands, Puerto Rico: Living Bird, v. 16, p. 21–50.

Kepler, C.B., and Parkes, K.C., 1972, A new species of warbler (Parulidae) from Puerto Rico: Auk, v. 89, no. 1, p. 1–18. [Also available at http://sora.unm.edu/node/22201.]

Lindsey, G.D., 1992, Nest guarding from observation blinds: Strategy for improving Puerto Rican parrot nest success: Journal of Field Ornithology, v. 63, no. 4, p. 466–472. [Also available at http://www.jstor.org/stable/4513745.]

Lindsey, G.D., and Arendt, W.J., 1991, Radio tracking Puerto Rican parrots—Assessing triangulation accuracy in an insular rain forest: Caribbean Journal of Science, v. 27, nos. 1–2, p. 46–53.

Lindsey, G.D., Arendt, W.J., and Kalina, Jan, 1994, Survival and causes of mortality in juvenile Puerto Rican parrots: Journal of Field Ornithology, v. 65, no. 1, p. 76–82. [Also available at https://sora.unm.edu/node/51865.]

Lindsey, G.D., Arendt, W.J., Kalina, Jan, and Pendleton, G.W., 1991, Home range and movements of juvenile Puerto Rican parrots: Journal of Wildlife Management, v. 55, no. 2, p. 318–322. [Also available at http://dx.doi.org/10.2307/3809157.]

Meyers, J.M., 1994, Leg bands cause injuries to parakeets and parrots: North American Bird Bander, v. 19, no. 4, p. 133–136. [Also available at https://sora.unm.edu/node/93291.]

Meyers, J.M., 1995, A colored leg banding technique for *Amazona* parrots: Journal of Field Ornithology, v. 66, no. 4, p. 582–589. [Also available at https://sora.unm.edu/node/52018.]

Meyers, J.M., 1995, Puerto Rican parrots, *in* LaRoe, E.T., Farris, G.S., Puckett, C.E., Doran, P.D., and Mac, M.J., eds., Our living resources—A report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems: Washington, D.C., U.S. Department of the Interior, National Biological Service, p. 83–85. [Also available at https://pubs.er.usgs.gov/publication/70148108.]

Meyers, J.M., 1996, Evaluation of 3 radio transmitters and collar designs for *Amazona*: Wildlife Society Bulletin, v. 24, no. 1, p. 15–20. [Also available at http://www.jstor.org/stable/3782826.]

Meyers, J.M., 1996, New nesting area of Puerto Rican parrots: Wilson Bulletin, v. 108, no. 1, p. 164–166. [Also available at http://sora.unm.edu/node/131371.]

Meyers, J.M., Arendt, W.J., and Lindsey, G.D., 1996, Survival of radio-collared nestling Puerto Rican parrots: Wilson Bulletin, v. 108, no. 1, p. 159–163. [Also available at http://sora.unm.edu/node/131370.]

Post, William, and Wiley, J.W., 1976, The yellow-shouldered blackbird—Present and future: American Birds, v. 30, no. 1, p. 13–20. [Also available at https://sora.unm.edu/node/112547.]

Post, William, and Wiley, J.W., 1977, Reproductive interactions of the shiny cowbird and the yellow-shouldered blackbird: Condor, v. 79, p. 176–184. [Also available at https://sora.unm.edu/node/102731.]

Post, William, and Wiley, J.W., 1977, The shiny cowbird in the West Indies: Condor, v. 79, p. 119–121. [Also available at https://sora.unm.edu/node/102712.]

Rodríguez-Vidal, J.A., 1959, Puerto Rican parrot study: San Juan, Puerto Rico, Department of Agriculture of the Commonwealth of Puerto Rico, Monograph no. 1, 15 p.

Snyder, N.F.R., 1977, Puerto Rican parrots and nest-site scarcity, *in* Temple, S.A., ed., Endangered birds—Management techniques for preserving threatened species: Madison, WI, University of Wisconsin Press, p. 47–53.

Snyder, N.F.R., 1978, Increasing reproductive effort and success by reducing nest-site limitations—A review, *in* Temple, S.A., ed., Endangered birds—Management techniques for preserving threatened species: Madison, WI, University of Wisconsin Press, p. 27–33.

Snyder, N.F.R., Derrickson, S.R., Beissinger, S.R., Wiley, J.W., Smith, T.B., Toone, W.D., and Miller, B., 1996, Limitations of captive breeding in endangered species recovery: Conservation Biology, v. 10, no. 2, p. 338–348. [Also available at http://www.jstor.org/stable/2386850.]

Snyder, N.F.R., King, W.B., and Kepler, C.B., 1982, Biology and conservation of the Bahama parrot: Living Bird, v. 19, p. 91–114.

