United States Department of Agriculture

Natural Resources Conservation Service

CEAP Conservation Insight
Conservation Effects Assessment Project

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Migrating and Wintering Waterfowl Select WRP Easements to Meet Annual Life-cycle Needs

Summary Findings

Through a Conservation Effects Assessment Project (CEAP) partnership, University of Missouri investigators used GPS satellite transmitters to track and assess wetland habitat use by mid-continent mallards, including the contribution of Wetlands Reserve Program (WRP) easements to habitats selected during the non-breeding season. Investigators used multinomial discrete choice models that accounted for variance in wetland type.

Wetland selection patterns observed varied among autumn migration, winter, and spring migration, but mallards consistently selected wetlands with greater areas of WRP and sanctuary in the surrounding landscape regardless of season, time period, or hunting season status.

Results demonstrated that mid-continent mallards selected wetlands near private conservation easements (i.e., WRP easements) and wetlands with high conservation easement area in the surrounding landscape.

Results illustrate the importance of WRP easements to migratory waterfowl and demonstrate that conservation easements have the potential to provide habitat for migratory birds throughout the non-breeding period in the mid-continent region.

Strategically positioned WRP easements adjacent to large public areas and existing wetland complexes may provide maximum waterfowl conservation return on easement program investments.

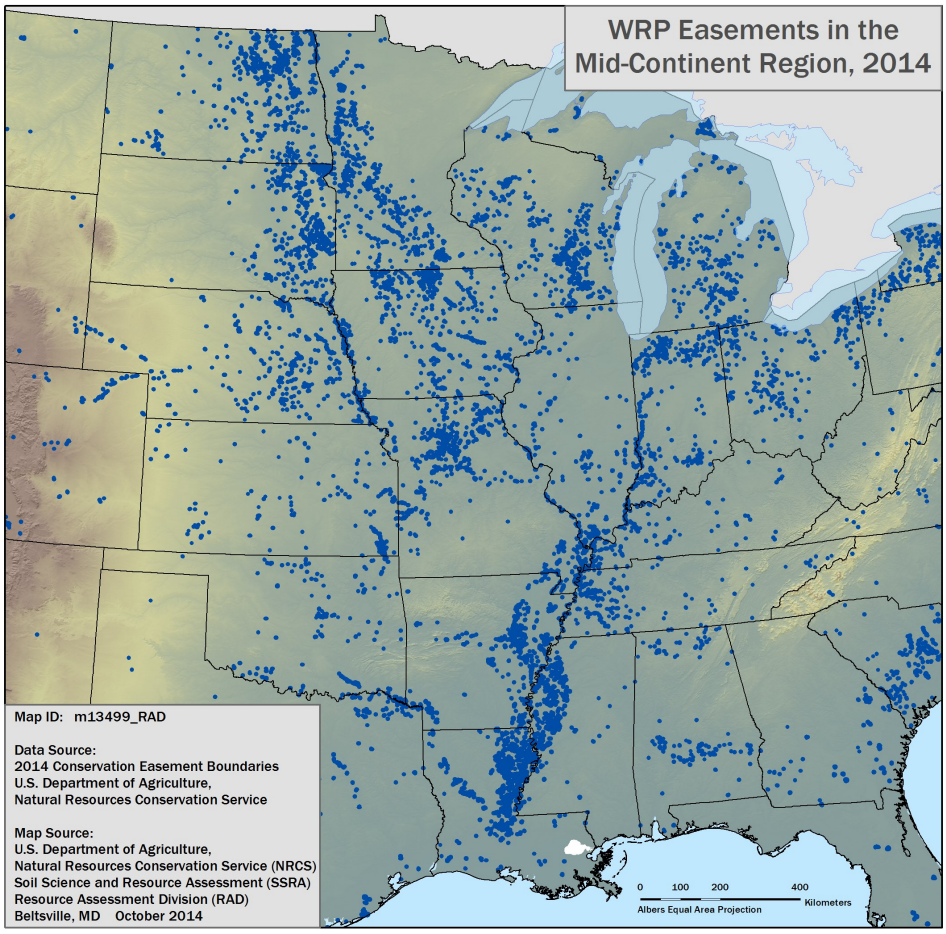
A decade of collaboration—In the mid-2000s, waterfowl managers and researchers in the North American mid-continent region posed questions about mallard migration in light of real changes in habitat distribution across the landscape and perceptions of shifting waterfowl distribution. These questions led to large-scale, state-led mallard telemetry projects in Arkansas and Mississippi. While these independent projects held potential for addressing some shared research and management questions, Mississippi and Central Flyway waterfowl biologists saw greater value in a broader partnership to more fully incorporate broader interests. Over several years this partnership grew to include regular information sharing at Flyway meetings and multiple workshops among federal, state, nongovernmental and academic colleagues. With substantial investment in satellite telemetry transmitters by the Arkansas Game and Fish Commission, a wealth of information to help answer some of the key questions became available. The culmination of this lengthy collaborative process is seen here, whereby University of Missouri researchers used an available telemetry data set to answer questions of common interest to state agencies and Ducks Unlimited while evaluating mallard response to one of NRCS's key conservation programs.

