CONSEQUENTIAL DISCOVERIES

The Center for Conservation Biology

Annual Report 2018

WILLIAM & MARY

VIRGINIA COMMONWEALTH UNIVERSITY

CCB's

ONGOING MISSION

The mission of The Center for Conservation Biology, through all of its diverse programs, is to provide the global community with the information needed to drive thoughtful, science-based conservation, to educate and train the next generation of conservation scientists, and to make lasting contributions to the natural world through critical thinking, innovation, and ground-breaking research.

The Center for Conservation Biology is a research unit shared by William & Mary and Virginia Commonwealth University. The Center is a part of the VCU Rice Rivers Center. Rice Center scientists conduct cutting-edge environmental research on the James River and around the world.

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ON THE COVER:

A female peregrine falcon returns to her nest in Virginia. Once extirpated east of the Mississippi River an experimental captive breeding program was successful. This game-changing effort would be the key to recovery. *Photo by Bryan Watts*

A MESSAGE FROM THE DIRECTOR

Anticipation builds over months and years as we climb on through wandering trails, plateaus, and false summits. Until that one day in a glorious, heart-pounding gesture we crest over and look out onto a view that no other human being has ever witnessed. This is the nature of discovery - to find or recognize something wholly new to humanity. The exhilaration of this moment is the allure of research and the reward for dogged persistence. The research life follows a path of continual exploration and discovery. A long grind of preparation and work punctuated by sparks of epiphany. These epiphanies are coupled with the profound satisfaction of contributing to the well of human understanding.

The Center for Conservation Biology (CCB) has made thousands of discoveries that have propelled conservation forward. Some of these have been bold departures from the dogma-of-the-day while others have been subtle brush strokes on a painting that is half finished. All have contributed to the ongoing evolution of mind and the collective wisdom used to guide day-to-day decisions. It is impossible to look back over the course that avian conservation has taken and not see how that course has been shaped by CCB research.

Contributing to our expanding web of knowledge has been our great honor. Discoveries are not something to be hidden or locked away in a vault. They are stepping stones to be freely shared in the hope that they will ignite the fires of innovation that are so essential to successful conservation. Within this annual report I describe a handful of discoveries that have moved conservation or our understanding forward in both bold and subtle ways.

We stand only ankle deep in a journey across the vast ocean. Help us to keep the journey moving.

Bryan D. Watts

Mitchell A. Byrd Professor of Conservation Biology

Director, The Center for Conservation Biology

There is nothing like the "view" from a recent discovery. Often full of unexpected colors the scene ahead always includes an endless range of other questions that most researchers are eager to explore.
Photo by Bryan Watts

A yellow-crowned night heron just arriving on its breeding grounds in Tidewater Virginia. CCB research has shown that this species is arriving sooner and laying eggs 20 days earlier than just 50 years ago. Yellow-crowns appear to be capable of shifting their annual cycle in response to warming temperatures.
Photo by Bryan Watts

