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## Status and recommendations for the recovery of the Elfin-woods Warbler (*Setophaga angelae*) in Puerto Rico

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*Photo: Gloria Archilla*

**A Special Issue on the Status of Caribbean Forest Endemics**

## Status and recommendations for the recovery of the Elfin-woods Warbler (*Setophaga angelae*) in Puerto Rico

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**Abstract** The endemic Elfin-woods Warbler (*Setophaga angelae*) occurs solely in two regions on the Caribbean island of Puerto Rico: in the east at El Yunque National Forest, where it is thought to have declined, and in the west at Maricao Commonwealth Forest and adjacent private lands, where the population appears to be stable. We conducted surveys from 2012 to 2016 to determine the presence of a potential third population in Carite Commonwealth Forest and to validate an island-wide habitat predictability model for the species. We used two different survey methods: (1) a rapid assessment using a single-season occupancy approach to validate the model and assess the species' current geographic distribution, and (2) a combination of an automated species-specific identification approach with occupancy models. Both methods resulted in no positive detections of Elfin-woods Warbler in Carite Commonwealth Forest and surrounding habitat suggesting that the species is extirpated from the area. Additionally, using the first method, the species was not detected at four other forest locations and private farms in the central mountains. In Maricao Commonwealth Forest, 72% of survey plots were occupied by Elfin-woods Warbler, and the probability of detection was 0.7. We applied the second method in El Yunque National Forest where it suggested the Elfin-woods Warbler occurs at elevations of 600–900 m asl and is still dependent on Palo Colorado forest. In 2016, the Elfin-woods Warbler was listed as a Threatened species under the United States Government's Endangered Species Act. Plans are now underway for the designation of Elfin-woods Warbler critical habitat, and a recovery team of experts will be assembled to draft a species recovery plan. We propose actions necessary to restore habitat for the recovery of the species with the long-term goal of stabilizing the population in El Yunque National Forest and expanding the population in Maricao Commonwealth Forest and adjacent private lands.

**Keywords** Elfin-woods Warbler, Puerto Rico, *Setophaga angelae*

**Resumen** Estado y recomendaciones para la recuperación de la Reinita de Bosque Enano (*Setophaga angelae*) en Puerto Rico—El parúlido endémico la Reinita de Bosque Enano (*Setophaga angelae*) se encuentra solamente en dos regiones de la isla caribeña de Puerto Rico: al este, en el Bosque Nacional El Yunque donde se piensa que ha disminuido, y en el oeste, en el Bosque Estatal de Maricao y tierras privadas adyacentes donde la población parece ser estable. Del 2012–2016 llevamos a cabo muestreos para determinar la presencia de una tercera población potencial en el Bosque Estatal de Carite y para validar los modelos de predicción de hábitat para esta especie en toda la isla. Utilizamos dos métodos de muestreo diferentes: (1) una evaluación rápida utilizando el enfoque de ocupación de una temporada para validar el modelo y evaluar la distribución geográfica actual de la especie y, (2) la combinación de un enfoque automatizado de identificación de especies con modelos de ocupación. Los resultados de ambos modelos en el Bosque Estatal de Carite y los hábitats circundantes no mostraron una detección positiva de la Reinita de Bosque Enano. Esto sugiere que la especie está extirpada del área. Además, utilizando el primer método, la especie no fue detectada en otras cuatro localidades boscosas y fincas privadas en las montañas centrales. En el Bosque Estatal de Maricao, el 72% de las parcelas muestreadas fueron ocupadas por esta especie y la probabilidad de detección fue del 0,7. Aplicamos el segundo método en el Bosque Nacional El Yunque donde se sugiere que la Reinita de Bosque Enano se encuentra en elevaciones de 600–900 m.s.n.m y todavía es dependiente del bosque de Palo Colorado. En 2016, esta especie fue catalogada como Amenazada bajo la Ley de Especies Amenazadas del gobierno de los Estados Unidos. Ya están en marcha planes para la designación de hábitats críticos para la Reinita de Bosque Enano y un grupo de expertos en recuperación se reunirá para redactar un plan de recuperación para la especie. Proponemos las acciones necesarias para restaurar el hábitat para la recuperación de la especie con el objetivo a largo plazo de estabilizar la población del Bosque Nacional El Yunque y expandir la del Bosque Estatal de Maricao y tierras privadas adyacentes.

