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Quantifying Restoration of Hakalau Forest National Wildlife Refuge, Hawai‘i (1989–2024) Using NDVI and Moisture Indices from Remote Sensing Imagery

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Abstract

Over the past four decades, reforestation of koa trees (*Acacia koa*) and other native vegetation in Hakalau Forest National Wildlife Refuge (NWR) on Hawai‘i has restored forest areas and helped preserve habitats for endangered endemic species. However, the extent of koa regrowth was not previously quantified. Using Normalized Difference Vegetation Index (NDVI) and Normalized Difference Moisture Index (NDMI) spatial analyses of Landsat, National Agriculture Imagery Program (NAIP), and Sentinel imagery, we classified tree and non-tree areas to estimate forest recovery between 1989 and 2024. Our results suggest approximately 49% koa tree cover has been reestablished in cleared regions. This quantitative assessment of forest growth provides essential data for the management of the refuge, offers spatial tools to track progress toward full forest restoration, and can guide other tropical forest conservation projects.

Introduction

Hawaiian forest ecosystems are highly unique (Cuddihy & Stone, 1990). Approximately 90% of species on the islands are endemic (Rønsted et al., 2022), with Hawaiian forests providing habitats and supporting ecological processes that are critical to native species survival. They provide key ecosystem services such as regulating hydrologic function and climate, filtering water, storing carbon, and supporting biodiversity (Wainger & Mazzotta, 2011). Deforestation and degradation due to invasive ungulates and plants are a threat to these forest ecosystems and the species that depend on them across the Hawaiian Island chain (Cook et al., 1989, Powers et al., 2011).

The introduction of livestock to Hawai‘i in the late 1700s led to widespread grazing, promoting invasive grasses and shrubs while displacing native vegetation (Conrad et al., 1988). Prior to large-scale land conversion, upland forests in Hawai‘i consisted primarily of montane koa-ōhi‘a ecosystems, dominated by koa and ōhi‘a (*Metrosideros polymorpha*) with a diverse set of native understory species (Selmants et al., 2017; Owen et al., 2022). Much of this forest was cleared for pasture, reducing habitat for endemic forest birds (Scowcroft & Jeffrey, 1999; Ralph & Fancy, 1994). In contemporary restoration, koa often emerges as the dominant canopy species due to its rapid growth and ability to overtop invasive grasses. In addition to habitat loss, the introduction of non-native avian species and the accidental introduction of mosquitoes enabled diseases, such as avian malaria, to spread throughout the islands (Atkinson & LaPointe, 2009; U.S. Geological Survey [USGS], 2023). Avian malaria causes high mortality of endemic Hawaiian forest birds, which evolved with no inherent defenses to such diseases. For example, the ‘i‘iwi (*Drepanis coccinea*) suffers a 90% mortality rate from a single mosquito bite, making disease a significant contributor to population range limitations and species decline (Atkinson et al., 2000). Most native birds have been significantly impacted by avian diseases; of the original estimated 84 endemic bird species, at least 58 have gone extinct. Of the remaining 28 species, 24 are listed by the IUCN as vulnerable, threatened, endangered, or critically endangered.

In response to deforestation and habitat loss combined with the avian malaria mortality threat, the U.S. Fish and Wildlife Service (FWS) established the Hakalau Forest National Wildlife Refuge (NWR) in 1985, with the intent to improve habitat conditions and restore native forest on pasture lands within the refuge. A significant portion of the refuge had been cleared, and kikuyu grass (*Cenchrus clandestinus*) and other non-native pasture grasses were introduced to facilitate cattle operations for almost 100 years prior to the establishment of the refuge. Covering nearly 33,000 acres, the refuge serves the goal of conserving habitats for species such as the ʻākepa (*Loxops coccineus*), ʻakiapōlāʻau (*Hemignathus wilsoni*), and ʻiʻiwi (U.S. Geological Survey [USGS], 2023; U.S. Fish and Wildlife Service, 2010). In 2006, the Friends of Hakalau Forest National Wildlife Refuge was established to further support these conservation efforts. Key conservation strategies included replanting koa in areas previously cleared for pasture and promoting stewardship through community and educational outreach. These integrated efforts represent one of the most sustained and ambitious forest restoration projects in the state.