Background

Wetlands provide essential staging, stopover, and wintering habitats for migratory waterbirds (Webb et al. 2010, Pearse et al. 2012). However, wetlands have declined in the contiguous United States by approximately 53% since European settlement, and remaining wetlands are often fragmented patchworks with reduced capacities to provide ecosystem services (Dahl 2011).

To alleviate the effects of wetland loss and degradation, public agencies have opportunistically acquired and protected wetlands through various conservation initiatives (Scott et al. 2004). In recent years, conservation agencies and non-governmental organizations (NGOs) have emphasized the importance of incorporating private and working lands into wetland protected area networks in the mid-continent region. Conservation easement programs are one mechanism used to preserve biodiversity on privately owned lands and to improve the overall effectiveness of wetland habitat networks (King et al. 2006).

The largest public conservation easement program specifically targeted to conserving wetland wildlife habitat is the Natural Resources Conservation Service (NRCS)-administered Wetlands Reserve Program (WRP)



The NRCS-administered Wetlands Reserve Program is the largest public conservation easement program in the mid-continent region specifically targeted to conserving wetland wildlife habitat (easement locations not to scale).

established by the 1990 Farm Bill. The program was recently incorporated into the Agricultural Conservation Easement Program (ACEP) by the 2014 Farm Bill, with the wetland component referred to as Wetland Reserve Easements (WRE). Along with other conservation easements held by land trusts, WRP has significantly contributed to wetland habitat and conservation goals throughout North America (Kaminski et al. 2006, King et al. 2006).

In contrast to public lands programs, private lands conservation initiatives such as the WRP are recent components of landscape-level conservation strategies (Scott et al. 2004, King et al. 2006). Although studies have evaluated waterfowl abundance on private conservation easements and wetland management areas, abundance studies often do not account for the availability or accessibility of wetlands (Kaminski et al. 2006). However, studies of wetland selection do account for wetland availability and assume that waterfowl are choosing from a suite of wetlands within a defined area.

Relatively few studies have compared patterns of wetland selection by waterfowl among private conservation easements, federally managed wetlands, state managed wetlands, or wetlands on working lands. Further, most waterfowl habitat selection studies have been spatially limited or temporally restricted to one major life-history phase, such as migration, wintering, or breeding (Webb et al. 2010, Pearse et al. 2012). However, waterfowl habitat selection and space use can be studied across the annual life cycle using new technologies, including global positioning system (GPS) satellite transmitters. A broader spatial and temporal approach is now available to evaluate the influence of landscape composition on waterbird habitat use, and it has potential to provide additional insight into resource utilization by birds throughout the annual cycle.

Landscape context greatly influences wetland wildlife habitat function. Isolated wetlands rarely contain sufficient resources for individual waterbirds to meet daily, weekly, and seasonal energetic requirements within a dynamic annual cycle (Webb et al. 2010, Tidwell et al. 2013). Conversely, landscapes that include clusters of a variety of wetland types can provide access to a diverse array of food types (Pearse et al. 2012, Tidwell et al. 2013) while minimizing flight distances among wetlands. Whereas landscape composition is assumed to influence migratory waterbird habitat selection during the non-breeding portion of the annual cycle, quantitative evidence has been lacking.

Waterfowl populations may benefit from the network of protected wetlands in North America. In the mid-continent region, waterfowl hunting is a prominent and traditional recreational activity, and as such, protected wetlands have been managed by numerous conservation entities with a broad range of interests, which may include waterfowl hunting. A better understanding of the relative role of

the various types of protected areas in migratory waterfowl conservation is needed.

