TECHNICAL NOTE

USDA NATURAL RESOURCES CONSERVATION SERVICE PACIFIC ISLANDS AREA

Biology Technical Note – No. 16

NĒNĒ HABITAT ENHANCEMENT AND MANAGEMENT*

Figure 1. The Nēnē is the State Bird of Hawai`i (Photo F. Woog).

PURPOSE

To provide an introduction to the habitat requirements of Nēnē (Hawaiian Goose) and guidance on conservation practices to enhance and manage Nēnē habitats.

INTRODUCTION

The Nēnē is a member of the waterfowl family (Anatidae), which consists of ducks, geese, and swans. It's a medium-sized descendant of the Canada Goose. Though similar in appearance, the gander (male) is slightly larger than the goose (female). The Nēnē is light gray-brown with a mostly black head, cream-colored neck with dark furrows, and black tail and feet (Fig. 1). Prior to human arrival, Nēnē were common in the main Hawaiian Islands. From over 13 Hawaiian waterfowl species in the fossil record, Nēnē is Hawaii's only native resident goose to survive into modern times. It is a Federal and State endangered species.

Species Profile

Hawaiian Goose, Nēnē (pronounced "naynay")
Federal listing: Endangered
Scientific name: *Branta sandvicensis*
Length: 25-27 inches (63-69 cm)
Weight: male 63-88 oz (1800-2500 g); female 53-74 oz (1500-2100 g)
Range: Hawai`i, Maui, Moloka`i, and Kaua`i, 0-9800 ft (3000 m) elevation
Breeding season: October - March
Female age at first breeding: 2-3 years
Clutch size: 3-5 eggs
Incubation period: 29-31 days
Age at fledging: 10-12 weeks
Molt period: 4-6 weeks
Nest sites: nests are on the ground under shrubs or trees in sparsely to densely-vegetated beach strand, grassland, shrubland, and woodland
Food habits: Herbivorous; eats grass and sedge leaves and seeds, herbaceous composite leaves and flowers, and shrub fruits
Population estimate: 1840-1890
Longevity: 28 years (oldest wild bird)

*** This information was taken primarily from Black et al. (1994), Banko et al. (1999), Woog and Black (2001), and USFWS (2004).**

STATUS & DISTRIBUTION

In the 1950s, the Nēnē population had declined to about 30 birds on Hawai`i (using primarily Keauhou Ranch on Mauna Loa and Pu`u `O`o Ranch on Mauna Kea) because of introduced predators, historic over-hunting, and habitat loss from modifications made by ungulates and people. Today, there are around 1840-1890 Nēnē on four islands (Fig. 2).

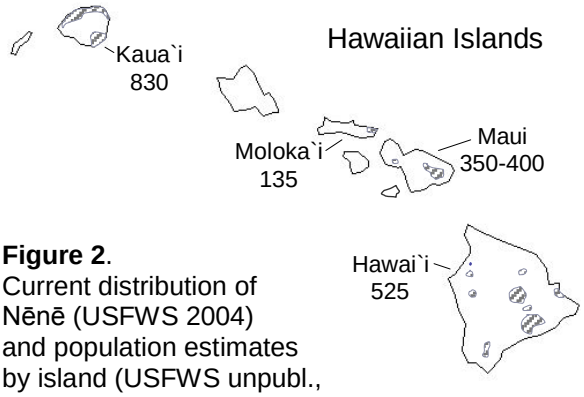


Figure 2.
Current distribution of Nēnē (USFWS 2004) and population estimates by island (USFWS unpubl., J. Medeiros, DOFAW, pers. comm.).

The current distribution of Nēnē is heavily influenced by the location of release sites of captive-reared birds. Nearly all birds are the result of an aggressive captive propagation and release program which was initiated by the Territorial government (State) in 1949 and continues on a smaller scale today. This program is credited with bringing Nēnē back from the brink of extinction; however, despite some successes the species still faces major obstacles on the road to recovery. Releases of captive-bred birds have kept populations artificially high. On Hawai`i and Maui, on average, <10% of pairs produce fledglings (goslings that survive long enough to attain flight) in the wild. On Kaua`i, Nēnē reproduce successfully because of abundant lush pastures, available lowland habitat, and absence of established mongoose populations. Nēnē regularly use protected areas, developed lands, and agricultural lands, thus, the cooperation of private landowners and availability of private land to Nēnē remains a critical aspect in their recovery.

ANNUAL CYCLE

Historically, Nēnē are believed to have bred and molted in the lowlands during the winter and to have moved to higher elevations in the summer. Today, birds move daily between feeding and roosting areas and seasonally between breeding and nonbreeding areas, but altitudinal patterns are less apparent.

Nēnē mate for life. During breeding, the female is responsible for incubation and rearing the young; the male is responsible for helping with rearing and protecting the family. Nēnē breed during the wet winter months, mainly from October to March, when there is more fresh plant forage to support reproduction (Fig. 3). Most nest building and egg laying occurs from November to January; brood-rearing occurs from December to February (Fig. 4); and molting occurs from March to June. When molting, adults become flightless for four to six weeks while they grow new flight feathers. During this period, they become secretive, and are particularly vulnerable to introduced predators. During the rest of the year, from June to September, Nēnē disperse or flock with other family groups in nonbreeding areas where young Nēnē have opportunities to find their mates.

Figure 3. Nēnē annual cycle

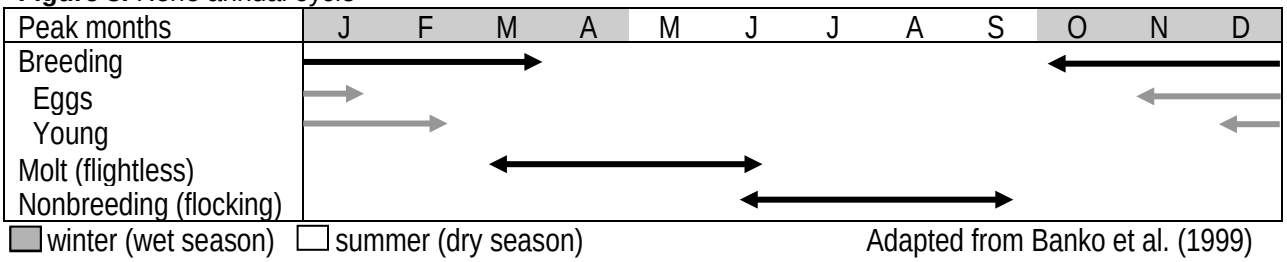


Figure 4. A: Nest constructed of feather down, grass, and leaf litter (Photo J. Medeiros); **B**: Goose with 3-week-old goslings (Photo NRCS); **C**: Adult (left) with fledglings (center, right), note subdued plumage of fledglings (Photo J. Medeiros).

