PROGRAM
&
ABSTRACTS

PINOLA AVIARY

FIVE OAKS
AG RESEARCH & EDUCATION CENTER

Lower Mississippi Valley
JOINT VENTURE

DUCKS UNLIMITED

U.S. FISH & WILDLIFE SERVICE

The Lower Mississippi Valley Joint Venture is a self-directed, non-regulatory conservation partnership that exists for the purpose of sustaining bird populations and their habitats within the Lower Mississippi Valley region through implementing and communicating the goals and objectives of relevant national and international bird conservation plans.

We are excited to convene students, scientists, and managers whose work advances the state of knowledge of waterfowl science and conservation within the Lower Mississippi Valley Joint Venture region. We intend for the 2022 LMVJV Waterfowl Symposium to serve as a forum for the exchange of ideas, to celebrate our successes and to gain a better understanding of how we all contribute to waterfowl conservation.

To that end, we ask that symposium participants keep the following in mind:

Be present

Listen attentively to others. Silence phones. Don't interrupt or have side conversations. Treat all meeting participants with the same respect you would want from them.

Be inclusive and welcoming

Respect each other's thinking and value everyone's contributions. All questions are valid and welcomed.

Remember the power of partnership

Challenge ideas, not individuals. Focus on the collective interest, not individual positions. Diversity of opinions and differences of opinion can lead to better decision-making. Think of how we collectively contribute to further waterfowl conservation.

Have fun and go do good things for waterfowl

Many bright minds are sitting in the room! Make new friends. Forge new collaborations. We hope you leave this meeting with renewed inspiration to continue doing good things for waterfowl and wetland management.

We value your attendance, and want to make the conference experience as educational, productive, motivating, and fun as possible. Thank you for your contributions to a great symposium!!

Lower Mississippi Valley
JOINT VENTURE
www.lmvjv.org

The LMVJV mission is to function as the forum in which the conservation community develops a shared vision of bird conservation for the Lower Mississippi Valley region; cooperates in its implementation; and collaborates in its refinement.

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† Student presenter

TUESDAY October 4 - Memphis Ballroom		First Author	Theme
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† Student presenter

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† Student presenter

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2:50	Student Awards		
3:00	Symposium wrap-up & looking ahead to LMVJV waterfowl plan revision	Mini, Anne	
3:30	Adjourn		

† Student presenter

†Spatial and temporal variation in body condition of late-winter female mallards in the lower Mississippi Alluvial Valley

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Lipid stores reflect the body condition of birds and can be used to make inferences about the health and survival of populations. These stores are especially important to waterfowl during winter: an energetically costly period due to increased thermoregulatory costs, limited food availability, and increased predation risk from hunting. While direct measure of lipid content requires lethal collection and carcass deconstruction, non-lethal indices of lipid content can be derived from morphological measurements and direct measures of lipid content. Non-lethal indices allow ecologists to predict lipid content in live-caught birds and aid in understanding the relationship between exogenous factors and variation in lipid content during winter. To develop a non-lethal index of lipids for female mallards in the lower Mississippi Alluvial Valley, we collected nine morphological measurements derived from published indices of body condition from 49 experimentally collected female mallards (*Anas platyrhynchos*) during November – January 2019 – 2021. We determined carcass lipid composition using proximate analysis and evaluated the relationship between morphometric measurements and percent lipid content using generalized linear models. Model selection was conducted to determine the best predictors of lipid content. Percent lipid content was best predicted by an interactive model of mass by age (juvenile versus adult; $R^2 = 0.43$). We then used the mass by age model to predict lipid stores of banded, female mallards (n = 1,446) and evaluated the factors influencing spatial and temporal variation in lipids. We modeled the effects of year, week, and location of capture on predicted lipid stores. We found differences in predicted lipids, by week ($F = 3.40$, $p < 0.05$), year ($F = 6.19$, $p < 0.05$), and among banding site ($F = 6.19$, $p < 0.05$), but not latitude ($F = 2.66$, $p = 0.10$). Differences in predicted lipids between banding sites suggest potential effects of landscape factors, such as availability of food and water, influencing body condition of captured mallards. We are continuing to examine the influence of landscape composition, hunting pressure, and weather severity on predicted lipid stores of captured birds. Results of this study will provide a better picture of how geospatial, temporal, and climatic factors influence the body condition of female mallards at the end of the wintering period.

Effects of land use and forest characteristics on site-selection by wintering mallards

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The Mississippi Alluvial Valley of Arkansas supports a large proportion of the continental mallard population during winter, providing hunter opportunity and bolstering local economies. These abundance of dabbling ducks rely on resources provided through rice agriculture, bottomland forests, and abundant surface water. However, changes in agriculture and bottomland forest health could have consequences on long-term sustainability of wintering mallard abundances in the region. Altered hydrology and poor water management has led to large-scale forest die offs, decreased forest health, and shifts to less desirable, water-tolerant tree species. Understanding how landscape characteristics influence mallard resource selection at multiple scales can help prioritize management and conservation efforts. We were interested in how land use and forest characteristics influence resource selection. We used GPS telemetry to quantify diurnal and nocturnal selection in relation to landscape and forest characteristics. We deployed 45 GPS transmitters on mallards (*Anas platyrhynchos*) near Humphrey, Arkansas during November 2021 and tracked movements during the 2021 – 2022 hunting season. We developed geospatial layers of canopy height and stem density using LiDAR data and adapted the National Wetlands Inventory layer to classify wetland types. We generated 20 available points per 1 use point within kernel density estimates of home range for each individual and used logistic resource selection functions to quantify field and site level selection. Selection was greatest for managed moist-soil wetlands ($\beta = 0.34 \pm 0.02$ SE) and emergent wetlands (0.27 ± 0.02) with lower selection intensity for scrub shrub ($\beta = 0.13 \pm 0.02$) and forested ($\beta = 0.02 \pm 0.00$). Within forested wetlands, mallards selected for low to intermediate stem density (0 - 15 trees per .1 acre) and low to intermediate canopy height (0 – 20 m). These preliminary results provide insights into the relatively importance of different wetland types and highlight the importance of emergent wetlands and managed moist-soil wetlands for wintering mallards. Furthermore, this study highlights the utility of GPS data and advance remote-sensing techniques for identifying desirable forest characteristics for mallards.

Potential for reducing flood stress on willow oaks in greentree reservoirs by adjusting the timing of inundation

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A critical need for waterfowl habitat management is an understanding of oak tree root dormancy sufficient to develop hydrologic regimes that allow sustained oak survival in greentree reservoirs (GTRs), while providing flooded habitat for waterfowl. We investigated whether cold soil temperatures and other seasonal environmental cues reduced root activity in willow oak (*Quercus phellos*) during winter, and if reduced activity increases root tolerance to winter soil flooding. We employed both a manipulative experimental approach in a greenhouse, and a correlative approach in the field. In the greenhouse, soil temperatures of potted seedlings were either held constant at 15°C, or transitioned to cold winter temperatures (10°C and 5°C treatments) which were held constant until returning all soil temperatures to 15°C and then 20°C in spring. Root growth, nitrate uptake, and respiration rates were used as indicators of overall root activity. Reductions of root growth and respiration were dependent on soil temperature. Nitrate uptake was reduced during winter independent of soil temperature. An indicator of metabolic acclimation, Q_{10}, was not affected by soil temperature treatments. This does not support acclimation of root respiration to cold temperatures, but rather indicates that temperature directly and reversibly affected root respiration rates. Additionally, half of the seedlings were subjected to soil waterlogging to the root collar from December through early February. Waterlogging immediately halted root growth, but did not reduce root respiration compared to unflooded roots. Survival and spring growth were high for seedlings in all treatments. However, there were morphological stress responses in seedlings that experienced warmer winter temperatures while flooded. Naturally seeded, 1-year-old willow oak seedlings at Cutoff Creek WMA, Arkansas were sampled for root respiration as an instantaneous measure of root activity. Root respiration in the field was much more variable than in the greenhouse, and was significantly correlated with both soil and air temperatures. Furthermore, roots appeared to acclimate to environmental changes during the fall. Together these results indicate that root activity might not be reduced uniformly throughout winter, but that roots may cycle between periods of low and moderate activity, fluctuating with temperatures. Root growth could continue during typical winter soil temperatures in the LMAV. However, the stress of flooding was reduced even when soil temperature was not low enough to stop root growth.

†Wood duck nest survival in Mississippi and Louisiana: the combined effects of partial clutch loss and nest parasitism

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Nest boxes for wood ducks (*Aix sponsa*) are used to provide additional nest sites on the landscape and increase nest survival (i.e., the probability a nest will survive to hatch ≥ 1 egg). Conspecific brood parasitism is common in wood ducks, especially in nest box populations as boxes are often highly visible. Additionally, black-bellied whistling-ducks (*Dendrocygna autumnalis*) will lay eggs in wood duck nests, and their distribution has recently expanded into the southeastern United States. Parasitism often results in abnormally large clutch sizes that are not incubated; therefore, our objective was to determine the influence clutch size has on wood duck nest survival. During 2020−2021, we monitored an average of 455 nest boxes in Mississippi (129 and 173 boxes, respectively) and Louisiana (283 and 325 boxes, respectively), and documented 1,164 nest attempts across both years. Our top-ranked model for nest survival included parameters for maximum observed clutch size and study site, and an interaction between them. That is, at some sites, high nest survival was associated with a larger maximum clutch size, but at other sites we observed the opposite effect. At sites where the effect was positive, wood duck nests experienced repeated partial clutch losses, primarily due to red-bellied woodpeckers (*Melanerpes carolinus*), so those nests benefited from parasitic egg-laying, because additional eggs buffered against total clutch loss and also reduced the risk of nest abandonment. For example, parasitic egg-laying allowed 32 nests to hatch at one Louisiana study site despite 72% of them losing ≥ 1 egg during incubation. On the other hand, at sites where partial clutch losses were uncommon, rampant parasitic egg laying eventually caused nests to be abandoned, thereby driving the negative relationship between maximum clutch size and nest survival. Our results suggest wood ducks may actually benefit from receiving additional eggs via brood parasitism when a portion of eggs are lost through partial clutch predation.

† An evaluation of box-nesting wood duck egg survival and productivity

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Nest boxes for wood ducks (*Aix sponsa*) are used to provide additional nest sites on the landscape and increase productivity. Brood parasitism is common in wood ducks, especially in nest box populations as boxes are often highly visible. High rates of brood parasitism often yield abnormally large clutch sizes that are not incubated by the nest host; however, when eggs are simultaneously lost (hereafter, partial clutch loss), individuals may choose to incubate. Here we monitored box-nesting wood ducks in Louisiana to understand the influence partial clutch losses have on productivity. Our objective was to compare estimates of egg survival and productivity (i.e., the average number of ducklings produced per nest box) across different study sites. We hypothesized study sites experiencing lower egg survival would be more productive as reductions in clutch size would buffer against nest abandonment, allowing more eggs to hatch. During 2020-2022, we monitored a total of 895 wood duck nests containing 12,526 eggs. A total of 406 nests were successful (i.e., hatched ≥1 egg). All non-depredated eggs were considered to have survived regardless of each nest's fate (e.g., 4 eggs remaining in a depredated nest were considered "survivors"). We observed 9,412 (75.1%) eggs survive and 3,114 (24.9%) that were depredated. Across study sites, apparent egg survival ranged from 52.5−91.3% and the average number of ducklings produced per box ranged from 5.1−40.6. We found no clear relationship between our two parameters of interest; however, lower egg survival at a given site did not necessarily represent low productivity. For example, the site with the lowest egg survival estimate still produced an average of 11.8 ducklings per box.
While we only present apparent estimates here, we will conduct a more rigorous analysis to test our hypothesis.

† Regional examination of the contribution of nest boxes to wood duck recruitment in the southeast and mid-Atlantic United States: 2020–2022 project update

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Biologists who attended a waterfowl and wetlands workshop hosted by Nemours Wildlife Foundation, Yemassee, South Carolina, February 2018, ranked the status and management of wood duck (*Aix sponsa*) nest box programs a top-priority research question for the southeastern and mid-Atlantic United States. To address this research need, we initiated a collaborative study beginning in 2020 across the mid- to south Atlantic and lower Mississippi Valley Flyways with study sites in Delaware, Florida, Georgia, Louisiana, Maryland, Mississippi, North Carolina, and South Carolina. We will estimate recruitment rates (i.e., females and their female offspring surviving to the next breeding season[s]) to assess the efficiency and economics of these nest box programs and their overall contribution to wood duck population dynamics across our regional study area. In 2020 and 2021 we sampled 1,272 and 1,437 nest boxes, respectively. Ducklings were marked with web- or PIT tags. Return rates of these marked individuals encountered as nesting females in subsequent years will be used to calculate recruitment estimates. Across states, box use was 73% (n = 1,272; 2020) and 79% (n = 1,437; 2021) with 1,902 (2020) and 2,051 (2021) individual nesting attempts resulting in an average of 45% nest success (> 1 duckling successfully hatching and exiting). Across states, we banded 747 (2020) and 479 (2021) nesting wood ducks and recaptured 366 and 646 previously banded females in 2020 and 2021, respectively. Of recaptured females, across states, we encountered 14 (2020) and 75 (2021) previously web- or PIT-tagged individuals with a mean return rate index of 2.70% across years. From 2020–2021 we marked 11,351 wood duck ducklings. As of 31 May 2022, we are sampling 1,391 nest boxes with 63% box use, 872 individual nesting attempts, and 45% nest success rate. During the current 2022 nesting season, we have banded 222 nesting females and encountered 449 previously banded females, including 78 web- or PIT-tagged individuals. Additionally, we have marked 3,414 ducklings. Data collection and mark-recapture efforts will continue through the 2023 nesting season.

