# Comment on "Ivory-billed Woodpecker (*Campephilus principalis*) Persists in Continental North America"

David A. Sibley,[1]* Louis R. Bevier,[2] Michael A. Patten,[3] Chris S. Elphick[4]

We reanalyzed video presented as confirmation that an ivory-billed woodpecker (*Campephilus principalis*) persists in Arkansas (Fitzpatrick *et al*., Reports, 3 June 2005, p. 1460). None of the features described as diagnostic of the ivory-billed woodpecker eliminate a normal pileated woodpecker (*Dryocopus pileatus*). Although we support efforts to find and protect ivory-billed woodpeckers, the video evidence does not demonstrate that the species persists in the United States.

The ivory-billed woodpecker has received considerable attention following the April 2005 announcement of its rediscovery in the "Big Woods" region of Arkansas (*1*–*3*). The conclusion by Fitzpatrick *et al*. (*1*) that the species persists is based on several observations, sound recordings that resemble ivory-billed woodpecker calls and double raps, and a short video recording. The recent sight records (*1*, *4*) were all very brief and most involved a single observer, matching the pattern of reported observations over the past few decades (*5*–*8*). Although such observations provide strong impetus for continued searching and habitat protection, they cannot be taken to confirm the species' presence because they do not provide independently verifiable evidence. Nor is the audio evidence reported to date considered definitive (*9*). Thus, confirmation that ivory-billed woodpeckers remain in the United States rests on demonstrating that the "crucial video of a large woodpecker" (*1*) cannot possibly be a pileated woodpecker.

Fitzpatrick *et al*. list five features to support their conclusion that the bird in the video is an ivory-billed woodpecker: (i) size, (ii) wing pattern at rest, (iii) wing pattern in flight, (iv) white plumage on dorsum, and (v) black-white-black pattern presumed to be a perched bird (*1*). Our analysis of the digital video and deinterlaced video frames (*10*) demonstrates that this conclusion rests on mistaken interpretations of the bird's posture, that several features visible in the video contradict identification as a typical ivory-billed woodpecker, and that other features support identification as a pileated woodpecker. The assessment that follows is keyed to the labeled frames in Fitzpatrick *et al*.'s supporting materials [fig. S3 in (*1*)].

**Size and wing pattern at rest.** Fitzpatrick *et al*. assume that the bird was positioned vertically on the trunk with its wings more or less folded in frames 33.3 and 50 (Fig. 1A). Our examination of specimens and photographs indicates that a typical ivory-billed woodpecker in that position would exhibit considerably less white and more black than is shown in these frames (Fig. 1). In our analysis [supporting online material (SOM) text], these frames show a bird that has already opened its wings in flight, exposing the underside of a fully spread right wing that is extended vertically (Fig. 1C). The observed pattern is that expected of a pileated woodpecker in this posture, with extensive white on the underwing coverts and bases of the flight feathers. Our estimate of the length of the white patch in the video better matches the extent of white on the ventral spread wing of a pileated woodpecker than that on the dorsal folded wing of a typical ivory-billed woodpecker (but see cautions in SOM). Movement of the tail away from the tree in these frames is also consistent with the hypothesis that the wings are fully spread (see SOM). With this interpretation of the bird's posture, it is impossible to determine the bird's size or wing pattern at rest.

**Wing pattern in flight.** To support their conclusion that the bird in the video showed "entirely white secondary and innermost primary flight feathers" (*1*), Fitzpatrick *et al*. presented

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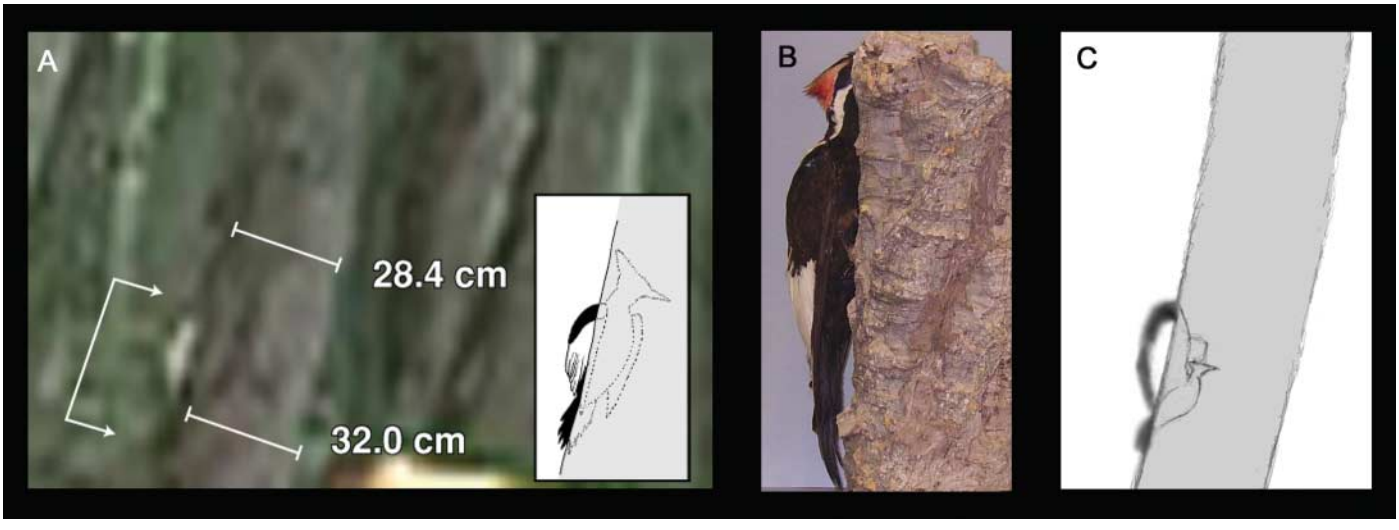


**Fig. 1.** (**A**) Frame 33.3 from (*1*), in which it is proposed that the black and white object to the left of the tree trunk is an ivory-billed woodpecker positioned as illustrated in the inset sketch. (**B**) Photograph of a mounted ivory-billed woodpecker specimen, illustrating the limited extent of white and the large amount of black on the folded wing typical of that species (Western Foundation of Vertebrate Zoology) (image flipped horizontally and cropped using Photoshop). (**C**) The posture we propose for the bird in the video.


**Fig. 2.** (**A**) and (**C**) show video frames (apparently frames 700 and 1000, although this is not stated) and interpretive sketches from Fig. 2 in (*1*). (**B**) and (**D**) show alternative explanations of the bird's positions in these frames that better match its appearance and behavior in adjacent frames, i.e., the bird is flying more directly away from the camera (sketches by D. Sibley). In each case, the new interpretation shows that the white in both wings is likely to be from their ventral surface. (**E**) and (**F**) illustrate the manner in which a bird's wings twist in flight, such that the leading edges are lower than the trailing edges, rendering the ventral surface of both wings visible during the downstroke when viewed from behind. (**E**) shows a female mallard *Anas platyrhynchos* [photograph, courtesy of Ducks Unlimited, scanned from (*11*); cropped slightly using Photoshop]. (**F**) shows a pileated woodpecker taking flight [video frame courtesy of M. M. Swan/ManyBirds]; cropped and adjusted slightly for contrast and brightness using Photoshop; note also the brighter translucent white at the base of the outer primary feathers, contrasting with the duller white underwing coverts and matching frame 300 shown in Fig. 3C.

video frames (with interpretive sketches) in which white can be seen on both wings and two photographs of pileated woodpeckers for comparison (video frames and sketches reproduced in our Fig. 2). Those sketches and the comparison pictures of pileated woodpeckers, however, are incongruent with the bird's posture in the selected frames (SOM text), as shown by the entire sequence of frames (fig. S2). In our analysis of the bird's posture, the white on the wings can be accounted for by the ventral surface; in addition, due to blurring, the video frames probably show more white than was actually present on the bird (SOM text). Throughout the bird's flight, it is seen in a rear view. Extensive white is visible only on the downstroke, during which the leading edge of the wings angles down to propel the bird forward and the rear of the wings twist up. Consequently, during the downstroke the ventral surface of both wings should be visible (Fig. 2, E and F) and the dorsal surface largely hidden. Pileated and ivory-billed woodpeckers both show extensive white on the ventral surface of the wings, and the presence of white is not diagnostic. In contrast, during the quick upstroke when the dorsal surface of the wings is most likely to be visible, the wings appear mostly dark (e.g., frames 216.7 and 333.3) (fig. S2); the entirely white secondary feathers of an ivory-billed woodpecker should be obvious throughout the wingbeat cycle. The observed pattern of little white on the upstroke followed by a large flash of white on the downstroke is expected for a pileated woodpecker.

