

## Ivory-Billed Woodpecker (*Campephilus principalis*) Persists in Continental North America

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**The ivory-billed woodpecker (*Campephilus principalis*), long suspected to be extinct, has been rediscovered in the "Big Woods" region of eastern Arkansas. Visual encounters during 2004 and 2005, and analysis of a video clip from April 2004, confirm the existence of at least one male. Acoustic signatures consistent with *Campephilus* display-drums also have been heard from the region. Extensive efforts to locate birds away from the primary site remain unsuccessful, but potential habitat for a thinly distributed source population is vast (over 220,000 ha).**

The ivory-billed woodpecker is one of six North American bird species suspected or known to have gone extinct since 1880 (1). One of the world's largest woodpeckers, this species of considerable beauty and lore was uncommon but widespread across lowland primary forest of the southeastern United States until midway through the 19th Century (2, 3). Its disappearance coincided with systematic annihilation of virgin tall forests across southeastern United States between 1880 and the 1940s. Relentless pursuit by professional collectors accelerated the species' decline from 1890 to the early 1920s. The last well-documented population occupied a stand of old-growth, bottomland hardwood forest in northeastern Louisiana (the "Singer Tract") during the late 1930s (3–6). That population disappeared as the Singer Tract was logged amidst cries for protection of both forest and bird. The final individual in the Singer Tract, an unpaired female, was last seen in cut-over forest remnants in 1944 (7).

A resident subspecies of ivory-billed woodpecker (*Campephilus principalis bairdii*) occupied tall forests throughout Cuba, and a small population was mapped and photographed in eastern Cuba as late as 1956 (8). Fleeting observations of at least two individuals in 1986 and 1987 by

several experts are widely accepted as valid (9), but repeated efforts to confirm continued existence of that population have failed (10).

Anecdotal reports of ivory-billed woodpeckers in southern United States continue to this day. Such reports are suspect because of the existence and relative abundance throughout this region of the superficially similar pileated woodpecker (*Dryocopus pileatus*). Three reports were accompanied by physical evidence, but their veracity continues to be questioned [supporting online material (SOM) text]. Thus, no living ivory-billed woodpecker has been conclusively documented in continental North America since 1944.

At approximately 13:30 CST on 11 February 2004, while kayaking alone on a bayou in the Cache River National Wildlife Refuge, Monroe County, Arkansas, G. Sparling spotted an unusually large, red-crested woodpecker flying toward him and landing near the base of a tree about 20 m away. Several field marks suggested that the bird was a male ivory-billed woodpecker (SOM text), and Sparling hinted at his sighting on a Web site. T. Gallagher and B. Harrison were struck by the apparent authenticity of this sighting and arranged to be guided through the region by Sparling. At 13:15 CST on 27 February 2004, within 0.5 km of the original sighting, an ivory-billed woodpecker (sex unknown) flew directly in front of their canoe with apparent intention to land on a tree near their canoe, thereby fully revealing its dorsal wing pattern. The bird instead veered into the forest, apparently landed briefly several times (each time blocked by trees), then flew off (SOM text and fig. S1). Efforts to locate the bird over the next several days failed, but subsequent surveys by teams of experienced observers yielded a minimum of five additional visual encounters between 5

April 2004 and 15 February 2005 (SOM text). All seven convincing sightings were within 3 km of one another.

At 15:42 CDT on 25 April 2004, M. D. Luneau secured a brief but crucial video of a very large woodpecker perched on the trunk of a water tupelo (*Nyssa aquatica*), then fleeing from the approaching canoe (fig. S2 and movie S1). The woodpecker remains in the video frame for a total of 4 s as it flies rapidly away. Even at its closest point, the woodpecker occupies only a small fraction of the video. Its images are blurred and pixilated owing to rapid motion, slow shutter speed, video interlacing artifacts, and the bird's distance beyond the video camera's focal plane. Despite these imperfections, crucial field marks are evident both on the original and on deinterlaced and magnified video fields (11) (fig. S3). At least five diagnostic features allow us to identify the subject as an ivory-billed woodpecker.

**(i) Size.** When the woodpecker first appears, perched on the left side of a tupelo trunk, two video fields reveal the dorsal surface of the right wing and a large, black tail (Fig. 1). The minimum distances between the "wrist" and the tip of its tail—measured independently on each of the two video fields and compared to known scales (diameter of the tupelo trunk at two places)—are 34 to 38 cm. These values exceed comparable values for pileated woodpecker and correspond to the upper range for ivory-billed woodpecker (fig. S4).