Assessment Partnership

Through contribution agreements between NRCS and Ducks Unlimited, with contributions from the Arkansas Game and Fish Commission, Missouri Department of Conservation, U.S. Fish and Wildlife Service, the Mississippi and Central Flyway Councils, the Livingston Ripley Waterfowl Conservancy, and the University of Missouri, investigators established protocols for using GPS satellite transmitters on adult mallards to track movements and habitat use throughout their annual cycle. This ultimately led to the ability to examine waterfowl use of protected area wetlands during the non-breeding period within the framework of a use-availability resource selection design.

Specifically, researchers at the University of Missouri used GPS satellite telemetry data from adult female mallards in the mid-continent region during the non-breeding season. The assessment involved development of multinomial discrete choice models that accounted for variance in wetland type, including the contribution of WRP easements to habitats selected. The mallard was used because it is a generalist waterfowl species that is the focus of extensive wetland protection, restoration, and management throughout North America (Drilling et al. 2002). The work was conducted in partnership with the Conservation Effects Assessment Project (CEAP) wildlife component.

Assessment Approach

Adult female mallards were captured in two separate groups in 2010 and 2011 (Beatty et al. 2013). The first group was captured near Yorkton, Saskatchewan, Canada in late September 2010 and the second group was captured at multiple locations in Arkansas in February 2011. Mallards were captured with rocket nets or swim-in traps and fit with Teflon-ribbon harnesses equipped with solar-powered GPS satellite transmitters (Fig. 1; Argos/GPS PTT 100, Microwave Telemetry, Inc.; ± 18 m accuracy) programmed to obtain four GPS fixes (i.e., locations) per day. Marked birds were monitored until transmitters failed or were immobile for at least one day (Beatty et al. 2013).

To address varying seasonal nutritional and energetic needs, the non-breeding portion of the mallard annual cycle was separated into three seasons (autumn migration, winter, and spring migration, based on actual migration movements of marked birds). This allowed habitat selection to be studied separately within each season. Wetland habitat selection was evaluated within a 30-km radius of each mallard location, which represents the maximum distance non-migrating mallards are known to move within a 24-hour time period (Link et al. 2011, Beatty et al. 2013, Beatty et al. 2014a).

Discrete Choice Models

Habitat selection models compare used habitats to available habitat to account for temporal and spatial var-

PHOTO: MIKE WINTHROATH, ARKANSAS GAME AND FISH COMMISSION

Figure 1. Female mallard equipped with a solar-powered global positioning system (GPS) satellite transmitter.

iance in availability. Discrete choice models were used to examine wetland selection by mallards. These models assume that resource use is the result of a series of choices made by an individual duck from a set of available alternatives, which is defined as the choice set. For these discrete choice models, wetlands were designated as the unit of selection; thus, choice sets included one used wetland and a suite of available wetlands. A used wetland was defined as a wetland that contained a mallard GPS fix during the non-breeding period. In contrast, availability was defined based on a circular buffer with a 30-km radius from the center of the used wetland. Nineteen wetlands were randomly selected from within the 30-km buffer to produce a choice set of 19 available wetlands and one used wetland.

Wetland Habitats and Landscape Composition

Geospatial information on used and available wetlands was obtained from the 2006 National Land Cover Database (NLCD 2006), which seamlessly classifies wetlands at 30-m resolution across the United States (Fry et al. 2011).

A series of proximity-to covariates were measured with a geographic information system (GIS; ArcGIS 10.0) to characterize the spatial conditions of each wetland and its management and conservation status. Variables representing the proximity-to wetland features were used because they are less sensitive to error in animal locations and geospatial covariate data than local wetland indicator variables. Proximity-to covariates equaled 0 if a wetland centroid was in the specific property boundary and they were negative (km) if the wetland centroid was outside the specific property boundary. The distance from the center of each wetland to the boundary of the nearest state Wildlife Management Area (WMA, WmaPx), National wildlife Refuge (NWR, NwrPx), waterfowl sanctuary (SancPx), WRP easement (WrpPx), and private land parcel (PrvPx) were also measured.

Sanctuary was defined as any area that prohibited waterfowl hunting throughout the duck hunting season. All sanctuaries included in this study occurred on public lands because data on private sanctuaries were not available for the mid-continent region. Sanctuaries on NWRs and WMAs were combined into one variable (SancPx) because management objectives on state and federal sanctuaries were similar (i.e., provide resting areas free of waterfowl hunting disturbance). In contrast, WMAs and NWRs were defined separately because overall patterns of human use differ between these two types of areas. For example, in this study area, approximately 69% of NWRs contained at least one waterfowl sanctuary compared to 8% of WMAs, and approximately 41% of NWRs were entirely closed to waterfowl hunting compared to 2% of WMAs. Similarly, approximately 52% of total NWR area in this study area was in sanctuary compared to approximately 11% of total WMA area.

