Catch, Release, Catch Again

Is bird banding still valuable in the 21st century?

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On a brisk July morning in Yosemite National Park, Lauren Helton walks up to a mist net near Hodgdon Meadow to find she has caught a Wilson's Warbler. With deft fingers, Helton quickly untangles the tiny bird, pops it into a soft cotton bag, and walks back to the bird banding station where the science will happen.

Helton, and now the warbler, are taking part in a 30-year-old bird banding program called MAPS, which stands for Monitoring Avian Productivity and Survivorship. The program is coordinated by The Institute for Bird Populations (IBP), but MAPS is really a collaboration of bird banders across North America, collecting critical data on birds and contributing the data to IBP for archiving in a central database available to scientists. The MAPS database contains over 2.5 million bird capture records covering almost every state in the U. S. and every Canadian province.

The MAPS program was started by IBP's founder David DeSante in 1989, but scientists have been banding birds since at least the 1890s. Why are we still using this antique technique in 2020? We now have sophisticated technology like miniaturized GPS transmitters and smart phones with eBird. What can a bird in the hand and a small metal band tell us that these other things can't? Quite a bit, it turns out.

For instance, after banding the bird, one of the first things Helton does is carefully examine the bird's skull. To Helton's trained eye, the skull provides important clues about the bird's age. Though it sounds grim, "skulling" is a non-invasive process. Small songbirds have conveniently thin, translucent skin. By holding the head feathers aside, Helton can see right through the skin to the crown of the skull.

Birds' skulls are delicate, especially when they are young. Initially the skull consists of a single thin layer of bone, which is translucent just like the skin. But as the bird ages a second layer forms, connected to the first with a series of struts. The additional layer and struts give the mature skull a less translucent and "stippled" appearance. Skull maturation occurs at different times in different species.

For Wilson's Warblers and most other wood-warblers, the second layer of the skull is completed in the autumn after hatching. Helton's examination shows this Wilson's Warbler's skull is only partially covered by a second layer, so, although the bird superficially appears to be an adult female, it hatched just a month or two ago.

If we observed this Wilson's Warbler through binoculars, we might assume it's an adult female, but it isn't. Helton will record its age as "hatch-year," which means it hatched within the past few months, it is not reproductively mature, and it won't breed until at least next spring.

Why is distinguishing a "hatch-year" bird from an "after-hatch-year" bird so important to population biologists? It helps them determine what stages in a bird's life cycle are driving changes in the population, by allowing them to estimate a key demographic parameter: *productivity*. Productivity is the rate at which young are produced and is estimated by comparing the number of hatch-year birds caught throughout the summer to the number of adult, or after hatch-year, birds caught.

Putting an old-fashioned band on a bird also permits estimates of the other two key demographic parameters: *survival* and *recruitment*. Most songbirds breed in the same area from year to year (especially if they are successful there), so the proportion of banded birds that are recaptured the following year is a good gauge of survival.

With some fancy math and information about population trends, you can then estimate recruitment. Recruitment in this case is the rate that breeding individuals are added to the population, either by surviving to breeding age or by emigrating from another population. Recruitment is critical because a given population might be very productive, hatching lots of chicks, but if too few of those chicks survive to make chicks of their own (low recruitment), the population will decline.

Sadly, populations of Wilson's Warblers are declining. In its 2014 climate report, the National Audubon Society categorized the species as being at risk due to climate change. In a recent study published in the scientific journal *Ecology and Evolution*, IBP researcher Jim Saracco, along with U. S. Geological Survey biologist Madeleine Rubenstein, used age data from Wilson's Warblers captured at MAPS stations to help understand productivity and recruitment. Based on 16 years of MAPS data from coastal California, the Sierra Nevada, and the Pacific Northwest, the researchers found that productivity and recruitment had a bigger effect on population growth than adult survival.

They also found that climate variability affected warblers' productivity and survival. Productivity was increased by warmer spring temperatures, possibly because warmer springs mean more insects to feed nestlings. Drought in portions of Mexico, where the Wilson's Warbler populations breeding in the Sierra Nevada and coastal California spend the winter, reduced adult survival in those populations.

