Journal of Caribbean Ornithology

RESEARCH ARTICLE

Vol. 37:1–11. 2024

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Photo: C.C. Rimmer

Birds Caribbean

Journal of Caribbean Ornithology
Research Article Vol. 37:1–11. 2024
jco.birdscaribbean.org ISSN 1544-4953 https://doi.org/10.55431/jco.2024.37.1-11
Birds Caribbean
birdscaribbean.org

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Associate Editor: Jaime Collazo

Cover Page: Pico Turquino, Cuba's highest peak at 1,974 m elevation, supports extensive montane cloud and elfin forest that are the primary habitat of overwintering Bicknell's Thrush on the island. Photo by C.C. Rimmer on 28 March 2017.

Published: 15 February 2024

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Cite this article as:

Rimmer, C.C., N. Viña Davila, J.D. Lloyd, Y. Aubry, C.P. León, Y.S. Vega, F.R. Santana, J.R. Fuentes, and A.L. Sosa. 2024. Overwinter status of Bicknell's Thrush (*Catharus bicknelli*) in eastern Cuba. Journal of Caribbean Ornithology 37:1–11. https://doi.org/10.55431/jco.2024.37.1-11

Abstract

To clarify the distribution, relative abundance, and habitat associations of overwintering Bicknell's Thrush (*Catharus bicknelli*) in eastern Cuba, we conducted extensive point count and presence-absence surveys during six winters between 1998–2005 and the four winters of 2017–2020, in a variety of forested habitats at varied elevations. During the earlier period, we detected a total of 84 Bicknell's Thrushes at 54 of 330 discrete sampling points, while in 2017–2020 we detected 33 individual thrushes at 21 of 497 points. We obtained evidence of clustering, with 2–6 individuals registered simultaneously at 24 (32%) of the 75 points with detections in both sampling periods. All thrushes detected in 1998–2005 and 29 (87%) of those detected in 2017–2020 occupied cloud forest habitats at elevations between approximately 1,250 and 1,850 m above sea level (asl) in Sierra Maestra, from Parque Nacional (PN) Pico Turquino in the west to PN Bayamesa in the east. Extensive surveys in lower-elevation forests of Sierra Maestra and other geographic regions of eastern Cuba documented four individual thrushes in non-cloud forest habitat during February of 2019. These were found at adjacent points at an elevation of 650 m asl on the south slope of PN Alejandro de Humboldt; follow-up surveys one year later detected no thrushes in the area. Our survey results in PN Pico Turquino yielded markedly lower numbers of individuals than those detected during early and mid-winter periods from 1998 to 2005. Our results suggest that Bicknell's Thrush is a rare overwintering species in Cuba, restricted almost entirely to high-elevation cloud forests. These forests are generally well-protected from direct anthropogenic disturbance or degradation. Our findings further suggest that Cuba harbors an overwintering population of Bicknell's Thrush second only to Hispaniola's in abundance, and that Cuba is of strategic importance as a refugium for conservation of this globally vulnerable passerine on its restricted wintering range.

Keywords

Bicknell's Thrush, *Catharus bicknelli*, cloud forest, Cuba, overwintering migrant surveys, winter distribution, winter habitat

Resumen

Estatus invernal del Tordo de Bicknell (*Catharus bicknelli*) en el oriente de Cuba

• Para esclarecer la distribución, abundancia relativa y asociaciones de hábitat del Tordo de Bicknell (*Catharus bicknelli*), que inverna en el este de Cuba, llevamos a cabo extensos muestreos de presencia–ausencia y puntos de conteo durante seis inviernos entre 1998 y 2005, y durante los cuatro inviernos de 2017 a 2020. Estos muestreos fueron llevados a cabo en una variedad de hábitats boscosos a diferentes elevaciones. Durante el período inicial, detectamos un total de 84 tordos de Bicknell en 54 de los 330 puntos de muestreo discretos, mientras que en 2017–2020 detectamos 33 individuos en 21 de los 497 puntos. Obtuvimos evidencia de agrupamiento, con la presencia simultánea de 2 a 6 individuos registrados en 24 (32%) de los 75 puntos con detecciones durante ambos períodos de muestreo. Todos los tordos detectados en el período de 1998–2005 y 29 (87%) de los detectados en 2017–2020 ocuparon hábitats de bosque nublado a elevaciones entre aproximadamente 1.250 y 1.850 m sobre el nivel del mar (snm) en la Sierra Maestra, desde el Parque Nacional (PN) Pico Turquino al oeste hasta el PN Bayamesa al este. Extensos muestreos en bosques a menor elevación de la Sierra Maestra y otras regiones geográficas del este de Cuba, se documentaron cuatro individuos de esta especie en hábitats diferentes del bosque nublado durante febrero de 2019. Estos se encontraron en puntos adyacentes, a una

altura de 650 m snm, en la ladera sur de PN Alejandro de Humboldt. En los muestreos de seguimiento un año después no se detectó ningún tordo en el área. Los resultados de nuestro estudio en el PN Pico Turquino arrojaron un número marcadamente menor de individuos que los detectados durante los períodos de principio y mediados de los inviernos de 1998 a 2005. Nuestros resultados sugieren que el Tordo de Bicknell es una especie rara que inverna en Cuba, restringida casi por completo a los bosques nublados a grandes elevaciones. Por lo general, estos bosques están bien protegidos de las perturbaciones antropogénicas directas o la degradación. Nuestros hallazgos sugieren además que Cuba alberga una población invernal del Tordo de Bicknell, sólo superada por la de La Española en términos de abundancia, y que Cuba tiene una importancia estratégica como refugio para la conservación de este paseriforme globalmente vulnerable en su restringida área de distribución invernal.

Palabras clave
bosque nublado, *Catharus bicknelli*, Cuba, distribución invernal, hábitat invernal, muestreos de migrantes invernales, Tordo de Bicknell

Résumé
Statut de la Grive de Bicknell (*Catharus bicknelli*) hivernant dans l'est de Cuba • Pour mieux connaître la répartition, l'abondance relative et les habitats de la Grive de Bicknell (*Catharus bicknelli*) hivernant dans l'est de Cuba, nous avons réalisé de nombreux points de comptage et relevés de présence–absence au cours de six hivers entre 1998 et 2005 et quatre hivers de 2017 à 2020, dans divers habitats forestiers à différentes altitudes. Au cours de la première période, nous avons détecté au total 84 individus sur 54 des 330 points d'échantillonnage distincts, tandis qu'en 2017–2020, nous en avons détecté 33 sur 21 des 497 points. Au cours des deux périodes d'échantillonnage, nous avons observé des regroupements de 2 à 6 individus enregistrés simultanément sur 24 (32 %) des 75 points. L'ensemble des grives détectées en 1998–2005 et 29 (87 %) individus détectés en 2017–2020 étaient présents dans des habitats de forêt humide d'altitude situés environ entre 1 250 et 1 850 m au-dessus du niveau de la mer dans la Sierra Maestra, du Parc national Pico Turquino à l'ouest au Parc national Bayamesa à l'est. Des prospections approfondies réalisées en février 2019 dans les forêts de basse altitude de la Sierra Maestra et d'autres régions de l'est de Cuba ont permis de documenter la présence de quatre grives dans un habitat différent de la forêt humide d'altitude. Elles ont été détectées sur des points adjacents à une altitude de 650 m sur le versant sud du Parc national Alejandro de Humboldt. Des recherches réalisées un an plus tard dans cette zone n'ont pas permis de détecter l'espèce. Les résultats de notre étude dans le Parc national Pico Turquino font état d'effectifs nettement inférieurs à ceux relevés au cours des périodes de début et de milieu d'hiver entre 1998 et 2005. Nos résultats suggèrent que la Grive de Bicknell est une espèce hivernante rare à Cuba, presque entièrement inféodée aux forêts humides de haute altitude. Ces forêts sont généralement bien protégées des dégradations ou des dérangements anthropiques directs. Nos résultats montrent également que Cuba abrite une population hivernante de Grives de Bicknell dont l'abondance se situe juste après celle d'Hispaniola, et que Cuba revêt une importance stratégique en tant que refuge pour la conservation de ce passereau mondialement vulnérable dans son aire d'hivernage restreinte.