Landscape composition also has the potential to affect wetland use by mallards during the non-breeding portion of the annual cycle (Cox and Afton 1997, Webb et al. 2010). To evaluate the importance of sanctuaries at the landscape scale, a covariate that quantified area of sanctuary (SancAr) within a 3.46-km buffer around the center of each used and available wetland was included in the analysis. In addition, WRP area (WrpAr) was measured within a 3.46-km local buffer around each used and available wetland. The 3.46-km local buffer corresponds to previously published estimates on the average local flight distance for mallards (Beatty et al. 2014a). Thus, landscape composition within 3.46 km of selected and available wetlands not selected was examined to provide insight on local landscape factors influencing use.

Sanctuary areas free of disturbance during the hunting season and surrounding landscape composition were examined to determine their influence on mallard wetland habitat use.

Habitat Use

Waterfowl habitat use may vary between diurnal and nocturnal periods or as a result of hunting disturbance. Both spatial and temporal variability in duck hunting seasons were accounted for by using geospatial information on hunting zones and season dates from 2010-2011 and 2011-2012. All GPS fixes recorded during autumn migration occurred during duck hunting season whereas all fixes recorded during spring migration occurred outside the duck hunting season. Thus, for autumn and spring migrations, data were analyzed separately between day and night time periods. In contrast, winter GPS fixes were recorded both within hunting season and after hunting season. Thus, wetland selection patterns were analyzed separately according to hunting season and time period (i.e., diurnal or nocturnal) during winter.

Candidate models including all 7 proximity-to covariates were developed and analyzed to assess nocturnal and diurnal wetland habitat selection during each season. Models were ranked using Akaike's Information Criterion adjusted for sample size (AICc) and the model averaged parameter estimates were calculated for the top models. Confidence intervals were calculated for model averaged parameter estimates by multiplying unconditional standard errors by 1.96. Parameters that had confidence intervals that did not overlap zero were inferred to be important variables for predicting mallard wetland selection during the non-breeding period.

Findings

A total of 40 adult female mallards with GPS satellite transmitters were monitored over the course of the study (Fig. 2). Seven transmitters failed before initiation of autumn migration in 2010 so the sample was reduced to 33 birds and 2,382 locations (Beatty et al. 2013, Beatty et al. 2014b). The number of individuals included in each wetland selection model varied according to season, hunting season, and time period (Table 1).

Wetland selection patterns varied among autumn migration, winter, and spring migration, but mallards consistently selected wetlands with greater areas of WRP and sanctuary in the surrounding landscape regardless of season, time period, or hunting season status (Figs 3, 4, and 5). In addition, proximities to WMA and WRP were more important predictors of wetland selection in both nocturnal and diurnal periods outside hunting season (Figs. 4B and 5)

