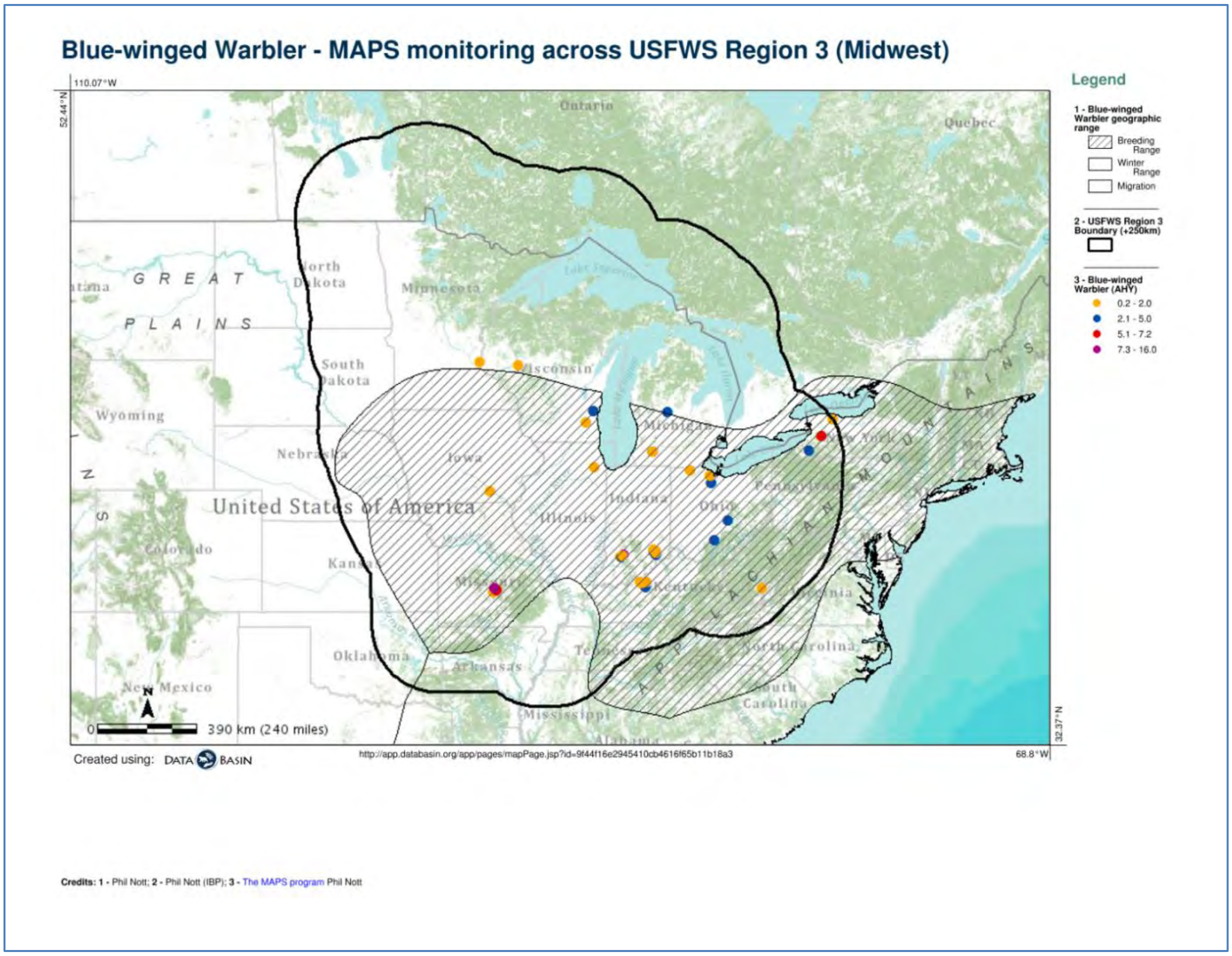
MAPPING LANDBIRD DIVERSITY AND POPULATION PERFORMANCE METRICS ACROSS THE MIDWEST LANDSCAPE: AN ANALYSIS OF LONG-TERM MONITORING AVIAN PRODUCTIVITY AND SURVIVORSHIP (MAPS) DATA.



Above. Sample output from Data Basin Midwest Avian Conservation map server www.databasin.org

A report to the United States Fish and Wildlife Service (USFWS) Region 3

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September 30th, 2011

Recommended citation: Nott, M. P. 2011. Mapping landbird diversity and population performance metrics across the Midwest landscape – an analysis of long-term Monitoring Avian Productivity and Survivorship (MAPS) data. A report to the U.S. Fish and Wildlife Service Midwest Region 3. [September 30, 2011].

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OVERVIEW

Since 1992, a network of Monitoring Avian Productivity and Survivorship (MAPS) bird banding stations has operated on predominantly forested lands throughout the Midwestern states (Figure 1). Forested lands of the region are highly fragmented by agriculture and development but most extensive forested refugia are under the stewardship of the USDA Forest Service, Department of Defense, USFWS National Wildlife Refuges, state, county, or city. The network of ~150 MAPS stations (Figure 1) operated during the breeding season and collected mark-recapture data and in-the-hand information from over 140,000 individual birds and over 170 species, including Neotropical migrants on conservation concern. These data were analyzed to provide information to improve regional avian monitoring networks (NABCI 2007), contribute to the Midwest Coordinated Bird Monitoring Partnership (MCBMP; Koch et al. 2010a), and populate the Midwest Avian Data Center (MWADC; Koch et al. 2010b). This study includes an assessment of past and present MAPS monitoring efforts and provides critical information at various geographic scales to the future of Midwest landbird conservation planning and coordinated monitoring.

In a separate study (Nott and Kaschube 2011), the mark-recapture data were collated and analyzed to quantify demographic parameters of survival rates, productivity, and population trends at regional scales. At the scale of individual stations, however, MAPS data also provide a rich diversity of station-specific “population performance metrics” that convey information pertaining to community structure (e.g., richness and diversity), morphometrics (e.g., wing chord length, body condition), phenology (breeding peak), breeding condition, and age structure.

Custom software (named VizBand) was used to quantify a suite of population performance metrics (Nott 2010) that were used for spatial visualization, landscape-scale modeling (Nott 2011a), and here to evaluate the current and historical MAPS network (Figure 1) towards recommending which active stations should be maintained and which non-active stations should be reestablished. Priority status was given to stations that monitor a high diversity of species of concern listed in the Partners in Flight (PIF) North American Landbird Conservation Plan (Rich et al. 2004). I emphasize that stations not categorized as high or medium priority in this study were not considered low priority because they may have been established to address other important monitoring requirements such as post-management monitoring, or directed at target species of local interest.

The results of this study are provided to regional planners and other interested parties as interactive maps through the Conservation Biology Institute's Data Basin online mapping interface (Data Basin 2011). This report describes the station-specific parameters used to a) calculate and visualize the monitoring potential of Midwestern MAPS stations, and b) map the spatial distributions of a suite of population performance metrics for a set of individual species of concern.

By inspecting these maps and identifying the relationships between performance metrics provided information towards identifying source breeding habitat, and post-breeding habitat. Furthermore, the station- and species-specific metrics quantified in this study contributed to a landscape-scale modeling effort (Nott 2011a) in which the data were combined with derivations of USGS National Land Cover Datasets and other region-wide spatial datasets.

METHODS

At the community level (all species captured at an individual station), different approaches were taken to dividing the data into useful categories and calculating statistics designed to answer two questions; i) what is the spatial pattern of species diversity and richness among Midwestern MAPS stations, and ii) what is the potential of each station to monitor a diversity of continental species of concern during the breeding season? At the species- and station-specific level, a suite of parameters were quantified towards examining the distribution of population performance, and the identification of stations that effectively monitor source populations of priority species.

Regional patterns of diversity

To calculate and visualize community-level parameters I considered all stations and species. A table of station- and species-specific numbers of adult captures (provided digitally in Supplementary Information: Table A) revealed many zero values so I chose a subset of the 50 most captured species region-wide (Table 1) to calculate species richness (ALL_SPR), Shannon's Diversity Index (SDI), and Shannon's Evenness Index (SEI). These parameters were quantified for two groups of species; summer resident breeding species (BRD), and passage migrant (MIG) species according to the MAPS Breeding Status Lists (DeSante et al. 2008). The capture rate of breeding species (BRD_TOT) and migrant species (MIG_TOT) was expressed as individuals captured per year. A migrant index (MIG_PC) was expressed as the percentage of species captured that were passage migrants (100 x MIG_SPR/ALL_SPR). The parameters described above are summarized in Table 2.

Defining priority species monitoring potential

To assess the potential of a station to monitor species of concern an additional set of parameters were formed using a subset of priority species (PS) listed in the PIF continental plan (Rich et al. 2004) and other species representative of particular habitat types (Table 1). For these priority species I calculated the number of species captured (PS_SPR), the total number of captures (PS_Total), the mean annual rate of capture (PS_Cap), and species richness expressed as a percentage of the total number (PS_PC) of top 50 captured species (100 x PS_SPR/ALL_SPR). The parameters described above are summarized in Table 3 and station-specific values are provided digitally in Supplementary Information: Table B.

After examining the distributions of each of these four parameters I set criteria to include those stations with values above the mode of each distribution and classified these as high priority monitoring stations. Relaxing these criteria to include the mode to ~66% of each distribution created a second set of medium priority stations. The third group included all stations that did not meet the criteria of the high and medium priority categories (Table 3) but were not classified as low priority because they may be meeting other important monitoring requirements (e.g., post-management monitoring, or targeting one or more local species of concern).

To aid regional assessment and planning the spatial distribution of each of the parameters described above was mapped in Data Basin and shown in Figures 1 through 9.

Species-specific population performance metrics

For each of a subset of continental species of concern, and other species of interest (Table 1), I defined a set of parameters that permitted the region-wide examination of station-specific population performance. These parameters are a subset of the species- and station-specific parameters quantified by a MatLab-based MAPS data analysis package (VizBand 2011). They included the mean annual number of individual adults captured (ADULT or AHY), the slope of the adult trend (ADSLP) and P-value of the regression thereof (ADSPR), the mean known age of adults (ADAGE), the mean annual number of individual young captured (YOUNG), and station-lifetime productivity index (STAPI=YOUNG/ADULTS).

The proportion of adult captures in active breeding condition (ADPBR) was expressed as the proportion of all adult captures with a cloacal protuberance score of 2 or 3 in males, or a brood patch score of 2, 3, or 4 in females (DeSante et al. 2008). The seasonal peak of adult captures varies by species, geography, and year and may inform phenology of trends or annual variation influenced by seasonal weather patterns (Nott and DeSante 2002b). Finally, I calculated the mean wing chord length of adult birds (ADWCL), a useful parameter for resolving population age-structure because older birds tend to have longer wings (Nott 2010). I calculated the proportion of male captures (PAHYM) under the assumption that a high proportion of males may help identify source populations. In high quality breeding habitat we might expect females to be mostly attending the nest, and dominant territory owners with well-developed persistent cloacal protuberances (high values of ADPBR) would exclude floater males (lower values of ADPBR) would be excluded, resulting in high values of PAHYM.

To show map figures of all species and metrics in this written report would be unwieldy, so I show examples in Figures 2 through 9 for Wood Thrush (entire region), White-eyed Vireo (southerly breeding range), Chestnut-sided Warbler (northerly breeding range), and Blue-winged Warbler (close to entire breeding range). I report the results with reference to significant correlations (JMP 2007) between metrics and make inferences thereof pertaining to the ecology of the species and/or performance characteristics of source populations.

Other species and metrics can be viewed through the Data Basin-supported Midwest Avian Conservation group because single figures of the region hide much of the detail in areas where stations are clustered and users can zoom into areas of interest, download the data, add other spatial datasets, and produce figures (PNG format) or annotated maps (PDF format) for reporting purposes (e.g., cover page figure). A guide to accessing these maps is provided as a separate document (Nott et al. 2011c).

RESULTS AND INTERPRETATIONS

The network of 149 MAPS stations (Figure 1) operated during the breeding season and collected mark-recapture data and in-the-hand information from over 140,000 individual birds and over 170 species. Of the 149 stations 135 were selected to examine species richness and diversity among a subset of 50 most captured species, and to assess stations' potential to effectively monitor continental species of concern.

Region-wide, the majority (72%) of the 137 stations were inactive in 2011, and 59 (60%) of those inactive stations were located in the westernmost states (west of 83.1W). Similarly, within the boundaries of the eight states comprising USFWS Region 3 a total of 60 stations have ever operated and 35 (58%) of those were inactive in 2011. Of the eight Region 3 states, Indiana and Ohio MAPS networks are relatively intact (<50% inactive). Conversely, three of the four Iowa and Illinois stations, 13 of the 19 Michigan, Minnesota and Wisconsin stations, and all of the nine Missouri stations were inactive in 2011 (Table 5).

At the scale of bird conservation regions 118 (86%) stations operated within the five core BCRs considered in this study (Table 6), of which 73% were inactive in 2011. All the BCRs suffered high levels of attrition in their MAPS networks; Boreal Hardwood Transition (75%), Eastern Tall Grass Prairie (82%), Prairie Hardwood Transition (61%), Central Hardwoods (70%), and Appalachian Mountains (67%).

Patterns of species richness and diversity

A longitudinal pattern of total species richness (ALL_SPR) emerged (Figure 1) in which the easternmost stations (east of 83.1W) captured an average of 43 species (including 34 summer resident breeders) compared to 36 (including 27 breeders) among the westernmost stations (ANOVA: $R2=0.10$, $F=15.4$, $P<0.0001$).

Figure 2 shows a fairly uniform distribution of breeding species richness ranging between 16 and 39.1 (Nebraska). Two states in Region 3 exhibited high average breeding species richness; Wisconsin (35 species) and Michigan (36 species), whereas Iowa (22 species) and Illinois (24 species) exhibited the lowest richness scores (Table 5). All of the BCRs exhibited breeding species richness in excess of 30 (Table 6), except the Boreal Hardwood Transition region (26.5). Figure 3 shows a wide distribution of high values for Shannon's Diversity Indices of summer resident species.

Figure 4 shows a relatively uniform distribution of passage migrant species richness (species captured at MAPS stations between May 31 and August 11 that do not breed there). Seven states exhibited mean values in excess of 10 passage migrant species; Manitoba (10.0), Michigan (11.2), Minnesota (12.6), Ohio (12.6), Oklahoma (11.9), Pennsylvania (11.0), and South Dakota (13.0). The migrant indices (Figure 5), expressed as the percentage of total species richness due to passage migrant species, were highest for Oklahoma (35%) and Nebraska (38%).

Potential for monitoring priority species of conservation concern

The MAPS stations that captured most priority species were mostly located in the southern half of the region, including the states of Ohio, West Virginia, Indiana, Kentucky, Tennessee, Illinois, Missouri, and Kansas (Table 5). Values were lowest in Oklahoma and the northwestern portion of the region, and of the Region 3 states low priority scores (<1.0) were recorded for Iowa, Michigan, Minnesota, and Wisconsin.

Figure 7 shows the distribution of active and non-active stations which was combined with the three category priority status to monitor priority species of conservation concern (Figure 8) to map stations that are inactive but should be reestablished. The numbers of inactive stations recorded for high and medium priority categories that should be reestablished are given by state (Table 6) and BCR (Table 7). At least 19 medium and high priority stations should be reestablished among the Region 3 states, and 37 stations should be reestablished across the entire study area.

Species-specific population performance metrics

Figures 10-16 show maps of seven population performance measures calculated for the wide-ranging Wood Thrush monitoring stations. Figure 10 shows, not surprisingly, that the stations capturing Wood Thrush adults were associated with forested areas. The highest annual numbers of Wood Thrush were recorded for the clusters of stations monitoring Naval Support Activity (NSA) Crane Big Oaks National Wildlife Refuge in Indiana (formerly Jefferson Proving Ground). High numbers were also recorded at the inactive stations of Fort Knox, Kentucky (six stations), Hell's Hollow and the Taft Reserve stations in Ohio, Alma College Bird Observatory in Michigan, and the Hazeltop Ridge station in Shenandoah National Park, Virginia.