Mots clés
Catharus bicknelli, Cuba, étude des migrateurs hivernants, forêt humide d'altitude, Grive de Bicknell, habitat hivernal, répartition hivernale

Among North America's most rare, at-risk breeding songbirds, Bicknell's Thrush (*Catharus bicknelli*) is a range-restricted habitat specialist that faces multiple threats at both ends of its migratory range (Rimmer and McFarland 2013, Rimmer *et al.* 2019, Townsend *et al.* 2020). The species overwinters on only four islands in the Caribbean Greater Antilles, and up to 90% of its global population is estimated to occur on Hispaniola (Townsend *et al.* 2009, 2020). With fewer than 120,000 individuals estimated across its North American breeding range (Hill and Lloyd 2017), Bicknell's Thrush is a species of high hemispheric conservation concern (Rosenberg *et al.* 2016). It is federally Threatened under Canada's Species at Risk Act (COSEWIC 2009, Government of Canada 2012) and designated as globally Vulnerable by the International Union for the Conservation of Nature (BirdLife International 2020). The International Bicknell's Thrush Conservation Group (IBTCG), established in 2007, has identified the numerous threats faced by Bicknell's Thrush in its Conservation Action Plan, and recommended conservation actions (Lloyd and McFarland 2017).

Among high priority actions identified by the IBTCG are expanded surveys for Bicknell's Thrush in areas where a winter habitat model (McFarland *et al.* 2013) indicated potentially suitable habitat. Specifically, the IBTCG recommended extending Bicknell's Thrush surveys beyond Hispaniola to clarify the species' distribution and habitat use in Cuba. The winter habitat model indicated that Cuba contains 15.1% (5,003 km²) of all suitable habitat range-wide; most of this is within two mountainous areas in the extreme southeast: Sierra Maestra and the Nipe-Sagua-Baracoa range. Of this modeled habitat island-wide, only 38% occurs within currently protected areas (McFarland *et al.* 2013). The montane and cloud forests preferred by overwintering Bicknell's Thrush are considered to be among the most highly endangered forests in the Greater Antilles, and they support exceptionally high rates of endemism (Latta 2005).

Previous surveys and opportunistic banding encounters indicated that Bicknell's Thrush is a rare but regular winter resident in southeastern Cuba. All prior verifiable records were obtained in high-elevation forests of Sierra Maestra, the island's largest massif in the provinces of Granma and Santiago (Rompré *et al.* 2000, Oviedo *et al.* 2001, Maceira *et al.* 2005, YA unpubl. data). Most detections and all mist-net captures were obtained in Parque Nacional (hereafter, PN) Pico Turquino, where a maximum of 19 individuals was detected between elevations of 1,600–1,960 m above sea level (asl) during vocal playback surveys in December of 2000 (YA unpubl. data). Additional records within Sierra Maestra include a single individual near Pico Botella at 1,400 m elevation on 2 February 2004 (Maceira *et al.* 2005) and six birds in PN La Bayamesa at ~1,355–1,625 m asl on

17–18 February 2005 (YA unpubl. data). Several individuals were mist-netted in PN Turquino, confirming the species' identity and contributing data to ancillary studies (e.g., Rimmer *et al.* 2005).

Although all extant Cuban records of the species outside of its migratory periods derive from Sierra Maestra, the Bicknell's Thrush winter habitat model of McFarland *et al.* (2013) indicates that a considerable extent of potentially suitable habitat exists in Cuba in areas outside Sierra Maestra. Recent findings that Bicknell's Thrush is a rare and local overwintering species on Puerto Rico (Rimmer *et al.* 2019), coupled with ongoing and severe habitat loss on its core Hispaniolan wintering range, highlighted the need for systematic, island-wide surveys on Cuba and an assessment of the protected status of occupied areas on the island.

The overall goal of our study was to clarify the overwinter distribution and habitat use of Bicknell's Thrush in eastern Cuba, using two data sets collected 12–20 years apart (1998–2005 and 2017–2020). Specifically, we sought to: (1) determine the distribution and relative abundance of Bicknell's Thrush in Cuba during November–March, comparing results obtained between the two sampling periods; (2) examine landscape-level features (vegetation cover type, elevation, slope, aspect) of all sites at which we detected thrushes and those sites at which we did not detect the species; and (3) assess the protected status of and potential threats to areas in which Bicknell's Thrush was found to occur.

Methods

Field surveys in eastern Cuba were conducted during two periods: 1998–2005 and 2017–2020.

Field Sampling in 1998–2005

During this period, we conducted surveys in six winters: February 1998, January–February 1999, November 1999–January 2000, November–December 2000, February 2003, and February 2005 (Supplemental file; Fig. 1). Six initial surveys in February of 1998 targeted western Cuba and were conducted in areas with dense stands of broadleaf forest and pine, following field survey methods used on Hispaniola (e.g., Rimmer *et al.* 2001). We subsequently surveyed eight additional sites in western Cuba in 1999 (n = 5), 2000 (n = 1), and 2003 (n = 2); we excluded these 14 surveys from analyses, as they were outside our primary geographic area of coverage (results included in the Supplemental file).

Beginning in November of 1999, we focused survey efforts at higher altitudes in eastern Cuba, primarily in mountainous areas that support extensive cloud forests ("bosque nublado"; Capote and Berazaín 1984, Borhidi 1987), which constitute the preferred habitat of Bicknell's Thrush on Hispaniola (e.g., Townsend *et al.* 2020). Our sampling consisted of opportunistic surveys or unlimited distance point counts made along trails at a mean interval of 186 m and at varying altitudes. During all surveys, we broadcast recorded Bicknell's Thrush calls and songs (recorded by K.P. McFarland on Mt. Mansfield in Vermont, USA) in an attempt to elicit vocal responses from thrushes. During the winters of 1997–1998, 1999–2000, and 2000–2001, we broadcast playbacks of 1 min at each survey point, followed by 2 min of passive listening. In 2002–2003 and 2004–2005, we conducted unlimited distance point counts of 3–5 min duration, following a 1-min vocal playback. All sampling points and thrush detections were spatially referenced on handheld Garmin 12CX GPS units with an accuracy of 15 m.