Although reforestation—defined here as the reestablishment of koa-dominated forest cover—has been considered a success, a quantitative measure of regrowth is necessary to fully assess the impact of conservation efforts within the NWR. Because monitoring of the refuge is both time and resource intensive, remote sensing can be applied to the region to understand forest regrowth since planting began in the late 1980s. Here, we analyze Landsat, NAIP, and Sentinel data to measure the growth of previously and newly planted trees in the NWR from 1989 to 2024, focusing primarily on canopy cover dominated by koa. Quantifying canopy expansion in this way allows forest managers to better assess restoration success cost-effectively, target efforts in specific regions, monitor annual growth, and identify areas with poor growth to troubleshoot and improve reforestation outcomes. If successful, these strategies could inform future forest restoration initiatives across Hawaiʻi and other island ecosystems facing similar challenges.

Methods

Landsat Imagery

We first used the Normalized Difference Vegetation Index (NDVI) to quantify refuge regrowth, as NDVI is a well-established metric to quantify tree cover, forest health, and vegetation change through time (Aziz et al., 2024; Pettorelli et al., 2005; Tucker, 1979). To calculate the NDVI, satellite data from the Landsat 4-5, 7, and 8–9TM, ETM+, and OLI sensors was utilized. These sensors have 30 m resolution and capture up to 11 spectral bands, making the time series valuable for tracking long-term land-use changes over large areas. The data were obtained for Hawaiʻi Island using the USGS Global Visualization Viewer (GloVis; U.S. Geological Survey [USGS], 2005). Red and Near-Infrared bands were selected to detect NDVI (Taloor et al., 2021). Image selection included carefully reviewing GloVis frames to avoid high cloud coverage and patterned lines from Landsat 7 scan line corrector failures (National Aeronautics and Space Administration [NASA], 2025). Images were selected for each year from 1989 to 2024 to track changes in forest growth through time, focusing on the years 1989, 2000, 2014, and 2024. Care was taken to avoid images with cloud cover. Data were downloaded and processed in ArcGIS Pro (Gandi et al., 2015) using the formula NDVI = (NIR − Red) / (NIR + Red).

The resulting NDVI calculations were then symbolized using a “Minimum-Maximum” stretch, with pixel values scaled between 0 and 1 to represent the range of vegetation cover, where higher values indicate more dense vegetation than lower values. To distinguish between trees/forest and clearcut regions, threshold values were determined by examining pixel values in areas where reforestation efforts had been made. Three thresholds (most conservative, mid-level, least conservative) were tested to estimate tree cover (Table 1). Areas were calculated using the 30 m spatial resolution of each cell and resulted in a difference in area from 6.8 km^2 to 10.9 km^2.

NAIP Imagery

Preliminary analyses indicated that, while sub-canopy species are generally not detectable, Landsat data alone could be confounded by high grass NDVIs in previously cleared areas. We therefore refined these estimates using NAIP NDVI, which provides sub-meter resolution aerial images (up to 0.3 m) but only launched in Hawaiʻi in 2021 (U.S. Department of Agriculture, 2021). Images collected between 2021 and 2023 were taken from the NAIP collection of ArcGIS Online's data platform and directly downloaded into ArcGIS Pro (Esri, 2025). Due to the high-quality resolution (0.3 m) of the data, a clear delineation could be made between forest and unforested regions. A Boolean analysis was performed, and forested area was calculated based on a 0.3-meter cell size.

Table 1. Koa Tree Regrowth Estimates Derived from Landsat NDVI, NAIP NDVI, and Sentinel-2 NDMI Under Varying Thresholds. Comparison of Landsat NDVI, NAIP NDVI, and Sentinel-2 NDMI showed the most conservative Landsat threshold aligned best with Sentinel and NAIP derived data.

Dataset	Metric	Most Conservative	Mid-Level	Least Conservative
Landsat NDVI	Area (km^2)	6.8	9.9	10.9
	Cover (%)	49	69	78
NAIP NDVI	Area (km^2)	—	6.3*	—
	Cover (%)	—	45*	—
Sentinel-2 NDMI	Area (km^2)	7.5	8.0	8.4
	Cover (%)	53	57	59

Sentinel Imagery

To further validate our models, we then used Sentinel-2-derived Normalized Difference Moisture Index (NDMI) data (18.8 m), which reflects vegetation water content and helps distinguish tree cover from other vegetation types (Lastovicka et al., 2020). Sampling 13 multispectral bands every five days, Sentinel-2 provides high spatial resolution but is only available from 2014 onward (Phiri et al., 2020). NDMI was calculated using near-infrared (Band 8) and shortwave infrared (Band 11) data obtained from the Copernicus Data Space Ecosystem (Copernicus Data Space, 2025). Data were then processed in ArcGIS Pro using the formula NDMI = (Band 8 − Band 11) / (Band 8 + Band 11).