Inspection of the Wood Thrush maps and table of population performance metrics (Table 8) revealed highly significant correlations ($P<0.005$) between the ratio of young to adults (Figure 11; STAPI), the proportion of adults in breeding condition (Figure 12; ADPBR), and the mean adult wing chord (Figure 13; ADWCL). This suggests that higher productivity is associated with station where older adults are in more persistent breeding condition.

Figure 14 shows 87 stations that captured Wood Thrushes, of which 59 (69%) exhibited stationary or positive trends, 10 of which were statistically significant at the level of $P<0.05$, and 15 were significant at the level of $P<0.10$. An additional metric, the proportion of adults recorded as males (PAHYM) was also highly correlated (after removal of outliers) with ADWCL ($R=0.475$, $P<0.0001$) and ADPBR ($R=0.344$, $P<0.002$). This suggests that male-dominated habitats held older birds in more persistent breeding condition.

The mean known age of adults (ADAGE; Figure 15) correlated highly significantly ($P<0.01$) with the numbers of adults captured (ADULT; Figure 10). The mean day of adult capture (Figure 16) varies considerably among stations.

Figure 17 shows the distribution of stations that captured adult White–eyed Vireo relative to their breeding range (Ridgely 2003). The mean annual numbers of adults showed no particular pattern but the pattern of adult day-of-capture (ADDOY; Figure 18) correlated positively and strongly (Table 9) with productivity (STAPI; $P<0.002$), the proportion of adults in breeding condition ($P<0.005$), and elevation ($P<0.0001$). This may suggest post-breeding dispersal to higher elevations.

Figure 19 shows the distribution of stations that captured adult Chestnut-sided Warblers relative to their breeding range. The mean annual numbers of adults captured showed no particular spatial pattern but correlated positively and strongly (Table 10) with the proportion of males among sexed adults (PAHYM; $P<0.01$), the proportion of adults in breeding condition (ADPBR; $P<0.05$), mean wing chord length ($P<0.005$), and numbers of young (YOUNG; $P<0.0001$). This suggests that denser breeding populations are dominated by older males, all adult birds stay in breeding condition longer, and that the numbers of fledglings increase with increasing numbers of adults. A quadratic fit of paired ADULT and YOUNG data ($R2=0.51$, $F=10.96$, $P<0.0005$) revealed an asymptote suggesting that productivity is maximized in habitats where the MAPS station captures ~10 adults per year.

Figure 19 shows the distribution of stations that captured adult Blue-winged Warblers relative to their breeding range. The mean annual numbers of adults captured showed no particular spatial pattern but correlated positively with the numbers of young ($P<0.001$), and negatively ($P<0.001$) with trend (Table 11) suggesting populations decreased where they have been most abundant. At stations where the adults were mostly detected early in the season (low ADDOY), wing chord lengths ($P<0.002$) were longer, the mean known age (ADAGE) was older ($P<0.001$), but the productivity was lower ($P<0.001$). It is not immediately obvious why productivity would be lower in habitats that support experienced adult populations, unless the fledglings are driven away from the breeding territories upon fledging.

Although ADAGE was lower in more northerly ($P<0.002$) and easterly populations ($P<0.05$) warbler populations increased among easterly stations ($P<0.05$), suggesting the increasing populations may be increasing by virtue of dispersal from other parts of the range. The mean adult day-of-capture increased (peaked later) with latitude.

Correlation matrices for other species may be obtained digitally (Supplementary Information: Dataset A).

DISCUSSION

The most obvious feature of this regional study is that only 28% of the MAPS stations ever operated for more than four years, the minimum recommended length of operation, are currently active. Between 1994 and 2008 a number of clusters of stations operated in this study region on U.S. Department of Defense (DoD) installations which were funded by the DoD Legacy Resources Management Office, U.S. Navy, and Army Corps of Engineers. These included Fort Leonard Wood, Missouri (six stations); Fort Knox, Kentucky (six stations); Naval Support Activity Crane, Indiana (six stations); Big Oaks National Wildlife Refuge, Indiana (six stations) formerly Jefferson Proving Ground, and NIOC Sugar Grove, West Virginia (four stations). In 2011, 12 stations were reestablished at NSA Crane and Big Oaks NWR and six stations were newly established on Hoosier National Forest tracts and state lands. These stations are expected to continue operating through 2014 directed at intensive Wood Thrush studies (a collaboration of the Institute for Bird Populations, Smithsonian Institute, and Oregon State University).

Study-wide, 56 inactive MAPS stations were categorized as high or medium priority of which 19 stations lie within the boundaries of USFWS Region 3, and nine of those operated in Missouri. The high and medium priority stations at Fort Leonard Wood (Big Piney IBA), Missouri and Fort Knox should be reestablished to monitor a diversity of species of concern and contribute greatly to demographic monitoring requirements within the Central Hardwoods BCR (Fitzgerald and Nigh 2001). Likewise, 11 high and medium priority stations that operated on Fort Riley (1994-2006), a globally Important Bird Area and Fort Leavenworth (1993-2002), associated with the Iatan/Weston River Corridor IBA, should also be reestablished. The Shenandoah National Park stations in Virginia that operated between 1992 and 2003 should be reestablished to monitor landbird communities recovering from extensive forest damage due to Gypsy moth infestation (1986-1994).

Apart from these clusters, single stations or smaller clusters should be reestablished to monitor recent community change, and monitor priority species in the future. In New York State the Beaver Meadow station monitored 15 priority species, South Illinois Bird Observatory station (1999-2003) monitored 12 priority species, and Tennessee’s Big Sandy (1993-2005) and Radnor Lake (1997-2006) stations monitored 13 and 12 priority species, respectively. These stations should be reestablished to form a set of five stations with Clark’s River NWR (KY) and Warner Park (Belle Meade, Tennessee to monitor the Tennessee River watershed from NW Tennessee through western Kentucky and southern Illinois, including lands adjacent to

Important Bird Areas of Shawnee National Forest (IL), Big Sandy Unit (TN), and Radnor Lake NWR (TN). In Missouri, the Proving Grounds Res. Sta. station.

Two high priority stations that operated on Ohio state-managed land, Taft Reserve (1993-2000) and Hell's Hollow (1993-1996), monitored 14 and 11 priority species, respectively. The high priority Pewaukee station (1997-2001), between Wisconsin's North and South Kettle Moraine Forest IBAs, and Minnesota's Belwin station (1995-2002), associated with the Lower Saint Croix National Scenic River IBA, also monitored 11 priority species. Three medium priority stations should be reestablished at Alma College Bird Observatory of central Michigan (1999-2005) which monitored six priority species, Audubon Center of the North Woods, Minnesota (1998-2003) which monitored nine priority species, and Fallingsnow One near Kakabeka Falls, Ontario which monitored 7 priority species. Although Virginia is not within Region 3 a separate study addressed the MAPS network in Virginia through 2008 (Nott et al. 2008).

Inactive stations not categorized as high or medium priority should not be regarded as lacking importance, the operator may be using the station for educational or outreach purposes, post-management monitoring, or directed at one or more species of local concern. The operation of active medium and high priority stations should be maintained.

Species-specific mapping and interpretations

The maps of species richness, diversity, and population performance metrics provide useful visualizations for a) locating where MAPS data are available for a given species, b) identifying locations where adults are numerous and/or productive, and c) identifying inactive stations that could be reestablished to better monitor a species at various scales (e.g., state or BCR). The Data Basin online mapping interface allows the user to explore patterns of diversity and performance metrics and combine them with many layers including public land stewardship, and administrative boundaries such as federal agency regions, state, BCR, and USFWS Joint Venture boundaries. Visualizations and data describing the annual variation in performance metrics were also produced (under DoD funding) by the custom software (VizBand) and are available online for four important forested refugia of the Central Hardwoods BCR, Fort Leonard Wood (MO), NSA Crane (IN), Big Oaks NWR (IN), and Fort Knox (Nott and Chambers 2008). A guide to interpreting the visualizations and data tables is provided therein (Nott 2010).

For a given species, the relationships between population performance metrics (with abiotic factors of latitude, longitude, and elevation) may allow important inferences to be made regarding the performance characteristics of source populations. However, confounding factors of behavior, geography, and habitat may result in a complexity that is difficult to interpret. For instance, it is well known that interior mature deciduous forest provides high quality Wood Thrush breeding habitat, where productivity was also recorded to be high from nest monitoring studies (Hoover et al. 1995). Unfortunately, newly fledged birds appear to move quickly from the interior forest to edge habitat and are therefore less likely to be captured by an interior MAPS stations. Thus, higher productivity is recorded in edgy riparian habitats. Identifying high quality post-breeding habitat is as important as identifying the habitat in which they most successfully breed. So, modeling station-specific population performance metrics as a function of landscape context (pattern and cover should provide further insight into the ecological complexities and provide region-wide quantitative mapping of predicted breeding and post-breeding habitat (Fauth et al. 2000).

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TABLES

Table 1. The top 50 most commonly captured species across the Midwest MAPS network with MAPS species code (NUMB), AOU four-character species code (SPEC), common name, genus and species. Migration strategy (MS) and nest location preference (NL). Species in bold denote continental species of concern and other species of concern or interest not included in 50 most commonly captured species (* in NUMB column).

NUMB	SPEC	Common Name	Genus	Species	MS	NS
9650	DOWO	Downy Woodpecker	*Picoides*	*pubescens*	R	C
11390	EAWP	Eastern Wood-Pewee	*Contopus*	*virens*	N	T
11460	**ACFL**	**Acadian Flycatcher**	***Empidonax***	***virescens***	**N**	**T**
11475	**TRFL**	**Traill's Flycatcher**	***Empidonax***	***alnorum/traillii***	**N**	**S**
12550	**WEVI**	**White-eyed Vireo**	***Vireo***	***griseus***	**NI**	**S**
12640	**BEVI**	**Bell's Vireo**	***Vireo***	***bellii***	**N**	**S**
12790	REVI	Red-eyed Vireo	*Vireo*	*olivaceus*	N	S
12930	BLJA	Blue Jay	*Cyanocitta*	*cristata*	T	T
13560	**CACH**	**Carolina Chickadee**	***Poecile***	***carolinensis***	**R**	**C**
13570	BCCH	Black-capped Chickadee	*Poecile*	*atricapillus*	R	C
13660	**TUTI**	**Tufted Titmouse**	***Baeolophus***	***bicolor***	**R**	**C**
14000	**CARW**	**Carolina Wren**	***Thryothorus***	***ludovicianus***	**R**	**C**
14070	HOWR	House Wren	*Troglodytes*	*aedon*	NI	C
14780	**VEER**	**Veery**	***Catharus***	***fuscescens***	**N**	**G**
14810	SWTH	Swainson's Thrush	*Catharus*	*ustulatus*	N	S
14830	**WOTH**	**Wood Thrush**	***Hylocichla***	***mustelina***	**N**	**T**
15000	AMRO	American Robin	*Turdus*	*migratorius*	T	T
15130	GRCA	Gray Catbird	*Dumetella*	*carolinensis*	NI	S
15200	**BRTH**	**Brown Thrasher**	***Toxostoma***	***rufum***	**T**	**S**
15550	CEDW	Cedar Waxwing	*Bombycilla*	*cedrorum*	TI	T
15630	**BWWA**	**Blue-winged Warbler**	***Vermivora***	***pinus***	**N**	**G**
15670	**NAWA**	**Nashville Warbler**	***Vermivora***	***ruficapilla***	**N**	**G**
15750	YWAR	Yellow Warbler	*Dendroica*	*petechia*	N	S
15760	**CSWA**	**Chestnut-sided Warbler**	***Dendroica***	***pensylvanica***	**N**	**S**
15570*	**MAWA**	**Magnolia Warbler**	***Dendroica***	***magnolia***	**N**	**T**
15930	PRAW	Prairie Warbler	*Dendroica*	*discolor*	N	S
16030	BAWW	Black-and-white Warbler	*Mniotilta*	*varia*	N	G
16040	AMRE	American Redstart	*Setophaga*	*ruticilla*	N	T
16060	**WEWA**	**Worm-eating Warbler**	***Helmitheros***	***vermivorum***	**N**	**G**
16080	**OVEN**	**Ovenbird**	***Seiurus***	***aurocapilla***	**N**	**G**
16100	**LOWA**	**Louisiana Waterthrush**	***Seiurus***	***motacilla***	**N**	**G**

NUMB	SPEC	Common Name	Genus	Species	MS	NS
16110	**KEWA**	**Kentucky Warbler**	***Oporornis***	***formosus***	**N**	**G**
16130*	**MOWA**	**Mourning Warbler**	***Oporornis***	***philadelphia***	**N**	**G**
16150	COYE	Common Yellowthroat	*Geothlypis*	*trichas*	NI	S
16280	**HOWA**	**Hooded Warbler**	***Wilsonia***	***citrina***	**N**	**S**
16300*	**CAWA**	**Canada Warbler**	***Wilsonia***	***Candensis***	**N**	**G**
16460	YBCH	Yellow-breasted Chat	*Icteria*	*virens*	N	S
17820	**EATO**	**Eastern Towhee**	***Pipilo***	***erythrophthalmus***	**T**	**G**
18050	FISP	Field Sparrow	*Spizella*	*pusilla*	T	G
18140	GRSP	Grasshopper Sparrow	*Ammodramus*	*savannarum*	T	G
18230	SOSP	Song Sparrow	*Melospiza*	*melodia*	T	G
18250	**SWSP**	**Swamp Sparrow**	***Melospiza***	***georgiana***	**T**	**S**
18270	**WTSP**	**White-throated Sparrow**	***Zonotrichia***	***albicollis***	**T**	**G**
18320	SCJU	Slate-colored Junco	*Junco*	*h. hyemalis*	T	G
18560	NOCA	Northern Cardinal	*Cardinalis*	*cardinalis*	R	S
18600	RBGR	Rose-breasted Grosbeak	*Pheucticus*	*ludovicianus*	N	T
18670	**INBU**	**Indigo Bunting**	***Passerina***	***cyanea***	**N**	**S**
18710	**DICK**	**Dickcissel**	***Spiza***	***americana***	**N**	**S**
18730	RWBL	Red-winged Blackbird	*Agelaius*	*phoeniceus*	T	S
18870	COGR	Common Grackle	*Quiscalus*	*quiscula*	T	T
18960	BHCO	Brown-headed Cowbird	*Molothrus*	*ater*	TI	N
19160	BAOR	Baltimore Oriole	*Icterus*	*galbula*	N	T
19510	AMGO	American Goldfinch	*Carduelis*	*tristis*	T	S

Table 2. Descriptions of species richness and diversity metrics.

Parameter	Description of parameter
ALL_SPR	Species richness (number of species ever captured)
BRD_SPR	Number of summer resident breeding species
BRD_SDI	Shannon's Diversity Index (SDI) for summer resident breeding species
BRD_SEI	Shannon's Evenness Index (SDI) for summer resident breeding species
BRD_TOT	Capture rate of summer resident breeding species
MIG_SPR	Number of passage migrant species captured
MIG_SDI	Shannon's Diversity Index (SDI) for passage migrant species
MIG_SEI	Shannon's Evenness Index (SDI) for passage migrant species
BRD_TOT	Capture rate of summer resident breeding species
MIG_PC	Percentage of passage migrant species (100 x MIG_SPR/ALL_SPR)

Table 3. Diversity parameter thresholds used to prioritize MAPS station potential to monitor continental birds of conservation concern.

Parameter	Description	Priority Criteria High	Medium
ALL_SPR	Total number of top 50 species captured		
PS_Total	Total number of priority species captures	>= 15	>= 10
PS_Cap	Mean capture rate of priority species	>= 0.5	>= 0.4
PS_SPR	Priority species richness	>= 8	>= 6
PS_PC	Percentage of priority species	>= 20	>= 10

Table 4. Description of population performance metrics.

