Improving Wisconsin's Wetland Compensatory Mitigation Program: Factors Influencing Floristic Quality and Methods for Monitoring Wildlife

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Prepared by: Wisconsin Department of Natural Resources
Bureau of Watershed Management
101 S. Webster St., Madison, WI 53707

Report Author: Julia C. Wilcox

Project Team: Julia Wilcox, Thomas Bernthal, Patricia Trochlell and Joanne Kline

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Executive Summary

We evaluated the project location and design of twenty wetland restoration projects within southern Wisconsin and collected vegetation data to analyze trends in the floristic quality of the wetland plant communities. The two most common types of wetland plant communities found within the projects were fresh wet meadow and shallow marsh, while the two most abundant plant species found were reed canary grass (*Phalaris arundinacea*) and narrow-leaved cattail (*Typha angustifolia*). The floristic quality index and mean co-efficient of conservatism of the restored communities ranged from low to moderate compared to other, natural wetland communities in southern Wisconsin. Sites where some maintenance had been performed had greater cover of native species, and sites with more species planted within them had more native species. Variability of floristic quality among projects may also be explained by site differences that we could not quantify with the available information. We recommend the project leaders of wetland restoration sites maintain more detailed records on the goals, design, and maintenance work completed at their project sites.

We also ran a pilot study to explore which methods could be used to monitor avian and amphibian populations found at wetland restoration sites. We used different avian monitoring methods at five restoration projects and amphibian monitoring methods at six restoration projects. For avian monitoring, we recommend using a modified version of the methods of the marsh bird monitoring program, where the numbers of specific target species are recorded during several listening and call-back periods held during the breeding season. We recommend using a combination of a frog- and toad- calling survey and a funnel-trapping survey for monitoring amphibians. Project leaders should develop goals and performance standards for restoring wildlife habitat that are flexible and focus on the habitat needs of species that are conservation targets.

Finally, we provided a brief outline of the steps we suggest restoration project leaders take as they plan their projects. Using the watershed approach to help set restoration goals will be easier for project leaders once detailed watershed plans that address wetland resources become available. However, information in Wisconsin is currently available that can help project leaders use a watershed approach to plan wetland restorations.

Introduction

Compensatory mitigation involves wetland restoration, enhancement or creation to compensate for permitted wetland losses. Mitigation projects can be completed either by the permit applicant or by bank sponsors who complete projects and sell credits to developers. Wisconsin's state mitigation program began in 2002, when the Wisconsin Department of Natural Resources (WDNR) developed administrative rules to implement 1999 WI Act 147. The Army Corps of Engineers (ACOE) also has a mitigation program that had been implemented for several decades prior to the creation of the state program in Wisconsin. Recently, most wetland impacts in Wisconsin have occurred due to transportation and utility projects (WDNR 2006; WDNR 2007). The ACOE has required wetland mitigation for most of these projects, especially wetland impacts made by the Wisconsin Department of Transportation (WisDOT). In contrast, state permits have rarely required wetland compensatory mitigation. By the end of 2006, only 55 projects involving wetland fill were approved with compensatory mitigation by the WDNR.

Wetland compensatory mitigation has received persistent criticism for failing to compensate lost wetland acreage and functions (Zedler and Callaway 1999, Morgan and Roberts 2003, Brooks et al. 2005). In particular, the 2001 report of the National Research Council entitled *Compensating for Wetland Losses under the Clean Water Act* outlined ecological and administrative missteps made by other states and the federal government in developing and implementing their mitigation programs. Frequently, wetland mitigation projects are not completed, or records are not maintained on their progress (NRC 2001). The report also recommended that the ACOE and states implement research programs to evaluate the long-term performance of mitigation projects and that a watershed approach be used in determining potential mitigation sites (NRC 2001).

The recommendations made in the 2001 NRC mitigation report influenced the new federal rules on wetland compensatory mitigation published by the ACOE and the U. S. Environmental Protection Agency (EPA; 73 FR 19593). The new rules established minimum monitoring periods and information that must be included in mitigation monitoring reports. These rules also provide a definition of the watershed approach:

> Watershed approach means an analytical process for making compensatory mitigation decisions that support the sustainability or improvement of aquatic resources in a watershed. It involves consideration of watershed needs, and how locations and types of compensatory mitigation projects address those needs. A landscape perspective is used to identify the types and locations of compensatory mitigation projects that will benefit the watershed and offset losses of aquatic resource functions and services caused by activities authorized by DA permits. The watershed approach may involve consideration of landscape scale, historic and potential aquatic resource conditions, past and projected aquatic resource impacts in the watershed, and terrestrial connections between aquatic resources when determining compensatory mitigation requirements for DA permits. (19690)

Recently, a team from the WDNR completed an informal review of WisDOT's mitigation program and made recommendations for improvement (Kline et al. 2008). Key recommendations include improving the database system to track site progress, developing appropriate site performance standards, increasing site management, and ensuring that lost wetland community types are restored. In addition, the report recommended that WisDOT evaluate the wildlife habitat created by mitigation projects, rather than only monitor floristic diversity and hydrology.

Our study had three goals: first, to review recently completed wetland restoration projects and learn how site location and restoration practices can influence floristic quality; second, to evaluate wildlife monitoring methods for possible use in wetland compensatory mitigation monitoring plans; and third, to propose ways to use a watershed approach to better define appropriate restoration goals for a site.

Part 1: Review of Wetland Restoration Sites

Background

In the first part of our study, we evaluated how site selection decisions and restoration practices influence the resulting wetland community. We chose restoration projects that were project-specific mitigation sites and mitigation banks approved by WDNR, as well as WisDOT mitigation projects. We also studied restoration sites that were not associated with compensatory mitigation but were voluntary restoration projects completed by the Wisconsin Waterfowl Association (WWA) and Natural Resources Conservation Service's Wetland Reserve Program (WRP). These projects had design elements that were similar to state-approved mitigation projects.

The 2007 report of Wisconsin's wetland gains and losses shows that most wetland restoration work is not completed as part of a mitigation requirement (WDNR 2008). Approximately 590 hectares of wetland were restored voluntarily in Wisconsin through partnerships among federal, state and local conservation organizations in 2007 (WDNR 2008). Voluntary wetland restoration projects often strive to achieve goals that are similar to mitigation restoration projects, such as improving local water quality and restoring diverse plant communities and quality wildlife habitat. Wetland restoration projects within the same region can be expected to experience similar challenges to reestablishing native biodiversity. Thus, lessons learned from a voluntary restoration project can be applied to a mitigation restoration project and vice versa.

We evaluated the plant communities of restored wetlands and measured their floristic quality. A recent review of a selection of WisDOT mitigation sites across the state found that sedge meadow, wet prairie, shrub-carr, hardwood swamp and floodplain forest were rarely restored, and that invasive plant species such as reed canary grass and hybrid cattails are common in restored wetlands (Kline et al 2008). We anticipated that restored wetland vegetation would be low in diversity and that invasive species would be abundant.

Another goal was to determine if the floristic quality of the plant community correlated with the size of the community, the number of species planted within the restoration site, the land use surrounding the restoration site or the size of the catchment. We predicted that larger communities and sites with many species planted would have greater floristic quality. We expected that disturbance near sites and large catchments would decrease floristic quality. We further expected that the presence or absence of various restoration practices, such as conducting follow-up maintenance work, would influence floristic quality.

Methods

We used the following criteria to select restoration sites for inclusion in the study:

- Located in the glaciated areas of WDNR's Southeast Region or South Central Region
- A wetland restoration project was completed between 1995 and 2005
- Information was available on what restoration activities took place
- The landowner was willing to participate in the study

Sites were selected among private mitigation sites, WisDOT mitigation sites, WRP sites and WWA assisted restorations. We selected a total of 20 wetland restoration projects. Ten of these projects were split into two separate study sites, because they were not spatially continuous or were not restored using the same methods. Additionally, some communities present at a study site were excluded from the study due to difficulty accessing them on foot for vegetation surveys. We included a total of 30 sites in the study. Figure 1 shows the locations of the 20 restoration projects, and Table 1 provides information on the 30 study sites. Aerial photographs of each study site can be found in Appendix A.

We determined when site construction was completed, what earthwork was completed to restore hydrology, which (if any) plant species were introduced, and what maintenance was done from various sources. For private mitigation sites, we used information from the mitigation plan, as-built report and the subsequent monitoring reports. Monitoring reports were also available for the WisDOT mitigation sites, but the original mitigation plans and as-built reports were generally not available. Site plans and various maps were available for the WRP restorations, but monitoring data and information on the restoration goals was limited. We obtained verbal information on the WWA restoration project from the project leader.

We estimated the area of the catchment that drains into each study site using ESRI's Arc Hydro Tool and a Digital Elevation Model of Wisconsin produced by the United States Geological Survey. The "Point Delineation" tool was used, as described by ESRI (2005), and points were selected that were immediately downstream of the study sites. Figure 2 provides examples of the delineated catchments for the two Walkerwin study sites and the Savoy study site.

We used the 2007 Wisconsin Cropland Data Layer from the National Agricultural Statistics Service to evaluate the land use of the area surrounding the restoration sites. This raster data layer was produced using satellite imagery and has a ground resolution of 56 m. We grouped the different land uses identified in the data layer into five different classes, with class one having the least land use intensity and class five having the greatest. We showed how the land uses were divided among the five classes in Table 2. We then calculated the percentage of area within each land use class within radii of 0.5-km and 1-km from the center of the study sites. Figure 3 provides an example of a 0.5-km circle and a 1-km circle around the Middleton study site. We then calculated land use intensity scores for each site at both radii using methods similar to Brooks et al. (2004) and Bernthal et al. (2007). The area within the circle of each cover class was multiplied by the land use intensity (1 for class one, 2 for class two, etc) and summed. A larger land use intensity score indicates a predominance of higher-intensity land uses, such as urban and residential development.

We visited each study site in 2008 to map the wetland community types, using descriptions provided by Eggers and Reed (1997) and recent aerial maps. We drew community boundaries observed on-site on the aerial photograph using landmarks visible on the image. Areas of polygons representing the community boundaries were estimated using a GIS. Subsequent measurements described below were completed within the boundaries of the community types, which are shown in Appendix B.

Our project team conducted a meandering vegetation survey from August 7 to October 1, 2008, and recorded all plant species that were identified within the wetland community types. Voucher specimens were collected to assist plant identification where necessary. Once the species list was created within each wetland community, the project team made a qualitative estimate of the abundance of each species in the field. This was done using broad cover classes: "monotype" (covers 90% of the community type or more), "abundant" (covers 20%-89% of the community type), "common" (covers 2-19% of the community type) and "uncommon" (covers less than 2% of the community type). The survey sheet we used to record the plant species found is included in Appendix D.

We calculated the number of occurrences of plant species using the percentage of the 82 restored communities where we found the species. The percent cover of each species within the 82 communities was calculated by averaging the midpoint value of the cover classes assigned to the species (including zero where the species was absent).

We estimated the floristic quality of each community type using several measures. Species lists of the vegetation present within plant communities were used to calculate native species richness, exotic species richness, mean coefficient of conservatism (mean C) and floristic quality index (FQI) for each community (Bernthal 2003). We compared floristic quality assessment values (mean C and FQI) for the restored communities to floristic quality assessment values for the 116 wetland communities presented in Bernthal et al (2007). We also calculated each community's native species proportional cover by dividing the total cover of native species within a community by the total cover of all species within the same community.

First, we tested for significant differences of four of the floristic quality measures (mean C, FQI, native species richness and exotic species richness) among the community types using one-way ANOVA and Tukey's HSD tests. Only one community was classified as seasonally flooded basin and two were classified as wet to wet-mesic prairie, so these two community types were excluded from this evaluation. Next, we tested the significance of multiple linear regression models with five site factors (age of restoration, size of community, size of catchment draining into site, number of species planted to the site, and land use surrounding the site) as independent variables and the four floristic quality measures as dependent variables. We log-transformed community size and catchment size to improve the normality of these datasets. We used backwards elimination to select the best model for each of the floristic quality measures. Two study sites did not have recorded information on the number of species planted, so we removed these data points from the initial model selection and then replaced them in the dataset if the number of species planted was not a variable in the final model. Finally, we tested for differences in floristic quality between groups of communities that did or did not have particular characteristics (such as maintained or not maintained) using Wilcoxon–Mann–Whitney tests. We did not transform any data for the Wilcoxon-Mann-Whitney tests. Communities without vegetation or sparsely vegetated were classified as shallow, open water and were excluded from all these evaluations. We conducted statistical tests using R 2.8.1 (R Development Core Team 2008).

Results

The site history of each restoration project varied, but all 30 sites had been drained for agricultural use in the past. Some sites remained in agricultural use until they were restored, while other had been fallow for several years until restoration work began. The restoration methods used included filling ditches (8 sites), plugging ditches (8 sites), scraping off and removing soil (16 sites), disabling drainage tiles (14 sites), and building berms (14 sites). One or more methods were used at some restoration sites. Many sites (14) had ditches left intact either within or, more commonly, surrounding the site in order to prevent flooding neighboring fields still in agricultural production. Eighteen of the sites had been planted, but 2 of these sites did not maintain records of which species were planted. Other sites planted the upland buffer area, but not the restored wetland.

Within the 30 study sites, we identified a total of 82 wetland communities. Figure 4 shows that the most prevalent wetland community restored at the study sites was fresh wet meadow. Shallow marsh and shallow, open water were also common. Wet to wet-mesic prairie, shrub-carr, sedge meadow, and seasonally flooded basin were less common. No wooded swamps, floodplain forest, bogs or fens were restored. Figure 5 shows that the types of wetland plant communities restored at voluntary restoration projects were similar to mitigation restoration projects.

A total of 255 species of plants were identified at the 30 study sites. About 20% of the species are exotic, and about 10% of the species are listed as invasive by the Invasive Plants Association of Wisconsin. Table 3 shows that the two plant species with the highest number of occurrences, reed canary grass and narrow-leaved cattail, are exotic, invasive species. The rest of the species with the highest number of occurrences were predominately native species, although only one of these was a tree.

Figure 6 shows that the restored sedge meadows generally had higher floristic quality assessment values than other plant communities. This is confirmed in Table 4, which shows that sedge meadows had significantly higher mean C than the other communities, but had similar FQI to fresh wet meadows. None of the restored communities had floristic quality assessment values that met or exceeded the "high" floristic quality benchmark of 4.2 for mean C and 22.8 for FQI established by Bernthal et al. (2007) for southern Wisconsin wetlands. Figure 7 also shows that the restored wetland communities had on average lower floristic quality than non-restored wetland communities.

Several plant species had cover within the "abundant" cover class. However, Figure 8 shows that there were differences between the types of species with high cover within communities classified as having medium floristic quality by Bernthal et al (2007), with the addition that total proportional cover by native species must be greater than 50%, than those classified as having low floristic quality. Communities with medium floristic quality had many communities dominated by a diversity of native grasses and graminoids. In comparison, most communities with low floristic quality were dominated by a few species of exotic forbs and grasses.

Of the five factors we expected to influence floristic quality, the best multiple linear regression models used three of these factors: area of the community, the number of species planted to the site, and the surrounding land use. The size of the catchment did not have a significant linear relationship with any of the floristic quality measures of the restored wetland plant community types. While some statistically-significant regression models did use age of restoration as a factor, these models contained other non-significant terms and were not as statistically strong as the regression models shown in Table 5. Area of the community was negatively related to mean C and positively related to native species richness and exotic species richness. Both the percentage of class one (least-disturbed) land use and the land use intensity score were negatively related to mean C. The number of species planted at the restoration site was positively related to both FQI and native species richness.

Only one Wilcoxon-Mann-Whitney test of differences between groups of communities was significant at the $p < 0.05$ level. Communities where some maintenance was performed had, on average, about 25% greater cover of native species than those with no record of maintenance. At the $p < 0.1$ level, communities with some maintenance had 15% higher FQI values than communities that were not maintained, and communities with berms had 35% more exotic species than those without berms. There were no significant results between communities where ditches were left intact and communities where there were either no ditches or all ditches had been filled, and communities with scrapes and communities with no scrapes. When we tested all communities, there was also no significant difference between communities restored voluntarily or through compensatory mitigation. However, only one of the sites restored voluntarily was a WWA restoration. With this one WWA restoration site removed from the dataset, mitigation communities had an average of 12% greater mean C than communities restored voluntarily (significant at $p < 0.05$).

Discussion

We found that the floristic quality of the restored communities varied widely, but that none had floristic quality comparable to intact wetlands with high floristic quality within southern Wisconsin. This has important implications for wetland compensatory mitigation. While a wetland restoration can achieve relatively good floristic quality, we did not find evidence that a wetland restoration can compensate for the loss of a wetland with high floristic quality. Furthermore, many of the restored wetlands had poor floristic quality.

One reason several plant communities had low floristic quality was that these communities were dominated by invasive, exotic species. *Phalaris arundinacea* (reed canary grass) and *Typha angustifolia* (narrow-leaved cattail) were the two most commonly occurring species found within all the wetland plant communities, and both of these species are aggressive invasive species. In the field, we observed that *T. angustifolia* frequently forms monotypic stands (greater than 90% cover by a single species) within shallow marshes and that few native plant species can co-exist within these stands. We less frequently observed *P. arundinacea* forming monotypic stands, but *P. arundinacea* was the most common species to achieve placement within the "abundant" cover class (between 20% and 89% cover of the site). While some native species did persist within communities dominated by reed canary grass, they tended to do so in patches where reed canary grass was less abundant. *Typha x glauca*, *Poa pratensis* and *Cirsium arvense* were three invasive species that were generally not dominant species within communities, but were still commonly found. Other invasive species, such as *Melilotus alba*, *Lythrum salicaria*, *Rhamnus frangula*, *R. cathartica*, *Phragmites australis* and *Pastinaca sativa*, were detected but were not common.

Although the prevalence of exotic species was problematic, most of the species we recorded within the restoration project were native. Many native species were classified as "abundant" within the surveyed wetland plant communities. Some of these species have a high tolerance for disturbance and therefore have low coefficients of conservatism, such as *Ambrosia trifida*, *Juncus tenuis*, *Solidago canadensis*, and *Typha latifolia*. Other native plant species with less tolerance for disturbance were among the dominant species within communities with higher floristic quality. In particular, *Aster firmis*, *Carex lacustris*, *C. stricta* and *Calamagrostis canadensis* were dominant in the wetland plant communities with medium floristic quality.

We sought evidence that specific restoration practices and site location would influence floristic quality. However, we were unable to test several factors that we believe to be influential in determining site floristic quality. For example, one wetland restoration practitioner told us that he believes the two most important factors in restoring native plant species diversity are an intact seed bank and how water is reintroduced to the site (J. Nania, personal communication, 2008). His experiences restoring wetland within Wisconsin have led him to conclude that intact seed banks are more likely to be found in well-drained former wetlands, because where water levels fluctuate prior to the restoration, the seed bank can be exhausted before conditions are appropriate for wetland species to successfully establish. If the seed bank is intact, then he recommends reintroducing water to the site by raising the water table, which can help species in the seed bank to establish, rather than flooding the site with surface water, which can discourage native species establishment. However, we could not evaluate these hypotheses, because we did not have information about the sites' seed banks prior to the completion of the restoration work, or the initial direction of water flow when wetland hydrology was reintroduced.

In general, we found more information about the mitigation projects than the voluntary restoration projects, because the mitigation projects had some reporting requirements in their wetland fill permits. While most projects had engineering plans, these were drawn prior to the restoration work and few notes were available on how plans might have changed during implementation. Most of the voluntary wetland restoration projects and some of the mitigation projects did not have documentation on site conditions prior to the restoration or the goals of the restoration. With all the projects, little detailed documentation was available on maintenance work completed after the restoration. Our evaluation of the restoration sites may have been able to reach more conclusions if more information about the restoration work had been recorded. Nevertheless, we used the data available to examine some of the common assumptions about how features of wetland restoration projects influence floristic quality.

We expected that larger plant communities would have greater floristic quality for two reasons. First, a larger area generally can support more species. Secondly, edges of a large community can serve as a buffer for the rest of the site to prevent exotic seed and excess nutrients from entering the site and facilitating domination by invasive, exotic species. We did find that our larger communities did have significantly more native and exotic species. However, smaller communities had significantly greater average mean C than larger communities. We anticipate that this may due to more maintenance work being completed in a smaller community, since it can be easier to control exotic species in a smaller area. Within the study sites, the average size of communities with a record of maintenance was 60% smaller than communities without a record of maintenance (a significant difference, $p < 0.01$). Also, all of the sedge meadows were small in area and the sedge meadows had significantly higher mean C than the other communities.

We expected floristic quality to improve over time since restoration completion. The initial species to colonize a newly-restored site were annual species with a high tolerance for disturbance, such as *Ambrosia trifida*, *Ambrosia artemisiifolia*, *Bidens frondosus*, *Echinochloa crusgalli* and *Polygonum persicaria*. Ideally, within a few years perennial native species appropriate for the site would establish and floristic quality would increase. However, we found weak relationships between the age of the site and floristic quality. Whether or not invasive species were able to establish may help explain our results. Initially, sites can be diverse as the seeds present in the seed bank, planted to the site, or dispersed into the site germinate, but not all of these species will necessarily establish and persist. If invasive species such as *Phalaris arundinacea* or *Typha angustifolia* establish, early colonists may not persist. Among the 37 communities that were restored more than ten years ago, about 40% had medium floristic quality (as defined as mean C > 2.4, FQA > 12.5, native cover > 50%) and the rest had poor floristic quality. Within these older restored communities with medium floristic quality, only three communities had abundant cover of either *P. arundinacea* or *T. angustifolia*. An implication is that proponents of compensatory mitigation should not assume floristic quality will improve over time, especially if invasive species are present.

A common expectation may be that sites surrounded by natural areas would have higher floristic quality, because neighboring forests, wetlands, and prairie can help buffer the restoration from disturbance and can be a source of native plant species. Agriculture and urban development can contribute nutrients and sediments to restoration sites and disrupt hydrology. Such disturbances can favor invasive plant species over native plants species (Green and Galatowitsch 2002, Kercher and Zedler 2004). However, we did not find strong relationships between the surrounding land use and the floristic quality measures. Land use did not contribute to our best regression models for species richness or FQI. While two land use factors were part of our multiple linear regression model for mean C, these results were only partially consistent with our expectations. The land use score was negatively related to mean C, which supports our prediction that urban development would be related to a decrease in site floristic quality. However, coverage of natural areas (class-one land use) was also negatively related to mean C. This is surprising, because we predicted that the presence of natural areas nearby would be related to an increase in mean C. We conclude that while natural areas can serve as a source of species for the restoration, not all introduced species are desirable. It is possible that the floristic quality of the surrounding natural areas was often low and that these areas failed to be a seed source for species with moderate or high coefficients of conservatism. We recommend that project proponents investigate areas adjacent to a proposed restoration site to identify which native or exotic species may become colonizers.