We then applied three different threshold values to the NDMI data, ranging from least to most conservative (Table 1). These calculations were used to provide an independent estimate of tree cover to validate our NDVI threshold values. Landsat NDVI, NAIP NDVI, and Sentinel-2 NDMI values were then compared (Figure 1). Using this information, we concluded that the most conservative Landsat NDVI threshold values were likely to provide the most accurate estimate for tree cover. This conservative estimate was therefore applied to the historical Landsat images to determine

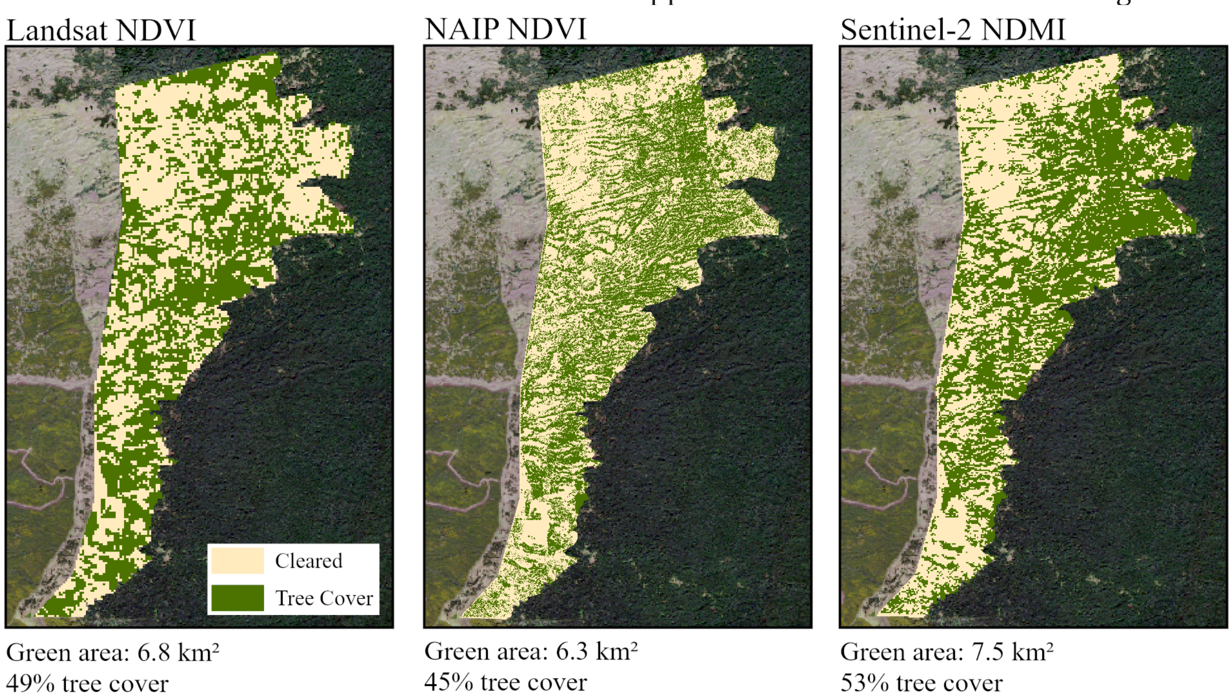

Figure 1. Cross-comparison of Landsat NDVI, NAIP NDVI, and Sentinel-2 NDMI. Comparison of Landsat NDVI, NAIP NDVI, and Sentinel-2 NDMI showed the most conservative Landsat threshold aligned best with Sentinel and NAIP derived data.

changes in koa forest cover through time (Figure 2).