HABITAT REQUIREMENTS

An important job of a wildlife manager is to provide new opportunities and improved conditions for at-risk species to survive, reproduce, and maintain sustainable breeding populations. If existing conditions are unsuitable, management treatments are recommended which are often manipulations needed to meet landowner and NRCS conservation goals and Nēnē Recovery Plan objectives. If existing conditions are suitable, the landowner and NRCS may decide to forego manipulations, maintain existing conditions, and protect the area from introduced predators and other disturbances.

Historically, Nēnē probably occupied grasslands, grassy shrublands, and dryland forest. Today, Nēnē can be found using a variety of native and nonnative habitats:

- Grasslands
  - Native subalpine
  - Pastureland
  - Lawns
  - Golf courses
- Croplands
  - Taro farms (Fig. 5)
  - Tomato farms (Fig. 11A)
  - Corn fields
  - Noni farms
- Water bodies
  - Reservoirs
  - Ornamental ponds
  - Wetlands
- Shrublands
  - Grassy shrublands
  - Open-canopy shrublands
  - Shrubland-woodland interfaces
- Sparsely-vegetated lava flows

Figure 5. Nēnē on taro farms at Hanalei National Wildlife Refuge, Kaua`i (Photo J. Surface).

Food. Nēnē are herbivores and browsing grazers of the leaves, seeds, fruits, and flowers of mainly upland (nonwetland) plants, such as grasses, sedges, forbs, and shrubs. Invertebrates are probably eaten incidentally while foraging on plants, but Nēnē are not known to seek animal foods. They are opportunistic foragers and eat a wide variety of native and nonnative plants. What birds feed on is influenced by life stage, breeding status, location, local climate, and plant availability. Little is known about foraging needs in the lowlands; however, food selection studies conducted in mid-elevation Hawai`i (Ka`u District) and Maui (Hana District) found that (see Black et al. 1994, Woog & Black 2001; Appendix A and B):

- Nēnē fed mainly on cultivated grasses (Fig. 6)
  - Legumes (*Trifolium* sp., partridge pea) and grass leaves had more protein than berries and grass seeds

- Pasture grasses (e.g., Kikuyu grass, Yorkshire fog) had more protein than grasses found in shrublands (e.g., broomsedge, molasses grass)
- Livestock-grazed or mowed grasses had more protein than rank grasses

- During incubation, some Nēnē in native shrublands fed mainly on berries and other plants in nesting territories (Fig. 7)
  - Pūkiawe and `ōhelo berries and gosmore flowers and leaves were preferred over `a`ali`i, broomsedge, beardgrass, and molasses grass
  - Berries had more water (e.g., kūkaenēnē, `ōhelo) and carbohydrates (e.g., pūkiawe, `ōhelo, māmaki) than grasses
- Breeding success was higher for Nēnē with more grasses in their diet

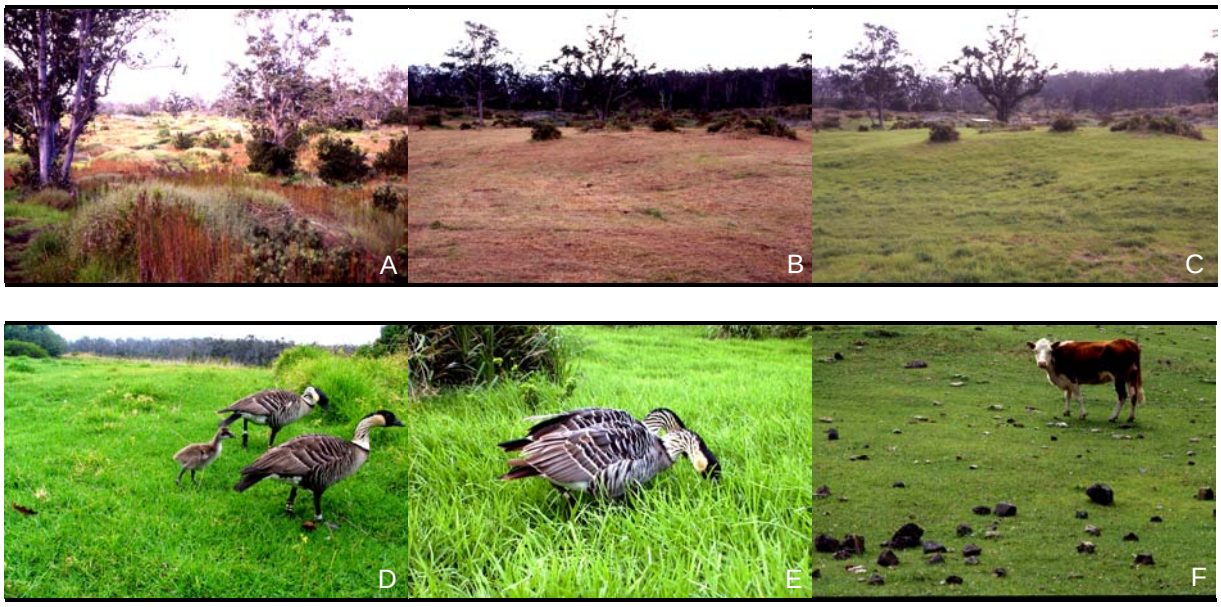


Figure 6. Experimental plots at a mid-elevation grassland in Hawai`i Volcanoes National Park (NP) on Hawai`i **A:** before mowing, **B:** freshly mown, and **C:** after regrowth (Photos F. Woog). For foraging, Nēnē prefer short, sward-forming grasslands, such as **D-E:** Kikuyu-legume grasslands (Photos K. Uyehara, J. Medeiros), over rank (A) and **F:** over-grazed pastures.