Climate change is a broad term encompassing changes in temperature, precipitation, and other factors that vary from region to region. Studies like Saracco and Rubenstein's identify specific aspects of climate change that affect species like the Wilson's Warbler, and help target conservation efforts toward key points in the species' life cycle. But this study would not be possible without old-fashioned bird

The adult male **Wilson's Warbler** is easy to recognize to species, but what about all the aspects of warbler biology that go beyond field identification? The MAPS program (Monitoring Avian Productivity and Survivorship) emphasizes the importance of studying birds' age, molt, reproductive status, and more. The eventual goal is to develop a comprehensive view of avian population dynamics in North America. *Box Elder County, Utah; Sept. 23, 2018. Photo by © Mia McPherson.*

banding and the careful age determinations made by MAPS banders like Helton.

Back to the warbler in hand, Helton turns her attention to its feathers. MAPS banders collect detailed information on feather condition and molt. Helton blows on the bird's body, ruffling the plumage to look for "pin feathers" or newly emerged feathers still partially covered in their sheaths. She gently extends the bird's wings, examining the flight feathers for wear to determine if they've been recently replaced. Helton also examines the wing coverts and the tail.

Why focus on feathers? First, they provide another set of clues about a bird's age. Even in species without distinctive juvenile plumages, a bird's first set of adult feathers typically has subtle but diagnostic differences from its second set. Also, molt is an energetically demanding and essential process in a bird's life. Understanding the timing and the process of molt can yield insights into what bird populations need to thrive.

The bird banding process provides the only opportunity to assess molt in songbirds. In some larger species, such as shorebirds or gulls, a good photo may be all you need to examine a bird's feathers, but for most species this strategy is often impractical. With smaller birds that inhabit dense vegetation, like the Wilson's Warbler, a bird in the hand provides by far the best look at individual feathers.

And feathers are worth a closer look. In 2018, IBP scientists analyzed data from 936 MAPS banding stations to learn where different species molt. Most migratory landbirds in North America had long been thought to molt on the breeding grounds just before they migrate to their winter habitats. But a few species were known to undergo a *molt migration*, moving to discrete *molting grounds* where they replace their feathers before migrating to their wintering grounds.

IBP

The Institute for Bird Populations applies both traditional and emerging methods to the study of avian population health.

The scientists wondered if molt migration might be more widespread than previously known. So, they calculated the probability of catching molting birds at the same MAPS station where that individual was also known to breed. They found evidence that many species, including several previously thought to molt on their breeding grounds, are actually *molt migrants*.

Although the breeding grounds may have plenty of food early in the summer, food availability may decline towards the end of the season—especially in the arid Interior West, where molt migration is especially prevalent. Molt migrants are on the move to take advantage of habitats where food is more abundant late in the summer so they have the necessary energy to replace their feathers. In Colorado and elsewhere in the Western Interior, molt migrants may be on the move as early as late June, around the time of the solstice!

The discovery that molt migration is more common than previously thought has significant conservation implications. To conserve birds, we must protect the habitat they need

Is this "just a female" **Wilson's Warbler?** If so, is it a hatch-year or after-hatch-year female? Could it be a hatch-year male? Digital photography and other technologies have improved our ability to resolve such questions, but bird banding gives us access to avian morphology and physiology that other methods cannot. *Box Elder County, Utah; Sept. 2, 2018. Photo by © Mia McPherson.*

through their entire life cycle. Molt is an important part of that life cycle, and protecting the habitat where birds undergo molt will help conserve populations.

At the banding station, Helton next looks to see if the Wilson's Warbler is in breeding condition. If the bird has a brood patch, she notes that and scores its condition. A bare and swollen brood patch indicates that a bird is actively incubating eggs or nestlings, whereas a shriveled brood patch suggests that incubation is complete. Likewise, if the warbler has a cloacal protuberance, Helton notes its development. These details provide information on the timing of the breeding cycle and serve as an accuracy check. If a bander records a bird as female based on plumage, but also records that the bird has a cloacal protuberance, clearly a mistake has been made and it will be flagged in the data proofing process.

