

APPENDIX 1

Assessment of Damage to Guam's Natural Resources from Supertyphoon Paka

PERIOD COVERED: December, 1997 to January, 1998

BACKGROUND

Supertyphoon Paka struck Guam on 16-17 December 1997 and is considered the most destructive storm to affect the island since Typhoon Pamela in 1976. Wind speeds were estimated at 150 mph sustained and gusting to 185 mph, which was approximately 20-30 mph faster than values recorded during Typhoon Omar in August 1992. Although weather instruments at Andersen Air Force Base (AAFB) recorded a peak gust of 236 mph during Paka, a figure widely quoted in the national news media, reevaluation of this wind speed by the Joint Typhoon Warning Center and National Weather Service after the storm indicates that actual maximum gusts were considerably lower than this. Duration of sustained winds greater than 60 mph was about 16-20 hours. Winds blew from the northwest and west during the initial half of Paka. They became more intense in the second half of the storm, coming primarily from the southwest and south. The typhoon was unusual in that it had two concentric eye walls. The center of the smaller inner eye passed through the Rota Channel, with the southern edge of the eye wall skimming Ritidian and Pati Points. The larger outer eye wall extended further south and took about six hours to cross the island in the vicinity of Chalan Pago, Ordot, and Piti. Paka dropped approximately 21 inches of rain during a 15-hr period. The storm also produced destructive surf conditions between Orote Peninsula and Tarague Beach, where sea heights were 6-30 feet above normal.

Paka caused severe damage to natural resources throughout much of Guam. An initial assessment of the destruction was made by staff of the Division of Aquatic and Wildlife Resources on 18-19 December, with follow-up field observations and surveys conducted through 16 January 1998.

Damage to Forests and other Habitats

Severe widespread damage to forests occurred north of a line extending from Malojloj to Cetti Bay, with somewhat reduced damage further south. Within northern and central Guam, pockets of greater or lesser damage to vegetation were noticeable, indicating that peak wind values differed somewhat among sites. Variation of this type was presumably caused by localized differences in 1) wind strength generated within the typhoon, or 2) topographic features, notably clifflines, ravines, and ridgelines, that offered some protection from high winds or which channeled winds through certain sites, resulting in greater wind speeds. As noted in previous typhoons (e.g., Russ, Yuri, and Omar), forests dominated by certain tree species, such as tangantangan (*Leucaena leucocephala*), pago (*Hibiscus tiliaceus*), African tulip (*Spathodea campanulata*), and bamboo (*Bambusa vulgaris*), were particularly susceptible to high winds and displayed extreme damage. Nearly all stands of tangantangan on Guam suffered complete defoliation and some loss of branches. Specific areas of the island that were surveyed for damage are described below:

Northern Plateau - Ground and aerial surveys revealed nearly uniform forest defoliation across the top of Guam's extensive northern plateau, with minor to moderate numbers of trees blown down. Many areas of native limestone forest showed 100% foliage loss in the mid- to upper canopy layers several days after the storm, once storm-damaged remnant

foliage dried up and fell to the ground. In the worst hit locations, including sites at Pati Point, the Munitions Storage Area (formerly Conventional Weapons Storage Area), and Northwest Field on AAFB, leaf cover in the shrub and short tree layer was largely lost, giving the forest a deciduous appearance and exposing much of the forest floor to open sunlight. Limb breakage, blow downs of small trees, and destruction of epiphytes were great at these sites, but surprisingly, most canopy and emergent trees survived without being knocked down. The storm's overall effect was to give forests at these sites the appearance of being a collection of bare tree trunks standing side by side without any of the other characteristic features of a forest being present. Many stands of tangantangan in northern and central Guam also appeared this way.

Fortunately, the shrub and understory came through with only moderate damage in many forested areas on the northern plateau, as did coconuts and pandanus. Aerial observations on 2 January revealed several areas on the plateau holding considerable amounts of green vegetation, including a large site along the eastern side of the Munitions Storage Area (above the Tarague and Jinapsan basins) and smaller sites above Late, Anao, and Pagat Points.