Most important, three additional features of the wing pattern in flight match a typical pileated woodpecker but not a normal ivory-billed woodpecker: (i) Several frames of the bird apparently show a black trailing edge to the wings. In particular, frame 350 (Fig. 3A) shows a solid black patch on the left wing, and frame 383.3 (fig. S2) shows no white on the left wing. In both cases, one would expect the entirely white secondary feathers of an ivory-billed woodpecker to be obvious on both wings. We maintain that the lack of an obvious black trailing edge in most video frames does not rule out an identification of pileated woodpecker (see SOM). (ii) Several frames (e.g., 266.7 and 366.7) (Fig. 3B) reveal a black band that curves around the wingtip and back along the wing's trailing edge. On an ivory-billed woodpecker, only the outer six primary feathers are black to their tips, creating a relatively small black patch on the wingtip that ends abruptly where it meets the outermost extent of the white trailing edge and does not curve back along the wing; in contrast, this curved appearance is typical of the black wingtip of a pileated woodpecker. (iii) Various frames (e.g., 300, 416.7, 533.3, and 650) (Fig. 3C) show a brighter white area on the outer wing that contrasts with the black wingtips and the duller, shaded, white closer to the body. This matches the translucent white patch at the base of the primary feathers of a pileated woodpecker. An ivory-billed woodpecker would be expected to show bright white along the entire length of the wing.

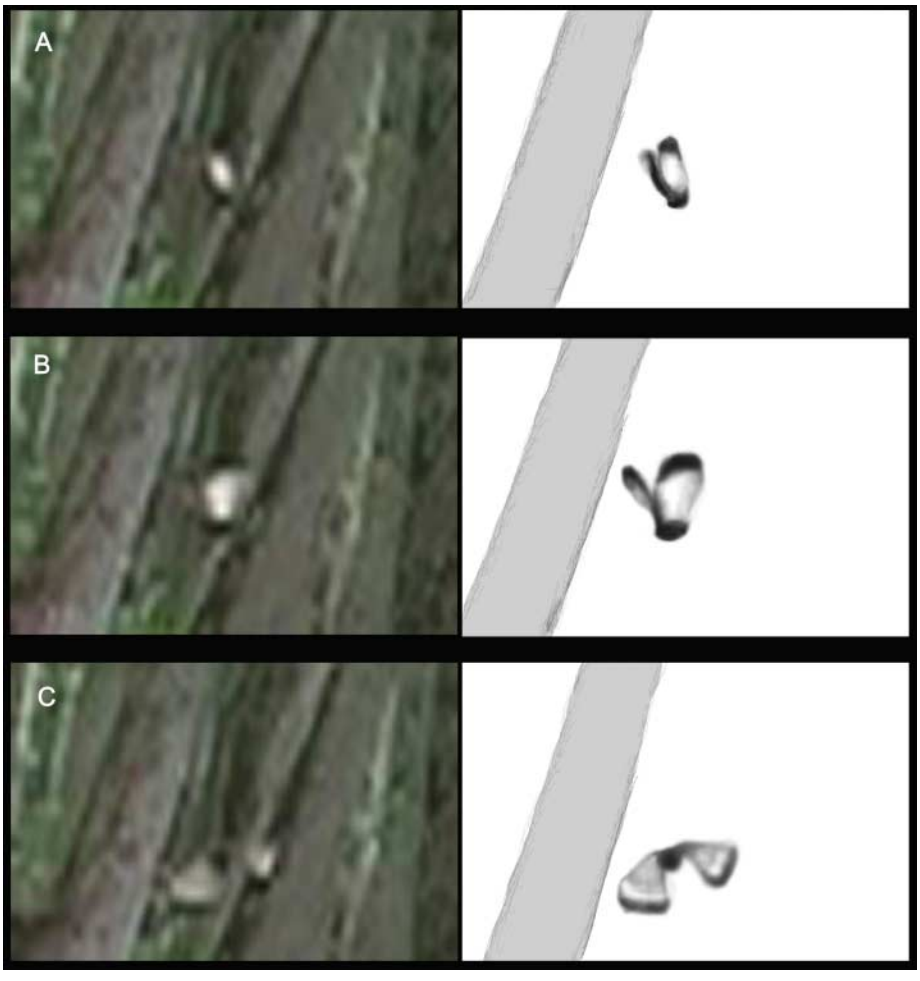


**Fig. 3.** Video frames on left, with interpretive sketches by D. Sibley on the right. (**A**) Frame 350 showing extensive black on the secondary feathers along the trailing edge of the elevated left wing. (**B**) Frame 366.7 showing the ventral surface of the wing and a broad black band curving across the wingtip and down toward the trailing edge of the wing. (**C**) Frame 300 showing both wings moving down rapidly, near the bottom of the downstroke, with the brightest white visible on the outer wing just inside the black wingtips (compare also Fig. 2F). All three features are typical of a pileated woodpecker, and all are inconsistent with the expected appearance of an ivory-billed woodpecker.

**White plumage on dorsum.** The video frame shown in Fig. 2C also shows a vague pale blur in the region of the bird's back that was used as evidence for the presence of dorsal longitudinal white stripes. Contrary to the sketch in Fig. 2C (*1*), however, the bird is flying almost directly away and little of its back is visible. This pale area occupies only a few pixels in the original video frames and is only apparent in a few frames. The image quality does not allow resolution of the striped pattern diagnostic of an ivory-billed woodpecker, and other possible sources of this pale blur include the pale head markings of a pileated woodpecker, light reflecting off the bird's back, or video processing artifacts.

**Black-white-black pattern.** In the video, a black-white-black pattern is present 26 to 21 s before the flying bird appears. The source of this pattern was neither seen when the video was made nor found when the site was revisited but was interpreted as "a large, perched woodpecker" (*1*). It is not clear that the object is a bird or that it was actually on the tree trunk, rather than between the tree and the camera. Most disconcertingly, similar patterns are visible elsewhere in the video (see SOM). One appears to be a cluster of emerging leaves (frames 0455 to 0520), two are visible shortly after the bird has flown away (fig. S1), and none show diagnostic features of an ivory-billed woodpecker.

Two additional features—wingspan and flight pattern (fast wingbeats, direct flight)—were proposed as features suggesting that the bird is an ivory-billed woodpecker (*1*). We agree that "we lack sufficiently comparable data for objective comparison" (*1*) of these features (see SOM text).