We were surprised to find no relationships between the size of the catchment and floristic quality. Our expectation was that smaller catchments would have greater floristic quality, because placement near the top of a watershed may decrease the amount of nutrients and sediments draining into the site. While some restoration projects with large catchments did have poor floristic quality, some projects with small catchments also had poor floristic quality. For example, the Martinelli West site had the second smallest catchment size, but the two wetland plant communities present within the site, shallow marsh and fresh wetland meadow, both had poor floristic quality.

Encouraging native species to establish by planting selected species to the site is a common approach to improving floristic quality. Within the restored wetland communities we examined, increasing the number of species planted did increase both native species richness and FQI. However, we found no evidence that planting was related to mean C. The coefficients of conservatism of the species planted to the site varied greatly. Many species with coefficients greater than five may not have been successful at establishing within a restoration site—by definition, such species should generally be found in undisturbed areas. Additionally, the species selections at some restoration sites were questionable. For example, at the Waupun North restoration, only one of the seven species seeded was native to Wisconsin, and floristic quality was low within the wetland plant communities of this site eleven years after it was seeded.

Some sites that were not planted did have moderately good floristic quality, and this may have been because a native seed bank was present. Unfortunately, testing what species are present in the seed bank prior to doing the restoration is usually not practical, because most practitioners do not have access to the necessary greenhouse space or can easily identify newly-germinated plant species. Sometimes evidence of an intact seed bank is present in the field. For example, adjacent to the Dane project was an area that sometime prior to the restoration work had become too wet to farm. Native sedge meadow species became established in this area, and the project proponents took this as evidence that an intact seed bank was likely present in the restoration site. They chose not to seed the site, and this decision might have been warranted, since most of the wetland plant communities within this project have medium floristic quality. Seeding or planting sites with native species can be very expensive, especially if the site is large. However, we usually do not know what species may establish from the seed bank, and so we recommend that native species be seeded or planted to a site if possible.

Common maintenance activities completed at restoration sites to improve floristic quality include doing prescribed burns, mowing the site, and selectively removing undesirable species manually and/or through the use of chemicals. Many factors can influence whether or not these activities help achieve floristic quality goals. For example, if reed canary grass control is attempted through the use of herbicides, influential factors may include the type and concentration of herbicide, how it was applied to the plants, when it was applied to the plants, and how often the treatment was repeated. If this information is not recorded, it can be difficult in the future to determine why a treatment failed or replicate successful control. Unfortunately, most of the restoration projects did not have detailed information about the site maintenance. Instead general notes such as "the site was burned this year," or "we removed Canada thistle" were found in monitoring reports. We compared the floristic quality of sites where the project proponent recorded doing some maintenance to sites where there was no record of any maintenance. In general, we found moderate evidence for our hypothesis that sites with a record of maintenance had better floristic quality.

A variety of construction techniques were used at our study sites to return water to the landscape. These included filling or plugging ditches, disabling drainage tile, removing soil, and either constructing or removing berms. Most restoration projects made use of several of these techniques. Overall, we identified two approaches to the design construction. The first approach was to try to return the landscape to what it looked like prior to human disturbance. This involved removing all drainage tile and berms, filling all ditches, and removing any sediment that had accumulated on-site to reveal the original hydric soils. The second approach was to shape the landscape in order to meet specific goals. For example, many of the sites were adjacent to drained fields still in agricultural production. An important goal was to protect these neighboring properties from flooding by placing ditches or berms along the site boundaries. Most records of restoration projects did not include restoration goals, but we believe that several sites were intended to have shallow marsh and shallow, open water, because the restoration practitioners built berms or removed soil in specific areas. Finally, construction costs may have played a role in some of the decisions to only plug or partially fill some internal ditches or not remove accumulated sediment.

We found it challenging to evaluate how construction decisions may have influenced floristic quality, especially because most projects involved several techniques to restore water. We compared sites with and without berms, sites with and without scrapes, and sites with ditches and without ditches or with filled ditches. There was some weak evidence that sites with berms have more exotic species, but otherwise we did not detect differences in floristic quality between the pairs of groups. We expected that sites where attempts were made to restore the natural landscape, without berms, ditches, or removal of the original soil, would have plant communities with higher floristic quality. Native plant species in neighboring wetlands or in the seed bank may establish more easily if the historic landscape was restored, and seeded or planted species may be more likely to establish if planted in the site's original hydric soils. Evaluating these hypotheses would require more site information, especially about the soil horizons and site hydrology before and after the restoration work is done. We recommend that restoration practitioners be more explicit about the restoration goals of their projects.

While our primary goal was to evaluate the floristic quality of restored wetland plant communities, our secondary goal was to assess the diversity of the types of wetland plant communities found within the restoration projects. Fresh wet meadows, shallow marshes, and shallow, open water were the most common communities restored. All other plant communities were either uncommon or were not found. We believe that this result was driven by the ease with which *Phalaris arundinacea* and *Typha angustifolia* can colonize newly restored sites. Most areas dominated by *P. arundinacea* were classified as fresh wet meadow and most areas dominated by *T. angustifolia* were classified as shallow marsh. However, nine fresh wet meadows did not have *P. arundinacea* as a dominant, showing that native species such as *Calamagrostis canadensis* and *Juncus tenuis* can establish and dominate this community type. In comparison, all of the shallow marshes in our study had *T. angustifolia* as one of the dominant species (if not the only dominant), demonstrating the difficulty of restoring communities of this type that are dominated by native species. Several of the restoration sites were likely designed to increase the area of shallow, open water. This wetland type can be easy to create since no plant species need to establish.

We identified a few communities that we classified as sedge meadow, wet prairie, seasonally flooded basin and shrub-carr. Sedge meadows shared many of the same forb species as the fresh wet meadows, but while fresh wet meadows were dominated primarily by grass species, the sedge meadows were dominated by *Carex* species, particularly *C. lacustris* and *C. stricta*. This community type is likely limited by the difficultly of establishing some *Carex* species within restoration sites. The wet prairies were found within the transition area between fresh wet meadow and (non-wetland) mesic prairie at two young wetland restorations. These wet prairies were dominated by *Elymus virginicus* and *Elymus canadensis*, which had been seeded to the site and may not persist over time. Ideally, wet prairies are dominated by species such as *Andropogon gerardii* and *Spartina pectinata*. While we did find the former in the wet prairies and the latter in some fresh wet meadows, these species were never dominant. Seasonally flooded basins are depressions that are commonly flooded and can be dominated by annual species. Few of our restored sites had the appropriate hydrology for this community type, but it is also possible that some of the areas we classified as shallow, open water may dry out often enough that we should have classified them as seasonally flooded basins. Finally, while we commonly found scattered shrubs within fresh wet meadows or sedge meadows, we only found a few areas of dense shrubs that we would classify as shrub-carr. Most shrub-carrs were dominated by willow species, especially *Salix exigua*. Young shrubs were planted at only three of the restoration projects, and some of the projects were burned or mowed regularly, which would have prevented shrub growth. Shrub species also may not easily establish in some of the restoration projects covered by dense stands of *Phalaris arundinacea*.

Several wetland plant communities found within southern Wisconsin were absent from all of the restoration sites. We were not surprised that bogs and calcareous fens were missing—these uncommon communities are only found under specific conditions. It is also not too surprising that no forested wetlands were found, because it can take tree species decades to grow to maturity. Only one of our study sites had planted tree species. Gundrum West was the only site that seemed likely to naturally succeed to a forested wetland within the near future. Factors that limit the establishment of shrub-carr communities also limit the establishment of forested wetland.

The final issue we examined concerned differences between voluntary and mitigation wetland restoration projects. We did not detect any significant differences in floristic quality of communities between these two groups when both WRP and WWA voluntary restoration sites were included in the dataset, and the types of wetland plant communities restored within both groups were also similar. Mitigation communities did have slightly higher mean C compared to WRP communities, but this was the only difference that was significant. Since both types of restoration sites face similar challenges to restoring diverse wetland communities, we recommend that the restoration practitioners record and share their experiences.

Part 2: Pilot Study of Wildlife Monitoring Methodology

Background

Two key sections of the compensation site plan of a wetland mitigation site are the performance standards and the monitoring plan. The performance standards are quantitative goals that must be met in order for the site to be considered a successful restoration. The monitoring plan must describe the assessment methods that will be used to determine whether or not the performance standards are met.

Wetlands are valued for providing habitat for many animal species, but few mitigation plans in southern Wisconsin have animal-related performance standards. A few private mitigation sites have had performance standards requiring a minimum number of amphibian or avian species to be observed within the site. The number of species to be observed is often arbitrarily set, and animal species that are conservation priorities are not given preference over very common species. No specific monitoring methodology has been prescribed in mitigation site plans, and so mitigation consultants record accidental animal observations while doing maintenance or plant monitoring at restoration sites. These observations may be made at times that are not appropriate for animal observations, and often when an animal is observed, the species is assumed to inhabit at the site throughout the monitoring period.

Our primary goal was to evaluate the suitability of wildlife monitoring methods for future use in Wisconsin's mitigation programs. We specifically focused on monitoring birds and amphibians, since these animals can be relatively easy to detect and standard methodologies exist for monitoring them in Wisconsin. We wanted to evaluate the level of difficultly to learn the monitoring methods, the time spent in the field conducting the monitoring, and the results achieved after one year of monitoring at several restoration sites.

Our secondary goal was to evaluate whether or not species currently considered to be conservation targets by wildlife experts were detected at our selected restoration sites. We anticipated that restoring habitat for such species is a high priority, and successfully meeting such an objective should be detected by mitigation monitoring programs.

It was not our goal to determine benchmarks for the numbers or types of species that ought to be detected in order for a wetland to be considered high- or low-quality. The results from studies larger than ours would be needed to determine what species could serve as indicator species for overall wetland quality in performance standards. However, we did want to examine how wildlife performance standards can be developed for a given mitigation site by determining which conservation target species may use the site if restored according to plan.

Methods

Avian monitoring

Birds were monitored within all study sites in Dane County: Middleton, Dane North, Dane South, Wilke Preserve, Martinelli East, Martinelli West, Witte-Dane North and Witte-Dane

South. These sites encompass five separate restoration projects. The locations of monitoring stations, where project team members both listened to and observed birds, were determined randomly. We rejected stations if the locations were inaccessible by foot or closer than 250 m to another monitoring station. Middleton and Wilke Preserve each had one monitoring station, Dane and Martinelli each had two monitoring stations, and Witte-Dane had three monitoring stations. The locations of the nine monitoring stations are shown within the maps included in Appendix C.

We visited each station between 5:00 and 9:30 a.m. on three dates in 2008: May 1, May 21 and June 4. On each of these dates, the weather was appropriate—it was not raining, foggy, very windy, or unseasonably cold. The order that we visited stations remained the same on all three monitoring dates.

The three-member project team tested two different methodologies simultaneously. At each station, two team members used monitoring methodology from the new Marshbird Monitoring Program for Wisconsin (Conway 2005 and Brady 2008). In this monitoring program, nine major species (yellow rail, sora rail, Virginia rail, king rail, American bittern, American coot, common moorhen, pied-billed grebe and least bittern) and eight minor species (red-necked grebe, marsh wren, Wilson's snipe, swamp sparrow, black tern, Le Conte's sparrow, Forster's tern, yellow-headed blackbird) were targeted for monitoring. Monitors did not record any other bird species observed or seen. After a five-minute silent point count, a six-minute playback recording of six of the major species (each with a one-minute playback segment) was played. These six major species were least bittern, yellow rail, sora rail, Virginia rail, king rail and American bittern. For major species, the two team members recorded the detection of each individual bird observed or heard during each one-minute segment of the 11-minute monitoring period. The distance to each individual bird was also estimated. For minor species, the team members only recorded the total number of individual birds for each species observed or heard during the 11-minute monitoring period.

Another team member conducted the second monitoring methodology during the same 11-minute observation and listening period. She recorded all bird species seen and heard, except that she disregarded birds seen outside the restoration project or flying overhead. She did not count numbers of individuals or estimate distance to birds. The survey sheets that we used for both methodologies can be found in Appendix D.

We investigated which bird species are conservation targets in Wisconsin, and developed one list of primary target species and another list of secondary target species. We defined primary species as Wisconsin's avian species of greatest conservation need (WDNR 2005). The list of secondary species was derived by combining avian species from three lists—the Wisconsin Natural Heritage Working List (available at http://dnr.wi.gov/org/land/er/wlist/index.asp?mode=detail&Grp=7&track=yes), target species in the Marshbird Monitoring Program for Wisconsin (Brady 2008) and Wisconsin species included in the Partners in Flight Landbird Conservation plan (available at http://www.wisconsinbirds.org/plan/species/priority.htm)—and subtracting those species that are already listed as primary species. The current lists of primary and secondary species are listed in

Appendix E. Since the source lists are dynamic, the lists of primary and secondary species are also intended to change over time as the status of species change.

Amphibian monitoring

We used two different methods of surveying amphibians. First, we conducted a frog and toad calling survey at six projects. Five of these projects were the Dane County sites were easily accessed by the road: Middleton, Dane, Wilke, Martinelli and Witte Dane. Additionally, the frog call survey was conducted at Gundrum in Washington County.

We followed the methodology and the survey sheets of the Wisconsin Frog and Toad Survey for the calling survey (Paloski et al 2006). Each study site had one monitoring station, which the project team determined in advance, where team members listened for frogs and toads. Appendix C includes maps that show the locations of the monitoring stations. During 2008, three team members visited all the Dane County sites on April 17, May 26 and July 8, and one team member visited the Gundrum East site on April 8, May 30 and July 8. These days were selected for monitoring because the water temperature met the requirements of the three monitoring periods: early spring (April 8-30 and minimum water temperature of 50°F), late spring (May 20 - June 5 and minimum water temperature of 60°F) and summer (July 1-15 and minimum water temperature of 70°F). We visited monitoring stations after sunset and recorded the species of frogs heard during a five-minute period. The amount of calling heard for each species was recorded using a qualitative three-tier calling index (1= individual calls, 2= calls overlapping, 3= full chorus).

In addition to the frog and toad calling survey, we also set funnel traps at four of the restoration projects: Wilke, Martinelli East, Witte Dane South, Witte Dane North and Gundrum East. Traps were not set at the Middleton or Dane projects, because these sites did not have standing water present in summer. A total of 28 traps were set in areas of shallow water within these sites. The locations of the traps within the four projects can be seen in the maps of Appendix C. In general, the protocol for Wisconsin's Salamander Survey Traps was used (Wisconsin Audubon Council 2008). We chose to place traps in early July to target larval salamanders, all life stages of the central newt, and both adult and juvenile frogs. Traps were set on July 7 and checked for amphibians daily over the next three days. None of the traps were baited. When we checked the traps, we emptied the contents of the trap on to a sorting pan. We recorded the species of all adult and juvenile amphibians present using the survey sheet shown in Appendix D, and then we released the animals. All funnel traps were removed from the study site on July 10, the last day the traps were checked.

Results

Avian monitoring

We spent about 12 hours in the field (including transportation time) visiting all nine stations three times. Our team members also attended a weekend training program, which lasted a total of about 8 hours, in order to learn the methods for the Marshbird Monitoring Program for

Wisconsin. One team member was a highly experienced birder, and the other two members were less experienced.

A total of 43 avian species were observed; of these, 30 were present at a monitoring station during at least two of the three monitoring dates. Table 6 shows that red-winged black birds were detected at all nine monitoring stations on all three dates, while several primary target species were only observed once or twice. Table 7 shows that while primary species were only observed twice at a station within one project, at least one secondary species was detected at all of the five restoration projects. Twelve different target species were detected at least twice at a monitoring station, and the common yellowthroat was the most common target species detected.

Table 8 shows that while the abundance of some marsh birds varied from project to project, other species were consistently detected in small numbers. Approximately two marsh wrens were detected at each visit to the stations at the Witte-Dane project, but this species was rarely detected at the other projects. We rarely detected a single Virginia rail or American bittern at all of the station visits.

Amphibian monitoring

We spent a total of about 10 hours in the field (including transportation time) conducting frog call surveys at six locations. We spent about 20 hours in the field checking 28 funnel traps for three days, and an additional 6 hours initially setting the traps. Only one project team attended training for amphibian monitoring methods, which lasted about 8 hours. Most had prior experience conducting frog call surveys, but only one team member had prior experience using funnel traps. The less experienced team members also devoted about 6 hours of study to ensure correct identification of frog calls and amphibian larvae.

Of the thirteen species of amphibians likely to be found in south-central and south-eastern Wisconsin, we detected eight species. We did not detect bullfrogs, pickerel frogs, wood frogs, blue-spotted salamanders or central newts. Table 8 shows that we detected American toads, chorus frogs and green frogs at most of the six projects, but we detected tiger salamanders at only one of the projects where we set traps. We did not detect any new frog species during the trapping survey that we had not already detected during the call survey. The maximum number of amphibian species detected at a single project was six, while the minimum was three.

Figure 9 shows how the percent frequency of frog and toad species detected during our call survey compares to the detection frequencies recorded in earlier years by the statewide frog and toad survey. While we detected American toads and Cope's gray treefrogs more frequently than the statewide survey, we detected spring peepers and leopard frogs less commonly.

Only four species were detected during the trapping survey: chorus frogs, treefrogs, green frogs and tiger salamanders. Since we could not distinguish between the tadpoles of eastern gray treefrogs and Cope's gray treefrogs, these two species were lumped together as "treefrogs." Green frogs were most frequently found in traps (54% of the time), followed by treefrogs (50%), tiger salamanders (25%) and chorus frogs (14%). However, where they were found in traps, chorus frog tadpoles were found in the greatest abundance (2.8 individuals), followed by green frogs (2.2 individuals), tiger salamanders (1.1 individuals) and treefrogs (1 individual).

Discussion

Methodology

We feel we met our first goal of testing wildlife monitoring methodology that could be used at wetland mitigation sites. Neither the avian nor the amphibian methodology was too time-consuming to either learn or implement. The avian monitoring approach where all detected species were recorded was best implemented by a highly experienced birder who already knows all the local species, much like most vegetation monitoring is best implemented by an experienced botanist. However, if a few target species are the only species that need to be detected, as was the case with the marsh monitoring protocol, it would be possible for a less experienced birder to conduct the monitoring with adequate training. Since there are not many amphibian species in Wisconsin, both amphibian monitoring methods could be implemented by someone with minimal prior experience with amphibians with adequate training. Ideally, the training would last at least two days and include implementing the monitoring in the field with the guidance of an expert.

The equipment needs to implement the monitoring we conducted were generally minimal. The most expensive field item was the mp3 player and the speakers used to conduct the play-back calls for the marsh bird monitoring. The funnel traps used for capturing amphibians were the next most costly item. The project team used their personal binoculars for the avian monitoring. No other necessary equipment (thermometer, timer, sorting pan, clipboards, flashlights, flagging, stakes, and wire) represented a significant cost, and none of the equipment was difficult to obtain.

We conducted two different bird monitoring methodologies simultaneously in the field. The difference between these methodologies was which species were targeted and how much information was recorded about each species detected. In the first method, a team member recorded the presence of all birds that were detected, but no other information about the species was recorded. In the second method, only a few species were targeted for monitoring, but more information was recorded about those target species. In general, we prefer the second approach, because we believe that focusing on fewer species allows the monitor to record abundance data with less risk of missing other species. For example, if a monitor tried to count all red-winged black birds present, the single call of a more secretive bird such as a least bittern might go unnoticed. Since least bitterns are a higher conservation priority than red-winged black birds, the monitor would be better off focusing on conservation priorities and ignoring more common birds. We recommend that monitors focus on target birds so that they can record the number of individuals detected. We feel that abundance data are worthwhile and can help distinguish species that are casual visitors from those that are using the wetland for breeding habitat.

Some of the collected information required by the marsh bird monitoring program may not be necessary for the purposes of mitigation monitoring. The marsh bird monitoring aims to collect data on under-surveyed marsh birds, while the mitigation monitoring seeks to determine whether or not specific restoration goals for habitat have been met. Estimating detection probability and species density is important for a statewide monitoring program, but less important for determining the species composition at a single site. We recommend that mitigation monitors do not try to estimate the distance to each individual target species detected. Minute-by-minute detection of each individual may not be critical information for mitigation monitoring, but should be recorded if it is possible to do so without distracting the monitor from detecting target species. In our experience, playing calls of secretive marsh birds helped us detect these species, and so we recommend using playback calls in mitigation monitoring. The marsh bird monitoring program used no more than six minutes of playback calls so that a monitor would be able to reach many monitoring stations. In mitigation monitoring, a monitor would likely only need to reach one or a few monitoring stations at a single restoration project, so more playback calls could be used to help detect more target species.

Overall, we were satisfied with the methodology of the frog and toad calling survey. The methodology is simple and has been used state-wide since 1984, and we were able to detect many different frog and toad species. However, there were some challenges with implementing this methodology. At two sites, it was difficult to distinguish whether calls we heard came from the restored wetland or from neighboring farm ponds. Since the monitoring is done at night, it may not be easy to enter the restored wetland far enough to verify the source of calls heard. An additional problem we encountered is that loud calls from prevalent species can make it difficult to hear calls from uncommon or quieter species. For example, we only heard a leopard frog at one site, and this frog only called once. If a full chorus of Cope's gray treefrogs had been calling, as was the case at other sites, we might not have heard the leopard frog. A final limitation with the frog and toad calling survey is that it will not detect amphibian species other than frogs and toads.

The most time-consuming methodology we tested was the amphibian trapping. While we set traps at four sites, at three of those sites, we did not detect new species that were not already detected using the call survey. However, at one site we did find tiger salamanders, which we could not have detected during the call survey. Distinguishing the species of tadpoles was also challenging. We could not tell apart the two species of treefrogs, and distinguishing the *Rana* species was also difficult. While we were confident in the field that the *Rana* tadpoles we found were all green frogs, it is possible that we were mistaken and one or more tadpoles were actually leopard frogs. Overall, amphibian trapping was helpful to determine whether salamanders and newts were present at a site and to verify the presence of other amphibians heard during the frog and toad survey. We also caught many fish and invertebrate species in our traps, and information about these wildlife groups could also be used if these data would help show whether the restoration site has met its goals. However, if time and resources are limited and salamanders or newts are unlikely to be present, conducting the frog and toad survey alone may be sufficient for amphibian monitoring.