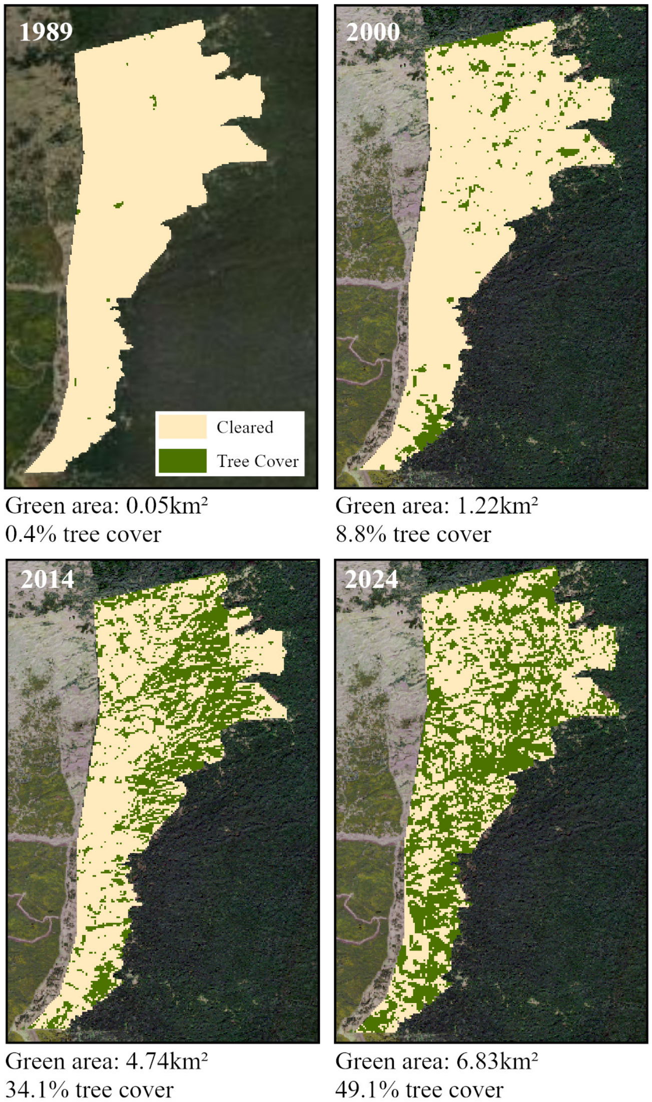

Figure 2. Final Reforestation Estimate for Hakalau Forest (1989-2024). Final reforestation estimate shows forest cover in Hakalau Forest increased from 0.4% in 1989 to 49.1% in 2024 using the most conservative Landsat NDVI threshold.

Results

Applying three different NDVI thresholds to present day Landsat imagery led to varying forest cover estimates, ranging from 6.8 km^2 to 10.9 km^2, or 49% to 78% cover (Table 1). To improve our estimates and determine which NDVI threshold is the most accurate through time, we utilized NAIP NDVI calculations with 0.3 m resolution, which estimated regrowth at 45%, corresponding to 6.3 km^2 (Table 1). These calculations had higher resolution and were within 5% of the most conservative Landsat-derived NDVI estimates for present-day forest cover (49%).

We also used Sentinel-derived NDMI to further refine the accuracy of our estimates for present day tree cover. We again applied three different threshold values, ranging from least to most conservative. The estimates generated by this method were 7.5 km^2 (53%), 8.0 km^2 (57%), and 8.4 km^2 (59%) forest cover (Table 1). Both NAIP and Sentinel analyses supported the most conservative Landsat NDVI threshold—49% forest cover—as the most accurate.

We then applied this threshold to Landsat images from 1989 to 2024 (Figure 2). The first image, from 1989, reflects minimal forest cover (0.4%) at the time of analysis, indicative of clear-cut conditions. By 2000, forested area had increased to 1.2 km^2, or 9%. By 2014, the forest had expanded to 4.7 km^2, representing 34% regrowth. In 2024, our estimate places the forest recovery at 49%, or 6.8 km^2. These findings demonstrate that approximately 50% of the forest has been repopulated with koa since the initiation of reforestation efforts in 1989, highlighting the significant progress made in Hakalau Forest's restoration over the past three decades.

Discussion

This study provides a quantitative analysis of the reforestation efforts at Hakalau Forest National Wildlife Refuge, utilizing Landsat-derived NDVI data to track changes in forest cover from 1989 to 2024. Our results demonstrate significant increases in koa tree cover through time, from small, remnant stands of scattered native forest (a benchmark representing 0 km^2) in 1989 to approximately 6.8 km^2 in 2024. That is, reforestation efforts resulted in the former pasture area of the refuge reaching nearly 50% tree cover in just over 30 years.