With our new understanding of the bird's movements, all observed features are consistent with a typical pileated woodpecker and some are inconsistent with a normal ivory-billed woodpecker. We conclude that one cannot reject the hypothesis that the bird is a normal pileated woodpecker (i.e., the null expectation); moreover, the evidence firmly supports this hypothesis. Ivory-billed woodpeckers may persist in the southern United States, and we believe that conservation efforts on their behalf should continue. Verifiable evidence for the ivory-billed woodpecker's persistence, however, is lacking.

**References and Notes**

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10. Materials and methods are available as supporting material on *Science* Online.
11. E. M. Queeny, *Prairie Wings* (Lippincott, New York, 1947; Dover Publications edition).
12. We are extremely grateful to J. Fitzpatrick, M. Dantzker, K. Bostwick, R. Charif, M. Lammertink, R. Rohrbaugh, and K. Rosenberg at Cornell University's Laboratory of Ornithology for providing access to video frames described in the original paper and discussions on this topic. We thank everyone who has discussed the topic with us; especially insightful comments came from B. Benz, S. Cardiff, D. Dittmann, R. Erickson, G. Graves, S. Howell, J. Jackson, K. Kaufmann, D. Lane, C. Marantz, R. Prum, P. Pyle, M. Robbins, J. Rowlett, M. Rubega, B. Whitney, C. Witt, and four anonymous peer reviewers. We gratefully acknowledge the use of the following collections: Academy of Natural Sciences of Philadelphia (N. Rice), American Museum of Natural History (P. Sweet), Louisiana State University Museum of Natural Science (J. V. Remsen Jr., S. W. Cardiff, D. L. Dittmann), Museum of Comparative Zoology at Harvard University (A. Pirie, J. Trimble), and Western Foundation of Vertebrate Zoology (WFVZ) (R. Corado). We thank L. Ballard and D. Compton for photographing the specimen at WFVZ and M. M. Swan/ManyBirds for use of the pileated woodpecker video frame.

**Supporting Online Material**

www.sciencemag.org/cgi/content/full/311/5767/1555a/DC1
Materials and Methods
SOM Text
Figs. S1 and S2
References

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# Supporting Online Material for

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**This PDF file includes:**

**1. Materials and Methods.**

**Material.** The 25 April 2004 video was made available to us by J. Fitzpatrick and M. Dantzker; for details see (*S1*). Note that frame-numbers in (*S1*) represent elapsed time and differ from the scheme employed for analysis of the original video by the Cornell Laboratory of Ornithology. We follow the paper's scheme when referring to the sequence described in (*S1*), and the frame-numbers from the original video as made available to us in all other cases.

**Specimen measurements.** Although we caution that poor focus and limited temporal resolution make all measurements of the bird in the video prone to error, we used the calibration method developed by Fitzpatrick *et al.* (*S1*) to compare the size of the white patch visible in frame 33.3 of the video to the size of white patches visible on ivory-billed and pileated woodpeckers under the two alternative explanations for the bird's movement. Using the caliper tool in the software GraphicConverter, we estimated that the white patch is 59% of the length between the bracketed arrows in Fig. 1A. Fitzpatrick *et al.* estimated this length to be 34–38 cm, making the visible white patch 20–22 cm long. In contrast, the longest extent of the white upperwing patch of ivory-billed woodpecker specimens with closed wings was 14 ± 1 cm (mean ± standard deviation; n = 8; range 12–16 cm; specimens at the Academy of Natural Sciences of Philadelphia [ANSP] and Louisiana State University Museum of Natural Science [LSUMNS]). We did not make similar measurements with the wing partially open because we had no basis for assessing how much force should be used to open the wings in order to be representative of a live bird's movements. Using a length of 20 cm, we estimate that the patch in the video appears 43% larger than the mean and 25% larger than the maximum of specimens measured. For two LSUMNS specimens of pileated woodpecker (*Dryocopus pileatus pileatus* collected in Louisiana and Mississippi), the longest extent of white on the underside of the spread wing were 18.5 cm and 20.5 cm. Although the complete range of variation in live birds is not known, and the actual size of this white patch cannot be precisely determined because of the blur in the video, these results are more consistent with the hypothesis that the video shows the white on the underwing of a pileated woodpecker than with the notion that the folded wing of an ivory-billed woodpecker is shown. All measurement details and specimen numbers are available from the authors.

**2. SOM Text.**

**Wing pattern at rest.** Fitzpatrick *et al*. (*S1*) propose that the bird's "right wing begins to open" in frame 16.7 (their fig. S3) and that frame 33.3 shows the "opening wing." They further suggest that even though the wing is opening in frame 33.3, the underwing pattern "would be obscured at this early stage of wing extension." On the contrary, the initial wing extension happens very quickly and, given the angle at which the bird is viewed, the underwing should be visible. (This rapid wing opening can be seen in several video clips of woodpeckers at http://www.manybirds.com/ (M. M. Swan / ManyBirds); see especially the clip of pale-billed woodpecker *Campephilus guatemalensis*.) The suggestion that the wings are more-or-less closed in their fig. 1 also is inconsistent with the movements of the bird in the video. A woodpecker's tail provides essential support when clinging to a tree trunk (*S2*), and in normal takeoff a woodpecker in the near vertical position illustrated in *S1* would hold its tail against the trunk until after its wings are extended and ready for the initial downstroke (see below). Frames 33.3 to 66.7 show the bird's tail lifting up and moving away from the tree (Fig. S2) suggesting that the wings were already spread at this point in the video. When a woodpecker flies from a vertical position, in which its tail is supporting its weight, without opening its wings first, it will necessarily lose altitude before gaining flight (see video of red-cockaded woodpecker *Picoides borealis* at http://www.manybirds.com/ (M. M. Swan / ManyBirds) for an example). Frame 166.7, however, shows the bird emerging from behind the tree at the same height at which it appears to take flight and it then gains altitude throughout the remainder of its flight.

The full video clip showing a pileated woodpecker during normal take-off (see our Fig. 2) can be viewed at http://www.manybirds.com/pileated.htm (M. M. Swan / ManyBirds; video taken 27 May 2000). By scrolling through the video one can see that the tail remains in contact with the trunk until after the wings are extended well above the back. We have examined a number of other video clips in which woodpeckers take off from a vertical position and do not lose altitude, and all show the tail remaining close to the trunk until after the wings have opened. In addition, examining the frames from this pileated woodpecker video in sequence shows the translucent white patches at the base of the outer primaries better than is possible with the single frame shown in our Fig. 2F, and (although this video shows the bird at a somewhat different angle

than the Arkansas video) illustrates how the wing-twisting effect of a flapping bird allows the undersides of the wings to be seen from behind.

**Wing pattern in flight.** In the video frames selected for fig. 2 of (*S1*), and in much of the video, the bird is flying almost directly away from the camera. Fitzpatrick *et al.*'s interpretive drawing (Fig. 2A) incorrectly illustrates a bird in rear-quarter view, showing the upperside of the left wing in addition to the head and tail, none of which are distinguishable as the bird flies away from the camera (Fig. 2B). Likewise, Fitzpatrick *et al.*'s other interpretive drawing (Fig. 2C) incorrectly shows the bird in a posture that is typical of braking (e.g., slowing abruptly to land on a tree trunk), with the body angled upward and the whole upperside of the bird visible, rather than moving directly away in continued flight (Fig. 2D). Neither of the original sketches (Fig. 2A, 2C) is consistent with the bird's continued flight into the woods. For similar reasons, the pileated woodpecker pictures included for comparison in (*S1*) also do not match the postures of the bird in the video.