Performance metric	Description of metric
LATIT	Latitude
LNGIT	Longitude
ELEVN	Elevation (m)
ADULT	Mean annual number of individual adults (birds/station)
ADSLP	Regression slope of the adult trend (bird/year)
ADSPR	P-value of regression slope
YOUNG	Mean annual number of HY individuals
STAPI	Station-lifetime productivity (YOUNG/ADULT)
ADAGE	Mean known age of adults
ADPBR	Proportion of adult captures in breeding condition
ADWCL	Mean wing chord length of adults
ADDOY	Mean adult day-of-capture
PAHYM	Proportion of males in sexed individuals

Table 5. Total numbers of MAPS stations and numbers of inactive stations categorized by potential to monitor species of conservation concern listed in the Partners in Flight North American Landbird Conservation Plan, and by state. The analysis included all eligible stations within the eight states of USFWS Region 3 (in bold) completely encapsulated, and an additional 13 states partially covered by a 250km buffer surrounding Region 3.

	Total	Total	Mean	High Priority		Medium Priority		Other Priority	
State	Number	Inactive	BRD_SPR	N	Inactive	N	Inactive	N	Inactive
Iowa	**1**	**1**	**22.0**	**0**	**0**	**0**	**0**	**1**	**1**
Illinois	**3**	**2**	**24.0**	**2**	**1**	**0**	**0**	**1**	**1**
Indiana	**17**	**6**	**29.7**	**13**	**4**	**0**	**0**	**4**	**2**
Michigan	**6**	**4**	**36.1**	**1**	**0**	**1**	**1**	**4**	**3**
Minnesota	**8**	**6**	**29.9**	**2**	**1**	**1**	**1**	**5**	**4**
Missouri	**9**	**9**	**27.4**	**6**	**6**	**2**	**2**	**1**	**1**
Ohio	**11**	**4**	**24.0**	**6**	**2**	**2**	**0**	**3**	**2**
Wisconsin	**5**	**3**	**35.0**	**1**	**1**	**1**	**0**	**3**	**2**
Arizona	1	1	33.5	0	0	1	1	0	0
Kansas	12	12	33.2	4	4	7	7	1	1
Kentucky	10	8	16.3	9	7	0	0	1	1
Manitoba	1	0	34.0	0	0	1	0	0	0
Nebraska	8	5	39.1	0	0	2	1	6	4
New York	4	2	22.5	2	1	1	0	1	1
Oklahoma	15	15	23.2	0	0	3	3	12	12
Ontario	6	5	34.5	0	0	4	4	2	1
Pennsylvania	2	1	31.0	1	0	0	0	1	1
South Dakota	1	1	30.4	0	0	0	0	1	1
Tennessee	5	3	30.3	4	2	0	0	1	1
Virginia	7	7	33.4	4	4	2	2	1	1
West Virginia	5	4	29.6	1	0	1	1	3	3
Study-wide Total	137	99		56	33	29	23	52	43
FWSR3 Total	60	35		31	15	7	4	22	16
Other Total	77	64		25	18	22	19	30	27

Table 6. Total numbers of MAPS stations and numbers of inactive stations categorized by potential to monitor species of conservation concern listed in the Partners in Flight North American Landbird Conservation Plan, and by NABCI bird conservation region (BCR). The analysis included all eligible stations within the 11 BCRs overlapping USFWS Region 3 plus a 250km buffer around Region 3. Of the 11 BCRs the five core BCRs in bold are best represented (>10 stations).

					High Priority		Medium Priority		Other Priority	
BCR	BCR	N	Inactive	BRD_SPR	N	Inactive	N	Inactive	N	Inactive
Prairie Potholes	11	3	1	28.0	1	0	1	0	1	1
Boreal Hardwood Transition	**12**	**12**	**9**	**26.5**	**1**	**0**	**5**	**5**	**6**	**4**
Lower Great Lakes	13	3	3	29.7	1	1	0	0	2	2
Central Mixed Grass Prairie	19	6	3	10.7	0	0	2	1	4	2
Oaks and Prairies	21	4	4	19.0	0	0	0	0	4	4
Eastern Tall Grass Prairie	**22**	**34**	**28**	**30.2**	**8**	**5**	**12**	**10**	**14**	**13**
Prairie Hardwood Transition	**23**	**14**	**9**	**37.0**	**1**	**1**	**2**	**1**	**11**	**7**
Central Hardwoods	**24**	**37**	**26**	**32.6**	**31**	**20**	**2**	**2**	**4**	**4**
West Gulf Coastal Plain	25	2	2	29.5	0	0	1	1	1	1
Southeastern Coastal Plain	27	1	0	28.0	1	0	0	0	0	0
Appalachian Mountains	**28**	**21**	**14**	**31.6**	**12**	**6**	**4**	**3**	**5**	**5**
Total		137	99		56	33	29	23	52	43
Core BCR Totals		118	86		53	32	25	21	40	33

Table 7. Mean species richness and diversity scores for top most captured species region-wide and for priority species of concern. Priority scores above unity indicate state-specific MAPS networks with a high potential to monitor priority species of conservation concern.

		Top 50 most captured species									Priority Species				
State	NUM_YRS	BRD_TOT	BRD_SPR	BRD_SDI	BRD_SEI	MIG_SPR	ALL_TOT	ALL_SPR	MIG_PC	PS_Total	PS_Cap	PS_SPR	PS_PC	Priority Score
IA	**5.0**	**25.0**	**24.0**	**2.6**	**0.8**	**4.0**	**26.0**	**28.0**	**14.3**	**5.4**	**0.2**	**7.0**	**25.0**	**0.0**
IL	**9.0**	**34.6**	**29.7**	**2.8**	**0.8**	**8.7**	**36.5**	**38.3**	**19.7**	**20.7**	**0.6**	**11.0**	**30.8**	**1.3**
IN	**11.1**	**76.9**	**36.1**	**2.9**	**0.8**	**9.8**	**79.1**	**45.8**	**20.8**	**33.6**	**1.0**	**12.3**	**27.4**	**1.5**
MI	**11.0**	**92.7**	**35.0**	**2.7**	**0.8**	**11.2**	**95.6**	**46.2**	**24.7**	**12.1**	**0.4**	**7.3**	**19.1**	**0.5**
MN	**9.3**	**91.5**	**33.5**	**2.8**	**0.8**	**12.6**	**96.0**	**46.1**	**27.5**	**12.9**	**0.4**	**7.0**	**15.4**	**0.6**
MO	**11.4**	**67.4**	**33.2**	**2.9**	**0.8**	**8.1**	**69.5**	**41.3**	**18.7**	**42.2**	**1.2**	**11.6**	**28.6**	**1.6**
OH	**9.5**	**124.2**	**39.1**	**2.8**	**0.8**	**12.6**	**128.2**	**51.7**	**23.7**	**26.1**	**0.8**	**10.3**	**20.7**	**1.3**
WI	**7.0**	**68.9**	**33.4**	**2.9**	**0.8**	**8.6**	**70.9**	**42.0**	**19.4**	**17.5**	**0.5**	**6.6**	**16.1**	**0.6**
AR	5.0	64.6	22.0	2.6	0.8	2.0	65.0	24.0	8.3	20.0	0.6	7.0	29.2	1.0
KS	10.1	58.9	29.9	2.7	0.8	8.3	62.3	38.2	20.7	24.3	0.7	8.8	23.9	1.3
KY	9.4	50.2	27.4	2.7	0.8	7.8	52.5	35.2	21.6	33.8	1.0	11.5	33.0	1.8
MB	7.0	55.3	24.0	2.5	0.8	10.0	57.6	34.0	29.4	23.5	0.7	6.0	17.7	1.0
NE	6.0	65.9	16.3	2.1	0.8	8.6	68.9	24.9	38.2	17.9	0.5	4.3	19.8	0.3
NY	7.0	83.6	34.0	2.9	0.8	8.0	85.6	42.0	19.1	22.0	0.6	10.5	24.5	1.3
OK	6.1	49.7	22.5	2.6	0.8	11.9	57.3	34.4	34.9	15.2	0.4	5.0	15.0	0.2
ON	5.7	76.0	23.2	2.7	0.8	9.3	81.4	32.5	28.8	33.5	1.0	7.0	21.6	0.7
PA	8.0	62.8	34.5	3.1	0.9	11.0	64.6	45.5	23.8	22.6	0.7	10.5	23.2	1.0
SD	5.0	80.2	31.0	3.0	0.9	13.0	86.2	44.0	29.6	46.9	1.4	5.0	11.4	0.0
TN	10.2	54.8	30.4	2.7	0.8	9.4	56.5	39.8	23.6	32.2	0.9	11.4	28.5	1.6
VA	10.4	79.3	30.3	2.6	0.8	6.7	80.4	37.0	18.1	23.7	0.7	9.1	24.8	1.4
WV	7.0	55.1	29.6	2.8	0.8	6.4	56.7	36.0	15.9	17.7	0.5	9.2	27.4	0.6

Table 8. Statistically significant pairwise correlation coefficients (and P-values) between Wood Thrush population performance metrics.

Variable	By Variable	Coefficient	P-value
YOUNG	ADULT	0.790	0.000
STAPI	ELEVN	-0.235	0.037
STAPI	YOUNG	0.446	0.000
ADAGE	ADULT	0.385	0.000
ADAGE	YOUNG	0.254	0.024
ADWCL	LNGIT	0.211	0.062
ADWCL	LATIT	0.356	0.001
ADWCL	STAPI	0.228	0.043
ADPBR	ADWCL	0.227	0.044
PAHYM	LATIT	0.216	0.056
PAHYM	ADWCL	0.362	0.001
PAHYM	ADDOY	-0.319	0.004

Table 9. Statistically significant (P<0.10) pairwise correlation coefficients (and P-values) between White-eyed Vireo population performance metrics (46 stations).

Variable	By Variable	Coefficient	P-value
YOUNG	ADULT	0.820	0.000
STAPI	YOUNG	0.600	0.000
ADAGE	YOUNG	0.261	0.080
ADPBR	STAPI	0.368	0.012
ADDOY	YOUNG	0.358	0.015
ADDOY	STAPI	0.482	0.001
ELEVN	ADAGE	0.296	0.045
ELEVN	ADDOY	0.284	0.056
ELEVN	ADWCL	0.278	0.062

Table 10. Statistically significant (P<0.10) pairwise correlation coefficients (and P-values) between Chestnut-sided Warbler population performance metrics (24 stations).

Variable	By Variable	Coefficient	P-value
ADULT	LATIT	0.651	0.001
YOUNG	ADULT	0.702	0.000
STAPI	YOUNG	0.411	0.046
ADAGE	ELEVN	0.465	0.022
ADWCL	ADULT	0.582	0.003
ADPBR	LATIT	0.445	0.030
ADPBR	ADULT	0.466	0.022
PAHYM	ADULT	0.548	0.006
PAHYM	ADWCL	0.654	0.001

Table 11. Statistically significant (P<0.10) pairwise correlation coefficients (and P-values) between Blue-winged Warbler population performance metrics (42 stations).

Variable	By Variable	Coefficient	P-value
YOUNG	ADULT	0.773	0.000
STAPI	YOUNG	0.602	0.000
ADSLP	LNGIT	0.312	0.045
ADSLP	ADULT	-0.660	0.000
ADAGE	LNGIT	-0.309	0.046
ADAGE	LATIT	-0.461	0.002
ADPBR	LATIT	0.334	0.031
ADPBR	ADAGE	-0.359	0.020
ADDOY	LATIT	0.450	0.003
ADDOY	STAPI	0.477	0.001
ADDOY	ADAGE	-0.482	0.001
ADDOY	ADWCL	-0.464	0.002

FIGURES

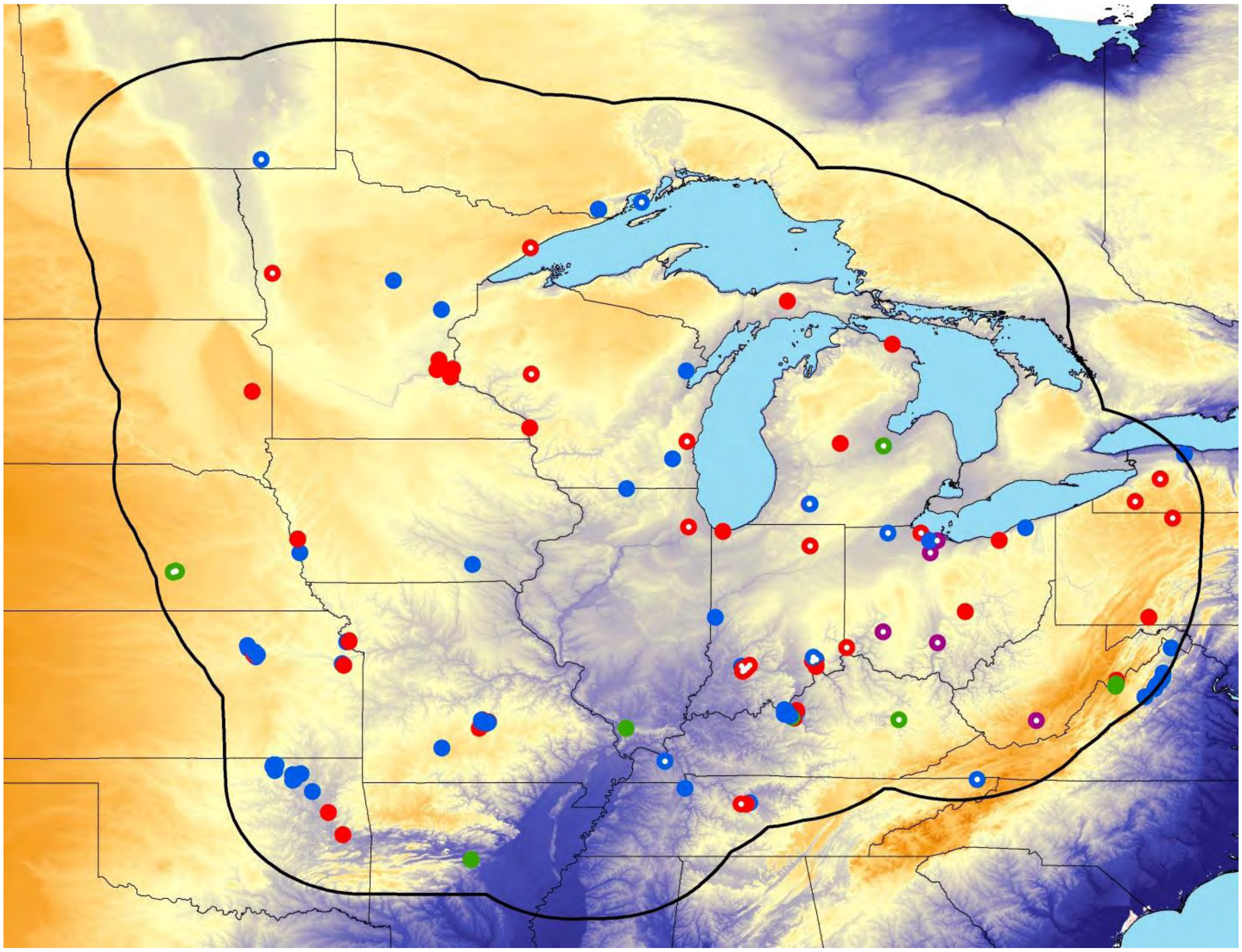

Figure 1. Map of the Midwestern states (plus 250km buffer) showing species richness (number of species ever captured) at MAPS stations, superimposed upon USGS topography (TOPO30). Species richness classes increase from gold (16-25), through blue (26-40), red (41-60), and purple (61-80). The latter two classes (>40 species) exceed the mode of species richness distribution. White centers denote stations that were active in 2011.