Appropriate timing and repetition of the wildlife monitoring methodologies are important. In general, we recommend not beginning wildlife monitoring until at least two years after completion of the restoration project, so that the vegetation has had some time to establish. Most wetland mitigation projects have a five-year monitoring period, so we recommend conducting wildlife monitoring during each year of the final three years. For avian monitoring, we were satisfied with the amount of repetition we did and recommend repeating the survey three times during the breeding season. For the frog and toad call survey, we were not satisfied with repeating the survey only once during each phenology period (for a total of three call surveys per year). Since the timing of the call survey heavily influences the ability to detect species while they are calling, we recommend repeating the call survey twice during each phenology period (for a total of six call surveys per year.) For the amphibian trapping survey, we chose to only set traps in early July, when the results of trapping would not be weather dependent. While this makes the decision of when to set traps much easier, some amphibian species that are early breeders are missed by July trapping, such as wood frogs and spring peepers. Traps could also be set in early spring, but the traps must be set when conditions are right (generally after temperatures rise when ponds have recently thawed). While we were satisfied with setting traps only in July and leaving them in place for three days, a monitor who wants to makes sure that no species are missed may want to consider leaving traps in place longer, setting more traps and also placing traps in spring.

Site goals and performance standards

Our study was too small and brief in order to do more than to suggest possible performance standards for wetland mitigation sites. There is no consensus among wetland ecologists on what wildlife populations ought to be found in a wetland for the restoration work to be considered a "success," and much more needs to be learned about the habitat needs of many animals. Therefore, we recommend that mitigation performance standards relating to presence of wildlife be approached with flexibility and not be relied upon as key standards.

Every wetland restoration should have many goals and performance standards, but we recommend that the primary focus should remain on restoring natural wetland hydrology and vegetation. A site with a diversity of wetland plant communities that is connected to other natural areas can reasonably be assumed to provide good wildlife habitat for many species. While we believe that it is important to test this assumption and evaluate what animals are using restored wetlands, we do not think that the presence of a certain number of wildlife species should be used to de-emphasize the importance of establishing good floristic quality within restored wetland plant communities.

We used our restoration sites in Dane County (and one site in Washington County) as models to propose one approach to setting wildlife performance standards and then evaluate whether or not these standards would have been met. We sought to show how flexibility could be incorporated in setting standards and how the planned characteristics of the restoration site should influence the development of standards.

For our approach to setting performance standards, we decided to focus on species that are considered conservation targets by wildlife experts. We wanted to use established lists of wildlife species that would be dynamic over time as the status of species change. Wisconsin's Wildlife Action Plan (WDNR 2005) designates the species of greatest conservation need for the state, which includes 84 bird species and six amphibian species. If a site can provide appropriate habitat for any of these species, the monitoring program should evaluate whether or not these species were found within the restoration site. However, these species are generally rare and restoring habitat for these species does not necessary mean the species will be found. If the habitat is appropriate but the species is absent, there is little that the project manager can do in response. Therefore, we do not recommend that successfully meeting a performance standard should ever hinge on the presence of a single species. Even detecting any single species of greatest conservation need may be too ambitious. We decided to designate these species as primary species, because while these species may be the most important targets for restoring habitat, it may be unlikely that these species will be detected.

For example, at the sites where we monitored wildlife, few primary species were detected. None of the amphibians of greatest conservation need were detected. A few birds of greatest conservation need were detected, but only three species were detected at least twice at a single monitoring station. These species—eastern meadowlark, field sparrow, Henslow's sparrow—were all found in the upland/wetland transition area at the Dane site. American bittern, black-billed cuckoo, blue-winged teal, solitary sandpiper, willow flycatcher, and yellow-billed cuckoo were not detected more than one time at a single station.

We also attempted to establish lists of secondary bird species that are more common than the primary species but are species of possible concern for conservationists. We combined three different lists of species to form our list of secondary species (see Appendix E). Some of these bird species are lower priorities as conservation targets, but we found that many good wetland-dependant species were on these lists. We believe that if no primary species are detected at a restoration site, the presence of many secondary species could also indicate that good avian habitat had been restored. Since there are so many bird species in Wisconsin, we think it is important to distinguish between relatively common birds found in natural habitats and very common birds that are generalists. In comparison, we did not establish a list of secondary species for amphibians. We did not think it was necessary to limit the species recorded in the field, because there are so few amphibian species found in Wisconsin.

A total of ten avian secondary species were identified at the five Dane County sites. Each site had at least two secondary species. The Dane-Witte site, a WRP restoration project with the most secondary species, had a total of seven secondary species that were found at least twice at a monitoring station. Only one secondary species, the common yellowthroat, was found at all five sites. For amphibian species, no primary species were identified, but a total of eight other species were detected. Each site had at least three amphibian species, and two sites had six species.

Prior to setting performance standards, we recommend that restoration managers develop a list of which target species may potentially use their restoration sites. Many primary and secondary species are not found throughout the state, and most have specific habitat requirements. For example, most of the amphibian primary species would not be expected to be found at our sites in Dane County and Washington County. Mink frogs are not found in either of these counties, and Blanchard's cricket frogs are highly unlikely to be found in either county. None of our sites were adjacent to large rivers or lakes that would provide the deep aquatic habitat required for mudpuppies or had forest with moss-lined pools required for four-toed salamanders. Therefore, these species should not be taken into consideration when developing performance standards for the Dane County sites. In Table 10, we list the amphibian species potentially present within the restoration sites.

With bird species, other decisions must be made in developing a list of expected target species for a restoration site. While amphibian species found in sites can generally be assumed to be using the site for breeding, bird species may be using sites for foraging or as a stopover during migration, rather than for breeding. Since the avian monitoring methodology we recommend is designed to detect birds during the breeding period, we recommend only listing birds as potential target species that are likely to be using the sites for breeding, or foraging during the breeding season. However, the target species should be carefully selected so that they are representative of the site's restoration goals. If a goal of the site is to provide stop-over habitat for migrants, then the anticipated target list and the monitoring methodology should be adjusted accordingly. Furthermore, while nearly all amphibians use wetlands for breeding, many potential target birds are found primarily in upland habitat. A decision should be made in the planning stages of the restoration whether or not birds found in upland habitats adjacent to the wetland site should be target species. If restoring uplands is a key component of the overall restoration project, then we recommend the upland species be included at potential target species. The bird species we listed as target species for the Dane County restoration projects are listed in Table 11. Information from the Wisconsin All-Bird Conservation Plan (Kreitlinger and Paulios 2007) was used to prepare Table 11, as well as expert advice from WDNR avian ecologists Ryan Brady and Andrew Paulios (personal communication, 2009).

Developing a list of potential target wildlife species during the planning stages of the restoration can also help decisions on how the site will be restored and maintained. In general we recommend that such decisions be primarily influenced by what the wetland was like prior to being drained for agriculture, and then using the anticipated post-restoration communities to choose appropriate target species. However, certain decisions like planting shrub species or avoiding setting prescribed burns in certain areas of the restoration can be made to help improve the site's ability to provide habitat for target species.

Once a list of potential target species has been developed for the planned restoration site, it can be used to develop performance standards. In setting the performance standards, we recommend incorporating flexibility and keeping in mind that if the project proponent fails the wildlife standard, there may be little that can be done in response. However, performance standards should also not be set too low. Ideally, the full set of performance standards for a site should be set at a consistent level so that a site either meets all standards or fails all standards. If a site fails to restore the intended types of wetland plant communities, or is dominated by invasive plant species, we expect that the wildlife standard would also not be met.

If a site is unlikely to provide breeding habitat for many target species, we recommend that no performance standards be set for those species. For example, at the Middleton site, we felt few target birds or amphibians would likely use this site, because it is small, with little standing water, no adjacent forest, and surrounded by urban development. In our monitoring, we did find a few secondary species, but less than at other sites. At both the Dane and Wilke Preserve sites, we also did not anticipate finding many amphibians due to the lack of standing water at the former and the lack of adjacent forest at the latter. We were surprised to find six amphibian species at Wilke Preserve, which may show that there can be value in monitoring sites where few species are expected.

For sites where many target species have the potential to be found, we recommend that the wildlife performance standard follow an "either/or" format. We suggest that in order to meet the performance standard, the monitor must detect either one (or a few) primary species or several secondary species while conducting wildlife monitoring. This way, the project proponent has two ways to meet the standard. While it is likely that the standard will be met through the detection of secondary species, the monitor will have an incentive to try to detect primary species. Another possibility for setting a performance standard would be to require the detection of a defined level of abundance of individuals of a few secondary species, although we believe it would be challenging to predict what numbers of individuals would be reasonable to expect.

The performance standard should also indicate how often the species must be detected at the site, both within a season and over the multi-year monitoring period. We recommend that a species only detected once should not count towards meeting the performance standard. This can help insure that the species was identified correctly, or in the case of birds, was not just passing through. If the monitoring period for wildlife is three years, then we suggest that the species should be detected two of those years. An amphibian species may only need to be trapped once during a year for its presence to be verified, but we recommend that the species be heard twice a year during the call survey (assuming that the call survey is conducted twice during each phenology period). For birds, we recommend that the species be detected twice during a single breeding season, although allowances may need to be made for secretive species that are difficult to detect.

In general, we believe that a reasonable performance standard for birds at the sites we monitored in Dane County would be to detect either one primary species or five secondary species and detect these same species over two years. Of the four sites where we believe avian performance standards could have been reasonably met, three would have shown that they had met the standard for one year. Only two secondary species were detected at Dane, but three primary species were detected. All of these species are primarily upland bird species, so it would have been important in the planning stages of the restoration to determine whether these species were appropriate target species for this site. Since the restoration of upland habitat was a significant component of the overall restoration of this site, we listed these primary species as potential target species. Both the Martinelli and Witte-Dane sites had more than five secondary species. Only four secondary species were detected at Wilke Preserve, but an American bittern was observed once. If this primary species, which can be secretive, was detected again in subsequent years, this site would likely be close enough to meeting the performance standard. Also, only one monitoring station was placed in this site, but we believe we could have justified placing a second monitoring station on the other side of the site. This action might increase the likelihood of detecting secretive species that were present at the site.

For amphibians at the six restoration sites, we suggest that an appropriate performance standard would also be detecting one primary species or five other species for at least two years. This standard would be appropriate for sites with habitat for many different amphibians species, including salamanders or newts. For example, we anticipated that four of our restorations sites could have habitat for at least six different amphibian species, and traps were set at three of these sites. Two of those sites would have met the standard, but the Gundrum site was one species short of meeting the standard. We believe that an increased monitoring effort at this site would like show that another species is present. No American toads were detected at Gundrum, but we would be surprised if this common species is truly absent from the entire site. Another listening station for the calling survey might have been placed at the other end of the site, or more traps might have been placed at other locations with some standing water.

For sites where habitat for salamanders or newts are likely absent and no traps are set, an appropriate standard could be one primary species or four other species. We detected at least three species at all sites while conducting the frog and toad survey, and it is possible that with an increased monitoring effort that another frog or toad species may be detected in future years. However, if few amphibian species are listed as potential target species at the beginning of the monitoring effort, it may be best to not set an amphibian performance standard for that site.

Other approaches could be taken to setting performance standards for wildlife. Standards could be set that focus on the planned habitat, rather than the actual presence or absence of animal species. In the planning stages of the restoration, the project proponent could define the structure within plant communities needed by a particular group of target species, and then subsequently evaluate that the structure was created. The advantage of this approach would be that the project proponents would be evaluated on primarily vegetation factors that they could more easily control. However, there would be little incentive to collect monitoring information about whether or not the targeted wildlife actually used the habitat, because the presence of wildlife would not influence whether or not the project proponents met their performance standards.

Another approach to setting wildlife performance standards would be to devise a wildlife quality assessment similar to the floristic quality assessment. Coefficients of conservatism could be assigned for Wisconsin fauna based on their tolerance of disturbance. Other states have done this for different faunal groups; for example, coefficients of conservation for amphibian species have been proposed for use in Ohio (Michacchion 2004). A group of experts on Wisconsin wildlife would need to assign coefficients of conservatism, but there may not be enough knowledge of some groups to do this. Furthermore, adequate testing of the assessment system would needed before appropriate benchmarks for assessment scores could be determined and used in performance standards. However, we believe that this approach holds promise to help develop meaningful, quantitative performance standards in the future.

Part 3: Application of Study Results to Planning a Wetland Restoration Site

As we examined the wetland plant communities, amphibian populations and bird populations at different wetland restoration projects in southern Wisconsin, we discussed how restoration goals could have influenced the design of the restoration project. For example, several projects may have had a goal of creating habitat for waterfowl, and consequently these projects were designed to create areas of shallow marsh and open water. However, most projects did not have records that explained what the goals of the restoration project were and how these goals were developed. In this section, we briefly discuss how future wetland restoration projects may use the watershed approach to set project goals.

The National Research Council recommended that mitigation programs use a watershed approach when designing wetland restoration projects (NRC 2001), and the new federal rules for mitigation explicitly state that a watershed approach must be used where practicable (73 FR 19674). The basic principle behind the watershed approach is to encourage restoration practitioners to make informed decisions based on watershed needs as they plan their restoration project. Rather than plan each restoration project on a case-by-case basis, project leaders should understand how their restoration projects can fit into a larger context and help meet a variety of watershed goals to improve aquatic resources.

Ideally, wetland restoration practitioners can use a comprehensive watershed plan that has already been developed to help them plan their projects. Such a plan should address the current status of wetland resources and other water resources and identify specific wetland services needed in different areas. Plans that are comprehensive to this degree and specifically geared toward wetland resources are generally not available in Wisconsin at this time. However, a GIS layer of potentially restorable wetlands has been completed for the southern third of Wisconsin (see Table 12). Efforts to prioritize wetland restoration opportunities and address specific wetland services have been undertaken in the Milwaukee River Basin (Kline et al. 2006), the Mead Lake watershed (Voss 2007) and the Rock River Basin (Hatch and Bernthal 2008). Additionally, information from other resources listed in Table 12 can further help restoration project leaders set their restoration goals.

Selecting the location for wetland restoration is generally the first step in the process of planning a wetland restoration. In theory, project leaders can set restoration goals first, and then use watershed plans and other information to determine the best location for meeting these goals. Compensatory mitigation should work like this, because the primary goal of compensatory restoration projects should be to compensate for wetland services lost due to permitted activities. In practice this can be difficult to achieve. A wetland restoration cannot be placed just anywhere—a drained wetland must be present. The wetland hydrology must also be restorable and the current landowner must allow the work to be done on his or her property. It can be very difficult to find locations that meet these conditions, and so the project leader may be limited to selecting among a small set of viable sites.

Once a site location for a restoration project has been selected, the project leader can focus on learning more about that location and using this information to guide the restoration design. We recommend gathering information at three different scales: first the restoration site, second the areas immediately adjacent to the site, and lastly the watershed or basin where the site is located. Information on the immediate vicinity can help determine the wetland plant community types that are most likely to be successfully restored, while local and regional information can help the project leader understand what wetland services are needed within the area.

We recommend using information about the site to try to determine how the site was altered and what wetland community types were present prior to European settlement. Some useful information may be found from historical information, such as Original Government Survey notes, but most information must be collected onsite, such as data about soils and topography. The restoration project leader may then be better able to predict the types of wetland plant communities that can establish once hydrology is restored.

If there are natural areas surrounding the restoration site, information about these neighboring communities can provide further clues about suitable restoration goals. The floristic composition of adjacent areas can help predict some of the plant species that may colonize the restoration site. The presence of a nearby reference wetland is especially useful for determining the types of native plant species the restoration project leader may want to encourage to re-establish in the restored wetland. However, if the surrounding communities are dominated by invasive species, it may not be realistic for the project leader to aim to restore plant communities with high floristic quality.

After restoration project leaders have evaluated the restoration site and the immediate vicinity, they will hopefully have a better idea of the possibilities and limitations of the types of wetland services that might be provided by the completed restoration project. The next step in the planning process is to return to a watershed approach to understand all the identified watershed needs that can be met in that location. If a watershed plan for wetland resources is available, then the information needed to help restoration project leaders take advantage of their wetland restoration opportunities may be easy to obtain. If not, then the project leader will need to seek information about different wetland services from multiple sources.

First, we recommend that the project leader examine the status of wetland resources within the watershed or basin. Information about the acreage and types of wetlands currently present and the acreage and types of wetlands that were lost can help indicate which wetland types are higher priorities for restoration. The current condition of wetlands within the region can indicate limitations to restoring floristic diversity. For example, if maps of reed canary grass coverage indicate that most wetlands within the target watershed are dominated by this invasive species, it might be difficult to get native species re-established within the project site. Information about development trends within the region can also be useful to indicate how the area may change in the future and whether or not wetland resources are likely to be impacted.

Next, the project leader should study the types of wetland services that are needed to enhance water quality and abate flooding. Within the watershed, wetland restoration project leaders should examine whether their project is in a strategic area for flood abatement or water quality treatment. The project leader should examine whether impaired water bodies or sources of watershed impairment are located near the project. Storm water plans may also indicate whether or not excess water may frequently enter the restoration site. If the location of the restoration project indicates that there is a local need to abate these types of problems, the project leader may want to revise the design of the restoration to help improve retention of flood waters or sediment.

Many wildlife species depend on wetlands for habitat, and the project leader should investigate whether their project might provide needed habitat for species that are conservation targets. There are resources in Wisconsin that can help project leaders determine whether their project is located in a priority area to restore habitat for particular species. For example, the Upper Mississippi River and Great Lakes Region Joint Venture has produced a habitat conservation strategy for waterbirds (Soulliere et al. 2007) and other groups of birds that show high priority areas for wetland restoration in Wisconsin. Best management practices for the habitat of target species should be studied so that the restored wetland communities can be managed properly.

The restoration project leader must then use all the accumulated information about the project location to help set the project's restoration goals. In some cases, the project leader will need to reconcile the needs of the watershed with the limitations of the site. For example, there may be a need for forested wetlands in the area, but if the project area is small and not adjacent to any other forested areas, a forested wetland restoration might not make sense in that location. In other cases, different watershed needs may conflict with each other. For example, the project may be located in an area that is a high priority for flood abatement and a high priority for restoring habitat of a rare animal species, but the wetland types that can best store flood water to abate flooding many not be the same type of wetland that can provide habitat for the animal. Ideally, a watershed plan should identify the highest priorities for wetland restoration activities; otherwise, the project leader will need to decide the most practical set of restoration goals based on the available information.

We hope that placing individual wetland restoration projects in a larger context will encourage the restoration of wetlands that are constructed and managed so that they will help meet local and regional needs for aquatic resources. The watershed approach should be helpful to wetland restoration practitioners in planning their restoration projects, especially once watershed plans specific to wetland resources become more widely available.

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Tables

Table 1: List of restoration study sites included in our study.

Site Name	Site Type	County	Year Restoration Completed	Wetland Hectares
Cull	WisDOT mitigation	Waukesha	2000	7.3
Dane County North	Private mitigation bank	Dane	1998	7.0
Dane County South	Private mitigation bank	Dane	1998	10.5
Glacier Ridge North	Private mitigation bank	Dodge	2004	4.8
Glacier Ridge South	Private mitigation bank	Dodge	2004	0.7
Gundrum East	WisDOT mitigation	Washington	1998	10.5
Gundrum West	WisDOT mitigation	Washington	1998	2.1
Mann	Wetland Reserve Program	Walworth	2005	11.5
Martinelli East	Wetland Reserve Program	Dane	2003	7.6
Martinelli West	Wetland Reserve Program	Dane	2003	3.6
Middleton	Private mitigation	Dane	2003	0.8
Moyer-Kemper North	WisDOT mitigation	Waukesha	1996	1.4
Moyer-Kemper South	WisDOT mitigation	Waukesha	1996	0.8
Murn	Wetland Reserve Program	Waukesha	1999	2.7
Peters East	WisDOT mitigation	Waukesha	1995	9.7
Peters West	WisDOT mitigation	Waukesha	1995	3.9
Princes Point	WisDOT mitigation bank	Jefferson	1996	18.0
Savoy	Wetland Reserve Program	Columbia	2003	3.9
STH 20	WisDOT mitigation	Racine	1998	1.8
Target	Private mitigation	Milwaukee	2003	6.2
Walkerwin East	Private mitigation bank	Columbia	1996	18.2
Walkerwin West	Private mitigation bank	Columbia	1996	11.4
Wangard North	Private mitigation	Waukesha	2003	0.6
Wangard South	Private mitigation	Waukesha	2003	0.4
Waupun North	WisDOT mitigation bank	Dodge	1997	17.0
Waupun South	WisDOT mitigation bank	Dodge	1997	14.4
Wilke Preserve	WWA restoration	Dane	1997	3.6
Witte-Dane North	Wetland Reserve Program	Dane	2002	7.9
Witte-Dane South	Wetland Reserve Program	Dane	2002	5.5
Witte-Jefferson	Wetland Reserve Program	Jefferson	1999	5.7

Table 2: Classification of National Agricultural Statistics Service land cover types by land use intensity.

Class 1	Class 2	Class 3	Class 4	Class 5
Deciduous Forest	Barren	Alfalfa	Low Intensity Urban	High Intensity Urban
Evergreen Forest	Clover/Wildflowers	Barley		
Grassland Herbaceous	Fallow/Idle Cropland	Canola		
Herbaceous Wetlands	Grass/Pasture/Non-agriculture	Corn		
Mixed Forest		Dry Beans		
Open Water		Misc. Vegetables/Fruit		
Shrubland		Oats		
Wetlands		Other Crops		
Woodland		Other Small Grains		
Woody Wetland		Peas		
		Potatoes		
		Rye		
		Soybeans		
		Spring Wheat		
		Sunflowers		
		Winter Wheat		
		Winter Wheat/Soybeans		

Table 3: The 38 plant species with the highest mean of the relative occurrence and cover. Occurrence is the average frequency that species were found within wetland plant community types. Cover is the average cover that species were found within wetland plant community types.