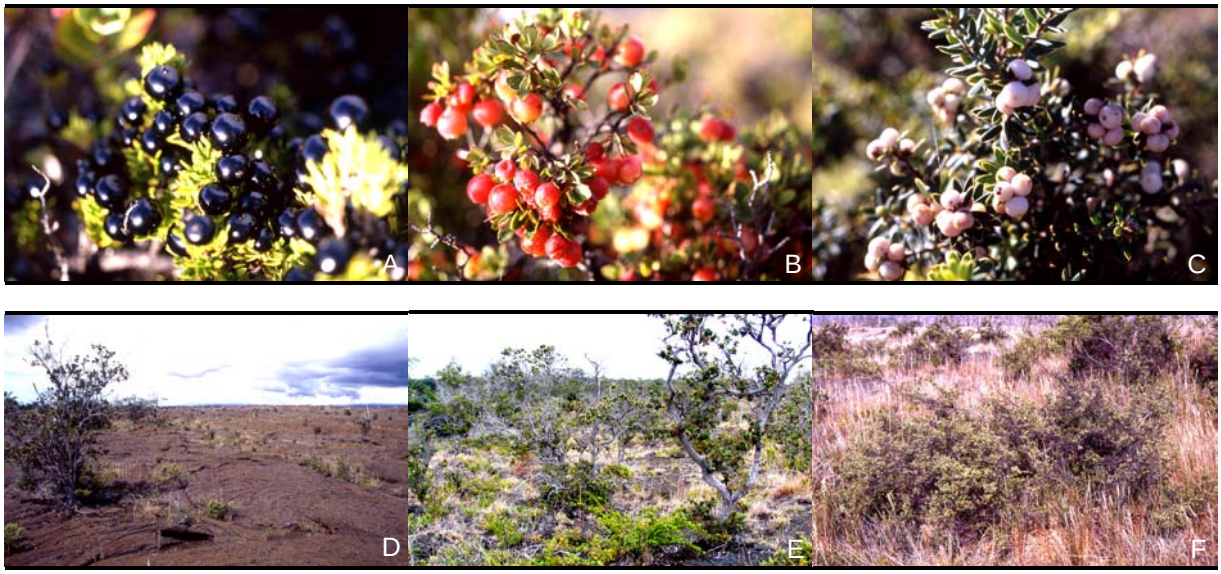


Figure 7. Native berries used for forage in mid-elevation shrublands include **A:** kūkaenēnē, **B:** `ōhelo, and **C:** pūkiawe. In Hawai`i Volcanoes NP, vegetation cover in shrub habitats ranges from **D:** sparsely-vegetated lava flows (Photos F. Woog) to **E:** open-canopy shrublands (Photo K. Uyehara). **F:** Closed-canopy, grassy shrublands are generally undesirable; control of tall grasses would enhance this site (Photo F. Woog).

Figure 8. Nesting under **A**: `ōhi`a (Photo K. Misajon) and **B**: strawberry guava (Photo J. Medeiros).

Cover (nesting). Nēnē build nests on the ground usually under woody and herbaceous plants with an open canopy (See Appendix C for native plant list). Nesting habitats range widely from beach strand, grassland, shrubland, to lava rock. Species composition varies; for instance, in mid-elevation Hawai`i and Maui, native shrubs (e.g., `a`ali`i, `ōhelo, pūkiawe, small `ōhi`a) predominate (Fig. 8). On Kaua`i, similar plants are used in highlands, but in lowlands both native (e.g., naupaka-beach vitex) and nonnative (e.g., lantana, Christmas berry, koa haole-Guinea grass) plants are used. In Ka`u Desert on Hawai`i, nesting territories (~10 ac [4 ha] per pair) contain the nest site (more densely vegetated) and areas for foraging (less densely vegetated).

Cover (foraging). Nēnē graze and browse plants from ground to slightly above Nēnē head level. Sometimes they forage on berries up to 26 inches (66 cm) high and occasionally climb into the bushes to reach berries (i.e., māmaki). In many areas Nēnē feed on cultivated grasses. In mid-elevation Hawai`i, birds select forage with high water and protein content such as the young shoots of a Kikuyu grass–Spanish clover grassland. They prefer sward-forming (turf-like growth) over bunch grasses and short (2-4 inches [5-11 cm]) over tall grasses and use grasslands less during drought (see Woog and Black 2001; Fig. 6).

Water. Daily forage provides Nēnē with an adequate amount of water in their diet. Although Nēnē are not an obligate wetland species, they readily use fresh and sometimes brackish, open-water wetlands and reservoirs (when available) to drink, bathe, swim, and escape from predators during the breeding and molting periods. Nēnē have been observed using sumps, cow troughs, wastewater or settling basins, stock ponds, reservoirs, golf course ponds, taro patches, emergent wetlands, and riparian zones.

Interspersion of habitat components. All habitat components should be available within close proximity to one another.

Minimum habitat size. The Nēnē is a wide ranging species capable of both high altitude and interisland flight; there are several records of birds flying between Maui and Hawai`i. Nēnē managers hope to reestablish traditional movements between populations and islands. Today, birds generally range within 77 mi2 (200 km2), but some range more widely. Thus, they require large-scale sanctuaries including both managed grasslands and native shrublands. Large areas adjacent to existing sanctuaries or within Nēnē flyways are favorable.

Breeding. Historically, Nēnē nested primarily in leeward lowlands (<2300 ft [700 m]) during

the wet months when winter rains caused new growth of food plants and warmer temperatures improved gosling survival. Modern-day Nēnē breeding areas have been influenced by release sites (see Woog 2000 for details). Nēnē have been found from 0-7500 ft (2300 m) elevation.

Nēnē show a high nest site fidelity (females, who decide where to nest, often return to breeding sites where they were hatched) and occasionally reuse old nests. Nests are generally placed under trees or shrubs in areas with well-drained soils, protected from the elements, and concealed from predators (Fig. 8). Nests are shallow bowls (~12 inches wide x 3 inches high [30 x 8 cm]) built with feather down and plants, such as grasses, leaves, and small twigs (Fig. 4A).

Nonbreeding. Historically, Nēnē used grasslands and shrublands in the highlands (>3000 ft [900 m]) primarily during the nonbreeding season or summer when drier conditions prevailed and temperatures were mild. Today, low and mid-elevation managed grasslands appear to play an important role during the nonbreeding season.