† Effects of moist-soil seed density on body condition of dabbling ducks foraging in National Wildlife Refuges

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Moist-soil wetlands are used by dabbling ducks for replenishing nutrients lost during migration and for building stored energy reserves for the winter ahead. Strategies for restoring and acquiring energy reserves vary among species of dabbling ducks, thus identifying variation in preferred moist-soil food items among duck species can aid wetland managers in targeting moist-moist soil plants communities that benefit a diversity of dabbling duck species. The purpose of this research was to evaluate selection intensity (SI) of moist-soil seeds and determine the effects of food density on stored lipid composition by dabbling ducks located in moist-soil wetlands on National Wildlife Refuges in Arkansas. We lethally collected mallards (*n* = 200; *Anas platyrhynchos*), green-winged teal (*n* = 61; *Anas crecca*), northern pintail (*n* = 36; *Anas acuta*), gadwall (*n* = 24; *Mareca strepera*), and American wigeon (*n* = 10; *Mareca americana*) during autumn and winter of 2019-2020 and 2020-2021. Overall, Pennsylvania smartweed (*Polygonum pensylvanicum*), signal grass (*Urochloa platyphylla*), wild millet (*Echinichloa spp*.), and redroot flatsedge (*Cyperus erythorhizos*) accounted for 75% of the total dry weight of moist-soil seeds consumed. Mallards and green-winged teal selected for signal grass (SI = 1.70) and redroot flatsedge (SI = 0.94), respectively. Northern pintail carcasses had the greatest lipid content ($\overline{x}$ = 57.8 % SE ± 1.11%), followed by American wigeon ($\overline{x}$ = 48.4%, SE = 1.09%), green-winged teal ($\overline{x}$ = 46.8%, SE = 1.02%), mallard ($\overline{x}$ = 44.8%, SE = 0.53%), and gadwall ($\overline{x}$ = 43.8%, SE = 1.88%). Lipid content was 6.0% greater in ducks collected in areas with high food availability of >600 kg/ha ($\overline{x}$ = 50.2%, SE = 0.65) than moderate food availability (250-600 kg/ha; $\overline{x}$ = 44.3%, SE = 0.75%), and 9.0% higher than low food availability (<250 kg/ha; $\overline{x}$ = 41.5%, SE = 1.53). These results highlight important similarities and differences in food items between dabbling ducks species and the need for management for diverse stand of moist-soil vegetation. Thus, refuge managers should ensure that their moist-soil wetlands contain desired plant communities that reflect the composition of dabbling duck species that most frequents the area.

†Immediate and longer-term responses of wintering mallards to experimental disturbance on sanctuaries

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Winter is an energetically and physically stressful time for animals and may be especially demanding for hunted species such as waterfowl. Often, wildlife managers provide spatial sanctuaries and food resources for waterfowl along autumn migration routes and across wintering areas; however, studies indicate that waterfowl increase their use of sanctuaries diurnally during hunting seasons. Increased use of sanctuaries by waterfowl during hunting seasons may result in pressure from the hunters and other stakeholders to offer access to sanctuaries for hunting or other activities (e.g., birding, photography). However, empirical evidence quantifying waterfowl responses to disturbance, particularly on sanctuaries, is lacking but may affect energy-expenditures, movements, site-fidelity, and survival. We placed GPS/GSM transmitters programmed to take hourly locations on 480 mallards (*Anas platyrhynchos*) during winters of 2019–2022 and evaluated how experimental disturbance on sanctuaries affected immediate and longer-term behavior (i.e., movements, space use, and site fidelity). We conducted disturbance treatments which represented activities that could potentially occur on waterfowl sanctuaries including 1) waterfowl surveys from a vehicle, 2) pedestrian access, and 3) accessing wetland units via motor boat or all-terrain vehicle (ATV). Disturbing mallards had little effect on their overall sanctuary use; however, mallards increased movement and used more space on days when they were disturbed compared to control days. For instance, daily core areas were 57% larger (35–60 % [95%CI]) when pedestrians disturbed sanctuaries, whereas vehicular access resulted in less severe impacts on mallard behavior. Furthermore, we will extend current analyses to investigate both immediate (i.e., hourly) and longer-term (i.e., days following disturbance) responses to disturbance. If waterfowl vary use of specific managed habitats such as sanctuaries or experience fitness consequences in response to disturbance, management of these resource may require reconsideration.

†Coming up short? Do mallard winter home ranges contain sufficient energy?

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Habitat conservation planning for wintering waterfowl in North America typically aims to maximize energetic carrying capacity from a landscape-population perspective. However, because spatial and temporal configuration of resources can influence animal space use, there may be potential ramifications if conservation planning does not consider energetic availability from the individual's perspective. We demonstrated this possibility using three pieces of information for mallards (Anas platyrhynchos) located in the Mississippi portion of the Mississippi Alluvial Valley: (1) established energetic values for different landcover types (quantified as duck energy days; DEDs), (2) maps of landcover and water availability, and (3) home ranges created from location data of radiomarked birds. We first transformed landcover types into energetic carrying capacity using DED values, and then restricted the amount of energy accessible within mallard home ranges using water availability and DED decay rates. We found that relatively energy-rich landcover types, such as moist-soil wetlands and agricultural crops, were less likely to inundate, although mallards seemingly exploited these areas during flooding events. Mallard home range size was not associated with DEDs and most home ranges met minimum winter energetic needs (i.e., 123 DEDs). However, 4% of individuals appeared not to meet the minimum DED requirements which may have ramifications at larger population scales. Further, the potential number of mallards with insufficient DEDs may be underestimated as we did not account for a variety of other factors that may limit energy acquisition. Our findings highlight the need for waterfowl habitat management to consider energetic capacity from the perspective of individual animal space use.

True metabolizable energy of targeted and unfavorable seed species commonly seen in Tennessee waterfowl management areas

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True metabolizable energy (TME) assays were developed to refine poultry diets but have been adapted to determine the available metabolizable energy within natural wetland foods for wild waterfowl. TME values of wetland food resources are needed before generating bioenergetic models to calculate impacts habitat management has on the energetic carrying capacity of wetlands. Prior TME research has focused on the food items commonly found in waterfowl diets and mostly focused on a single species of waterfowl, leaving an information gap within multiple waterfowl species and moist-soil seeds. In this project, we determined TME values of moist-soil seeds considered beneficial (i.e., *Cyperus erythrorhizos*, *Cyperus iria*, Leptochloa panicoides, *Panicum rigidulum*, and *Polygonum lapathifolium*) and seeds considered unfavorable (i.e., *Polygonum hydropiperoides*, *Sesbania herbacea*, and *Sida spinosa*) within three species of wild-caught waterfowl (i.e., mallard [*Anas platyrhynchos*], northern pintail [*A. acuta*], and green-winged teal [*A. crecca*]). From December to February 2019-2022, we completed three fasting trials and 27 feeding trials across three duck species and eight seed species during the non-breeding period. Trials began with a fasting period, with the length of time determined by examining data collected during fasting trials (24-hours for *A. platyrhynchos* and *A. acuta*, 12-hours for *A. crecca*). Following the fasting period, we fed individuals a seed mass not exceeding 1% of an individual's body mass. Once fed, the individuals were held for an additional fasting period to allow the collection of excreta. Excreta was dried and remaining energy (Kcal/g) was quantified using a calorimeter. Our results will be used to support conservation planning models to refine waterfowl objectives stepped down from the North American Waterfowl Management Plan to better inform waterfowl conservation planners and wetland managers throughout the Mississippi Flyway of the United States.

†Evaluation of wintering waterfowl survey methodology in Alabama

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One of the principal management goals of the North American Waterfowl Management Plan is to monitor waterfowl populations and obtain long-term average population estimates, therefore federal and state wildlife agencies estimate wintering waterfowl abundance annually. However, historical survey methods significantly underestimate abundance and species presence due to imperfect detectability, variation in methodologies, and variability in proportion of population surveyed. We are working with the Alabama Wildlife and Freshwater Fisheries Division (AWFF) to evaluate and increase robustness of wintering waterfowl population estimates reported annually to the U.S. Fish and Wildlife Service (USFWS). Our specific objectives are to quantify the effectiveness of using unmanned aerial vehicles (UAVs) and other methods to decrease bias and variability of waterfowl population estimates; to compare the effectiveness, cost, time requirements, and safety aspects of both UAV and crewed aerial surveys; and to estimate detectability for crewed aerial surveys conducted by AWFF using a double observer method. During November-February 2021-24, we are conducting crewed aerial and UAV surveys on public land in the Tennessee River Valley of north Alabama, with additional crewed aerial surveys in the coast, bay, and Delta areas of Mobile, Alabama. We are implementing a double observer method during crewed aerial surveys to develop a detectability factor to build into the overall population estimate, with analyses of 2021-2022 data in progress. Survey locations exhibit a variety of vegetative composition which will be roughly categorized by the primary vegetation (or lack thereof) present to determine how vegetation may impact detectability of waterfowl. During 2021-2022 we implemented short duration repeated unmanned aerial vehicle counts to assess utility of an N-mixture model approach for addressing detection probability. However, large changes in waterfowl counts on survey polygons surveyed twice per hour suggest violation of basic model assumptions. Therefore, we are developing other avenues for estimating detectability using UAV flight imagery and videography, and repeated flights. Employing UAVs provides an opportunity to assess changes in waterfowl availability and temporal variation as survey replicates are easier to conduct and with reduced risk to participants. Crewed aircraft double-observer strategies provide instantaneous double samples for whole survey areas and may allow estimation of large-scale detection probability.

Refuge connectivity for wintering mallards in western Tennessee

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Unhunted lands within U.S. Fish and Wildlife National Wildlife Refuges and state Wildlife Management Areas serve as a network of protected areas that collectively meet life-history needs and spatially distribute risk across the landscape for highly mobile species like waterfowl. Managers operate under the assumption that protected areas are a complex with movement between refuges. Consequently, waterfowl would fly between refuges to exploit different resources and possibly increase harvest opportunity. Refuge connectivity, however, has seldom been evaluated for wintering waterfowl at the southern terminus of their migration. Our objective was to assess connectivity of and movement rates between wintering refuges for migratory waterfowl. We used Global Positioning System (GPS) data from 478 radio-collared mallards during winter in western Tennessee from 2019–2022. We evaluated connectivity and movement rates using a Bayesian multi-state mark-recapture model and estimated daily probabilities of movement between refuges. Most mallards (73%) only used 1 refuge, whereas 20% used 2 refuges, 6% used 3 refuges, and 1% used 4 or more refuges. Daily probabilities of movement between refuges were extremely low, further suggesting connectivity of refuges was limited. Probability of using multiple refuges was unaffected by the length of time mallards were on their wintering grounds. However, daily probabilities of movement between refuges increased as distance between refuges decreased. Refuges in closer proximity may serve as a protected area network for waterfowl during the non-breeding season, however most refuges seem too far apart to facilitate movement among refuges. Stationary waterfowl not only deplete food resources on refuges but may also limit harvest opportunities.

North American Waterfowl Management Plan survey regional profile: Southeast Region

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Objectives:
Support US Fish and Wildlife Service waterfowl management decisions by stepping down national survey data to a regional scale.
Body:
With the 2012 NAWMP revision, an emphasis was placed on describing the human dimensions of waterfowl management and waterfowl-related outdoor recreation. Specifically, the revision suggested engaging waterfowl hunters and non-traditional stakeholder communities to nurture support for waterfowl and wetland conservation. To successfully meet the objectives laid out in the 2012 NAWMP revision, it is first necessary to collect human dimensions information that describes the perceptions and beliefs of waterfowl and wetland stakeholders to inform future engagement and communication strategies. In most cases, one size fits all engagement and communication will not be effective because stakeholders perceive them differently based on unique backgrounds, life experience, and trust. The objective of this profile was to incorporate the assumption of a heterogeneous waterfowl hunting community and identify where perceptions and views of waterfowl hunters may diverge in the Southeast United States. In most cases, the Southeast Mississippi sub-flyway reported similar opinions with hunters in the Atlantic sub-flyway. Differences that were identified tended to center around harvest and harvest-related regulations.

Long-term trends in wintering waterfowl use of Mississippi's Alluvial Valley

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Recently, literature has reported that mallard (*Anas platyrhynchos*) and other ducks are wintering farther northward in relation to increased winter temperatures, presumably from climate warming. The Mississippi Department of Wildlife, Fisheries, and Parks and partners have conducted line-transect aerial surveys across Mississippi's Alluvial Valley (MAV) for nearly 20 years allowing us to estimate long-term population trends for a variety of wintering duck species, including mallards, gadwall (*Mareca strepera*), green-winged teal (*Anas crecca*), northern shoveler (*Spatula clypeata*), northern pintail (*Anas acuta*), and wood duck (*Aix sponsa*). Numbers of mallard, gadwall, green-winged teal, shoveler, pintail, and wood duck groups detected ranged from 212–2078, 45–359, 15–200, 17–224, 17–93, and 5–96, respectively. Groups of birds were comprised, on average, between 18 and 129 individuals across species. Preliminary analyses indicated no long-term apparent increasing or decreasing trends across species. We will examine and report abundance dynamics over winter months (November-January) and years in relation to environmental variables. Lastly, we will compare our December aerial survey results with that generated by The National Audubon Society's Christmas Bird Count during this same period.