Latin name	Common name	Indicator status	Vegetation type	Average occurrence (%)	Average cover (%)	Mean of relative occurrence and cover (%)
Phalaris arundinacea [ab]	reed canary grass	FACW	Grass	73.2	21.4	7.3
Typha angustifolia [ab]	narrow-leaved cattail	OBL	Forb	57.3	13.9	4.9
Salix exigua	sandbar willow	OBL	Shrub	48.8	7.5	3.0
Juncus tenuis	path rush	FAC	Graminoid	35.4	7.1	2.6
Aster firmus	shining aster	FACW+	Forb	46.3	6.3	2.6
Leersia oryzoides	rice cutgrass	OBL	Grass	48.8	4.9	2.3
Solidago canadensis	Canada goldenrod	FACU	Forb	47.6	4.6	2.2
Typha x glauca [ab]	hybrid cattail	OBL	Forb	37.8	5.1	2.1
Aster lanceolatus	panicled aster	NI	Forb	48.8	3.7	1.9
Scirpus atrovirens	green bulrush	OBL	Graminoid	50.0	3.6	1.9
Eleocharis erythropoda	red-rooted spike rush	OBL	Graminoid	31.7	3.5	1.6
Solidago gigantea	giant goldenrod	FACW	Forb	41.5	2.7	1.5
Agrostis gigantea [a]	red top	FACW+	Grass	28.1	3.6	1.5
Lemna minor	duckweed	OBL	Forb	22.0	4.0	1.5
Calamagrostis canadensis	bluejoint grass	OBL	Grass	24.4	3.3	1.4
Typha latifolia	broadleaf cattail	OBL	Forb	31.7	2.7	1.4
Carex vulpinoidea	fox sedge	OBL	Graminoid	30.5	2.7	1.3
Scirpus fluviatilis	river-bulrush	OBL	Graminoid	34.2	2.3	1.3
Populus deltoides	eastern cottonwood	FAC+	Tree	26.8	2.7	1.2
Carex lacustris	lake sedge	OBL	Graminoid	17.1	3.2	1.2
Poa pratensis [ab]	Kentucky blue grass	FAC-	Grass	23.2	2.8	1.2
Scirpus cyperinus	woolgrass	OBL	Graminoid	39.0	1.7	1.2
Polygonum amphibium	water knotweed	OBL	Forb	36.6	1.8	1.2
Eupatorium perfoliatum	common boneset	FACW	Forb	36.6	1.7	1.2
Schoenoplectus tabernaemontani	softstem bulrush	OBL	Graminoid	36.6	1.6	1.1
Helenium autumnale	common sneezeweed	FACW	Forb	29.3	2.1	1.1
Epilobium coloratum	purpleleaf willow-herb	OBL	Forb	26.8	2.0	1.0
Ambrosia trifida	giant ragweed	FAC+	Forb	23.2	2.0	1.0
Verbena hastata	swamp verbena	FACW	Forb	36.6	1.1	1.0
Salix discolor	pussy-willow	FACW	Shrub	28.1	1.4	0.9
Bidens cernuus	nodding beggartick	OBL	Forb	23.2	1.7	0.9
Carex stricta	tussock sedge	OBL	Graminoid	13.4	2.4	0.9
Asclepias incarnata	swamp milkweed	OBL	Forb	35.4	0.8	0.9
Eupatorium maculatum	spotted joepyeweed	OBL	Forb	29.3	1.3	0.9
Cirsium arvense [ab]	Canada thistle	FACU	Forb	26.8	1.4	0.9
Euthamia graminifolia	flat-top goldentop	FAC	Forb	25.6	1.5	0.9
Alisma subcordatum	American water plantain	OBL	Forb	24.4	1.4	0.8
Juncus torreyi	Torrey's rush	FACW	Graminoid	19.5	1.6	0.8

[a]Species is not native to Wisconsin

[b]Species is listed as a invasive species by the Invasive Plant Association of Wisconsin

Table 4: ANOVA analysis of differences in floristic quality among wetland plant community types. Mean values followed by different letters are significantly different (Tukey's HSD test, p < 0.05).

Measure of floristic quality	Mean value				F	P-value
	Fresh wet meadow	Sedge meadow	Shallow marsh	Shrub - carr		
Mean C	2.5a	3.8c	2.9b	2.6ab	11.4	< 0.001
Floristic quality index	17.7b	20b	11.6a	10.3a	12.0	< 0.001
Native species richness	38.6b	25.5a	12.6a	12.6a	27.9	< 0.001
Exotic species richness	12.0b	2.3a	3.3a	3.1a	34.5	< 0.001

Table 5: Multiple linear regression models for each of the floristic quality measures selected through backwards elimination.

Measure of floristic quality	Slope of significant factors in final models				Y-intercept	R-squared	P-value
	Area of plant community (log square meters)	Number of species planted to site	Percent cover of class one land use within 0.5 km	Land use intensity score within one km			
Mean C	-0.36	—	-1.80	-2.40	5.87	0.231	0.001
Floristic quality index	—	0.17	—	—	13.61	0.123	0.005
Native species richness	7.89	0.60	—	—	-12.40	0.217	0.001
Exotic species richness	3.94	—	—	—	-9.24	0.152	0.001

Table 6: Percent frequency of occurrence of avian species at monitoring stations during three dates in 2008 at five wetland restoration projects in Dane County. Overall percent frequency is the number of times a species was observed at any of the nine monitoring stations during all three monitoring dates.

Common name	Latin name	Dane	Martin-elli	Middle-ton	Wilke Preserve	Witte-Dane	Overall frequency
	Number of stations	**2**	**2**	**1**	**1**	**3**	**9**
Red-winged blackbird	*Agelaius phoeniceus*	1	1	1	1	1	1
Song sparrow	*Melospiza melodia*	1	0.83	1	0.33	0.89	0.85
Common yellowthroat[2]	*Geothlypis trichas*	0.67	0.83	0.67	0.67	0.44	0.63
Sora[2]	*Porzana carolina*	0	1	0	1	0.89	0.63
Swamp sparrow[2]	*Melospiza georgiana*	0	0.83	0.67	1	0.56	0.56
Canada goose	*Branta canadensis*	0	0.17	0.33	0.67	0.67	0.37
Sedge wren[2]	*Cistothorus platensis*	0.83	0.5	0.33	0	0.11	0.37
Tree swallow	*Tachycineta bicolor*	0	0.33	0.67	0	0.67	0.37
Barn swallow[2]	*Hirundo rustica*	0	0.17	0	0	0.89	0.33
Marsh wren[2]	*Cistothorus palustris*	0	0.67	0	0.67	0.11	0.26
Eastern meadowlark[1]	*Sturnella magna*	0.67	0.17	0.33	0	0	0.22
Willow flycatcher[1]	*Empidonax traillii*	0.33	0.33	0.33	0	0.11	0.22
American goldfinch	*Carduelis tristis*	0.67	0.17	0	0	0.22	0.19
Sandhill crane	*Grus canadensis*	0.33	0.33	0	0	0.11	0.19
Virginia rail[2]	*Rallus limicola*	0	0.33	0	0.33	0.22	0.19
American robin	*Turdus migratorius*	0	0.33	0.33	0	0.11	0.15
Mallard	*Anas platyrhynchos*	0	0	0	0.67	0.22	0.15
Pied-billed grebe[2]	*Podilymbus podiceps*	0	0	0	0	0.44	0.15
Ring-necked pheasant	*Phasianus colchicus*	0.33	0	0.33	0	0.11	0.15
Yellow warbler	*Dendroica petechia*	0.17	0.17	0	0	0.22	0.15
American coot[2]	*Fulica americana*	0	0	0	0	0.33	0.11
Mourning dove	*Zenaida macroura*	0.17	0.17	0	0.33	0.11	0.11
American bittern[1]	*Botaurus lentiginosus*	0	0	0	0.33	0.11	0.07
American crow	*Corvus brachyrhynchos*	0.17	0	0	0	0.33	0.07
Black-billed cuckoo[1]	*Coccyzus erythropthalmus*	0.33	0	0	0	0	0.07
Common grackle	*Quiscalus quiscula*	0	0	0	0	0.22	0.07
Field sparrow[1]	*Spizella pusilla*	0.33	0	0	0	0	0.07
Henslow's sparrow[1]	*Ammodramus henslowii*	0.33	0	0	0	0	0.07
Northern rough-winged swallow[2]	*Stelgidopteryx serripennis*	0	0	0	0	0.22	0.07
Savannah sparrow	*Passerculus sandwichensis*	0	0	0.67	0	0	0.07
Black-capped chickadee	*Poecile atricapillus*	0	0.17	0	0	0	0.04
Blue-winged teal[1]	*Anas discors*	0	0.17	0	0	0	0.04
Greater white-fronted goose	*Anser albifrons*	0	0	0	0	0.11	0.04
Green heron	*Butorides Virescens*	0	0	0	0.33	0	0.04

Common name	Latin name	Dane	Martin-elli	Middle-ton	Wilke Preserve	Witte-Dane	Overall frequency
	Number of stations	2	2	1	1	3	9
Killdeer	*Charadrius vociferus*	0	0	0	0.33	0	0.04
Northern cardinal	*Cardinalis cardinalis*	0	0.17	0	0	0	0.04
Orchard oriole	*Icterus spurius*	0	0	0	0	0.11	0.04
Rock dove	*Columba livia*	0.17	0	0	0	0	0.04
Solitary sandpiper[1]	*Tringa solitaria*	0	0	0	0	0.11	0.04
Turkey vulture	*Cathartes aura*	0	0	0	0	0.11	0.04
Wood duck	*Aix sponsa*	0	0	0	0	0.11	0.04
Yellow-billed cuckoo[1]	*Coccyzus americanus*	0	0	0	0	0.11	0.04
Yellow-rumped warbler	*Dendroica coronata*	0	0	0	0	0.11	0.04

[1]Primary species. See Appendix E.

[2]Secondary species. See Appendix E.

Table 7: Total number of avian point count stations and total wetland area within each wetland restoration project. Total species = Total number of avian species detected during at least two monitoring dates at one or more count stations. Number primary species or secondary species = Number (see Appendix E) detected during at least two monitoring dates at one or more stations.

Project	Point count stations	Meadow wetland hectares	Marsh wetland hectares	Open water hectares	Total species	Number primary species	Number secondary species
Dane	2	14.3	2.6	0	9	3[a]	2[b]
Martinelli	2	6.5	4.1	0.7	9	0	6[c]
Middleton	1	0.8	0	0	6	0	2[d]
Wilke Preserve	1	1.5	2	0.1	7	0	4[e]
Witte-Dane	3	4.7	4.5	4.2	11	0	7[f]

[a]Eastern meadowlark, field sparrow, Henslow's sparrow
[b]Common yellowthroat, sedge wren
[c]Common yellowthroat, marsh wren, sedge wren, sora, swamp sparrow, Virginia rail
[d]Common yellowthroat, swamp sparrow
[e]Common yellowthroat, marsh wren, sora, swamp sparrow
[f]American coot, barn swallow, common yellowthroat, pied-billed grebe, sora, swamp sparrow, Virginia rail

Table 8: Average number of individuals of the marshbird target species detected per visit within restoration projects. We detected birds at monitoring stations, and restorations projects had either one, two or three stations. We visited monitoring stations three times.

Project	Number of stations	American bittern	American coot	Marsh wren	Pied-billed grebe	Sora	Swamp sparrow	Virginia rail
Dane	2	0	0	0.2	0	0	0	0
Martinelli	2	0	0	0.5	0	1.3	1.5	0.3
Middleton	1	0	0	0	0	0	1.0	0
Wilke Preserve	1	0.3	0	2.0	0	1.7	2.7	0.3
Witte-Dane	3	0.1	0.4	0	0.4	2.1	0.7	0.2

Table 9: Detection of amphibian species within six wetland restoration projects, including the overall frequency at which the species was observed all sites, and the total number of species detected at each site. Call = Species was detected during the frog and toad survey. Trap = Species was detected during the trapping survey. Call + Trap = Species was detected during both surveys. Seen = Species was observed at the site outside of a trap. Not Detected = Species was not observed at the site.

Common name	Latin name	Dane	Gundrum	Martinelli	Middleton	Wilke	Witte Dane	Site Frequency
	Number of traps	0	6	8	0	4	10	
American toad	*Bufo americanus*	Call	Not Detected	Call	Call	Call	Call	0.83
Chorus frog	*Pseudacris triseriata*	Not Detected	Call	Call + Trap	Call	Call	Call + Trap	0.83
Cope's gray treefrog	*Hyla chrysoscelis*	Call	-	Call	Not Detected	Not Detected	Call	0.50
Eastern gray treefrog	*Hyla versicolor*	Not Detected	Call	Call	Not Detected	Call	-	0.50
Treefrog[a]	*Hyla sp*	-	Trap	Trap	-	-	Trap	-
Green frog	*Rana clamitans*	Not Detected	Call + Trap	Call + Trap	Call	Call + Trap	Call + Trap	0.83
Leopard frog	*Rana pipiens*	Not Detected	Not Detected	Not Detected	Not Detected	Call	Seen	0.33
Spring peeper	*Pseudacris crucifer*	Call	Call	Not Detected	Not Detected	Call	Not Detected	0.50
Tiger salamander	*Ambystoma tigrinum*	No Traps	Not Detected	Not Detected	No Traps	Not Detected	Trap	0.25[b]
	Total number of species observed	3	4	5	3	6	6	

[a]We could not distinguish between the two *Hyla* species observed within traps at the tadpole stage

[b]The site frequency of salamanders was calculated using only the four sites where traps were set

Table 10: Amphibian species that may be found within six wetland restoration projects, based on presence of appropriate habitat with the species' breeding range. Primary species are amphibian species of greatest conservation need in Wisconsin (WNDR 2005).

	Dane	Gundrum	Martinelli	Middleton	Wilke Preserve	Witte-Dane
Primary species						
Pickerel frog	x					
Other species						
American toad	x	x	x	x	x	x
Central newt		x				
Chorus frog	x	x	x	x	x	x
Cope's gray treefrog	x	x	x			x
Eastern gray treefrog		x				
Green frog	x	x	x	x	x	x
Leopard frog	x	x	x	x	x	x
Spring peeper		x				
Tiger salamander		x	x			x

Table 11: Target avian species (see Appendix E) that may be found within five wetland restoration projects, based on the presence of appropriate habitat with the species' breeding range.

	Dane	Martinelli	Middleton	Wilke Preserve	Witte-Dane
Primary species					
American bittern		x		x	x
American woodcock	x				
Bell's vireo	x				x
Black-billed cuckoo	x				x
Black tern		x		x	x
Blue-winged teal		x		x	x
Bobolink	x				x
Brown thrasher	x				
Dickcissel	x				x
Eastern meadowlark	x				x
Field sparrow	x				x
Henslow's sparrow	x	x		x	x
King rail		x		x	x
Loggerhead shrike	x				x
Northern bobwhite	x				
Northern harrier	x				x
Redhead		x		x	x
Red-necked grebe		x		x	x
Willow flycatcher	x	x	x		x
Yellow-billed cuckoo	x				x
Secondary species					
American coot		x		x	x
Common moorhen		x		x	x
Common yellowthroat	x	x	x	x	x
Great blue heron		x		x	x
Least bittern	x	x		x	x
Marsh wren	x	x		x	x
Northern pintail		x		x	x
Pied-billed grebe		x		x	x
Sedge wren	x	x	x	x	x
Sora		x		x	x
Swamp sparrow	x	x	x	x	x
Wilson's snipe	x	x	x	x	x
Virginia rail		x		x	x
Yellow-headed blackbird		x		x	x

Table 12: Examples of resources that can be used when planning a wetland restoration in Wisconsin

Resource name	URL	Description of information provided
State of the Basin Reports	http://dnr.wi.gov/org/gmu/stateofbasin.html	Provides an overview of the state of water resources within each basin and makes recommendations for resource protection and restoration
Ecological Landscapes	http://dnr.wi.gov/landscapes/	Allows users to find the best opportunities to protect, manage and restore natural communities, selected habitats and aquatic features within the framework of ecosystem management
Surface Water Data Viewer	http://dnr.wi.gov/org/water/data_viewer.htm	Displays interactive maps of wetlands and all water resources (including monitoring and water quality assessment data), Outstanding/ Exceptional Resource Waters, impaired waters, and a full range of aquatic resource management data
Potentially Restorable Wetlands GIS Layer	Available for southern Wisconsin watersheds upon request through Christopher Smith, Wetland Assessment Data Coordinator, and will soon be included in the Surface Water Data Viewer	Displays areas with a potential for wetland re-establishment based on soils, wetlands and land use data
Wisconsin Wildlife Action Plan	http://dnr.wi.gov/org/land/er/wwap/implementation	Identifies wildlife Species of Greatest Conservation Need, priority conservation actions to protect them and their habitats, and the best places in the state to undertake the conservation actions
Wisconsin All-bird Plan	http://www.wisconsinbirds.org/plan/	Provides information about priority bird species, their needed habitat types and bird-related conservation opportunities within each Ecological Landscape that have high regional or continental importance
Joint Venture Strategic Plans	http://www.uppermissgreatlakesjv.org/publications.cfm	Describes conservation strategies and priority focus areas for habitat work to benefit landbirds, shorebirds, waterbirds and waterfowl

Figures

Figure 1: Location of restoration projects included in our study within southern Wisconsin.

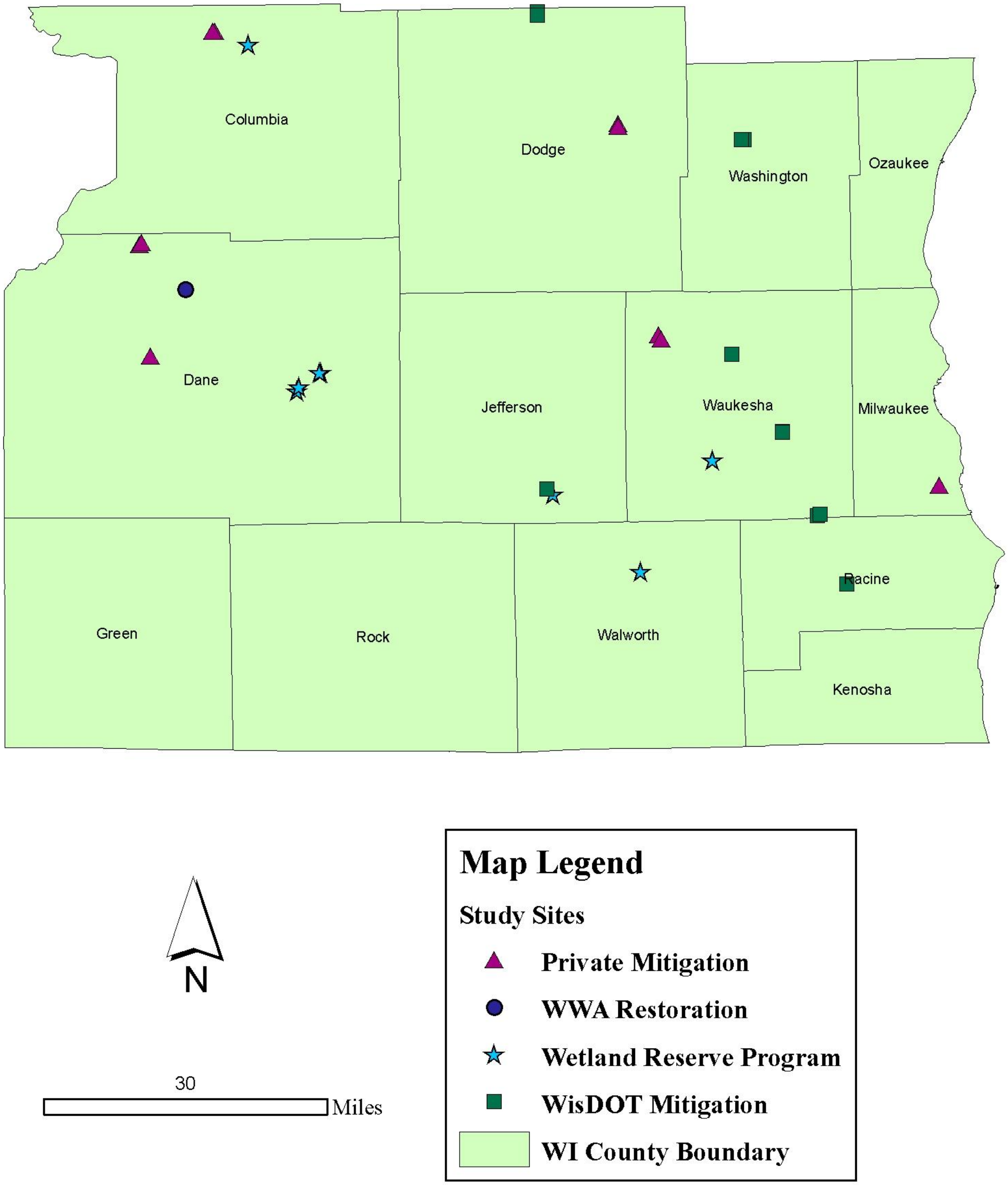


Figure 2: Catchment area that drains into the A) Walkerwin East and West and B) Savoy study sites. Site locations shown in red in the locator maps.