Determining the exact wing pattern in flight is impossible because of the severely blurred nature of the video. This blurring arises because of both the low spatial resolution (with few pixels involved and poor focus) and low temporal resolution (slow shutter speed). Within a single video frame the bird's wings move vertically (perhaps by a few cm in a single frame) and twist, creating blurring that could exaggerate or de-emphasize certain features, and making it possible that both the upper and lower surfaces of the wing would be visible in the same frame (personal communication from an anonymous reviewer).

In addition, Fitzpatrick et al. reported that "bleeding tends to exaggerate the apparent extent of white in the wings" (*S2*: fig. 2 caption), and, in their re-enactments with wooden models of the two species, found that "Both woodpecker models show more white in the re-enactment video than is actually present, an artifact of the dominance of white in video imaging under normal outdoor conditions" (see SOM from *S2*). Therefore, it seems likely that the amount of white seen in the video is deceiving. We further maintain that the absence of an obvious dark trailing edge on most video frames does not rule out identification as a normal pileated woodpecker, and can be accounted for by these observed effects, by the blurred images, and by the acute angle at which the wings were viewed.

In their reenactments with a wooden pileated woodpecker model, Fitzpatrick *et al*. did, nonetheless, always see the black trailing edge to the wing that is indicative of that species. Because stiff wooden wings do not move and twist in the manner of a real bird's wings, and because video conditions could not be matched exactly, these tests are insufficient to demonstrate that the black trailing edge will always be visible in blurry video of a real pileated woodpecker. In a video image of a known pileated woodpecker (fig. 2B in *S1*), for example, the black trailing edge of the right wing and the mostly black upperside of the left wing are much less obvious than expected and closely match video images of the subject bird.

**Wingspan measurements**. Given the quality of the video, wingspan cannot be measured accurately enough to distinguish the two species, and there are several reasons to view the measurements in (*S1*) with caution. Factors contributing to uncertainty in measurement and assessment of wingspan include: (i) There are few published measurements of wingspan for either pileated or ivory-billed woodpecker; none are given in (*S1*). (ii) All wingspan estimates that we are aware of come from in-hand specimens with wings presumably stretched to their full extent. It is unknown how this measurement relates to the normal wingspread of a free-flying woodpecker as seen in the video. (iii) Since black wingtips are not clearly visible in the video, wingspan was calculated in (*S1*) by measuring the maximum extent of white in each frame and multiplying by a correction factor to account for the black wingtips. This method could overestimate the wingspan given Fitzpatrick et al.'s observation that video images can show more white than is actually present (see above; *S1*). (iv) The multiplicative correction factor would exaggerate any overestimation, and this correction factor is untested. (v) The reference measurement used to calibrate wingspan estimates was the diameter of a tree trunk that stood between the camera and the bird, so accurate measurement of the tree diameter at the exact same point in the field and image is fundamental to all subsequent calculations. (vi) The distance of the bird beyond the tree is unknown but any distance would lead to some underestimation of wingspan. Overall, we conclude that it is impossible to determine the net effect of all potential sources of error, especially when so many have not been quantified.

**Flight pattern.** The bird in the video flaps its wings at a rate slightly faster than the documented range for pileated woodpecker (*S1, S3*). The flapping rate of ivory-billed woodpecker is unknown, but flapping rates among other woodpeckers generally decrease with increasing body mass (*S3*), which suggests that an ivory-

billed woodpecker would flap at a slower rate than a pileated woodpecker. More important, flapping rates and other flight details are quite variable in woodpeckers (*S4*), and comparisons cannot be made without good characterization of the variation within species, which would require large samples. The direct flight path taken by the bird in the video is not unusual for an escaping pileated woodpecker, and is perhaps not unexpected given that the bird is low, over water, and gaining altitude. In his classic work on ivory-billed woodpeckers, James Tanner wrote that flight pattern "cannot be used as a reliable field character" because he had "frequently seen Pileateds fly directly, in no way different from the flight of the larger bird" (*S4*). The long "rowing" downstroke and quick upstroke of the bird in the video, as shown in Fig. S2, is typical of a pileated woodpecker. It is not known what the flight of an ivory-billed woodpecker would be like under similar conditions.

**Additional online material.** Subsequent to the publication of (*S1*), additional information on the identification of the bird in the video was presented at the 2005 annual meeting of the American Ornithologists' Union and on a website devoted to analysis of the video (for both see: http://www.birds.cornell.edu/ivory/). Although not part of the peer-review record, we briefly address some of the additional points raised. (i) In the presentation by K. Rosenberg the image of a dark-white-dark pattern identified as an ivory-billed woodpecker differs from the one published in fig. S5A of (*S1*). One of these images reportedly is a "branch stub" (*S5*). We have examined both images, and all others that show similar dark-white-dark patterns in the video (see Fig. S1), and see none that show diagnostic features of an ivory-billed woodpecker. (ii) In the same presentation, and subsequently on the website, a pileated woodpecker wing is shown held against a tree trunk to test how extensive the black trailing edge of the wing would appear. In these tests, the bird's wing was apparently held with the surface perfectly perpendicular to the camera, which maximizes the amount of black visible. This position is very different from the posture we propose in which the bird's wing is almost vertical, tilted away, and moving, as the bird flies from the tree. (iii) J. Fitzpatrick also reported that sounds in an old audio recording from Louisiana have been identified as the wingbeats of an ivory-billed woodpecker and that the rate of those wingbeats closely matched the bird in the Arkansas video. In the absence of any visual confirmation, it is impossible to be certain of the source of these sounds. Furthermore, identification based on the wingbeat rate of the bird in

the Arkansas video requires clear evidence both that it can be matched by an ivory-billed woodpecker and that it cannot be matched by a pileated woodpecker.

**Video reconstruction.** Fig. S2 shows a sequence of consecutive video frames with interpretive sketches, illustrating in full our explanation for the bird's movements during that part of the video. Note that the downstroke is powerful and relatively slow, completed in about 6 video frames. As the downstroke nears its lowest point, the wings are pulled in towards the body as if the bird were rowing through the air. The entire upstroke happens very quickly, in a single frame, and is almost invisible as the wings are pulled in and raised alongside the body before extending again straight up above the body to begin another downstroke (e.g., see frames 233.3 to 333.3 for an entire cycle).