THREATS

Major threats to Nēnē include:

- Predation by introduced predators
- Inadequate nutrition
- Lack of suitable lowland habitat
- Human-related disturbance and mortality
- Behavioral problems
- Lack of genetic diversity
- Disease

Landowners can also benefit Nēnē by minimizing threats. Only the first four threats are addressed here because landowners have considerable influence over these factors. For information on other threats, consult the Nēnē Recovery Plan. In general, Nēnē populations are limited by lack of adequate nutrition in the highlands and introduced predators in the lowlands; however both threats occur in high and low elevations.

Figure 9. A: Nēnē predated by a cat (Photo K. Misajon) and **B:** mongoose (Photo J. Medeiros).

Introduced predators. Nēnē had no mammalian predators prior to human arrival. Currently, introduced predators (see table) are the greatest threat to Nēnē, including domestic dogs and cats. Nēnē are particularly vulnerable to dogs because they have little instinctive fear of them. During molt, adults are flightless and extremely vulnerable to predation. Effective predator control is known to increase Nēnē survival and reproduction (Fig. 9-10).

Figure 10. Live-trap (for cats and mongooses) with barrier to prevent Nēnē entrapment (Photo K. Uyehara)

Introduced predators	Predators of Nēnē		
	Adults	Goslings	Eggs
Dogs	X	X	
Cats	X	X	x
Mongooses	x	X	X
Pigs	x	X	X
Rats		X	X

X = frequent; x = infrequent

Inadequate nutrition. Habitat loss and degradation contribute to nutrient-poor forage for Nēnē. Proper nutrition is critical for successful reproduction. Breeding females require carbohydrates and protein to increase fat reserves for egg laying and incubation; goslings require high-protein foods for growth

and development. One of the leading causes of gosling mortality on Hawai`i and Maui is starvation and dehydration.

Criteria for reestablishment of Nēnē populations (USFWS 2004):

1. Habitat elements are suitable and under long-term protection
2. Introduced predators can be eliminated or effectively controlled
3. The release site is not completely isolated from other Nēnē populations
4. Annual monitoring and reporting on Nēnē population conducted for ≥10 years
5. Participation in public outreach to build support for Nēnē conservation

Lack of suitable lowland habitat. Nēnē use lowlands (<2300 ft [700 m]) seasonally on Hawai`i and Maui and year-round on Kaua`i. Limited lowland habitat is thought to be a missing component for breeding birds. Lowlands, however, are often unsuitable because of intense human activity or dense predator populations. Thus, Nēnē managers seek suitable lowland to mid-elevation areas to reestablish new breeding populations.

Human-caused disturbance and mortality. There are many human activities that negatively impact Nēnē. Collisions with vehicles and other objects are a major cause of bird mortality. For example, between 1992 and 1997, 7 Nēnē were killed by golf balls and related events at two golf courses; between 1988 and 1999, at least 55 Nēnē were killed by cars at two National Parks. The problem is worse in some areas because birds are attracted to handouts by visitors and the young shoots of recently-manicured lawns of roadsides and golf courses. In many areas, Nēnē habitat is bisected by roads; nesting and roosting on one side, foraging on the other. This poses a serious threat, particularly during the breeding season, when adults walk goslings across roads.

Photo K. Misajon

Photo F. Woog

Although there is little information on hazards to Nēnē on agricultural lands, landowners should be aware that normal operational activities may alter feeding and breeding patterns or bring harm to birds. Negative impacts might result from farm or recreational vehicles, pesticide use, or livestock grazing in areas where birds breed or roost. Nēnē could also imprint on humans and become perceived as a nuisance to the agricultural operation.

Too much of a good thing: Nēnē have the potential to become a perceived nuisance in areas where they're abundant, particularly if birds associate people or buildings with something positive, like food or protection. Potential problems include begging for food, feeding on livestock grains, nesting or loafing in potentially hazardous sites, creating unsanitary conditions from droppings or parasites, and depredation of garden plants and crops (Fig. 11). In new housing developments, birds may use water catchments and feed on the tender shoots of recently-seeded lawns.

To do your part in preventing a nuisance **situation, do not feed Nēnē or interact with** them in any way. "A fed Nēnē is a dead Nēnē" because this puts the bird at risk for eating unsafe food and brings it much closer to human-related hazards.

Figure 11. Nēnē foraging at a **A:** tomato farm (Photo L. Shinshiro) and **B:** picnic area (Photo F. Woog).

To avoid these complications, follow the guidelines presented here and consult with the NRCS Biologist and/or a Nēnē Biologist during planning. To maintain good neighbor relations, landowners are highly encouraged to talk with their neighbors about Nēnē habitat improvements and conservation programs.

What to do with a sick, injured, or dead Nēnē?

1. Note the bird's condition, behavior, and exact location
2. Call the Division of Forestry & Wildlife (DOFAW) as soon as possible for guidance (phone numbers below)

Summary of Nēnē habitat components

Habitat component	Habitat characteristics
Food	▪ Leaves, seeds, fruits, and flowers of a wide variety of native and nonnative upland plants, mainly grasses, sedges, and shrubs ▪ Grasses, forbs, and shrubs with high nutritional value
Cover – nesting	▪ Ranges from sparsely to densely-vegetated beach strand, grassland, shrubland, and woodland; cover may be largely a function of availability ▪ In mid-elevation Hawai`i and Maui, native-dominated, open-canopy shrublands are used; pūkiawe, `ōhelo, `a`ali`i, and `ōhi`a are common ▪ On Kaua`i, native and nonnative plants are used; e.g., `a`ali`i, pūkiawe (highlands), Christmas berry, koa haole-Guinea grass, naupaka-beach vitex (lowlands) ▪ Nests are constructed on the ground usually under woody and herbaceous plants with an open canopy ▪ Nests are shallow bowls (~12 inches wide x 3 inches high [30 x 8 cm]) constructed of grasses, leaves, twigs, feather down
Cover – foraging	▪ Nēnē forage from ground to about 26 inches (66 cm) above ground level mainly in grasslands, grassy shrublands, and open-canopy shrublands ▪ In mid-elevation Hawai`i and Maui, grasslands are used most of the year and grasslands or native shrublands during incubation periods ▪ In mid-elevation Hawai`i, Nēnē feed mainly on cultivated grasses, select forage with high water and protein content (e.g., Kikuyu grass–Spanish clover grassland), prefer sward-forming (turf-like growth) over bunch grasses and short (2-4 inches [5-11 cm]) over tall grasses, and use grasslands less during drought
Water	▪ Plant foods generally provide adequate water in diet ▪ Open-water wetlands and reservoirs used (when available) for bathing, swimming, and may provide predator-escape during breeding and molting periods
Interspersion of habitat components	▪ Both managed grasslands and native shrubland nesting habitats are available ▪ Habitat components are available within close proximity to one another
Minimum habitat size	▪ Wide ranging species; home range is generally within 77 mi^2 (200 km^2) ▪ Large-scale sanctuaries <2300 ft (700 m) elevation (breeding habitat) or >3000 ft (900 m) elevation (nonbreeding habitat) when on Hawai`i or Maui are preferred
Human-related impacts	▪ Introduced predators (dogs, cats, mongooses, pigs, rats) are able to be excluded or controlled ▪ Livestock are able to be excluded or rotated out from Nēnē breeding areas during the breeding season (Oct - Mar) ▪ Nēnē-human interactions and hazards to Nēnē are minimal ▪ Nēnē are unlikely to become a nuisance to landowners or their neighbors