Occurrence and abundance of wintering ducks detected on aerial surveys in the lower Mississippi Alluvial Valley

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Mallards and other ducks require diverse resources to meet daily energy and other socio-biological needs to survive during winter. Previous work reported that a complex of landcover types, including 50% agriculture, 20% forested wetlands, 20% emergent herbaceous wetland, 10% and permanent water, attracted the greatest abundance of mallards (*Anas platyrhynchos*) in Mississippi's Alluvial Valley (MAV). While this 'habitat complex' has been described for mallards, it is uncertain for other species. Herein, we used winter (November-January) detections of mallards and other species obtained from stratified random diurnal aerial surveys in the MAV and related occurrence and abundance of species to aforementioned landcover types along with a measure of landscape complexity and an index of water recurrence. We consistently detected 6 duck species during surveys, including mallards, gadwall (*Mareca strepera*), northern pintail (*Anas acuta*), green-winged teal (*A. crecca*), northern shoveler (*Spatula clypeata*), and wood duck (*Aix sponsa*). Complexes with a greater amount of agriculture increased mallard, green-winged teal, and pintail occurrences along with mallard, gadwall, and shoveler abundances. A greater coverage of emergent herbaceous wetlands also increased mallard and pintail occurrences and mallard abundance. Forested wetland prevalence was associated with an increase in mallards and wood duck occurrence. Across species, an increase in landscape complexity either increased occurrence or abundance, except for mallards, which had greater abundances in less diverse landscapes. Finally, complexes more prone to flooding were positively associated with all species occurrence and abundance. Despite different niches and habitat affinities, mallards, gadwall, pintail, and shoveler were in greatest abundances in a complex similar to what has been previously described. However, gadwall and wood ducks required complexes low in agricultural composition. As agricultural land use dominates the MAV landscape, our results signal a continued need for assertive inclusion of natural wetland conservation within MAV habitat complexes.

Low levels of hybridization between domestic and wild mallards wintering in the lower Mississippi Flyway

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Mallards (*Anas platyrhynchos*) are a ubiquitous and socio-economically important game bird in North America. Despite their generally abundant midcontinent population, mallards in eastern North America are declining, which may be partially explained by extensive hybridization with human-released domestically-derived game-farm mallards. We investigated the genetic composition of mallards in the middle and lower Mississippi flyway, key wintering regions for the species. We found that nearly 30% of wild mallards carried mitochondrial haplotypes derived from domestic mallards present in North America, indicating that the individuals had female game-farm mallard lineage in their recent past; however nuclear results identified only 4% of the same sample set as putative hybrids. Recovering 30% of samples with OW A mtDNA haplotypes is concordant with general trends across the Mississippi flyway and this percentage was stable across mallards we sampled a decade apart. The capture and perpetuation of OW A mtDNA haplotypes is likely due to female breeding structure, whereas reversal of the nuclear signal back to wild ancestry is due to sequential backcrossing and lower and/or declining admixture with game-farm mallards. Future studies of wild ancestry of Mississippi flyway mallards will benefit from coupling molecular and spatial technology across flyways, seasons, and years to search for potential transitions of mallard populations with different genetic ancestry, and whether the genetic ancestry is somehow linked to an individual's natal and subsequent breeding location.

The consequences of interspecific nest parasitism in wood duck and hooded merganser nests

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The use of artificial nesting structures (hereafter, nest boxes) for wood ducks (*Aix sponsa*) has a storied history in North America. Nest boxes are often used by other species of cavity-nesting birds, including hooded mergansers (*Lophodytes cucullatus*). Herein, we report results for interspecific nest parasitism occurring between wood ducks and hooded mergansers in Louisiana and Mississippi. In Mississippi, we found 883 total nests from 1994−1997; 615 (70%) hatched and 112 (18%) of those contained eggs from both species. 7,142 eggs hatched with 1,479 (21%) ducklings hatching from parasitized nests. Of the ducklings hatching from parasitized nests, 1,120 (78%) were wood ducks and 359 (24%) were hooded mergansers. In Louisiana, we found 998 nests from 2020−2021; 431 (41%) hatched and 51 (12%) of those contained eggs from both species. 4,389 eggs hatched with 533 (12%) ducklings hatching from parasitized nests. Of the ducklings hatching from parasitized nests, 240 (45%) were wood ducks and 293 (55%) were hooded mergansers. The number of parasitized nests observed across six breeding seasons, in two states, represents some of the greatest reported in North America. Ongoing analyses will explore clutch sizes and other metrics among all nests. These results will provide some basis for exploring potential consequences of shared use of nest boxes given the differences in life history between these cavity-nesting Anatids in southern wetlands. Habitat selection by brood-rearing females and survival of ducklings in mixed versus single-species broods, for example, are interesting research questions.

†Mallard use of sanctuary and non-sanctuary around White River National Wildlife Refuge

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Many public lands are only partially open to waterfowl hunting with some portions of that land being closed to hunting to provide waterfowl sanctuary where waterfowl can exist with limited human disturbance. It is understood that sanctuary areas are vital for waterfowl management but little research has been done to assess to what degree they are utilized by ducks. We deployed 105 Ornitela GPS-GSM transmitters on mallards (*Anas platyrhynchos*) in four sanctuaries across Dale Bumpers White River National Wildlife Refuge (DBWRNWR) during the winters of 2019 (*n*=15), 2020 (*n*=45), and 2021 (*n*=45). We collected ~144k non-flight locations within a 50-km buffer around DBWRNWR. Of the ~59k GPS locations located on DBWRNWR, 79.1% (SE ± 2.6) were within spatial sanctuary, 14.9% (SE ± 2.4) were within areas closed to duck hunting but open to other forms of recreation, 4.2% (SE ± 1.0) were within open hunt areas, and 1.8% (SE ± 0.6) were within areas open to duck hunting on a limited basis. Day time land cover use was dominated by woody wetlands (69.0%, SE ± 1.9), while night time land cover use was largely split between cultivated crops (45.8%, SE ± 2.7) and woody wetlands (39.5%, SE ± 2.5). For winter 2020-2021, the majority of diurnal locations were on the refuge (68.1%), while the majority of night time locations were off the refuge (57.0%). In contrast, the majority of diurnal (63.9%) and nocturnal (66.7%) locations were off the refuge in winter 2021-2022. Interestingly, winter precipitation was less than half in 2021-2022 than 2020-2021, limiting the availability of flooded area available for use on DBWRNWR. We will use integrated step selection analysis (iSSA) to further investigate mallards use of sanctuary and land cover types from hourly winter locations to demonstrate the importance of sanctuary areas for wintering mallards in the Delta of Arkansas. We expect that this research will provide managers with applicable information regarding mallard use of sanctuary areas that can be applied directly to the management and design of waterfowl hunting areas. By understanding how mallards utilize sanctuary areas, conservation planners can identify local and regional areas of priority for the development of protected areas to provide the greatest impact possible for waterfowl conservation.

† Development of an aerial waterfowl survey for northeastern Louisiana

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Aerial surveys are a valuable tool for monitoring North America's waterfowl populations and habitat conditions. For waterfowl management, there is the Waterfowl Breeding Population and Habitat Survey, and Mid-winter Waterfowl Survey, along with federal and individual state surveys monitoring migrating and wintering waterfowl. This project will redesign the northeastern portion of the Louisiana wintering waterfowl survey to align with transect surveys conducted in neighboring states in the Mississippi Alluvial Valley (MAV). To identify the optimal sampling method, we will evaluate three transect weighting schemes: stratified random, based on expert opinion, and based on watershed. We will randomly select ~10% of the total sampling area for each survey period. Transects may be surveyed multiple times in a given year. Aerial flights will be flown by an LDWF biologist and myself following existing protocol from LDWF (survey dates, speed, data recording, flight altitude). We are proposing two observers, one on either side of the aircraft, with transects being 250 m on either side. In addition, we will use an unmanned aerial vehicle equipped with thermal and optical cameras to evaluate season- specific visibility correction factors (VCFs) for species and habitat types of interest. We will determine the extent of sampling coverage necessary to reduce the coefficient of variation (CV) to desired levels of precision, which will provide information to make economic cost-benefit decisions about sampling coverage. Our goal is to develop analytical tools to facilitate transect selection and population data summaries for use in future years by the Louisiana Department of Wildlife and Fisheries (LDWF).

The Wetlands Management Tool 2.0 for the Lower Mississippi Valley Joint Venture Partnership

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Since the establishment of the Lower Mississippi Valley Joint Venture (LMVJV) in 1987, monitoring and evaluating waterfowl populations and habitats has been a strong focus for the partnership in both the Mississippi Alluvial Valley and the West Gulf Coastal Plains/Ouachitas, as evidenced by continual maintenance of a public lands waterfowl management unit database since the 1990s. Advances in technology have led to increased capabilities in habitat monitoring and, to that end, to the creation of a newly developed LMVJV Wetlands Management (WMU) Tool 2.0 for public lands waterfowl and shorebird habitat monitoring of managed impoundments across the partnership. First released in the fall of 2020, the WMU Tool is an online data repository that partner managers access and annually record wetlands habitat information that is both contextual and spatial in context. Transfer of such detailed information to the WMU Tool by knowledgeable managers is the key ingredient in the process. Inputs are invaluable in providing information for waterfowl habitat apportionment and allocation modeling, providing the LMVJV partnership with high quality waterfowl habitat goals and objectives.

Visibility correction factors for multiple species of waterfowl using an aerial remote sensing approach

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Aerial ocular surveys are a cost and time-efficient method to evaluate the relative abundance and spatial distributions of waterfowl. However, many ocular survey methods are subject to substantial visibility bias and correction factors must be calculated for incomplete detection. Calculation of visibility correction factors in remote or hard to access places, such as open water environments, is difficult but new technologies offer a means to estimate them. During fall 2021, we used the advanced remote sensing capabilities of the U.S. Fish and Wildlife Service - Division of Migratory Bird Management and Wisconsin Department of Natural Resources ocular survey crew to collect data to estimate visibility correction factors for waterfowl staging on the Wisconsin waters of Green Bay, a sub-basin of Lake Michigan. During two and half flight missions we captured high-resolution digital imagery (e.g., 1-1.5 cm) at 305 meters above ground level in one plane, while a second plane followed along the same transect conducting a blind double observer ocular survey at 61 meters above ground level. Avian targets within the collected imagery will be annotated to the lowest possible taxonomic level (e.g., species) and used to estimate visibility correction factors, along with associated uncertainties at different spatial and temporal scales for multiple species of waterfowl. In addition, annotated imagery will be incorporated with existing databases for training machine learning algorithms that would automate enumeration and classification of targets from remotely sensed data. Estimation of visibility correction factors, leading to more accurate estimates, is important for agencies that are conducting aerial surveys over open water environments to assess waterfowl abundance and distributions during the non-breeding time period.

Understanding waterfowl hunter experiences to inform management

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Understanding waterfowl hunter experiences on public lands is important for state natural resource agencies for a myriad reasons. In Arkansas, hunter experience data have become increasingly important as waterfowl hunter use of Arkansas Game and Fish Commission (AGFC) Wildlife Management Areas (WMAs) and perceived crowding and conflict between user groups has grown. Often waterfowl hunter social science data are collected via post-season surveys, when hunter memory may be unclear. To minimize recall bias, AGFC conducted waterfowl hunter intercept surveys at select WMAs during the 2016-2021 duck seasons. Throughout each season, a minimum of two surveys per week were conducted at randomly selected access points on randomly selected days, stratified by duck season segment and day type (weekdays or weekends). These surveys measured hunter satisfaction and perceived crowding to inform WMA waterfowl hunting management decisions. In the 2018-19 season, most people rated their daily hunting experience as fair or poor. The number of ducks hunters saw and shot were cited as variables that detracted from their hunting experience by the largest number of respondents. Conversely, most hunters indicated that crowding had no negative affect on their experience, and the vast majority of hunters reported feeling not at all or slightly crowded during their hunt. These results challenge common perceptions that crowding is a primary detractor from the public-land duck hunting experience, and are in contrast to post-season hunter surveys in which Arkansas duck hunters cite “overcrowding” as the greatest source of disturbance to their hunting experience. Hunters’ experiences on WMAs are influenced by many factors and are not static. Thus, managers must carefully consider potential management actions intended to enhance waterfowl hunting experiences.

Assessing forest composition and health related to elevation in greentree reservoirs at George H. Dunklin Jr. Wildlife Management Area, Arkansas

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Arkansas Game and Fish Commission (AGFC) has recognized that water management practices in some of its greentree reservoirs (GTRs) have led to stress and possible mortality of trees, particularly red oaks (willow, Nuttall, cherrybark oak) that are important to waterfowl. Significant mortality has occurred in Henry Gray Hurricane Lake WMA, and AGFC is concerned that the GTRs in George H. Dunklin Jr. Bayou Meto WMA may experience similar consequences. This WMA is world-renowned, and degradation of this area would be significant. Therefore, AGFC is considering altered water and forest management practices, but requires data to support changes. We address this by characterizing the relationship between forest species and elevation (a surrogate for timing and duration of inundation). AGFC forest inventory utilizes variable radius (10-factor BA prism) plots that are georeferenced by GPS. At each point, the diameter of every tree tallied by the prism is recorded. This allows both basal area and density of trees to be estimated. Relative density and relative basal area are combined into a Bray-Curtis Importance Value of each species at each point. In addition, a number of features indicative of tree health are estimated for each tallied tree – crown, tree and bark condition, epicormic branching and basal swelling. These are combined into an overall health assessment (OHA) of each tree, and averaged for each species within each plot. Also, woody stems from 1 to 5 inches in diameter are tallied by species within a 1/100-acre plot at each point. These are used to evaluate regeneration of potential overstory species or prevalence of shrubs. Statewide LiDAR data are available at a typical horizontal resolution of 1m (39.4”) and vertical resolution of 15cm (6”) or better. Therefore, the IV, OHA and abundance <6” of each species at an inventory point are related to elevation. The elevations of the plots are correlated with past water management dates and elevations to evaluate effects on species composition, regeneration and health. Initial results demonstrate that red oak importance and health decline at lower elevations, and indicate that delayed and reduced inundation, along with aggressive forest management, can contribute to long-term sustainability of forests in the GTRs. In part based on these data, Heitmeyer and Foti will make recommendations to AGFC on modifications to water control infrastructure and/or operation of GTRs at Bayou Meto WMA.