**3. Supporting Figures.**

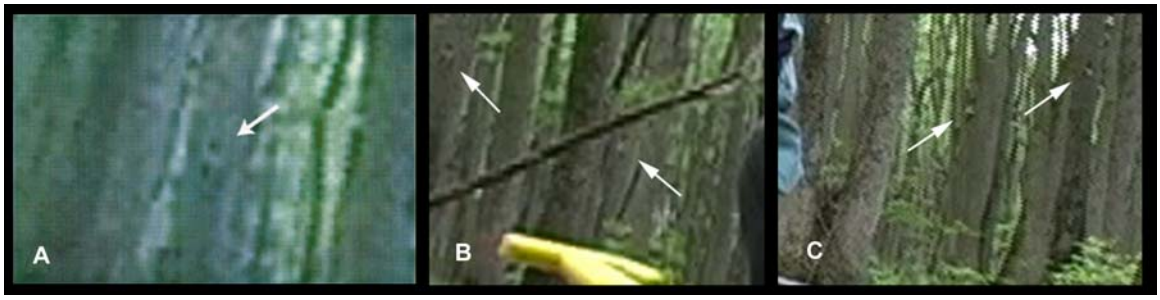
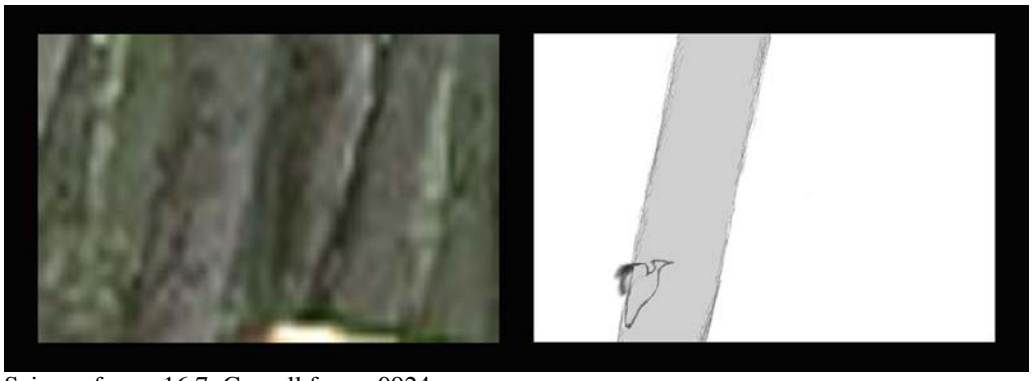
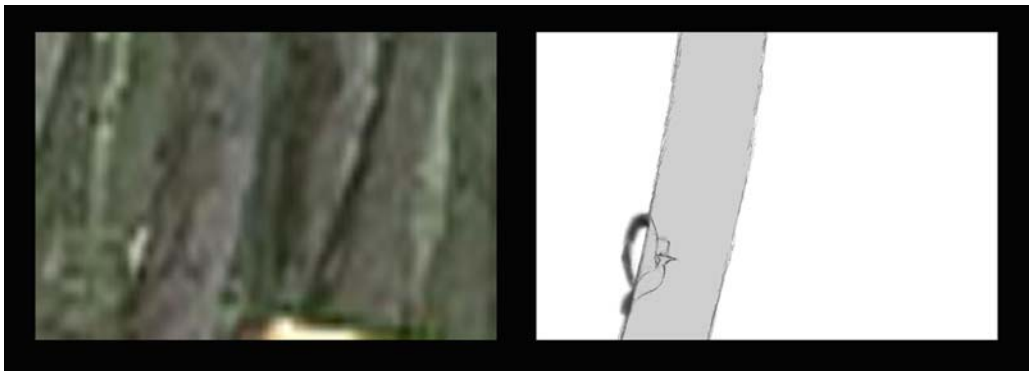



**Figure S1.** A. Video frame identified in fig. S5A of (*S1*) as showing a black-white-black object thought to be a perched ivory-billed woodpecker. B. A portion of frame 0135, a point about 26 seconds before the bird flies in the original video, showing two dark and light patterns (the upper left pattern apparently being the one reproduced in (*S1*) and A here, although that image was taken from an earlier frame; the lower right pattern the one discussed at the AOU conference). C. A portion of frame 1260 that shows two similar patterns on trees to the right of the observers shortly after the bird has flown away.

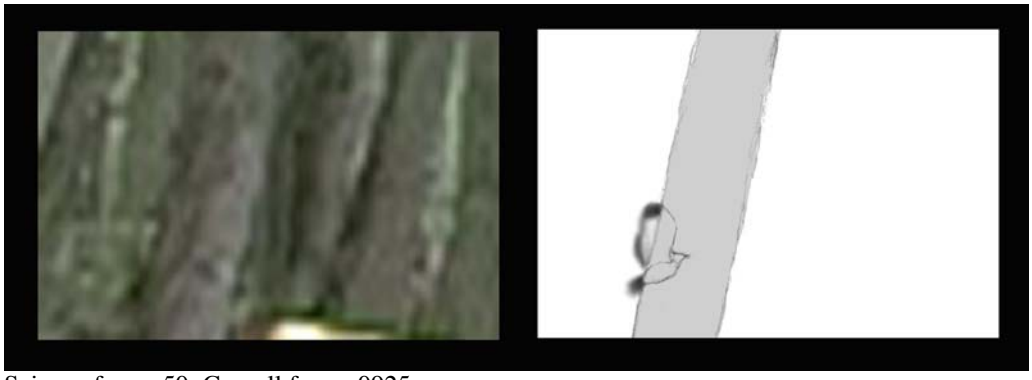
**Figure S2.** Sequence of 23 consecutive frames with interpretive sketches by D. Sibley illustrating our understanding of the bird's movement as it takes off and begins to fly away.



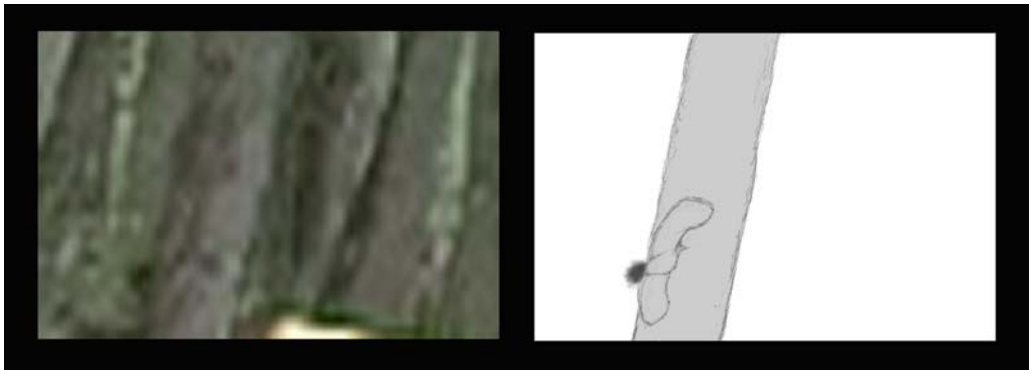
Science frame 16.7; Cornell frame 0924a
Black tip of right wing appears from behind tree



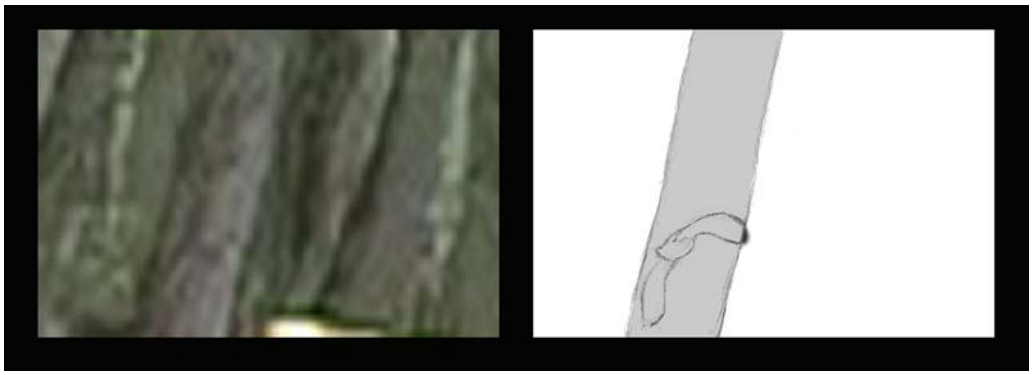
Science frame 33.3; Cornell frame 0924b
Most of right wing appears as it spreads showing the white underwing