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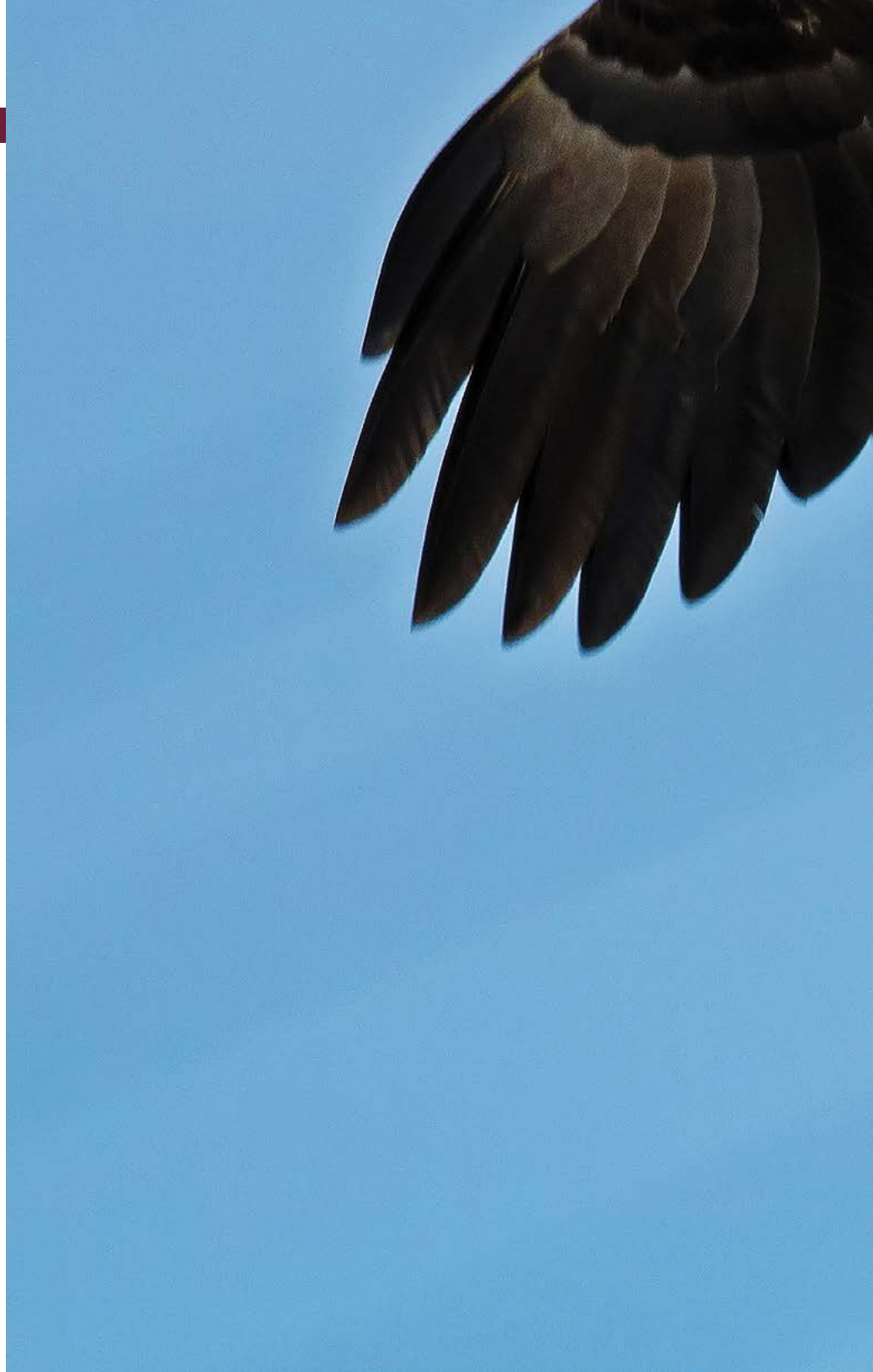
GAME CHANGERS

Some discoveries are defining moments separating what happened before from what happened after. They are like a key to a locked door that instantly provides clarity on the path ahead. These discoveries have the potential to leapfrog conservation forward, changing a dismal failure into a soaring success in short order. Like an old oysterman searching for pearls, all researchers search for bold discoveries. Often the difficulty is not that solutions are rare but rather that our minds are not prepared to recognize them when they appear. Maintaining a “beginner’s mind” open to novelty is an important condition for discovery.

CCB research has made many discoveries that have changed the course of conservation. Much more than this, CCB has been open to utilizing the discoveries of others and whatever it takes to advance conservation objectives.



(Opposite page) An adult bald eagle with a transmitter catches a fish in the upper Chesapeake Bay. CCB has now archived millions of eagle locations in order to study movement patterns. Identified movement corridors have been used to manage the location of hazards. *Photo by Brian Kushner*

SHOREBIRD HUNTING

THE PROBLEM

The decline of shorebirds has become a global crisis with more than fifty percent of all species exhibiting significant declines. The Western Atlantic Flyway is experiencing some of the highest rates of decline. In the fall of 2010, several shorebird biologists (including CCB) assembled in Hadley, MA for a meeting to discuss the growing crisis and the possibility of producing a flyway-wide recovery plan. Several possible causes of declines were discussed but no unifying factor emerged that would explain observed patterns for the diverse list of species.