Snyder, N.F.R., and Taapken, J.D., 1978, Puerto Rican parrots and nest predation by pearly-eyed thrashers, *in* Temple, S.A., ed., Endangered birds—Management techniques for preserving threatened species: Madison, WI, University of Wisconsin Press, p. 113–120.

Snyder, N.F.R., and Wiley, J.W., 1994, Puerto Rican parrot conservation—A retrospective evaluation by two former leaders of the program (1972–1986): PsittaScene, v. 6, no. 1, p. 6–7. [Also available at https://www.parrots.org/files/psitta/442/ps_6_1_feb_94.pdf.]

Snyder, N.F.R., Wiley, J.W., and Kepler, C.B., 1987, The parrots of Luquillo—Natural history and conservation of the Puerto Rican parrot: Los Angeles, CA, Western Foundation of Vertebrate Zoology, 384 p.

U.S. Fish and Wildlife Service, 2016, Conserving the nature of America--Significant achievement in the transfer of Puerto Rican parrots to the Maricao Commonwealth Forest: accessed November 10, 2016, at https://www.fws.gov/news/ShowNews.cfm?ID=26D2B5A7-5056-AF00-5BA3BAAD09E24C98.

Wiley, J.W., 1979, The white-crowned pigeon in Puerto Rico: Status, distribution, and movements: Journal of Wildlife Management, v. 43, no. 2, p. 402–413. [Also available at http://dx.doi.org/10.2307/3800349.]

Wiley, J.W., 1980, The Puerto Rican parrot (*Amazona vittata*)—Its decline and the program for its conservation, *in* Pasquier, R.F., ed., Conservation of New World parrots: Washington, D.C., Smithsonian Institution Press for the International Council for Bird Preservation, Technical Publication no. 1, p. 133–159.

Wiley, J.W., 1983, The role of captive propagation in Puerto Rican parrot conservation, *in* Risser, A., and Todd, F., eds., Jean Delacour/International Federation for the Conservation of Birds—Symposium on breeding birds in captivity: Los Angeles, CA, International Federation for the Conservation of Birds, p. 441–453.

Wiley, J.W., 1985a, Bird conservation in the United States Caribbean, *in* Temple, S.A., ed., Bird conservation 2: Madison, WI, University of Wisconsin Press for International Council for Bird Preservation, p. 107–159.

Wiley, J.W., 1985b, Shiny cowbird parasitism in two avian communities in Puerto Rico: Condor, v. 87, no. 2, p. 165–176. [Also available at http://sora.unm.edu/node/103553.]

Wiley, J.W., 1985c, Status and conservation of forest raptors in the West Indies, *in* Newon, I., and Chancellor, R., eds., Raptor conservation: International Council for Bird Preservation, Technical Publication no. 5, p. 199–204.

Wiley, J.W., 1985d, The captive programme for the endangered Puerto Rican parrot *Amazona vittata*: Aviculture Magazine, v. 91, no. 2, p. 110–116.

Wiley, J.W., 1985e, The Puerto Rican parrot and competition for its nest sites, *in* Moors, P.J., ed., Conservation of island birds—Case studies for the management of threatened island species: Cambridge, England, International Council for Bird Preservation, Technical Publication no. 3, p. 213–223.

Wiley, J.W., 1986a, Habitat change and its effects on Puerto Rican raptors: International Council for Bird Preservation Birds of Prey Bulletin no. 3, p. 51–56. [Also available at http://www.raptors-international.org/book/birds_of_prey_1986/Wiley_1986_51-56.pdf.]

Wiley, J.W., 1986b, Status and conservation of raptors in the West Indies: International Council for Bird Preservation Birds of Prey Bulletin no. 3, p. 57–70. [Also available at http://www.raptors-international.org/book/birds_of_prey_1986/Wiley_1986_57-70.pdf.]

Wiley, J.W., 1988, Host selection by the shiny cowbird: Condor, v. 90, no. 2, p. 289–303. [Also available at http://sora.unm.edu/node/103956.]

Wiley, J.W., 1991, Status and conservation of parrots and parakeets in the Greater Antilles, Bahama Islands, and Cayman Islands: Bird Conservation International, v. 1, p. 187–214. [Also available at https://doi.org/10.1017/S0959270900000599.]

Wiley, J.W., 1996, Ornithology in Puerto Rico and the Virgin Islands, *in* Figueroa Colón, J.C., ed., The scientific survey of Puerto Rico and the Virgin Islands—An eighty-year reassessment of the islands' natural history: New York, Annals of the New York Academy of Sciences, v. 776, p. 149–179. [Also available at http://dx.doi.org/10.1111/j.1749-6632.1996.tb17419.x.]

