Wetland use by Mallards During Spring and Fall in the Illinois and Central Mississippi River Valleys

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Abstract.—The Illinois and central Mississippi river valleys provide important habitats for migrating waterfowl. Unfortunately, both river systems have experienced large-scale hydrologic alterations, resulting in considerable loss of waterfowl habitat. To provide information to guide wetland conservation and rehabilitation efforts, we used data from aerial inventories of waterfowl conducted by the Illinois Natural History Survey to model Mallard (*Anas platyrhynchos*) use in relation to wetland characteristics. Mallard use was positively associated with the proportion of wetland area classified as "emergent" (e.g., containing robust or moist-soil wetland vegetation) during spring and fall in both river valleys. Use by Mallards was also related to proportion of inventoried locations where hunting and other disturbances were prohibited during fall and spring, perhaps indicating better management of fall refuges to provide foraging habitat during spring. We suggest wetland habitat acquisition and rehabilitation efforts intended to benefit waterfowl emphasize emergent-wetland components. Further, we recommend investigations of wetland use by waterfowl in each river system to elucidate the role of areas where hunting and disturbance is prohibited.
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The Illinois and central Mississippi river valleys (IRV and CMRV, respectively) are considered important ecoregions for migratory waterfowl by the Upper Mississippi River and Great Lakes Region Joint Venture [hereafter, UMRGLRJV] of the North American Waterfowl Management Plan (UMRGLRJV Board 1998). To this end, the UMRGLRJV specifically relies on the CMRV, IRV, and other migratory focus areas to meet habitat requirements of 8.9 million waterfowl for 30 days during fall (UMRGLRJV Board 1998). Unfortunately, both river regions have experienced large-scale wetland losses and degradation (Havera 1999). Correspondingly, fall populations of many dabbling and diving ducks have declined significantly in these regions since 1948 (Havera 1999).

Recent efforts to rehabilitate wetlands were designed to return structure and function to segments of each river. For example, extensive restoration has been initiated in the CMRV and IRV as part of the Upper Mississippi Restoration Program (UMRP), which was authorized by Congress under the Water Resources Development Act of 1986. The UMRP identifies habitat rehabilitation and enhancement projects (HREP) to improve wetland conditions in this important ecoregion. As of 2004, 64 HREP projects were initiated, representing nearly 16% of the Upper Mississippi River system floodplain (U.S. Army Corps of Engineers 2004).

In addition to rehabilitation efforts, many wetlands in both river floodplains are actively managed during fall as staging areas for migratory waterbirds. Specific strategies differ, but moist-soil management is a common practice to provide food and cover for migratory waterfowl by encouraging growth of annual plants through the manipulation of water levels and seed banks (Low and Bellrose 1944; Fredrickson and Taylor 1982). However, other management regimes have resulted in a mosaic of wetland types in both regions, including large areas of open water with submerged aquatic vegetation, floodplain forests, and shallow-water lakes.

Wetland rehabilitation and management efforts in the region are commendable, but studies relating waterfowl use to wetland characteristics at spatial extents relevant to the CMRV and IRV are lacking. Collecting data across large areas over time is expensive; hence, it is not surprising that previous research investigating habitat use by waterbirds was conducted at local scales (Weller and Spatcher 1965; Kaminski and Prince 1984; Paquette and Ankney 1996). Such investigations are of primary importance to avian ecology, but information from these studies may not be applicable to restoration or planning efforts at greater spatial extents (Morrissey 1996; Haig *et al.* 1998). Although large-scale analyses may lack precision of local-scale investigations, they are necessary to reveal broad patterns in habitat use that may subsequently guide restoration efforts and management decisions at comparable scales (Austin 2002).

Clearly, an analysis of wetland characteristics in relation to waterfowl use across the CMRV and IRV would benefit wetland conservation efforts in the region. To this end, the Illinois Natural History Survey (INHS) has inventoried waterfowl populations aerially in both river valleys during fall since 1948 and intermittently during spring since 1955 (Havera 1999). Mallards (*Anas platyrhynchos*) were disproportionately common in the region, accounting for 80.8% of waterfowl use in the IRV during falls 1948-1996 (Havera 1999:245). Therefore, we modeled Mallard use during fall and spring in relation to wetland and deepwater habitat (Cowardin *et al.* 1979; hereafter, wetland) characteristics at the scales of the CMRV and IRV, respectively. Our objectives were to: 1) model Mallard use based on aerial counts conducted during fall and spring in relation to wetland characteristics recorded by the National Wetlands Inventory (NWI), total wetland area, and proportion of locations designated as refuge, and; 2) make recommendations to guide regional conservation planning and restoration efforts.