THE DISCOVERY

On September 12, 2011, two whimbrels named Machi and Goshen were shot over hunting swamps on Guadeloupe. The birds were being tracked by CCB using satellite transmitters for a study of connectivity. Hunting was not one of the factors discussed during the 2010 meeting. This single event led to a sea change in the direction of conservation efforts and mobilized shorebird biologists to establish a working group focused on hunting. The group has rapidly evaluated sustainable mortality limits, begun to quantify mortality, examined hunting policy throughout the Western Hemisphere, and assessed hunting within local cultures in order to initiate an international dialog about hunting policy. Through this work, it has become clear that hunting has played a significant role in the declines of some species. This discovery has spawned similar activities within other flyways. ■

A whimbrel shot on Guadeloupe. Hunting is part of the culture within several locations throughout the Western Atlantic Flyway. Increasing evidence suggests that overharvest may play a role in population declines. Many partners are now mobilized to assess potential impacts that may lead to policy changes. *Photo Anonymous*

Bart Paxton places a whimbrel in a crate just before sunset on the Eastern Shore of Virginia. The whimbrel tracking study has provided a wealth of information about their annual cycle and was key to uncovering hunting as a possible driver of shorebird declines in the Western Atlantic Flyway. *Photo by Barry Truitt*

Libby Mojica attaches satellite transmitter to Machi on 20 August, 2009. Machi would be shot by a Guadeloupe hunter on 12 September, 2011. The loss would awaken the conservation community to the possible role of hunting in shorebird declines. *Photo by Bart Paxton*

RESTORING PEREGRINE FALCONS

THE PROBLEM

The widespread use of DDT and similar compounds for insect control in the post-World War II era resulted in catastrophic declines in many bird species on a global scale. By the early 1960s, peregrine falcons had been extirpated east of the Mississippi River. Peregrines were listed in 1969 as federally endangered under the Endangered Species Conservation Act and subsequently in 1973 under the Endangered Species Act. The U.S. Fish and Wildlife Service appointed a recovery team in 1975 which immediately faced the challenge of how to restore a population with no residual breeding pairs. It was clear that recovery would require a new and bold approach.

THE DISCOVERY

The peregrine falcon recovery team decided to back a plan to breed falcons in captivity and release the young into the wild in the hopes of establishing new breeding pairs. Although common today, captive breeding of endangered species for the purpose of release and restoration was experimental in the early 1970s. The captive-breeding program, along with the use of “hacking” to release young into the wild, was very successful and led to the recovery of peregrine falcons and their eventual removal from the federal list of threatened and endangered species. This bold approach has now been used widely for hundreds of species around the world. CCB has been involved in peregrine restoration since the very beginning and has released several hundred birds using hacking techniques. ■

Young peregrine falcon in Shenandoah National Park after release from hack box. The bird has yellow tape on its USGS band so that it may be readily identified by observers. This bird was taken from a bridge in coastal Virginia and moved to the mountains. CCB and partners have released nearly 400 falcons in Virginia to restore the population. *Photo by Bryan Watts*

Rolf Gubler monitoring fledged peregrine falcons near the hack box within Shenandoah National Park. Rolf has spearheaded the hacking program within the park since 2000. *Photo by Bryan Watts*

Young peregrine falcon stands in a hack box within Shenandoah National Park. Birds are fed daily until they are old enough to fly, released to fledge and then fed and monitored until they disperse on their own. The ancient technique of hacking has been an essential tool in the restoration effort. *Photo by Bryan Watts*

ARTIFICIAL WOODPECKER CAVITIES

THE PROBLEM

The red-cockaded woodpecker is a true specialist that requires old-growth pine trees. All aspects of their ecology have evolved around pines. Red-cockadeds are the only woodpecker in North America that excavates cavities in live pines. Excavating a cavity through pine sapwood often requires two to three years with small advances followed by time to allow the sapwood to cure. This species experienced catastrophic declines as old-growth pines were harvested down to 1% of historic levels throughout their Southeastern range, leading to their listing as federally endangered in 1973. As the population stabilized and conservation efforts began in earnest, it became clear that the species' ability to excavate cavities was a restoration bottleneck. Because each bird requires its own roost cavity, it was neither possible to either establish birds in new sites nor to rapidly expand existing populations if all depended on natural excavation.