The combination of Landsat NDVI, NAIP NDVI, and Sentinel NDMI data offered a diverse set of metrics for monitoring and refining the accuracy of our estimates. One of our primary challenges included establishing an appropriate Landsat NDVI threshold to distinguish between koa forest and other vegetation types, such as grasses. High background NDVI values, in addition to frequent cloud cover, resulted in a large range of restoration estimates. Our analysis demonstrated that slight changes in threshold values had significant impacts in determining reforestation area, with a range from 6.8 km^2 to 10.9 km^2. Such variability highlights the challenge of using Landsat-derived NDVI alone to differentiate between vegetation types. The use of NAIP imagery was a valuable tool for refining this estimate. While the higher spatial resolution of these data allowed for a more precise classification of vegetation types and an estimate of 45% regrowth (6.3 km^2), it failed to offer an extensive analysis of change through time. This limitation in temporal coverage highlights the importance of using multiple data types for long-term forest monitoring.

Incorporating Sentinel-derived NDMI data into our analysis further improved the accuracy of our estimates. NDMI provided additional insight into vegetation water content, helping to refine the NDVI thresholds and enable more accurate differentiation between tree cover and other vegetation types. By using three different threshold values, we obtained a range of estimates from 7.5 km^2 to 8.4 km^2 that helped substantiate our NDVI analyses and provided a more nuanced understanding of the extent of reforestation.

Our findings highlight the potential use of multiple remote sensing datasets as cost-effective and accessible tools for organizations with limited resources to track long-term reforestation progress. While NAIP and Sentinel imagery offer higher resolution data, they lack the temporal availability of Landsat and require more processing time and computational power to analyze. Therefore, by integrating datasets, we were able to use Landsat-derived NDVI values to estimate a conservative change in koa tree cover through time.

Ultimately, the results of this study validate the long-term success of the Hakalau Forest National Wildlife Refuge habitat restoration program. The combination of native species replanting, active management, and protected status has yielded measurable, landscape-scale recovery. These findings can inform other restoration projects in tropical or island ecosystems, particularly those seeking cost-effective, scalable methods for monitoring forest regrowth.

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In his striking breeding feathers, a male kōlea patrols a quiet lawn—preparing for the journey that will carry him 3,000 miles north across the Pacific. Photo © Laura Doucette, 2021.

Visitors from the North

By Paula Nixon

Run. Pause. Peck.

He is alone on a large lawn, about half the size of a football field, bordered by sidewalks and flanked by two six-story hotel buildings. It's early April and he spends every day, all day, on the grass. I watch him from the balcony of my hotel room from my first cup of coffee until the sun goes down over the nearby Pacific Ocean.

When I am away a twelve-foot-tall, laughing Buddha at the far end of the lawn keeps an eye on him.

The bird is about ten inches tall with dark eyes. His black face, belly, and breast are outlined with a row of white feathers that run low across his brow and down both sides of his chest like a fancy stole. His back is cloaked in a speckled pattern of gold and black feathers. This showy spring look will help him attract a female in the coming weeks.

Pacific Golden-Plovers (*Pluvialis fulva*) live about eight months each year, including the fall and winter, in the Hawaiian Islands. Mid-spring, they migrate to the Alaskan tundra to nest, mate, and raise their chicks.

Known as kōlea in Hawaiʻi, they are not from the islands but found their way here from the north thousands of years ago. With habitats ranging from backyards on Kauaʻi to cemeteries on Oʻahu to golf courses on the Big Island, the personable birds are well-known by island residents and visitors. Schoolchildren eagerly await their return each fall.

*

As a child, I was told stories about another April before I was born: a young man's journey three thousand miles northwest from Kansas to the territory of Alaska. It was 1957 and although he had some familiarity with the place this experience would be new. Dressed in a uniform he reported for duty on a military base in Anchorage. He arrived alone and prepared a small apartment for the arrival of his wife.

*

The kōlea on the lawn is nearing the end of his yearly stay on the Big Island of Hawai'i. He continues to hunt—roaches, spiders, earthworms—preparing for a long flight. The boundaries of his territory are invisible to me. A female with a similar golden color but muted white and black feather accents has claimed the far north end of the lawn.