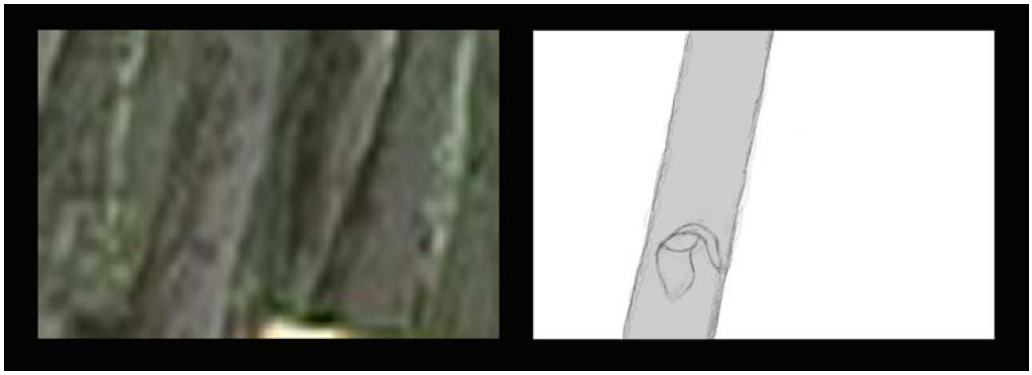
Science frame 50; Cornell frame 0925a
Bird taking flight off back of tree as right wing moves to the right in downstroke and tail swings up. Note the apparent black trailing edge on the wing, consistent with pileated woodpecker, but not with ivory-billed woodpecker. Also, note that the tail's position in this frame is inconsistent with a bird that is positioned vertically on the tree with wings mostly closed, contradicting the interpretation of the white as the white patch on the folded wing of an ivory-billed woodpecker.



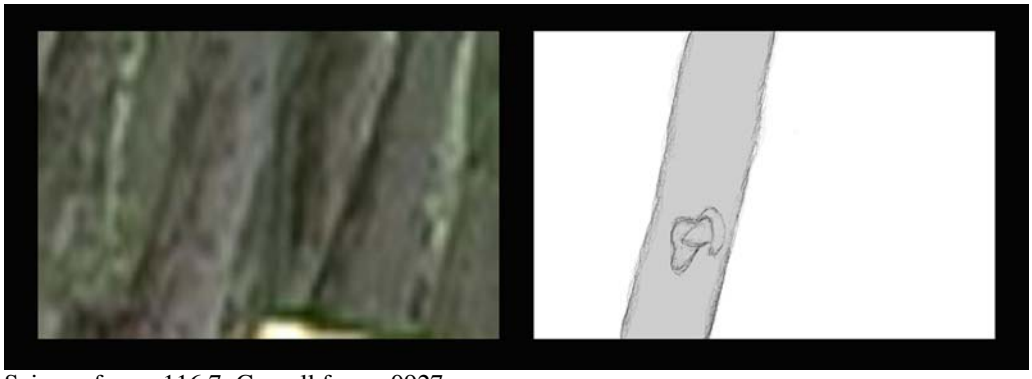
Science frame 66.7; Cornell frame 0925b
Tail still visible and nearly horizontal as bird turns to flap away behind tree.



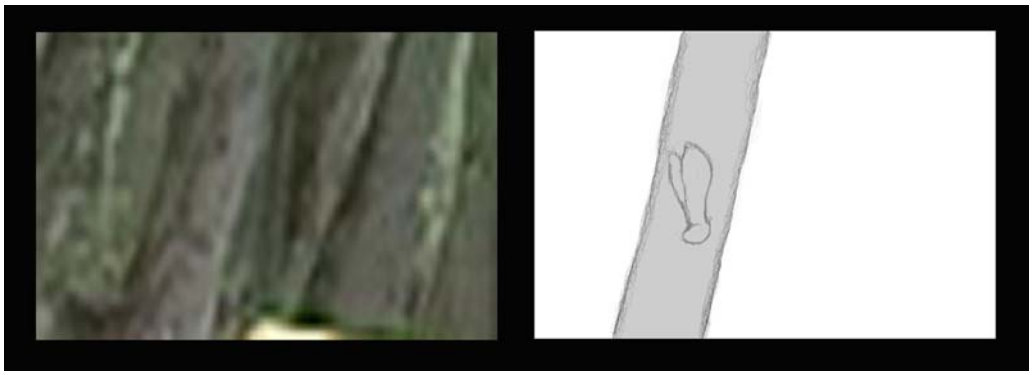
Science frame 83.3; Cornell frame 0926a
Hidden behind tree; a suggestion of black at right of tree trunk could be tip of right wing.



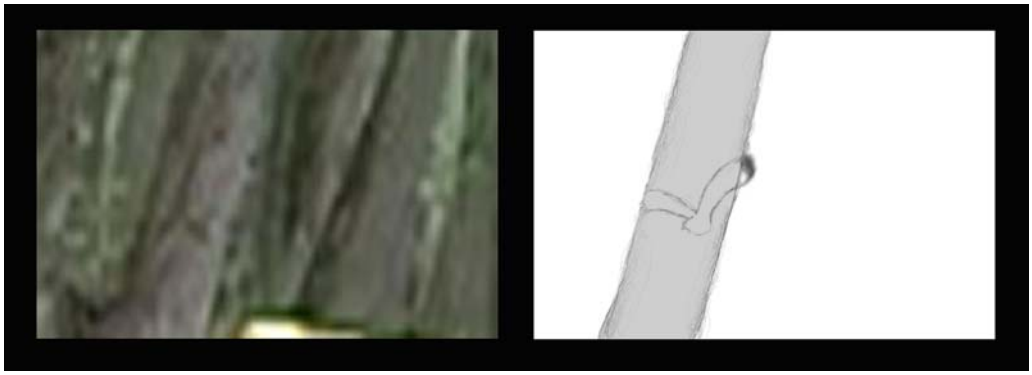
Science frame 100; Cornell frame 0926b
Hidden behind tree; in this and the following two frames the sketch suggests a likely posture for each frame in order to connect the observed motion in frame 83.3 to that in frame 150.



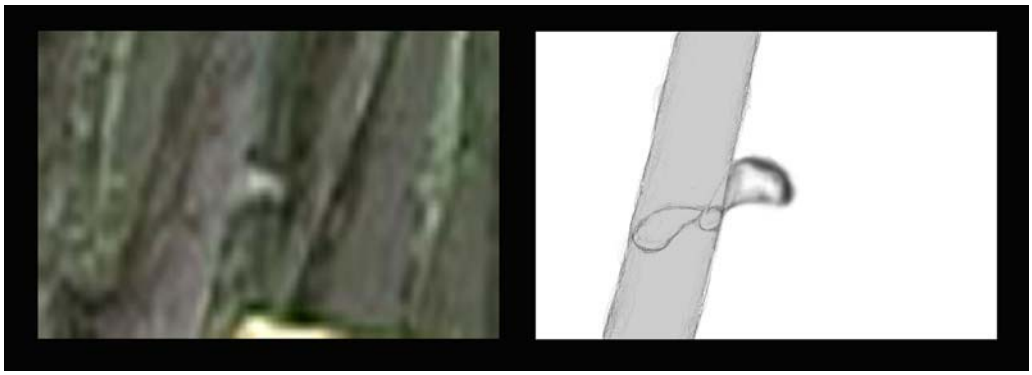
Science frame 116.7; Cornell frame 0927a
Hidden behind tree; sketch suggests a likely posture.