THE DISCOVERY

Beginning in the mid-1980s, experiments with artificial cavities were initiated, and by the mid-1990s both the devices and the techniques to use them for restoration had been perfected. This single development revolutionized woodpecker management. Artificial cavities have been effective in re-establishing populations throughout most of the historic range, as well as managing existing populations. Although CCB did not develop this technology, we, along with our partners, were early adopters and have used cavities to rebuild the Virginia population. ■

A young male red-cockaded woodpecker ready to be placed in an artificial cavity as part of a translocation project to establish a new population within the Great Dismal Swamp. These efforts would not be possible without the use of artificial cavities. *Photo by Bart Paxton*

Bobby Clontz from The Nature Conservancy works with an artificial cavity in Virginia. Bobby has installed dozens of cavities that have been critical for red-cockaded woodpecker recovery in the state. *Photo by Bryan Watts*

(Opposite page) A nestling red-cockaded woodpecker being extracted from cavity for branding. The use of artificial cavities has been a game changer for management of this species allowing for rapid population expansion and establishment. *Photo by Bryan Watts*

REDUCING FLIGHT HAZARDS

THE PROBLEM

Humans kill billions of birds every year. Most of this mortality is unintentional. As the infrastructure associated with modern society expands across the globe, man-made hazards within the airspace such as buildings, electrical lines, and towers represent a growing source of mortality for flying birds. Such mortality has been identified as a threat to populations of many birds of conservation concern. One of the best strategies for reducing this source of mortality is to place hazards away from major movement corridors. Historically, the most significant impediment to applying this strategy has been the lack of data and approach to identifying major movement corridors.

THE DISCOVERY

Since the early 1990s, the miniaturization of tracking devices has allowed scientists to generate tremendous datasets that include movements for an increasing number of bird species. This revolution has opened the door for the possible identification of major flight corridors that could be used for infrastructure planning. Between 2007 and 2012, CCB deployed more than seventy transmitters on bald eagles for the U.S. Department of Defense that collected more than 1.5 million locations. CCB used these locations in a first-of-its-kind modeling exercise to identify movement corridors that crossed electrical lines and successfully predicted where mortality was most likely to occur. The effort saved eagles and saved millions of dollars by allowing for the burial of only the problem lines. Since this effort, the approach has been used on many species around the world. ■

Bryan Watts attaches a solar-powered satellite transmitter to a bald eagle in the Chesapeake Bay. CCB biologists have deployed large numbers of transmitters to track eagle movements and to identify major corridors where flight hazards should be removed. *Photo by Reese Lukei*

Rocket nets were the primary technique used to capture eagles for transmitter deployment. *Photo by Bryan Watts*

CCB biologists use hand-made harnesses to attach eagle transmitters. The harnesses are made of Teflon ribbon and are intended to last for several years. *Photo by Bryan Watts*

An adult bald eagle with a transmitter catches a fish in the upper Chesapeake Bay. CCB has now archived millions of eagle locations in order to study movement patterns. Identified movement corridors have been used to manage the location of hazards. *Photo by Ted Ellis*

SLOW BURNS

Most discoveries are incremental. Periodic looks back in time reveal that the track of progress has taken hundreds of small steps to move only a short distance. Taken individually these steps are not significant, but like an inchworm feeling its way along, they slowly advance into the unknown. Progress requires patience and persistence. Like sitting on a mountain peak in the predawn hours, we strain our eyes to see the forms below and wait for the sun to rise and show the valley in all its vivid color. That view is the reward for years of work and contemplation.

Much of the progress in conservation is the result of a slow burn made by the few of us with an unquenchable thirst for answers, plodding forward and painstakingly accumulating results. It takes years for information to coalesce into a meaningful image, and many more years until the lessons from that image are successfully applied to conservation problems.

(Opposite page) A pair of American oystercatchers forage along an oyster bar. Oystercatchers nest in low-lying habitats and are one of many bird species that are struggling with sea-level rise with no immediate solutions. *Photo by Brad Winn*

IMPORTANCE OF THE TIDAL FRESH

THE PROBLEM

Estuaries are places where rivers meet the sea. Within large enclosed estuaries like the Chesapeake Bay, a gradient of salt concentrations is formed between the freshwater inputs from rivers and the saltwater inputs from the ocean. Salt concentration influences the distribution of plants and animals within the estuary. The little-studied and least understood of the so-called salinity zones is the tidal fresh. Tidal-fresh waters represent small percentages of most estuaries but likely have outsized significance. The tidal fresh is the spawning ground for commercially important fisheries, supports a diverse marsh community, and is highly productive. The importance of tidal-fresh waters to bird populations is still poorly understood.

