7-8 JULY 2020 VIRTUAL WORKSHOP

THE ROAD TO RECOVERY

PHASE 1: IDENTIFYING CAUSES OF BIRD DECLINES

ACKNOWLEDGEMENT

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EXECUTIVE SUMMARY

JUSTIFICATION

The recent publication in Science documented the loss of nearly 3 billion birds from the North American avifauna. Although general threats to birds are well known, we still cannot point to the specific causes of declines for most bird species. We must take a species-specific approach to understand species- and population-specific limiting factors across the full annual cycle, including knowledge of migratory connectivity and demographically distinct populations. This will allow us to efficiently target limited conservation resources to the highest-priority landscapes.

THE ROAD TO RECOVERY

The purpose of this first virtual workshop in the Road to Recovery sequence was to initiate the process of consolidating knowledge of life history, available data, and analytical approaches in order to develop a clear and complete roadmap toward identifying the specific causes of declines for bird species breeding in the U.S. and Canada. The workshop convened 122 virtual attendees to hear from experts on (1) priority taxa and specific threats to birds; (2) current statistical approaches, such as integrated population modeling; and (4) data availability (especially tracking and vital rate information) necessary for identifying causes of declines.

The Road to Recovery Workshop (Part 1) highlighted the need to focus research and action on priority species that are (1) at risk of slipping into threatened or endangered status or (2) common, but whose declines make up a large percentage of the overall loss in bird abundance. To this end, we must first determine where each species is situated along the road to recovery, from a starting point of little knowledge of a species' broad threats or specific limiting factors, toward an end goal of identifying limiting population factors, developing a full annual cycle conservation business plan, and implementing targeted conservation actions to address and reverse declines.

SCIENCE NEEDS

Science Needs: New research to identify species' limiting factors should be geared towards developing Full Annual Cycle models. Understanding where populations are limited requires distinct estimates for parameters like adult and juvenile survival during each part of the annual cycle. In addition to temporal variation in vital rates throughout the annual cycle, we need to better understand spatial variation in population trends and vital rates within seasons. Finally, a key component of identifying limiting population factors across geographic space and throughout the full annual cycle is understanding population and migratory connectivity. Breeding and non-breeding populations of migratory species are often structured and linked through the annual cycle, and we need to determine for each species which breeding and non-breeding populations are linked, via which migratory pathways, and how strongly.

EXECUTIVE SUMMARY

ROAD TO RECOVERY PART 2

To this end, Part 2 of the Road to Recovery workshop (1-3 December 2020) will focus on linking populations via research on migratory connectivity and demographics. This second virtual workshop will convene experts on tracking techniques, genoscape analysis, and demographic analysis across the full annual cycle. In addition to talks, the workshop will include interactive demonstrations of how to incorporate demographic and migratory connectivity data into full annual cycle models (such as Integrated Population Models) in order to pinpoint specific causes of decline.

LINKING RESEARCH TO CONSERVATION ACTION

While this first workshop focused primarily on research needs and emerging tools and methods for addressing the loss of 3 billion birds in North America, it is clear that science alone will not be enough to recover North America's avifauna. Reimagining bird conservation will involve fostering better communication between researchers and the general public, conservation practitioners, and policy-makers. Multiple stakeholders should work together to articulate a coordinated plan that identifies data gaps as well as relevant decision-makers and governance structures, and links new research with potential management actions.

FUNDING THE RECOVERY

Although it is important to allocate available funding efficiently, it is equally important for the bird conservation movement to work across both public and private sectors to mobilize more funding for bird conservation from a broader range of sources. Conserving North America's avifauna will require conducting research and protecting or restoring habitat outside North America, where Neotropical migrants spend the majority of the year. Thus it is critical to convince U.S. and Canadian federal agencies to recognize the importance of non-breeding habitat and migratory stopover areas for North American species, and to fund research on and protection of those areas. We must also seek to leverage larger funding sources from the private sector. Finally, the scale of habitat protection and restoration necessary to address bird declines will require broadening potential funding sources beyond those tailored specifically toward bird conservation, and tapping into funding tied to broader initiatives around forest restoration or general sustainability.

THE DECLINE OF NORTH AMERICAN BIRDS

Problem Statement: The recent publication in Science documented the loss of nearly 3 billion birds from the North American avifauna; loss of abundance is pervasive across biomes, taxonomic groups, and among common and familiar species. Although general threats to birds are well known (e.g., habitat loss, anthropogenic causes of mortality), we still cannot point to the specific causes of declines for most bird species. These need to be assessed on a species-by-species basis, even if solutions to reverse declines are implemented more broadly across habitats, geographies, or suites of species. Understanding species- and population-specific limiting factors (the "smoking guns") across the full annual cycle, including knowledge of migratory connectivity and demographically distinct populations, will allow us to efficiently target limited conservation resources to the highest-priority landscapes.