STUDY AREA

The land area inventoried for waterfowl abundance during our study period encompassed much of the CMRV and IRV of central Illinois (Fig. 1). Havera (1999) described the region and its importance to migrating waterfowl in detail. Briefly, the surveyed area of the CMRV extended from River Mile (RM) 473 near Rock Island, Illinois, south to RM 201 near Alton, Illinois. We surveyed the IRV from RM 216 near Spring Valley, Illinois, south to RM 0 at Grafton, Illinois (i.e., the confluence with the Mississippi River).

METHODS

Although the INHS has inventoried waterfowl aerially in the CMRV and IRV since 1948, analyses were constrained to data from inventories conducted during 1977-1987 (inventories were not flown in spring 1986). This range of years was chosen because it encompassed the dates (1980-1987) of aerial photographs used to produce NWI data, from which wetland characteristics used in subsequent analyses were derived (Suloway and Hubbell 1994; U.S. Fish and Wildlife Service 2004).

Regardless of year, approximately-weekly inventories were conducted from a fixed-wing, single-engine aircraft at altitudes of 61-137 m and speeds of 161-241 km/h (Havera 1999:186). We estimated Mallard abundance at predetermined locations in each river valley (Fig. 1). Inventoried locations in the IRV were typically distinct floodplain lakes and associated bottomland forests and marshes that flanked the Illinois River (see Bellrose *et al.* 1979, 1983, and Havera 1999 for further explanation). In many cases the area surveyed was bounded by the mainstem of the Illinois River and the upland bluff, and some sites were impounded by levees. Inventoried areas of the Mississippi River included leveed wetlands within the floodplain, unleveed lateral lakes and marshes, and impounded mainstem reaches between navigation dams. Habitat-specific data on wetland use by waterfowl were not collected; rather, waterfowl abundance was estimated for the entire area of each location. Thus, each distinct complex of wetland habitats was sampled as a discrete unit.

A few locations were not counted in every year or season, and such cases were treated as missing data. Additionally, two power-plant cooling lakes were omitted in analyses of the Illinois River because it was believed they were not characteristic of natural and restored wetlands with respect to habitat composition and bird use (e.g., cooling lakes are man-made and rarely freeze). Mallard use of cooling lakes was variable, and cooling lakes generally only accumulated concentrations of Mallards after nearby wetlands froze. Four IRV locations (Godar Swamp, Stump, Fuller-Swan, and Gilbert lakes; Fig. 1) were grouped with the CMRV locations due to their proximity to the CMRV (i.e., distance between the two river floodplains was less than ten km), and because their hydrology was heavily influenced by water-level manipulations at Lock and Dam 26 on the Mississippi River. Thus, we inventoried waterfowl at 48 locations in the IRV and 40 and 39 sites in the CMRV during fall and spring, respectively, 1977-1987.

Biologists have used aerial surveys to estimate waterfowl abundance in North America since 1935 (Bellrose 1980). Nonetheless, this technique is not without criticism; for example, uncertainty regarding detection (Stott and Olson 1972; Conant *et al.* 1988). Aerial inventories conducted during our study did not employ concurrent ground counts. However, recent (2003-2005) ground counts of Chautauqua National Wildlife Refuge in the IRV during fall correlated positively with counts from aerial inventories conducted during the same weeks ($r = 0.78$-0.85; J. D. Stafford, Illinois Natural History Survey, unpublished data). Thus, we believed our aerial inventory data were reliable for analyzing trends in Mallard abundance with respect to wetland characteristics.