Limiting Factors

For planning purposes, use the table below to subjectively rate the availability and quality of Nēnē habitat within a planning area, based on the above habitat characteristics. Habitat components absent or rated low are likely limiting Nēnē habitat quality.

	Quality / Availability			
Habitat component	High	Medium	Low	Absent
Food				
Cover – nesting				
Cover - foraging				
Water				
Interspersion				
Minimum habitat size				

Management Recommendations

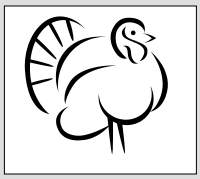
Management treatments should address the habitat components that appear to limit habitat potential for Nēnē. Management options are listed below that may increase the quality or availability of each habitat component determined to be limiting. NRCS Conservation Practices and various programs that may provide financial or technical assistance to carry out practices are also listed.

Habitat component	General management options for increasing habitat quality or availability	Conservation Practices
Food *Emphasize (1) restoring native plant communities and/or (2) maintaining existing nonnative plant communities with high food value*	▪ Plant a diversity of native food plants that are nutritious (See Appendix B for plant recommendations) ▪ Avoid planting invasive or potentially invasive species (See http://www.hear.org/pier/index.html) ▪ Consult with NRCS Biologist or Plant Materials Center on best sources, spacing, care, and maintenance of plants; when possible, strive to restore native plant community structure and function not just native species	314, 550, 595, 612, 643, 645
	▪ Selectively maintain existing nonnative, noninvasive plant communities of known functional value to Nēnē (Not always practical or possible to convert a heavily-modifed to a native-dominated habitat; some nonnative plants such as Kikuyu grass, clovers, and gosmore provide equal or better forage for Nēnē)	643, 645, 647
Cover – nesting *Emphasize restoring native shrublands with an open character without tall grass cover*	▪ Restore or enhance native shrubland communities using the guidelines above (See Appendix C for plant recommendations) ▪ Plant native shrubs that provide nest cover and food (e.g., pūkiawe, `ōhelo, kūkaenēnē, māmaki, naupaka) ▪ Improve nesting cover in slightly-elevated areas that have good visibility of predators but also offer protection from inclement weather	314, 550, 595, 612, 643, 645, 647
	▪ Avoid or minimize negative effects of pest management practices (e.g., loss of nesting, brood-rearing, or thermal cover during breeding season) on Nēnē by developing an integrated pest management plan ▪ If Nēnē are breeding in area, schedule major habitat manipulations outside the breeding season	314, 595, 645
Cover – foraging *Emphasize enhancing and managing protein-rich grasslands*	▪ Maintain good interspersion of grassland-forb communities by strip disking, mowing, or prescribed rotational grazing	528, 645
	▪ Enhance grasslands through prescribed grazing, mowing, fertilizing, irrigating, or weed control; for example, mow sward-forming grasslands (e.g., Kikuyu grass–Spanish clover mix) at a frequency to maintain short grass-legume forage (2-4 inches [5-11 cm]) with high moisture-protein content	314, 528, 595, 645, 647
Water	▪ Modify or fence existing reservoirs with steep and slippery side slopes to prevent gosling entrapment; if fenced, mesh size should be ≤0.5 inches (1.3 cm) and fence height ≥2 ft (61 cm) to prevent gosling access	382, 645
	▪ Cover water tanks to prevent Nēnē access, particularly if used for human consumption	472
Interspersion and minimum habitat area	▪ Consider interspersion of shrublands and grasslands ▪ Consider relationship of planning area to habitat components on neighboring lands ▪ If planning area is near a Nēnē sanctuary, expand existing habitat types or establish a buffer zone ▪ Large contiguous areas remote from human activity are preferred over small areas or areas near human activity	643, 645
Human-related impacts	▪ Fence protected areas with a game-proof fence to exclude large mammalian predators and allow for controlled livestock grazing (see "Building a Nēnē Fence" below)	382, 528, 595, 645

Habitat component	General management options for increasing habitat quality or availability	Conservation Practices
	▪ Modify habitats to minimize predator populations (e.g., remove debris piles that provide mongoose cover) ▪ Develop and implement a predator control plan for introduced predators (consult with Nēnē Biologists) - Control feral dogs and cats through trapping and hunting - Control mongooses and rats using traps and rodenticides (e.g., Diphacinone) - Reduce feral pig populations through trapping and hunting - Restrain pet dogs and cats by keeping dogs tied up and cats indoors to prevent any disturbance or harm to Nēnē ▪ Do not introduce exotic or domestic birds that may compete with Nēnē for resources or spread disease ▪ Remove feral waterfowl (contact DOFAW for guidance)	
	▪ Avoid all interactions with Nēnē to keep birds wild ▪ Avoid enhancing habitats within roughly 5 mi (8 km) of an airport or establishing new Nēnē flyways near airports	645
	▪ Modify habitats so that Nēnē are not attracted to potentially hazardous areas (e.g., convert grassy roadside easements to natural lava rock) and/or modify people's behavior, as the National Parks have done, through education and interpretive signs that explain why people should not feed Nēnē	380, 472, 568, 645
	▪ Work with public transportation departments to decrease vehicle speed in Nēnē crossing zones by installing cautionary signage and speed bumps	472
	▪ Provide a route for traffic that minimizes disturbance to Nēnē and protects other natural resources	560
	▪ Manage recreation and ecotourism activities in ways that prevent or minimize disturbance to Nēnē; e.g., disallow hunting or re-route ecotours away from breeding areas during the breeding season	472, 568