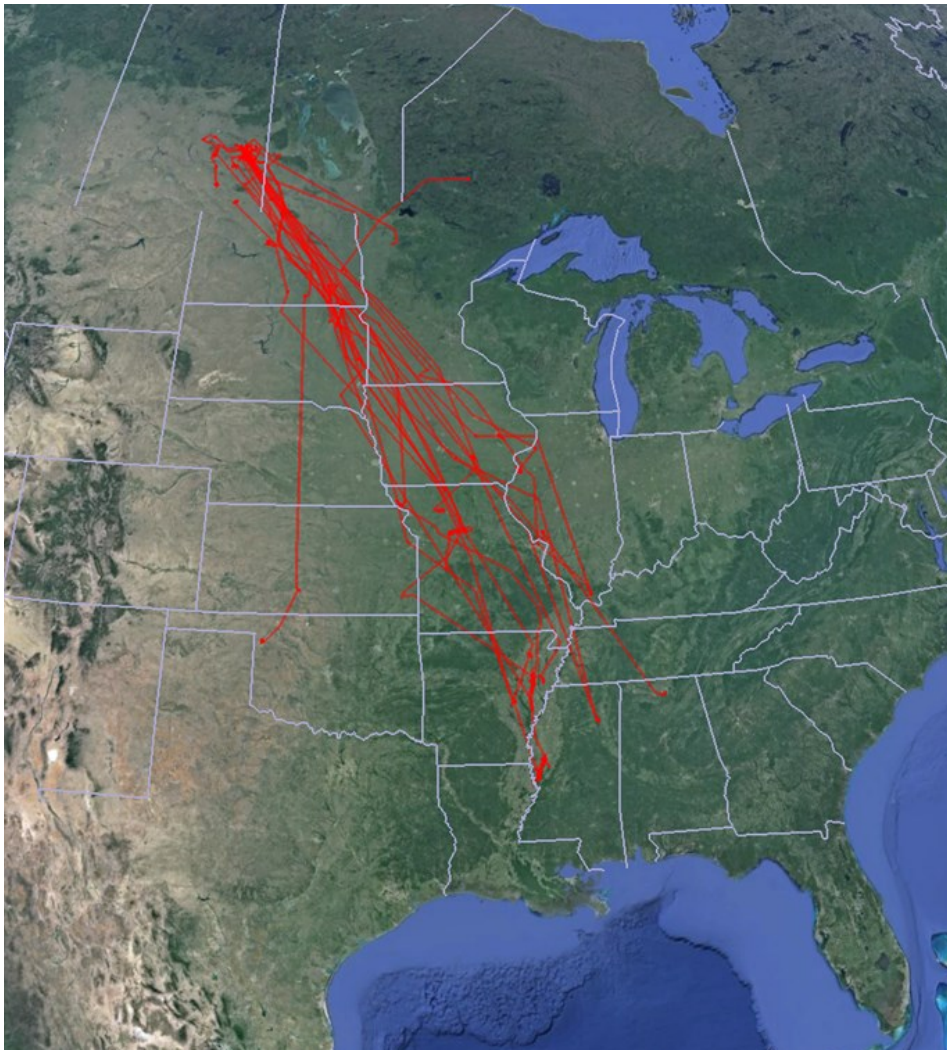


Figure 2. Example migration routes and locations used by 22 female mallards during 2010 and 2011.

Table 1. Sample size statistics for models to examine midcontinent mallard wetland selection patterns during the non-breeding period of the annual cycle. The number of birds (A), total number of global positioning system fixes (n), and range of the number of fixes per individual (Range) are displayed for each model.

Season	Hunt Season	Diurnal/ Nocturnal	*A*	*n*	Range
Autumn Migration	Yes	Diurnal	18	151	1 - 44
		Noctural	18	118	1 - 36
Winter	Yes	Diurnal	16	234	1 - 34
		Noctural	16	252	2 - 45
	No	Diurnal	21	367	2 - 63
		Noctural	22	358	1 - 76
Spring Migration	No	Diurnal	23	380	3 - 69
		Noctural	23	522	1 - 64