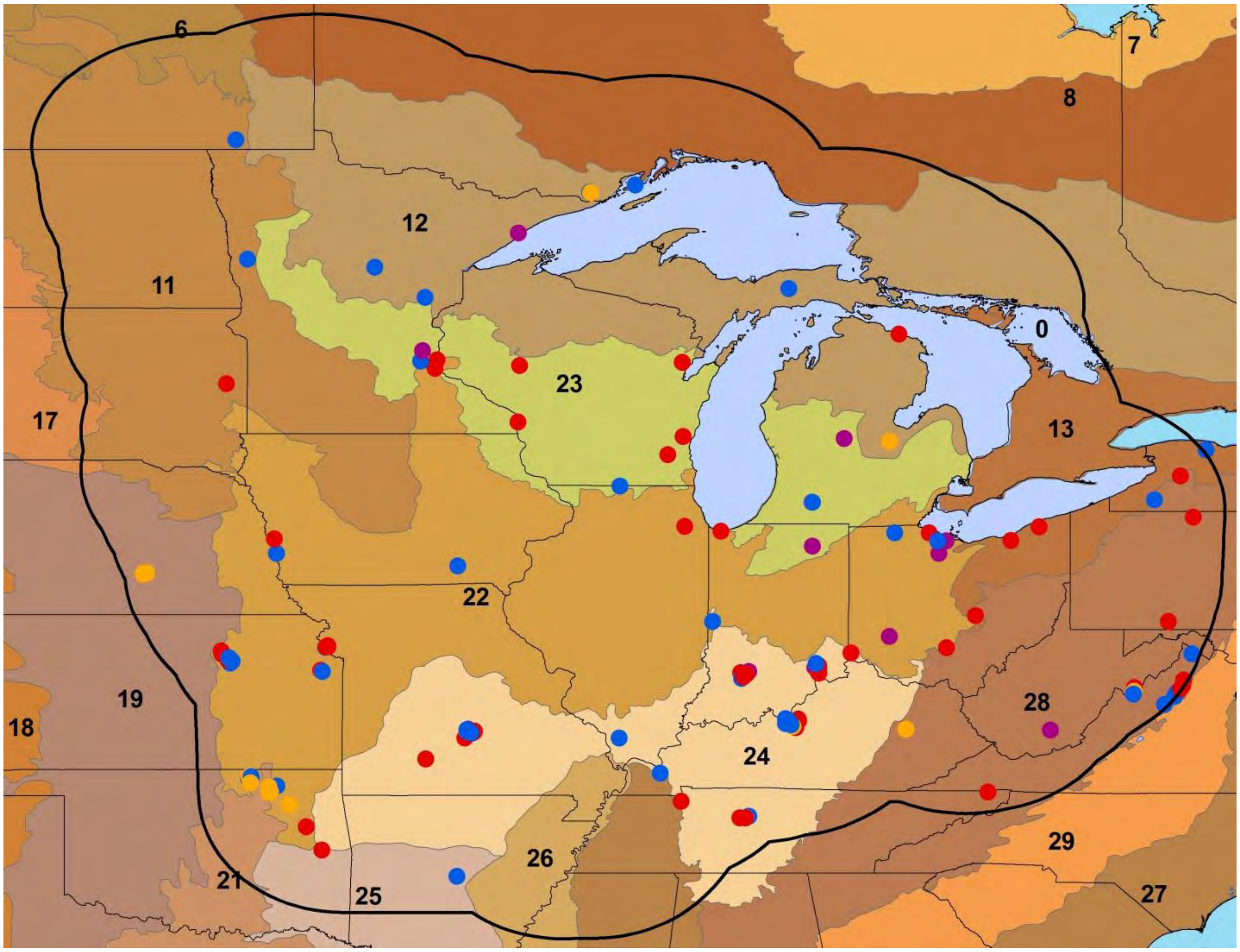

Figure 2. Map of the Midwestern states (plus 250km buffer) showing MAPS station-specific summer resident breeding species richness (excluding passage migrants) superimposed upon bird conservation regions as defined by the North American Bird Conservation Initiative (NABCI 2007). Species richness classes increase from gold (8-20), through blue (21-30), red (31-40), and purple (41-60). The latter two classes (>30 species; red and purple) exceed the mode of breeding species richness distribution.

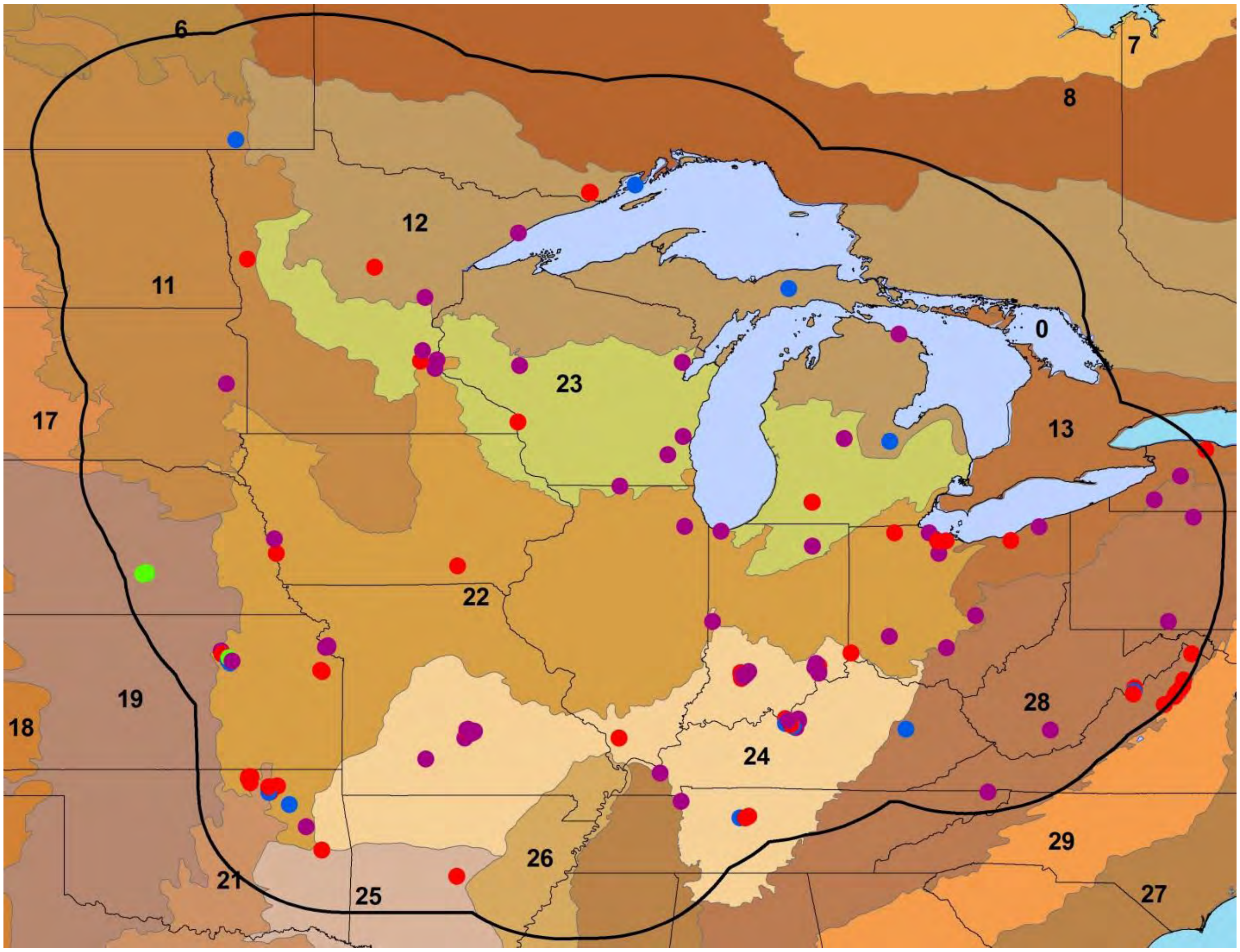

Figure 3. Map of the Midwestern states (plus 250km buffer) showing MAPS station-specific diversity, Shannon's Diversity Index (SDI) indices, for summer resident breeding species (excluding passage migrants) superimposed upon bird conservation regions (numbered) as defined by the North American Bird Conservation Initiative (NABCI 2007). Species diversity classes increase from green (1.73-2.00), through blue (2.01-2.50), red (2.51-2.80), and purple (2.81-3.50). The latter two classes (>2.51; red and purple) exceed the mode of the breeding species diversity distribution.

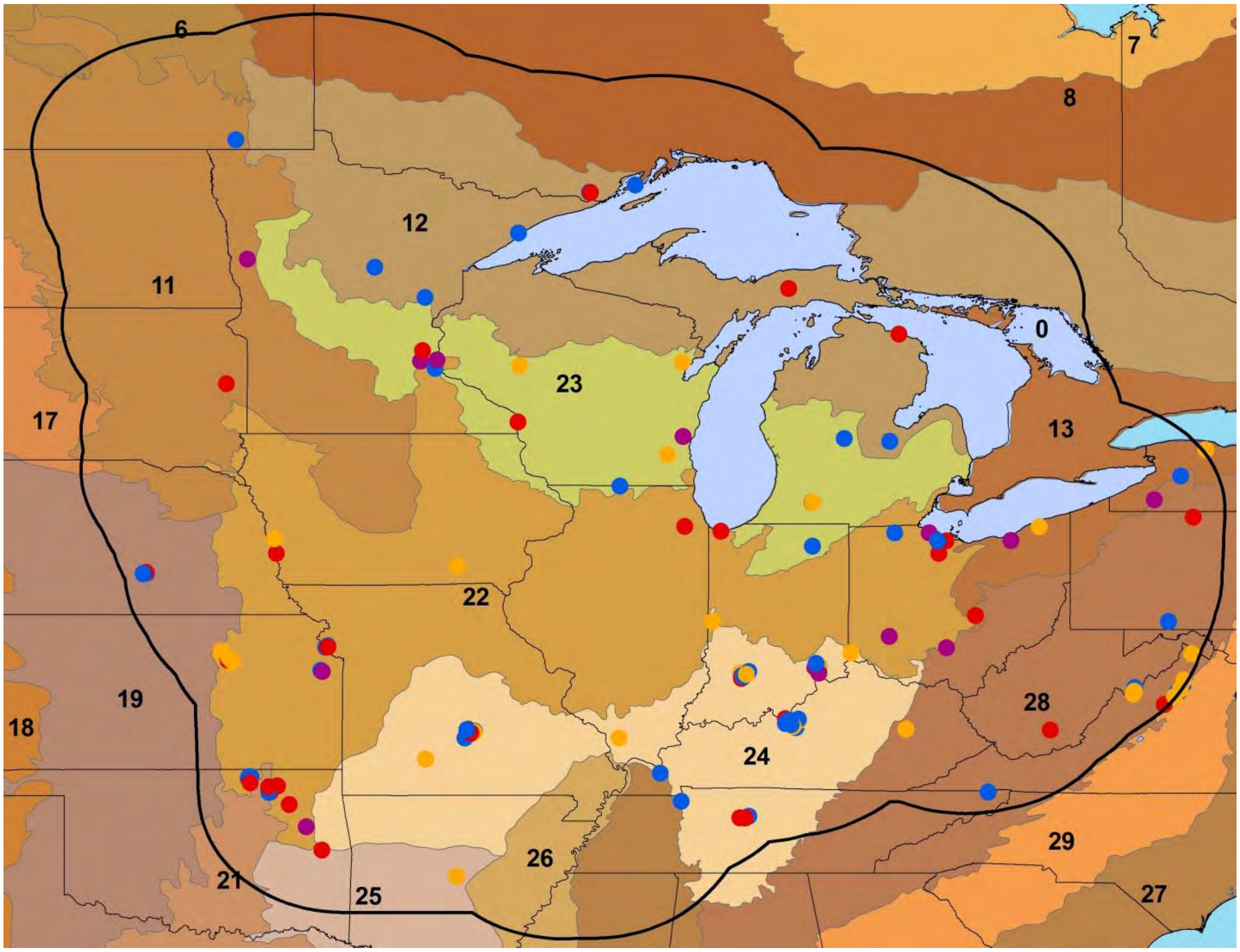

Figure 4. Map of the Midwestern states (plus 250km buffer) showing MAPS station-specific passage migrant species richness (excluding summer residents) superimposed upon bird conservation regions as defined by the North American Bird Conservation Initiative (NABCI 2007). Migrant species richness classes increase from gold (1-6), through blue (7-10), red (11-15), and purple (16-22). The latter two classes (>10 species; red and purple) exceed the mode of passage migrant species richness distribution.

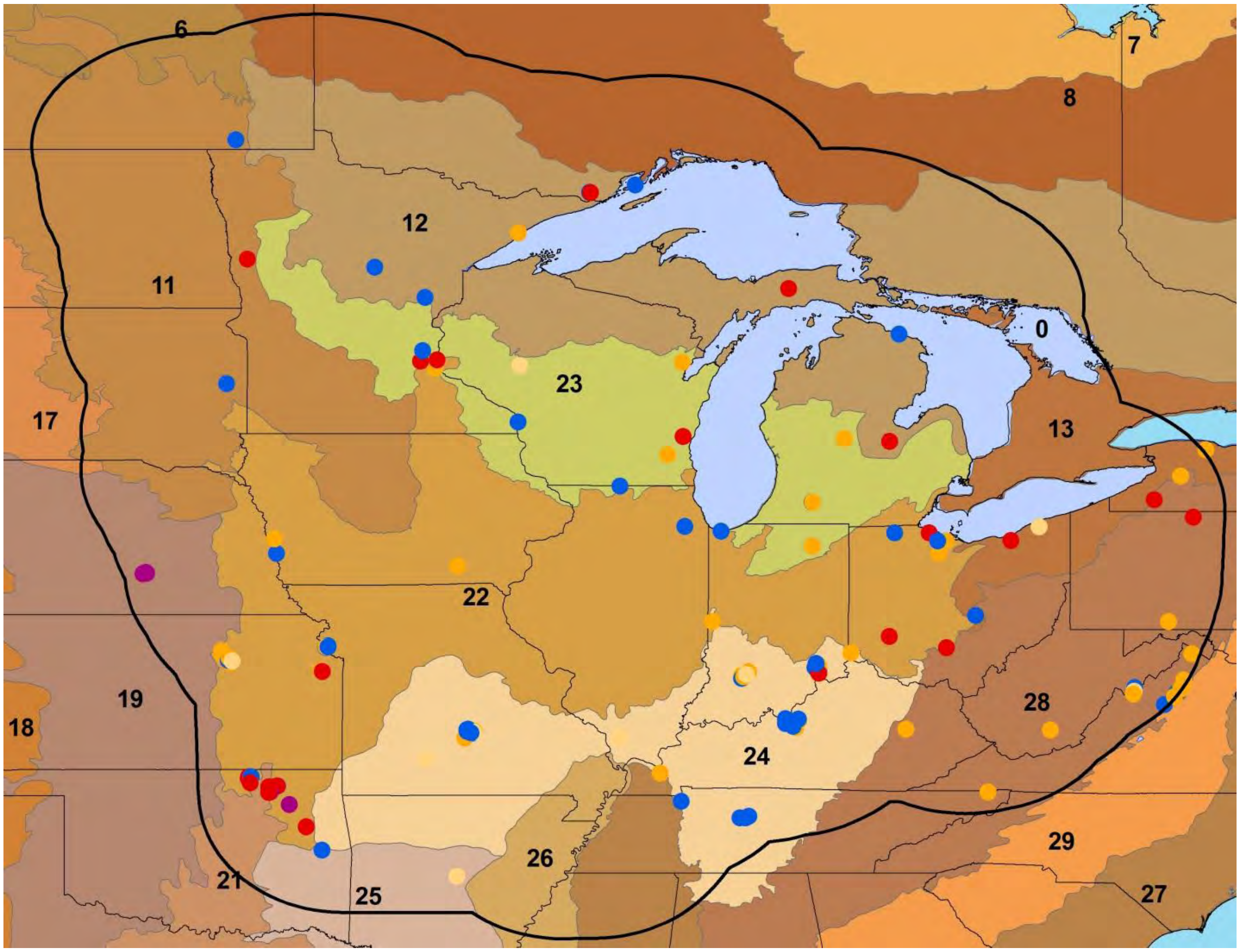

Figure 5. Map of the Midwestern states (plus 250km buffer) showing MAPS station-specific passage migrant index (percentage of total richness that are passage migrants) superimposed upon bird conservation regions as defined by the North American Bird Conservation Initiative (NABCI 2007). Migrant index classes increase from yellow (2-10%), through gold (11-20%), blue (21-30%), red (31-40%), and purple (41-60%). The latter two classes (>30%; red and purple) exceed the mode of passage migrant species richness distribution.