Conservation Practices: 314 Brush Management, **380** Windbreak/Shelterbelt Establishment, **382** Fence, **472** Use Exclusion, **528** Prescribed Grazing, **550** Range Planting, **560** Access Road, **568** Recreation Trail and Walkway, **595** Pest Management, **612** Tree/Shrub Establishment, **643** Restoration and Management of Rare or Declining Habitats, **645** Upland Wildlife Habitat Management, **647** Early Successional Habitat Development/Management, (More info: http://efotg.nrcs.usda.gov/efotg_locator.aspx?map=HI).

NRCS Conservation Programs that apply: CREP Conservation Reserve Enhancement Program (FSA-administered); **CSP** Conservation Security Program; **EQIP** Environmental Quality Incentives Program; **GRP** Grassland Reserve Program; **WHIP** Wildlife Habitat Incentives Program; **WRP** Wetlands Reserve Program (More info: http://www.hi.nrcs.usda.gov/programs/).



Is gamebird hunting a compatible use?

In 1992-1993, DOFAW conducted a study at Kapapala Gamebird Management Area to assess the effects of gamebird hunting on Nēnē and concluded that, when properly conducted, gamebird hunting has minimal effects on Nēnē in the area. However, this a subject of continuing debate (DOFAW 1993, USFWS 2004).

Building a Nēnē fence - Examples of modifications to the NRCS Game-proof Fence Specification (382):

- Omit barbed wire strand on top to prevent potential injury to low-flying birds
- On outside, cover the standard fence with a small gauge mesh (<1 inch) to deter small mammals
- Bury a 2-ft skirt of the mesh to prevent predators from burrowing beneath fence
- Design gates to prevent predator ingress
- Inspect fence regularly, particularly before and during the breeding season and after stormy weather, to detect and repair breaches before predators gain access
- Fence designs will vary by location, target predator species, and other management objectives; consult with the NRCS Range Specialist, NRCS Biologist, and/or a Nēnē Biologist about specifications for your site

Examples of Nēnē fences and pens

Pig exclusion fence at Hawai`i Volcanoes NP (Photos K. Uyehara)

Pig, dog, cat, and mongoose exclusion fence at Hawai`i Volcanoes NP (Photos K. Uyehara)

Open-top pens used for breeding and release of captive-reared birds (Photos J. Medeiros)

Common and scientific and names of animals and plants in text

Animals
Canada Goose (*Branta canadensis*)
Hawaiian Goose or Nēnē (*Branta sandvicensis*)
Pig (*Sus scrofa*)
Rat (*Rattus* spp.)
Small Indian mongoose (*Herpestes auropunctatus*)

Plants
`A`ali`i (*Dodonaea viscosa*)
Beach vitex (*Vitex rotundifolia*)
Beardgrass (*Schizachyrium condensatum*)
Christmas berry (*Schinus terebinthifolius*)
Gosmore (*Hypochoeris radicata*)
Guinea grass (*Panicum maximum*)
Koa haole (*Leucaena leucocephala*)
Kūkaenēnē (*Coprosma ernodeoides*)
Māmaki (*Pipturus albidus*)
Molasses grass (*Milinis minutiflora*)
Broomsedge (*Andropogon virginicus*)
Kikuyu grass (*Pennisetum clandestinum*)
Lantana (*Lantana camara*)
Naupaka (*Scaevola* spp.)
Noni or Indian mulberry (*Morinda citrifolia*)
`Ōhelo (*Vaccinium reticulatum*)
`Ōhi`a (*Metrosideros polymorpha*)
Partridge pea (*Chamaecrista nictitans*)
Pūkiawe (*Styphelia tameiameiae*)
Rattail grass (*Sporobolus africanus*)
Spanish clover (*Desmodium sandwicense*)
Strawberry guava (*Psidium cattleianum*)
Taro or kalo (*Colocasia esculenta*)
Yorkshire fog (*Holcus lanatus*)

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Appendices

A. Composition of Nēnē food plants (Black et al. 1994)
B. Native plants used for food by Nēnē (USFWS 2004)
C. Native plants used for nesting cover by Nēnē (USFWS 2004)

For more Nēnē information contact:

NRCS State Biologist
(808) 541-2600 Honolulu, O`ahu

U.S. Fish & Wildlife Service
(808) 792-9400 Honolulu, O`ahu

DOFAW
(808) 274-3433 Lihue, Kaua`i
(808) 984-8100 Kahului, Maui
(808) 887-6063 Waimea, Hawai`i
(808) 974-4229 Hilo, Hawai`i
(808) 587-0166 Honolulu, O`ahu

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Appendix A.