Shortly after sundown each evening both disappear, probably to roost on a nearby flat roof where they are safe from roaming feral cats but still must be alert for the occasional passing owl, hunting in the dark.

*

Back in Kansas, the young woman was excited but edgy, making preparations for her upcoming trip to Alaska. Except for a brief time after her wedding, she had never been more than a few hundred miles from home. She studied for her university finals and finished sewing the dress she planned to wear under her black robe. On the day she walked across the stage her parents were in the audience but her husband was not.

*

On Thursday the hotel yard crew arrives. Not just a riding mower but the whir and grind of weed wackers and hedge clippers. Mowing, pruning, edging—it goes on for hours. I don't see him take flight but the kōlea disappears.

When I return in the evening, he is back. The trimmings have been carted off and the kōlea appears unfazed, probably well-used to the yard routine.

I study the kōlea with a small pair of binoculars but don't see a band on his leg so his history is unknown. It is almost certain that he returns to this same patch of ground each autumn and fights for it if another tries to move in. I wonder how long he has been coming here, three or four years, maybe more? His life expectancy is six or seven years but could extend well beyond that.

*

The day finally arrived for the young woman's flight: Kansas City to Anchorage. But her travel plans were fouled up. She discovered she didn't have a reservation for her flight to Alaska when she landed in Seattle. Her husband made more than one trip to the Anchorage airport to look for her. Eventually, she arrived and they were reunited. She was bone tired. All she wanted was to sleep.

*

On my final night in Hawai'i a full moon lights up the lawn. The kōlea is not there but the marble Buddha shines.

A marble Buddha overlooks the lawn where a kōlea (*Pluvialis fulva*) forages each day on the Kohala Coast—its steady presence marking the seasons of departure and return. Photo © Paula Nixon, 2024.

The next morning, I rise with the sun but the kōlea has gotten an even earlier start. I pack for my return flight to New Mexico and pull my suitcase down the sidewalk. The kōlea doesn't look up. Not wanting to startle him I bid him farewell under my breath and wish him safe travels. In three weeks, at the end of April, he will fly to the north end of the Big Island to congregate with other kōlea, all preparing for their flights to Alaska.

I wonder if anyone at the hotel will notice that he is gone.

What happens when the birds gather? How do they sort themselves into flocks? What spurs them on to take flight—something in the wind or the angle of the sun? So many unanswered and maybe even unknowable questions. But they know. The kōlea and his flock take off.

Up. Up. Up.

For three days he flies over the Pacific Ocean. Not a speck of land in the dark water below him. Three thousand miles to the western side of Alaska. He travels at forty miles an hour—sometimes more, sometimes less. It depends on the winds and will test how well he has prepared for the journey.

If adverse winds throw him off course, he'll have to adjust, but there will be no place to stop and rest. His absolute certainty about his destination spurs him onward.

When the kōlea lands it will be somewhere in the Alaskan Peninsula or the Yukon-Kuskokwim Delta where he is known as a Plover.

By the time he arrives on the treeless tundra most of the snow should have melted although the mosquitos and insects will not yet have returned. He will make do with last season's freeze-dried berries still hanging on the low-growing shrubs. It's a remote place with few humans except the occasional researcher or intrepid birder.

Pee-chew-ee! Pee-chew-ee!

The Plover stakes out his territory. Compared to his lawn in Hawaiʻi, it's huge, acres and acres of open tundra. If he cannot reclaim his nesting site from the prior year, he scouts for a new spot on the ground. He scrapes out an indentation with his feet, rubs it with his breast, and lines it with leaves and moss. He works to keep it concealed in the low-growing grasses where it will be safe from the gulls and falcons always on the prowl for eggs and chicks.

He begins to advertise for a mate and makes big, looping flights. He calls and loops until a female appears. She has also recently arrived from Hawaiʻi.

*

Within a few weeks of the young woman's arrival, it was the summer solstice. She basked in the long, almost endless days. No more textbooks or training manuals for the couple. When their boxes and crates arrived from the Lower Forty-Eight, her husband was thrilled to find a new fishing pole sent by her father. They celebrated their first wedding anniversary in July.

*

The female Plover lays four cream-colored eggs with dark brown speckles. Both adults take turns incubating the eggs. He sits on the nest during the day while she roams widely, eating and preening. Late in the day, they trade places.

In less than a month the eggs begin to hatch, four gold and brown speckled fluff balls, well-camouflaged for their first few weeks on the tundra. The adults carry the white-lined eggshells, which might attract predators, to a distant site.