Field Sampling in 2017–2020

During 2017–2020, our sampling design included both standardized and opportunistic field surveys of forested habitat in southeastern Cuba, which the McFarland *et al.* (2013) model predicted as the island's region of greatest occupancy by Bicknell's Thrush. Because most areas of predicted high- and medium-probability habitat occur in remote, high-elevation areas with no roads and few trails, we were unable to use a probabilistic sampling approach, instead conducting surveys in tracts of suitable forest habitat that could be reasonably accessed by foot trails. Most of these were inside three national parks: PN Turquino, PN Bayamesa, and PN Alejandro de Humboldt (hereafter PN Humboldt; Fig. 1). Within each protected area, we sought to survey a variety of forested habitats across an elevational gradient, including forest types and elevations not predicted by the McFarland *et al.* (2013) model to support habitat for Bicknell's Thrush.

From 29 March to 6 April 2017, we conducted trail-based surveys in PN Turquino between elevations of ~1,400–1,975 m asl, near Pico Botella in PN Bayamesa at elevations of ~1,385–1,465 m asl, and in the eastern Nipe-Sagua-Baracoa range at elevations of ~300–475 m asl. Because our primary objective was to ascertain presence or presumed absence of Bicknell's Thrush, we did not conduct standardized, fixed-radius point counts, but conducted 3-min unlimited distance counts at points spaced 200–250 m apart. Counts were conducted over 2–2.5 hr beginning 30 min before sunrise. Before each 3-min count, we broadcast 1-min playbacks of Bicknell's Thrush calls (recorded by K.P. McFarland on Mt. Mansfield in Vermont, USA). After the completion of counts each morning, we conducted opportunistic surveys of the route in reverse, walking slowly while broadcasting Bicknell's Thrush playbacks until reaching the first point. Numbers of all species detected during each point count, including Bicknell's Thrush, were entered into eBird on mobile devices (Sullivan *et al.* 2009). Data on Bicknell's Thrushes encountered opportunistically were spatially referenced on GPS units and recorded in field notebooks.

From 28 January to 17 March 2018, we modified our survey protocols and expanded our area of geographic coverage in southeastern Cuba, visiting three mountainous areas within Sierra Maestra and two smaller ranges east of Santiago de Cuba (Supplemental file). In each area, we conducted standardized 10-min counts at points spaced 200–300 m apart, beginning ~30 min before sunrise and continuing over 2–2.5 hr. Each point count was divided into four 2.5-min intervals conducted in immediate succession, with 1-min playbacks of Bicknell's Thrush calls broadcast before the second and fourth periods. No counting occurred during the two 1-min playback periods. As in 2017, following completion of daily point counts, we conducted opportunistic surveys, walking routes slowly in reverse while broadcasting Bicknell's Thrush playbacks until reaching the first point. All Bicknell's Thrush detections were spatially referenced, with details recorded in field notebooks.

From 25 January to 9 March 2019, we expanded our survey

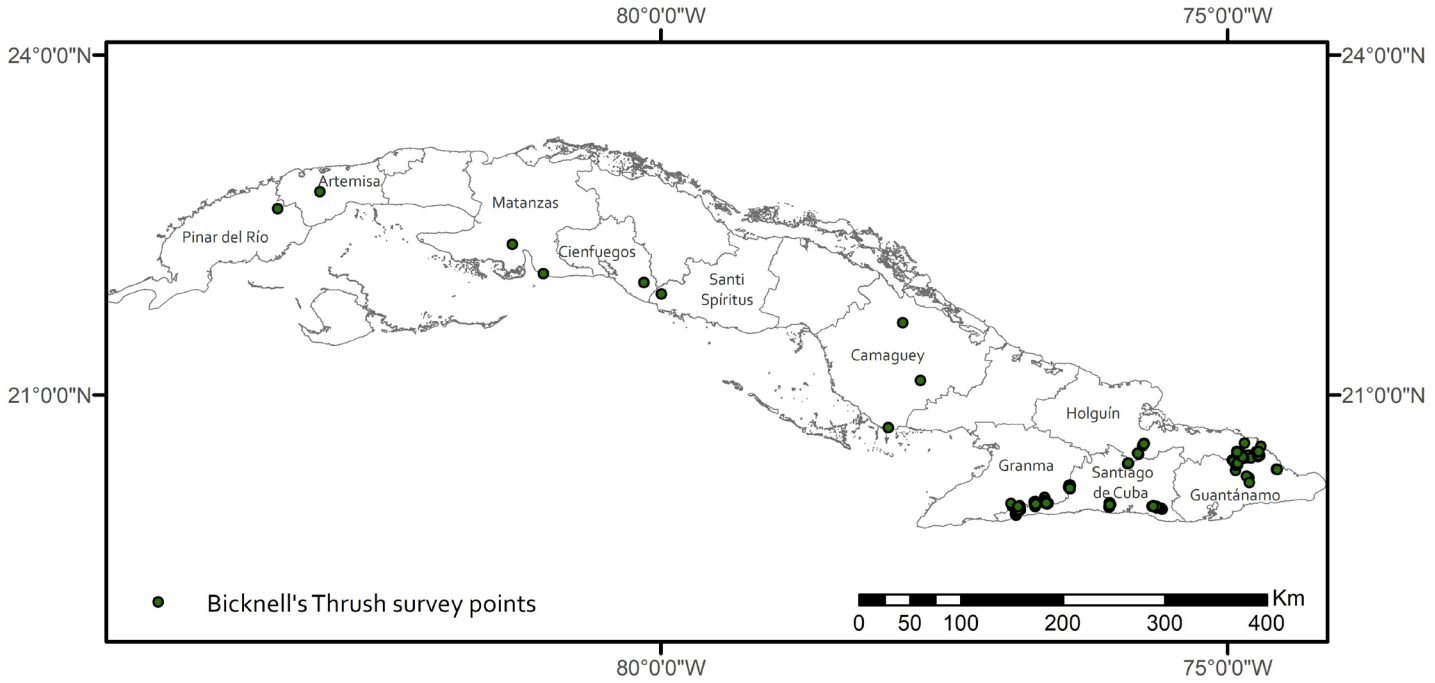

Fig. 1. Distribution of Bicknell's Thrush survey points on Cuba, 1998–2020. Green circles represent clusters of 1–74 individual points surveyed at discrete sites in different years.

coverage to include: (1) a trailless area of PN Bayamesa between the summit of Pico Bayamesa (1,750 m asl) and Pico Maceo (1,720 m asl) to the east; (2) an area on the south slope of PN Humboldt between elevations 486–750 m asl; (3) El Yunque de Baracoa, near Baracoa in the northeastern Nipe-Sagua-Baracoa region (elevations 93–468 m asl); and (4) Carso de Baire, a karstic area on the northern slope of the Sierra Maestra (elevations 538–614 m asl). Field methods followed those used in 2018.