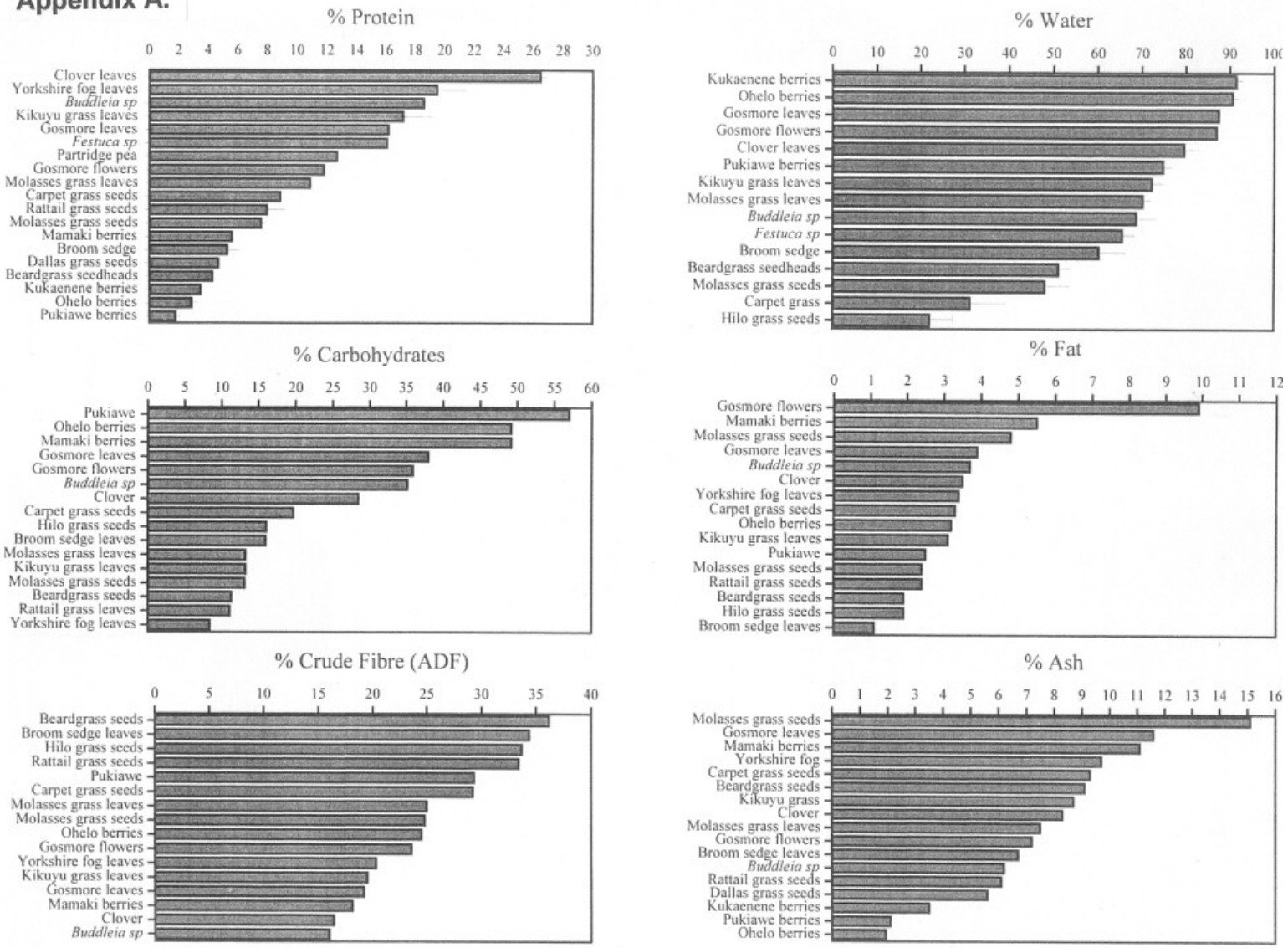

Figure 19. Composition of different Nene food plants. Water content on the basis of fresh weight, all other components on dry weights.

(Black et al. 1994, permission to reprint from J.M. Black)

Appendix B.

Native Hawaiian plants known to be food items for nēnē for use by managers interested in nēnē habitat restoration.

Family	Common Name (Scientific Name)	Status[1]	Part Eaten	Protein Rank[2]	Islands[3]/Elevation	Information Source[4]
Asteraceae (Sunflower family)	Kookoolau (*Bidens hawaiensis*)	E	leaves	high	H/50-1,400 m	HAVO field notes, Sherry 2001
	Naenae (*Dubautia scabra*)	E	flowers, leaves, seeds	low	H, L, M, Mo/75-2,500 m	Black *et al.* 1994, Swift 2000
	`Ena`ena (*Pseudognaphalium sandwicensium*)	E	flowers, leaves	high	H, K, L, M, Mo, N, O/0-3,000 m	Baldwin 1947, Swift 2000
Caryophyllaceae (Pink family)	Catchfly (*Silene hawaiiensis*)	E	leaves	high	H/900-1,300(-3,050) m	Sherry 2001
Cyperaceae (Sedge family)	Sedge (*Carex macloviana*)	I	leaves, seeds	not tested	H, M /1,190-2,740 m	Baldwin 1947
	Sedge (*Carex wahuensis*)	E	seeds	low	H, K, L, M, Mo, O /(10-)250-2,500 m	Baldwin 1947, Rojek 1994
	Mau`u `aki`aki (*Fimbristylis cymosa*)	I	leaves, seeds	not tested	H, K, L, M, Mo, N, O/0-60 m	Sherry 2001
	Kilioopu (*Cyperus polystachyos*)	I	leaves, seeds	low	H, K, L, M, Mo, N, O/0-1,420 m	Baldwin 1947, Swift 2000
Epacridaceae (Epacris family)	Pūkiawe (*Leptecophylla tameiameiae*)	I	berries, leaves	low	H, K, L, M, Mo, O (may have occurred on N and Ko in past)/15-3,230 m	Baldwin 1947, Black *et al.* 1994, Kear and Berger 1980, Rojek 1994, Swift 2000, Woog 1993

Appendix B (continued). Native Hawaiian plants known to be food items for nēnē for use by managers interested in nēnē habitat restoration.

Family	Common Name	Status[1]	Part Eaten	Protein Rank[2]	Islands/Elevation	Information Source[2]
	Hair grass (*Deschampsia nubigena*)	E	seeds, leaves, stems?	low	H, K, M, Mo/ (30-)600-2,830 m	Baldwin 1947, Black *et al.* 1994, Rojek 1994, Woog 1993
	Kūkaepua`a, Itchy crabgrass (*Digitaria setigera*)	I?	leaves, seeds	high	H, K, L, M, Mo, N, O/10-980 m	Baldwin 1947, Sherry 2001
	Kāwelu (*Eragrostis variabilis*)	E	leaves, seeds?	low	H, K, Ko, L, M, Mo, N, O/0-1,130 m	HAVO field notes
	Pili (*Heteropogon contortus*)	I?	leaves, seeds?	low	H, K, Ko, L, M, Mo, N, O/0-700m	Hu 1998, Sherry 2001
	Mountain pili (*Panicum tenuifolium*)	E	leaves, seeds	low	H, K, L, M, Mo, O/ 1,200-2,300 m	Baldwin 1947
Polygonaceae (Buckwheat family)	Pāwale (*Rumex skottsbergii*)	E	leaves	high	H/460-1,300 m	Baldwin 1947, Sherry 2001, Woog 1993
Rosaceae (Rose family)	`Ōhelo papa, white strawberry (*Fragaria chiloensis*)	I	berries	not tested	H, M (east)/ 1,160-3,070 m	Pope 1932
	`Ūlei (*Osteomeles anthyllidifolia*)	I	berries	not tested	H, K, L, M, Mo, O/ 2-2,320 m	Sherry 2000
	`Ākala (*Rubus hawaiensis*)	E	berries	not tested	H, K, M, Mo/ 660-3,070 m	Pope 1932
	`Ākala (*Rubus macraei*)	E	berries	not tested	H, M (east)/ 1,610-2,080 m	Pope 1932

Appendix B (continued). Native Hawaiian plants known to be food items for nēnē for use by managers interested in nēnē habitat restoration.