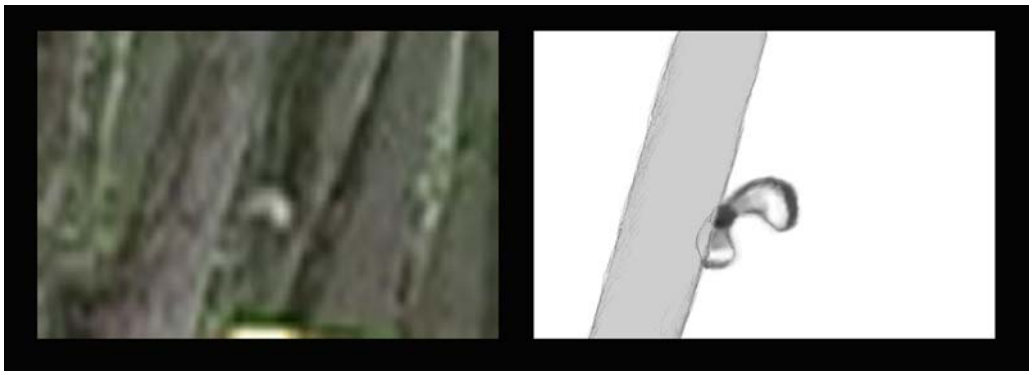
Science frame 133.3; Cornell frame 0927b
Hidden behind tree; sketch suggests a likely posture.



Science frame 150; Cornell frame 0928a
Right wingtip appears on downstroke to right of tree.



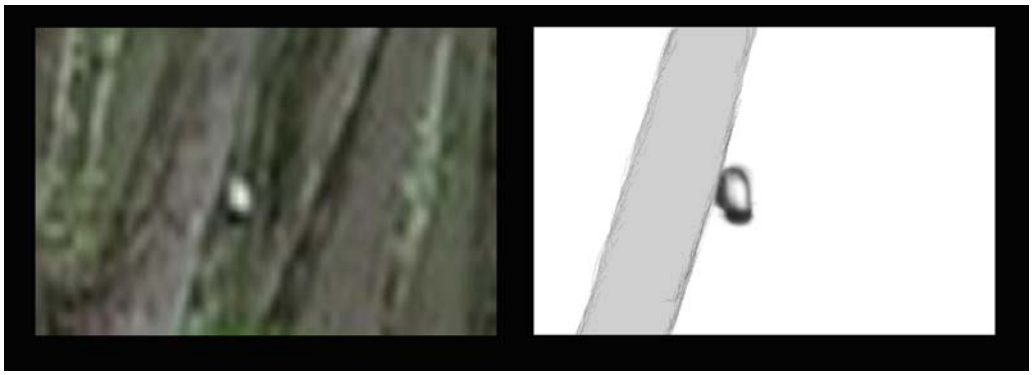
Science frame 166.7; Cornell frame 0928b
Much of ventral surface of right wing visible on downstroke, twisting to show white underside.



Science frame 183.3; Cornell frame 0929a
Body and entire ventral surface right wing visible to right of tree, part of left wing visible below body; showing white underwing and apparent dark trailing edge.

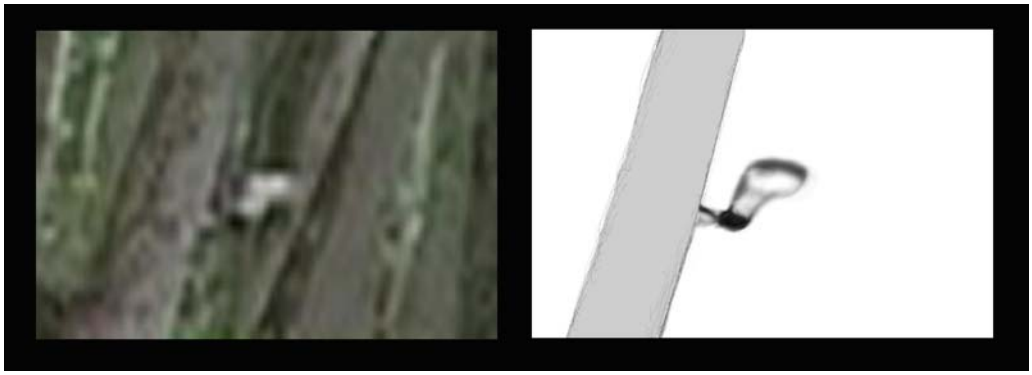
Science frame 200; Cornell frame 0929b
Both wings visible near bottom of downstroke.

Science frame 216.7; Cornell frame 0930a
Wings lifting alongside body in upstroke, The almost complete absence of white is consistent with the dark dorsal surface of pileated woodpecker, and not with the entirely white secondaries of ivory-billed woodpecker.

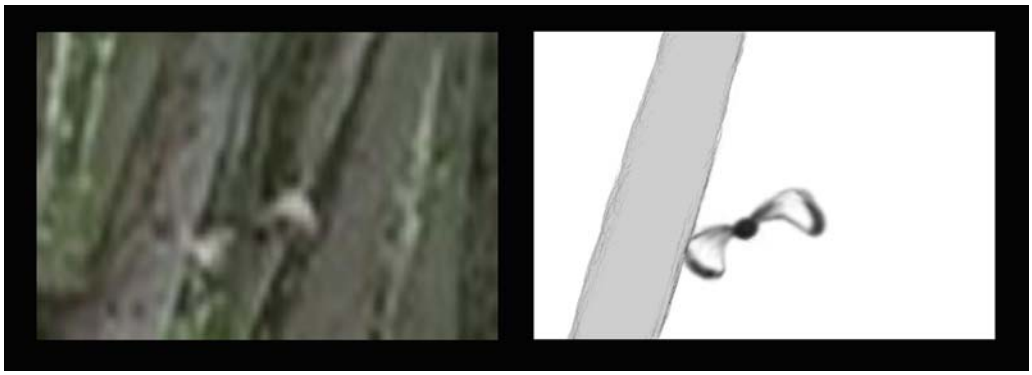


Science frame 233.3; Cornell frame 0930b
Wings extending straight above back near end of upstroke. Right wing appears to have a dark tip and trailing edge, although the poor video quality makes this assessment uncertain. Dorsal surface of the secondaries on left wing appear to be black.

Science frame 250; Cornell frame 0931a
Twisting wings reveal white underwing on both left and right; dark tip of right wing curves down along trailing edge as expected on a pileated woodpecker, but not on ivory-billed woodpecker.

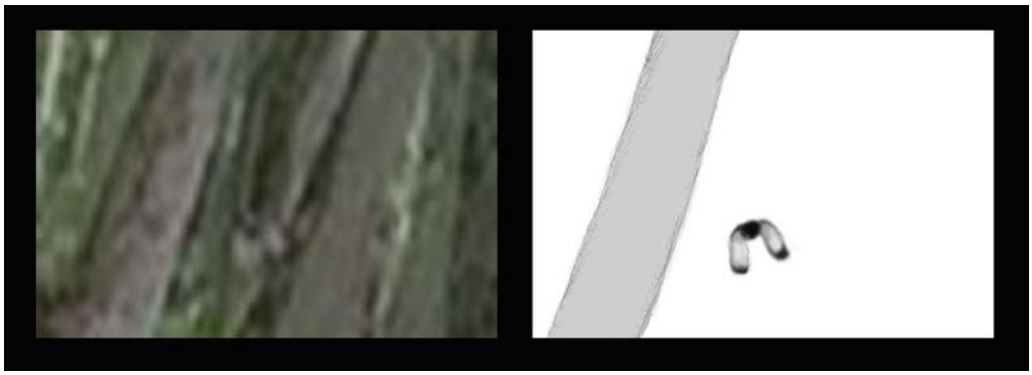


Science frame 266.7; Cornell frame 0931b
Twisting right wing reveals extensive white below, while the left wing shows very little white, less than would be expected on an ivory-billed woodpecker.