From 20 January to 1 February 2020, we further expanded our geographic field sampling to include two areas of Nipe-Sagua-Baracoa: the El Toldo plateau (elevations 477–1,049 m asl) and Pinares de Mayarí and surrounding areas (elevations 172–659 m asl). We also resurveyed our 2019 sampling area on the south slope of PN Humboldt (elevations 486–614 m asl), and we surveyed new routes in the Carso de Baire region (elevations 574–702 m asl). Field methods followed those used in 2018 and 2019.

In all years of field surveys, we attempted to minimize the probability that any individual Bicknell's Thrush was counted two or more times within a single winter. Although our assessments of birds that might have been double-counted were inevitably subjective, we based our determinations on proximity of survey points or other detection locations, our field-based knowledge of how far Bicknell's Thrush calls can carry (up to ~100 m), and the fact that overall densities of birds at all survey sites were invariably low. For all suspected instances of double-counted birds, we excluded putative second detections and adjusted our total counts for each site within each year.

Habitat Classification

The vegetation type of each sampled point was obtained from the Map of Forest Cover of the Republic of Cuba (scale 1:100,000; Estrada *et al.* 2012). This map was constructed from Landsat 7 ETM+ satellite images and uses the vegetation classification of Capote and Berazaín (1984) and Borhidi (1987). Because the map depicts only forest cover, vegetation cover data were lacking for four sampled points, one of which corresponded to a village and three to undifferentiated thickets. For those points, we used field notes and direct review of Landsat 7 ETM+ satellite images to derive a vegetation classification.

Results

In 1998–2005, we conducted field surveys at 354 individual points, 339 of which were located in southeastern Cuba, mainly in the Sierra Maestra, Gran Piedra, and the Nipe-Sagua-Baracoa range (Fig. 1, Table 1). We detected a total of 108 Bicknell's Thrushes at 70 sampling points in two geographically distinct sites (PN Turquino and PN Bayamesa) in Sierra Maestra (Table 1). All birds were found at elevations between 1,369–1,971 m asl (mean = 1,708 m ± 147 SD; Fig. 2, Supplemental file). No thrushes were detected during surveys in Nipe-Sagua-Baracoa or Gran Piedra, or at any sites in central and western Cuba. Discounting 24 individuals that may have been counted twice within a single winter at 17 points, our adjusted total was 84 individual thrushes detected at 54 discrete points (Table 1, Supplemental file).

In 2017–2020, we conducted surveys at 497 discrete points, accumulating 48 detections of Bicknell's Thrushes at 29 points in four geographically distinct sites (Fig. 1, Table 1). Adjusting for the possibility that 15 individuals were counted two or more times at eight points, we detected a minimum of 33 birds at 21 discrete points (Table 1, Supplemental file). Of these 33 detections, 29 (87.9%) occurred in Sierra Maestra at elevations between 1,337–1,801 m (mean = 1,540 m ± 141), while four individuals were found at two nearby points 800–900 m outside PN Humboldt's

Table 1. Results of presence-absence surveys for Bicknell's Thrush in Cuba, 1998–2020. Adjusted totals reflect exclusion of 14 points that were surveyed in western Cuba, points sampled two or more times within a given year, and individual thrushes that may have been detected more than once in a given year.

	Total #			Adjusted #		
Year	Sampling Points	Sampling Points with Detections	Detections	Sampling Points	Sampling Points with Detections	Detections
1998	6[a]	0	0	0	0	0
1999	99[a]	15	21	90	13	18
2000	114[a]	18	27	106	15	23
2003	102[a]	16	24	93	11	18
2005	33	21	36	27	15	25
2017	125	2	2	125	2	2
2018	131	16	28	130	10	16
2019	89	8	13	89	6	10
2020	152	3	5	152	3	5
Total	**851**	**99**	**156**	**826**	**75**	**117**

[a]includes points surveyed in western Cuba, outside focal study area (*n* = 6 points in 1998, 5 in 1999, 1 in 2000, 2 in 2003); these are excluded from summary analyses.