Northern Clifflines - The aerial survey revealed a number of cliffline areas in northern Guam that retained relatively intact forest vegetation. These locations were obviously protected from the typhoon's strongest winds blowing from the southwest and south. The largest of these sites covered most of the Tarague and Jinapsan clifflines. The lower elevations of the Ritidian area were also well protected, while the cliffsides along Urunao and NCTAMS showed a mix of foliated and stripped trees. Pockets of green tree cover dotted the northeastern coastal cliffs from Fadian Point to Pati Point. However, areas immediately adjacent these sites were often heavily defoliated, showing that protection by topographic features was extremely localized. An example occurred in the Tarague basin, where coconut forest along the coast was severely impacted (many trees retained only a few hanging fronds), while inland cliffline forest experienced much less damage.

Asan and Agana Heights - A stand of 50 coconut trees next to Route 1 in the War in the Pacific National Historic Park had all of the fronds broken from their crowns. A large grove of tangantangan across the highway was also extremely damaged, indicating high winds blew through the site along a small ridge next to the trees. In contrast, coconut trees 150-200 m away (along the park's shoreline) showed much less damage.

The upper reaches of the Fonte River valley, a deep ravine east of Nimitz Hill, was fairly well protected from winds and retained much of its normal foliage after the storm. However, further downstream, where the river flows along Route 7 in Maina, the valley was severely thrashed by strong winds. Damage included many smashed bamboo clumps, palma brava palms (*Heterospathe elata*) with only remnant crowns or blown down entirely, large trees barren of leaves and branches, and large expanses of clearly visible ground.

Piti - Forests showed extreme damage along Route 1 and the west-facing inland ridgeline between the Masso and Atantano Rivers. These forests are dominated by exotics and *Hibiscus tiliaceus*, species that are particularly susceptible to high winds. Many of the large numbers of African tulip along the highway were entirely skeletonized, with only their main trunks remaining intact. The band of mangrove forest along Sasa Bay in Apra Harbor was partially stripped of foliage, but did not appear to suffer any loss of trees.

Orote Peninsula - Forests on the peninsula experienced some of the worst damage seen on the island. At locations along or adjacent to cliffsides, standing tangantangan trees were shortened to heights of just 1.2-2.5 m, with many other individuals blown down or leaning at severe angles. Scattered native trees at these sites were commonly reduced to bare trunks

and perhaps a few branches, while *Pandanus tectorius* exhibited small remnant crowns with no leaves remaining. Tangantangan forests greater than 100 m from cliffs sustained less damage and were not shortened or thinned to the same extent. On Orote Island, the tops of all trees, shrubs, and cycads growing on the west end of the island were shaved off to heights of 1.0-1.5 m. Trees on the lower eastern half of the island were damaged less severely.

Ordnance Annex (formerly Naval Magazine) - Damage to forests was quite variable, with some areas badly torn up and others much less so. Ridgetop forests along the western boundary of the installation were badly damaged, particularly on west-facing slopes. Another of the worst hit areas on the island was along the High Road between the West Tower Lookout and Mt. Alifan, where nearly all larger trees lost numerous limbs, *Pandanus* had heavily damaged crowns or were blown down, and *Casuarina* were stripped of most needles and even some bark. This area suffered similar destruction during Typhoon Omar in 1992. On the eastern side of the Annex, low lying limestone forests were defoliated and suffered broken trees on western slopes, but retained some foliage on eastern slopes.

Ipan, Talofofu - The forested cliffline bordering the southern half of Ipan was relatively protected from high winds and appeared well foliated after the storm.