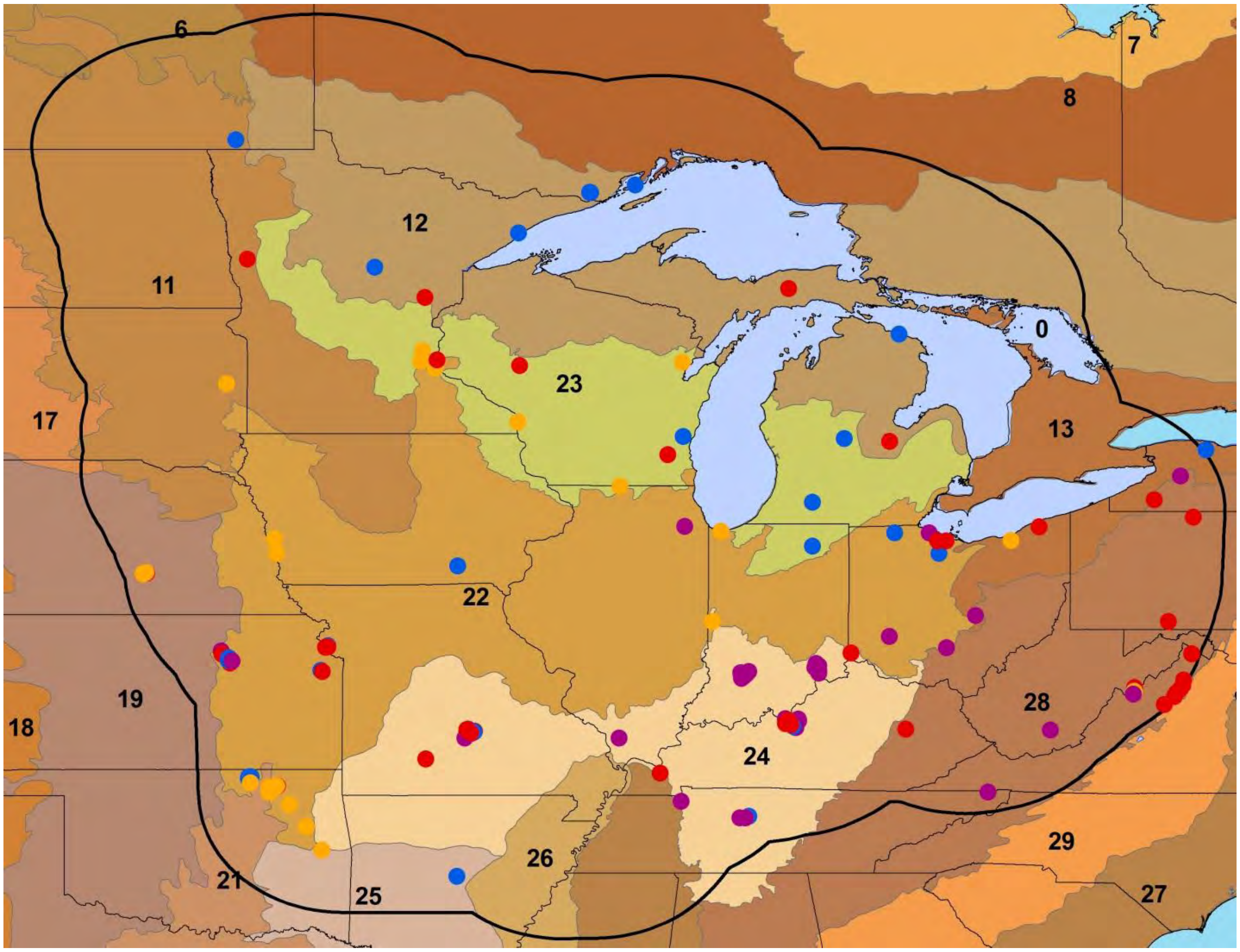

Figure 6. Map of the Midwestern states (plus 250km buffer) showing MAPS station-specific species richness for priority landbirds of continental concern (Rich et al. 2007) superimposed upon bird conservation regions as defined by the North American Bird Conservation Initiative (NABCI 2007). Priority species richness classes increase from gold (2-5), through blue (6-7), red (8-11), and purple (12-17). The latter two classes exceeded the mode of priority species richness distribution (captured >=8 priority species) indicating high priority stations, and stations colored blue may be included in medium priority class (captured 6 or 7 priority species).

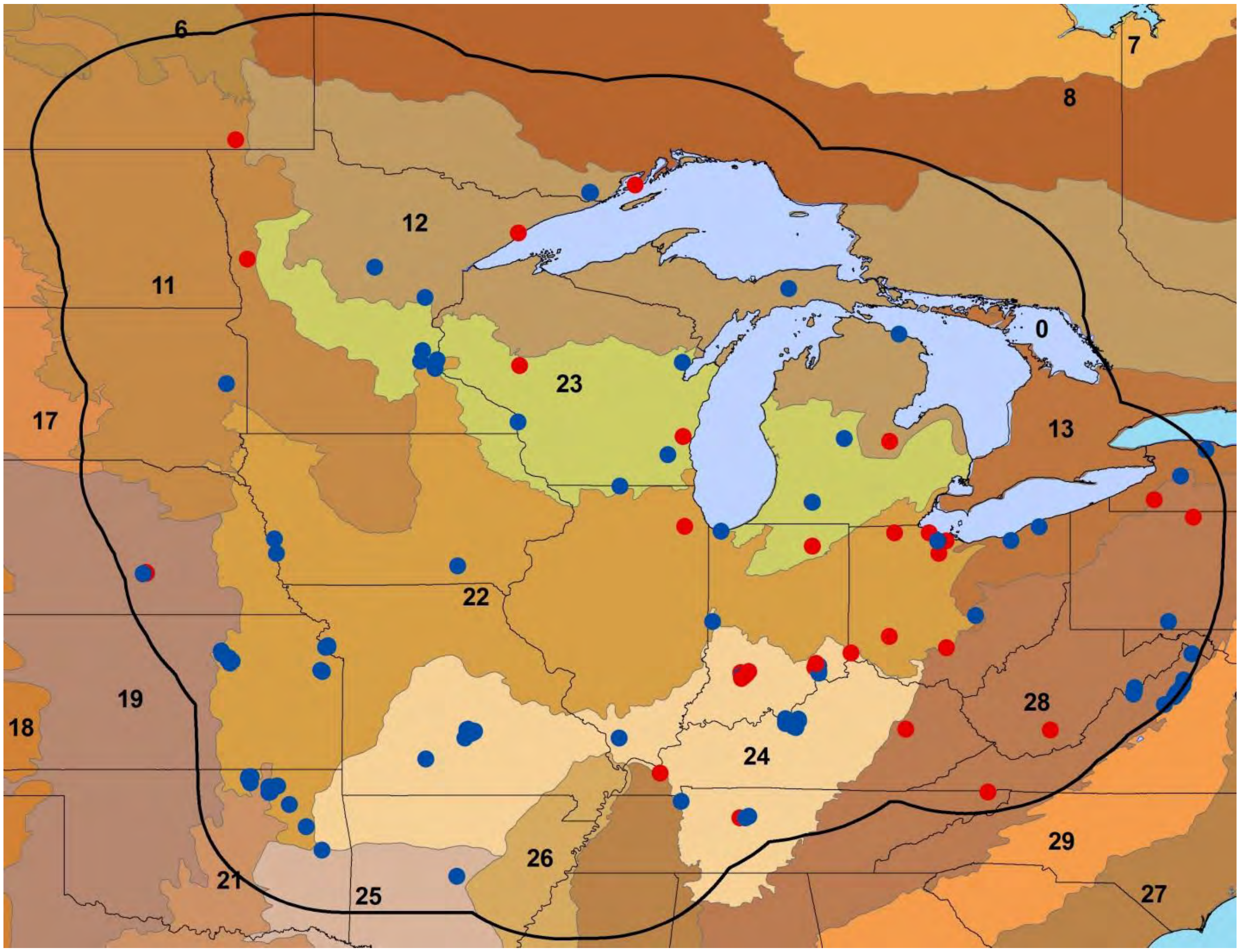

Figure 7. Map of the Midwestern states (plus 250km buffer) showing MAPS stations that were active in 2011 (red dots) or non-active (blue dots) superimposed upon bird conservation regions as defined by the North American Bird Conservation Initiative (NABCI 2007).

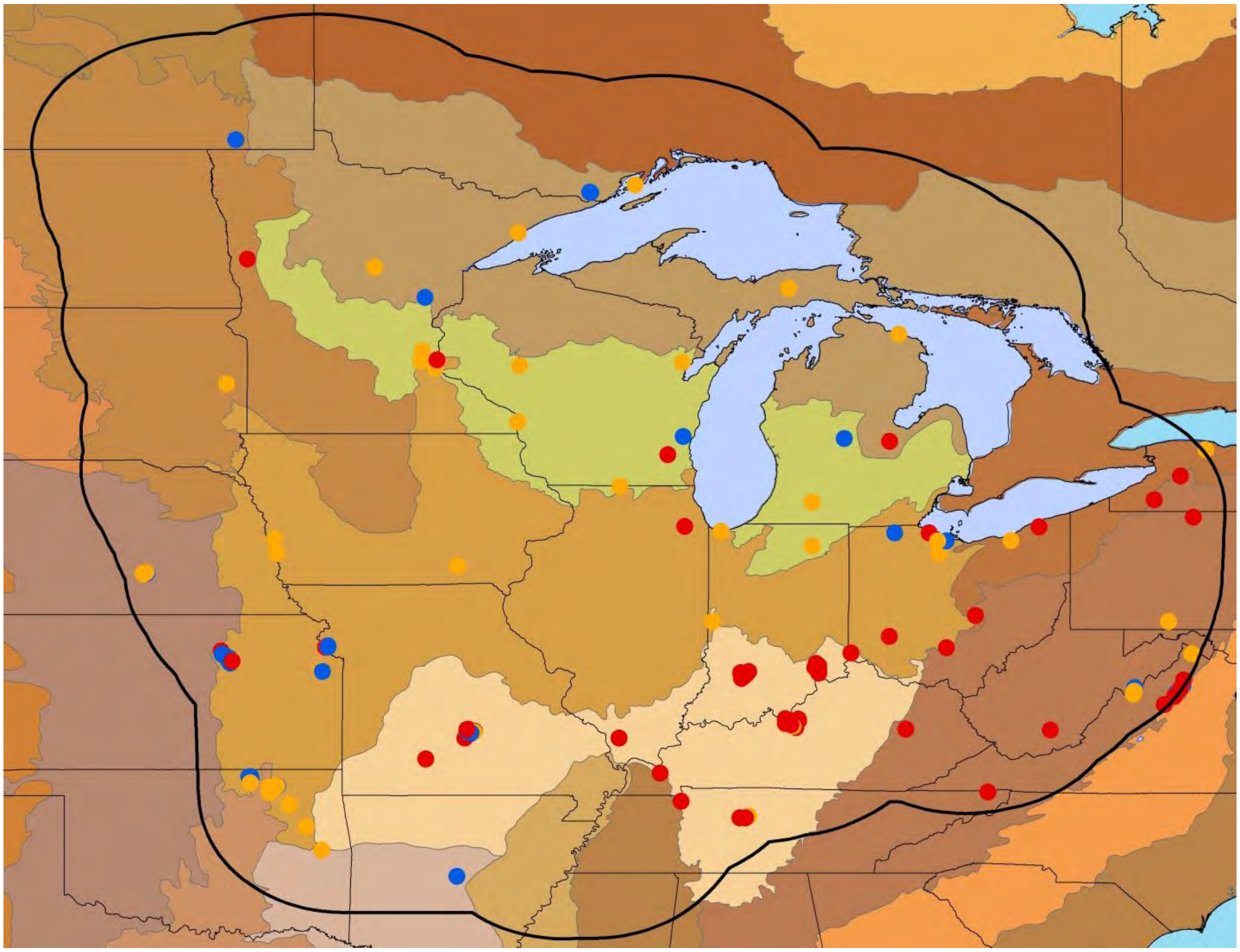

Figure 8. Map of the Midwestern states (plus 250km buffer) categorizing the potential of MAPS stations to monitor landbirds of continental concern superimposed upon bird conservation regions as defined by the North American Bird Conservation Initiative (NABCI 2007). Monitoring potential classes increase from gold (other), blue (medium potential), to red (high potential).

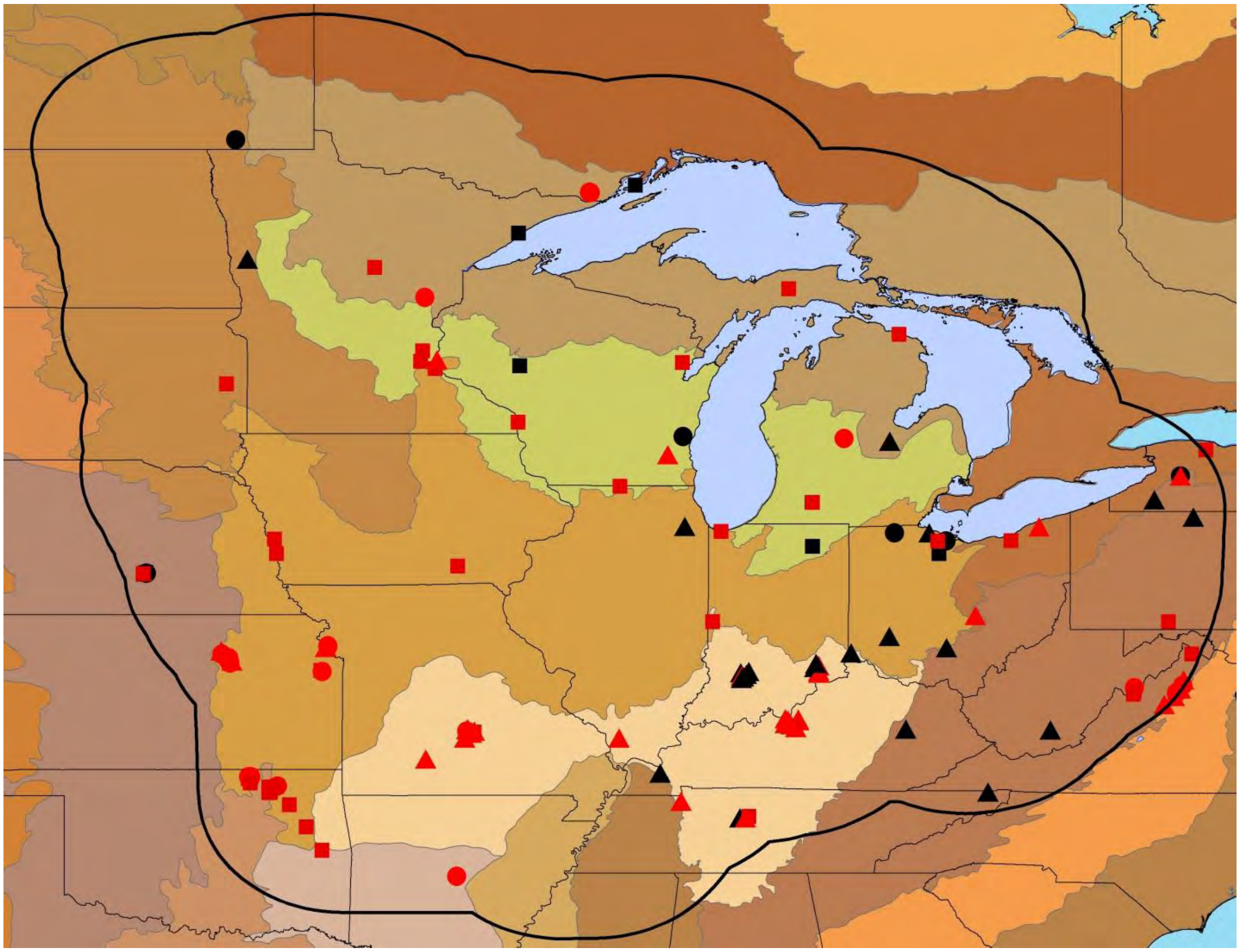

Figure 9. Map of the Midwestern states (plus 250km buffer) categorizing the potential of MAPS stations to monitor landbirds of continental concern (and recommended action) superimposed upon bird conservation regions as defined by the North American Bird Conservation Initiative (NABCI 2007). Priority classes increase from gold (other), blue (medium potential), through red (high potential). Monitoring potential classes are coded by symbol: high priority (triangle), medium priority (circles), and other (square). Active stations (in 2011) are colored black and inactive stations are colored red. Thus, stations appearing as red triangles or red circles should be reestablished because they previously monitored a high diversity of continental species of concern.