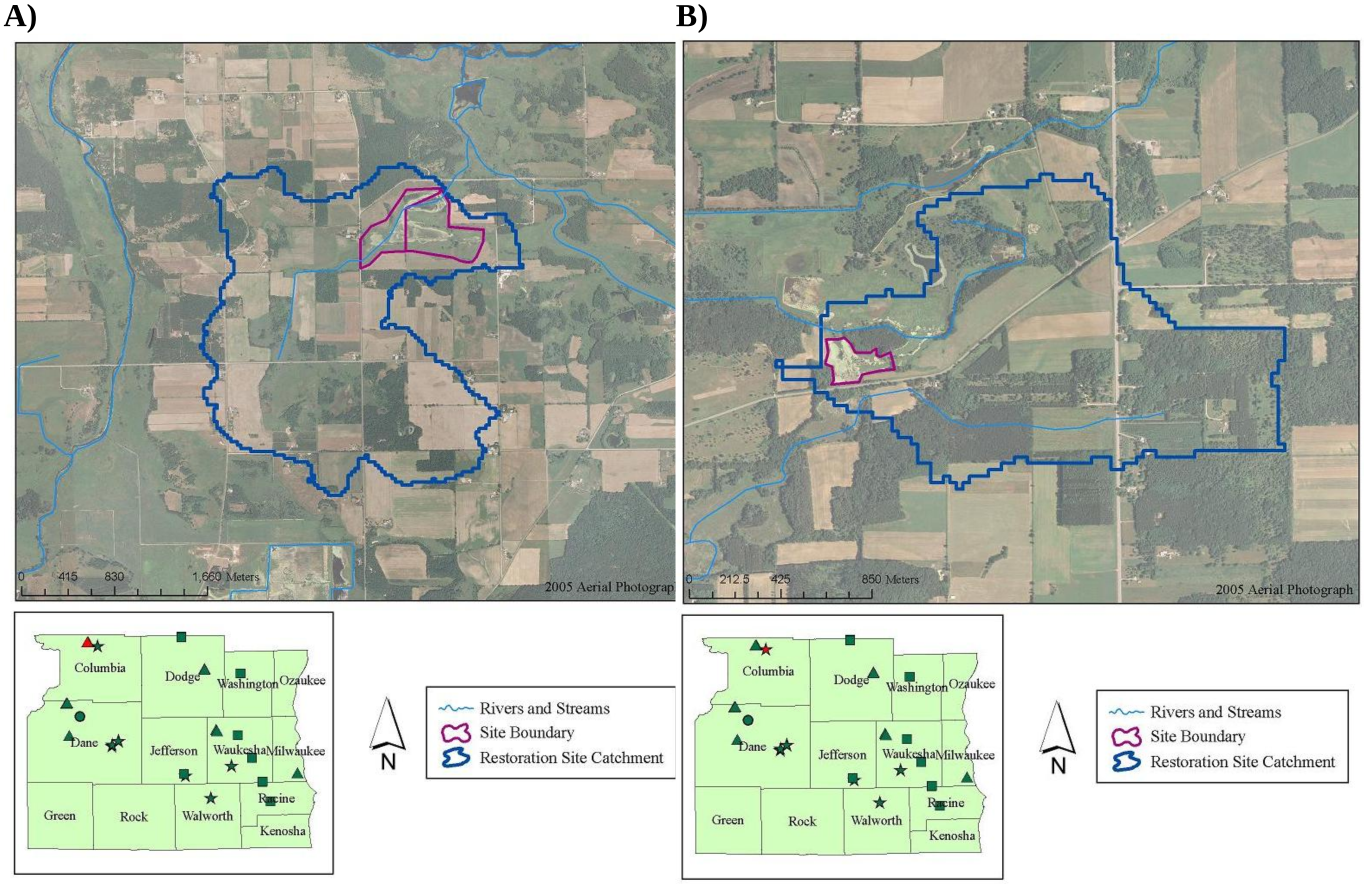


Figure 3: Comparison of land uses within A) 1 km and B) 0.5 km of the center of the Middleton restoration site. Land use data are from the 2007 Wisconsin Cropland Data Layer, National Agricultural Statistics Service.

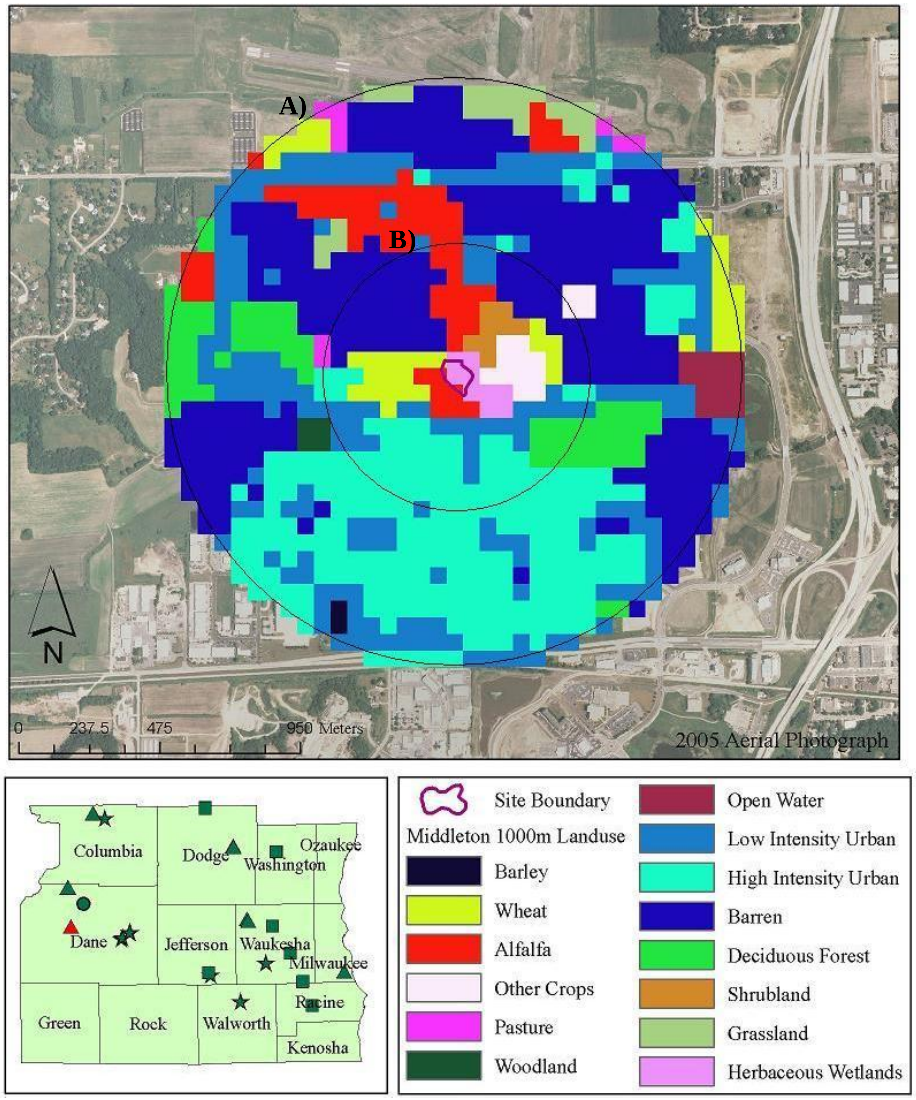


Figure 4: Wetland plant community types restored at study sites. Chart A) shows how many of the 30 study sites contain the community types and chart B) shows how the total area of all study sites is divided among the community types. The total area of all study sites is 200 hectares.

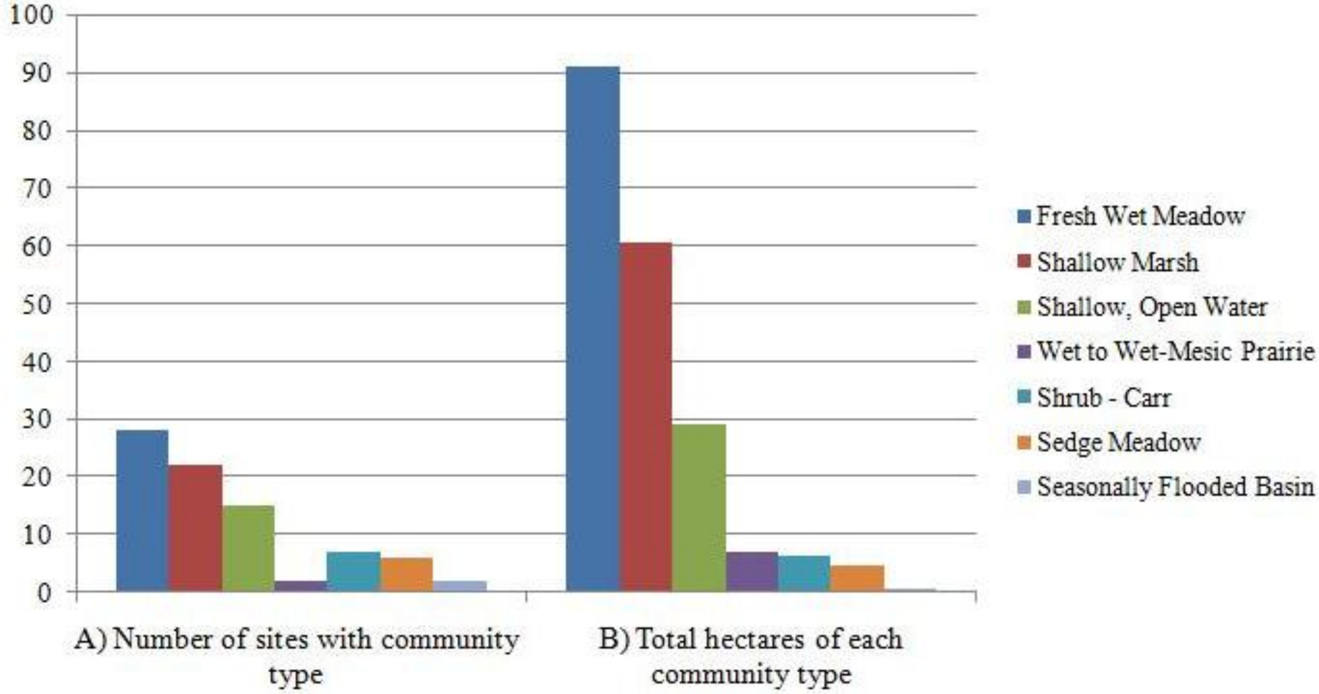


Figure 5: How the total area within A) mitigation restoration sites and B) voluntary restoration sites is divided among different wetland plant community types.

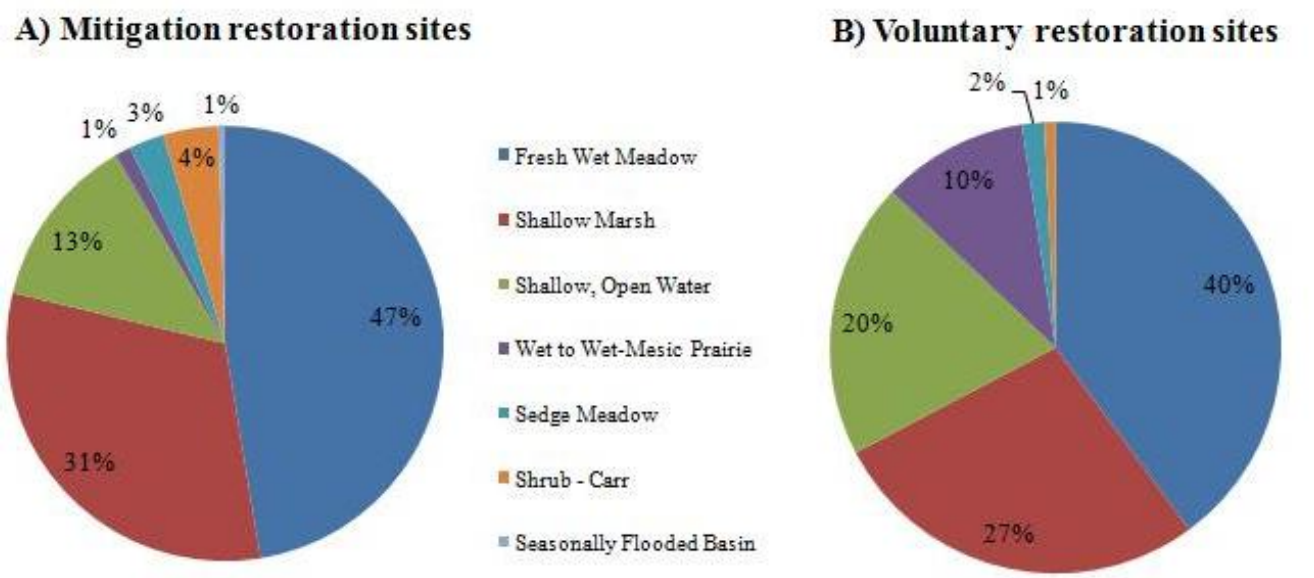


Figure 6: Floristic quality assessment values for wetland plant communities at study sites. Benchmarks for low (yellow area), medium (green area), high (blue area) and excellent (purple area) floristic quality in southern Wisconsin wetland communities are provided by Bernthal et al (2007).

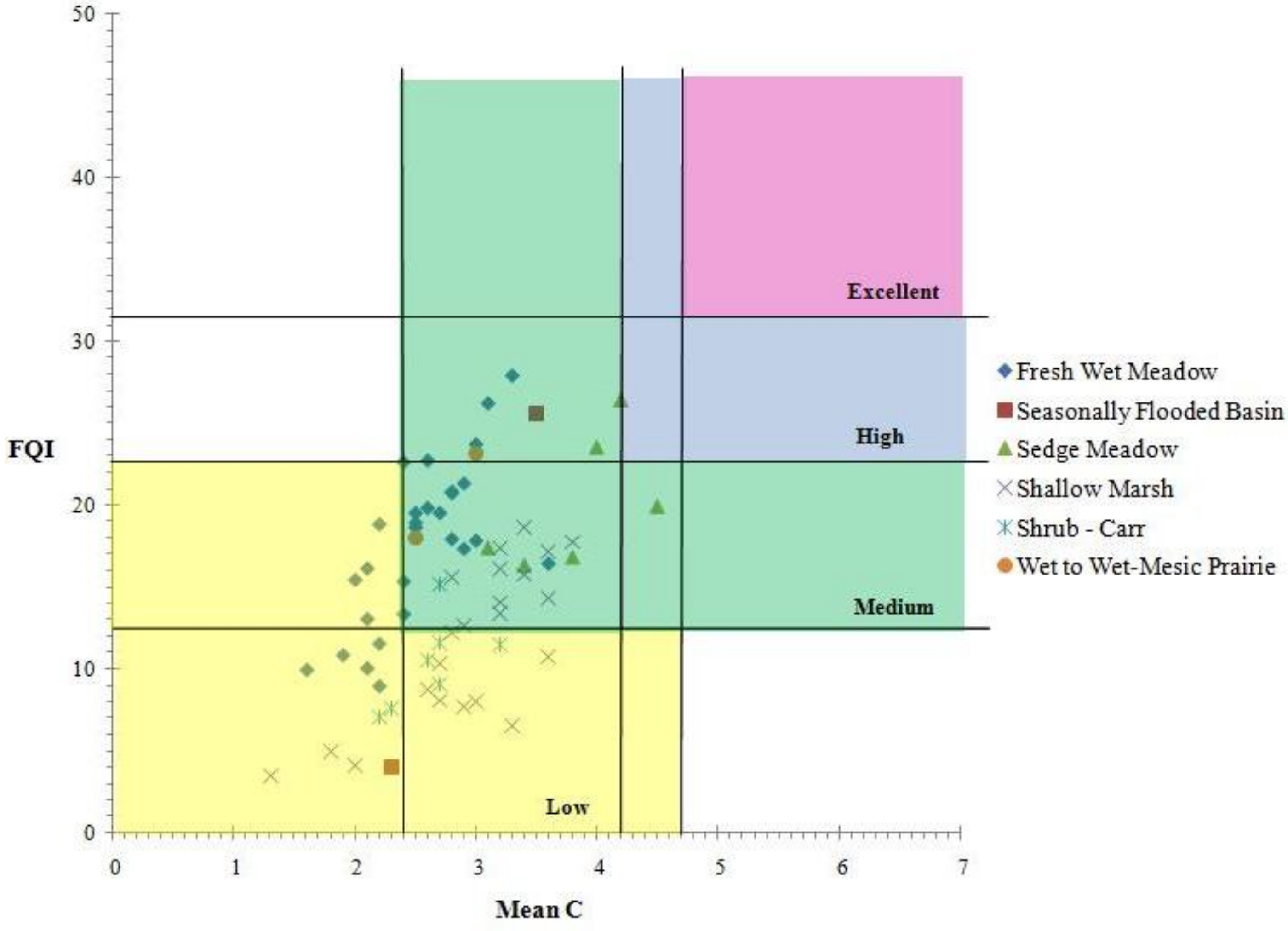


Figure 7: Comparison of floristic quality assessment values of plant communities of wetland restoration sites evaluated in 2008 with plant communities of existing (non-restoration) wetlands evaluated from 2000-2005 (data from Bernthal et al 2007). Wetland restoration plant communities are divided into communities restored as part of a mitigation requirement and those restored voluntarily. Benchmarks for low (yellow area), medium (green area), high (blue area) and excellent (purple area) floristic quality in southern Wisconsin wetland communities are provided by Bernthal et al (2007).

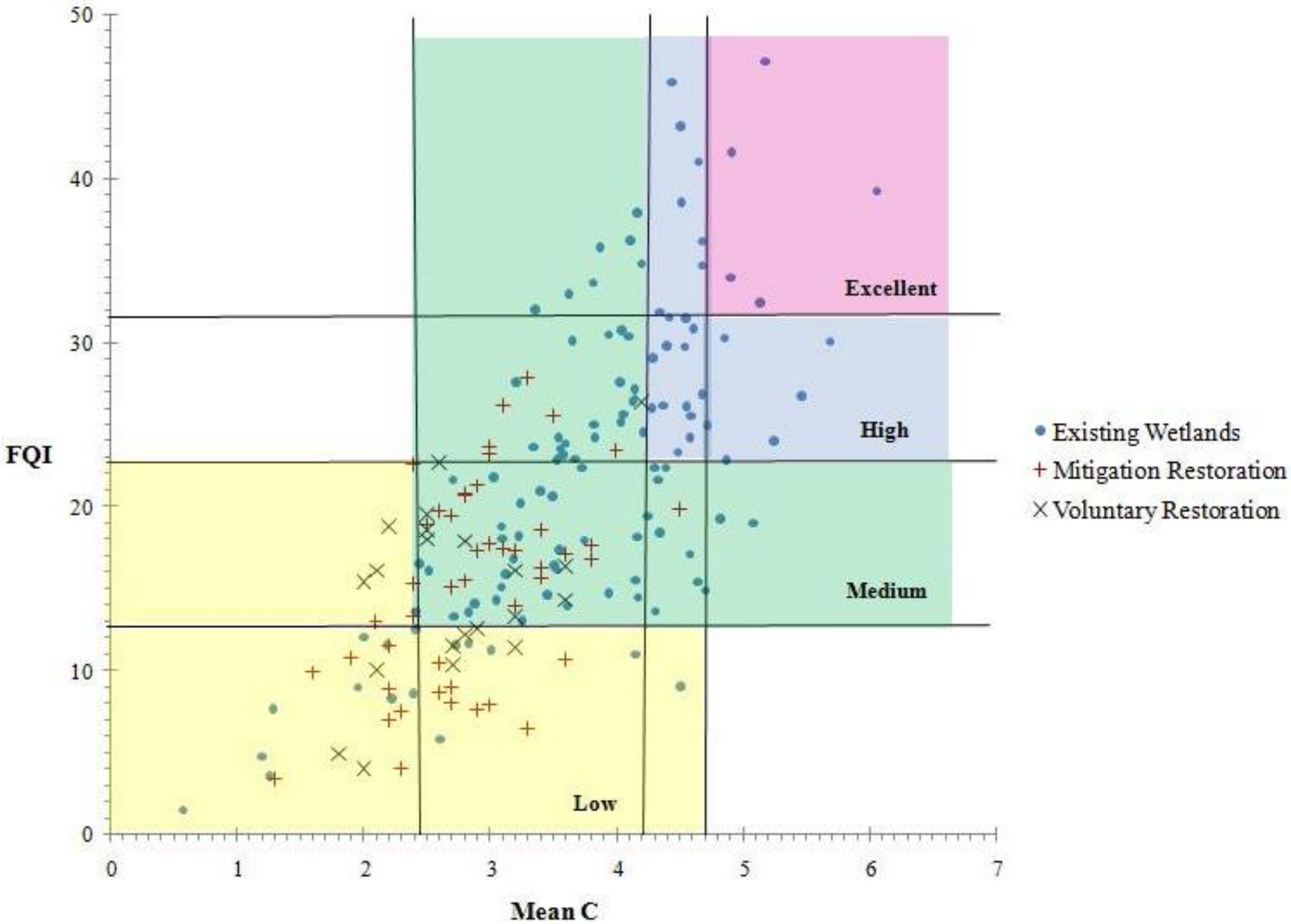


Figure 8: Comparison of the percentage of communities with certain plant types that were dominant species within A) communities with medium floristic quality (Mean C > 2.4, FQA > 12.5, Native Cover > 50%) and B) communities with low floristic quality (Mean C < 2.4, FQA < 12.5, Native Cover < 50%). Dominant species were defined as species with cover classified as abundant (between 20-89% cover) or monotype (more than 90% cover). The dominant species found within the two groups of communities are listed under the plant types.