**(ii) Wing pattern at rest.** These same two video fields (Fig. 1) reveal an extensive, posterior white region on the opening wing, sharply bordered by an anterior black patch that corresponds to upper wing coverts and wrist area. Such extensive white on the secondary flight feathers is consistent with both sexes of ivory-billed woodpecker. The only comparably large white patch anywhere on a pileated woodpecker is the underwing lining, which would be obscured at this early stage of wing-extension, and any barely visible portion of the white underwing should appear anterior, not posterior, on the wing.

**(iii) Wing pattern in flight.** During the first 1.2 sec of flight, the fleeing woodpecker completes 11 full wingbeats before being obscured temporarily by a tupelo trunk (fig. S3). All visible wingbeats reveal extensive white patches on both the posterior dorsal and ventral wing surfaces, representing entirely white secondary and innermost primary flight feathers. Body and wing tips are black. Video images of flying Pileated woodpeckers, including our model during re-enactment (11), consistently reveal a different pattern: Ventrally, white wing-linings are bordered by a dark trailing edge. Dorsally, a white band (proximally narrow, distally broadening into a wide spot along the base of the inner primaries) is surrounded by an otherwise all-dark upper wing surface (Fig. 2).

**(iv) White plumage on dorsum.** As the fleeing woodpecker gains elevation (e.g., video fields 966.7–1016.7

in fig. S3), white plumage is clearly evident on the back between the wings. Ivory-billed woodpeckers have a pair of longitudinal dorsal stripes that approach one another on the middle and lower back (Fig. 2), producing a white area visible on a dorsal view of a fleeing bird. Pileated woodpeckers have lateral white marks on the sides of the head and neck, but lack any trace of white on the dorsum

**(v) Black-white-black pattern of perched bird.** In the Luneau video (26 to 21 s prior to the zero-point in fig. S3), a blurry white object bordered above and below by black is visible on a distant tupelo trunk (fig. S5). The object was not present during subsequent inspections of the site, when we determined that it had been situated 4 m above the water, on a tree located 3 m from the trunk from which the woodpecker flew 21 sec later. We interpret the object to be a large, perched woodpecker. Among candidate species, the observed pattern fits only that of ivory-billed woodpecker. Placing a life-sized model on the same tree trunk produced a similar image (fig. S5).

Two other features suggesting ivory-billed woodpecker are evident on the Luneau video, but we do not currently regard them as diagnostic, in part because we lack sufficiently comparable data for objective comparison with pileated woodpecker. First, the estimated wingspan of the fleeing woodpecker exceeds 71 cm (11), a value within the published range for ivory-billed woodpecker and at or above the maximum published wingspan of pileated woodpecker. Second, the video shows a woodpecker on a sustained escape flight that is rapid (9 wingbeats  $s^{-1}$ ) and direct for at least 4 sec. This flight pattern matches many anecdotal descriptions of ivory-billed woodpecker (2–5) and is atypical for pileated woodpecker.

We considered and rejected the hypothesis that the sightings and video can be explained by a "pibald" or partially leucistic pileated woodpecker with symmetric white patches on wings and back approximately matching the pattern of an ivory-billed woodpecker. Several observers described the bird they saw as conspicuously larger than a pileated woodpecker, and the video bears this out (fig. S4). We are unaware of any examples of extensively and symmetrically pibald pileated woodpeckers in museum collections or the literature (12). During 14 months of nearly continuous fieldwork by dozens of observers, pileated woodpeckers were encountered virtually daily throughout the study region, where they are common and noisy residents occupying permanent territories. We would expect any strikingly plumaged leucistic individual in the study area to have been observed regularly.

Despite substantial survey efforts by skilled observers following the original sightings, we obtained minimal acoustic evidence for ivory-billed woodpecker in the region. Distinctive, "double-knock" display-drums characteristic of

most members of the genus *Campephilus*, including ivory-billed woodpecker, were heard sporadically by 7 different observers between March 2004 and March 2005, and series of these display-drums were heard on three occasions (SOM text). No observer has positively heard or recorded nasal "kent" notes that are typical of the species (5). During late spring 2004, and again from 16 December through the present, we acoustically monitored a 20 km<sup>2</sup> region of forest in the vicinity of the sightings and potential habitat elsewhere in the White River and Cache River refuge complex (11). Recordings of series of "kent" notes exist in these data but cannot be positively distinguished from exceptional calls by blue jays (*Cyanocitta cristata*).

Our field surveys (11) to date have revealed little about population size or breeding. Work covering substantial portions of the Cache River and White River National Wildlife Refuges from December 2004 through April 2005 yielded remarkably few encounters. Except for the flurry of sightings and the video in April 2004, our surveys have provided no evidence for the predictable occurrence of ivory-billed woodpecker in a localized area and no evidence of a mated pair. Indeed, we cannot rule out the possibility that all of our fleeting encounters involved the same bird. In three sightings (including the initial one of a perched bird), the observer saw red on the hind-crest, which indicates that at least one male exists (the female's crest is all black). Life spans of large woodpeckers rarely exceed 15 years (13). Hence the individual(s) documented here probably hatched no earlier than the 1990s and could even represent dispersing non-breeders hatched in the 21st century.