NOAA Firebird: fire effects in Gulf of Mexico marshes on mottled ducks, black and yellow rails

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Although extensive work has been done in upland systems to understand the role of fire in maintaining ecosystem functions, little has been done on the maintenance of coastal wetlands, or the response of birds in high marsh wetlands. High marsh is a unique habitat type, imminently threatened by sea level rise and characterized by a community of specialized emergent vegetation that tolerates irregular tidal inundation. Land managers' decisions about prescribed fire in high marsh systems are complicated by uncertainty around the response of birds to the application of prescribed fire. Without an understanding of how prescribed fire impacts high marsh ecosystems, natural resource managers will be limited in our ability to manage and conserve the biodiversity of the Gulf Coast. Black rail, yellow rail, and mottled duck are birds of concern, and uncertainty currently limits the application of prescribed fire for the benefit for all three species. We will present our work to date in monitoring the response of our three focal species to prescribed fire management of their habitats, and what we've learned along the way in terms of sampling design for three birds that can be challenging to study.

Evaluating natal / molt origins of non-banded ducks harvested in the northern Mississippi Flyway using stable isotope techniques

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Understanding the source area of harvested migratory waterfowl is a vital component of sustainable management. Linkages that establish connectivity between breeding, stopover, and wintering geographies are used to inform conservation and management strategies at both regional and continental scales. These linkages have historically been identified primarily through banding programs that use a capture-mark-recovery framework to understand migratory connectivity. While critically important for the continental monitoring of waterfowl population demography, one limitation of the capture-mark- recovery framework is the high reliance on capture that is spatially representative of each species complete breeding distribution. For many waterfowl species, portions of the breeding range, particularly in remote regions of Canada, are logistically inaccessible or cost prohibitive to maintain annually. As a result, banding programs may inadvertently be skewed towards species and regions where capture and banding are more feasible and therefore may underrepresent portions of the breeding region not monitored. We investigated the potential for a biased marked and recovered sample in mallards (*Anas platyrynchos*) harvested in the Upper Mississippi River Great Lakes Region by comparing regional origins of band encounters to origins of unmarked harvested wings using stable isotope techniques. We collected adult (AHY) and juvenile (HY) wings from the 2019, 2020, and 2021 U.S. Fish and Wildlife annual Parts Collection Survey and analyzed feathers for stable hydrogen isotope (δ^2 H) values. Subsequently, we applied a Bayesian assignment approach to determine the probability of origin based off an isoscape derived from continental monitoring of mean annual δ^2 H in precipitation but calibrated to feather δ^2 H using a rescaling function. Based on initial analyses, we found that 19% of HY and 11% of AHY mallards showed δ^2 H values compatible with natal / molt geographies other than Wisconsin. Comparatively, direct-recovery band encounter data from 2012 – 2021 revealed that 92.8% and 74.7 % of HY and AHY encounters, respectively, were banded in Wisconsin. While similar studies have investigated natal / molt origin in other northern regions where both breeding and hunter-harvest occur, to our knowledge no studies have applied stable isotope techniques to hunter-harvested ducks collected in wintering grounds within the Lower Mississippi Valley Joint Venture (LMVJV). Therefore, we plan to initiate a similar study looking at duck species harvested within the LMVJV to evaluate potential mismatch between estimates of harvest derivation using banding data and stable isotope techniques.

Postbreeding ecology of wood ducks in the Illinois River Valley

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The wood duck (*Aix sponsa*) is the most abundant nesting duck species in Illinois and consistently rank second only to mallards (*Anas platyrhynchos*) in both Illinois and the Mississippi Flyway duck harvest. Much research on wood ducks has involved their breeding ecology. However, despite the consistent and maintained harvest of this species, relatively few studies have investigated the postbreeding ecology of the species, especially in Illinois. We captured and marked wood ducks with either a very high frequency (VHF) radio transmitter or a solar charged GSM transmitter during the postbreeding period in late July and August 2018-2020. Capture locations were within the La Grange Pool of the Illinois River extending from near Pekin, IL to the La Grange Lock and Dam near Meredosia, IL. We used standard radio-telemetry techniques to track wood ducks to determine habitat use, home range size, daily movement patterns, survival, and migration chronology. We identified 13,029 point locations (diurnal: 8,367; nocturnal: 4,662) from wood ducks with VHF transmitters and 30,939 point locations (diurnal: 15,791; nocturnal: 15,148) from wood ducks with GSM transmitters. Wood ducks primarily used forested (46%), emergent vegetation (36%), and aquatic bed (12%) wetland habitats. Home range size (95% MCP) for wood ducks averaged 6,820 ± 572 ha. Daily movement distance from diurnal to nocturnal locations of wood ducks within the IRV was 2,906 ± 28 m. Comparison of means revealed that daily movement distance of wood ducks in October and November was significantly greater than daily movement distance in August and September ($F=151.1$, $P=0.000$). Most wood ducks departed La Grange Pool by early November ($\bar{x}$ = October 28, median = November 4), and the latest bird to emigrate was on December 15th. On average wood ducks traveled 422 ± 41 km per migration event to a migratory stopover location during autumn migration.

†Assessing waterbird conservation of alternative rice residue management strategies in the lower Mississippi Alluvial Valley

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Rice cultivation offers ample opportunity to address and overcome the problem of providing sufficient food for the world's continuously growing population while maintaining biodiversity conservation and agricultural systems sustainability. The effects of fallow-season flood timing and residue management on waterfowl conservation have been studied in some regions, however, the conclusions drawn for waterfowl diversity conservation do not necessarily extrapolate to all locations and the entire waterbird (esp. the non-waterfowl) community. Therefore, this research aimed to assess the conservation value of the timing of fallow-season flooding along with various other rice residue practices for waterbirds. We conducted waterbird censuses in fallow-season rice fields managed in various ways (related to flooding timing, depth, and residue retention) during the Sep. 2021 to Feb. 2022 season in northeast Arkansas (within the Lower Mississippi Alluvial Valley or LMAV). During censuses, all individual waterbirds in a field were identified to species and counted, and water depth and the percentage of residue remaining in the field were estimated (among other variables). After one season, the top linear model explaining variation in species richness included the predictors of water depth and the percentage of residue remaining in the field but did not include timing of flooding. Increased water depth positively affected species richness, and the percentage of residue remaining in the field had an inverse effect. It is possible that the timing of flooding is still important, but it may not be a linear relationship, as it may impact diversity both early and later in the season. Censuses will be conducted again during the 2022-2023 season. Ultimately, this research will likely facilitate the development of cost-benefit analysis to scale up conservation programs across the LMAV and foster a paradigm shift beyond waterfowl-centric conservation to an all-waterbird conservation model.

Rapid yield assessment methods for moist-soil wetlands and crops on National Wildlife Refuges in the Southeast

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Federal, state, and private entities manage seasonal flooded, shallow wetlands to provide food and other habitat resources for wetland-dependent migratory birds, including migrating and wintering waterfowl. Individual National Wildlife Refuges managed by the U.S. Fish and Wildlife Service need methods to annually monitor seed production in moist-soil wetlands and crop fields to track performance relative to foraging habitat objectives and to evaluate local habitat management activities. We built, evaluated, and validated rapid yield estimation indices for moist-soil vegetation and rice on National Wildlife Refuges and private lands in the southeastern U.S. We used Akaike Information Criterion to evaluate linear models comprised of combinations of visual metrics reflecting the density and quality of plant species as well as factors such as year, location, observer experience, and others on actual seed yield from core samples or plot-based harvest methods. Best-supported models for moist-soil seed yield included only common plant species and a single visual assessment of overall coverage (1-5) and seed quality (1-4) for each moist-soil unit (R^2_{adj} = 0.71). Experience level of observer had a moderate effect on accuracy (R^2_{mar} = 0.20) and geographic range increased variation in overall seed yield estimates within moist-soil wetlands. Best-supported models for rice yield estimates included visual assessments of overall coverage (1-10) and seed quality (1-10) within each rice field (R^2 = 0.86). Performance of the rapid assessment model for yield did not vary by geography or total yield. Standardizing the use of efficient and reliable methods to estimate seed and grain yield in moist-soil wetlands and croplands managed for waterfowl will provide mangers the ability to consistently estimate performance relative to objectives, evaluate management actions, and track trends on National Wildlife Refuges in the southeastern U.S.

Aerial midwinter waterfowl survey design for National Wildlife Refuges in the Southeast

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National Wildlife Refuges (NWR) in the Southeast have objectives to provide habitat resources for approximately 6.5 million waterfowl during the non-breeding season. Although many NWRs in the Southeast conduct some form of waterfowl monitoring (e.g., abundance, habitat, harvest, etc.), there has traditionally been no standard protocol or regionally coordinated effort to ensure statistically robust surveys for waterfowl to address local and regional information needs. Coordinated monitoring following best practices would enhance strategic resource allocation, facilitate adaptive resource management, and significantly increase the scientific basis of waterfowl management activities as required by Fish and Wildlife Service policy. Wetlands and croplands on NWRs were divided into primary (i.e., high density strata) or secondary (i.e., unknown density strata) survey units based on size, logistical considerations, and anticipated abundance. Surveys included 309 polygons totaling 687,839 ha and 442 transects totaling 4,127 km. Primary polygons accounted for 51% of estimated waterfowl abundance and secondary polygons (transect-style surveys) accounted for 49% of waterfowl abundance estimates. Two aircraft covered 67 NWR units in 19 flight days ranging from 1 to 7 units surveyed per day (2–8 flight hours/day) with an average of 4 NWR units / day surveyed over a 22-day survey period. Observers counted 804,840 waterfowl, including 580,242 dabbling ducks, 93,354 diving ducks, 106,642 geese, 12,932 swans, and 11,669 cranes. Following visibility bias correction and extrapolation to survey areas, approximately 1.8 million total waterfowl were estimated on NWRs surveyed. Dabbling ducks (71%) comprised the majority of estimates, followed by diving ducks (16%), geese (11%), swans (1%), and cranes (1%). Total estimated use days from aerial surveys across all NWRs were greatest for dabbling ducks (99.7 million), followed diving ducks (19.7 million), by geese (14.6 million), swans (2.1 million), and cranes (0.8 million). Total estimated use days from aerial surveys across all NWRs were greatest for dabbling ducks (99.7 million), followed diving ducks (19.7 million), by geese (14.6 million), swans (2.1 million), and cranes (0.8 million). Across taxa, predicted use equated to approximately 172.2 million waterfowl energy days. Estimates of total duck abundance on NWRs averaged 22% (range = 9–34%) of regional abundance in four survey regions (0.8 of 4.8 million ducks and geese). Excluding salary costs for pilot and observers, planning, accounting, data entry and processing, and report development, aerial waterfowl survey costs were $717/NWR, $535/hr, and $0.07/ha.

† Effects of hunting disturbance on waterfowl abundance in the Tennessee River Valley

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State agencies must navigate the trade-offs between maximizing waterfowl hunter opportunity (i.e., number of hunting days and areas open to hunting), ensuring a quality hunting experience (i.e., number of birds seen and harvested), and providing waterfowl habitat. The severity of this trade-off depends partly on the degree to which hunter disturbance affects waterfowl use of hunted lands. We implemented a study in the Tennessee River Valley (TRV) in North Alabama with the objective of quantifying the effects of hunting pressure on waterfowl relative abundance on state management units. Surveys included hunted units with varying regulations (i.e., hunted 4 vs. 7 days/week), and refuges (unhunted). During the winters of 2020-2021 and 2021-2022, we conducted day and night surveys before, during, and after the hunting season using a combination of unmanned aircraft vehicle (UAV) and ground-based methods to assess waterfowl numbers in survey units much larger than most previous studies. We compared estimates of relative abundance during each time period across each unit type. Relative abundance of waterfowl was greatest on unhunted areas before, during, and after the hunting season. During the hunting season, relative abundance was significantly lower on hunted units. Before and after the season, abundance was more evenly distributed. Similarly, night surveys showed that abundance was lower on hunted units during the season and was highest on the refuges. Overall, abundance on the wildlife management areas were very low. Interestingly, there was a spike in abundance post season on the dewatering units that were hunted four days a week for both dayand night. These results are consistent with our prediction that daytime waterfowl relative abundance would be greater on unhunted units during the season and ducks would be more evenly distributed before and after the season. Our findings from night surveys do not match our prediction that waterfowl would utilize hunted areas more at night. Reductions in hunter opportunity on the hunted areas we surveyed may be required to increase hunter satisfaction and waterfowl use of those areas.

Diversified partnership opportunities for wetland restoration in east Texas: a model for future conservation funding

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Texas Parks and Wildlife Department (TPWD) and Ducks Unlimited (DU) have been active developing and implementing priority conservation actions benefiting waterfowl habitat in East Texas. These actions include upgrading critical infrastructure for existing managed wetland units, constructing new managed wetlands, and acquiring priority floodplain wetlands. This region of the state is within the West Gulf Coastal Plain planning region of the Lower Mississippi Valley Joint Venture. The wetland acres influenced by TPWD and DU actions represent significant contributions to LMVJV habitat objectives for waterfowl and other priority birds. These projects also advance the public outdoor recreation mission of both organizations in a state lacking public lands relative to its size and population, and provide important ecological services such as nutrient removal and flood abatement. The costs associated with these wetland conservation activities are not trivial and could not be covered by federal and state funding in a timely manner alone. Rather, TPWD and DU developed several funding partnerships with public and private entities to accomplish priority habitat projects across East Texas. The range of partners included those conventional to the waterfowl conservation community and some unique entities with specific environmental targets. This presentation will explore the partnerships leveraged by TPWD and DU and the mutually shared missions and goals of the funding entities that resulted in maintaining, creating, and protecting wetlands critical for waterfowl and wetland-dependent species, and providing ecological services beneficial to the environment and community.