To estimate seasonal abundance of Mallards, we calculated total use-days (UDs) as the sum of the moving average (Eberhardt and Thomas 1991; Williams *et al.* 2002:218) of Mallards counted during spring (1 Febru-

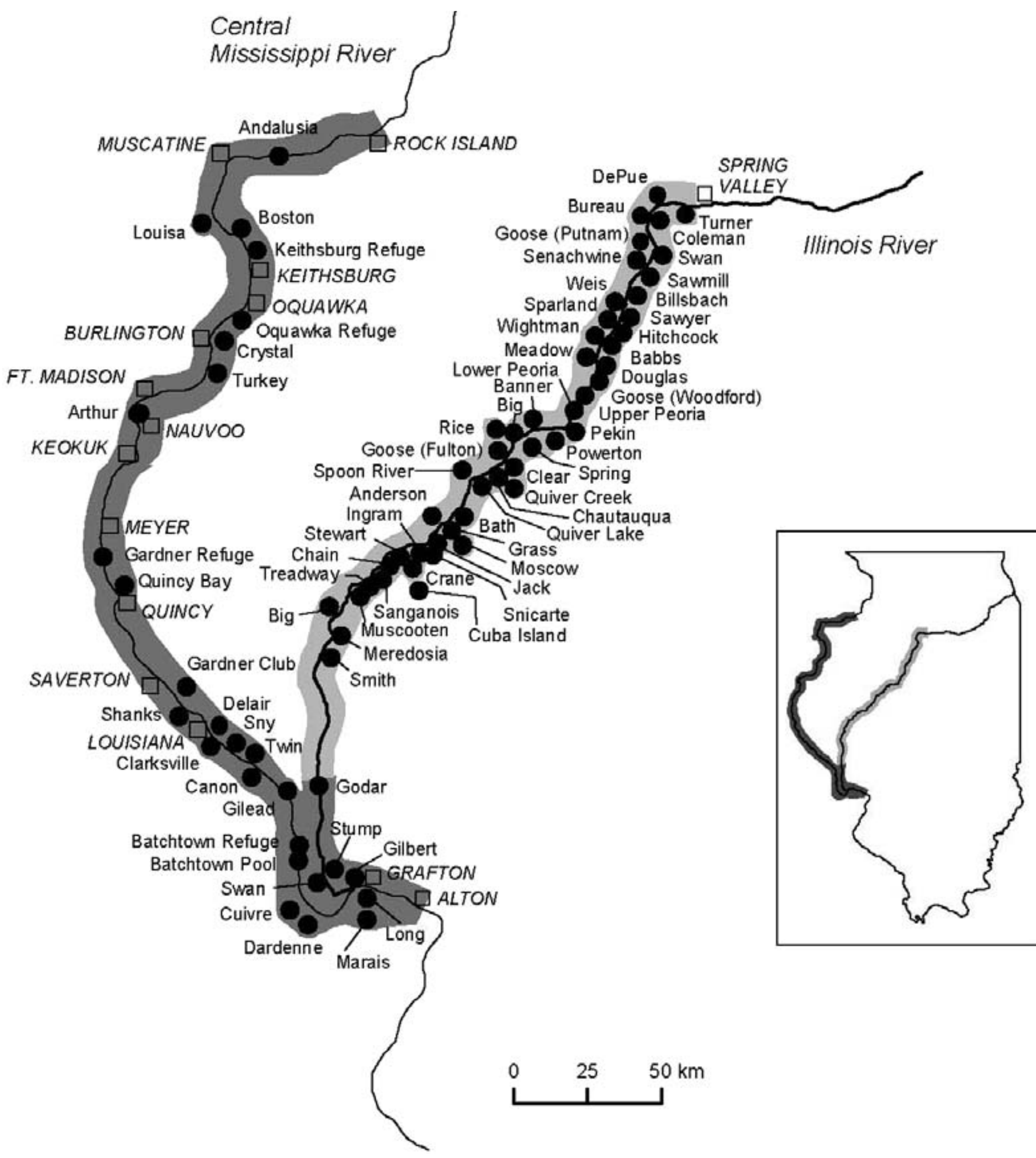

Figure 1. General areas of, and specific locations within, the Illinois and central Mississippi river valleys aerially inventoried for waterfowl by the Illinois Natural History Survey, 1977-1987.