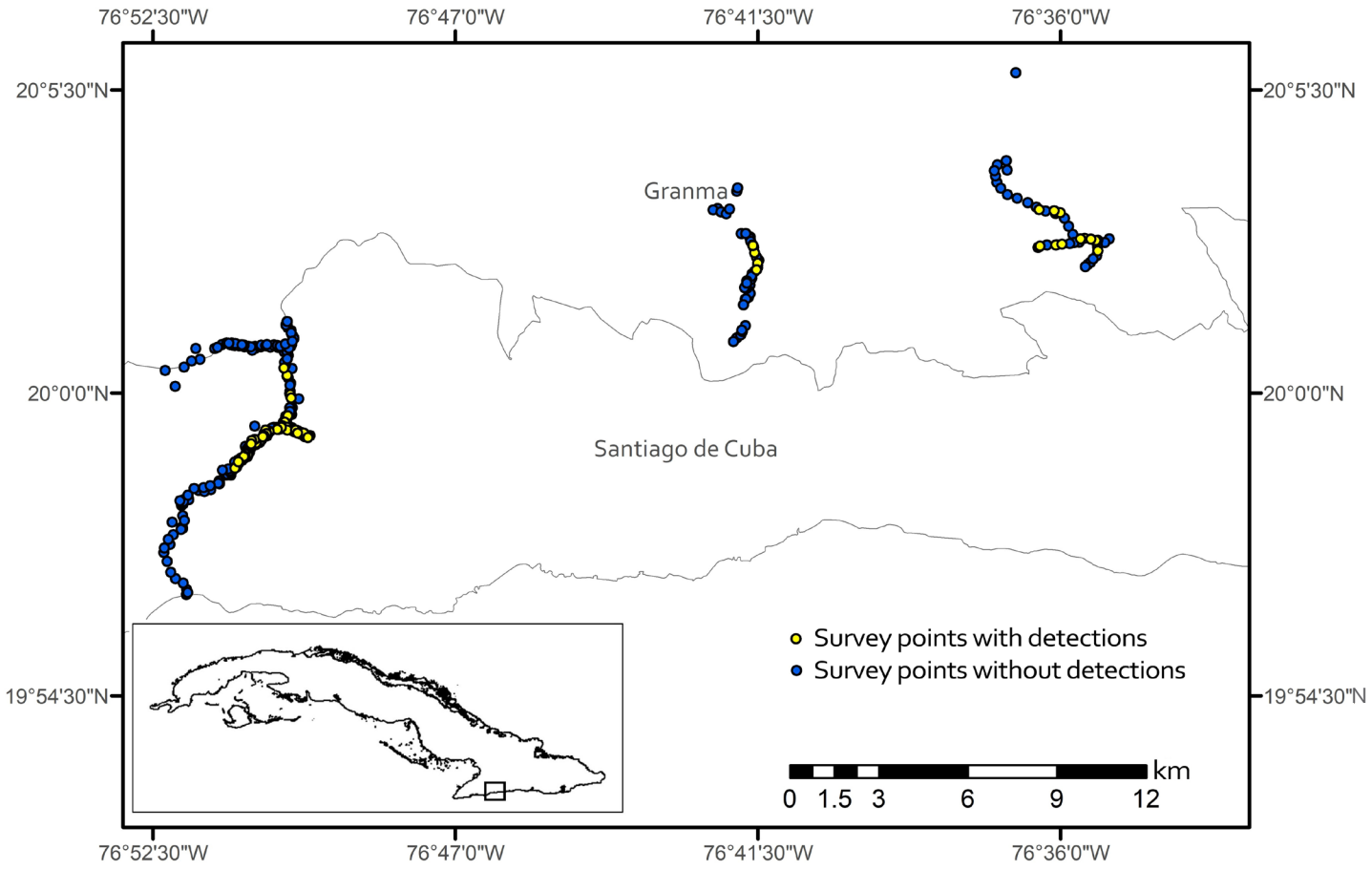

Fig. 2. Distribution of Bicknell's Thrush survey points in Sierra Maestra of eastern Cuba, 1999–2020. Yellow circles depict points with thrush detections; blue circles depict points at which no thrushes were detected. Inset shows location of area in Cuba.

southern boundary at an elevation of 650 m asl (Fig. 3, Supplemental file).

Overall, we sampled 851 points between 1998–2020, detecting 156 Bicknell's Thrushes at 99 of those points (Table 1). Discounting points that were sampled more than once within a given winter and thrushes that may have been counted two or more times, we sampled 826 discrete points during the two sampling periods, detecting at least 117 individual Bicknell's Thrushes at 75 (9.1%) of those points (Table 1, Supplemental file).

During late March and early April of 2017, we detected only two Bicknell's Thrushes during four mornings of surveys in Sierra Maestra; both responded to playback during 3-min point counts at Pico Botella on 1 April (Supplemental file). No thrushes were detected in PN Turquino, despite extensive and repeated surveys over more than 12 km of cloud forest habitat, including many sites where the species had been detected during the winters of 1999–2005 (Supplemental file, Fig. 2). During late January of 2018, we retraced our 2017 route through much of the cloud forest habitat surveyed in 1999–2005. We detected seven Bicknell's Thrushes, all between ~1,605–1,850 m elevation; no thrushes were detected at the 20 point counts we conducted between elevations 1,150–1,600 m.

Overall, during both survey periods, 51 of 75 (68%) points with Bicknell's Thrush detections registered single birds, while the remaining 24 points yielded detections of two to six individuals. Of these 24 points, two birds were detected at 13 points, three birds were detected at eight points, four at one point, and six at two points. This clustering behavior was documented both in cloud forests and at the lower-elevation site Camino Riíto, where three of four individuals were detected at a single point. In general, and especially during the later sampling period, Bicknell's Thrushes were widely dispersed within areas of contiguous, largely homogeneous cloud forest; for example, in January of 2018, we detected only seven individuals during 7 km of surveys through undisturbed cloud forest habitat in PN Turquino.

Habitat Occupancy

Of the 75 points at which we detected Bicknell's Thrush, 67 (89.3%) were located in habitat classified as cloud forest (73.3%) and elfin forest (16%), or "mossy forests", according to the Cuban vegetation classification of Capote and Berazaín (1984) and Borhidi (1987) (Fig. 4). Both vegetation types occupy very small areal extents on the Cuban landscape, collectively covering about 2,300 ha. Elfin forest in particular occupies a miniscule area of only 49 ha, mainly on the summits of Pico Turquino and Pico Bayamesa. Cloud forest is distributed more broadly in three areas: Pico Turquino, Pico Botella, and Sierra de los Libertadores (including Pico Bayamesa), with a total area of 2,251 ha. The

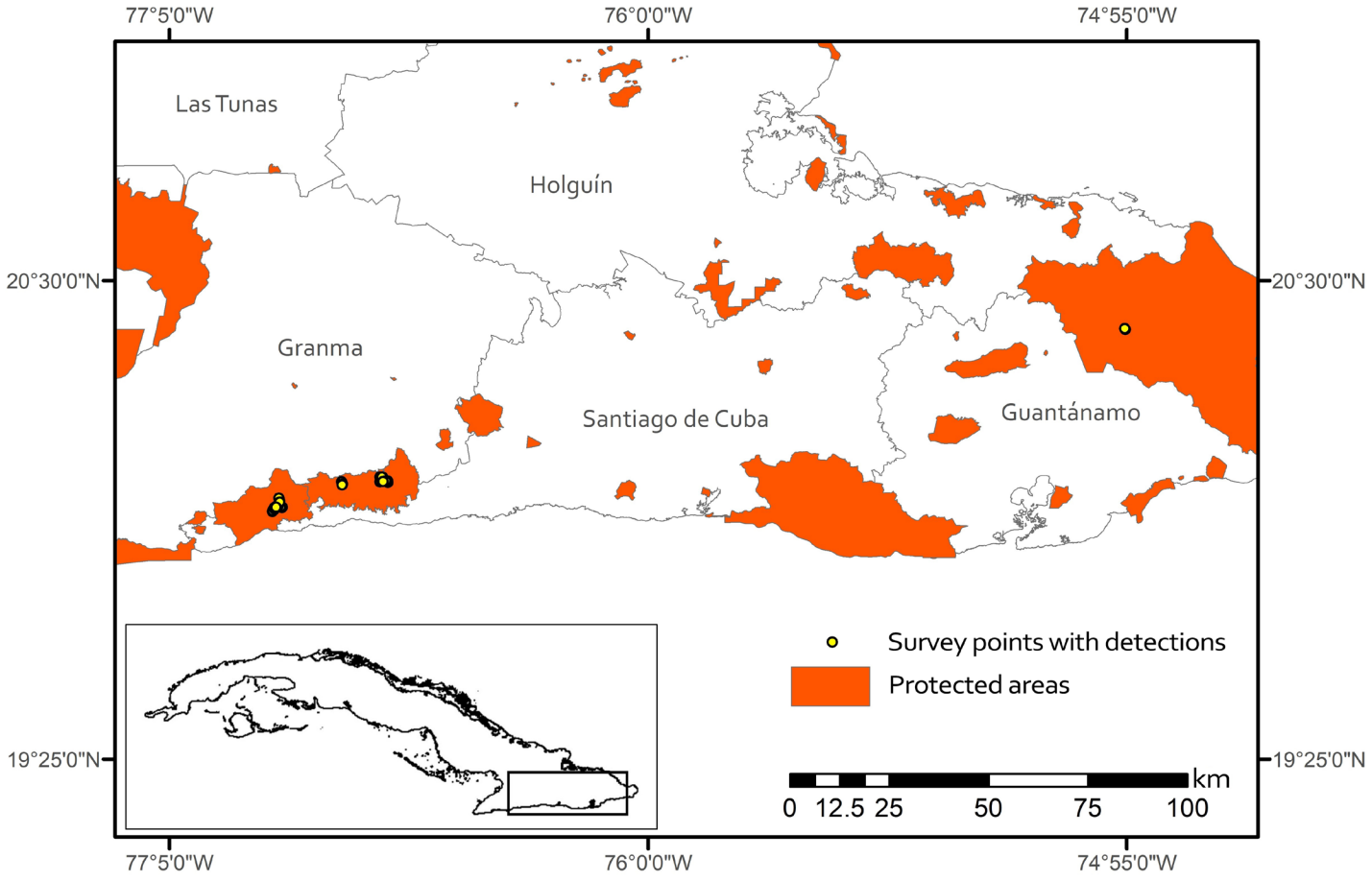

Fig. 3. Protected areas in southeastern Cuba with clusters of Bicknell's Thrush detections (yellow circles), 1999–2020. Inset shows location of area in Cuba.