A comparison of the insulatory capacities of wooden versus plastic waterfowl nest boxes

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Artificial nest boxes are an easy way to increase nesting opportunities for cavity nesting waterfowl species. Wildlife managers can employ nest boxes as a tool to attract and help ducks in their area and have been used in the past to establish and build waterfowl populations. Nest boxes can be constructed from multiple materials and wood boxes and plastic boxes are now the most common. Waterfowl readily use both types of boxes. The plastic boxes have several benefits over wooden, they are lighter, last longer, and easier to set; but we are unaware of how the plastic boxes compare to wooden in their insulatory capacities. The goal of this study was to compare the temperature fluctuations between the two box materials and the ambient temperature. We used kestrel dataloggers to monitor twelve boxes split by construction material and six ambient locations in SW Shelby County, TN from May through August, 2021. We also looked to determine how direct sunlight affected the boxes performance. Thus, we placed half of our boxes and ambient sensors in direct sunlight and the other half in shade. Both box types in sun and shade showed a significant decrease in average temperature and max temperature compared to the ambient temperatures, but plastic boxes in full sun were significantly warmer than wooden boxes in full sun (max temp plastic= 48.4 C vs max temp wooden = 44.1 C compared to ambient max temp = 69.8 C). Minimum temperature showed much less variation only a 2.3 C difference. The results indicate that both box material types are sufficient to maintain suitable nesting environments during all but the hottest times of the year in the midsouth. If nesting will occur in the hottest months wooden boxes or plastic boxes in shade would be preferred.

Development of blood metabolite index for mallards

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Accurately predicting habitat quality for migratory waterfowl is an important aspect of the management of stopover and wintering areas. Birds need enough calories to cope with the increased energetic demands associated with migration and thermoregulation, and managers need to assess if they are meeting those demands. Plasma metabolites can yield valuable physiologic information about the current health state of migrating waterfowl and the habitats they select. As birds accumulate lipids from their food, they build triglycerides, and as they burn fat, there is an increase in β-hydroxybutyrate, a metabolic breakdown product of triglycerides. These metabolites accumulate in the blood plasma and can be measured to provide a snapshot of whether a bird is depositing lipids or undergoing lipolysis. Plasma metabolite concentrations have been found to fluctuate with daily mass change in diving ducks, such as lesser scaup and canvasbacks, and therefore can index foraging habitat quality where the birds were sampled. Our goal was to determine if plasma metabolites could also be used as an index of foraging habitat quality for dabbling ducks like mallards. We assayed blood metabolite concentrations (i.e., triglycerides and β-hydroxybutyrate, n = 82) from captive, wild-caught mallards maintained on various diets (e.g., plant-, invertebrate, or agricultural seed-based diets) to validate an index of lipid acquisition for determining foraging habitat quality. We found strong correlation between β-hydroxybutyrate and daily mass change in mallards (R^2 = 0.61), but plasma triglycerides did not improve the model. We believe that this index could be a useful tool to assess the effectiveness of habitat management and quality. This index will be applied to samples from experimentally-collected or trapped dabbling ducks (e.g., mallard, and northern pintail, green-winged teal) to assess foraging habitat quality relative to wetland management practices, body condition, diet, and other factors on National Wildlife Refuges in the Southeast.

† Depletion of unharvested flooded corn in waterfowl impoundments

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Conservation planners use bioenergetic models to create energy objectives and inform localized management practices for wintering waterfowl. Regional conservation strategies need information on waterfowl food density, availability, and depletion during non-breeding periods to parameterize landscape bioenergetic models. While previous research has examined availability and depletion of natural waterfowl foods, considerably less research has investigated availability and depletion of agricultural seeds. Unharvested flooded corn is one of the most widespread waterfowl management practices in the Mississippi Alluvial Valley (MAV). However, initial availability and depletion rates of unharvested flooded corn during winter are generally unknown. We quantified field-level factors affecting availability and depletion rates of unharvested flooded corn among land ownership entities in western Tennessee, USA. We surveyed 181 unharvested flooded corn fields to estimate initial biomass in late fall prior to use by waterfowl and then repeatedly surveyed a subsample of fields (n = 60) biweekly from October through March 2019–2021 to quantify depletion. Private properties provided greatest corn biomass (6,953 ± 448 kg/ha), followed by public properties (5,138 ± 320 kg/ha) and sanctuary properties (3,893 ± 371 kg/ha). Corn was depleted more rapidly on sanctuaries compared to private and public fields. Fields with water flooded closer to corn ears were depleted more rapidly as well, whereas larger fields and fields closer to sanctuary areas did not have an impact on depletion rates. Sanctuary fields were completely depleted by mid-February, whereas 50% of private fields and 55% of public fields had corn remaining by March 15. Sampled private lands alone contributed nearly seven times more energy than assumed for the entire MAV region of Tennessee in Joint Venture models. Regional waterfowl conservation strategies may be improved by more accurate assessments of waterfowl energy allotments on private lands, which may allow public-land managers to incorporate a diversity of non-energy focused management efforts to benefit a wide range of species.

† Overstory tree species composition of green tree reservoir in Humphrey, Arkansas

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The management and conservation of bottomland hardwood forests as Green Tree Reservoirs (GTR) is important for providing habitat to overwintering waterfowl along the Mississippi Alluvial Valley. In order to maximize waterfowl populations within a GTR, forest composition assessment is vital to providing an informed management decision to help promote tree species that are most beneficial to waterfowl. We inventoried overstory tree species (>5 inches in diameter at breast height) in 68 plots of 0.1 acres in size within a 173-acre GTR at Five Oaks, a duck hunting lodge in Humphrey, Arkansas, in 2021. The results showed that the relative dominance index of Overcup oak (*Quercus lyrata*) was high 64 than Nutall oak (*Quercus texana*) 50 and Willow oak (*Quercus phellos) 44*. Further, the Principal Component Analysis (PCA) explained 65% variatioun in overstory tree species' relative dominance. The first axis explained 38% variability between Overcup oak and other tree species, while the second axis explained 27% of the variability between Nutall oak and Willow oak. This preliminary result indicates the overstory tree species composition is dominated by less preferred white oak species (Overcup oak) than the more preferred red oak (Nuttall and Willow oak) by ducks. Managing the dominance of less preferred white oak species using a silviculture system, such as the variable retention method, could help a GTR maintain the dominance of preferred red oak species. Such a management strategy would help continue to support wintering habitats of waterfowl populations for a long period in this region.

Applying eBird status and trends products to conservation planning for non-breeding waterfowl of the Western Gulf of Mexico Coast

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North American Migratory Bird Habitat Joint Ventures are tasked with stepping down population objectives from national or international bird plans to their regional geographies as the foundation for developing habitat objectives for desired landscape conditions that alleviate regional population limiting factors. For Joint Ventures like the Gulf Coast (GCJV) where waterfowl habitats serve primarily to support population energetic demands during migration and wintering periods, bio-energetic models are a common planning framework for empirically linking regional midwinter population targets to habitat needs. A critical step in this framework is converting stepped-down midwinter population targets to cumulative use-days over the conservation planning period, requiring spatially explicit species-specific relative abundance (i.e., migration chronology) across the non-breeding period. Robust datasets from multi-temporal aerial waterfowl surveys conducted in Texas and Louisiana used historically are no longer available, necessitating the GCJV explore alternative datasets like the global citizen science project eBird to assess migration chronologies. Through an agreement with the Cornell Lab of Ornithology, we used the eBird Status and Trends weekly relative abundance data product, accessed through the R package *ebirdst,* to quantify species-specific migration chronology for 17 waterfowl species across 6 GCJV sub-geographies. These model-derived, contemporary migration patterns survived scrutiny of expert opinion and were incorporated into 2021 refinements of GCJV waterfowl habitat objectives. We believe this is a transparent and repeatable process to migratory bird conservation planning across Joint Ventures or similar-sized planning geographies.

Apparent daily survival of female mallards wintering in Mississippi's Alluvial Valley

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Meeting species needs at local and landscape scales is fundamental for conservation planning and management of waterfowl and other wildlife populations. Previous research has demonstrated the importance of forested wetlands to mallards (*Anas platyrhynchos*) wintering in the Mississippi Alluvial Valley (MAV), including possible survival advantages to individuals, given female mallards that occupied forested habitats were less likely to switch habitats and consequently moved shorter distances than those occupying non-forested habitats. From aerial surveys across the MAV, wintering mallards have been detected in abundance within habitat complexes of agriculture lands, forested, moist-soil, and permanent wetlands; however, forested wetlands comprised only 20% of these complexes. Because bird density is not necessarily an indicator of habitat quality and related to demography, we estimated survival of female mallards in relation to their use of wetland complexes. We hypothesized that a complex of aforementioned habitats would be important to winter survival of female mallards, especially the availability of and access to forested wetlands. We radiomarked 241 female mallards in the Yazoo Basin and obtained 7,250 diurnal locations across 4 winters (2010-2012 and 2013-2015). We excluded nocturnal locations from analysis to reduce overall model complexity as hunting and its associated disturbances occur diurnally, and nocturnal data were limited. We estimated apparent daily survival using a multi-state, capture-recapture with dead recovery model and found (1) weak support for survival differences among habitat complex types, and (2) flooded cropland, not forested wetlands, promoted greatest daily survival rates among female mallards. Seasonal survival estimates varied <1.2% among complexes used by female mallards. Despite survival rates differing little among habitat types, model predicted female mallard seasonal survival was greatest for females that used 44% agriculture, 34% forest, 19% moist-soil, and 2% permanent wetlands, which emphasized a greater importance of forested wetlands to mallard survival than complexes associated with greatest abundance of wintering mallards in the Yazoo Basin. Although female survival rates were negligibly different among complex compositions used by female mallards, we nevertheless conclude availability of complexes of these landcover types used by mallards were important for mallard winter survival and thus conservation planning and actions.

Mallard winter use of conservation wetlands in Mississippi

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The Mississippi Alluvial Valley (MAV) was once a vast bottomland hardwood forest ecosystem with associated wetlands and intrinsic resources; however, conversion for human uses transformed this region to an agriculturally dominated system. Since the late 1980s, investments into incentivized conservation programs have helped reestablish wetland resources on private lands in the MAV. There is need to evaluate these lands in relation to waterfowl use, particularly with incentivized private wetlands being popular for hunting which may influence use and value of these wetlands for waterfowl. We monitored 241 radiomarked female mallards and their use of 8 different categories of incentivized private lands, non-incentivized private lands, and public lands in the Mississippi portion of the MAV across 4 winters (2010-2012 and 2013-2015). While incentivized lands were used least among incentivized, non-incentivized, and public land categories, 96% of mallard locations on incentivized program lands occurred on Wetland Reserve Easement and Conservation Reserve Program wetlands, largely reflecting their ubiquity and abundance in the region. Within the hunting season, mallards made greatest use of public wetlands diurnally, where designated sanctuaries and forested wetlands may have provided refuge and other resources for birds. At night within the hunting season and diurnally post-hunting season, mallards increased their use of incentivized and non-incentivized private wetlands, perhaps in response to reduced disturbance, which increased accessibility of high-energy forage on seasonally emergent and flooded agricultural lands within these lands. This and previous studies in the MAV support need for (1) complexes of habitat resources including disturbance free sanctuary during hunting season for mallards and other ducks on private and public lands, and (2) active management of incentivized private lands to yield their intended conservation values for mallards and other waterfowl during winter.

Selection for wetland complexes and use of landcover types by female mallards during and after waterfowl hunting season

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Resource use by non-breeding birds can be influenced by multiple factors including food quality and availability, environmental variables, and hunting and associated disturbances. Mallards (*Anas platyrhynchos*) wintering in the Mississippi Alluvial Valley (MAV) exploit landcover types such as flooded croplands, and emergent, forested, and scrub-shrub wetlands, all of which confer general trade-offs between food and cover. Previous information on habitat use by mallards in the MAV is largely derived from diurnal aerial surveys of wintering ducks, which can be updated using contemporary diel information to determine use and selection of landcover types and habitat complexes. Here, we used data from 241 radiomarked female mallards studied across 4 winters (2010-2012 and 2013-2015) that generated 7,402 diurnal and 1,827 nocturnal locations in the MAV. Overall, female mallard selection for wetland complexes of various composition did not vary by period of day or during hunting and post-hunting seasons. However, mallards did alter their use of specific landcover types within complexes, with greater use of agriculture and emergent wetlands at night and forested wetlands during the day compared to after the hunting season, indicating that hunting disturbance may shift mallard use to areas which provide more cover diurnally. We emphasize the importance of wetland complexes for wintering mallards in the MAV that provide forage, sanctuary from disturbance, and other resource needs. Use of forested wetlands by mallards in this and other studies continues to emphasize the value of this resource for mallards. Considering large areas of reforested bottomland forests on public and private lands in the MAV since the 1980s, there's need to determine flooding recurrence and management of these lands to render them accessible to ducks and other wetland wildlife.

† Migration phenology and habitat selection of adult female blue-winged teal throughout the Central and Mississippi Flyways

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Migration is an energetically demanding period for waterfowl and although habitat conditions experienced during the non-breeding season have been found to impact body condition with a range of waterfowl species, substantial knowledge gaps remain during this crucial period for some species. We investigated migration chronology and habitat selection during the non-breeding season for blue winged teal (*Spatula discors,* BWTE), an early autumn and late spring migrant with a distribution extending further south and more widespread than any other North American species of waterfowl. Despite a lack of information on BWTE migration phenology and habitat selection during the non breeding period, their abundance and early autumn migration have resulted in early BWTE hunting seasons for decades. We deployed GPS/GSM transmitters on 176 adult female BWTE during the spring in Louisiana (n=116) and during autumn in the Prairie Pothole Region (South Dakota, n= 51; Saskatchewan, n=9) in 2019-2022. We quantified migration chronology using net displacement models and evaluated habitat selection within the Central and Mississippi Flyways. During spring, BWTE initiated migration ~22 April and arrived at the breeding grounds ~11 May; while in autumn, initiated migration ~27 September and arrived at the wintering grounds ~29 October. Spring migrating BWTE averaged 4.7 stopover sites with a mean duration of 3.8 days per site, while autumn migrating BWTE averaged 3.1 stopover sites with a mean duration of 8.9 days per site. Results indicate during spring and autumn, BWTE selected for areas with large amounts of emergent herbaceous wetlands and cultivated crop in the surrounding landscape and locations near emergent herbaceous wetland and open water habitats. Alternatively, during winter, BWTE selected areas with large amounts of emergent herbaceous wetland and less cultivated crop and open water; however, selected locations near cultivated crops, open water, and emergent herbaceous wetlands. Habitat selection patterns and timing of migration for an early autumn and late spring migrant can guide future habitat management decisions at major stopover and wintering locations throughout the Mississippi and Central Flyway.