THE DISCOVERY

Since the 1970s, CCB biologists have monitored populations of major consumers like bald eagles, great blue herons, and osprey throughout the Chesapeake Bay. We determined in the 1990s that congregations of non-breeding bald eagles were concentrated within the tidal-fresh reaches of the Susquehanna, Potomac, Rappahannock, and James Rivers. It was not until the early 2000s that we began to recognize that breeding populations of eagles, osprey, and herons were increasingly focused on these waters. By 2016, we determined that 70% of these populations were supported within these relatively small areas. This finding both demonstrates the importance of the tidal fresh to bird conservation and raises concerns about the possible impacts of sea-level rise. ■

A brood of eagles in the nest along the upper James River in Virginia. Research by CCB has documented that breeding density within the tidal fresh is now 15 times higher than within other salinity zones pointing to the importance of these areas to avian consumers. *Photo by Bryan Watts*

An adult osprey rises from a nest along the tidal-fresh reach of the James River. The osprey population within the tidal fresh has the highest growth rate of any area throughout the Chesapeake Bay. Tidal-fresh waters have very high conservation value for consumers like osprey, bald eagles and great blue herons. *Photo by Bryan Watts*

A tidal-fresh marsh along the Rappahannock River in Virginia. These marshes are believed to be one of the supports for high productivity within this salinity zone and may be threatened by saltwater intrusion and sea-level rise. *Photo by Bill Portlock*

GROWING ENERGY FOR MIGRANTS

THE PROBLEM

Virtually all passerine migrants are incapable of carrying enough energy to make a nonstop flight between breeding and winter quarters, forcing them to stop en route to replenish fuel reserves. Significant migration bottlenecks form “upstream” of physical barriers such as deserts, mountain ranges, or major water bodies, where large numbers of migrants become concentrated and compete for limited food. Fall fruits are an important food resource for birds during autumn migration because of their relatively high availability and because they are packed with high-energy lipids that can be utilized directly or stored as fat. One of the best strategies for improving migrant condition and survival is to manage stopover habitats to produce more fruit-producing plants. An impediment to applying this strategy is that we have not had adequate information on preferred fruits that would allow for goal-oriented management.

THE DISCOVERY

CCB has conducted a series of studies on the lower Delmarva Peninsula (a significant migration bottleneck located around the mouth of the Chesapeake Bay) to better understand fruit preference and consumption by fall migrants. Studies have focused on the time of ripening and fruit preference by migrants. Some fruits were found to ripen too late to be useful to migrants. Fruit species fell into three preference categories including high, medium, and low demand. Migrants stripped virtually 100% of fruits in the high demand category during the height of the migration season. Information from these studies is now available to “tilt” plant species composition to benefit migrants. ■

Fox grapes on the Delmarva Peninsula in Virginia. These fruits are sought out by fall migrants and are consumed as soon as they ripen. This plant should be promoted in forests to support migrants. *Photo by Bart Paxton*

A devils walking stick with an exclusion bag used by CCB researchers to quantify consumption rate and fruit preference by fall migrants along the Delmarva Peninsula. *Photo by Bart Paxton*

A young bluebird during fall migration. Bluebirds are one of several dozen species of migrants that depend on fruit and would benefit from managing forests to produce fruiting plants. *Photo by Bryan Watts*

PEOPLE, KNOTS AND BEACHES

THE PROBLEM

The *rufa* subspecies of the red knot has declined precipitously over the past three decades, leading to its listing as threatened under the federal Endangered Species Act. The population is highly migratory and depends on the outer beaches of the mid-Atlantic as a critical staging area where birds must put on adequate fat before making a final flight to Arctic breeding grounds. Coastal areas are in high demand for recreational use on a global scale, and in the United States 180 million tourists visit beaches annually. Knots are sensitive to human disturbance and chronic human activity will render foraging areas unsuitable. How to accommodate both the use of beaches by tourists, which is essential to local economies, and foraging shorebirds is a continuing global concern.

THE DISCOVERY

CCB surveyed 500 kilometers of beaches along the Outer Banks of North Carolina over three years to better understand the relationship between the density of knots and humans. This area is part of the mid-Atlantic staging area for knots and local towns are economically dependent on beach tourism. People and knots were widely scattered but 80% of knots occurred on beaches with less than five people per kilometer, a condition mostly confined to government lands. The study demonstrates that this use conflict may be mitigated by limiting access to some government-owned beaches during the month of May. ■

A large portion of all Americans spend time on the beach each year. Beach tourism is an important driver of coastal economies. CCB has been working toward finding solutions to mitigate use conflicts between shorebirds and people. *Photo by Bryan Watts*

(Opposite page) Red knot foraging on the beach with other shorebirds. Red knots require beach habitats within mid-Atlantic staging areas. Providing disturbance-free foraging sites is an ongoing management objective within the region. *Photo by Jan van de Kam*