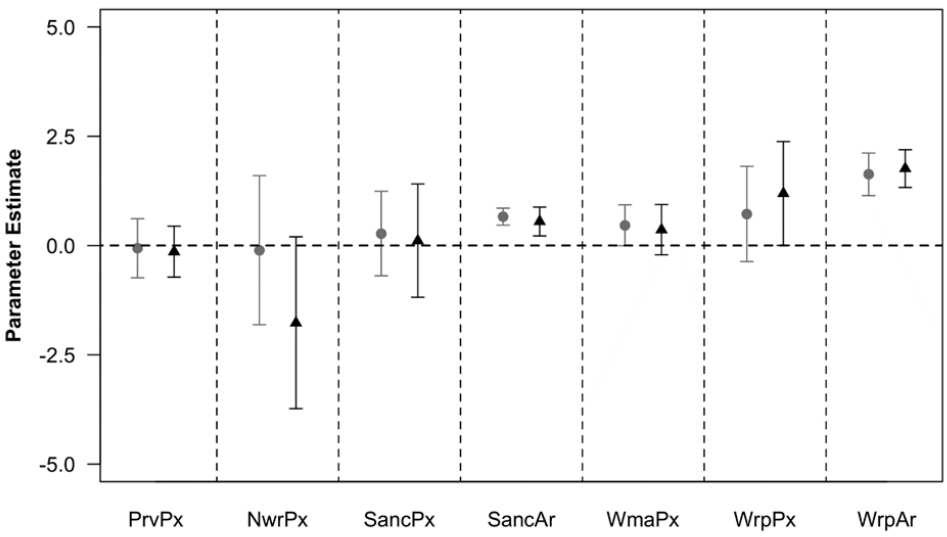


Figure 3. Model averaged parameter estimates and 95% confidence intervals for discrete choice models that examined mallard wetland selection patterns during autumn migration within hunting season. Gray circles represent diurnal models and black triangles represent nocturnal models. PrvPx is proximity to nearest private land, NwrPx is proximity to nearest National Wildlife Refuge, SancPx is proximity to nearest waterfowl sanctuary, SancAr is area of waterfowl sanctuary in surrounding landscape, WmaPx is proximity to nearest state wildlife management area, WrpPx is proximity to nearest Wetland Reserve Program easement, and WrpAr is area of Wetland Reserve Program easements in surrounding landscape.

compared to within hunting season (Figs. 3 and 4A). Changes in wetland selection patterns occurred between diurnal and nocturnal periods within hunting season with regard to proximities to WMA and WRP, indicating that mallards may have alternated habitat use as a result of daytime hunting pressure (Figs. 3 and 4A).

Autumn Migration

During autumn migration (within hunting season), mallards selected wetlands near WRP easements at night but not during the day, although confidence intervals substantially overlapped between time periods (Fig. 3). Additionally, mallards selected wetlands that had greater area of sanctuary and WRP in the surrounding landscape. Confidence intervals for all other parameters evaluated for autumn migration overlapped zero, indicating that although there were patterns in the data, the results were not strongly informative.

Winter

Within the winter hunting season, mallards selected wetlands close to sanctuaries during both day and night (Fig. 4A). Wetlands proximate to WRP were selected at night but not during the day, whereas wetlands near WMAs were selected during the day but not at night. Sanctuary area and WRP area were again positive indicators of mallard wetland selection. Proximity to private land was a negative indicator of wetland selection during the day in winter within hunting season, although confidence intervals between diurnal and nocturnal models substantially overlapped. Similar to autumn migration, mallards selected wetlands near NWRs in accordance with random expectations.

Winter wetland selection patterns after hunting season were substantially different than those during the winter hunting season. In winter after hunting season, mallards selected wetlands close to sanctuaries, WMAs, and WRP easements, and in contrast to within hunting season, selection patterns for proximity to WMA and WRP were similar between nocturnal and diurnal periods (Fig. 4B). In addition, sanctuary area and WRP area were positive indicators of wetland selection. However, in contrast to wetland selection patterns observed within the hunting season (autumn migration and winter), mallards used wetlands proximate to NWRs less than random expectations in winter outside hunting season.

Spring Migration

During spring migration in both diurnal and nocturnal periods, mallards selected wetlands near sanctuaries, WMAs, and WRP easements (Fig. 5). Similar to selection patterns observed during autumn migration and winter, sanctuary area and WRP area in the surrounding landscape were important predictors of mallard wetland selection in nocturnal and diurnal periods during spring migration. At night, however, mallards used wetlands proximate to NWRs less than would be expected if movements were random, but used them in accordance with random expectations during the day, although confidence intervals partially overlapped between time periods.