Next, Helton assesses the warbler's body condition. The translucent skin of songbirds makes it easy to see subcutaneous fat deposits on the abdomen and above the clavicle. Body fat is a useful clue about food abundance and whether a bird is migrating. In early summer, a bird with ample fat deposits is likely a migrant passing through, still fueled up for the journey north. Birds also pack on the pounds—or, in their case, a few grams—prior to migrating south at the end of the summer.

Finally, Helton takes a few measurements, including wing and tail length and body mass. This will allow scientists to look at a more complex metric like the bird's body mass index. Researchers are currently using MAPS data to determine how wing length and body size might change as birds age.

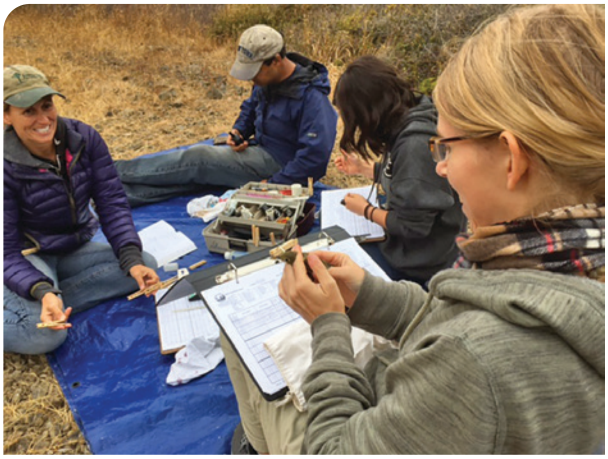
A bird in the hand is an opportunity. With advances in genetic sequencing and miniaturized tracking devices, many MAPS banders are adding a high-tech element to their banding protocol. For instance, by plucking a single feather, MAPS banders can collect enough DNA to allow scientists to do advanced genetic sequencing of individual birds.

Researchers have used DNA samples collected by MAPS banders, as well as by banders participating in its sister program, MoSI (Monitoreo de Supervivencia Invernal, or "monitoring overwinter survival"). MoSI operates in Latin America and the Caribbean—to examine *migratory connectivity* in Wilson's Warblers and other birds. Migratory connectivity is the degree to which birds from the same breeding site migrate to the same wintering site. Understanding migratory connectivity is critical for conservation because population declines observed on the breeding grounds may be caused by factors on the wintering grounds and vice versa.

The researchers have identified six genetically distinct groups of Wilson's Warblers, as well as each group's migratory route and wintering region. Wilson's Warblers that breed in the Pacific Northwest, Coastal California, and the Sierra Nevada all winter in the same region in western Mexico, but only the group that breeds in the Sierra Nevada has shown significant population declines. This strongly suggests that the cause of the population decline lies at the breeding grounds rather than in winter habitat. This finding will help make conservation efforts more precise and effective, and would not be possible without the broad network of MAPS and MoSI banding stations.

The vast majority of **Wilson's Warblers** spend a considerable chunk of time each year south of the Mexico–U. S. border. That's where MoSI (Monitoreo de Supervivencia Invernal, "monitoring overwinter survival") comes into view. MoSI operates in Latin America and the Caribbean, and provides valuable data on such phenomena as migratory connectivity across species' entire ranges. *Parque Ecológico de Tepic, Nayarit; Oct. 13, 2018. Photo by © José Antonio Robles Martínez.*

Another way to look at migratory connectivity is to track movements of individual birds. In the summer of 2019, Hankyu Kim, a doctoral candidate at Oregon State University studying migratory connectivity in Hermit Warblers, teamed up with IBP's MAPS banders in Yosemite to fit the birds with geolocator devices. Geolocators are tiny, weighing just 0.4 grams, and consist of a light sensor, internal clock, tiny battery, and miniature computer. The device is secured on the bird with leg loops that allow the warbler to wear it like



MAPS researcher Lauren Helton (right) handles a Pacific-slope Flycatcher, making measurements that are routine on a bird in the hand but essentially impossible otherwise. *Photos by © Steve Albert.*

a tiny fanny pack—a fanny pack that will allow Kim to track the warbler through its entire migratory cycle.