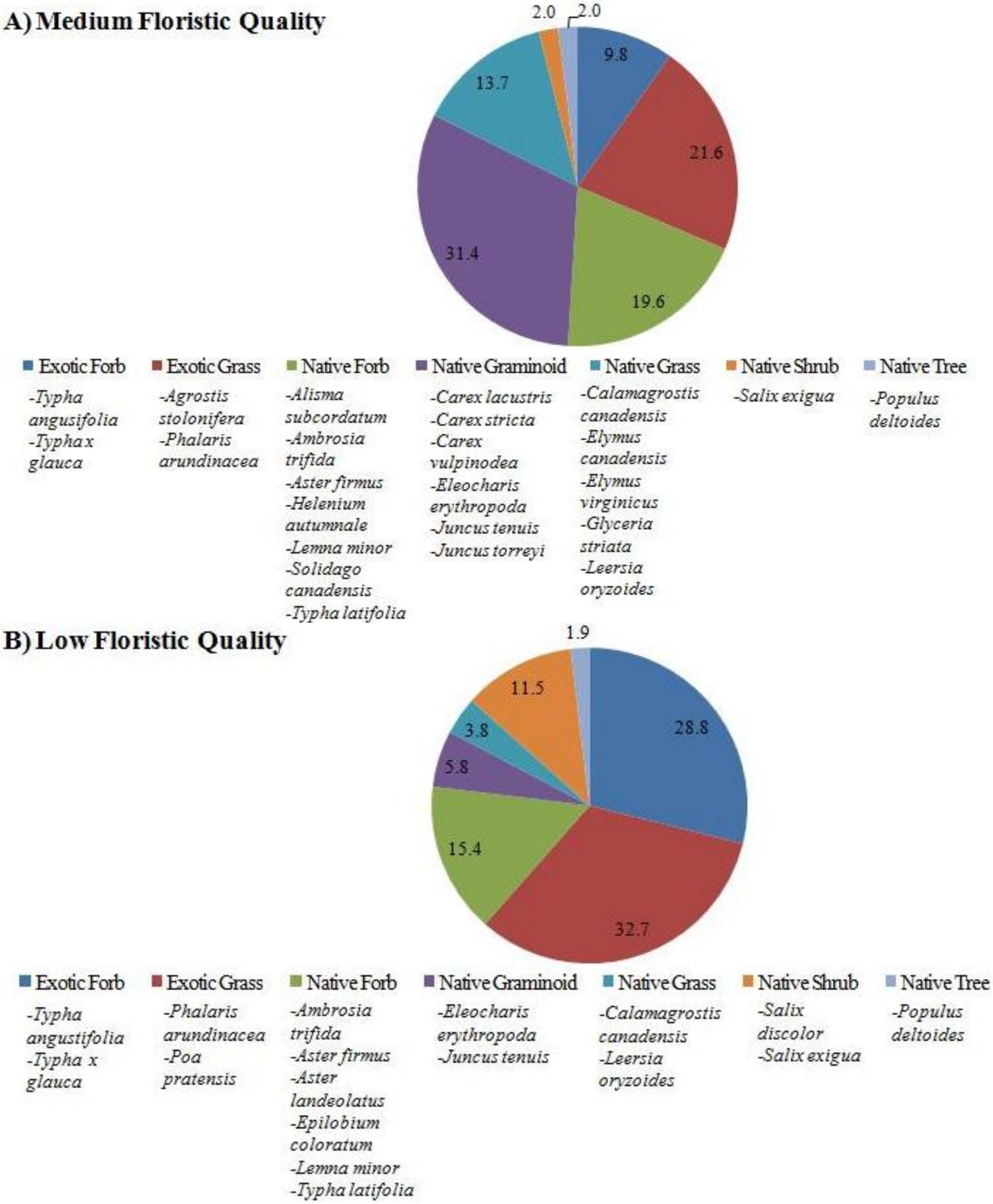
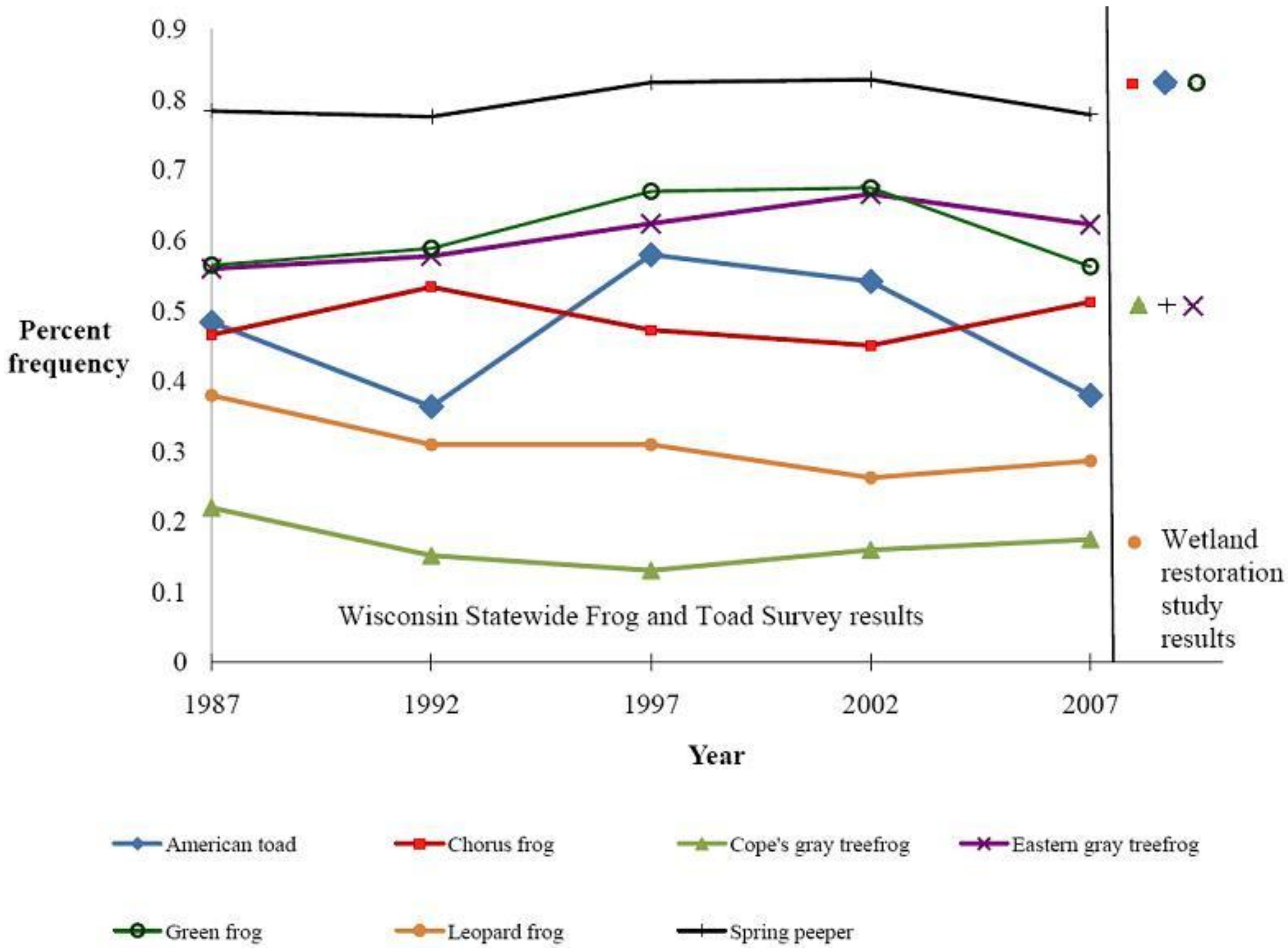


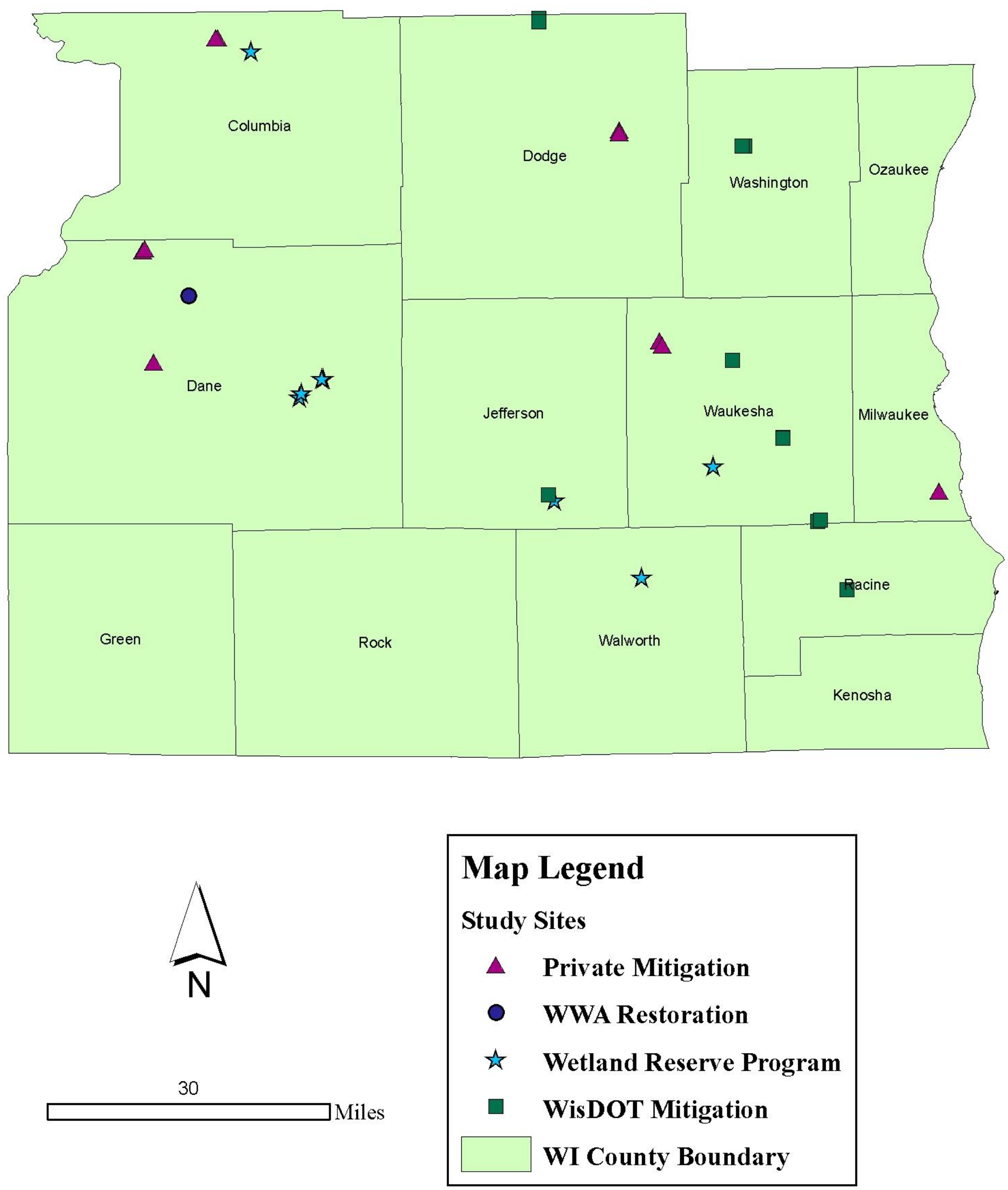
Figure 9: Percent frequency of amphibian species detected at calling stations. Results from the Statewide Frog and Toad Survey from 1987 through 2007 (to the left) are compared with the results from six wetland restoration sites in southern Wisconsin in 2008 (to the right). Only species detected during the restoration study are included.



Appendices

Appendix A: Aerial photographs of each of the study sites

Location of wetland restoration study sites



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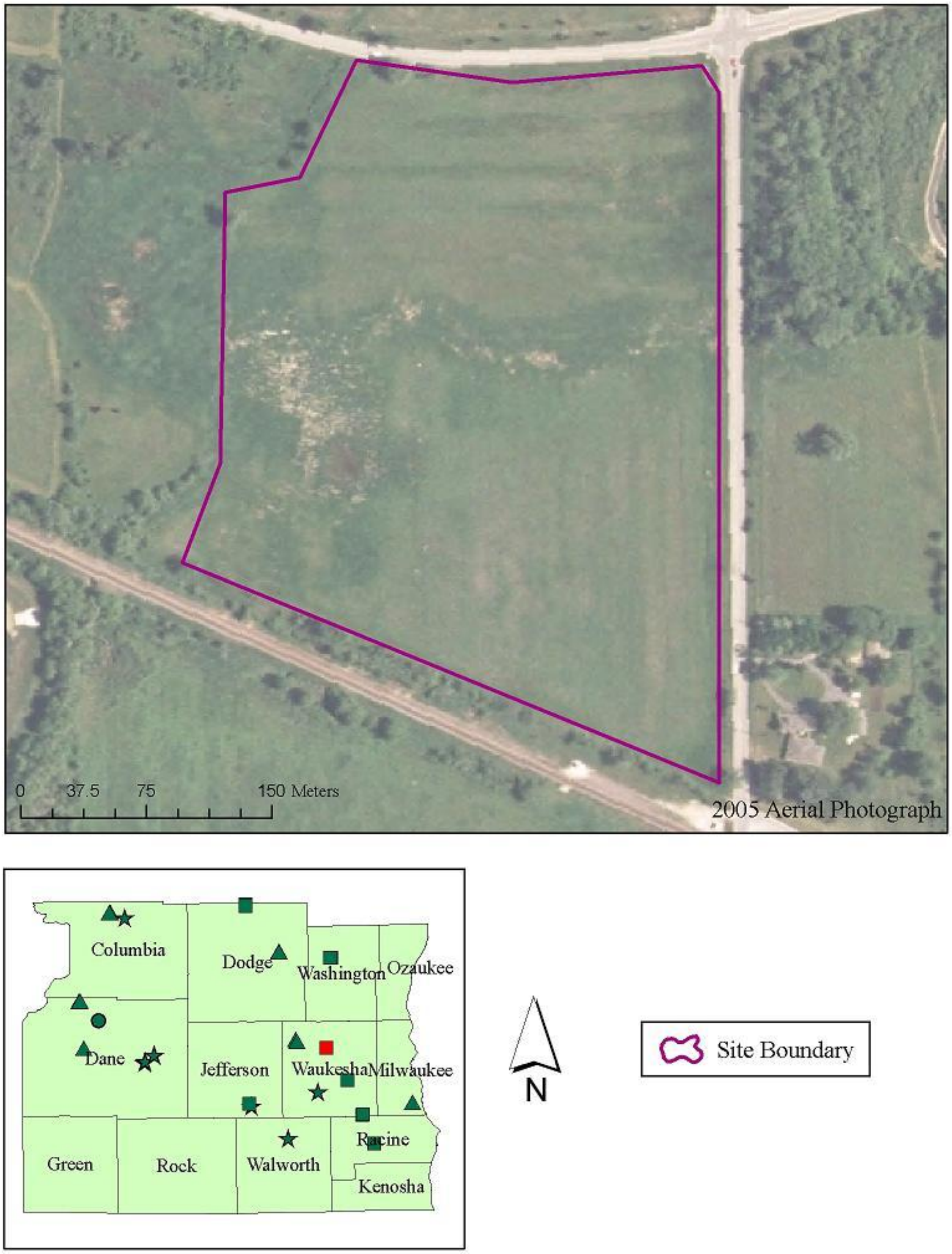
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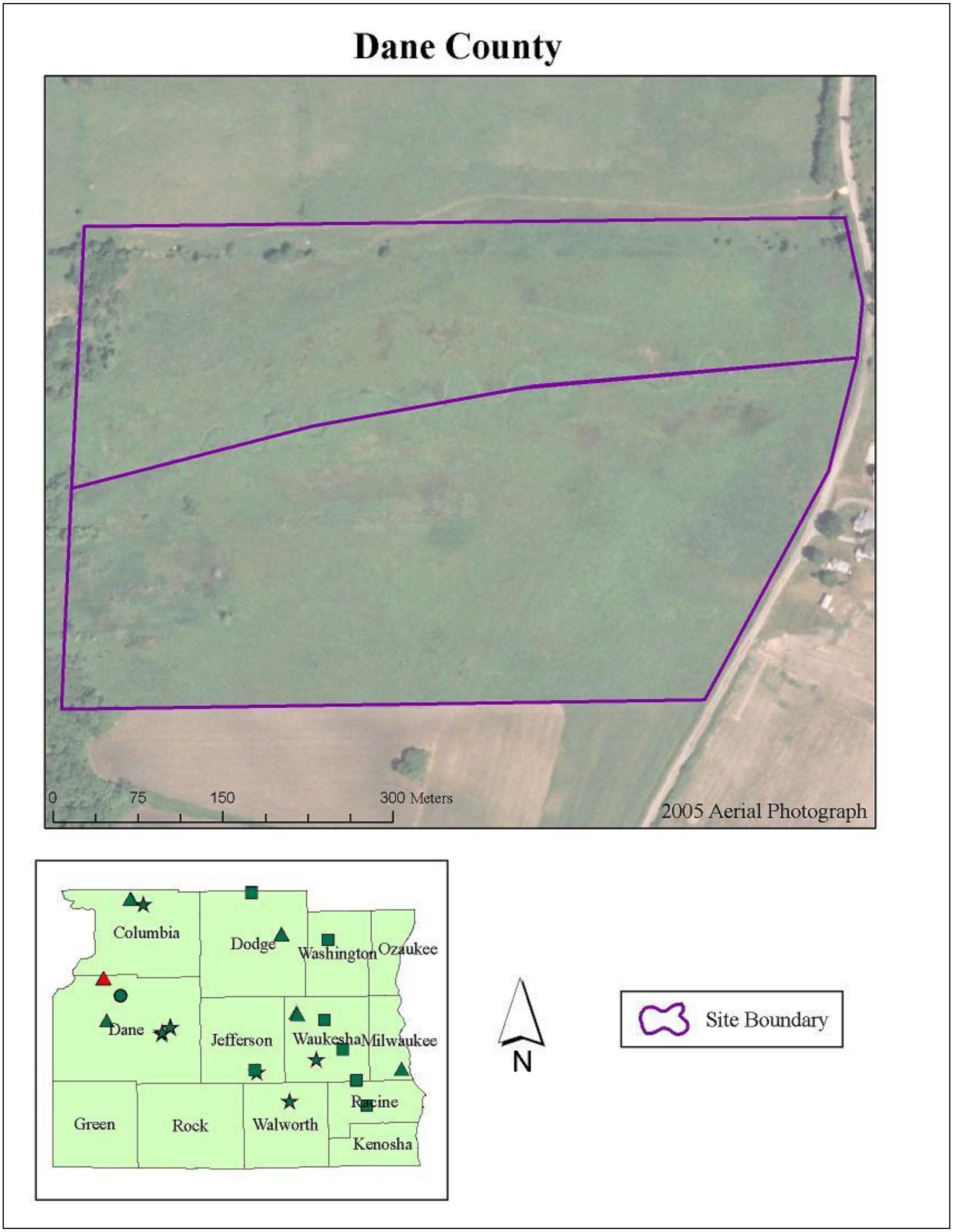
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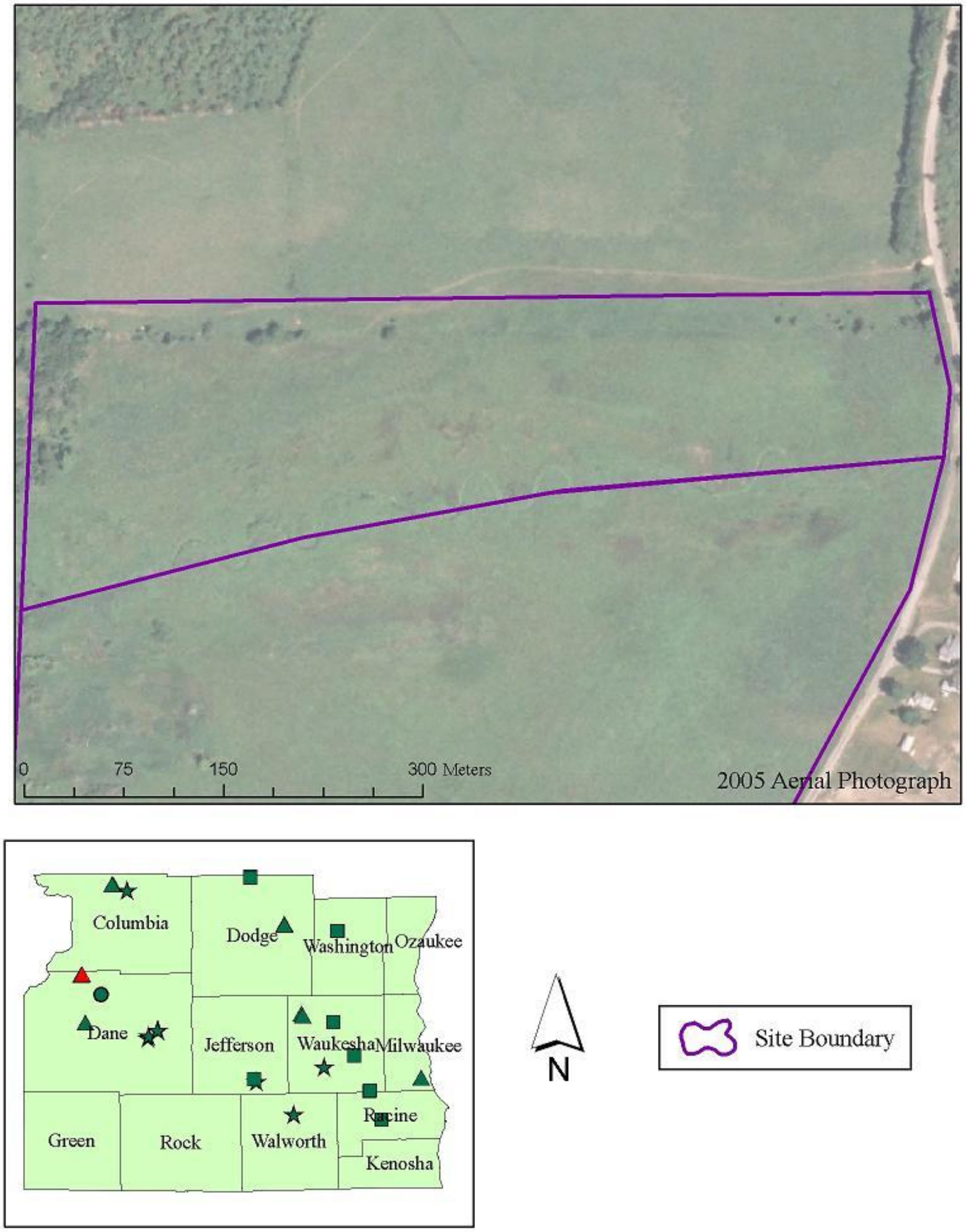
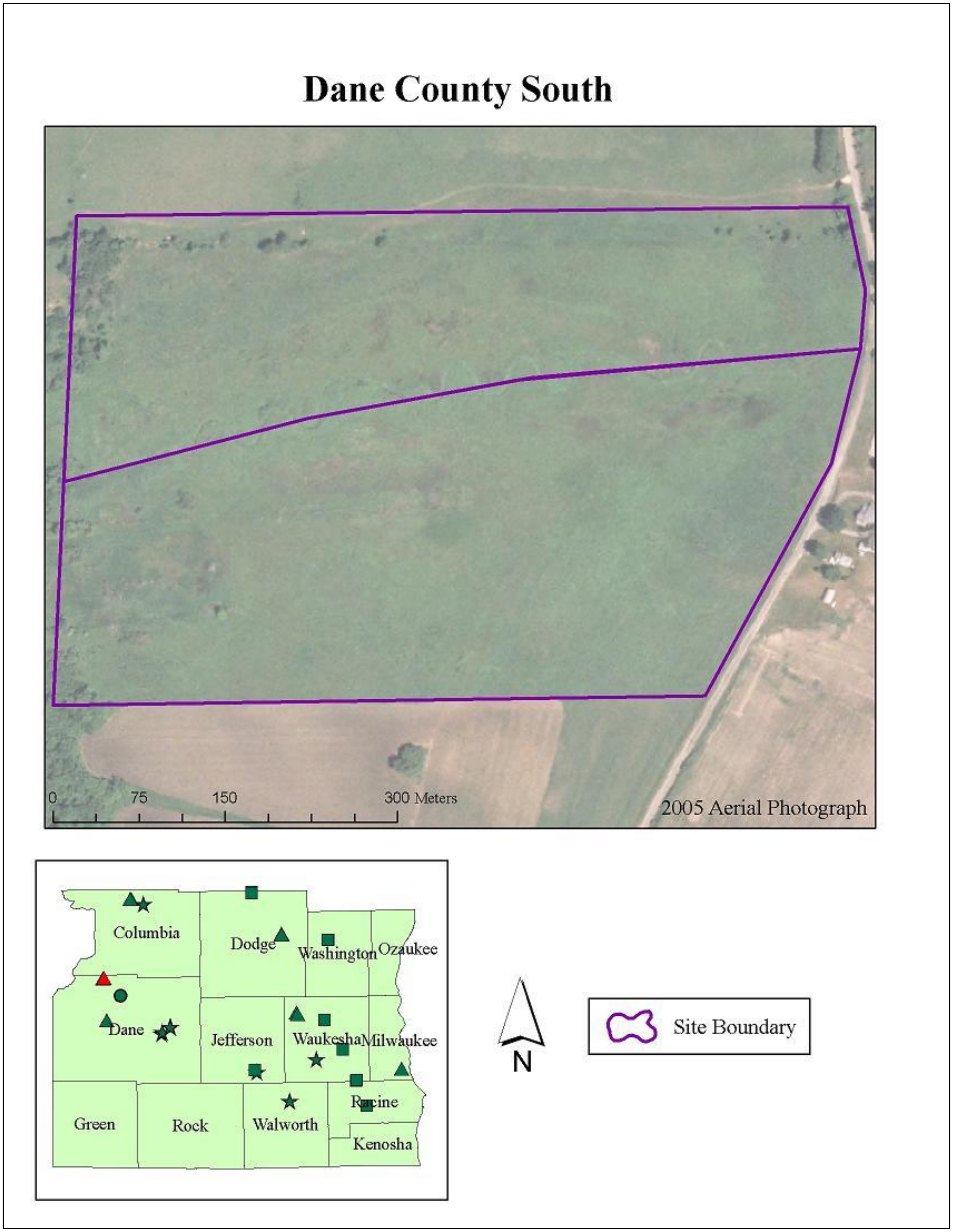
Dane County North