Wiley, J.W., 2003, Habitat association, size, stomach contents, and reproductive condition of Puerto Rican boa (*Epicrates inornatus*): Caribbean Journal of Science, v. 39, no. 1, p. 189–194.

Wiley, J.W., 2006, The ecology, behavior, and conservation of a West Indian corvid, the white-necked crow (*Corvus leucognaphalus*): Ornithología Neotropical, v. 17, no. 2, p. 105–146. [Also available at https://sora.unm.edu/node/119745.]

Wiley, J.W., Cotte, R., Parker, W.T., Raffaele, H.A., Vivaldi, J.L., and Snyder, N.F.R., 1982, Puerto Rican plain pigeon recovery plan: Atlanta, GA, U.S. Fish and Wildlife Service, 52 p. [Also available at https://www.fws.gov/caribbean/PDF/Recovery_Plans/Columba_inornata_wetmorei.pdf.]

Wiley, J.W., and Gee, G., 1981, Using captive propagation to help save the Puerto Rican parrot: AFA Watchbird, v. 8, no. 5, p. 4–11. [Also available at https://journals.tdl.org/watchbird/index.php/watchbird/article/view/2037/0.]

Wiley, J.W., Gnam, R.S., Koenig, S.E., Dornelly, A., Gálvez, X., Bradley, P.E., White, T., Zamore, M., Reillo, P.R., and Anthony, D., 2004, Status and conservation of the family *Psittacidae* in the West Indies: Caribbean Journal of Ornithology, v. 17, p. 94–154.

Wiley, J.W., and Perry, H.R., Jr., 1985, El programa de investigaciones ornitológicas de Patuxent, *in* Stiles, F.G., and Aguilar, P.G., eds., Proceedings I Symposio de Ornitologia Neotropical, IX Congreso LatinAmericano de Zoologico, 14–15 Octobre 1983: Arequipa, Peru, Asociación Peruana para Conservación de la Naturaleza, World Wildlife Fund–U.S. and U.S. Fish and Wildlife Service, 126 p.

Wiley, J.W., Post, William, and Cruz, Alexander, 1991, Conservation of the yellow-shouldered blackbird *Agelaius xanthomus*, an endangered West Indian species: Biological Conservation, v. 55, no. 2, p. 119–138. [Also available at http://dx.doi.org/10.1016/0006-3207(91)90052-B.]

Wiley, J.W., Snyder, N.F.R., and Gnam, R.S., 1992, Reintroduction as a conservation strategy for parrots, *in* Beissinger, S.R., and Snyder, N.F.R., eds., New World parrots in crisis—Solutions from conservation biology: Washington, D.C., Smithsonian Institution Press, p. 165–200.

Wiley, J.W., and Wiley, B.N., 1979, The biology of the white-crowned pigeon: Wildlife Monograph no. 64, 54 p.

Wiley, J.W., and Wunderle, J.M., Jr., 1993, The effects of hurricanes on birds, with special reference to Caribbean islands: Bird Conservation International, v. 3, no. 4, p. 319–349. [Also available at http://dx.doi.org/10.1017/S0959270900002598.]

Wilson, K.A., Field, R., and Wilson, M.H., 1995, Successful nesting behavior of Puerto Rican parrots: Wilson Bulletin, v. 107, no. 3, p. 518–529. [Also available at http://sora.unm.edu/node/131313.]

Wilson, K.A., Wilson, M.H., and Field, Rebecca, 1997, Behavior of Puerto Rican parrots during failed nesting attempts: Wilson Bulletin, v. 109, no. 3, p. 490–503. [Also available at http://sora.unm.edu/node/131502.]

Wilson, M.H., Kepler, C.B., Snyder, N.F.R., Derrickson, S.R., Dein, F.J., Wiley, J.W., Wunderle, J.M., Jr., Lugo, A.E., Graham, D.L., and Toone, W.D., 1994, Puerto Rican parrots and potential limitations of the metapopulation approach to species conservation: Conservation Biology, v. 8, no. 1, p. 114–123. [Also available at http://dx.doi.org/10.1046/j.1523-1739.1994.08010114.x.]

Wunderle, J.M., Jr., Snyder, N.F.R., Muiznieks, Britta, Wiley, J.W., and Meyers, J.M., 2003, Histories of Puerto Rican parrot nests in the Caribbean National Forest/Luquillo Experimental Forest, 1973–2000: Portland, OR, U.S. Department of Agriculture, Forest Service, International Institute of Tropical Forestry, General Technical Report IITF–GTR–21, 28 p. [Also available at http://www.fs.fed.us/pnw/pubs/iitf/gtr21.pdf.]