ary-15 April) and fall (1 September-15 December) inventories. Specifically, we used data from inventory t at site j in year k to compute UDs as

$$UD_{jk} = \sum_{t=0}^{N}\left(\left(\frac{n_{(t)jk} + n_{(t+1)jk}}{2}\right) \times (d_{t+1} - d_t)\right)$$

where n was the number of Mallards observed, n_0 and n_1 the number of Mallards counted on the earliest survey of site j in year k, and n_N the average of counts prior to and after the end of each period of interest (i.e., nearest count after 15 April [spring] and 15 December [fall]). Similarly, d was the Julian date (day of year) of inventory t, d_0 one day prior to the first day of the period of interest, and d_N the last day of the period of interest. For example, if a site was inventoried on 1 March (n_t) and again on 8 March (n_{t+1}), these counts were averaged and multiplied the value by the number of days between inventories ($[d_{t+1} - d_t]$; e.g., 7 d). Then, these values were summed over all days during the season of interest, and averaged site-specific spring and fall UDs for the period 1977-1987. Finally, site-specific coefficients of variation (CV) of UDs during 1977-1987 were computed for use in weighting models of duck abundance.

Analytical Approach

An information-theoretic approach to model Mallard UDs in the CMRV and IRV during spring and fall was used with respect to wetland characteristics at each inventoried location by developing candidate models *a priori* that included combinations of wetland habitat categories (Burnham and Anderson 1998; Anderson *et al.* 2000). Four candidate sets of models were analyzed, one for each river valley and season.

Covariates

Site-specific NWI data were compiled for use as covariates in analyses using ArcView GIS 3.3 (Environmental Systems Research Institute 1996). National Wetlands Inventory classified wetland characteristics into wetland and deepwater habitats following Cowardin *et al.* (1979). To limit the number of variables 617 unique NWI classifications were grouped into six habitat categories, described below, that were believed to represented broad-scale wetland and deepwater habitats important to Mallards (Suloway and Hubbell 1994; U.S. Fish and Wildlife Service 2004). The site-specific proportions of each category were used as covariates in analyses to account for variation in wetland area among sites. Additionally, a covariate accounting for the categorical proportion of a site where hunting and other disturbances were prohibited was included. Finally, models were not fully parameterized to account for the unit-sum constraint.

1) Emergent wetland (EMERGE): Wetland area was summed at each site for the habitat types of palustrine and lacustrine (e.g., marsh-like and lake-like; see Cowardin *et al.* 1979:11-12) emergent regardless of water regime modifiers to represent wetland area potentially containing emergent, non-woody vegetation (i.e., robust and moist-soil emergent plants). It was hypothesized that Mallard UDs would vary positively with proportional area of emergent wetland ($\overline{x}_{IRV}$ = 7.1 ± 1.2% [SE], range: 0.0-35.1%; $\overline{x}_{CMRV}$ = 10.8 ± 3.1% [SE], range: 0.1-75.8%).

2) Submerged aquatic vegetation (SUBVEG): Areas classified as palustrine and lacustrine aquatic bed were combined to represent wetland habitat potentially containing submergent vegetation. It was hypothesized Mallard UDs would be positively associated with the proportion of this variable at each site ($\overline{x}_{IRV}$ = 0.7 ± 0.2% [SE], range: 0.0-7.2%; $\overline{x}_{CMRV}$ = 1.2 ± 0.7% [SE], range: 0.0-26.5%).

3) Forested wetland (FOREST): Wetland area within each site classified as forested or scrub-shrub was summed to represent forested wetland habitat for Mallards. It was hypothesized that proportion of woody habitat would be negatively associated with Mallard UDs in the IRV, but exhibit a positive association in the CMRV ($\overline{x}_{IRV}$ = 38.5 ± 2.5% [SE], range: 3.9-80.6%; $\overline{x}_{CMRV}$ = 37.0 ± 2.8% [SE], range: 0.3-82.7%).

4) Unconsolidated shore (MUDFLAT): Wetland areas at inventoried locations classified as palustrine and lacustrine were summed to comprise unconsolidated shore. These classifications represented habitats with sparsely vegetated substrates (Cowardin *et al.* 1979:18), which were predominantly mudflats in both river valleys. It was hypothesized that Mallard UDs would be positively related to proportional area of mudflat ($\overline{x}_{IRV}$ = 0.2 ± 0.1% [SE], range: 0.0-5.5%; $\overline{x}_{CMRV}$ = 0.3 ± 0.2% [SE], range: 0.0-7.9%).