Workshop Purpose: The purpose of this first virtual workshop in the Road to Recovery sequence will be to initiate the process of consolidating knowledge of life history, available data, and analytical approaches in order to develop a clear and complete roadmap toward identifying the specific causes of declines for bird species breeding in the U.S. and Canada.

Who will attend: Individuals and groups with expertise on (1) priority taxa and specific threats to birds; (2) population structure and migratory connectivity, (3) current statistical approaches, such as integrated population modeling; and (4) data availability (especially tracking and vital rates information) necessary for identifying causes of declines. Individuals with expertise in incorporating new science into conservation investment strategies and other plans will also participate; their expertise will be especially valuable in subsequent phases of the Road to Recovery. The workshop is grounded on conversations that emerged from the work of the Partners in Flight Science Committee and the American Ornithological Society Conservation Committee.

Desired Outcomes for Phase 1

- An inventory and urgency short list of declining bird species—based on criteria discussed prior to and introduced at the workshop—for which targeted research will be needed in order to identify causes of declines and initiate effective recovery actions
- Convergence on what it means to identify the specific causes of declines in bird populations—i.e., the critical pieces of evidence, or the "smoking guns"
- Consensus around a strategic approach for identifying causes of decline and proceeding down the road to species recovery

AGENDA

TUESDAY 7 JULY, 1:00 - 3:30PM EDT

1:00 Welcome and logistics (Tom Will)
1:10 Why are we here? — Developing a vision for recovering our avifauna (Pete Marra)
1:30 The Road to Recovery: Which species do we focus on first? (Ken Rosenberg)
2:00 KEYNOTE: Déjà vu? Paradigms for diagnosing causes of decline from 50 years of effort with T&E species — Steve Beissinger, University of California Berkeley

Populations decline because a demographic rate is depressed. But which one(s) and why? Different paradigms have emerged from conservation biology, wildlife management, and population ecology over the last 50 years for determining how to recover threatened species. The Small Population Paradigm evaluates extinction risk from various forms of stochastic and deterministic threats is contrasted with the Declining Population Paradigm, which uses multiple approaches to diagnose limiting factors causing decline. A similar dichotomy exists in population ecology from Prospective versus Retrospective analyses of demographic (matrix) models. While new statistical approaches with promise continue to emerge, like integrative population models, can they overcome data limitations? What challenges are you likely to encounter in making a diagnosis? What if the smoking gun is no longer smoking? What kinds of baselines are meaningful in the Anthropocene?

2:30 Lightning Talks and PANEL DISCUSSION — Perspectives on determining the causes of decline (Tom Will, moderating)

Scott Loss, Oklahoma State University — Importance of demographic compensation/additivity in identifying causes of bird decline

Viviana Ruiz, Cornell Lab of Ornithology — Data integration tools for improving population-level inferences: how do we assess the smoking guns?

Evan Buechley, Smithsonian Migratory Bird Center & HawkWatch International — Promises and challenges of using remote-tracking technologies to identify when, where, and why birds die

Steve Beissinger, University of California Berkeley

3:25 Wrap-up, Next Day (Tom Will)
3:30 ADJOURN

AGENDA

WEDNESDAY 8 JULY, 1:00 - 3:45PM EDT

1:00 Welcome and Recap (Tom Will)
1:10 - 1:30 Case Studies: What do recent approaches to full life cycle recovery conservation look like?
1:10 Scott Boomer and Patrick Devers, USFWS, Branch of Assessment & Decision Support — Evaluating population responses to national habitat and harvest management programs; lessons learned from waterfowl management

1:30 DISCUSSION: Q&A

1:45 - 2:45 Case Studies (continued): Recent approaches to full life cycle recovery conservation
1:45 Jim Lyons, USGS Patuxent — Conservation challenges and the annual cycle of Red Knots
2:00 Orin Robinson, Cornell Lab of Ornithology — Using eBird and Integrated Population Models (IPM) to understand Tricolored Blackbird causes of decline
2:15 Clark Rushing, Utah State University — Regional variation in the importance of breeding and non-breeding habitat loss in a declining migratory songbird
2:30 Hannah Nevins, American Bird Conservancy — Insights from multiple approaches to recover declining seabirds

2:45 PANEL DISCUSSION: What have we learned from recent attempts to reverse species declines? (Tom Will, moderating)
3:15 Revisiting the Vision & Next Steps (Ken Rosenberg and Pete Marra)
3:45 ADJOURN

SUMMARY OF TALKS: TUESDAY 7 JULY 2020

Purpose: Identify high-level scientific themes and concepts that contribute to our ability to understand the causes of avian declines

Pete Marra (Georgetown University): *Why are we here? — Developing a vision for recovering our avifauna*

The 2019 Science paper on the decline of the North American avifauna represents another watershed moment in bird conservation. Like the overharvest of herons and egrets in the early 1900s that led to the passing of the Migratory Bird Treaty Act; the DDT crisis in the 1940s that spurred the Endangered Species Act; or recognition of declines in 156 Neotropical migratory bird species by Robbins et al. in 1989 that motivated the establishment of Partners In Flight, the Smithsonian Migratory Bird Center, and the American Bird Conservancy; this Science paper must be another wakeup call for bird conservation.