(From top) A laughing gull gathers nest material along the seaside of the Eastern Shore. The distribution of nesting in marshes has been reduced by 95% since 1993 as the increase in sea levels has repeatedly washed out clutches over the past 30 years, causing gulls to abandon nesting areas used for centuries. *Photo by Bryan Watts*

A clutch of laughing gull eggs in a marsh along the Eastern Shore of Virginia. *Photo by Bryan Watts*

STRUGGLES WITH SEA-LEVEL RISE

THE PROBLEM

Sea levels are rising worldwide and the mid-Atlantic Coast is apparently ground zero, experiencing rates that are three to four times the global average. Just as coastal roadways, houses and other infrastructures are experiencing more frequent damage from inundation, low-lying habitats such as tidal saltmarshes are also being impacted. Bird species that depend on these habitats are experiencing a wide range of impacts. For some species, inundation rates have reached a tipping point that virtually eliminates any opportunity for successful breeding. For long-lived species with high site fidelity, pairs may persist in these demographic sinks until the adults die out. For other species, high inundation rates have created wide swaths of empty habitat. How specifically each species will respond to sea-level rise continues to be an open question.

THE DISCOVERY

CCB has monitored colonial waterbirds in coastal Virginia for decades, carefully counting and mapping thousands of colonies. For some species like the laughing gull, salt marshes have historically supported a large portion of the breeding population and sea-level rise is a growing concern. Between 1993 and 2018, the footprint of laughing gull colonies within the marshes of the Eastern Shore declined from 326 hectares to only 15 hectares, a 95% decline. Several colonies known to be occupied for centuries now sit idle. Other, more secretive marsh species including clapper rails, black rails, seaside sparrows, saltmarsh sparrows, willets, and American oystercatchers are no doubt suffering from the same tides and may also be increasingly vacating these historic habitats. ■

Saltmarsh elevation has not kept pace with sea-level rise within the mid-Atlantic region and marshes are increasingly inundated on regular tides. CCB research has shown that this sea change is impacting bird populations that depend on the marsh for breeding. *Photo by Bill Portlock*

ECOLOGICAL FOUNDATIONS

Aldo Leopold was famous for stating that "to keep every cog and wheel is the first precaution of intelligent tinkering," which is to say that just because we do not currently know the importance of something there is no reason to assume that it has none. Most of the day to day discoveries that we make conducting research are small puzzle pieces that contribute to what we know about species, communities, and ecosystems. As ecologists and students of the species we study, these are exciting discoveries. As conservation biologists, many of these findings have no obvious application to conservation work at the time of discovery. However, as implied in the Leopold quote, the importance of these findings to conservation may only be realized with the passage of time.

CCB makes discoveries that address questions of basic ecology on a regular basis during the course of our ongoing research or as the focus of targeted projects. Some of these findings resolve ecological mysteries, some speak to the foundation of ecological principles, and many place bricks in the walls of existing scientific theories. If nothing else, these discoveries contribute to human knowledge about our world which is one of our continuing missions.

(Opposite page) Chuck-wills-widow chicks in nest. CCB research has shown that that nesting in this species and some other nightjars is organized around the lunar cycle and that calling rates are influenced by moon phase. This information has been used throughout the range to adjust survey schedules. *Photo by Bart Paxton*

CLIMATE CHANGE AND BREEDING

THE PROBLEM

Climate change is a change in the statistical properties of the climate system over long periods of time. Regardless of the underlying causes of this change, the earth has been experiencing a documented shift in climate for decades. How wild species respond to changes in climate will determine many aspects of their ecology, including their geographic distribution, the timing of significant events in their annual cycle, and for some their survival. Understanding the implications of these shifts is a growing focus of conservation biology. Due to both their migratory status and their specialization on fiddler crabs which are highly sensitive to temperature, yellow-crowned night herons represent a model system for investigating how species respond to a changing climate.