5) Open water (OPENH2O): Areas of palustrine and lacustrine open water and unconsolidated bottom were combined to represent total area of open water at each site. It was hypothesized that UDs of Mallards would be negatively associated with proportion of open water ($\overline{x}_{IRV}$ = 52.4 ± 3.0% [SE], range: 4.7-90.7%; $\overline{x}_{CMRV}$ = 50.6 ± 3.8% [SE], range: 0.1-99.6%).

6) Riverine wetland (RIVER): Areas classified as riverine wetland and deepwater-riverine were combined to represent the area of surveyed sites with riverine habitat. Because the area of riverine habitat was relatively small at most sites, it was hypothesized that a modest, positive association existed between this variable and Mallard UDs ($\overline{x}_{IRV}$ = 1.0 ± 0.4% [SE], range: 0.0-14.0%; $\overline{x}_{CMRV}$ = 0.2 ± 0.1% [SE], range: 0.0-3.9%).

7) Wetland size (AREA): Larger wetlands often attract more waterfowl than smaller wetlands, thereby leading to greater total UDs simply due to wetland size. To control for variation in the size of inventoried locations, total area (ha) was included in all models and it was hypothesized it would be positively associated with Mallard UDs ($\overline{x}_{IRV}$ = 957.2 ± 115.1 ha [SE], range: 198.6-4,126.2 ha; $\overline{x}_{CMRV}$ = 1927.2 ± 253.1 ha [SE], range: 114.2-5,827.2 ha).

8) Proportion of site not disturbed (REFUGE): Wetland area where waterfowl hunting or other disturbances were prohibited (i.e., refugia) varied among sites. Unfortunately, refuge area changed at many locations since the period of inference, and it was not possible to retrospectively calculate exact area of refuge at each site. Therefore, the Illinois Department of Natural Resources and U.S. Fish and Wildlife Service personnel were consulted and the area of refuge at each site was categorized as: 1) 0-25%; 2) 26-50%; 3) 51-75%, and; 4) 76-100% of total area, and we included this variable as a categorical fixed effect in most models of Mallard UDs. It was hypothesized that UDs would increase with each categorical increase in refuge area.

Statistical Analysis

Mallard abundance was modeled using the maximum likelihood estimation method (METHOD = ML) in the MIXED procedure, SAS v9.1 (Littell *et al.* 1996; SAS Institute 2004). Further, models were weighted by the inverse of the site-specific coefficient of variation of UDs during the period of inference (i.e., 1977-1987) to account for interannual variability in Mallard abundance. Variance inflation factor (VIF) diagnostics was used to evaluate collinearity among covariates in candidate models and found no evidence of substantial intercorrelation (i.e., VIF ≤ 1.80; PROC REG; SAS Institute 2004). Best approximating and competing models from the candidate set were determined by computing second-order Akaike's Information Criterion (AIC_c; Burnham and Anderson 1998). Models were considered competitive within candidate sets if they were within approximately three AIC_c units of the best approximating model. Our definition of model-competition was slightly greater than that proposed by Burnham and Anderson (1998), because a more conservative estimate of average effects of parameters appearing repeatedly was desired. To report results concisely when model separation was poor, the following were presented: 1) model-averaged parameter estimates for effects appearing in multiple competing models weighted by the model weight (w_i; Burnham and Anderson 1998) and, 2) parameter estimates for main effects that appeared in a single competing model where the 95% CI excluded zero (i.e., significant).

RESULTS

Illinois River Valley

Fall. Five of 16 candidate models formulated to explain variation in fall Mallard UDs were considered competing, cumulatively accounting for 88.0% of model weight (w_i; Table 1). Averaged across all competing models containing the variables, total Mallard UDs was positively associated with REFUGE ($\hat{\bar{\beta}}_{REFUGE}$ = 274,476; 95% CI = 126,633 to 422,319), EMERGE ($\hat{\bar{\beta}}_{EMERGE}$ = 28,673; 95% CI = 5,304 to 52,042) and AREA ($\hat{\bar{\beta}}_{AREA}$ = 205; 95% CI = 7 to 404). No other parameter estimate differed from zero.