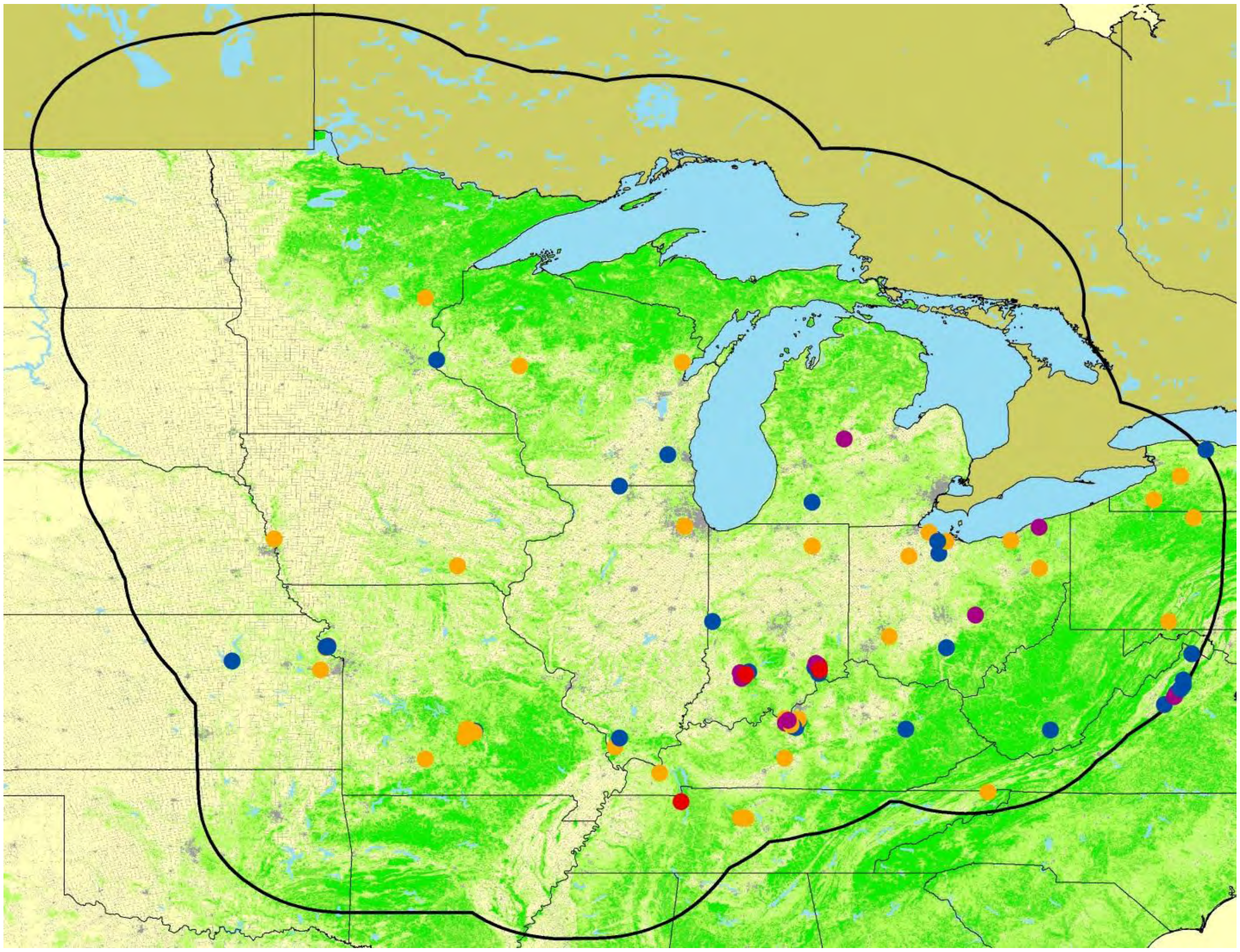

Figure 10. Map of the Midwestern states (plus 250km buffer) showing mean annual number of adult Wood Thrush captured at MAPS stations during the period 1992-2008 increasing from gold (0-2), blue (3-5), red (6-7), and purple (8-15). Stations are superimposed upon National Land Cover Dataset classes (3x aggregation; 90m resolution) depicting the forest canopy cover percentage (light green [10%] to darker green [~100%]), agriculture grassland (yellow) and impervious (including development and roads) cover (grey).

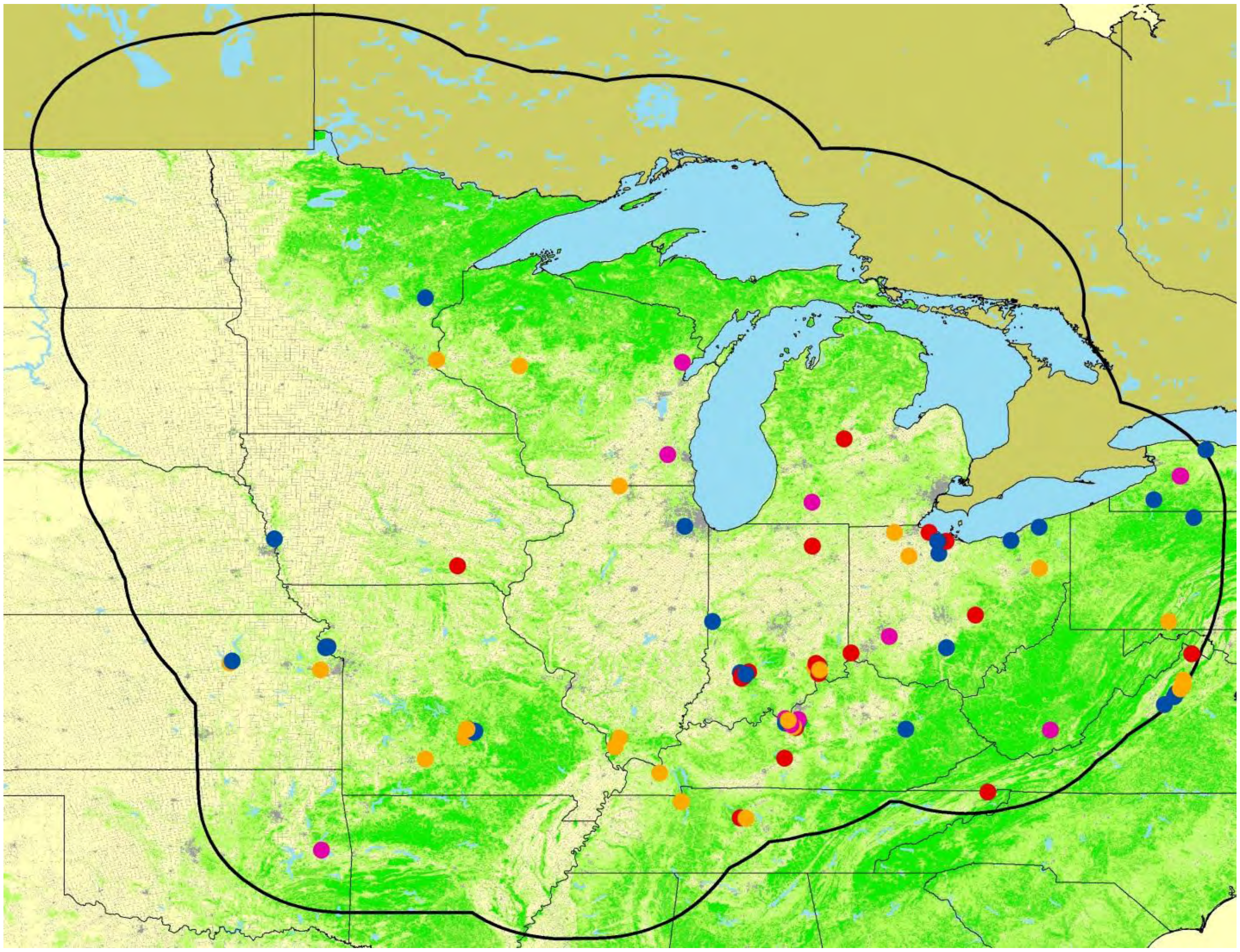

Figure 11. Map of the Midwestern states (plus 250km buffer) showing Wood Thrush productivity, expressed as the ratio of young to adults (STAPI) at MAPS stations during the period 1992-2008 increasing from gold (0-0.10), blue (0.11-0.25), red (0.26-0.40), and purple (0.41-0.60). Stations are superimposed upon National Land Cover Dataset (3x aggregation; 90m resolution) classes depicting the forest canopy cover percentage (light green [10%] to darker green [~100%]), agriculture grassland (yellow) and impervious (including development and roads) cover (grey).

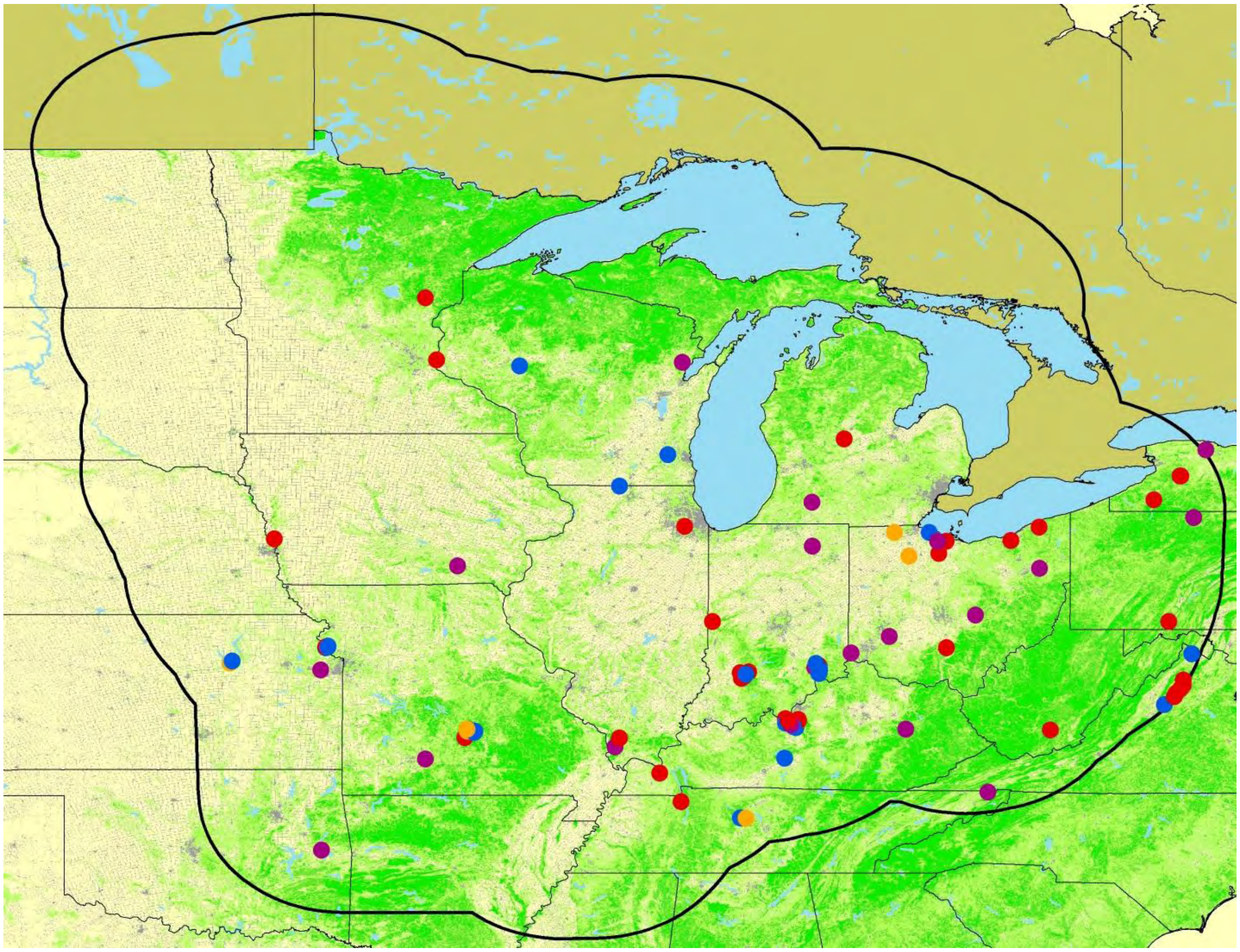

Figure 12. Map of the Midwestern states (plus 250km buffer) showing the proportion of Wood Thrush adults captured in breeding condition (ADPBR) at MAPS stations during the period 1992-2008 increasing from gold (0-0.50), through blue (0.51-0.75), red (0.76-0.90), and purple (0.91-1.00). Stations are superimposed upon National Land Cover Dataset (3x aggregation; 90m resolution) classes depicting the forest canopy cover percentage (light green [10%] to darker green [~100%]), agriculture and grassland (yellow) and impervious (including development and roads) cover (grey).

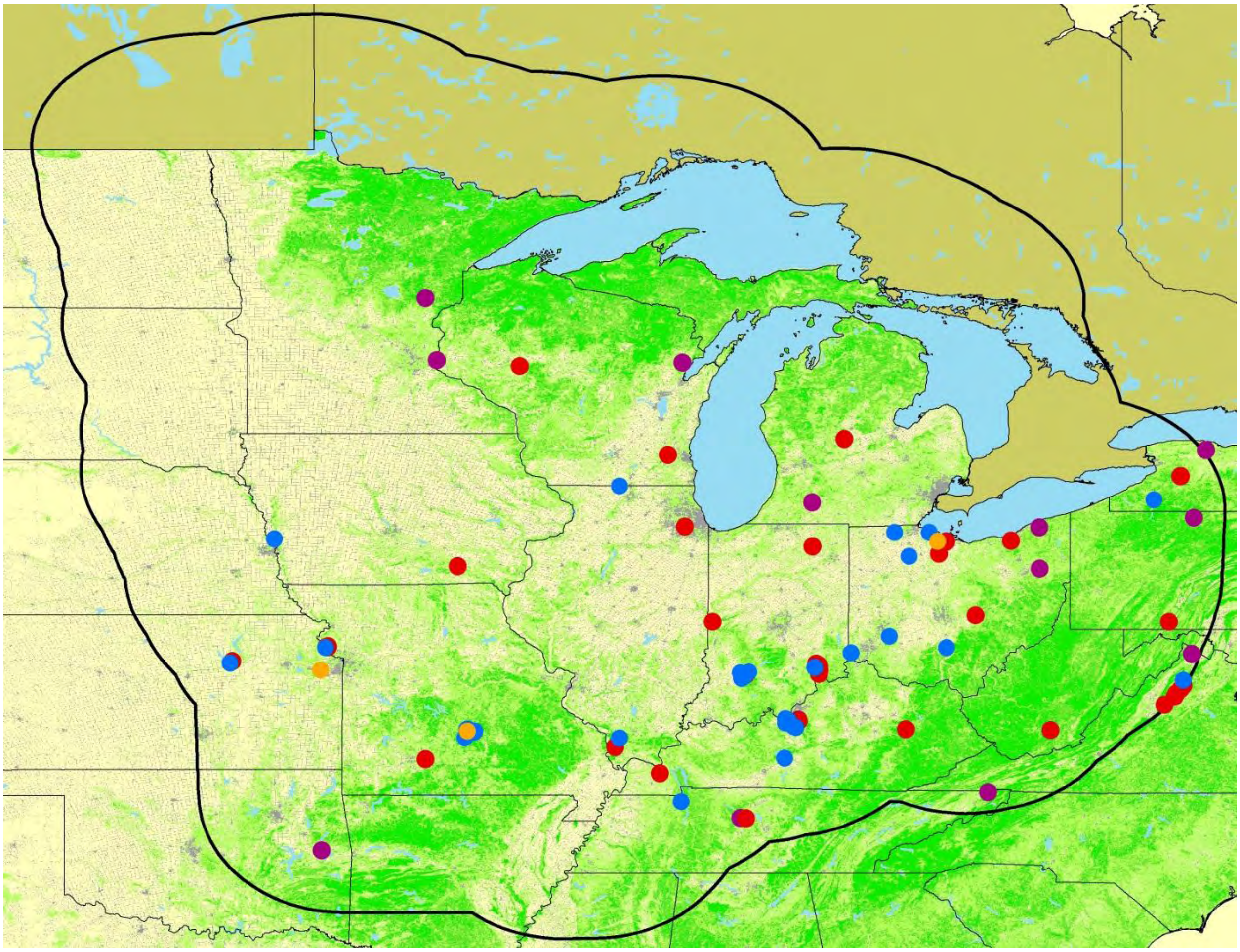

Figure 13. Map of the Midwestern states (plus 250km buffer) showing the mean wing chord length of Wood Thrush adults (ADWCL; mm) captured at MAPS stations during the period 1992-2008 increasing from gold (92.1-99.5), through blue (99.6-104.2), red (104.3-106.3), and purple (106.4-108.7). Stations are superimposed upon National Land Cover Dataset (3x aggregation; 90m resolution) classes depicting the forest canopy cover percentage (light green [10%] to darker green [~100%]), agriculture and grassland (yellow) and impervious (including development and roads) cover (grey).