Five "game-changers" give reason for hope in this moment: We have (1) an unprecedented coalition of bird research and conservation organizations (including Partners In Flight, NACBI, DOI, CLO, NAS, ABC, and academic institutions); (2) new science and technologies to identify limiting factors for bird populations; (3) a new range of conservation investment strategies; (4) a bold new legislative agenda (e.g. the Recovering America's Wildlife Act); and (5) unified messaging around the need to bring back 3 billion birds. This context will facilitate research to understand the causes of decline as well as the development of conservation policy and action.

This workshop will address several important questions:

- Which are the highest priority species?
- Where are the knowledge gaps for determining population limiting factors?
- How do we collect data to fill those gaps?
- What is the plan for species recovery?

Ken Rosenberg (Cornell Lab of Ornithology): *The Road to Recovery: Which species do we focus on first?*

Given limited funding for conservation, it is critical to identify the bird species in the most dire need of attention. We should focus on species that may soon slide into threatened or endangered status without conservation action, because once a species is listed, management becomes politicized and expensive. We are proposing (1) that coordinated future research focus on individual priority species and (2) a system for prioritizing species based on 3 metrics. These metrics are: (1) a Combined Concern Score (CCS), which in turn incorporates six vulnerability measures including global population size, breeding and non-breeding distribution, threats during both the breeding and non-breeding season, and population trend; (2) population change since 1970; and (2) an urgency metric, based on a species' half-life (the number of years until a species is projected to lose another 50% of its population). Under this proposed ranking system, there are 46 highest priority species that score highly in all 3 metrics (concern score, population change since 1970, and urgency).

Our first step should be to map each priority species along its Road to Recovery. We envision 7 generalizable stages along this road to recovery, from Level 1 (little known about the species, no conservation actions taken) to Level 7 (full life cycle conservation plan completed, limiting population factors identified, targeted conservation actions and costs identified, conservation actions implemented). We have created an open-access spreadsheet, or "species matrix" for researchers and members of species working groups to input existing information about each priority species. This will facilitate understanding where each species is situated along the road to recovery, identifying knowledge gaps, and targeting additional research using existing or new data.

SUMMARY OF TALKS: TUESDAY 7 JULY 2020

KEYNOTE

Steve Beissinger (UC Berkeley): *Déjà vu? Paradigms for diagnosing causes of decline from 50 years of effort with T&E species*

Historically there have been two main paradigms for diagnosing and recovering endangered species: the small population paradigm, and the declining population paradigm. The small population paradigm has focused on the role of (demographic, environmental) stochasticity in extinction risk for small populations. Population Viability Analyses (PVAs) are often used to project population dynamics into the future to estimate extinction risk over the next 50-100 years. The declining population paradigm deals with populations of any size, and focuses on whether there is a population trend and if so, why the population is declining or in a bottleneck. Diagnosing population declines requires determining which part of a species' demography is depressed and which factors contribute to the depressed rate. Reversing declines requires addressing those factors that cause depressed demographic rates for a species.

There are six general approaches for diagnosing the causes of population declines: experimentation to manipulate candidate factors and measure demographic responses; modeling of population responses to candidate variables; comparisons of populations exhibiting different trends to identify which demographic rates differ; comparisons of ecological or life-history traits between species with different population trends; analysis of the timing of decline to compare environmental variables before and after population declines; and development of multiple competing hypotheses that correspond to distinct predictions, and comparison of observed to expected patterns.

In diagnosing the causes of bird declines, it is critical to avoid single-factor thinking. Multiple factors are likely to contribute simultaneously to population declines, and we will likely need to manage multiple factors at once to maximize population growth.

LIGHTNING TALKS

Scott Loss (Oklahoma State University): *Importance of demographic compensation/additivity in identifying causes of bird decline*

Different threats to populations may interact in a compensatory or additive way. Whereas additive threats compound each other to depress demographic rates more severely than each threat individually, compensatory threats offset each other such that depression of vital rates during one part of the annual cycle or in one segment of a population increases vital rates in another. Compensation can occur in multiple ways: across different parameters (e.g., reproduction offsets mortality); across ages/sexes/stages (e.g., adult survival offsets juvenile mortality); across time scales (e.g., carryover effects of non-breeding conditions to breeding success); or across spatial scales (e.g., one population offsets another). Density-dependent processes are often compensatory: for example, higher fall mortality may increase winter survival via reduced density and competition. In addressing bird declines, we should not assume additivity of multiple threats in our models, and should focus on identifying and managing additive threats.