Spring. Three of 16 candidate models formulated to explain variation in Mallard UDs during spring were within 3 AIC_c units of the best model, and these cumulatively accounted for 88.2% of model weight (Table 2). The model-averaged parameter estimates for EMERGE ($\hat{\bar{\beta}}_{EMERGE}$ = 10,283; 95% CI = 1,068 to 19,498), REFUGE ($\hat{\bar{\beta}}_{REFUGE}$ = 110,720; 95% CI = 44,982 to 176,457), and AREA ($\hat{\bar{\beta}}_{AREA}$ = 106; 95% CI = 21 to 191) indicated significant and positive relationships with the dependent variable. Model-averaged OPENH2O ($\hat{\bar{\beta}}_{OPENH2O}$ = -6,547; 95% CI = -10,278 to -2,816) was negatively associated with spring UDs. The third best approximating model contained FOREST ($\hat{\beta}_{FOREST}$ = 5,588; 95% CI = 1,345 to 9,832), which was positively associated with spring Mallard UDs. No other variable in the competing set was significant.

Central Mississippi River Valley

Fall. Four of 16 candidate models were competitive, cumulatively accounting for 94.5% of model weight (Table 3). Similar to the IRV, model-averaged REFUGE ($\hat{\bar{\beta}}_{REFUGE}$ = 194,633; 95% CI = 101,568 to 287,698) and EMERGE ($\hat{\bar{\beta}}_{EMERGE}$ = 22,176; 95% CI = 15,979 to 28,372) were positively associated with the dependent variable. No other variables were significant.

Spring. Four of 16 candidate models of Mallard UDs during spring were considered competitive, accounting for 93.0% of model weight (Table 4). Model-averaged parameter estimates of EMERGE ($\hat{\bar{\beta}}_{EMERGE}$ = 7,185; 95% CI = 4,472 to 9,897), REFUGE ($\hat{\bar{\beta}}_{REFUGE}$ = 75,654; 95% CI = 33,774 to 117,535), and AREA ($\hat{\bar{\beta}}_{AREA}$ = 39; 95% CI = 11 to 68) indicated significant and positive relationships with the dependent variable. No other parameter estimate differed from zero.

DISCUSSION

We modeled UDs at inventoried sites to identify variables possibly explaining variation in Mallard abundance and acknowledge that many factors may influence duck use concurrently. However, information criteria alone do not necessarily imply good model fit. Fit of competing models in candidate sets of spring and fall UDs was generally fair for the IRV (R^2_{adj} range = 0.27-0.37), and better for the CMRV (R^2_{adj} range = 0.48-0.68). We believe variables identified in our analyses in-

Table 1. Candidate models to explain variation in use days of Mallards during fall at locations inventoried aerially for waterfowl in the Illinois River valley, 1977-1987, ranked by second order Akaike's information criterion (AIC_c). Also included are the number of estimable parameters (K), -2 log likelihood score ($-2\log(L(\hat{\theta}))$), model weight (w_i), and coefficient of determination (R^2).

Model	K	$-2\log(L(\hat{\theta}))$	AIC_c	ΔAIC_c	w_i	R^2
REFUGE+EMERGE+AREA	5	1411.8	1423.2	0.0	0.312	0.330
REFUGE+EMERGE+FOREST+AREA	6	1410.1	1424.1	0.9	0.197	0.338
REFUGE+EMERGE+OPENH2O+AREA	6	1410.2	1424.2	1.0	0.188	0.337
REFUGE+AREA	4	1416.7	1425.6	2.4	0.094	0.274
REFUGE+EMERGE+SUBVEG+AREA	6	1411.7	1425.7	2.5	0.089	0.316

Table 2. Candidate models to explain variation in use days of Mallards during spring at locations inventoried aerially for waterfowl in the Illinois River valley, 1977-1987, ranked by second order Akaike's information criterion (AIC_c). Also included are the number of estimable parameters (K), -2 log likelihood score ($-2\log(L(\hat{\theta}))$), model weight (w_i), and coefficient of determination (R^2).