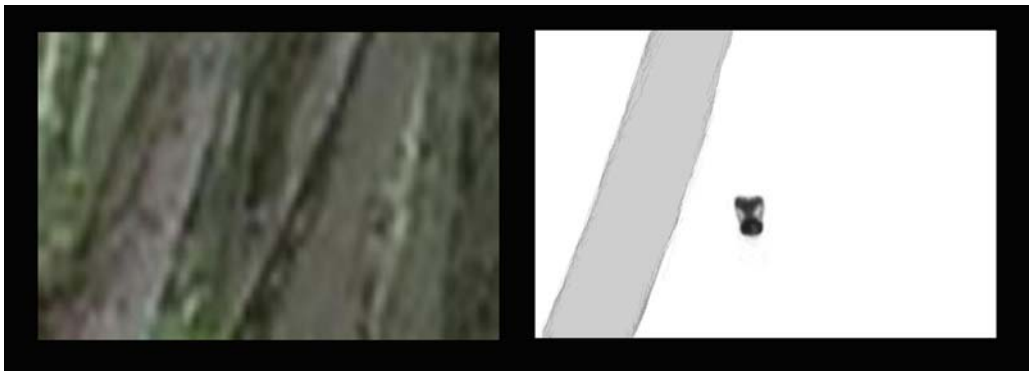


Science frame 283.3; Cornell frame 0932a
Wings tilted forward and viewed from behind show white underside typical of a pileated woodpecker; little white is visible on the wings close to the body contrary to the expectation if one were viewing the tops of an ivory-billed woodpecker's wings.

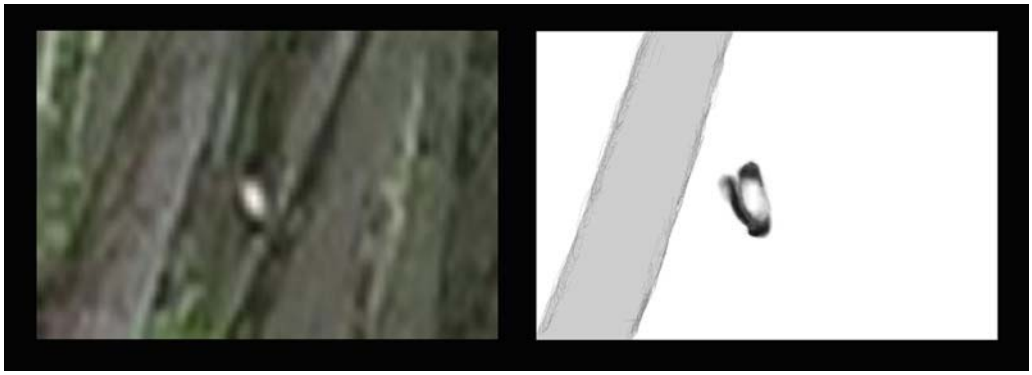
Science frame 300; Cornell frame 0932b
Wings moving quickly and blurred near bottom of downstroke; twisting to reveal underside and pulled in slightly as they move down. Note the bright white blur just inside the black wingtips. This is consistent with the wing pattern of a pileated woodpecker and not with that of an ivory-billed woodpecker.



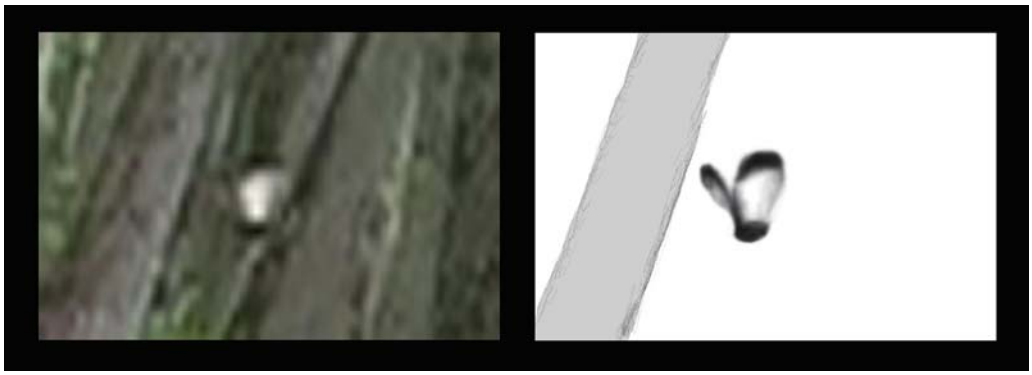
Science frame 316.7; Cornell frame 0933a
Near bottom of downstroke, the wings are already being pulled in and up towards the body.



Science frame 333.3; Cornell frame 0933b
Wings close together and rising above body in middle of upstroke. Tiny bit of white visible is most likely part of the underwing coverts. An ivory-billed woodpecker would not be expected to show so little white with the wings folded.

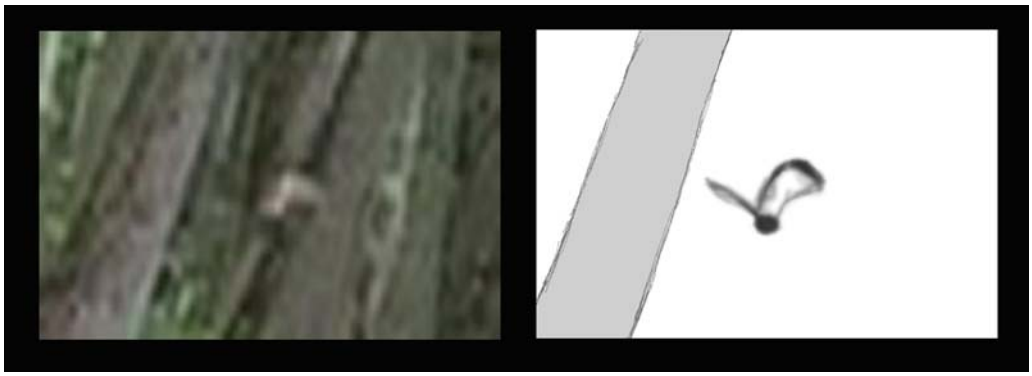


Science frame 350; Cornell frame 0934a
Wings extending straight above body at end of upstroke (similar to frame 233.3), just before wing-twisting effects of downstroke. Note the solid black edge of the left wing, apparently the dorsal surface of the secondaries. This color pattern is typical of pileated woodpecker and not correct for ivory-billed woodpecker, which would show a solid white trailing edge to the wing.



Science frame 366.7; Cornell frame 0934b
Beginning of downstroke with white visible on underside of both wings, again due to twisting. Right wing reveals the full extent of the white underwing coverts. Left wing exposes just a small part of the shaded white underwing coverts. Note the mostly dark left wing and the black tip of the right wing curving down

along the trailing edge. These features are consistent with the appearance of pileated woodpecker but not with that of ivory-billed woodpecker.



Science frame 383.3; Cornell frame 0935a
Downstroke continues, with both wings blurred and twisting. Ventral surface of right wing obvious, but left wing viewed edge-on. The relative obscurity of the left wing in this frame is consistent only with pileated woodpecker, as the white secondaries of ivory-billed woodpecker should always be conspicuous in a rear view, especially given the exaggeration of white in the video imaging process.

**4. Supporting References.**


S1. J. W. Fitzpatrick *et al*., *Science*, **308**, 1460 (2005).

S2. F. Richardson, *Univ. Calif. Publ. Zool*., **46**, 317 (1942).

S3. B. W. Tobalske, *Auk* **113**, 151 (1996).

S4. J. T. Tanner, *The Ivory-billed Woodpecker*, Research Report No. 1 (National Audubon Society, New York, 1942).

S5. J. A. Jackson, *Auk,* **123**, 1-15 (2006).

S6. E. M. Queeny, Prairie Wings, p. 176 (J. B. Lippincott, New York, 1947; Dover Publications edition).