SUMMARY OF TALKS: TUESDAY 7 JULY 2020

LIGHTNING TALKS

Viviana Ruiz (Cornell Lab of Ornithology): *Data integration tools for improving population-level inferences: how do we assess the smoking guns?*

As we begin to diagnose the causes of decline of the North American avifauna, we should take advantage of existing monitoring data and tools for integrating that data to better understand population trends and identify data gaps. For example, integrating count data from eBird and BBS can provide better inferences on spatial and temporal population trends. Integrated Population Models (IPMs) can incorporate productivity data (e.g. nest or juvenile counts), capture-recapture data (for juvenile or adult survival), and count data to develop a more complete picture of the factors driving population trends. We need to begin to account for spatial structure in both population trends (e.g. from eBird data) and survival (e.g. from MAPS data). Gathering and incorporating data on movement and migratory connectivity into IPMs will enable linking populations and their demographic rates across the full annual cycle.

One limitation is a lack of range-wide data sources for many species. It is critical to organize long-term monitoring efforts like BBS, eBird, MAPS and MoSI into a more integrated monitoring network to understand full annual cycle dynamics for more species. Finally, we need to ask (1) what species can we focus on now using available data? and (2) which methodological advances should we prioritize to fill in data gaps?

Evan Buechley (Smithsonian Migratory Bird Center & HawkWatch International): *Promises and challenges of using remote-tracking technologies to identify when, where, and why birds die*

An important component of understanding the causes of bird declines is identifying sources and patterns of mortality. Remote tracking technologies are powerful tools for determining causes of bird mortality. Tracking tools include archival tags such as geolocators; radio tags (e.g. nanotags) whose signals can be picked up by the expanding MOTUS tower network; and satellite tags (e.g. Argos, GPS, and ICARUS). ICARUS is a promising novel satellite tracking system that will enable further miniaturization of tags for tracking of smaller species, as well as cost reduction that will enable greater numbers of birds to be tagged. Increasing deployments, cost and size reduction, and data repositories such as Movebank, are all helping maximize the role of remote tracking in investigating causes of bird declines. Nonetheless, prior to undertaking a tracking study, it is important to consider (1) the sample size needed to make robust inferences about mortality; (2) whether tags will provide reception throughout the full annual cycle; and (3) how you will confirm the cause of mortality if and when tags are recovered. Distinguishing mortality from tag or harness failure can be quite challenging. It is also important to consider and design studies to evaluate potential detrimental effects of tagging on birds.

SUMMARY OF TALKS: WEDNESDAY 8 JULY 2020

Scott Boomer and Patrick Devers (USFWS): *Evaluating population responses to national habitat and harvest management programs; lessons learned from waterfowl management*

As a group, waterfowl have been a conservation success story. This is in part due to the development of comprehensive monitoring programs, the establishment of administrative flyways to coordinate harvest management, and dedicated funding sources to support habitat acquisition and conservation. The waterfowl management enterprise has been two-pronged, encompassing national programs to support Adaptive Harvest Management and the North American Waterfowl Management Plan. These two branches of management are linked: for example, habitat quality and availability affects the size of the harvestable surplus for a given species. However, until recently there was no formal coordination between habitat and harvest management. This poses challenges to waterfowl conservation because the spatial and temporal scales of habitat and harvest management are often mismatched: harvest management tends to be top-down, filtering from federal frameworks to the state level, and implemented on an annual basis, whereas habitat management tends to be done locally and over multi-annual timescales. Improving waterfowl conservation, particularly for individual species in decline, requires linking these two aspects of management more strategically.

To understand drivers of declines for declining waterfowl species, Full Annual Cycle (FAC) frameworks have been critical for representing key demographic events across breeding, nonbreeding, and migration habitats, and for facilitating the development of hypotheses about limiting factors for populations. Also critical are sub-models within FAC frameworks that define key relationships between vital rates and management outcomes for different parts of the range over the annual cycle. Finally, we can use FAC models within a decision making context to identify which management actions will provide the greatest return on investment, by comparing the sensitivity of population estimates to various potential management actions.

Jim Lyons (USGS Patuxent): *Conservation challenges and the annual cycle of Red Knots*

Shorebirds are experiencing some of the worst declines of any group, with 68% of shorebird species in decline since 1970 according to the 2019 Science paper. Red Knots breed in the Canadian Arctic; overwinter at 3 distinct sites in the Caribbean, the northeast coast of Brazil, and Tierra del Fuego; and stopover in Delaware Bay during migration, where they depend on horseshoe crabs to refuel. Declines in horseshoe crab populations due to overharvesting in the 1990s coincided with a steep decline in the Red Knot stopover population in Delaware Bay. Monitoring of the passage population of Red Knots between 2011-2019 based on counts of marked and unmarked birds during visual surveys suggests that the population has stabilized and may be experiencing a bottleneck. Remaining knowledge gaps for this species include seasonal survival and productivity and juvenile survival; these data are limited by the challenges of working on the breeding grounds.