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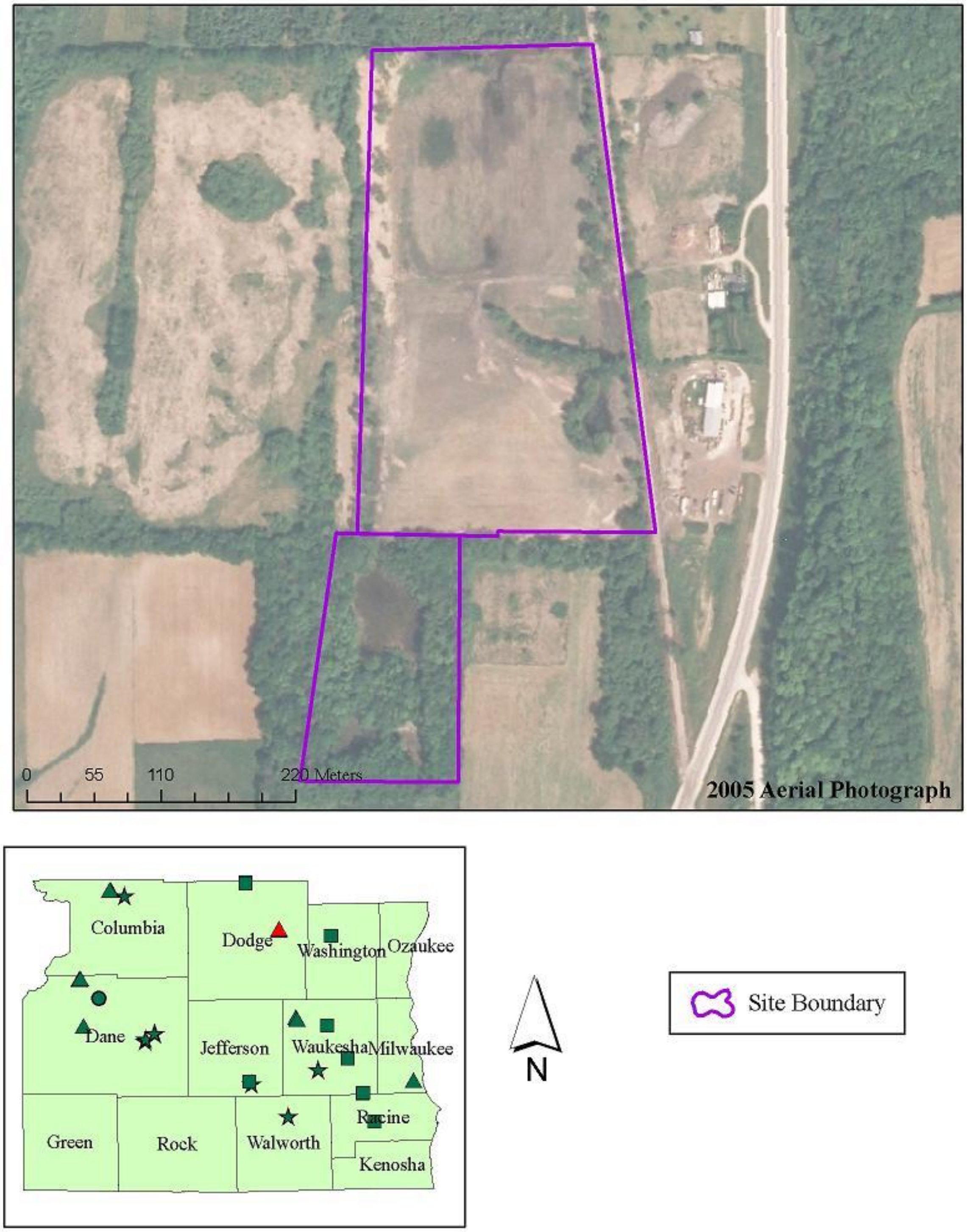
Glacier Ridge



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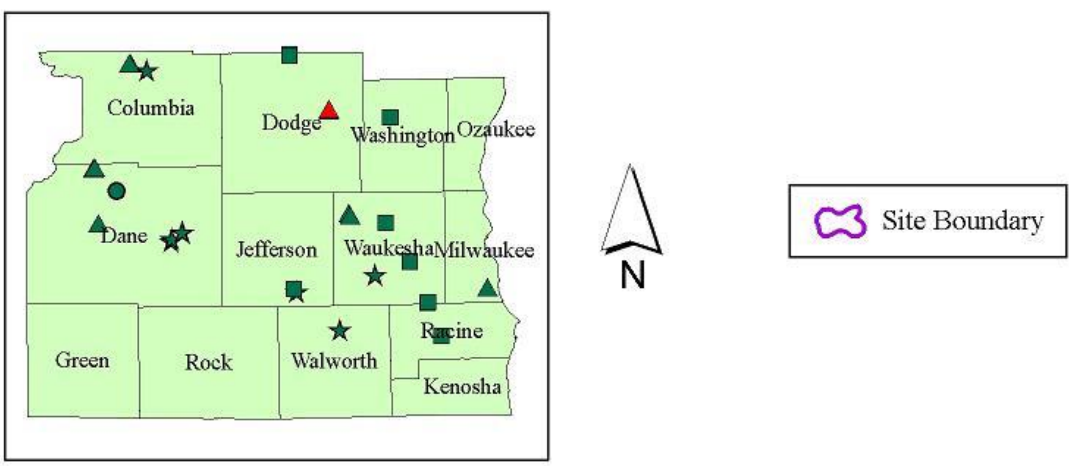

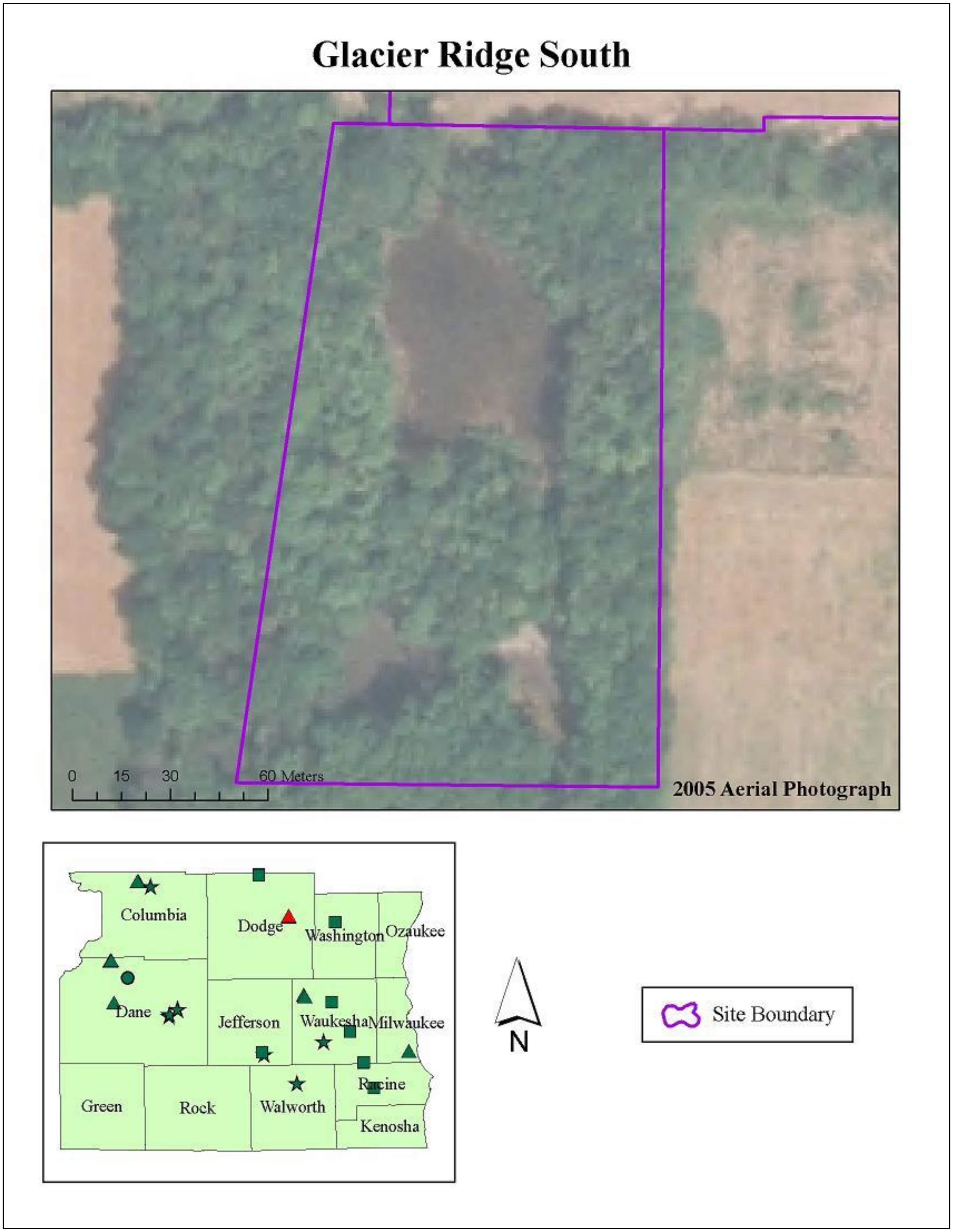
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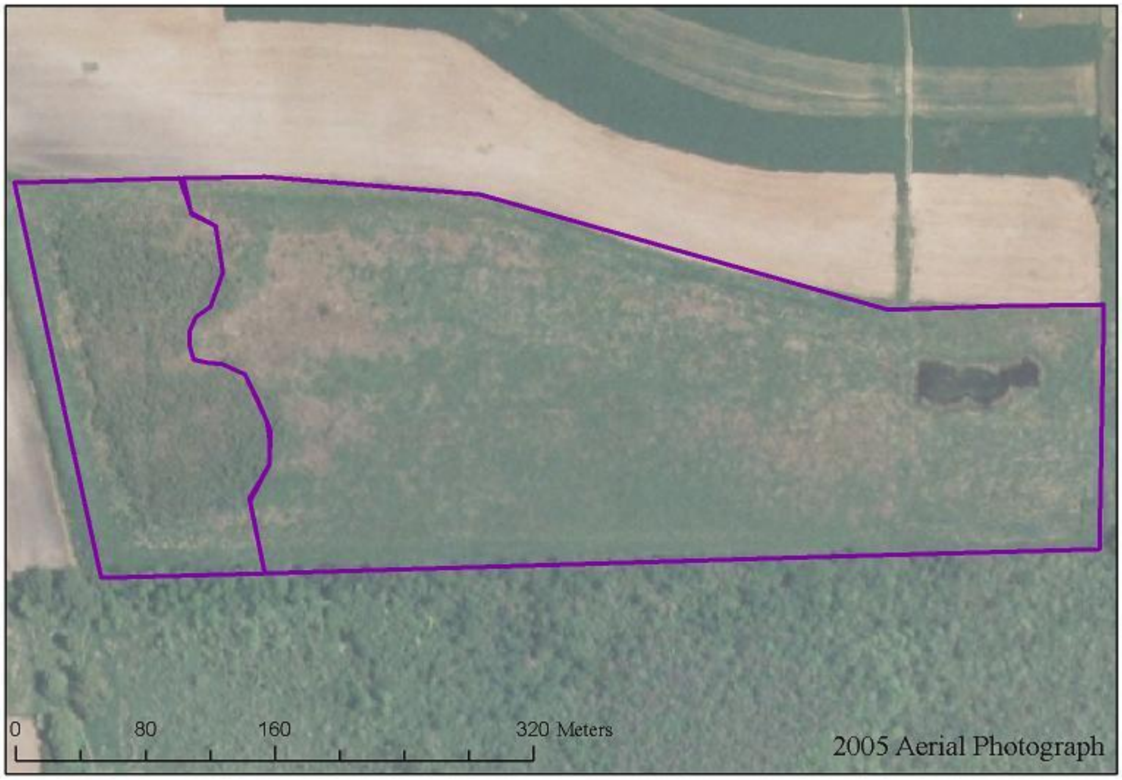
Gundrum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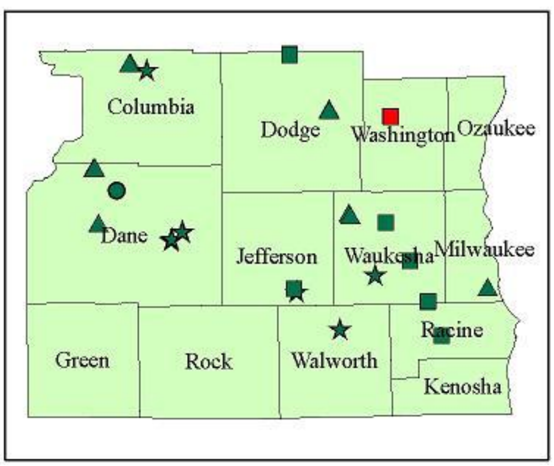
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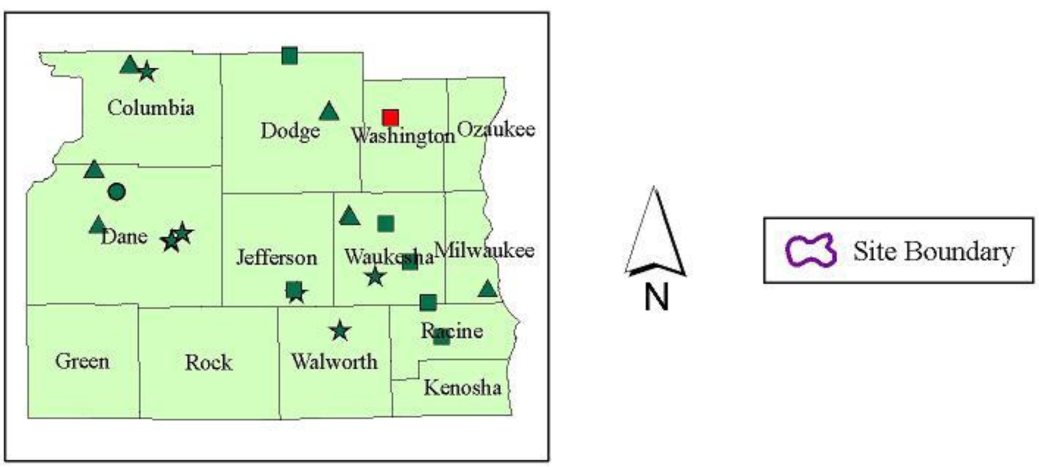
Gundrum East



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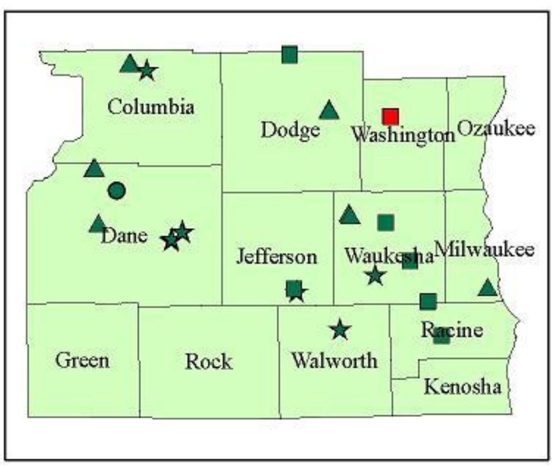

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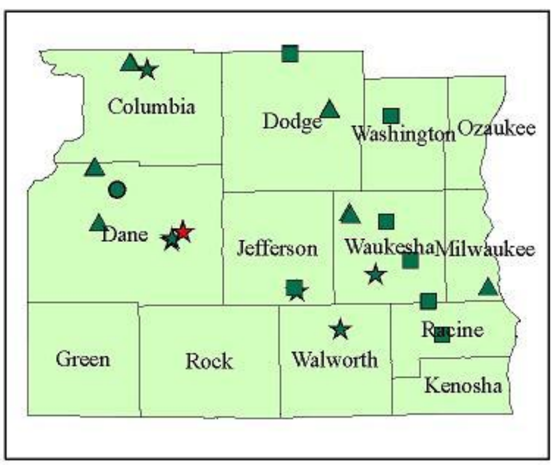