†Small uncrewed aircraft systems and artificial intelligence: a new approach for monitoring waterfowl response to wetland restoration

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Understanding how waterfowl respond to habitat restoration and management activities is crucial for evaluating and refining conservation delivery programs. However, site-specific waterfowl monitoring is difficult, especially in heavily forested systems such as the Mississippi Alluvial Valley (MAV)—a primary wintering region for ducks in North America. To address this need, we developed and implemented a monitoring protocol using a small, uncrewed aircraft system (sUAS) equipped with high- resolution thermal and optical cameras to survey wintering waterfowl on wetland restoration easements in the MAV. To enumerate waterfowl by species and assess general behaviors (i.e., foraging, loafing), we developed and trained deep residual neural network (ResNet) models in a PyTorch machine learning framework using the images and videos acquired during sUAS surveys. We compared the mean average precision of each ResNet model at two different complexity levels (34 and 50 identity mapping layers) to assess model performance. Although there was minimal difference in performance between models at counting waterfowl, ResNet-50 outperformed ResNet-34 at identifying species present and assessing general habitat use behaviors. These results suggest that the ResNet-50 model may be a practical algorithm for performing both tasks. By investigating the efficacy of sUAS and artificial intelligence technologies at quantifying waterfowl site use, this study facilitates the development of monitoring protocols necessary for comparing relative waterfowl use on lands enrolled in conservation programs. As such, these results will provide managers with the most efficient and cost-effective means to count waterfowl on project sites—thereby improving their capacity to evaluate waterfowl response to restoration efforts.

A new method of winter water classification of rice fields enrolled in federal conservation incentive programs: preliminary findings

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Waterfowl (family Anatidae) in the MAV benefit from agricultural fields flooded in winter. During this season, USA Rice/Ducks Unlimited Rice Stewardship Partnership staff monitor fields enrolled in NRCS conservation practices 644: Wetland Wildlife Habitat Management and 646: Shallow Water Development and Management on the producer's behalf. In the past, staff have relied upon geotagged photos taken with the app Solocator and passed these onto the producer to hand into NRCS. Increasing enrollments and therefore increased locations to visit calls for a new, more efficient solution. Our objective is to create a framework for relying upon readily available satellite imagery to quantify approximate percent flood of rice fields in the MAV to decrease need for in-person visits to producers. We used top-of-atmosphere, corrected Sentinel-2 imagery and Sentinel-1 interferometric wide swath data and a Random Forest algorithm within Google Earth Engine to estimate percent flood on enrolled fields in five states. Field staff utilized ArcGIS Field Maps to record on-the-ground flood validation. We generated maps and managed data via ArcGIS Online using edited shapefiles of enrolled fields retrieved from NRCS. We have conducted our study for three years, with the first two years involving on-the-ground whole field validation by biologists. Due to variability of flooding, size of reference tracts, and continuity between field visit and satellite flyover, we switched from using the entire field as reference data to collecting verified points within fields in Year 3. Our system is best at recognizing dry fields and very wet fields, but there is greater error with partially flooded fields and fields with rice stubble. The misclassification rate was 0.34 in Year 1 and 0.07 in Year 2. Switching to taking verified points increased accuracy from 0.93 in Year 2 to 0.95 in Year 3, which we believe can be attributed to better agreement between our reference and remotely sensed data. In Year 4, we plan to keep collecting points in fields using ArcGIS Field Maps to continue improving recognition of water, and we will also resume whole-field validation via a partial rollout on twenty to thirty producers. If successful, this technology will save time and may pave the way for a pay-for-performance system, in which producers are compensated based on the number of flooded acres per month.

Citizen science reveals waterfowl responses to extreme winter weather

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Global climate change is increasing the frequency and severity of extreme climatic events (ECEs) which may be especially detrimental during late winter when many species are surviving on scarce resources. However, monitoring animal populations relative to ECEs is logistically challenging. Crowd-sourced datasets may provide opportunity to monitor species' responses to short-term chance phenomena such as ECEs. We used 14 years of eBird— a global citizen science initiative—to examine distribution changes for seven wintering waterfowl species across North America in response to recent extreme winter polar vortex disruptions. To validate inferences from eBird, we compared eBird distribution changes against locational data from 362 GPS-tagged Mallards (*Anas platyrhynchos*) in the Mississippi Flyway. Distributional shifts between eBird and GPS-tagged Mallards were similar following an ECE in February 2021. In general, the ECE affected continental waterfowl population distributions; however, responses were variable across species and flyways. Waterfowl distributions tended to stay near wintering latitudes or moved north at lesser distances compared with non-ECE years, suggesting preparedness for spring migration was a stronger “pull” than extreme weather was a “push” pressure. Surprisingly, larger-bodied waterfowl with grubbing foraging strategies (i.e., geese) delayed their northward range shift during ECE years, whereas smaller-bodied ducks were less affected. Lastly, wetland obligate species shifted southward during ECE years. Collectively, these results suggest specialized foraging strategies likely related to resource limitations, but not body size, necessitate movement from extreme late-winter weather in waterfowl. Our results demonstrate eBird's potential to monitor population-level effects of weather events, especially severe ECEs. eBird and other crowd-sourced datasets can be valuable to identify species which are adaptable or vulnerable to ECEs and thus, begin to inform conservation policy and management to combat negative effects of global climate change.

Mallard winter resource selection trade-offs in an agriculturally dominated landscape

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Land use changes have altered structure and composition of ecosystems globally. In the United States, wetland loss and fragmentation has changed spatiotemporal dynamics of predator-prey relationships between waterfowl and people, especially in agriculturally dominated landscapes. “Safe spaces” are increasingly limited in these landscapes so waterfowl must balance hunter mortality risk with energy acquisition needs by selecting resources closer to refugia, with high energetic return on investment, and at optimal times. Surprisingly, few studies have evaluated these habitat selection trade-offs during winter despite importance of these individual decisions to waterfowl management and hunting communities. Therefore, we examined habitat selection of >400 GPS-marked mallards during winters 2019 through 2022 in western Tennessee. We evaluated 3rd order selection by defining spatial scales of resource selection as flight relocations based on empirically-derived step-length distributions. We developed 3 spatially-explicit wetland layers for each of 3 winters representing food resource patches, their quality, and associated anthropogenic disturbance. Lastly, we modeled habitat selection using discrete choice models where habitat availability was defined at the flight relocation scale. Unsurprisingly, mallards selected for spatial sanctuaries and avoided areas characterized by limited and unlimited anthropogenic disturbance during the day, regardless of forage quality. Mallards shifted selection for areas that were characterized by anthropogenic disturbance at night during hunting and post-hunting periods. Mallards selected for standing agriculture but avoided wooded and open water wetlands regardless of hunting season or diel periods. Mallards selected for managed moist-soil wetlands only at night during pre- and hunting-season and during both day and night in the post-hunting season. We suspect these results reflect depletion dynamics on sanctuaries and for specific food patches. Last, we found selection for wetland types was context-dependent; selection varied depending on winter period, intensity of anthropogenic disturbance, and wetland quality. Future research should incorporate food energetics, depletion dynamics, and more specific hunting pressure gradients into habitat selection models.

Spring migration strategies of mallards in the Mississippi Alluvial Valley

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Pre-breeding migration is a crucial time for waterfowl, yet stopover ecology and migration strategies are least understood in the otherwise well-studied Anatidae. Spring migration is thought to be energetically costly and time-constrained because earlier arrival to the breeding grounds provides competitive advantages. However, variation in time- and energy-minimizing migration strategies likely exist on a spectrum within and among wintering duck populations. We examined spring migration chronology, behavioral, and spatial patterns of mallards wintering across three states in the Mississippi Alluvial Valley (MAV). We deployed GPS-GSM transmitters on ~500 mallards across Tennessee, Arkansas, and Louisiana in winter through spring 2018–2022. Mallards wintering in Louisiana initiated migration on ~12 March, 10 and 13 days earlier than mallards wintering in Arkansas and Tennessee, respectively (SE ± 3 days). However, mallards wintering in Tennessee arrived and established residency on the breeding grounds 7 days later than birds migrating from Arkansas and 9 days later than those migrating from Louisiana, despite closer latitudinal distance to traditional breeding areas. We detected no sex-specific differences in migration timing. Mallards stopover frequencies were similar across wintering states ($n \approx 2$); however, mallards migrating from Tennessee stayed at stopovers 15 days (SE ± 2 days), compared to 11 days at stopovers for birds from Louisiana (SE ± 1 day), and 7 days for birds from Arkansas (SE ± 1 day). Furthermore, migration speeds of mallards from Arkansas were three times as fast as those from similar latitudes in Tennessee and twice as fast as those migrating from Louisiana. Overall, stopovers, migration corridors, and individual strategies appear to differ among geographically distinct wintering mallard metapopulations. Our results suggest that energy-minimization and partial migrations is a more common strategy for individuals from Tennessee. These migration strategies may be related to subtle yet important differences in breeding area destinations between wintering metapopulations. Spring habitat management and conservation programs should target highly used stopover areas across the Midwest.

†Eggshell strength in three cavity-nesting ducks in Mississippi

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Wood ducks (*Aix sponsa*), hooded mergansers (*Lophodytes cucullatus*), and black-bellied whistling ducks (*Dendrocygna autumnalis*) are sympatric secondary cavity-nesting duck species in the southeastern United States. Interspecific clutches are common, eggs accumulate in nests from parasitic laying, and strife between females may occur, potentially subjecting eggs to breakage. Understanding the durability of eggs of these species is important for explaining variation in nest and egg hatching success. Our prediction was that eggshell breaking strength (EBS) of hooded merganser eggs would be the greatest among the three species. We collected a total of 67 fresh eggs of the species from nest boxes at two sites in Mississippi in spring-summer 2021. We measured eggshell strength using an Instron Universal Testing Machine (Model 3345; Instron Inc., Norwood, MA) and eggshell thickness using a micrometer (Ames, IA). We measured EBS (Newtons) at the equators of all eggs. We used Tukey's pairwise comparison to test for differences in eggshell strength among species. Mean EBS differed among all species ($P < 0.0001$) and was greatest in hooded merganser, followed by black-bellied whistling duck and wood duck. The EBS was 120.05 (SD = 12.03, $n = 7$) for hooded merganser, 52.44 (SD =10.04, n=30) for black-bellied whistling duck, and 32.95 (SD =3.90, $n = 30$) for wood duck. Eggs of hooded merganser had the highest EBS, likely attributed to greater eggshell thickness among these species. We are currently investigating mineral composition in the eggshells of these species. Our results are preliminary, and further analyses will explore how eggshell strength and mineral components of eggshells correlates with egg breakage.

Determining Population and Habitat Objectives for Waterfowl in the Lower Mississippi Valley Joint Venture

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The Lower Mississippi Valley Joint Venture (LMVJV) was established in 1987 under the North American Waterfowl Management Plan because of its geographic importance to non-breeding waterfowl. Hence, this joint venture's partners have stepped down continental waterfowl population objectives into regional objectives based on historic bird distributions in midwinter. Habitat planning in the LMVJV is based on the premise that non-breeding waterfowl are primarily food limited, and uses a simple energy-based bioenergetic model to translate regional population objectives into habitat-based objectives measured in "Duck Energy Days" (DEDs). LMVJV partners recognize that many factors affect DED availability, or energy supply, in any given year, especially in complex alluvial floodplain ecosystems such as the Mississippi Alluvial Valley (MAV). Because of this, one of the most challenging aspects of biological planning is accurate assessment of food availability over time and across a matrix of habitats ranging from moderately to heavily human impacted, frequently to rarely flooded, and agricultural to natural.

Energy supply in the MAV is expressed in DEDs provided through natural flooding, and within managed impoundments on private and public lands. The MAV consists of six states that each have a DED goal based on the difference between energy demand (i.e., NAWMP objective) and energy supply (i.e., bioenergetic model results). Any deficiencies in our ability to accurately estimate demand or supply have important impacts on this output. The results of the 2015 bioenergetic model analysis indicated that the MAV was below its NAWMP objective for DEDs (variable however, among states). The reality of complex and dynamic landscape conditions important to waterfowl strongly impacts the degree to which states are regarded as meeting their respective goal. To ensure that the most accurate information is gathered and synthesized in arriving at these objectives, the Lower Mississippi Valley Joint Venture is working to update its bioenergetic model using a new modeling platform, updated DED values, a new flood model, revised NAWMP population objectives, and potentially new perspectives on landscape context.

† Nest box-mounted PIT tag readers provide new insights on breeding behaviors of cavity-nesting waterfowl in Louisiana

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Although North American ducks are a well-studied group of birds, we know astonishingly little about the nesting ecology of Black-bellied Whistling-Ducks (*Dendrocygna autumnalis;* hereafter Whistling-Duck). Native to Central and South America, the breeding distribution of this species has rapidly expanded throughout the southeastern United States since the late 20th century, and recent research at Louisiana State University has indicated widespread interspecific parasitism of Wood Duck (*Aix sponsa*) nests, which has the potential to negatively affect egg hatchability and reproductive success. Typical field methods used to study cavity- nesting waterfowl involve capturing and banding the incubating individual and collecting nest information (e.g. clutch size, nest age, parasitism) at weekly intervals. Banding and periodic nest monitoring preclude a full understanding of important breeding behaviors including nest prospecting, parasitic egg laying, and failed nesting attempts. Here, we quantified those factors using radio frequency identification (RFID) technology and subcutaneous passive integrated transponder (PIT) tags embedded in adults and day-old ducklings. 40 duplex-style nest boxes were equipped with PIT tag readers at Sherburne Wildlife Management Area in 2022 to potentially detect >1,200 wood ducks and whistling-ducks that were marked from 2020-2022.