More generally, management decisions based on knowledge of vital rates and limiting factors throughout the annual cycle should be informed by a management effectiveness metric (Nichols and Hines 2002). This metric incorporates elasticities, or the relative contributions of different vital rates to total population growth rate; the expected effect of various management actions on each vital rate; and the cost efficiency of each management action. Such a composite metric can facilitate decision-making by comparing the cost-effectiveness and biological effectiveness of different management actions throughout the annual cycle.

SUMMARY OF TALKS: WEDNESDAY 8 JULY 2020

Orin Robinson (Cornell Lab of Ornithology):
Using eBird and Integrated Population Models (IPM) to understand Tricolored Blackbird causes of decline

We used eBird data in an IPM for Tri-colored Blackbirds (TRBL) to understand their population trends in California, where 95% of the population breeds. Existing capture-recapture, nesting, and count data were sparse due in part to very low site fidelity for TRBL. We used spatially and temporally filtered count data from eBird to calculate yearly relative abundance for TRBL, which we then used in an IPM to complement data on survival and productivity. The overall population has declined by ~34% over the last 10 years, and the most important rate for population growth was female adult survival, followed closely by fecundity. In general, management decisions should consider "sensible sensitivity": for example, in this study the most important vital rate for overall population growth was female adult survival. But this rate was already quite high, without much room for increase. Fecundity, on the other hand, was the second-most important vital rate and could potentially be increased substantially via management.

Declines in TRBL were spatially biased, with the population in the southern half of California experiencing sharp declines, some of which was due to emigration to the north. The northern population appeared stable, but this stability was likely an artifact of immigration from the south. Management decisions should be informed by these spatial dynamics.

Clark Rushing (Utah State University):
Regional variation in the importance of breeding and non-breeding habitat loss in a declining migratory songbird

The Wood Thrush (WOTH) is a poster child for declining migratory species that breed in eastern deciduous forests. WOTH have declined by 60% across their range since 1970, but this range-wide decline masks substantial spatial variation in the magnitude and even the direction of population change. We should be studying and addressing declines at scales below the species level, but delineating sub-populations presents a challenge. How do we define populations or units, and at what scale? Bird Conservation Regions, for example, are arbitrarily drawn and encompass too much internal variation in population growth rates. We used individual BBS routes to calculate abundance and population change over time for WOTH, and used a cluster analysis to group routes based both on spatial proximity and similarity in abundance and population trend. To understand which factors may be driving population trends on the breeding grounds, we modeled breeding abundance in response to forest loss on the breeding grounds, forest loss on the non-breeding grounds in Central America, and a nonbreeding climate variable (EVI as a measure of greenness). We found a strong negative relationship between non-breeding forest loss in one year and breeding abundance in the following year. However, in terms of per-acre effect, forest loss on the breeding grounds may be more important than forest loss in non-breeding regions for limiting breeding abundance of Wood Thrush.

SUMMARY OF TALKS: WEDNESDAY 8 JULY 2020

Hannah Nevins (American Bird Conservancy): *Insights from multiple approaches to recover declining seabirds*

Seabirds are in steep decline both globally and in North America. One of the biggest threats at sea is overfishing, which impacts seabirds via direct mortality from bycatch and indirectly by depleting their food supply. On land, nearly all imperiled seabirds are threatened by invasive mammals. Seabird recovery requires (1) reduction of fishery impacts and (2) colony restoration efforts, which include protecting, enhancing, and creating new breeding colonies for seabird species. Several examples suggest that the road to recovery for seabirds can begin with colony restoration. Colony restoration using social attraction successfully recovered a colony of Common Murres at Devil's Slide Rock, California that had been nearly extirpated by a single oil spill. The Mexican Island Restoration Program off the coast of Baja California scaled up predator eradication efforts to multiple islands and has benefitted 19 species. Colony restoration can be more challenging for pelagic species that range widely, have slow life histories, and for which uncertainty about breeding sites is often higher. However, efforts to recover the Hawaiian Petrel, which have included protecting nests, installing predator-proof fencing and predator traps, and translocating chicks to imprint at safer sites, have been successful. Key elements to recovering seabirds via colony restoration are fostering partnerships, creating region-wide conservation plans, modeling threats and risks to populations using existing data, and building funding sources from federal, state, private, and mitigation funds.