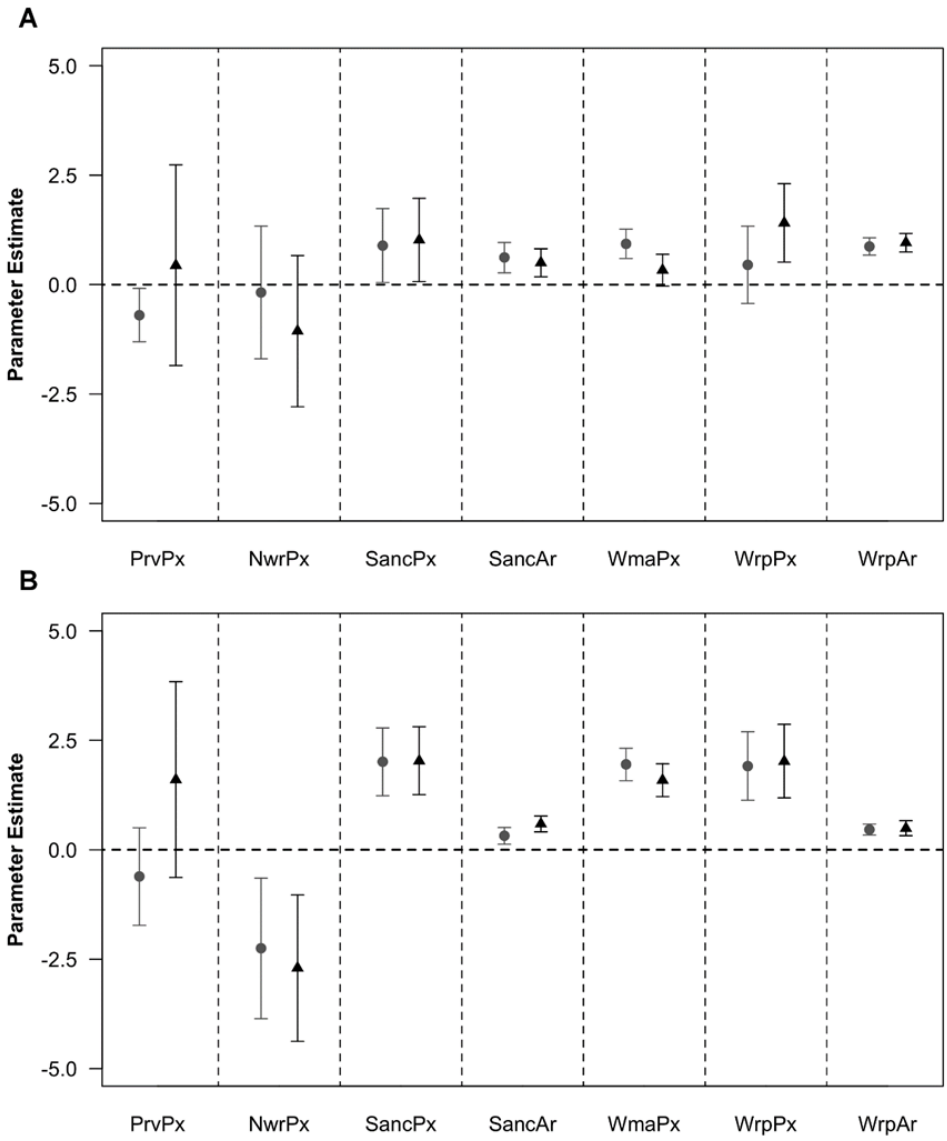


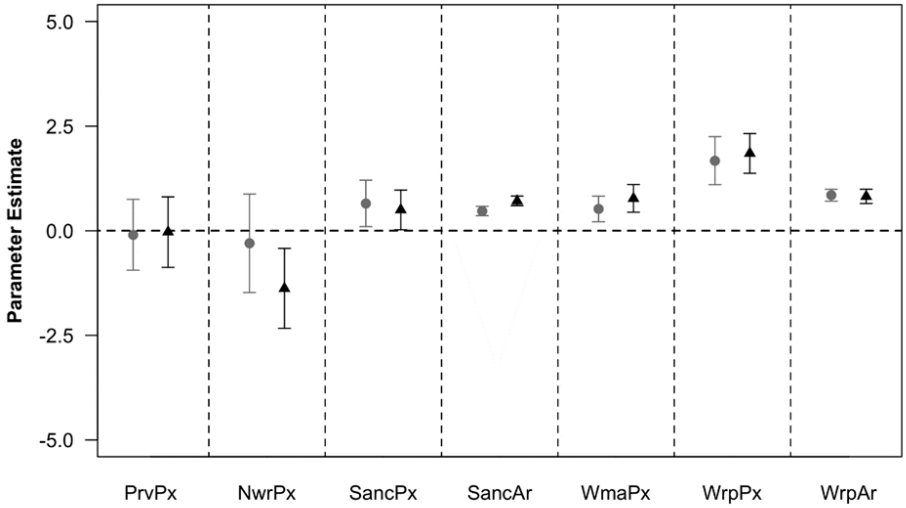
Figure 4. Model averaged parameter estimates and 95% confidence intervals for discrete choice models that examined mallard wetland selection during winter (A) within hunting season and (B) after hunting season. Gray circles and black triangles represent diurnal and nocturnal models, respectively.