Family	Common Name	Status[1]	Part Eaten	Protein Rank[2]	Islands/Elevation	Information Source[2]
	Hair grass (*Deschampsia nubigena*)	E	seeds, leaves, stems?	low	H, K, M, Mo/ (30-)600-2,830 m	Baldwin 1947, Black *et al.* 1994, Rojek 1994, Woog 1993
	Kūkaepua`a, Itchy crabgrass (*Digitaria setigera*)	I?	leaves, seeds	high	H, K, L, M, Mo, N, O/10-980 m	Baldwin 1947, Sherry 2001
	Kāwelu (*Eragrostis variabilis*)	E	leaves, seeds?	low	H, K, Ko, L, M, Mo, N, O/0-1,130 m	HAVO field notes
	Pili (*Heteropogon contortus*)	I?	leaves, seeds?	low	H, K, Ko, L, M, Mo, N, O/0-700m	Hu 1998, Sherry 2001
	Mountain pili (*Panicum tenuifolium*)	E	leaves, seeds	low	H, K, L, M, Mo, O/ 1,200-2,300 m	Baldwin 1947
Polygonaceae (Buckwheat family)	Pāwale (*Rumex skottsbergii*)	E	leaves	high	H/460-1,300 m	Baldwin 1947, Sherry 2001, Woog 1993
Rosaceae (Rose family)	`Ōhelo papa, white strawberry (*Fragaria chiloensis*)	I	berries	not tested	H, M (east)/ 1,160-3,070 m	Pope 1932
	`Ūlei (*Osteomeles anthyllidifolia*)	I	berries	not tested	H, K, L, M, Mo, O/ 2-2,320 m	Sherry 2000
	`Ākala (*Rubus hawaiensis*)	E	berries	not tested	H, K, M, Mo/ 660-3,070 m	Pope 1932
	`Ākala (*Rubus macraei*)	E	berries	not tested	H, M (east)/ 1,610-2,080 m	Pope 1932

Appendix C.

Native Hawaiian plants nēnē are known to nest under.

Family	Common name (Scientific name)	Status[1]	Island(s)[2]	Elevation	Habitat	Information source
Vascular Plants[3]						
Epacridaceae (Epacris family)	Pūkiawe *(Leptecophylla tameiameiae)*	I	H, K, L, M, Mo (may have occurred in the past on Ko, N)	15-3,230m	Ranges from dry to wet habitats; mesic forest to open areas of low elevation or montane wet forest, fogswept alpine shrubland, and bogs, rarely windward coastal sites.	Banko *et al.* 1999, Black *et al.* 1994
Ericaceae (Heath family)	ʻŌhelo[4] (*Vaccinium reticulatum*)	E	H, M, rare on K, Mo, O	640-3,700m	Common shrub of disturbed sites, usually occurring as member of the pioneer community found on lava flows, ash dunes, and cinder beds, or of exposed sites such as alpine or subalpine shrubland; much less common in mature or stable plant communities such as grassland, wet forest, or bogs.	Banko *et al.* 1999
Goodeniaceae (Goodenia family)	Naupaka kahakai (*Scaevola taccada*)	I	H, K, Ko, L, M, Mo, N, O	0-300m	Common in coastal sites.	Banko *et al.* 1999
Myrtaceae (Myrtle family)	ʻŌhiʻa, ʻŌhiʻa lehua[5] (*Metrosideros polymorpha*)	E	H, K, L, M, Mo, O	from near sea level to 2,200m	Ranges from dry to wet habitats; inhabits many ecological situations. 8 varieties recognized.	Banko *et al.* 1999, Black *et al.* 1994

Appendix C (continued). Native Hawaiian plants nēnē are known to nest under.

Family	Common name (Scientific name)	Status[1]	Island(s)[2]	Elevation	Habitat	Information source
Rubiaceae (Coffee family)	ʻAiakanēnē, Kūkaenēnē (*Coprosma ernodeoides*)	E	H, M (east)	1,220-2,590m	Dry? Primarily occurs in open sites, often on lava or cinder fields in subalpine woodland.	Banko *et al.* 1999
Sapindaceae (Soapberry family)	ʻAʻaliʻi, ʻAʻaliʻi kū makani, kūmakani (*Dodonaea viscosa*)	I	H, K, L, M, Mo, N, O	3-2,350m	Ranges from dry to wet habitats, from coastal dunes, low elevation shrublands to dry mesic and wet forest and subalpine shrubland.	Banko *et al.* 1999
Ferns [6]						
Blechnaceae	`Ama`u (*Sadleria cyatheoides*)	E	H, K, Ko, L, M, Mo, O, N	(5-)75-2,200m	Common in exposed habitats, mesic and wet forests and shrublands and a primary invader of new lava flows.	Banko and Manuwal 1982

[1] E=endemic, I=indigenous, I?=questionably indigenous (see Wagner *et al.* 1999)
[2] H=Hawaii, K=Kauai, Ko=Kahoolawe, L=Lanai, M=Maui, Mo=Molokai, N=Niihau, O=Oahu
[3] From Wagner *et al.* 1999
[4] Although flowering and fruiting occur year round, flowering is most prolific from April to September, and the peak of berry production occurs from June to September (Wagner *et al.* 1999).
[5] Banko and Manuwal (1982) found 3 nēnē nests in the wild under short (less than 4m) ʻŌhiʻa plants
[6] From Palmer 2003

(USFWS 2004, see original document for information sources listed above)