Model	K	$-2\log(L(\hat{\theta}))$	AIC_c	ΔAIC_c	w_i	R^2
REFUGE+EMERGE+OPENH2O+AREA	6	1333.2	1347.2	0.0	0.341	0.373
REFUGE+OPENH2O+AREA	5	1336.1	1347.5	0.3	0.296	0.349
REFUGE+EMERGE+FOREST+AREA	6	1334.7	1348.7	1.5	0.161	0.353
REFUGE+SUBVEG+OPENH2O+AREA	6	1336.0	1350.0	2.8	0.084	0.335

fluenced Mallard UDs; however, we interpret our results cautiously and acknowledge that these relationships do not imply causation.

The proportion of wetland area classified as "emergent" was positively and significantly associated with Mallard UDs during spring and fall in both river systems. Estimated effect sizes for EMERGE were similar among river valleys and seasons and indicated that use-days by Mallards increased 7,185-28,673 for each percent increase in the independent variable.

Maximum waterfowl use and diversity has been associated with an equal interspersion of standing emergent vegetation and open water (i.e., "hemi-marsh"; Weller and Spatcher 1965; Weller and Fredrickson 1974; Kaminski and Prince 1981; Murkin *et al.* 1982; Smith *et al.* 2004). We believe our results generally support management practices that promote emergent vegetation as a means of providing quality habitat for migratory Mallards.

The association of UDs to REFUGE was intuitive and consistent with previous research findings. Bellrose (1954) described the value of waterfowl refuges in Illinois, noting that waterfowl densities were nearly four times greater on wetlands devoted entirely as refuge compared with sites where only half the wetland area was undisturbed. He also concluded that 26.7-52.0% of direct recoveries of waterfowl banded on Illinois refuges during fall were harvested within 40 km of the banding site (Bellrose 1954). Research in Denmark revealed that hunting displaced considerable numbers of waterfowl, particularly when hunters were mobile (i.e., floating punts; Madsen 1998a). Further, hunting generally resulted in a less abundant and diverse waterfowl community, and intermittent hunting was not sufficient to minimize disturbance unless the time between hunts was on the order of weeks (Fox and Madsen 1997; Madsen 1998b).

Interestingly, the positive effect of REFUGE differed significantly from zero in competing models of Mallard UDs during spring as well as fall. We included REFUGE in spring models because we suspected that sites with greater proportions of refuge may have provided better foraging habitat for spring-migrating waterfowl than sites with less refuge. For example, if refugia were intensively managed to promote moist-soil vegetation, these sites may have had greater vegetative biomass that promoted production of invertebrates, an important food source for Mallards during spring. However, this notion was not supported by a *post hoc* investigation that indicat-

Table 3. Candidate models to explain variation in use days of Mallards during fall at locations inventoried aerially for waterfowl in the central Mississippi River valley, 1977-1987, ranked by second order Akaike's information criterion (AIC_c). Also included are the number of estimable parameters (K), -2 log likelihood score ($-2\log(L(\hat{\theta}))$), model weight (w_i), and coefficient of determination (R^2).

Model	K	$-2\log(L(\hat{\theta}))$	AIC_c	ΔAIC_c	w_i	R^2
REFUGE+EMERGE+AREA	5	1140.0	1151.8	0.0	0.507	0.680
REFUGE+EMERGE+SUBVEG+AREA	6	1139.3	1153.8	2.1	0.179	0.676
REFUGE+EMERGE+FOREST+AREA	6	1139.9	1154.4	2.7	0.133	0.671
REFUGE+EMERGE+OPENH2O+AREA	6	1140.0	1154.5	2.8	0.126	0.670

Table 4. Candidate models to explain variation in use days of Mallards during spring at locations inventoried aerially for waterfowl in the central Mississippi River valley, 1977-1987, ranked by second order Akaike's information criterion (AIC_c). Also included are the number of estimable parameters (K), -2 log likelihood score ($-2\log(L(\hat{\theta}))$), model weight (w_i), and coefficient of determination (R^2).