Ken Rosenberg and Pete Marra: *Revisiting the Vision & Next Steps*

What we have been doing in bird conservation does not appear to be working. We are failing even at keeping common species common, and it is imperative to understand why. We must:

- Determine which species are most in need of attention
- Prevent species from slipping into threatened or endangered status (because T&E status is politically charged and financially expensive)
- Decide as a community of researchers and conservationists whether we are okay with a species-level approach, and with the idea of collecting more data
- Take responsibility for greater oversight of groups other than waterfowl, raptors, and rare or threatened species
- Enhance cooperation between the public and private sectors, and seek bigger funding sources
- Organize and strategize around future data collection efforts to carefully target critical knowledge gaps

The Road to Recovery involves (1) advancing the science and (2) engaging the scientific community. Advancing the science requires determining priority species; filling in existing information and identifying research gaps; and doing the science to fill the gaps. Engaging the scientific community requires working within and across existing structures (NABCI, PIF, ABC, CLO, etc.) to push bird research and conservation groups to focus on studying and recovering declining species; and developing conservation business plans that combine science and strategy into a business framework.

Q&A SUMMARY: A SYNTHESIS OF AUDIENCE QUESTIONS AND COMMENTS

BROAD STRATEGY

It is important to determine where in the causal chain of causes of bird declines it is most effective to work to recover birds (i.e. root causes, like human population growth and consumption, vs immediate causes like loss of insect food resources due to pesticide use). Working on immediate causes may not be the most efficient or effective strategy.

How do we address issues that are large scale and affect many species, potentially in opposing ways in some cases (climate change, pesticide use, agricultural intensification)?

NEW RESEARCH DIRECTIONS

Species prioritization

Species that are not at the top of the priority list may be well along from a science perspective. Should we complete FLC models on those species to catalyze our understanding of them as well as similar species?

Agencies that produce status and trend estimates can help [the R2R] process by moving from a reporting framework to a causes and predictions framework that also incorporates modeling of threats and causes of declines, and predictions for the future under alternative scenarios

Other

We may learn interesting things by focusing on species and/or groups that do not fit the overall pattern of declines, e.g. vireos

Look for spatial patterns of covariation in species abundance to detect where interspecific competition during the breeding or non-breeding season may be playing a role in population dynamics

Investigate the physiological limitations of species to future environmental change in order to predict future responses.

Dual focus on scarce, near-threatened species and abundant declining species

A major take-home message from the 3 billion bird paper was that common species with large ranges carry the majority of the bird loss, and that the field has focused too much on scarce threatened species. Yet the species prioritization matrix also has many criteria that bring species with small populations and restricted ranges to the top. Is there a risk by focusing on these top species we will miss the large macro-scale effects that might cause the bulk of the bird declines?

Drivers of population declines vary regionally. Do you worry that an approach that prioritizes rare species with limited range size will limit our ability to identify drivers of regional population declines?

To augment the 3X ACAD effort, are there multivariate techniques that we could apply to temporal trends in conjunction with life history and environmental covariates to assemble birds into groups of concern? Or more simply do birds group by nuances in temporal trend and life history?

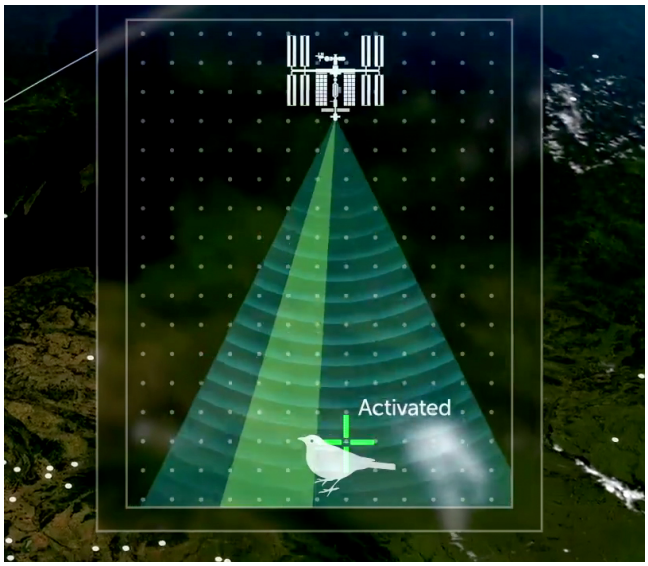
We should take a two-pronged approach to prioritizing species for which to investigate causes of decline: study (1) species that are scarce, vulnerable, and/or near-threatened, as well as (2) species that are common and whose population declines make up a high percentage of the overall loss in abundance; the latter species may be more symptomatic of broad landscape-scale environmental change

DATA USE & INTEGRATION

Tracking data should be made open and accessible in order to fill knowledge gaps. The Motus Wildlife Tracking System is working to harmonize existing and new Motus tracking data into a more open and accessible framework which will enable us to focus our analysis efforts to fill the identified information gaps.