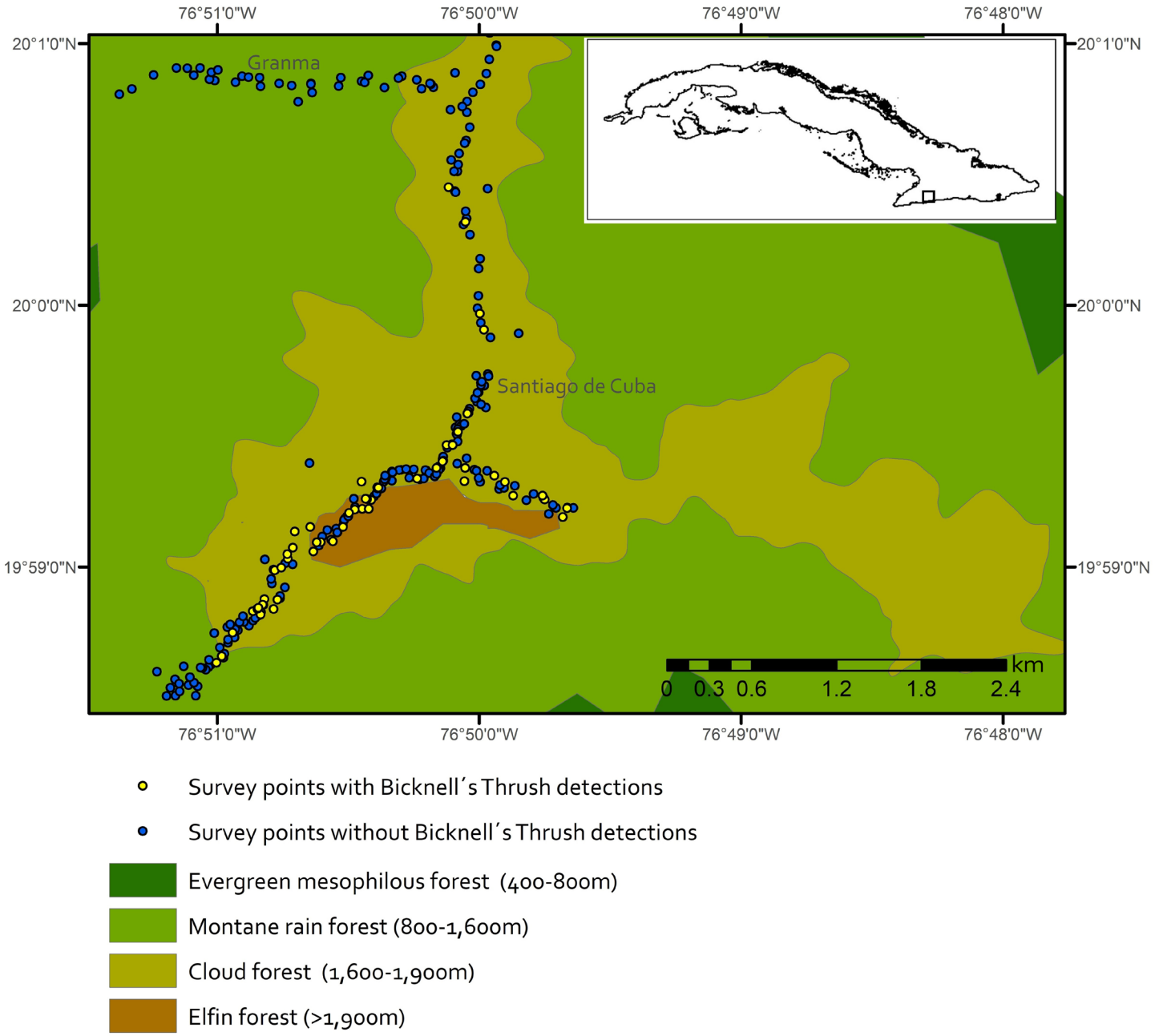

Fig. 4. Distribution of Bicknell's Thrush survey points in Parque Nacional Turquino (yellow circles depict positive detections, blue circles depict points with no detections) overlaid on forest cover types from Capote and Barazaín (1984). Inset shows location of area in Cuba.

largest extent is a continuous zone in the Sierra de los Libertadores, which comprises 60% of this cover type. Despite the predominance of Bicknell's Thrush detections in cloud forest and elfin forest, 76% of the sampling points in these habitats yielded no detections (Fig. 4).

Of the remaining vegetation types where we detected Bicknell's Thrushes, six points were in locations characterized by montane pluvial forest ("montane rain forest"; Capote and Berazaín 1984, Borhidi 1987), all of which were situated within 600 m of cloud forest areas. Although montane pluvial forest was the second most frequently sampled vegetation type, with 132 points (16.3% of total), it yielded only 8% of thrush detections. The remaining two points at which we detected thrushes were located in an area characterized by a mix of mesophilic submontane evergreen forest and pine (*Pinus cubensis*) forests ("submontane rain forest" and "pino de Mayarí forest" respectively; Capote and Berazaín 1984, Borhidi 1987). These constituted the only sites with Bicknell's Thrush detections outside of Sierra Maestra's cloud and elfin forests.

Nearly all of the sites at which we detected Bicknell's Thrush were situated in Sierra Maestra, which is an area of unique topography in Cuba. This is the only region of the island with elevations that exceed 1,300 m asl, and all our thrush detections in Sierra Maestra occurred above that altitude. The mean eleva-

tion of points with detections during both sampling periods was 1,636 m ± 230 asl (range = 649–1,970 m, *n* = 75). Points that did not yield detections were located at a mean elevation of 1,045 m ± 507 asl (range = 3–1,970 m, *n* = 751).

The mean slope of points (expressed as percent rise) yielding Bicknell's Thrush detections was 35.5% ± 19.9 (range = 2–93%, *n* = 75), while the corresponding mean slope of points without thrush detections was 27.1% ± 19 (range = 0–84%, *n* = 751). The mean aspect of points yielding Bicknell's Thrush detections was 194° ± 95.2 (range = 6–356°, *n* = 75), while the corresponding mean aspect of points without thrush detections was 169° ± 99 (range = 0–359°, *n* = 751). Mean annual precipitation of points yielding Bicknell's Thrush detections was 2,793 mm ± 1,083 (range = 950–4,500 mm, *n* = 75), while the mean annual precipitation of points without detections was 2,300 mm ± 706 (range = 950–4,500 mm, *n* = 751).