The difficulty of detecting ivory-billed woodpeckers in the Big Woods may be a consequence of extremely low population density. In the Singer Tract's mature bottomland hardwoods, Tanner documented only 1 pair per 16 km<sup>2</sup> of forest (5). The present Big Woods landscape consists of patches of mature forest amidst a matrix of regenerating trees of various ages; its resource base for ivory-billed woodpeckers is much reduced compared to that of the Singer Tract. Although we failed to find occupied roost holes in an intensive search of over 41 km<sup>2</sup> of forest around the sighting area (11), we have covered only a small part of the available potential habitat. Individuals may roost far from where our encounters are concentrated. Large woodpeckers are known to adapt to fragmented forest landscapes by expanding their home range sizes (14, 15) (SOM text). Ivory-billed woodpeckers are capable of rapid and sustained flight and were known to move widely in search of recently dead large trees (2–5). Individuals in the Big Woods could cover hundreds of square kilometers to accommodate their resource requirements. Such low densities would, in turn, explain the paucity of vocalizations and drumming signals we encountered.

The Big Woods (fig. S6)—at 220,000 ha, the second-largest contiguous area of bottomland forest in the Mississippi River basin—includes 20 distinct types of swamp and bottomland hardwood forests (16). About 40% of the forest is currently approaching maturity (oldest trees >60 years). The remainder, while younger (20 to 60 years), is growing rapidly. An additional 40,000 ha of adjacent or nearby land has been reforested in the last decade and is in early successional stages. If a few breeding pairs do exist, most of the conditions believed to be required for successful breeding and population growth (5) are becoming more available to them. Strategic additions to the public refuge system and successful restoration efforts by both public and private landowners are reestablishing mature hardwood forest, the crucial foraging habitat for ivory-billed woodpeckers (5). Increasing the extent and diversity of genuinely mature bottomland forest with large, very old trees and substantial standing dead and dying timber may allow future generations to see the awe-inspiring woodpecker again gracing old-growth treetops.

## References and Notes

1. The others are Labrador duck (*Camptorhynchus labradorius*), Eskimo curlew (*Numenius borealis*), Carolina parakeet (*Conuropsis carolinensis*), passenger pigeon (*Ectopistes migratorius*), and Bachman's warbler (*Vermivora bachmanii*).
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17. We gratefully acknowledge financial support from Joan Barksdale, Robert Berry, Ian Cumming, Marshall and Jamee Field, Kate Gooch, Samuel and Imogene Johnson, Edwin and Linda Morgens, John Norris, Henry and Wendy Paulson, Edward W. Rose III, John Ruthven, Chrissie and Lex Sant, Roger and Vicki Sant, Timothy Spahr, and the membership of the Cornell Laboratory of Ornithology. Further acknowledgments are listed in the SOM. J.W.F. is a past member of the Board of Governors, a Trustee of the Florida Chapter and a donor for the Nature Conservancy, M. L.'s wife is currently employed as research technician at the Nature Conservancy, D.L., B.H., and G.S hold contracts from the Nature Conservancy to perform inventories of the study area mentioned in this Report.

#### Supporting Online Material

[www.sciencemag.org/cgi/content/full/1114103/DC1](http://www.sciencemag.org/cgi/content/full/1114103/DC1)

Materials and Methods

SOM Text

Acknowledgments

Figs. S1 to S6

Movie S1

References and Notes

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**Fig. 1.** Zoomed segment of frame 33.3 from the Luneau video (see fig. S3), one of two consecutive frames in which the woodpecker's right wing is revealed immediately prior to flight. Large white area represents a dorso-lateral view of the secondary flight feathers. Bracketed arrows mark the exposed distance between a spot near the bird's wrist and the tip of its tail, which is thrusting laterally upon take-off. Parallel white bars identify two diameters of the tree trunk, measured later for scale. Inset sketch (by J. Fitzpatrick) interprets approximate position of the bird, including unrevealed portions (dotted lines, shaded background).

**Fig. 2.** Selected video frames of the woodpecker in the Luneau video [(A and C), left-hand column], comparably distant and imperfect video frames of pileated woodpecker recorded in the study area in similar postures [(B and D), left-

hand column], and interpretative sketches by J. Fitzpatrick (right-hand column). With these distances and light conditions, bleeding tends to exaggerate the apparent extent of white in the wings. However, careful study of these and numerous other video examples consistently reveals dark trailing edges on both upper and lower wing surfaces of pileated woodpeckers—features not present on the bird in the Luneau video.