Conservation Implications

Easement contributions

Public lands have historically played a prominent role in wildlife conservation and provide habitat for a variety of species, including migratory waterfowl (Scott et al. 2004). In contrast, conservation initiatives (e.g., WRP) on working lands have only recently been recognized as potential components of landscape-level conservation strategies (King et al. 2006). These results demonstrate that mid-continent mallards selected wetlands near private conservation easements and with high conservation easement area in the surrounding landscape. From a landscape-level perspective, conservation easements (i.e. WRP) in this study area were not only smaller on average ($\bar{x}$ = 65.3 ha, SD = 134.4 ha) than publicly managed parcels ($\bar{x}$ = 134.9 ha, SD = 1,265.3 ha), but also closer to publicly managed areas ($\bar{x}$ = 4.0 km, SD = 4.8 km) when compared to random wetlands ($\bar{x}$ = 7.8 km, SD 6.33 km). In addition, approximately 81% of conservation easements in this study area were permanent easements with the remaining 19% secured with 30-year contracts. Thus,

Figure 5. Model averaged parameter estimates and 95% confidence intervals for discrete choice models that examined wetland selection patterns of mallards during spring migration outside hunting season. Diurnal models are represented with gray circles and nocturnal models are represented with black triangles.



these results provide a conservative estimate of the utility of WRP easements to migratory waterfowl and demonstrate that conservation easements have the potential to provide habitat for migratory birds throughout the non-breeding period in the mid-continent region. Moreover, strategically positioned easements adjacent to large public areas may provide maximum conservation return on a given economic investment.

Sanctuary influences habitats selected during the hunting season

The National Wildlife Refuge System is the largest functional protected area network in North America specifically designated for wildlife conservation, but many properties are managed independently from one another (Scott et al. 2004). Although the System encompasses numerous types of ecosystems, many NWRs were established for the protection of migratory birds and are recognized as essential breeding, migrating, and wintering habitats for waterfowl (Scott et al. 2004).

In this study, mallards selected wetlands near known sanctuaries throughout the non-breeding period, and waterfowl sanctuaries were heavily concentrated on NWRs in the study area. Thus, NWRs are more likely than WMAs to provide essential sanctuaries for waterfowl that contain areas free of hunting disturbance, which likely shaped mallard wetland selection patterns (Reid et al. 1989). However, food resources on NWRs likely reached giving-up density during winter (Hagy and Kaminski 2012), providing limited energetic benefits of foraging on NWRs compared to foraging on private wetlands such as WRP sites after hunting season closed (Figs. 4 and 5). Consequently, WRP may provide important habitat for migratory waterfowl and supplement protected area networks in the mid-continent region.

Wetland complexes are important

Wetland landscapes represent an essential component of staging, stopover, and wintering areas for migratory waterbirds (Webb et al. 2010, Pearse et al. 2012, Beatty et al. 2014a). Sites with greater wetland area are more likely to include diverse wetland habitats that facilitate the acquisition of nutrients according to the needs of a dynamic annual cycle. Indeed, wetland landscapes allow birds to shift foraging patterns and/or diets in response to environmental conditions, life history requirements, or disturbance (Tidwell et al. 2013).

Conservation easements and sites with limited human disturbance such as waterfowl sanctuaries appear to influence waterbird space use within a wetland landscape during the non-breeding season (Beatty et al. 2014b). As a result, wetland landscapes including WRP easements allow migratory birds to exploit multiple wetland habitats to meet the needs of annual cycle events while minimizing energetically costly flights among foraging, roosting, and resting areas. Locating WRP sites within or adjacent to existing wetland complexes, as well as actively managing easements to provide foraging habitats during the nonbreeding season would greatly increase their capacity to meet the needs of migrating and wintering waterfowl in the mid-continent region.

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The Conservation Effects Assessment Project: Translating Science into Practice

The Conservation Effects Assessment Project (CEAP) is a multi-agency effort to build the science base for conservation. Project findings will help to guide USDA conservation policy and program development and help farmers and ranchers make informed conservation choices.

One of CEAP's objectives is to quantify the environmental benefits of conservation practices for reporting at the national and regional levels. Because wildlife is affected by conservation actions taken on a variety of landscapes, the wildlife national assessment complements the national assessments for cropland, wetlands, and grazing lands. The wildlife national assessment works through numerous partnerships to support relevant assessments and focuses on regional scientific priorities.

This assessment was conducted through a partnership among NRCS, Ducks Unlimited (DU) and the University of Missouri (MU). Primary investigators on this project were Dale Humburg (DU), Elisabeth Webb (MU), William Beatty (MU), and Dylan Kesler (MU). Luke Naylor (AR Game and Fish Commission) and Andrew Raedeke (MO Department of Conservation) were instrumental in providing data and laying the foundation for this assessment.

For more information: www.nrcs.usda.gov/technical/NRI/ceap/, or contact Charlie Rewa at charles.rewa@wdc.usda.gov.