Model	K	$-2\log(L(\hat{\theta}))$	AIC_c	ΔAIC_c	w_i	R^2
REFUGE+EMERGE+AREA	5	1072.9	1084.7	0.0	0.498	0.495
REFUGE+EMERGE+FOREST+AREA	6	1072.5	1087.0	2.4	0.151	0.485
REFUGE+EMERGE+OPENH2O+AREA	6	1072.6	1087.1	2.5	0.144	0.484
REFUGE+EMERGE+SUBVEG+AREA	6	1072.7	1087.2	2.6	0.137	0.483

ed weak relationships between REFUGE and EMERGE in the CMRV (R^2 = 0.04) and IRV (R^2 = 0.01). It is also plausible that inventoried locations with greater proportions of refuge may have been better managed to provide waterfowl habitat during spring migration (e.g., by holding water later in spring). Finally, some species of waterfowl exhibit interseasonal philopatry to spring staging sites (i.e., Black Brant [*Branta bernicla nigricans*]; Reed *et al.* 1998), but this topic remains largely unstudied in dabbling ducks. If Mallards did exhibit cross-seasonal site fidelity, perhaps they simply returned to sites in spring where they staged the previous fall.

We were unaware of previous research investigating cross-seasonal fidelity to fall refuges; however, Bellrose and Crompton (1970) reported 50-58% of Mallards banded on Illinois refuges during fall and surviving to the subsequent fall returned to the same degree of latitude of the banding site. Evans and Day (2002) documented greater densities of waterfowl on refuges compared to non-refuge sites during hunting season in the United Kingdom, but birds redistributed themselves among sites when hunting ceased. Similarly, Havera (1999) reported a noticeable shift in waterfowl use of Illinois refuges with the start of hunting season. Specifically, ducks expended 5.0-24.8% more UDs on refuges during the hunting season compared to pre-season use (Havera 1999:249). We suggest research investigating fall and spring habitat use by ducks in the midcontinent region is needed to more precisely identify factors associated proximately with habitat selection and fidelity to stopover locations.

Total Mallard UDs were negatively associated with proportion of open water area and positively associated with proportion of forested wetland in the IRV during spring. Much of the IRV was classified as open water wetland; thus, it is possible this association was spurious. However, many open water areas in the IRV have been severely degraded due to sedimentation (Bellrose *et al.* 1983), resulting in unproductive open water wetlands that offer little more than resting habitat (Havera 1999). We speculate Mallards may have avoided these areas in the IRV in lieu of wetlands with emergent vegetation that provided forage and thermal cover. Alternatively, the influence of open water and forested wetland area on Mallard use may have been related to increased probability of inundation during spring (U.S. Geological Survey 1999). Specifically, flooding of the Illinois River was more frequent during spring than fall, thereby increasing the chance that floodplain forests would contain water and attract Mallards. Conversely, flooding may deepen open water areas and make them less attractive to shallow-feeding Mallards in spring than in fall.

Summary and Implications

Our results indicated that the proportions of sites with emergent wetland and refuge area were important predictors of Mallard UDs, regardless of river valley or season. The better fit of spring than fall models (greater R^2_{adj} values) perhaps indicated increased selection of areas with a greater proportion of emergent wetland when habitat use was not constrained by disturbance (e.g., hunting). Additionally, 75% of CMRV locations (n = 40) and 59% of IRV sites (n = 48) contained ≤5% emergent wetland. Therefore, it appears this critical wetland component was limited, and we recommend conservation planners weight wetland acquisition decisions based on the potential to restore or effectively manage emergent wetland. Further, wetland management practices encouraging interspersion of annual emergent vegetation (i.e., moist-soil management) has been positively associated with waterfowl use (Bellrose *et al.* 1974; Gordon *et al.* 1998; Smith *et al.* 2004). Thus, we suggest moist-soil management is an appropriate strategy to increase quantity and quality of emergent vegetation on existing managed wetlands in the CMRV and IRV.

Refuges are a critical component of any habitat management plan for waterfowl, yet public lands are under increasing pressure to maximize recreational opportunities. Our models indicated that Mallard UDs were greatly influenced by refugia, but the resolution of our data did not allow for strong inference to guide refuge planning. To this end, we recommend future research investigate waterfowl abundance and harvest in relation to refuge area, ratio of refuge to total wetland area, and juxtaposition of refuge and non-refuge within and among locations. Such research could yield valuable information applicable at local, regional, and national scales, particularly if conducted experimentally (i.e., randomized allocation of refuge and hunted areas).

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