**Palabras clave** Puerto Rico, Reinita de Bosque Enano, *Setophaga angelae*

**Résumé** Statut et recommandations pour la reprise du Paruline d'Angela (*Setophaga angelae*) à Porto Rico—La Paruline

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d'Angela (*Setophaga angelae*) endémique de Porto Rico se produit uniquement dans deux régions de cet île des Caraïbes : à l'est en la Forêt Nationale El Yunque, où on pense que la population est diminuée, et à l'ouest en la Forêt Commonwealth de Maricao et les terres privées adjacentes, où la population semble être stable. Nous avons mené des enquêtes de 2012 à 2016 pour déterminer la présence d'une troisième population potentielle dans la Forêt Commonwealth de Carite et pour valider un modèle de prévisibilité de l'habitat à l'échelle de l'île pour l'espèce. Nous avons utilisé deux méthodes d'enquête différentes : (1) une évaluation rapide en utilisant une approche d'occupation en une seule saison pour valider le modèle et évaluer la répartition géographique actuelle de l'espèce, et (2) une combinaison d'une approche automatisée d'identification spécifique de l'espèce avec des modèles d'occupation. Les deux méthodes n'ont abouti à aucune détection positive de la Paruline d'Angela dans la Forêt Commonwealth de Carite et l'habitat environnant, ce qui suggère que l'espèce est disparue de la région. De plus, en utilisant la première méthode, l'espèce n'a pas été détectée dans quatre autres sites forestiers et des fermes privées dans les montagnes centrales. Dans la Forêt Commonwealth de Maricao, 72% des parcelles d'enquête ont été occupées par la Paruline d'Angela et la probabilité de détection était de 0,7. Nous avons appliqué la deuxième méthode dans la Forêt Nationale El Yunque, où il a suggéré que la Paruline d'Angela se trouve à des élévations de 600 à 900 m d'altitude et dépend toujours du forêt de Palo Colorado. En 2016, la Paruline d'Angela a été répertoriée comme espèce Menacée en vertu de la Loi sur les espèces en voie de disparition du gouvernement des États-Unis. Des plans sont en cours pour la désignation de l'habitat essentiel du Paruline d'Angela, et une équipe d'experts en rétablissement sera assemblée pour rédiger un plan de relèvement de l'espèce. Nous proposons des actions nécessaires pour restaurer l'habitat pour la récupération du Paruline d'Angela avec l'objectif à long terme de stabiliser sa population dans la Forêt Nationale El Yunque et d'élargir sa population dans la Forêt Commonwealth de Maricao et les terres privées adjacentes.

**Mots clés** Paruline d'Angela, Porto Rico, *Setophaga angelae*

The endemic Elfin-woods Warbler (*Setophaga angelae*) is restricted to the montane forests of Puerto Rico (Figs. 1 and 2). Soon after its discovery in El Yunque National Forest (EYNF) in 1968 (Kepler and Parkes 1972), a second population was found in Maricao Commonwealth Forest (MCF; Fig. 2; Gochfeld et al. 1973). At that time, due to the geographic separation of c. 128 km between the two populations, it was suggested that the species might have been widespread in the high mountains of Puerto Rico (Gochfeld et al. 1973) before the massive forest clearing that happened prior to the 1950s (Wiley 1986). Subsequently, another population was found in Carite Commonwealth Forest (CCF; Fig. 2; Pérez-Rivera and Maldonado 1977) where it continued to be seen during the 1980s and 1990s, but has not been ob-



**Fig. 1.** Adult Elfin-woods Warbler singing in Maricao Commonwealth Forest. Credits: Gloria Archilla.

served in this forest since 2000 (R.A. Pérez-Rivera pers. comm.).