Other Habitats - *Phragmites* reed beds in the Agana and Atantano marshes were severely wind blown, with the tops of most reed stalks heavily frayed. The Agana River flowing from the Agana Swamp nearly flooded its banks because of the heavy rains, and presumably the marsh was filled to near-maximum water levels. The Department of Education's mitigation marsh on Dry Dock Peninsula in Piti actually appeared to benefit from the typhoon. Heavy rains and winds inundated the wetland and created larger openings in the *Eleocharis* and invading weed beds. The *Eleocharis* reed beds showed little damage, but many of the marsh's thick accumulations of weeds were blown down.

Forest Recovery After the Typhoon

Guam's vegetation displayed initial signs of recovery fairly soon after the typhoon, with several species (tangantangan, *Hibiscus tiliaceus*, and some *Ficus* sp.) beginning to resprout new leaf shoots within six days. On AAFB, many forested areas showed ample evidence of refoitation by 13 January, with moderately dense understories present at these sites. However, canopy trees often remained sparsely foliated despite having considerable resprouting underway. Some of the tree species showing good levels of resprouting were tangantangan, *Macaranga thompsonii*, *Pandanus tectorius*, *Premna obtusifolia*, *Guamia mariannae*, *Neisosperma oppositifolia*, *Aglaia mariannensis*, *Guettarda speciosa*, *Cestrum diurnum*, *Wikstroemia elliptica*, *Hibiscus tiliaceus*, and some individuals of *Vitex parviflora* and *Ficus* sp. In contrast, *Elaeocarpus joga*, *Artocarpus mariannensis*, and most *Cycas circinalis* continued to show little or no resprouting of leaves by this date. In some of the most heavily impacted forest sites (e.g., a *Vitex* and *Hibiscus*-dominated section of forest in the Munitions Storage Area), little new foliage had reappeared and visibility through the forest remained quite high.

Tangantangan forest displayed the fastest recovery of any forest type, with many areas having greened up considerably by mid-January. Mixed exotic and *Hibiscus* forests along Route 1 in Piti also showed rapid refoitation by this time, as did many non-forest and ornamental plant species around the island.

Effects on Wildlife

Mariana Crows - An estimated 13-17 Mariana crows existed in the wild prior to Supertyphoon Paka (C.F. Aguon, pers. comm.). Post-storm searches accounted for 9-10 surviving birds, including all four marked individuals previously translocated from zoos, but have not yet been completed for several birds. This suggests that most crows survived the storm, although several individuals were possibly lost. Three marked birds were relocated in areas close to where they had occurred before Paka, but one bird wandered about 2 km from its previous center of activity (C.F. Aguon, pers. comm.). There was no evidence that any crows sought out and inhabited pockets of less severely damaged forest (i.e., areas with greater amounts of leaf cover), with nearly all surviving birds occurring in heavily defoliated forests during the first few weeks after the storm.

During the week prior to Paka, the "Pipeline" pair of crows (consisting of a Rota female and Guam male) built a nest above the cliffline in east Tarague Basin. This nest and the entire nest tree (a large *Ficus* sp.) were lost in the high winds, however, both members of the pair had begun renesting at a much lower elevation on Tagua Point by 5 January (C.F. Aguon, pers. comm.).

A small flock of five crows containing one translocated zoo female and four unbanded birds was observed in the Munitions Storage Area on 30 December (C.F. Aguon, pers. comm.). Flocking behavior of this type had not been recorded over the last two years and was perhaps related to the extreme defoliation of the forest, which may have facilitated birds finding one another. This aggregation was temporary and was not observed again.

No obvious evidence of food stress was observed among surviving crows since Paka (C.F. Aguon, pers. comm.). Although nearly all forest fruits were lost in the storm, the loss of foliage may have initially offset this problem by making insects easier to find and capture. As recovery of the forest understory proceeds at many sites, it is likely that adequate insect resources will continue to be available for crows.