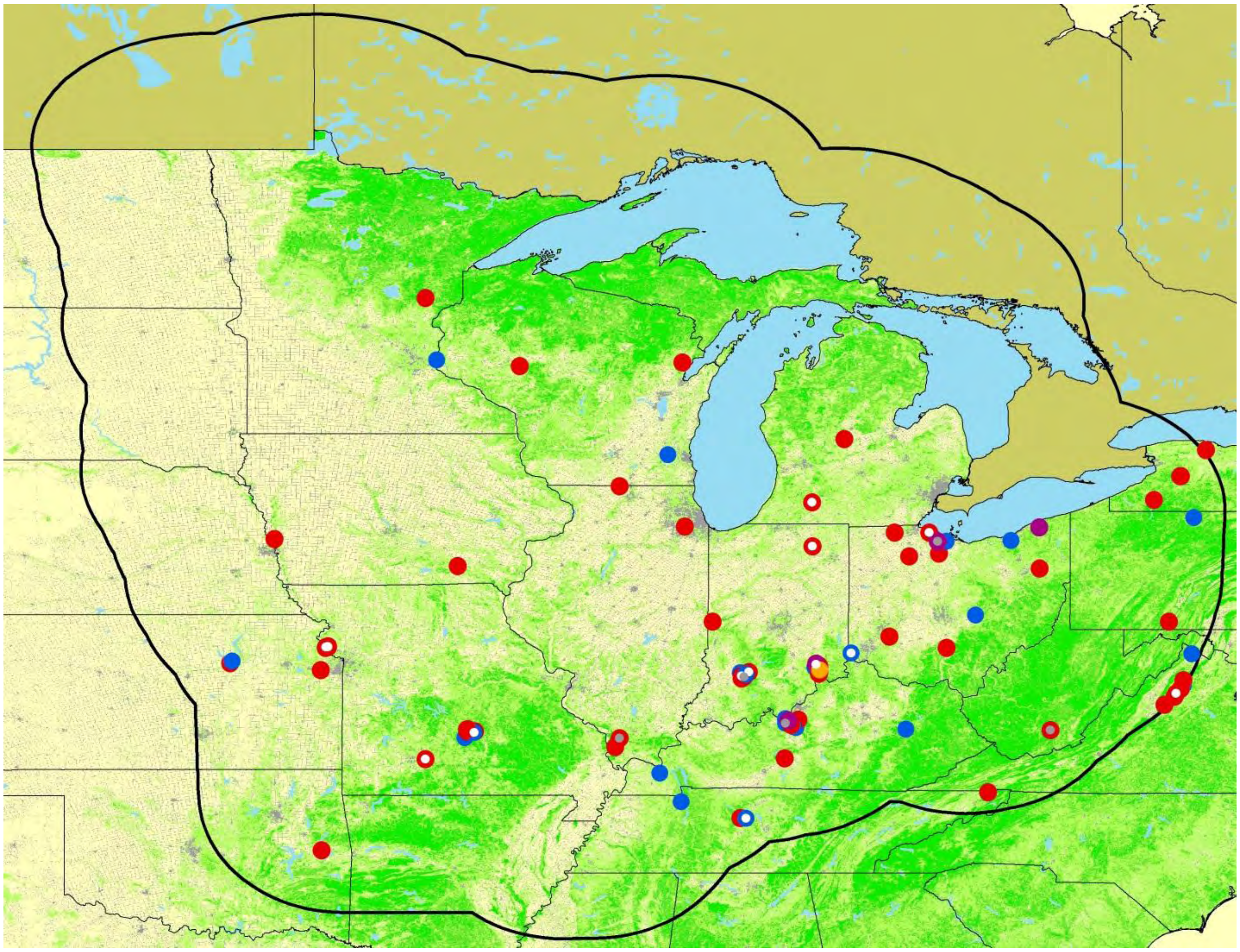

Figure 14. Map of the Midwestern states (plus 250km buffer) showing trends in annual adult Wood Thrush captures (ADSLP; birds/year) at MAPS stations during the period 1992-2008 increasing from gold and blue (negative), to positive trends red (0-1.00), and purple (1.01-3.00). Statistical significance of the trends (ADSPR) is denoted by white (P<0.05), and grey (P<0.01) center dots. Stations are superimposed upon National Land Cover Dataset (3x aggregation; 90m resolution) classes depicting the forest canopy cover percentage (light green [10%] to darker green [~100%]), agriculture and grassland (yellow) and impervious (including development and roads) cover (grey).

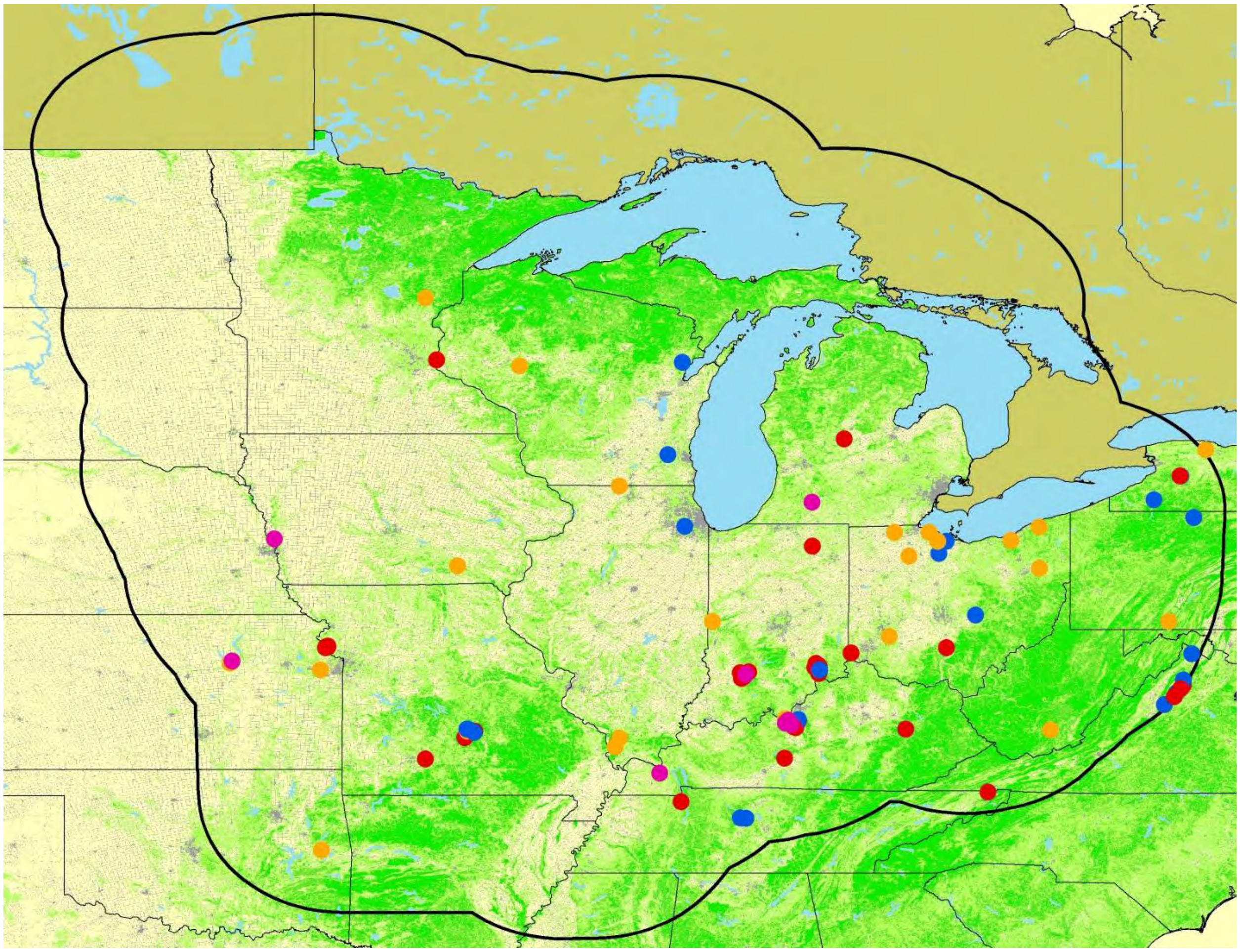

Figure 15. Map of the Midwestern states (plus 250km buffer) showing mean known age of adult Wood Thrush captures (ADAGE; years) at MAPS stations during the period 1992-2008 increasing from gold (1.00-1.14), blue (1.15-1.33), to positive trends red (1.34-1.63), and purple (1.64-2.00). Stations are superimposed upon National Land Cover Dataset (3x aggregation; 90m resolution) classes depicting the forest canopy cover percentage (light green [10%] to darker green [~100%]), agriculture and grassland (yellow) and impervious (including development and roads) cover (grey).

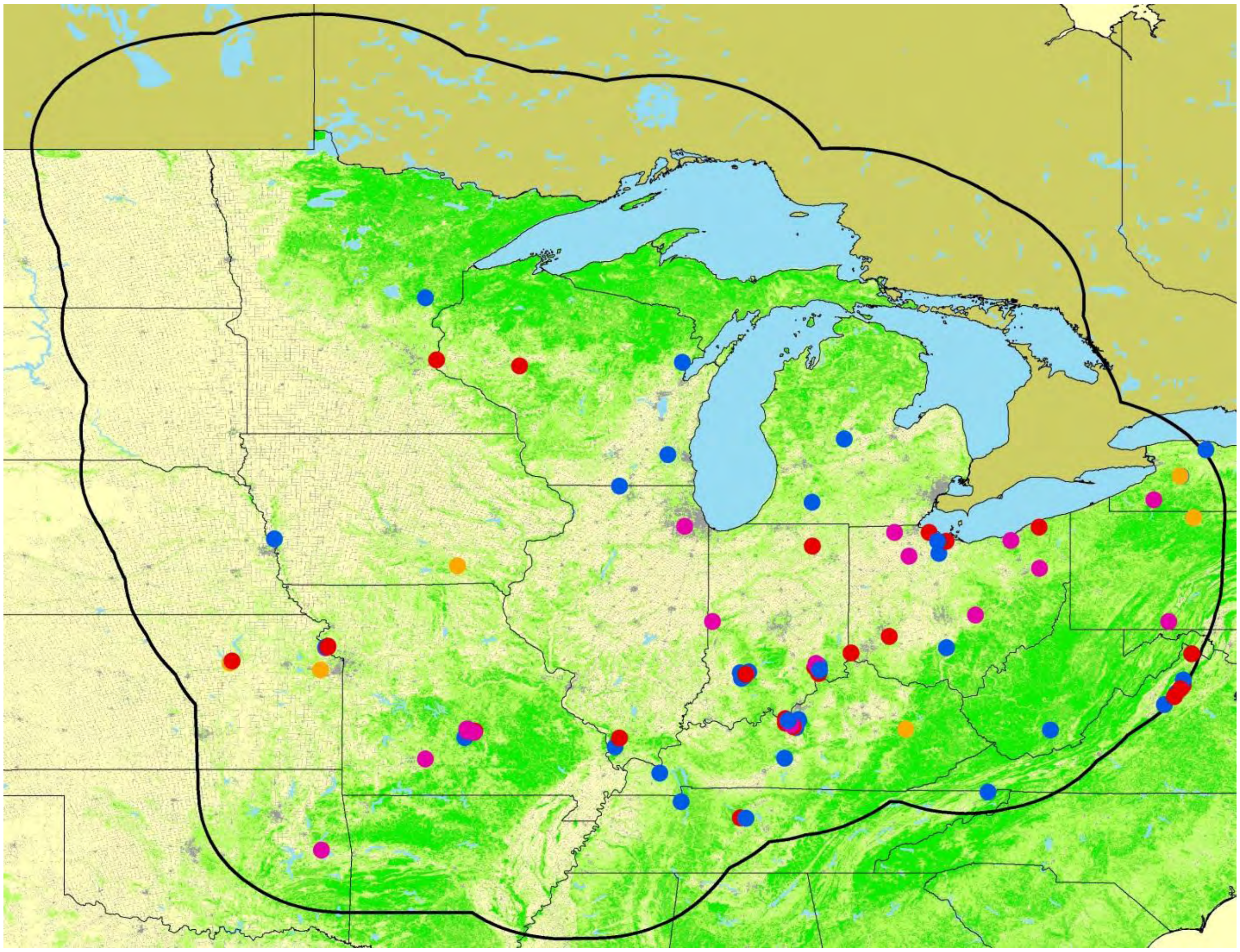

Figure 16. Map of the Midwestern states (plus 250km buffer) showing the mean day of capture of Wood Thrush adults (ADDOY; day-of-year) captured at MAPS stations during the period 1992-2008 advancing from the latest period colored gold (186-195; July 5-14), through earlier periods blue (176-185; June 25 – July 4), red (171-175; June 20-24), and purple (153-170; June 2-19). Stations are superimposed upon National Land Cover Dataset (3x aggregation; 90m resolution) classes depicting the forest canopy cover percentage (light green [10%] to darker green [~100%]), agriculture and grassland (yellow) and impervious (including development and roads) cover (grey).