In the late 1970s, a single report was made from Toro Negro Commonwealth Forest (TNCF; Fig. 2) by the botanist Roy O. Woodbury (Pérez-Rivera 1979), but Elfin-woods Warbler has not since been confirmed within that area. From the late 1970s until the end of the 1990s, Delannoy-Juliá (2009) led a raptor research team in TNCF and adjacent lands but did not detect Elfin-woods Warbler. In addition, Arroyo-Vazquez (1992) occasionally conducted bird surveys in TNCF after Hurricane Hugo impacted the island in 1989 but did not detect the species. More recently, Miranda-Castro et al. (2000) surveyed birds in Tres Picachos Commonwealth Forest (TPCF) in the central mountains from 1997 to 1999 without any positive detections of Elfin-woods Warbler. In 2003 and 2004, Anadón-Irizarry (2006) conducted island-wide surveys at EYNF, MCF, CCF, TNCF, Guilarte Commonwealth Forest (GCF), and Bosque del Pueblo (BdP), but presence of Elfin-woods Warbler was confirmed at only EYNF (see also Arendt et al. 2013) and MCF.

### Recent Efforts

In 2011, Colón-Merced (2013) developed a habitat predictability model to map the distribution of potential habitat for the Elfin-woods Warbler in Puerto Rico. The two variables used to develop the model were vegetation type and elevation as these were already well documented for the species (Kepler and Parkes 1972, Gochfeld et al. 1973, Waide 1995, Anadón-Irizarry 2006, Delannoy 2007, González 2008, Arendt et al. 2013). The habitat quality categories included in the habitat predictability model consisted of (a) very high, (b) high, (c) medium, and (d) low-quality habitats; however, the model was not validated when created by Colón-Merced (2013). Subsequently, the Puerto Rican Ornithological Society in collaboration with the U.S. Fish and Wildlife Service (USFWS) and BirdLife International conducted a rapid assessment to validate the model and assess the



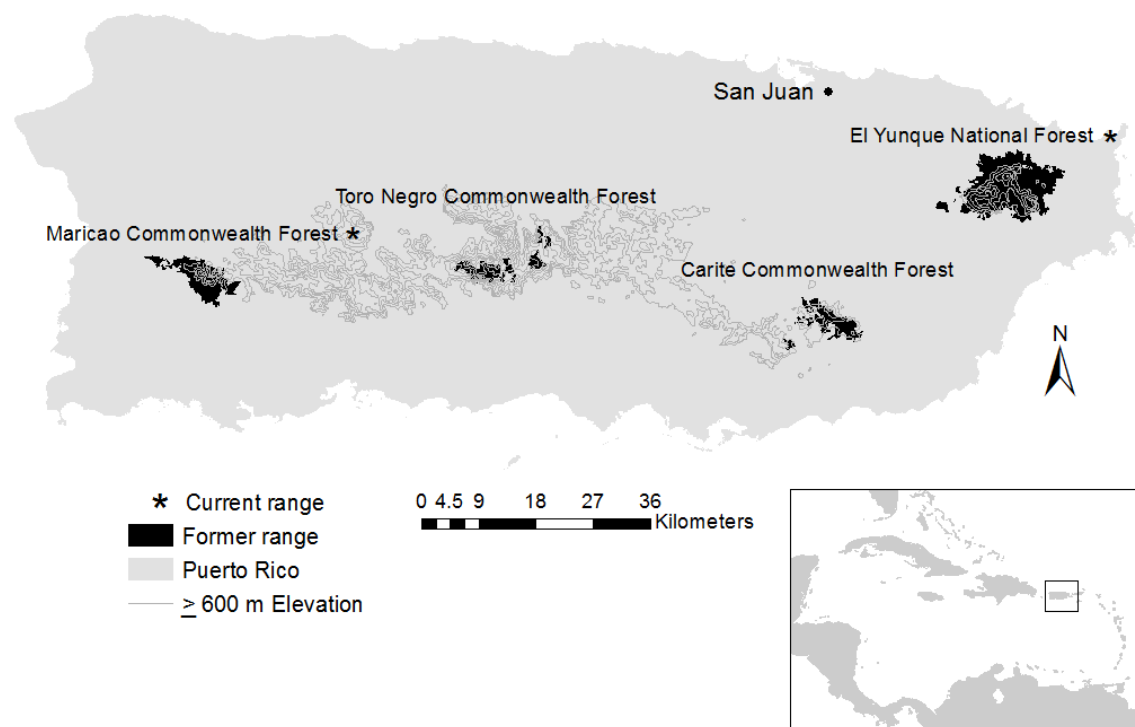


Fig. 2. Elfin-woods Warbler former and current ranges in Puerto Rico.

current geographic distribution of Elfin-woods Warbler using a single-season occupancy approach. In this article, we present the results of this unpublished survey.