The chicks have long legs and tiny wings.

The family leaves the nest and the chicks quickly learn to hunt for bugs and browse for berries. The parents are vigilant, watchful for roaming foxes and lumbering caribou, trying to protect their young from being eaten or trampled. When the air grows cold, they gather the youngsters under their wings.

The days are long and the Plover chicks mature quickly. Within a week they begin to grow their flight feathers. Not all of them will survive.

*

The couple took a weekend trip to the Matanuska Valley northeast of Anchorage. Fresh fruit and vegetables were a luxury most of the year in Alaska but in this fertile valley, produce was abundant during the short growing season—with twenty hours of sunlight each day it was a place where farmers grew 1000-pound pumpkins.

*

By the end of their first month, the chicks are adept hunters and have started to fly. The adults' breeding feathers are fading. They have finished raising the chicks. The female leaves first, the male a few days later. Each goes off to prepare alone for its solo flight back to Hawaiʻi.

The remaining chicks stay put and continue to eat. Without the adults to protect them they must be alert to the threat of predators, ready to disappear into the tundra or to take flight.

*

By late summer the couple was expecting a baby. The nights grew longer, and the air had a chilly edge to it. She bought a second-hand sewing machine. He checked the power outlet at the pole in the driveway to ensure it would keep their car battery charged during the coming sub-zero nights.

*

In early September, the male Plover sets off on his return trip to Hawai'i. With less favorable winds on the way south, it will take him four days.

The steadfast Buddha is waiting when the exhausted and thin kōlea lands.

Back on the tundra only a couple of the chicks have survived. They now look like the adults in their winter feathers, buff color all over with a speckled golden back. The males and females are indistinguishable from one another. They sense the coming change—the days grow shorter and the breeze colder—as they continue to forage.

In early October one of the remaining Plover chicks takes flight. Like millions of her ancestors before her, some combination of a map and a compass written into her DNA pushes her south. Perhaps she stops on the Alaskan coast for a few days and continues to hunt. But soon with only her instinct to guide her, she will lift off and fly ninety-six hours nonstop to a destination she has never seen. The journey will take all of her strength and perseverance.

If she succeeds on her maiden flight and lands on one of the islands, her next challenge will be to find a patch of unclaimed grass. It won't be easy. The adults, already arrived and settled, won't take kindly to her infringing on their long-established territories.

*

April finally returned after a long dark winter. In a snapshot, the smiling couple stands outside their quarters, a blanket-wrapped bundle in her arms. Years later they will tell me that it snowed on the day I was born.

*

Not many kōlea survive their first year. But some do. I often think about one that might have and try to imagine her life.

The author's parents in Alaska, 1958—the year of her birth. Their story of northern beginnings echoes through the generations, like the kōlea's return each spring. Photo courtesy of Paula Nixon.

I hope she found a quiet, unclaimed yard bordered by blooming hibiscus shrubs, the scent of plumeria in the air with coconut palms swaying overhead. A peaceful place where she spent the winter, foraging and gaining weight.

It's April now and she has grown her breeding feathers and is recognizable as a female. She still has a few weeks to prepare for her first flight to Alaska. This trip should be easier. She will gather with a flock of kōlea on the coast before she takes flight, bound for a place not completely unfamiliar to her.

Today she continues to run and peck, pausing to swallow a wriggling worm.

**

About the Author

Paula Nixon lives at the edge of the Santa Fe National Forest in northern New Mexico, where she writes about wildlife and the natural world. Her essays and nonfiction stories have appeared in Earth Island Journal, The Sun Magazine, Santa Fe Reporter, Albuquerque Journal, and Bosque Beast. Her essay "Visitors from the North"—originally published as "Alaskan Migrations" in the 2024 Mosaic Voices Anthology—won first place in the nonfiction category of the SouthWest Writers Annual contest.

* * * *END* * * *

Helping Hawaiʻi's Seabirds Through Fallout Season

Each autumn, young seabirds throughout the Hawaiian Islands take their first flights to sea. Many navigate by the moon and stars, but bright coastal lights can disorient them, leading to exhaustion, collision, or grounding. This recurring phenomenon, known as fallout, is most common from September through December, when fledglings of the ʻuaʻu kani (*Ardenna pacifica*, Wedge-tailed Shearwater) and other nocturnal species depart their colonies for open ocean.