Discussion

Our results suggest that Bicknell's Thrush seldom occurs in eastern Cuba outside high-elevation cloud and elfin forests of Sierra Maestra, where it appears to be rare. All birds that we detected responded to vocal playbacks, and 96.5% of detections were at elevations between ~1,300–1,850 m. We detected no thrushes below ~1,300 m in Sierra Maestra, despite our concerted efforts to survey lower elevation habitats, particularly in the extensive PN Turquino and Pico Bayamesa areas. Only four Bicknell's Thrushes were detected in lower-elevation regions of southeastern Cuba outside Sierra Maestra, all at the Camino Ríto sites, despite extensive surveys in PN Humboldt, Gran Piedra, Loma del Gato, and Carso de Baire.

The overall encounter rate of Bicknell's Thrush in Cuba was 9.1% (75 of 826 sampled points yielded detections), considerably lower than in Hispaniola, which supports the species' highest abundance and densities (Townsend *et al.* 2020). Point-count surveys in two mid-elevation (200–900 m asl), wet broadleaf forest protected areas of the Dominican Republic's Cordillera Septentrional—Loma Quita Espuela and Loma Guaconejo—following similar protocols to those we used in Cuba in 2017–2020, yielded an encounter rate of 30.3% (*n* = 99 survey points) (McFarland *et al.* 2018, CCR unpubl. data). Eighty percent of detections in these two protected areas were of single individuals, while 20% of points yielded detections of two individuals. At nearby Reserva Privada Zorzal, 13 km west of Loma Quita Espuela, Bicknell's Thrushes were detected at 48 of 107 points, an encounter rate of 44.9% (Almonte *et al.* 2016). Single individuals accounted for 46% of point-count detections, while 54% of points yielded detections of two to five individuals. However, in Puerto Rico, encounter rates were extremely low (encounter rate of 0.5%, with one detection in 211 point counts; Rimmer *et al.* 2019). Within Sierra Maestra, encounter rates varied among Turquino (15.9%, 53 of 332 points), Botella (13.6%, 8 of 59 points), and Bayamesa (25.5%, 12 of 47 points). Overall point count detection rates in PN Turquino also varied between the two sampling periods, 21.1% in 1999–2005 (51 of 242 points) and 2.2% in 2017–2018 (2 of 92 points).

The absence of Bicknell's Thrush detections in PN Turquino during late March of 2017, compared to a maximum of 18 detections in November–December 1999 and seven detections in late January 2018, is difficult to explain. Similarly, we detected only two individuals at Pico Botella in early April of 2017, compared to five individuals in each of January of 2018 and January of 2020, and seven individuals in PN Bayamesa during January of 2019 compared to 14 birds in February of 2018. Survey methods in all years, while not identical, were similar; although we cannot be certain that we exactly resurveyed points in both 1999–2005 and 2017–2018, we resampled many survey routes between our two sampling periods, and among years within each period. Further, we invariably conducted playback surveys during weather conditions and times of day that reliably elicit responses from overwintering birds (e.g., Townsend *et al.* 2020).

We suspect that the species' apparent absence at Turquino and relative scarcity at Botella in March–April 2017 may have reflected late winter movements of thrushes off their established territories. We cannot be certain of this, but radio telemetry and mist-netting data from the Dominican Republic suggest that some Bicknell's Thrushes begin moving off winter territories in March and April (Faaborg pers. comm., Townsend *et al.* 2020), possibly in response to dwindling supplies of high-quality arthropod food resources. Our late March and early April 2017 surveys took place during an abnormally dry winter, which may have diminished cloud forest arthropod populations, as is known to occur in high-elevation Dominican forests (Townsend *et al.* 2010). Although temporal patterns of spatial occupancy are not generally well documented for overwintering Nearctic-Neotropical migrant passerines, recent evidence from GPS archival tags indicates that nearly 40% of Wood Thrushes (*Hylocichla mustelina*) overwintering throughout Middle America vacate initial territories and establish new territories an average of 59 km, and as far as 180 km, away (Stanley *et al.* 2021a, 2021b). These movements likely constitute a response to changing moisture regimes, declining arthropod food supplies, and the need to prepare physiologically for northward migration. If Bicknell's Thrushes undertake similar late winter movements, documenting spatiotemporal patterns of such pre-migratory shifts in location could have important conservation implications.

Habitat Occupancy

Of 75 points at which we detected Bicknell's Thrush, 73 occurred in cloud forest (*n* = 55), elfin forest (*n* = 12), or montane rain forest (*n* = 6) at elevations greater than 1,300 m asl. Detections occurred in three geographic areas that lie within close proximity of one another in Sierra Maestra: PN Turquino, Pico Botella, and PN Bayamesa (Fig. 1). The total land surface in Cuba with elevations exceeding 1,300 m asl amounts to only 58 km², and this is situated in a block less than 40 km long, between PN Turquino to the west and PN Bayamesa to the east. Within this overall area, only five discrete habitat patches exceed 1 km² in size. These include Pico Botella (5.5 km²), Pico Turquino and a neighboring area to the north (20 km²), and the Pico Bayamesa region (32 km²). The remaining 0.5 km² is distributed in very small patches on several isolated peaks scattered throughout this habitat block. The total area of 58 km² represents only 0.17% of modeled Bicknell's Thrush winter habitat range-wide and only 1.2% of such habitat in Cuba (McFarland *et al.* 2013); it contains all cloud forest and elfin forest vegetation on the island.

Only two points of Bicknell's Thrush occurrence were in habitat

Table 2. Distribution of survey points for Bicknell's Thrush (BITH) in Pico Turquino, Pico Bayamesa, and Pico Botella across all years (top); point survey results in PN Turquino during 1999–2005 and 2017–2018 (middle); and point survey results of PN Turquino south slope in 1999–2005 and 2017–2018 (bottom).

Years	Area	Total # Points	# Points with Detections	Total # Individuals	% Points with Detections	# BITH per 100 Sampling Points
All	Pico Turquino	334	53	82	16	24.7
All	Pico Bayamesa	47	12	21	26	44.7
All	Pico Botella	59	8	10	14	16.9
1999–2005	PN Turquino	242	51	78	21	32.2
2017–2018	PN Turquino	92	2	4	2	4.3
1999–2005	PN Turquino South, 1,001–1,400 m asl	28	2	2	7	7.1
1999–2005	PN Turquino South, > 1,401 m asl	127	44	70	35	55.1
	January	1	1	1	100	100
	February	63	20	33	32	52.4
	November	14	9	14	64	100
	December	49	12	20	24	40.8
2017–2018	PN Turquino South, 1,001–1,400 m asl	0	0	0	0	0
2017–2018	PN Turquino South, > 1,401 m asl	24	1	3	4	12.5
	January	7	1	3	14	42.9
	March	17	0	0	0	0

that fell outside high-elevation forest. Both were located in Camino de Riíto at ~650 m asl and situated 230 m apart. Both featured mixed evergreen mesophilous forest and pine forest embedded in a matrix of secondary vegetation, which is recovering from recent agricultural and other human activity. The two points are located less than 1 km from areas characterized as potential habitat in the model of McFarland *et al.* (2013) and about 6 km from the Altiplicie del Toldo, which contains one of the few continuous areas of modeled habitat in the mountains of Nipe-Sagua-Baracoa.