Can we integrate other data sources going forward (e.g. eBird and IMBCR) given that BBS may not sample some of the 3X priority species well?

We should perform retrospective analyses on older data, even data collected just a few years ago, using new frameworks and modeling techniques (e.g. Bayesian)



HUMAN DIMENSIONS

Include human dimensions experts in discussions about how to move forward with the Road to Recovery. We need to change values and human behavior in order to conserve birds. Specifically, integrate conservation social science expertise to address how humans are driving these declines and how they might be part of the solution, via sustainable forestry, bird-friendly agriculture, etc.

Focusing on human-wellbeing as a co-benefit of conserving birds and the ecosystems they are a part of is a way to tap into larger funding sources.

We should consider how our work can be more inclusive of a wider range of voices in science. We also need to engage the communities and stakeholders that will be needed to implement conservation actions earlier in the process (e.g. through citizen science).

Joint Ventures are valuable because they tie together researchers, conservation practitioners, and private landowners.

LINKING RESEARCH TO CONSERVATION ACTION

We need to understand the data needs of conservation practitioners prior to conducting new research. We should include practitioners in the design of new research to make data collection most useful and effective for informing management.

We need to bridge the science-implementation gap by communicating our science to practitioners more effectively and frequently.

It is important to evaluate the effectiveness of conservation actions; we must monitor management actions to ensure that they are actually mitigating threats and positively impacting populations.

BUILDING FUNDING SOURCES

A main priority should be seeking out bigger and more consistent sources of funding for bird research and conservation. This will involve building new partnerships, particularly with the private sector, and tapping into large international initiatives (e.g. the World Resource Institute's 20x20 Initiative) around restoration and sustainability that are not specifically focused on conserving birds but that indirectly benefit birds and bird landscapes.

BUILDING PARTNERSHIPS

We need to get federal agencies to recognize the importance of migratory and non-breeding habitat, and fund more research on as well as conservation of those areas (NMBCA 3:1 match is cost-prohibitive for many organizations)

To mitigate large-scale threats that may be causing declines in common, widespread birds, we need to engage bigger partners: Big Ag, the forest products industry, carbon sequestration advocates, multilateral banks, etc.

We must better align research and conservation efforts occurring during stages of the annual cycle. We must identify linkages and actions targeting shared species across broad geographies, particularly in Latin America. It is critical to partner with organizations in Latin America to develop conservation actions in non-breeding areas. We need to also include an analysis of resident and threatened birds in Latin America so that when conservation of North American breeding migratory birds moves forward it also focuses on priority species in this region.

How do we integrate the bird conservation crisis that is occurring in Hawaii into messaging about the declines for North American birds so that these species are included in prioritization and funding decisions?

OUTCOMES AND NEXT STEPS

Focus for Future Research

Bringing back the North American avifauna will require a coordinated, targeted effort in terms of both science and conservation action. We need more science, based on both existing and new data, to understand the causes of decline and determine how to take conservation action most effectively and efficiently. However, limited funding means that future research toward reversing bird declines must be coordinated and targeted towards key knowledge gaps that are critical for informing conservation planning efforts.

The Road to Recovery Workshop (Part 1) highlighted the need to focus research and action on priority species that are at risk of slipping into threatened or endangered status. While a species prioritization approach does not preclude broader research on biomes or species groups, it is imperative that we prevent declining species from being listed as threatened or endangered, to avoid associated politicization and substantial financial cost.

To this end, we must first determine where each species is situated along the road to recovery. This workshop introduced the road to recovery concept as a trajectory from a starting point of little or no knowledge of a species' broad threats or specific limiting factors, toward an end goal of

identifying limiting population factors, developing a full annual cycle conservation business plan, and implementing targeted conservation actions to address and reverse declines. The first step in advancing species along the road to recovery must be collating existing data and expertise on each priority species to determine its current stage in the recovery process. Next, we must bring together (or leverage existing) working groups around priority species to identify remaining data gaps and focus new data collection to fill those gaps.

New research to identify species' limiting factors should be geared towards developing Full Annual Cycle models. Traditionally, demographic research on North American birds has focused on breeding ecology, but the non-breeding season and migration comprise large parts of the annual cycle for birds. Understanding population dynamics and threats outside the breeding season is critical for identifying which factors, and during which time(s) of year, most limit population growth. Specifically, understanding where populations are limited requires distinct estimates for parameters like adult and juvenile survival during each part of the annual cycle. Neotropical migrants in particular, which spend up to 8 months of the year in Central and South America and the Caribbean, face distinct threats on their breeding and non-breeding grounds. Determining why their populations are declining necessitates understanding threats and demographics on their North American breeding grounds, their non-breeding grounds in Latin America, and during migration.