These readers record each time a PIT-tagged individual enters or leaves the nest box, allowing us to detect individuals not captured on a nest, quantify nest visitation, and provide new insight into parasitism. Data collection is ongoing through the end of July, but thus far, we have accumulated >16,000 individual scans over 1145 reader-days. We have detected 123 unique individuals, including 19 adults that incubated nests in 2022, 20 adults that incubated nests in prior breeding seasons, 2 ducklings marked in prior breeding seasons that have returned as adults, and 82 new ducklings tagged in 2022 that exited nest boxes. One unique example is a Whistling-Duck female that was tagged in 2021 while incubating a nest and never captured in 2022 but was detected by stationary PIT tag readers. During our current field season, this female visited 12 nest boxes on 46 occasions and 6 of those contained active nests, 2 of which were parasitized by Whistling-Ducks. This female visited parasitized nests ≥10 times, while non-parasitized nests had ≤5 visits. While our field work is still ongoing, a quick synthesis of our PIT tag reader data suggests that RFID technology can be used to reshape the way we study cavity-nesting waterfowl.

† Nest box popularity among black-bellied whistling-ducks in Louisiana

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Black-bellied Whistling-Ducks (*Dendrocygna autumnalis*; hereafter Whistling-Duck) are a neotropical, cavity-nesting waterfowl species that have rapidly expanded their range into the southeastern United States in recent years. Although Whistling-Ducks may be of management concern due to their cavity-nesting and brood-parasitic nature, surprisingly little research has been conducted on their nesting ecology. Here, we looked at nest box popularity among Whistling-Ducks using radio frequency identification (RFID) technology. From March-April 2022, we installed 20 passive integrated transponder (PIT) tag readers on duplex-style nest boxes (40 boxes total) at Sherburne Wildlife Management Area, giving us the potential to detect ~400 individuals that were subcutaneously marked with PIT tags from 2020-2022. These readers detect each time a PIT-tagged individual enters or leaves the nest box, allowing us to capture breeding behaviors that cannot be observed using traditional field methods, including the frequency of nest box visits. We found that nest box popularity varied widely, with some boxes being visited ≥140 times by as many as 8 individuals, while others were never visited at all. Although a formal analysis is pending, we found that the overwhelming factor influencing nest box popularity was the age of the box itself. All nest boxes used in this study were converted to duplexes in February 2021 by adding an additional, freshly-made box to the pole with one that was installed several years prior, so that each duplex consisted of a single pole with one old and one new nest box of similar size and shape, and material (wood). The old boxes were visited a total of 683 times, averaging 34.25 ± 44.76 visits by 3.4 ± 2.33 individuals per box, while boxes installed in 2021 were visited 61 times, averaging 3.05 ± 7.59 visits by 0.9 ± 1.11 individuals per box. In addition, 17 (85%) old and 10 (50%) new boxes were visited ≥1 time. Although it remains unclear why Whistling-Ducks have a preference for older nest boxes, there may be a social aspect to nest site selection that we have yet to explore.

Partnerships and the benefit to participants

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Natural resource management, particularly waterfowl management, depends on the collaboration of agencies, organizations, and landowners. Collaborative management is ultimately to the benefit of the resource (e.g. species or habitat), but can also provide direct benefits to those that use the resource such as hunters or wildlife recreationalists. In an effort to achieve this beneficial management scenario, the Arkansas Game and Fish Commission, through funds from the USDA established the Arkansas Waterfowl Rice Incentive Conservation Enhancement or WRICE program. This effort, which began in 2018, sought private landowners that were willing to adopt alternative rice management practices for the benefit of waterfowl, and by incentivizing such action, opened these fields to hunters through a limited access seasonal permitted hunt process. In an effort to ensure that the goals of the program were being met, an annual programmatic review process was adopted. Following each permitted hunt draw, recipients of the permits received a survey about their experience and additional areas of improvements for the agency to consider. Results from the surveys suggest the WRICE program increased access to hunting, provided harvest opportunities, and yielded high hunter satisfaction. To date, the WRICE program has provided a waterfowl hunting experience to over 600 individuals, of which 13% indicated the WRICE hunt was likely their only seasonal hunting opportunity. The WRICE program continues to demonstrate how the benefits of collaborative management can impact the resource and those that utilize the resource.

Five Oaks Ag Research & Education Center: a training program for early-career waterfowl habitat and wetland management professionals

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The intersection of wetland and waterfowl management is complex—requiring skilled land managers conversant in hydrology, wetland plant identification, soils, entomology, forestry, waterfowl ecology. In addition, technical skills are needed for operating heavy equipment, herbicide application, and water management. While undergraduate programs provide a firm foundation in ecology, recent graduates often do not have the technical skills necessary to move into a land manager role without further training. Wetland and waterfowl managers are not made in the classroom—they are trained in the field. To facilitate this training, Five Oaks Duck Lodge partnered with the University of Arkansas System to establish the Five Oaks Ag Research & Education Center (FOAgREC). The FOAgREC provides post-baccalaureate students with applied learning opportunities for transferring principles learned in the classroom to on-the-ground land management. To administer this training, the University of Arkansas at Monticello offers a two-semester, Graduate Certificate in Waterfowl Habitat and Wetland Management. This program offers a full scholarship to four students annually. Students spend on average 75% of their time in the field working with FOAgREC land managers. They choose 18 credit hours from a list of graduate field courses in wetland ecology, science-based decision making, land and lodge management, farm applications in land management, among others. Five Oaks provides 8,000 acres of outdoor laboratory space for teaching and research, including a 12-bedroom dormitory, with full living accommodations, computer stations, and a research lab. The next generation of wetland managers will face unprecedented challenges as demands for improved wetland health and associated ecosystem services increase in the face of climate change and other environmental stressors. Therefore, the principal objective of FOAgREC is to help develop the next generation of land managers by refining and improving their technical skills needed for successfully managing our wetland resources.

† An easy-to-use Python-Google Earth Engine toolbox for wetland hydrologic monitoring: applications for waterbird conservation planning and delivery

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Waterfowl and other migratory waterbirds rely on wetlands for foraging, pairing, basic maintenance, stopover, breeding, and other activities throughout their annual cycle. Thus, real-time estimation of surface water extent, flood duration, and water depth are important factors to quantify for accurate and effective waterbird conservation planning and delivery. However, quantifying flood dynamics is challenging because monitoring systems often lack needed spatiotemporal resolution and field sampling is usually inadequate and/or cost-prohibitive. We developed the PyGEE-SWToolbox, an open-source Google Earth-enabled tool programmed in Python, to address challenges with contemporary and long-term surface water analysis. The toolbox enables users to easily obtain, orthorectify, and mosaic Landsat, Sentinel-1, and 2 satellite image time series, generate surface water inundation maps on these images, estimate water depth, and compute flood frequencies within a user-defined area. We examined the surface water extent and water depth estimation accuracy using field-collected occurrence and water depth from selected wetlands in West Tennessee and Kentucky (*n* = 136 and 392, respectively). Our results suggested generally accurate surface water maps with some errors in omission for wetlands with dense canopies (i.e., forested wetlands). Additionally, the toolbox accurately estimated water depth for shallow wetlands between 0–3 m (mean absolute errors [MAE] = 0.13–0.28) and with satisfactory accuracy for deeper wetlands 3–7 m (MAE = 1.10–1.25 m). Importantly, the PyGEE-SWToolbox provides an easy-to-use graphical user interface enabling a wide audience of wetland managers, researchers, and conservation planners—with limited programming experience—to use this tool. The toolbox itself and water modeling accuracies demonstrate vast potential across many user groups for monitoring surface water inundation and flood dynamics. Example uses for waterfowl and wetland conservation may include prioritizing flood-prone properties for land acquisition or enrollment in conservation easement programs (e.g., Wetland Reserve Program); remote monitoring of foraging wetland availability for waterfowl based on water depth estimations; or longitudinal analyses of flooding and surface water inundation dynamics.

† Effects of weather, moon illumination, and hunting season on fine-scale movements of dabbling ducks wintering in the Mississippi Alluvial Valley

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Daily movements of waterfowl are dynamic and are affected by changing resource availability, disturbance, dark and light periods, and environmental conditions. Fine-scale movement of dabbling ducks is related to their vulnerability to harvest, thus understanding factors influencing movement is linked to understanding hunter success. The purpose of this study is to determine the fine-scale movement differences of three dabbling duck species wintering in the Mississippi Alluvial Valley and assess the effects environmental and temporal factors on diurnal and nocturnal movements. We tracked green-winged teal (*Anas crecca*; n = 51), American wigeon (*Mareca americana*; n = 38), and mallards (*Anas platyrhynchos*; n = 31) using GPS satellite transmitters from 2020 to 2022. Mean distances for diurnal and nocturnal periods were calculated for each species, and we evaluated a candidate set of 47 linear mixed effects models to determine the effects of climatological factors, hunt season, Julian date, and sex on diurnal and nocturnal movement distances for each species. Green-winged teal moved 23% more during the nocturnal period ($\bar{x}$ = 3.7 km ± 0.28 SE) while American wigeon ($\bar{x}$ = 4.9 km ± 0.20 SE) and mallards ($\bar{x}$ = 4.3 km ± 0.23 SE) moved 28.6% and 18.6% more during the diurnal period, respectively. Combinations of moon illumination, mean wind, hunt season, and Julian date were the top predictors for diurnal and nocturnal movements. Fine-scale movement data revealed differences in factors influencing diurnal movement between the three species. Moon illumination was a unifying factor during the nocturnal period. Green-winged teal were affected most by moon illumination during the post-hunt season while mallards were more affected during the hunt season. American wigeon had greatest movements during peak moon illumination and increasing mean wind. This research improves our understanding of the influence of weather and lunar cycles on nocturnal movements of dabbling ducks as a proxy for harvest vulnerability.

†Evaluating capability for Wetland Reserve Program easements in the Mississippi Alluvial Valley to support multiple ecosystem functions

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In the lower Mississippi Alluvial Valley, the Wetland Reserve Program (WRP) focuses on restoring bottomland hardwood (BLH) forested wetlands because of their important ecosystem functions including wildlife habitat, and biogeochemical cycling. Previous BLH research has focused on evaluating the recovery of individual ecosystem functions, with limited information on whether wetland restorations can maximize multiple ecosystem functions simultaneously. Thus, we designed our study to evaluate the extent restored BLH wetlands concurrently provide wildlife habitat and biogeochemical functions. We assessed biotic communities and denitrification rates on 30 WRP easements across western Tennessee and Kentucky during springs 2019-2021. Our objective was to determine whether habitats with greater avian and plant species richness also had greater denitrification rates. Within each site we surveyed avian species in three cover types: shallow water area (SWA), tree planting, and remnant forest. Mean avian species richness was 8.9 (± 1.6) in remnant forest, 8.25 (± 3.1) in SWA, and 6.4 (± 2.6) in tree planting. Mean plant species richness was 9.82 (± 3.0) in remnant forest, 8.35 (± 4.5) in SWA, and 9.52 (± 2.7) in tree planting. Mean denitrification rates were 6.58 (± 3.9) for remnant forest, 5.37 (± 5.4) for SWA, and 6.58 (±3.85) for tree planting. We used principal component analysis to assess the tradeoffs and correlation structure between bird species richness, plant species richness, and mean denitrification rates. Our preliminary results show that in forest and SWA habitat eigenvectors for plant species richness and denitrification rates loaded strongly in the same direction on axis 1, whereas the eigenvector for bird species richness loaded weakly along the same axis. For plantings, we found eigenvectors for bird species richness and denitrification rates loaded strongly on axis 1 in opposite directions, whereas plant species loaded strongly on axis 2. These results suggest that remnant forest and SWA habitat on restored BLH wetlands can provide plant biodiversity and increased denitrification rates, whereas avian diversity was not correlated with plant species richness or denitrification rates. However, in tree plantings our results suggest a tradeoff between providing bird species biodiversity and increased denitrification given that these vectors pointed in opposite directions along the same axis. Ongoing work includes incorporating additional biotic communities and a redundancy analysis to evaluate habitat factors that may explain variation in ecosystem functions along principal component axes.

†Factors influencing mallard harvest within selected states of the Mississippi Flyway

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Mallard harvest has declined within the Mississippi Flyway over the last twenty years. I tested if mallard breeding population size, midwinter surveys, age ratios, or waterfowl hunter numbers were associated with mallard harvest and hunter success in an effort to explain this pattern. Mallard harvest declined overall within six states in the western Mississippi Flyway (MN, IA, AR, MO, MS, LA) while the mallard breeding population increased. Harvest was associated with the total number of duck hunters at the flyway scale. At the state levels, other variables were correlated with harvest and showed patterns while moving south in the flyway. Hunter success within these same states also declined and similar patterns were observed. The total number of duck hunters has declined over the time period studied, with the exception of Missouri. Future research into this area should include a focus on changes to habitat and hunting regulations within that state as compared to the remainder of the flyway.

Validation and use of citizen-science data for waterfowl management

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Information on patterns and dynamics of species occurrence and abundance are fundamental to our understanding of the ecological processes that shape the distribution of species, and critical for informing management efforts. Often, limited time, funding, personnel, or other limitations keep monitoring efforts smaller than managers and decision makers require to make informed evaluations of when and where to apply conservation or management intervention across the scale of a bird conservation region or within the footprint of a joint venture. Citizen-science (CS) data is often collected at higher resolution and across larger spatial extents than targeted monitoring programs. CS data has been signaled as a cost-effective approach to fill information gaps in current monitoring schemes, either by complementing existing monitoring programs, or by providing broad-scale information needed to contextualize more localized results. Here I will discuss two products created using observations from the eBird citizen science program, and their relevance to waterfowl monitoring and management. The first of these is species status, an abundance distribution throughout the year at 3x3 km spatial resolution, and weekly temporal resolution. I will show our efforts to validate these status products by comparing them with established aerial surveys for waterfowl throughout the annual cycle. The second product I will discuss is range-wide breeding season trends, calculated at 27 x27 km resolution across the western hemisphere. I will show the results of our work on validating these trends against the USFWS Breeding Population and Habitat Survey to determine where and why these trends may differ, and how we may use them in waterfowl management planning.