Mariana Fruit Bats - The fruit bat colony continued to reside at its normal roosting site on Pati Point after the typhoon. Censuses revealed almost no change in numbers of animals, with counts of 168 and 158 bats made on 2 and 18 December, respectively. Several important roosting trees were snapped or blown down in the storm, causing the bats to relocate to neighboring trees. Follow-up observations revealed a sizable increase in the colony sometime between 19-21 December, which was confirmed by a count of 348 animals of 31 December. An increase of this magnitude is highly suggestive that the additional bats came from Rota rather than from elsewhere on Guam, as no other colonies are known to occur on Guam. Emigration of this type was likely caused by 1) disturbance of a bat colony by poachers, which has occurred fairly regularly on Rota during the holiday season in previous years, or 2) by a typhoon-induced shortage of foods. However, post-storm observations suggest that Rota suffered less overall forest damage than Guam (G. Hughes, pers. comm.) and did not reveal unusual numbers of daytime sightings of bats (J. Morton, pers. comm.). This indicates there was no period of foraging stress after Paka, as occurred after Typhoon Roy in 1988. On Guam, bats in the colony showed normal sleeping and social behavior on 18 and 31 December, suggesting this population also did not experience an immediate food shortage. Presumably, Guam's bats have been able to find sufficient food resources in the less damaged pockets of cliffline forest remaining after the storm, especially along the Tarague and Jinapsan clifflines.

Island Swiftlets - Visits were made to both of the island's known swiftlet caves after Supertyphoon Paka, but counts of birds were not conducted until late January to assess potential changes in population size. At the main colony site at Mahlac Cave, leaves and a few small branches were blown into the center of the cave and five nests were found on the cave floor, but no other signs of disruption were evident. Relatively few swiftlets entered the

cave during the December visit, but this is normal during this month, when nesting is greatly reduced. A census of 430 swiftlets was obtained on 28 January, which was about 80 birds more than during the last count conducted in August 1997.

As expected, heavy rains associated with Paka flooded Fachi Cave, closing off the only entrance used by swiftlets. Water levels declined fairly rapidly after the storm so that the entrance was partially open by 25 December and entirely open by 31 December. A count of 34 birds was obtained on 26 January, which is similar to the previous census made in June 1997 (31 birds).

Forests on east-facing ridgelines on eastern Ordnance Annex retained much of their leaf cover after the typhoon, meaning that some suitable foraging habitat for swiftlets probably remained.

Other Birds - The effects of Supertyphoon Paka on other bird species are more difficult to assess because pre-storm censuses were not conducted for any species. Only one report of dead birds was received by the Division of Aquatic and Wildlife Resources after the storm. Single carcasses of a brown noddy (*Anous stolidus*) and Pacific golden plover (*Pluvialis fulva*) were found blown against chain link fences at AAFB and the Guam International Airport, respectively. Three yellow bittern (*Ixobrychus sinensis*) nestlings were found dead on Naval Activities (formerly Naval Station) after Paka. The birds were on the ground and had apparently been blown from their nest(s).

General observations indicate substantial reductions in the numbers of shorebirds (plovers, tattlers, etc.) at Duncas Beach and seabirds (brown noddies and brown boobies [*Sula leucogaster*]) in Apra Harbor after the storm and suggest the possibility of significant mortality. Nesting colonies of noddies at Anae Island and a rock inside the entrance of Apra Harbor were devoid of birds on 28 December, as was the booby roost on Orote Island. Extensive observations on the same date detected only a single noddy elsewhere in the harbor. Boaters traveling between Cocos Island and northern Guam also reported a reduction in the abundance of noddies seen in late December and early January. However, normal numbers of noddies had returned to both nesting locations by 16 January, indicating the birds may have simply departed Guam temporarily after Paka.

Serianthes nelsonii - The island's only mature tree at Ritidian Point lost one of its main limbs, which tore a 1-m-long segment of bark from the trunk. This injury could eventually cause the tree to die. Several small seedlings beneath the tree were possibly killed from being buried under fallen leaves and branches. All seedlings (n=5) at the four outplanting sites in northern Guam survived the storm, however, all were defoliated and most suffered broken twigs or bark loss caused by rubbing against protective caging.

LITERATURE CITED

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