Temporal Changes

The apparent decline in Bicknell's Thrush abundance in PN Turquino between 1999–2005 and 2017–2018 is puzzling (Table 2). Surveys in November–December of 1999, December of 2000, February of 2003, and February of 2005 consistently detected 15–20 individual Bicknell's Thrushes over the survey route on which we detected only seven birds from 28 January to 2 February 2018. During both sampling periods, we conducted surveys over multiple days and visited the same locations two or more times, resulting in multiple detections of birds that were presumed to be territory holders. Our 1999–2005 surveys detected birds at several sites, such as the summit of Pico Turquino itself, where we had no detections in 2017 or 2018. We cannot discount the possibility that local habitat may have changed and become less suitable for Bicknell's Thrush since 2005; however, between 2002 and 2022, PN Turquino lost only 1.7% of its original forest cover (University of Maryland and World Resources Institute 2023). Lower detection rates could also reflect actual population declines over a 13–year period since 2005; the species' U.S. breeding population declined at an annual rate of nearly 4% between 2010 and 2022 (Hill 2022). Although Bicknell's Thrushes overwintering on Hispaniola show little evidence of migratory connectivity (Hobson *et al.* 2001), investigation of connectivity of birds wintering in eastern Cuba is warranted (e.g., Hobson *et al.* 2014).

Sampling Design Constraints

We acknowledge that dispersion of our sampling points across the Cuban landscape was not randomly stratified, which introduces a geographic and habitat bias in our findings. Logistic constraints of physical access to the region's limited roads and trails forced us to rely on convenience sampling, rather than a probabilistic sampling scheme. Further, we used different field survey methods in each year, both within and across our two sampling periods, and we did not account for birds that may have been present but were not detected. Finally, we did not sample from across the entire potential range of Bicknell's Thrush in Cuba, rather concentrating our surveys in the mountainous eastern region. Thus, our scope of inference is necessarily limited to the areas near trails that we surveyed and to a small number of

non-random backcountry locations. Our interpretations of field results and conclusions about the species' habitat associations and distribution are therefore similarly limited and speculative.

Recommendations for Future Work

Despite considerable progress in clarifying the distribution, habitat use, and conservation status of Bicknell's Thrush in Cuba, important gaps in knowledge remain. To address these and other gaps, we recommend: (1) conducting repeated, standardized resurveys of areas in PN Turquino that we covered in both 1999–2005 and 2017–2018, to more effectively assess changes that may have occurred. Surveys should be concentrated between December and February when Bicknell's Thrush are stationary on mid-winter territories. (2) Completing field surveys in unsampled areas of eastern Sierra Maestra's Pico Bayamesa region, specifically in the vicinity of Pico Maceo and Pico Maximo Gomez, which support Cuba's largest extent of contiguous and undisturbed cloud forest. (3) Obtaining a more representative number of samples from modeled medium and low probability habitats, especially in western Cuba, which has received scant coverage to date. (4) Deploying archival GPS tags on breeding birds to investigate apparent late-winter movements and document migratory connectivity.

Conservation Status

Our findings indicate that Cuba supports an overwintering Bicknell's Thrush population second only to Hispaniola's in numeric abundance and geographic dispersion. The cloud, elfin, and montane rain forest habitats in which we found all of the 86 Bicknell's Thrushes detected in 1998–2005 and 87% of the 33 birds detected in 2017–2020 occur inside designated Cuban national parks. Human incursions into these protected areas are extremely rare, and they face little threat of direct anthropogenic habitat loss or degradation. The secure protection afforded to forest habitats occupied by the species in Cuba provides a stark contrast to the highly vulnerable habitats inhabited by Bicknell's Thrush in Hispaniola. Recent forest cover data from the Dominican Republic indicate overall forest loss of > 11% between 2000–2016, with cloud forests declining 6% (Lloyd and León 2019). The effect of protected area status on rates of cloud forest loss was almost negligible, as wildfires and agricultural expansion caused the most losses; three mountainous Dominican national parks (Sierra de Bahoruco, José del Carmen Ramirez, and Valle Nuevo) exhibited consistently high rates of deforestation.

Our survey results from Cuba affirm the strategic prominence of Hispaniola as a primary target for conservation efforts directed at overwintering Bicknell's Thrush. While we acknowledge that Cuba provides an important overwinter refugium for this globally vulnerable long-distance migrant, conservation must focus on forests in the Dominican Republic, which likely supports 80–90% of the species' total population in winter. These forests are highly susceptible to continued, if not accelerated, loss and degradation.

Acknowledgments

We are grateful for the excellent field assistance during 2017–2020 provided by Jorge A. Tamayo Fonseca, Leydis Sánchez Zaldivar, Allán Méndez Hernández, Amauris Rapado Cruzata, Flavia Tamayo, and Yunier Caignet. Invaluable logistical support was provided by staff of Centro Oriental de Ecosistemas y Biodiversidad (BIOECO), with special thanks to Ramón Cueto and Miguel Angel Rodríguez, both of whom drove many hundreds of kilometers to and from remote field sites with patience and good humor. Tim Rieser of U.S. Senator Patrick Leahy's office and Alejandro Padrón Corral of the Embassy of the Republic of Cuba offered valuable assistance in obtaining visas. Members of BIOECO's staff provided helpful logistic support. We are also grateful for the excellent collaboration provided during our 1998–2005 surveys by the following colleagues: Julio Martinez Betancourt, Hiram Gonzalez, Arturo Hernandez, Arturo Kirkconnell, Julie Paquet, Ghislain Rompré, François Shaffer, the staff of the Instituto de Ecologia y Sistematica, the Museo Nacional de Historia Natural, Empresa de Flora y Fauna, Parque Nacional Alejandro de Humboldt, Parque Nacional Turquino, Parque Nacional La Bayamesa, Centro Nacional de Areas Protegidas, and many more Cuban individuals and institutions who helped us in the field and with administration. Funding for this study was provided by Environment and Climate Change Canada, the UN Environment Programme's Corredor Biológico en el Caribe, and several generous individual donors. Kent McFarland offered helpful advice with data analyses and preparation of figures. Jaime Collazo, James Goetz, Ryan Rebozo, and two anonymous reviewers offered invaluable constructive criticism on earlier drafts of this manuscript.

Author Contributions

CCR, NVD, JDL, and YA conceived of and planned the study; all authors participated in field data collection; CPL, NVD, and YSV conducted data analyses and created figures; CCR wrote the first draft and made final edits; NVD, JDL, and YA carefully reviewed and edited all drafts. CCR, NVD, and YA were responsible for securing funding to support this study.

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