†Waterbird and vegetation response to drawdown of Big Lake National Wildlife Refuge

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Big Lake National Wildlife Refuge (NWR) is maintained as a wetland complex primarily composed of forested, scrub-shrub, and emergent wetlands in northeast Arkansas. Big Lake NWR is semi-permanently flooded with the last drawdown conducted >10 years ago. Big Lake NWR serves as a flood-water retention basin for the Army Corps of Engineers and requires periodic drawdowns to consolidate sediments, control invasive species, and allow management activities. In collaboration with U.S. Fish & Wildlife Service, we will monitor the response of waterfowl and other waterbirds, submerged aquatic and emergent vegetation, and sediments to the drawdown of Big Lake NWR in 2022–2023. We will estimate coverage of submerged aquatic and emergent vegetation, especially invasive species and other species of management concern (e.g., American water lotus [*Nelumbo lutea*], black willow [*Salix nigra*], giant cutgrass [*Zizaniopsis miliacea*]) prior to and following the drawdown. We will use high-spatial-resolution Sentinel-2 satellite imagery to develop a framework to regularly monitor changes in floating leaf and emergent vegetation coverage. We will conduct biweekly aerial surveys for waterfowl and other waterbirds during October – March annually to document bird use. We will use vegetation data and imagery to estimate energetic carrying capacity before and after the drawdown. This information will help NWR staff better understand the effects of the drawdown to inform the timing and frequency of this practice in the future.

Predicting consistent foraging ecologies of migrating waterbirds: using stable isotope and parasite measurements as indicators of landscape use

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The emergence of novel human pathogens is frequently linked with zoonotic events and human-wildlife interactions that promote disease transmission. Consequently, surveillance of wildlife populations for candidate diseases that could spread to humans is beneficial but requires widespread collections of numerous samples. A legitimate means to acquire large sample sizes of waterfowl is through cooperation between researchers and hunters, who also work in concert with natural resource managers, landowners, and agricultural entities -e.g., aquaculture facilities. In addition to understanding the occurrence and spread of parasites and pathogens by birds, these samples can be used to answer questions about the ecology of various waterbird species. Body mass and morphometric data on hunter-donated specimen are useful for understanding bird condition and other dynamics of birds; however, when breast meat is removed prior to the acquisition of specimen weight, samples might be less desirable. Here, we evaluate the utility of data obtained from a bay duck species, Lesser Scaup (*Aythya affinis*; hereafter, scaup), popular with hunters and thus subsequently used to investigate scaup disease dynamics. Scaup were collected at aquaculture facilities in eastern Arkansas and assessed for their stable isotope concentrations and parasites communities to learn about the birds' foraging ecology. Discriminant analyses designed to classify birds by the aquaculture pond type from which they were collected included isotope data, principal components derived from parasite community data of 7 types, and birds' body mass. We compared these to Double-crested Cormorants (*Nannopterum auritum*) feeding on catfish and found the two waterbird species exhibited different infracommunities of parasites. Furthermore, some scaup demonstrated fish aquaculture pond type fidelity. Bird body mass was an important metric to include in analytical models when all parasite datatypes were not available. However, the combination of stable isotope concentrations and parasite infracommunity data (that includes prevalence, abundance, volume, and energy use) in models resulted in host ecology differentiation equal or better than models where bird body mass was included. Hunter-derived samples should be encouraged as a means for sample acquisition and be considered as an approach for aquaculture-wildlife conflict management as the information obtained through these samples is multifaceted.

†Body mass dynamics in wintering mallards (*Anas platyrhynchos*) in the lower Mississippi Alluvial Valley

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Recent research from Europe and the western United States suggests that the body mass of mallards (*Anas Platyrhynchos*) has increased from the late 1960s to early 2000s. Some researchers hypothesize that increases in body mass are due to a more benign winter climate and increased food availability. Other studies suggest changes in body mass may result from introgressive hybridization with pen-reared mallards that were released into the wild. This phenomenon has yet to be studied within the lower Mississippi Alluvial Valley (LMAV). Because most waterfowl management plans in the LMAV are based upon the energy requirements for a mallard and body mass can be directly tied to energy acquisition in waterfowl, it is important to further understand how body mass may have changed in mallards over time. Thus, we analyzed body mass dynamics in mallards sampled throughout the LMAV of Arkansas and Mississippi from 1979-2021 to establish whether similar increases in body mass have occurred. During Arkansas and Mississippi duck hunting seasons, we measured harvested mallards from public hunting areas, hunting clubs, and duck-plucking businesses. For each bird, we determined sex, age, and recorded body mass measurements. We used linear mixed-effects models to explore mallard body mass trends within seasons and across time, as well as in response to meteorological variables and age and sex groups. Preliminary results determined that mallard body mass has increased by approximately 6% among all age-sex groups over the last four decades, while body mass decreased within years over the course of the hunting season. Mallard body mass was related to rainfall and river gage height, with ducks having larger body mass after periods of increased rainfall or river flooding, likely due to increased availability of food. Our research demonstrates that changes in mallard body mass are widespread in major flyways and that within-season precipitation and flooding most likely influence much of the annual observed variation. Future research should investigate other potential mechanisms contributing to these trends such as introgression of game farm mallard DNA and climate change.

Spatiotemporal dynamics of duck harvest distributions in the Central and Mississippi Flyways from 1960–2019

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Geographical distributions of non-breeding waterfowl can exhibit considerable annual variation in response to spatiotemporal variation in weather conditions and habitat availability. However, continuing changes in climate, habitat availability, and anthropogenic pressures could lead to persistent shifts of waterfowl distributions, potentially causing a mismatch with local habitat and harvest management decisions informed by historic distributions. We used band recovery and wing harvest data from 1960–2019 to assess how nonbreeding distributions of fifteen duck species in the Central and Mississippi flyways have changed across years. We used kernel density estimators to determine centroid location, area, and latitudinal extent of month-specific distributions. Since 1960, centroids have shifted northwards during the months of September/October ($\bar{x}_{\text{bands}}$ = +48 km, $\bar{x}_{\text{wings}}$ = +151 km), December ($\bar{x}_{\text{bands}}$ = +271 km, $\bar{x}_{\text{wings}}$ = +201 km), and January ($\bar{x}_{\text{bands}}$ = +316 km, $\bar{x}_{\text{wings}}$ = +132 km) for most species. Latitudinal shifts were similar between dabbling and diving ducks, except for January where shifts were greater for dabbling ($\bar{x}_{\text{bands}}$ = +334 km, $\bar{x}_{\text{wings}}$ = +218 km) than diving ducks ($\bar{x}_{\text{bands}}$ = +68 km, $\bar{x}_{\text{wings}}$ = -14 km). Core area (50% isopleth) size showed large annual variation, which was independent of centroid latitude. Northern extents moved northwards at similar rates as centroid locations, while southern extents moved north at slower rates. Next steps will link observed distributional shifts to spatiotemporal patterns in climate and land use variables. Understanding drivers of historical changes in non-breeding waterfowl distributions will allow for more informed conservation and management while anticipating future changes.

† Detection probability and bias in machine learning-based winter waterfowl population estimates from uncrewed aerial systems

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Monitoring waterfowl populations provides the basis for improving habitat quantity and quality, establishing harvest regulations, and ensuring sustainable waterfowl populations through components of state natural-resource management objectives, joint-venture objectives, and the North American Waterfowl Management Plan. Uncrewed aerial systems (UAS) may provide safer and more precise alternatives to traditional aerial survey techniques that cause less disturbance to waterfowl and are safer for people and waterfowl. We evaluated the feasibility of using UAS to monitor nonbreeding waterfowl abundance on intensively managed wetland Conservation Areas within the Upper Mississippi River Conservation Priority Area across Missouri, USA from October 2020 – March 2022. To evaluate the feasibility of using UAS for monitoring waterfowl abundance, we evaluated availability bias, perception bias, and species classification on aerial imagery using artificial intelligence. UAS surveys were flown using a DJI Mavic Pro 2 using a proprietary software for automated flight path planning in a back-and-forth transect flight pattern at 10 m/s. All surveys were flown no earlier than two hours after sunrise and ending by 1:00 pm at 15 - 90 meters in height, allowing for ground sampling distances between 0.342 and 2.052 cm/pixel. Waterfowl in images were labeled using LabelMe by trained labelers then classified to species by an expert with knowledge in waterfowl species identification, with unidentifiable birds labeled as unknown. These same images were simultaneously analyzed using a computer algorithm developed to detect and classify waterfowl images by species and sex. We modeled three generalized linear mixed models with Bernoulli distributions: one to model the probability that a bird present was detected and classified correctly, one to model the probability that a bird present was detected but classified incorrectly and one to model the probability that a generated detection was a bird and not a false positive.

Habitat type was the major factor influencing availability and perception bias, while cloud cover improved algorithm detection but decreased species classification accuracy. Time of year was strongly correlated with correct species classification, with species classification increasing later in the fall and winter as waterfowl molted into alternate plumage, increasing distinct species characteristic colors. These results show that UAS, aerial imagery, and artificial intelligence can be used to monitor waterfowl populations effectively, accurately, and precisely during the non- breeding season.

Use of an agent-based model to inform waterfowl conservation planning in the Mississippi Alluvial Valley: quantifying mallard response to wetland composition and configuration

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The Natural Resources Conservation Service administers Wetlands Reserve Easements through the Agricultural Conservation Easement Program, formerly the Wetland Reserve Program, to assist landowners conserve and improve wetland habitats on private land. These wetland easements constitute an important foraging resource for waterfowl; their management for the benefit of waterfowl populations depends on understanding waterfowl responses to habitat conditions, which may be based on complex and emergent interactions between behavioral, environmental and anthropogenic factors. We used an agent-based model (ABM) to evaluate conservation planning strategies related to the acquisition of new easements, with the aim of maximizing benefits for wintering waterfowl populations. To model mallards wintering in the Mississippi Alluvial Valley, we adapted an existing energetics-based ABM that allows for tracking the physiological and behavioral response of mallards to dynamic habitat conditions and emergent behaviors of populations at the landscape scale. We then developed a suite of conservation scenarios focusing on current and potential easement amount and configuration, including increasing easement area by 25%, either through adding new easements or rounding out existing easements at opportunistic or selected locations. Model results indicate removing existing conservation measures would reduce wintering mallard population size by ~70-80% in the study area, emphasizing the important role current wetland easements play in wintering waterfowl conservation. Increasing easement area through the addition of new easements was more effective than adding area to existing easements and increased mallard populations 10-16% over baseline conditions. Adding fewer, larger area easements generally increased mallard populations more than adding smaller, more numerous easements.

Where are the ducks? Quantifying environmental drivers of autumn migration departure decisions in midcontinental mallards

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The timing of autumn migration in ducks is influenced by a range of environmental conditions that may elicit individual experiences and responses from individual birds, yet most studies have investigated relationships at the population level. We used data from individual satellite-tracked mallards (Anas platyrhynchos) to model the timing and environmental drivers of autumn migration movements at a continental scale. We combined two sets of location records (2004–2007 and 2010–2011) from satellite-tracked mallards during autumn migration in the Mississippi Flyway, and identified records that indicated the start of long-range (≥ 30 km) southward movements during the migration period. We modeled selection of departure date by individual mallards using a discrete choice model accounting for heterogeneity in individual preferences. We developed candidate models to predict the departure date, conditional on daily mean environmental covariates (i.e. temperature, snow and ice cover, wind conditions, precipitation, cloud cover, and pressure) at a 32 × 32 km resolution. We ranked model performance with the Bayesian Information Criterion. Departure was best predicted (60% accuracy) by a “winter conditions” model containing temperature, and depth and duration of snow cover. Models conditional on wind speed, precipitation, pressure variation, and cloud cover received lower support. Number of days of snow cover, recently experienced snow cover (snow days) and current snow cover had the strongest positive effect on departure likelihood, followed by number of experienced days of freezing temperature (frost days) and current low temperature. Distributions of dominant drivers and of correct vs incorrect prediction along the movement tracks indicate that these responses applied throughout the latitudinal range of migration. Among recorded departures, most were driven by snow days (65%) followed by current temperature (30%). Our results indicate that among the tested environmental parameters, the dominant environmental driver of departure decision in autumn-migrating mallards was the onset of snow conditions, and secondarily the onset of temperatures close to, or below, the freezing point. Mallards are likely to relocate southwards quickly when faced with snowy conditions, and could use declining temperatures as a more graduated early cue for departure. Our findings provide further insights into the functional response of mallards to weather factors during the migration period that ultimately determine seasonal distributions.

†Five Oaks Ag Research & Education Center: a graduate certificate training program for early-career waterfowl habitat and wetland management professionals

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While universities across North America provide excellent academic training in ecology and natural resources, undergraduate students are often ill-prepared to engage in real world, land management after graduating. In order to provide students with the skill to meet land management needs, the Five Oaks Ag Research and Education Center (FOAgREC) provides post-baccalaureate students with applied learning opportunities for transferring principles learned in the classroom to on-the-ground land management. To administer this training, the University of Arkansas at Monticello offers a two-semester, Graduate Certificate in Waterfowl Habitat and Wetland Management. This program offers a full scholarship to four students annually. Students spend on average 75% of their time in the field working with FOAgREC land managers. They choose 18 credit hours from a list of graduate field courses in wetland ecology, science-based decision making, land and lodge management, farm applications in land management, among others. Five Oaks provides 8,000 acres of outdoor laboratory space for teaching and research, including a 12-bedroom dormitory, with full living accommodations, computer stations, and a research lab. The next generation of wetland managers will face unprecedented challenges as demands for improved wetland health and associated ecosystem services increase in the face of climate change and other environmental stressors. Therefore, the principal objective of FOAgREC is to help develop the next generation of land managers by refining and improving their technical skills needed for successfully managing our wetland resources.

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