THE DISCOVERY

Over a span of only 50 years, the yellow-crowned night heron has shifted its breeding season by more than 20 days in response to warming temperatures in Tidewater Virginia. CCB investigated breeding phenology during the 2015-2017 breeding seasons in order to compare to information from the 1960s. Herons are arriving earlier, laying clutches earlier, and the early breeders are more successful. The birds are proving to be a sensitive barometer of shifts in regional temperatures. ■

Male yellow-crowned night heron collecting sticks for nest building. CCB research has shown that this species is arriving sooner and laying eggs 20 days earlier than just 50 years ago. Yellow-crowns appear to be capable of shifting their annual cycle in response to warming temperatures. *Photo by Bryan Watts*

A recently fledged yellow-crowned night heron forages for fiddler crabs in a fringing marsh. The species close connection to fiddler crabs that are highly temperature sensitive makes it a model species for investigating adjustments to climate change. *Photo by Bryan Watts*

A brood of yellow-crowned night herons in Norfolk, Virginia. Broods are hatching and fledging significantly earlier compared to what was observed in the same locations during the 1960s. Yellow-crowns are one of several species CCB biologists are monitoring to better understand responses to climate change. *Photo by Bryan Watts*

COEXISTENCE OF SPARROWS IN WINTER

THE PROBLEM

How complexes of closely related species coexist is one of the great questions of community ecology that has implications for patterns of species diversity. Winter sparrows represent an ideal species complex to investigate factors contributing to community structure. Most sparrows forage almost exclusively on herbaceous seeds during the winter months. How do species that eat the same food coexist within the same habitats? One set of forces that may contribute to coexistence is differences in predator avoidance strategies or other factors that may contribute to spatial segregation. Because sparrows differ in weight and leg strength, one such factor is the ability to extract seeds that are buried in leaf litter or in other material.

THE DISCOVERY

CCB experimentally investigated the ability of six sparrow species to extract buried seeds and how differences may influence foraging efficiency and their ability to meet energy requirements. Species fell into three categories, including strong scratchers, weak scratchers, and non-scratchers. The latter two categories were unable to meet energy needs, suggesting that litter cover may restrict the distribution of some species and promote coexistence through spatial segregation. ■

Swamp sparrows (left) and song sparrows (right) are strong scratchers capable of extracting seeds from shallow soil or under modest leaf litter. They are found around shrub cover where leaf litter builds up during winter. *Photos by Bryan Watts*

Savannah sparrows do not extract seeds from soil or under leaf litter but instead feed on surface seeds on bare ground. They are restricted to areas where bare ground is readily available. *Photo by Bryan Watts*

CCB found that some sparrow species do not extract seeds buried in soil or from under leaf litter. These species collect seeds directly from plants or from the surface of bare patches of soil and so are restricted to locations where these conditions occur. *Photo by Bryan Watts*

MIGRANT IRRUPTIONS

THE PROBLEM

Several bird species that breed in northern latitudes are known for expressing irruptive patterns of migration, including seed eaters like pine siskins, purple finches, common redpolls, and red crossbills, and predators like northern shrikes, snowy owls, and rough-legged hawks. During extreme irruptive years these birds move like a wave en mass and penetrate the Deep South, in moderate years birds reach down to middle latitudes, and during normal years most birds remain in the north. The irruptive pattern is thought to be driven by varying combinations of food availability, bird density, and weather conditions. Although periodic irruptions have been noted for centuries, we know very little about how birds cope and fare during migration events.

THE DISCOVERY

For nearly 20 years, CCB biologists operated a fall trapping station for northern saw-whet owls near the tip of the Delmarva Peninsula. Three trapping stations were operated consistently from dusk to dawn in an effort to study movement patterns, stopover duration, and bird condition. The number of birds trapped per season varied from 21 to 1,007 and several irruption years were documented. Irruption years had higher juvenile to adult ratios, suggesting that irruptive migrations follow high reproduction. Birds captured during irruptive years had lower weights and shorter stopover lengths, suggesting that foraging opportunities and movements were density-dependent. The condition of both adults and juveniles were better in non-irruption years, implying a possible demographic mechanism for population regulation. ■

Thirty owls in holding boxes waiting to be processed. These owls were captured during a single net run in an irruption year. Capture rates and migration ecology varied significantly between irruption and normal years. *Photo by Bryan Watts*

A female red crossbill comes down for a drink. This species is one of several in North America that exhibits an irruptive pattern of migration. CCB's work with northern saw-whet owls spanning nearly 20 years has given insight into the ecology of irruptive species during migration. *Photo by Bryan Watts*

Northern saw-whet owl trapped on the lower Delmarva Peninsula in Virginia. Saw-whets are irruptive migrants that CCB biologists studied for nearly 20 years. The study investigated the stopover ecology of owls during irruptive and normal years. Findings have implications for other species that exhibit irruptive patterns of migration. *Photo by John DiGiorgio*

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