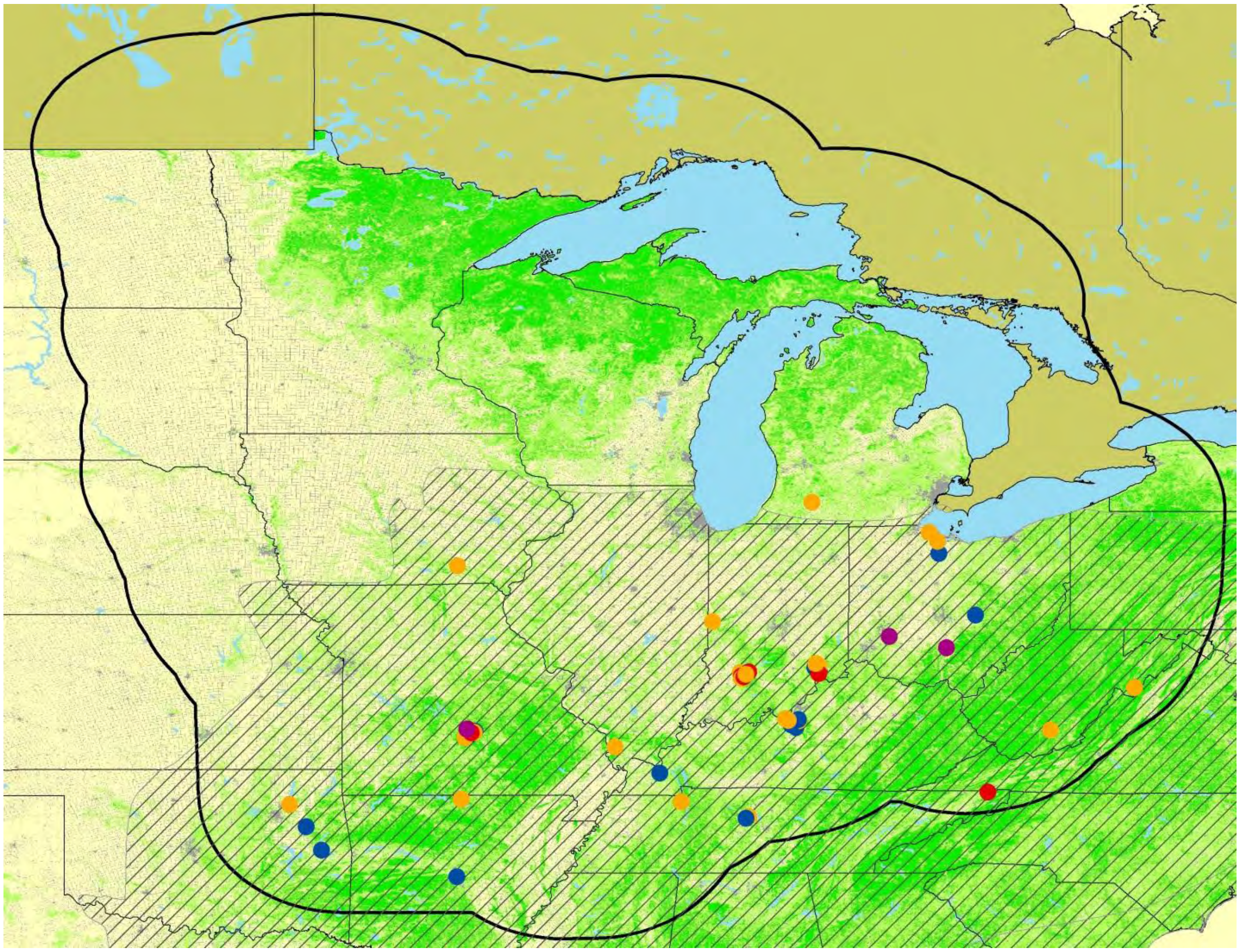

Figure 17. Map of the Midwestern states (plus 250km buffer) showing the mean number of White-eyed Vireo adults (ADULT) captured at MAPS stations during the period 1992-2008 increasing from gold (0.2-2.0), through blue (2.1-5.0), red (5.1-8.0), and purple (8.1-12.0). The hatched area represents the extent of the breeding range (Ridgely et al. 2003). Stations are superimposed upon National Land Cover Dataset (3x aggregation; 90m resolution) classes depicting the forest canopy cover percentage (light green [10%] to darker green [~100%]), agriculture and grassland (yellow) and impervious (including development and roads) cover (grey).

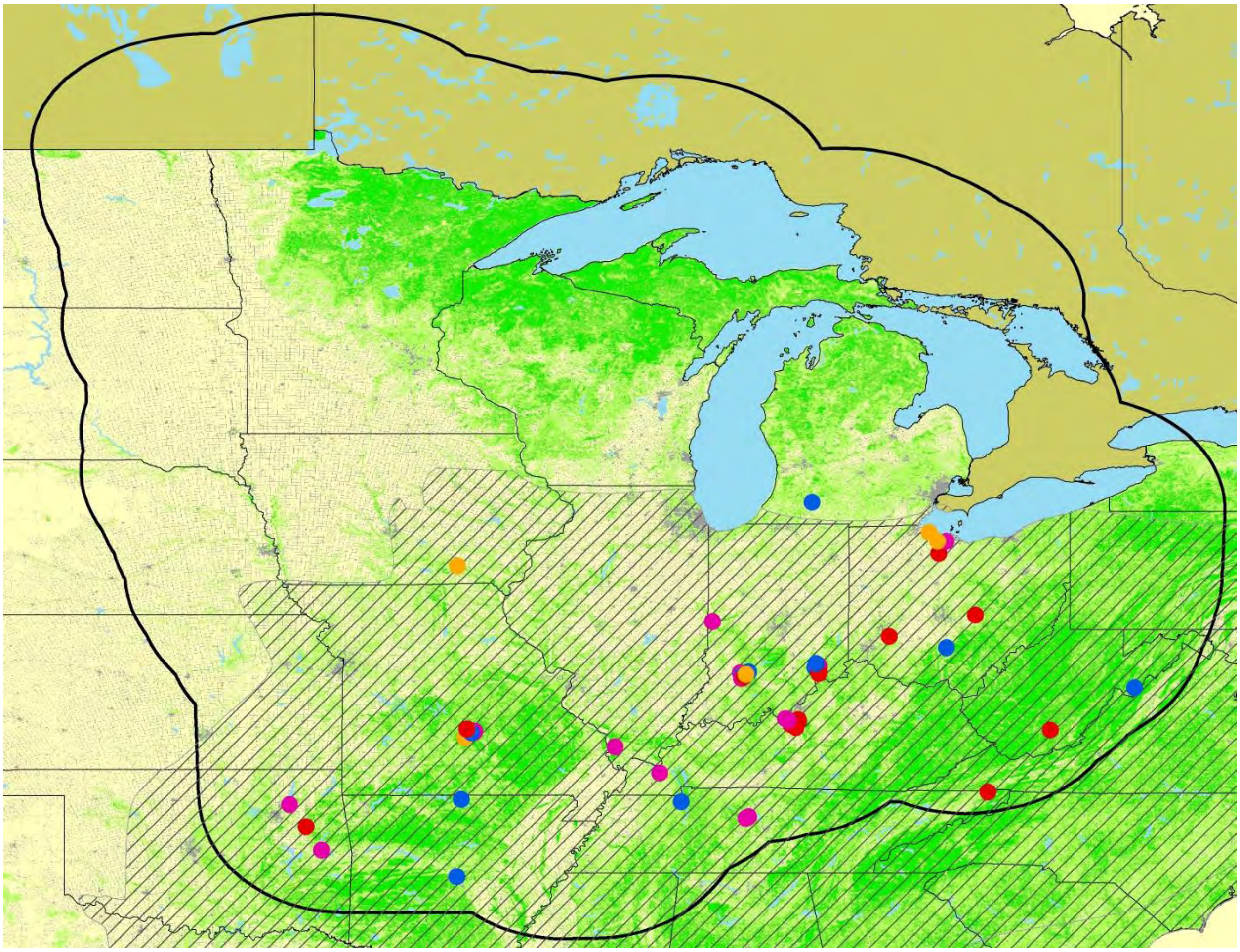

Figure 18. Map of the Midwestern states (plus 250km buffer) showing the mean day of capture of White-eyed Vireo adults (ADDOY; day-of-year) captured at MAPS stations during the period 1992-2008 advancing from the latest period colored gold (186-200; June 30 - July 19), through earlier periods blue (176-180; June 25–29), red (171-175; June 20-24), and purple (153-170; June 2-19). The hatched area represents the extent of the breeding range (Ridgely et al. 2003). Stations are superimposed upon National Land Cover Dataset (3x aggregation; 90m resolution) classes depicting the forest canopy cover percentage (light green [10%] to darker green [~100%]), agriculture and grassland (yellow) and impervious (including development and roads) cover (grey).

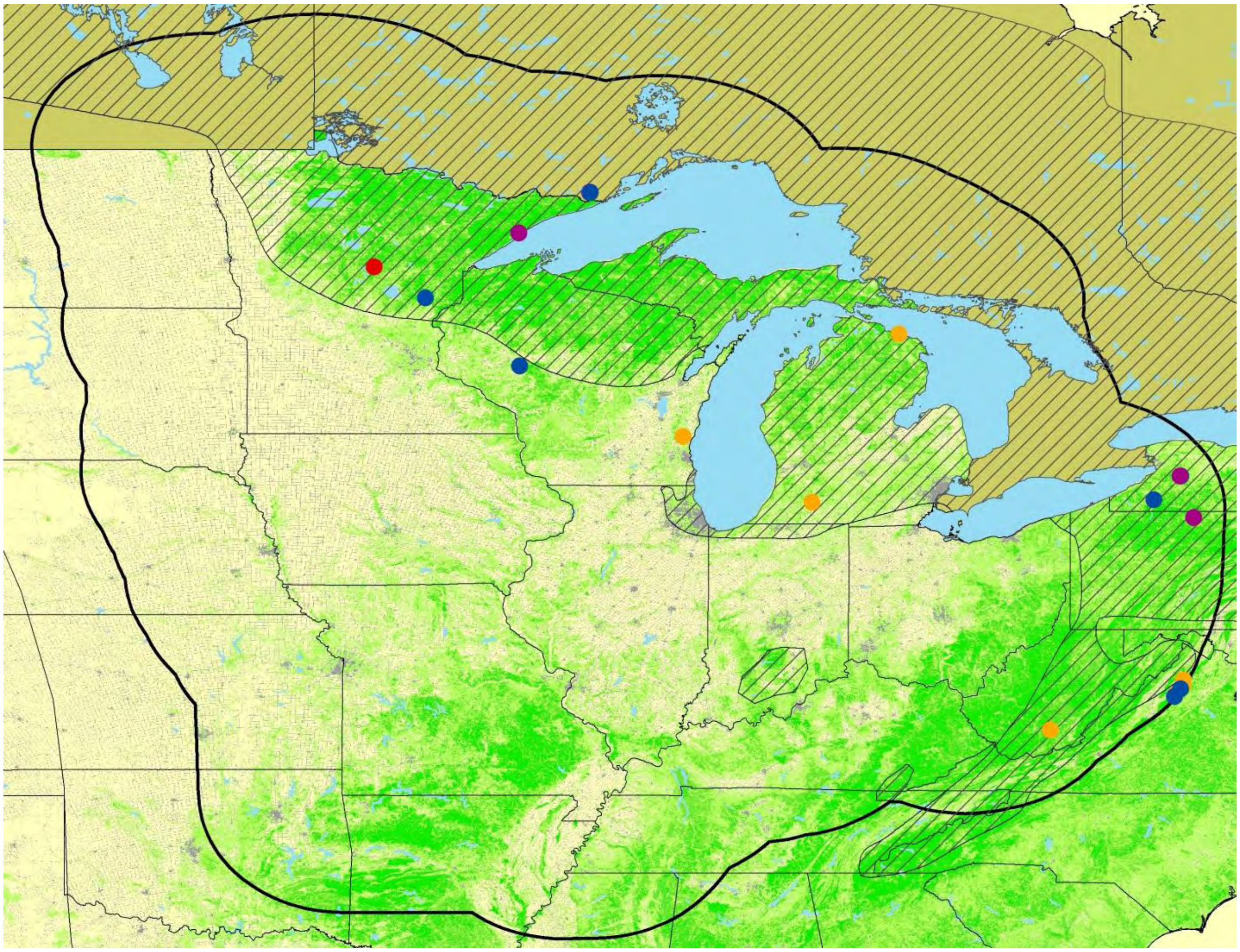

Figure 19. Map of the Midwestern states (plus 250km buffer) showing the mean number of Chestnut-sided Warbler adults (ADULT) captured at MAPS stations during the period 1992-2008 increasing from gold (0.2-2.0), through blue (2.1-5.0), red (5.1-8.0), and purple (8.1-17.0). The hatched area represents the extent of the breeding range (Ridgely et al. 2003). Stations are superimposed upon National Land Cover Dataset (3x aggregation; 90m resolution) classes depicting the forest canopy cover percentage (light green [10%] to darker green [~100%]), agriculture and grassland (yellow) and impervious (including development and roads) cover (grey).

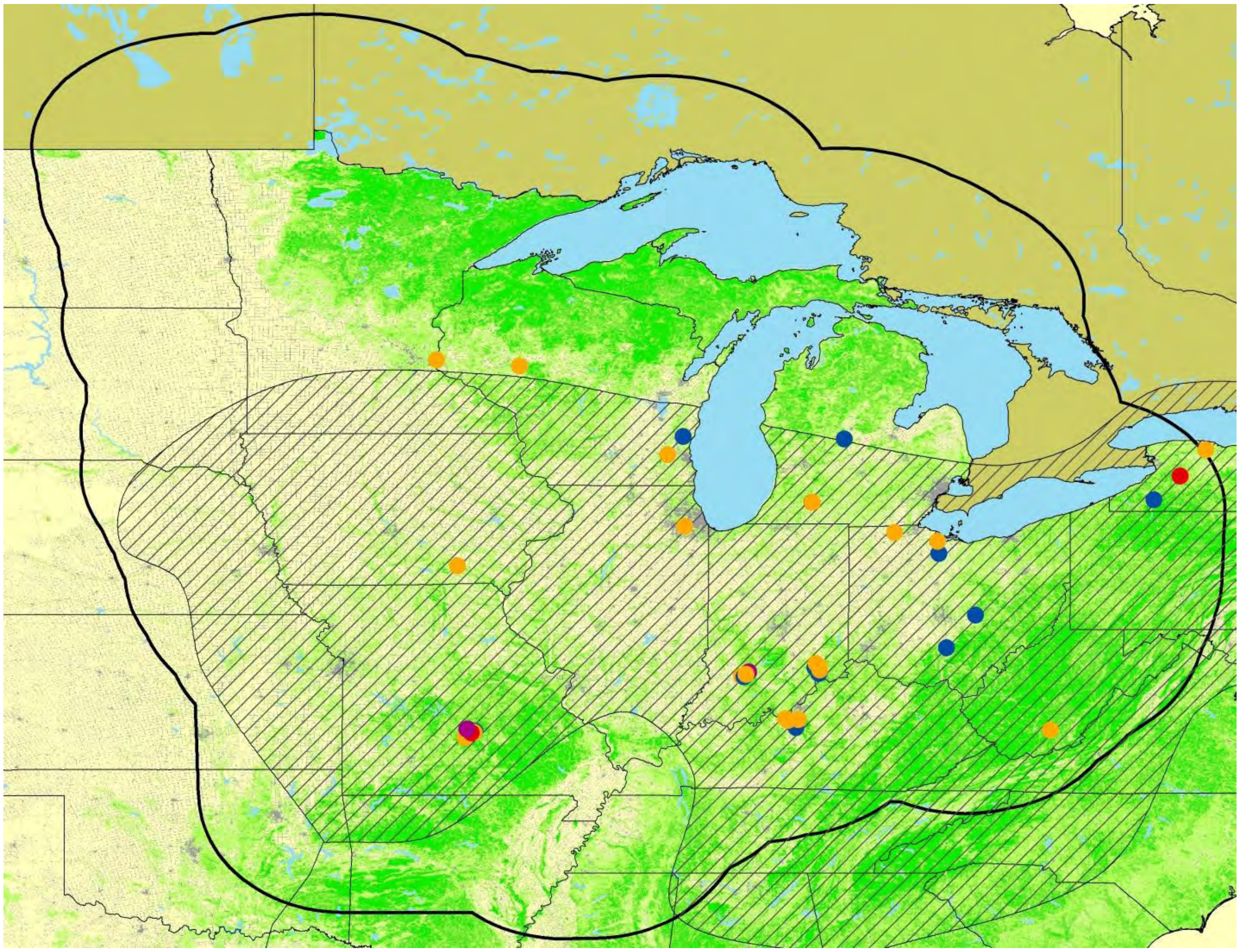

Figure 20. Map of the Midwestern states (plus 250km buffer) showing the mean number of Blue-winged Warbler adults (ADULT) captured at MAPS stations during the period 1992-2008 increasing from gold (0.1-2.0), through blue (2.1-5.0), red (5.1-7.2), and purple (7.3-17.0). The hatched area represents the extent of the breeding range (Ridgely et al. 2003). Stations are superimposed upon National Land Cover Dataset (3x aggregation; 90m resolution) classes depicting the forest canopy cover percentage (light green [10%] to darker green [~100%]), agriculture and grassland (yellow) and impervious (including development and roads) cover (grey).