Elfin-woods Warblers were not detected in any of the 176 replicates from 45 randomly stratified plots in five localities (TNCF, TPCF, GCF, BdP, and CCF) in the central mountains and private lands during 2012 and 2013. In MCF, Elfin-woods Warblers occupied 11 out of 14 plots during 2012, and were detected at least once in all four model habitat categories. Additionally, the single-season occupancy model in MCF indicated that 72% of survey plots were occupied by Elfin-woods Warblers and the probability of detection was 0.7.

In 2015, surveys at 60 sampling points along three elevational gradients in EYNF, using a combination of an automated species-specific identification approach with occupancy models, were able to detect the species at 22 sampling points (888 positive detections in total; Campos-Cerqueira and Aide 2016). This study showed that although this species has a wider distribution than previously reported in EYNF, it depends on Palo Colorado forest (predominantly composed of *Cyrtilla racemiflora*, *Ocotea spathulata*, *Micropholis chrysophylloides*, and *Prestoea acuminata*) and mainly occurs between elevations of 600 and 900 m above sea level (asl).

In 2016, the USFWS in collaboration with the University of Puerto Rico at Río Piedras, Effective Environmental Restoration, Inc., and Sieve Analytics, Inc. designed a passive acoustic monitoring study to collect acoustic data. Sixty sites were randomly located within the area predicted by the habitat predictability model for the Elfin-woods Warbler (Colón-Merced 2013) in CCF between 8 March and 4 April 2016 (41,884 1-min recordings) and 60 sites along three altitudinal gradients in EYNF (51,511 1-min recordings) between 12 April and 29 May 2016. All the record-

ings from the passive acoustic monitoring in 2016 were visually inspected for Elfin-woods Warbler vocalizations resulting in 17 sites found to be occupied by Elfin-woods Warbler in EYNF (314 positive detections), whereas there were no positive detections in CCF. These results agreed with previous studies suggesting that the Elfin-woods Warbler population is extirpated from CCF, limiting the current range to EYNF, MCF, and adjacent lands (Fig. 2).

### Threats and Conservation

The Elfin-woods Warbler is a newly listed Threatened bird species under the federal Endangered Species Act (ESA) with a final rule published on 22 June 2016 (USFWS 2016). Locally, the Puerto Rico Department of Natural and Environmental Resources (PRDNER) classifies the species as Endangered (DRNA 2016), and the international scientific community lists it as Vulnerable (BirdLife International 2017). The justification for this classification is based on the species' very small range. Moreover, the species has been evaluated to be uplisted to Endangered status by the International Union for Conservation of Nature (IUCN) due to its declining population in EYNF (Arendt et al. 2013) and likely extirpation in CCF.

Thus far, confirmed threats for the Elfin-woods Warbler are habitat loss, fragmentation, and degradation resulting predominantly from increasing urban development (Arendt et al. 2013), and unsustainable agricultural practices and vegetation clearance (USFWS 2016). Other potential causes of Elfin-woods Warbler habitat degradation include climate change, hurricanes, and human-induced fires (Arendt et al. 2013, USFWS 2016), while predation by invasive mammals is another potential threat (Arendt et al. 2013), but the extent to which these factors threaten the species is still not well understood.

The data presented here and in previous studies confirm that Elfin-woods Warbler currently occupies habitat within two disjunct montane forests—MCF and private adjacent lands in the west and EYNF in the east (Gochfeld *et al.* 1973, Anadón-Irizarry 2006, Campos-Cerqueira and Aide 2016). These two remnant populations are limited to specific forest types at different elevations. Within the boundaries of MCF, the habitat with the highest densities of Elfin-woods Warblers has been identified as *Podocarpus coriaceus* forest at 600–880 m asl (Delannoy 2007, González 2008). In private lands outside MCF, González (2008) reported that the Elfin-woods Warbler was detected within mature secondary forest (more than 25 yr of forest regeneration), young secondary forest (less than 25 yr), and existing shade-grown coffee plantations. Elfin-woods Warbler population trends in MCF have not been determined due to lack of information on population dynamics. However, it has been suggested that the population appears to have remained stable since the 1990s (Delannoy 2007).