These seasonal events remind us how closely seabird survival is tied to the rhythms of island life and the ways human activity shapes the nighttime environment. Light-induced fallout has been documented across all major islands, most often in coastal areas where nesting colonies occur near urban lighting. Grounded fledglings are vulnerable to predators, traffic, and dehydration, but community awareness and quick response can make the difference between loss and survival.

To help reduce fallout, seabird outreach groups have developed easy-to-follow reference materials for the public. The Oikonos fact cards (see below) summarize practical steps, supported by years of field research and rescue data:

- **Manage nighttime lighting.** Turn off or shield outdoor lights during the fledging season, and close window blinds that face the coast.
- **Drive carefully near nesting areas.** Fledglings may rest on roadways or parking lots after being grounded.
- **Handle grounded birds appropriately.** If a seabird is found on the ground, place it gently in a ventilated box lined with a towel, keep it quiet and dark, and do not give food or water. On Oʻahu, grounded birds may be taken to Feather and Fur Animal Hospital in Kailua or reported to the Hawaiʻi Wildlife Center hotline at (808) 884-5000.

Seabirds are vital to Hawaiʻi's coastal and marine systems. Through nutrient transport, species such as the ʻuaʻu kani link oceanic and terrestrial food webs that enrich coastal soils and support native vegetation. Reducing fallout helps maintain this ecological link and improves long-term colony stability. Each successfully released fledgling represents a future breeding adult that may return to its natal site, continuing the life cycle of these remarkable ocean travelers and their contribution to coastal ecosystem health.

Mahalo for protecting Hawaiʻi's seabirds. Small actions—turning off a porch light, slowing your car, or making a single phone call—can mean survival for a fledgling learning its first stars.

Learn more at www.oikonos.org and freemanseabirdpreserve.org.

Educational materials created by Oikonos, illustrating ways to identify and assist seabirds grounded during fallout season. Courtesy of Oikonos.

Hawaiʻi Audubon Society Donations and Membership

Mahalo for helping us inspire people to love and protect birds.
Founded in 1939, Hawaiʻi Audubon Society is an independent nonprofit 501(c)(3) organization.
Make a donation in any amount at https://hiaudubon.org/donate/

Your membership expires one year after you join or renew.

Renew your membership by choosing your level on our website: https://hiaudubon.org/membership
If you have any questions or need assistance, please email **membership@hiaudubon.org**
Please make checks payable to: Hawaiʻi Audubon Society.


Aloha Kea and Kōlea Nui enjoyed the 2nd Annual Welcome Home Kōlea Festival on September 6, 2025. Photo © Elena Arinaga.

Choose your Hawaiʻi Audubon Society membership level:

- ☐ $15 Student Membership
- ☐ $25 Regular Membership
- ☐ $40 Family Membership
- ☐ $100 Supporting Membership
- ☐ $1,000 Lifetime Membership

☐ Email me the *ʻElepaio* to my preferred email address below:

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Announcements

To keep pace with rising costs and support sustainable practices, beginning January 1, 2026, we're making small adjustments to our membership structure.

Regular Membership: $35
Family Membership: $65
Print ʻElepaio: $50 fee

Due to higher printing and mailing costs, a $50 annual fee will apply for members who wish to continue receiving the *ʻElepaio* by mail.

Members with email addresses on file will automatically receive the *ʻElepaio* digitally at no extra cost, starting January 1, 2026.

You'll receive a notice in the coming months with details on how to review or update your membership before these changes take effect.

Events

November 11: Makahiki Festival at Waimea Valley (Oʻahu)

November 15: Tree Trimming Workshop at Kapiʻolani Community College: Manu o Kū Training for Hands-on Tree Workers (Oʻahu)

November 16: Annual Members Dinner and Meeting (Oʻahu)

For more details, event additions, and updates visit:
hiaudubon.org/events
or email events@hiaudubon.org

Stay up-to-date by visiting us online:
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HAWAIʻI BIRD CRISIS FUND

The **Bird Crisis Fund** was created to support urgent bird conservation efforts impacted by federal funding cuts and to fill critical gaps.

100% of funds raised go directly towards bird conservation.

Help spread the word and if you are able, please consider donating to the fund.
Donate here and find out more:

https://tinyurl.com/birdcrisisfund

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