Geolocators use light levels and an internal clock to estimate a bird's location—a simple but elegant triangulation. The timing of sunrise (relative to a standard clock) gives an estimate of longitude, and latitude can be estimated by day length. To make a geolocator small enough for an 11-gram Hermit Warbler to carry, you have to sacrifice the ability to transmit data. So, to get the location information off the geolocator, the warbler must be recaptured. Hermit Warblers usually return to breeding territories where they've been successful, so there is a good chance that some of the geolocator-tagged Hermit Warblers will be recaptured at the MAPS stations in the summer of 2020. If they are, MAPS banders will remove the geolocators and return them to Kim for analysis.

Sophisticated genetic analysis and high-tech tracking devices add value to bird banding but are unlikely to replace it anytime soon. Only close visual inspection and measurements can provide crucial information on a bird's age, sex, and body condition. And after all, you have to have a bird in the hand to collect a DNA sample or apply a tracking device.

Helton's examination of the Wilson's Warbler yields a lot of data, but with her ample experience she completes it quickly—typically in under a minute—and releases the warbler unharmed. At the end of the summer, the capture record of this Wilson's Warbler, and all the other birds caught at the station this banding season, will be submitted to IBP—but the story doesn't end there.

Before the record is incorporated into the MAPS database, it goes through a meticulous proofing process. Banders are humans, and humans make mistakes. That is why IBP staff members do cross-checks to ensure that the record is correct before it is added to the database. The MAPS database is used by many scientists for a variety of research purposes; any errors could be propagated widely, so IBP works hard to ferret them out.

The rigorous proofing process is time-consuming and requires funding, but it is worth it. The MAPS database is one of the most accurate and well-regarded bird datasets available to scientists, and its significance is increasing every year with the growing volume of records. It has become prized as a long-term, geographically broad dataset. MAPS is precisely the kind of dataset needed to study long-term and large-scale processes like climate change and habitat loss.

IBP scientists recently used data from some of the longest-running MAPS stations in Yosemite to examine how climate variation affected montane birds over a period of 24 years. They found that warmer spring temperatures led to increased productivity—perhaps a bit of good news in the face of global warming. And the detailed age data in the MAPS dataset allowed the scientists to discern changes in the timing of breeding. As the climate warmed over the study period and snow melted earlier, birds adapted by breeding earlier in the season. Again, this is encouraging news, although birds' ability to track these changes in climate likely has limits.

Bird banding is done for science, not recreation. MAPS banders take the welfare of the birds they handle very seriously and work to minimize the stress that birds experience.

The methodological mainstay of MAPS is capture–recapture study of banded birds, but the program is also embracing newer technologies. Here, MAPS researcher Hankyu Kim affixes a geolocator to a Hermit Warbler, with the goal of better understanding where the species winters—and how it gets to the wintering grounds. *Photo by © Lauren Helton.*

Having a bird in the hand allows you to collect scientifically valuable information, but there nevertheless is also something a bit magical about the experience.

Waking at oh-dark-thirty, unfurling mist nets with cold fingers, and sharing thermoses of coffee creates a camaraderie among MAPS banders. Marveling over the delicate feathered wonders that you have the privilege to hold in your hand makes for shared memories that foster a community. MAPS banding stations have produced many fast friendships in addition to data.

Those early mornings, hard work, and painstaking data verification also leave a legacy—a data resource that scientists can use to answer critical questions in conservation, including new questions we may not conceive of until decades from now. And in our present moment, with bird populations showing alarming declines, more than ever, we need the kind of information that only a bird in the hand can provide.