In addition to temporal variation in vital rates throughout the annual cycle, we need to better understand spatial variation in population trends and vital rates within seasons. Within individual species, there is often substantial variation across the breeding range (and probably across the non-breeding range as well) in abundance and population trend.

A species may be in steep decline in some regions of its breeding range, but stable or increasing in others. Analyses using long-term monitoring data like eBird and BBS can provide a spatially explicit picture of where populations are declining and where they are doing well. Spatial analysis of population trends for individual species can be combined across species to ask whether there are certain geographic areas where many species are experiencing pronounced declines. If so, we can potentially identify threats that are acting broadly across species by investigating environmental changes in those regions.

A key component of identifying limiting population factors across geographic space and throughout the full annual cycle is understanding population and migratory connectivity. Breeding and non-breeding populations of migratory species are often structured and linked through the annual cycle, and we need to determine for each species which breeding and non-breeding populations are linked, via which migratory pathways, and how strongly. For example, understanding carryover effects of conditions on the non-breeding grounds on breeding success requires knowledge of where specific non-breeding populations go to breed. We can improve our understanding of migratory connectivity via a combination of tracking of individuals and populations. Advances in tracking technologies for individuals, including the new ICARUS satellite tracking system and an expanding MOTUS network, are enabling tracking of smaller species at lower cost. At the population level, genoscape analysis is emerging as a tool for understanding spatial population structure and connectivity throughout the annual cycle. In combination, these tools will enhance our ability to track individuals and populations across time and space. This in turn will enable us to connect demographic rates across the annual cycle, understand the drivers of spatial variation in population trends, and better identify limiting

factors for individual linked populations within species.

Important considerations for future science

As we move forward with research to recover North America's avifauna, it is essential to coordinate efforts across academic institutions, NGOs, and state and federal agencies to ensure that new research is targeted towards filling knowledge gaps that will advance species along the road to recovery. Additional recommendations for new science around bird declines that emerged from this workshop are to:

- Coordinate large-scale monitoring efforts throughout species ranges to facilitate data integration. When data collection protocols are designed differently by different organizations or in different regions, it is difficult to integrate data from various sources into analyses such as Integrated Population Models. Moving forward, it will be important to be more organized and intentional about standardizing protocols;
- Take advantage of "data orphans", or existing datasets that have not been fully mined, to help answer questions about population trends or causes of decline. Before devoting resources toward collecting new data, we must identify and use existing datasets;
- Leverage citizen science efforts. From eBird to standardized point count data being collected across Latin America under the PROALAS protocol to volunteer monitoring of bird window collisions, there are many ways in which citizen science can be incorporated into research on population trends and causes of decline

Important considerations for management and conservation action

While this workshop focused primarily on research needs and emerging tools and methods for addressing the loss of 3 billion birds in North America, it is clear that science alone will not be enough to recover North America's avifauna. Reimagining bird conservation will involve fostering better, more frequent communication between researchers and the general public, conservation practitioners at state and federal agencies and NGOs, and policy-makers. Multiple stakeholders should work together on problem-framing, to articulate a coordinated plan that identifies data gaps as well as relevant decision-makers and governance structures, and links additional research with potential management actions. One salient point to emerge from this workshop is that given limited funding for conservation, it is critical to consider which management actions will provide the biggest "bang for our buck", or return on investment. Researchers and practitioners should consider using a management efficiency metric (Nichols and Hines 2002) to determine quantitatively the relative cost-effectiveness of different potential management actions for conservation. Such a metric would incorporate information on (1) the degree to which each vital rate for a species influences its overall population growth; (2) the extent to which a given management action is likely to affect a given vital rate; and (3) the cost of each potential management action. A management efficiency metric can facilitate conservation decision-making by calculating which management actions will have the greatest conservation impact at the lowest cost. Although it is important to allocate available funding efficiently, it is equally important for the

bird conservation movement to work across both the public and private sector to mobilize more funding for bird conservation from a broader range of sources. Conserving North America's avifauna will require conducting research and protecting or restoring habitat outside North America, where Neotropical migrants spend the majority of the year. Thus it is critical to convince U.S. and Canadian federal agencies to recognize the importance of non-breeding habitat and migratory stopover areas for North American species, and to fund research on and protection of those areas. We must also seek to leverage larger funding sources from the private sector. Finally, the scale of habitat protection and restoration necessary to address bird declines will require broadening potential funding sources beyond those tailored specifically toward bird conservation, and tapping into funding tied to broader initiatives around forest restoration or general sustainability. One example initiative is the World Resource Institute's 20x20 initiative to bring 20 million hectares of deforested or degraded land across Latin America into restoration by 2020. Working within large-scale initiatives whose goals are broader than bird conservation can potentially direct more funding towards programs that will ultimately benefit birds.

LINKS TO WORKSHOP RECORDINGS

Causes of Decline Day One 7 July 2020
Causes of Decline Day Two 8 July 2020