In EYNF, the Elfin-woods Warbler was first detected in the elfin forest (a single-story forest found on exposed peaks above 800 m dominated by shrubs and small trees, with mosses and liverworts covering branches, trunks, and leaves; Kepler and Parkes 1972) and later a shift in its habitat use was recorded with Palo Colorado forest having more substantial numbers and occupied habitat compared with elfin forest (Waide 1995, Anadón-Irizarry 2006, Arendt *et al.* 2013, Campos-Cerqueira and Aide 2016). It has been suggested that the Elfin-woods Warbler population decline documented from 1989 to 2006 in EYNF may have been related to genetic or physiological causes, or more likely, to natural habitat degradation from hurricanes and other major cyclonic storm events (Arendt *et al.* 2013). Additionally, there was an increase in the frequency of dry periods and prolonged dry seasons between 1970 and 1990 in EYNF (Burrowes *et al.* 2004) and the mean minimum temperature in EYNF has increased over the past 30 yr (Lasso and Ackerman 2003). Staudinger *et al.* (2012) have suggested that changes in precipitation regimes and extreme events can cause ecosystem transitions, particularly the timing of reproduction of animals and plants, species distributions, and population sizes. It is therefore possible that climate change could also be affecting Elfin-woods Warbler distribution and population dynamics. The synergistic effects of the Elfin-woods Warbler's restricted distribution, limited use of habitat found at specific elevations, and continued habitat degradation make the species increasingly vulnerable to extinction (USFWS 2016).

### Recommendations

Despite substantial knowledge gaps, we propose actions to support the recovery of the Elfin-woods Warbler. All actions should be adaptive and refined as dictated by new findings. Priority actions need to be focused on the two known populations in order to stabilize the population in EYNF and expand the population in MCF and adjacent private lands. In 2014, the USFWS, the United States Forest Service, and PRDNER agreed to coordinate management actions for the species (USFWS *et al.* 2014). Since then, the Elfin-woods Warbler has been listed under the ESA, the critical habitat is soon to be designated, and it is expected that a recovery team of experts will be assembled to

draft the conservation recovery plan. The team's experience and expertise should complement and expand upon the capacity of the three lead agencies in support of the actions listed below.

### Management Actions

In order to assist current habitat maintenance and restoration efforts, we recommend preparing written and visual descriptions of occupied Elfin-woods Warbler habitat at the patch level based on synthesizing existing literature and experts' reviews. The habitat patch description should include soil, vegetation (including trees, ferns, vines, and ground layer), elevation, topography, associated fauna, prey items, diseases and parasites, and to the extent it is known, how these metrics interact and influence each other. This information can then be used both as a guide for land managers and to identify patches of degraded habitat suitable for restoration. Additionally, this information will help to identify suitable habitat not occupied by Elfin-woods Warblers but with potential for future reintroduction.

### Research Actions

The detailed habitat description and Elfin-woods Warbler occupancy models can be used to refine the island-wide habitat predictability model. This habitat model can be used to develop and establish an island-wide, long-term Elfin-woods Warbler population estimate and habitat evaluation monitoring program. A standardized sampling protocol should be established and shared among stakeholders to allow comparisons between the populations and habitats in EYNF and MCF. This will enable collaborators to evaluate how management actions are affecting the Elfin-woods Warbler population and habitat dynamics, and thus adapt management prescriptions to improve restoration efforts. In the long-term, the monitoring will also support understanding of any impact of climate change on the species' abundance and distribution.

In addition, research projects need to be designed and undertaken to understand Elfin-woods Warbler life history, foraging behavior, and population dynamics. Conducting passive acoustic monitoring to search for the Elfin-woods Warbler in unoccupied habitats represents a cost effective way to continue learning about the species without diverting resources from more immediate needs. Coordination among stakeholders will be essential to address species knowledge gaps through well-designed projects.

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