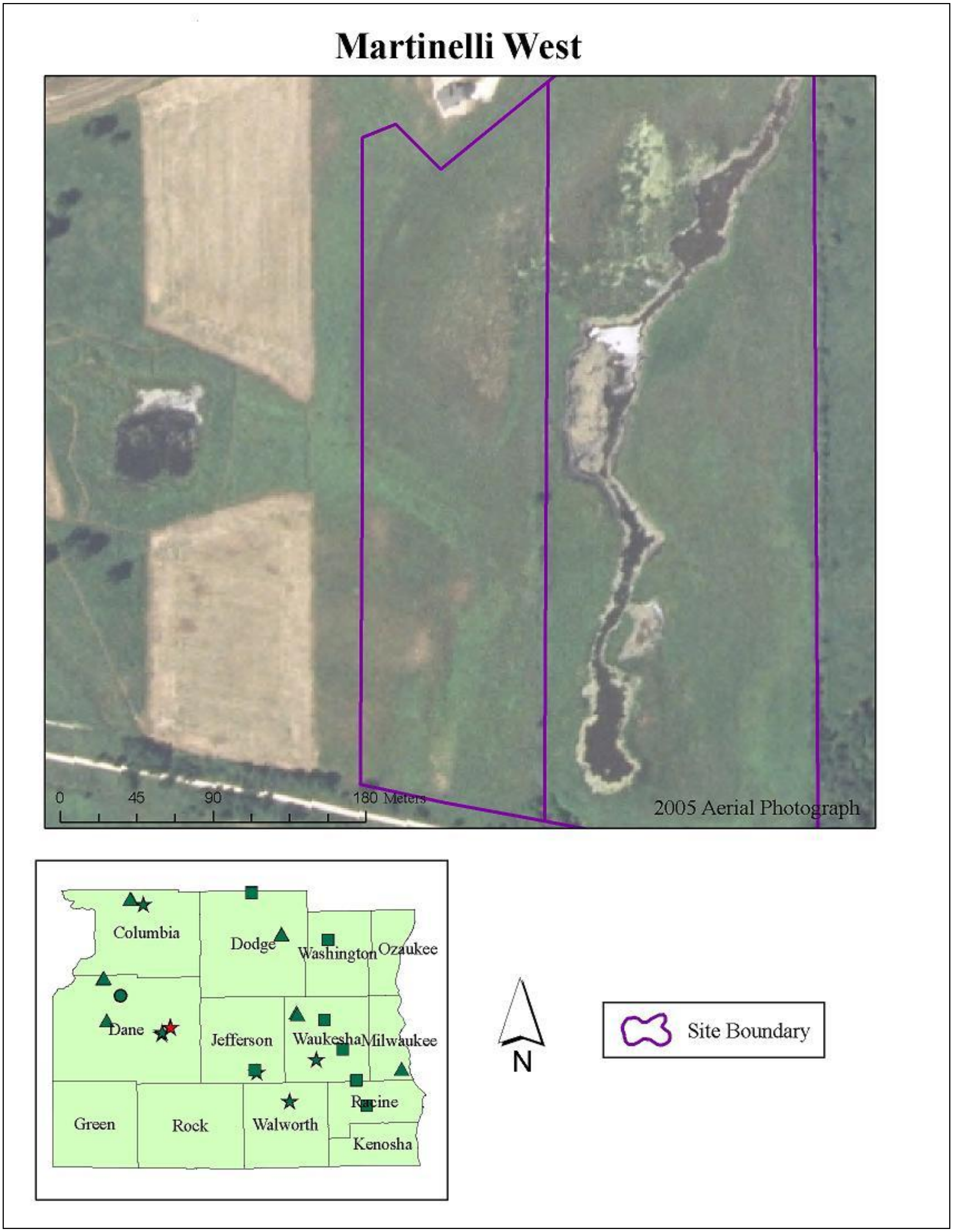
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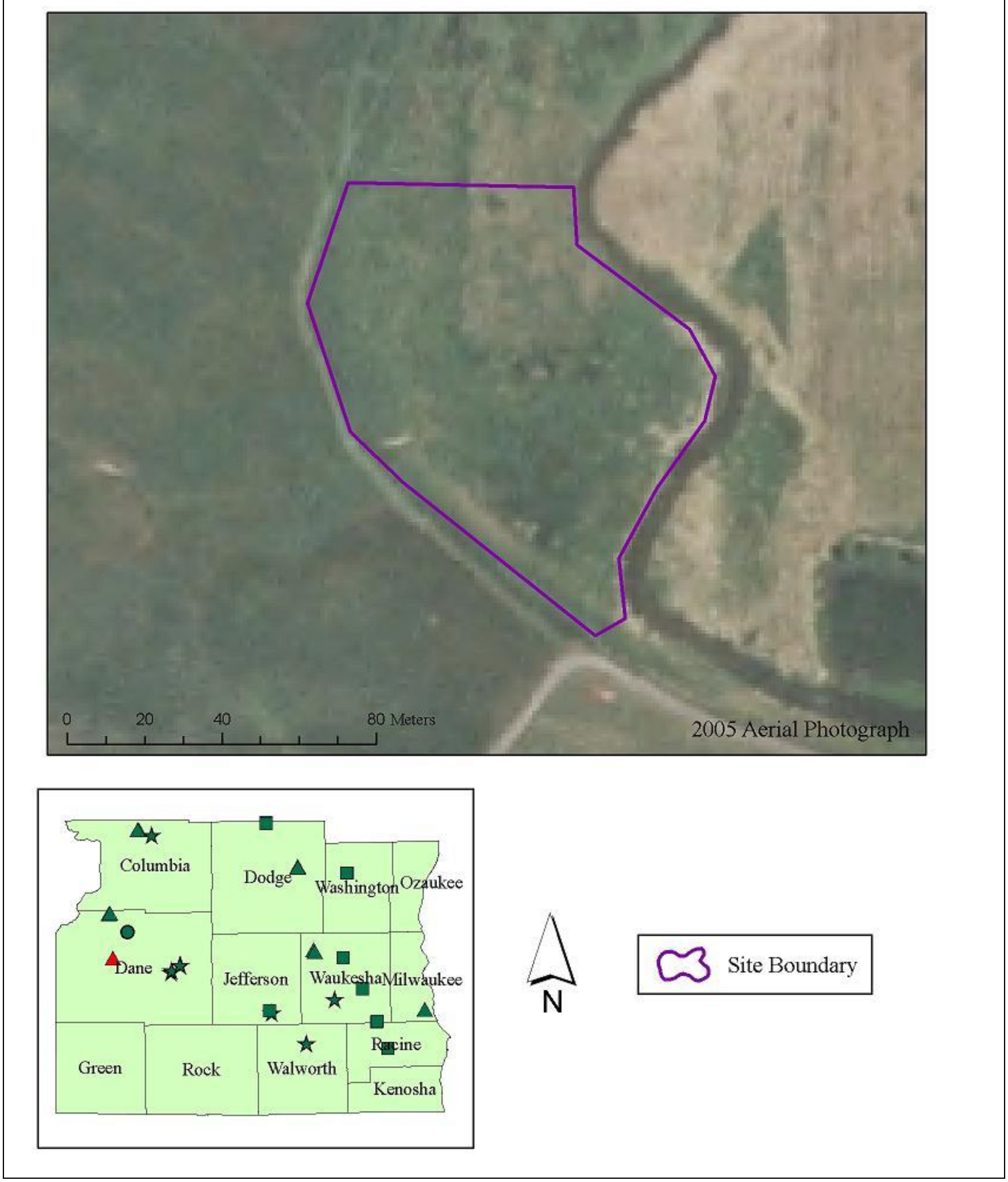
Middleton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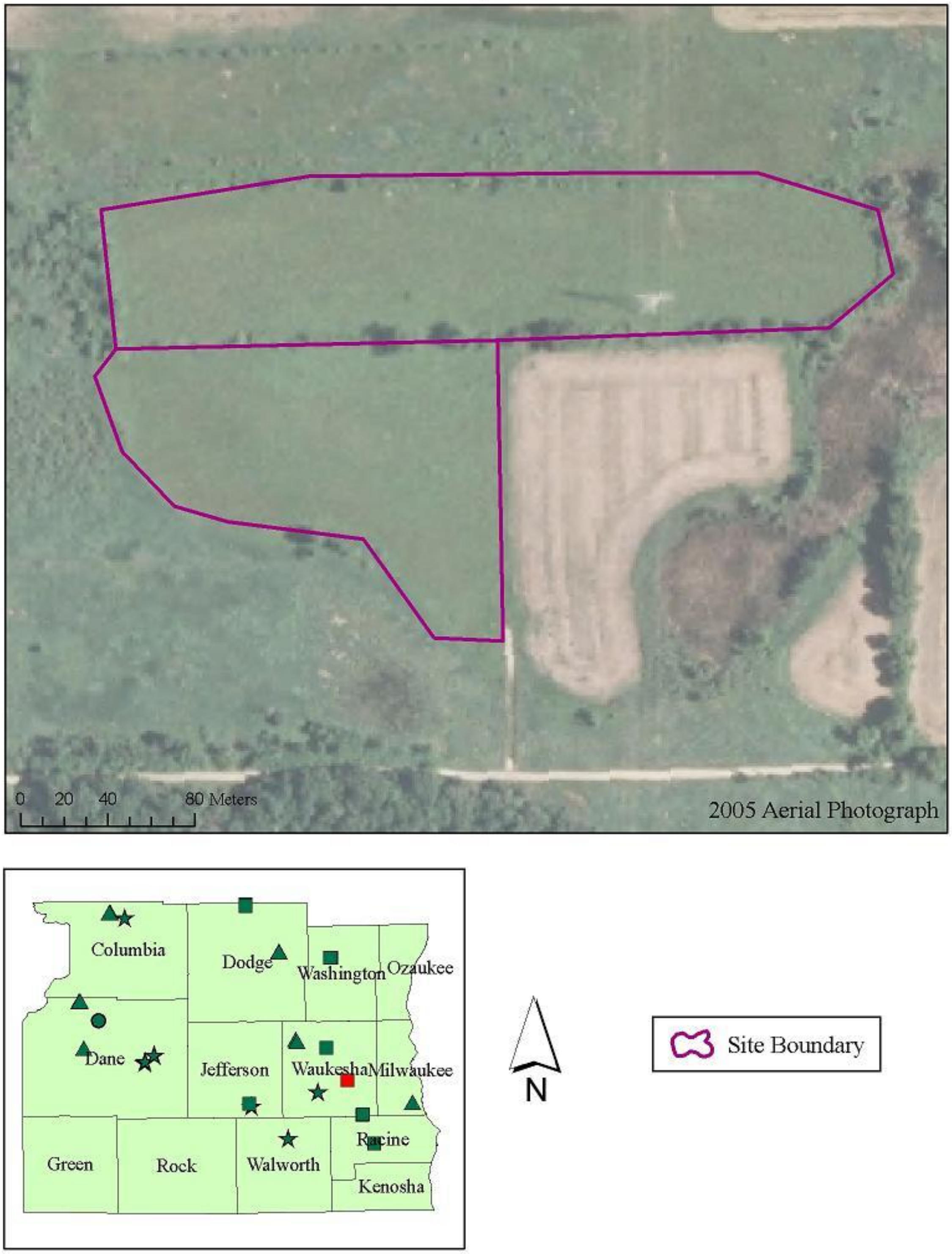
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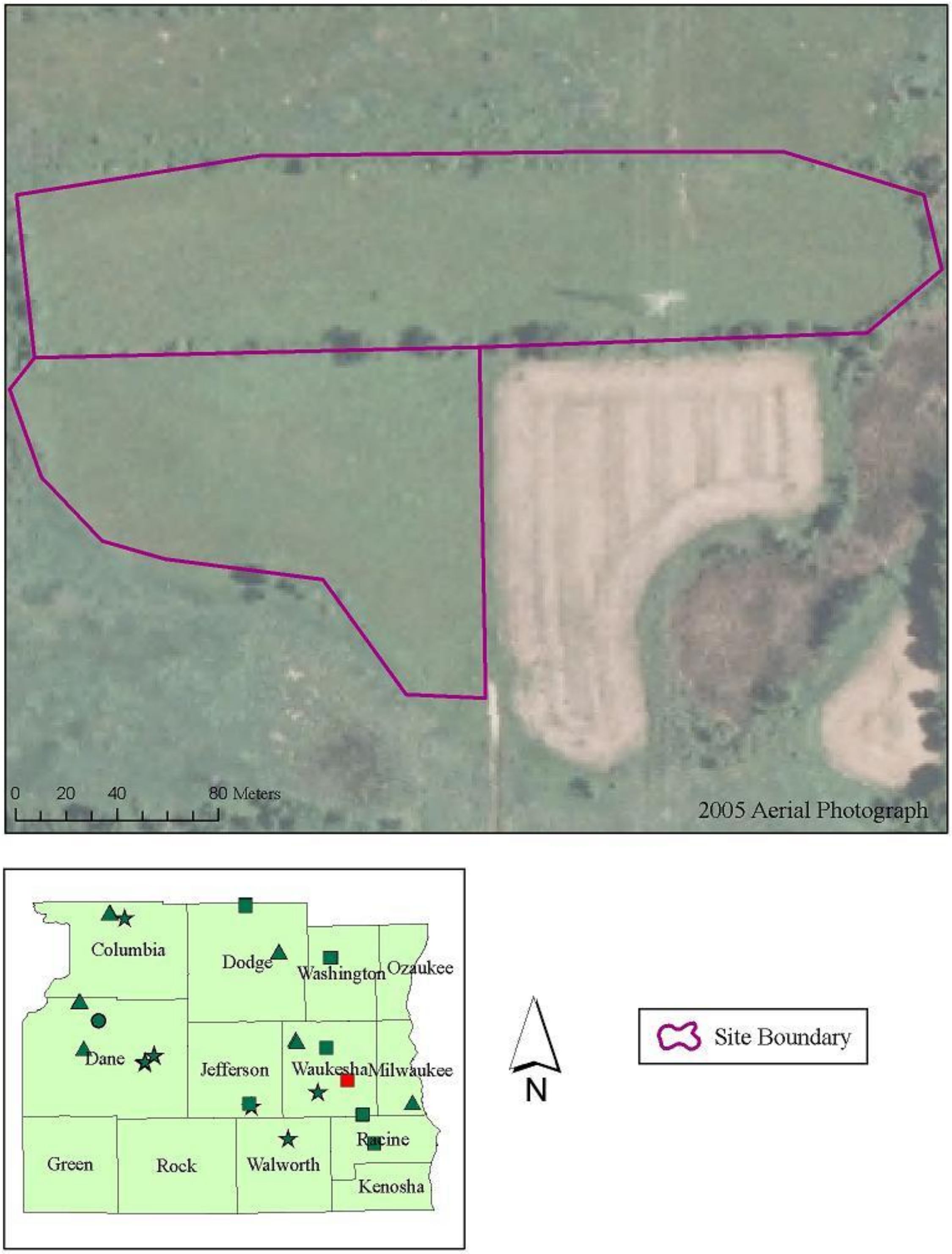
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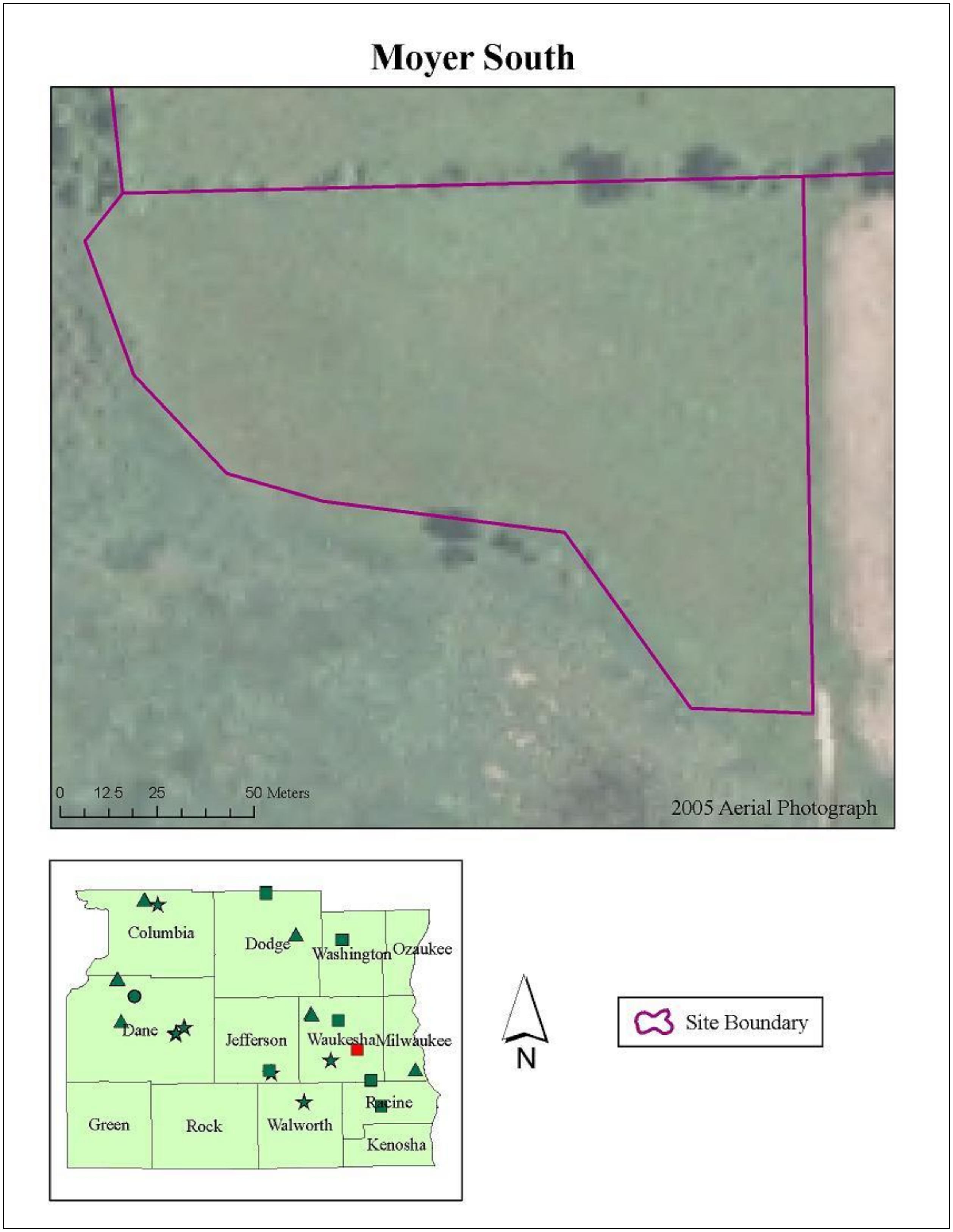
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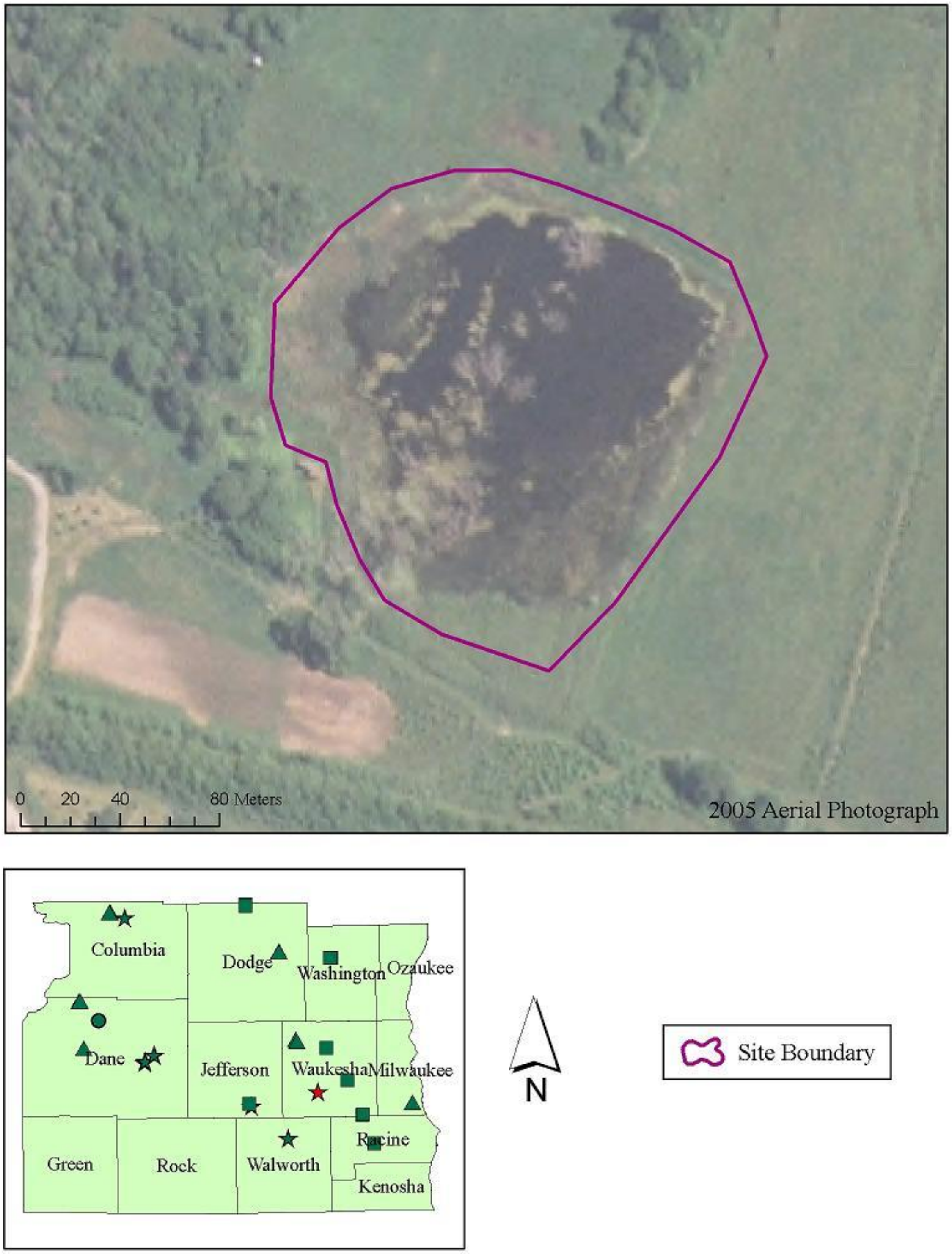
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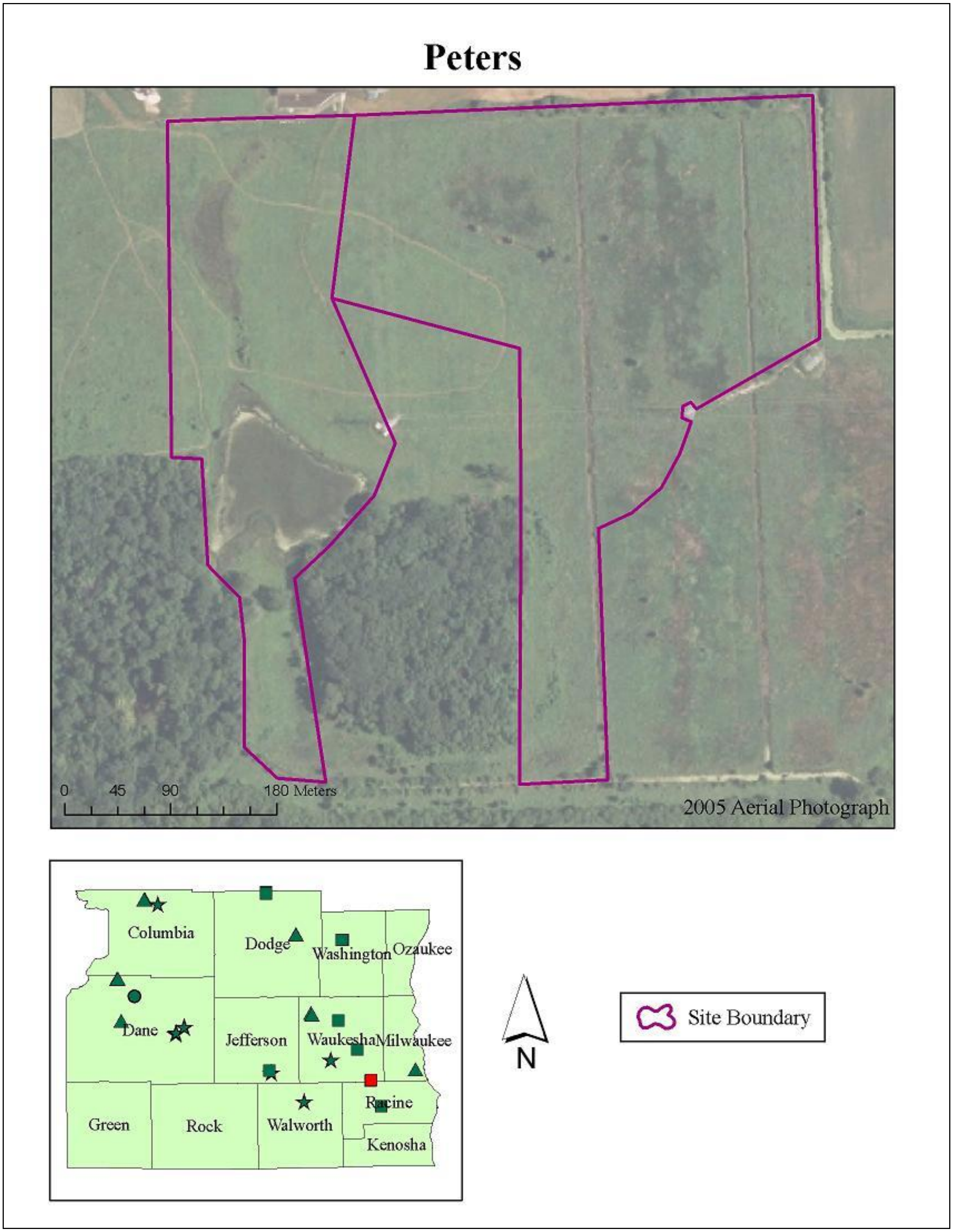
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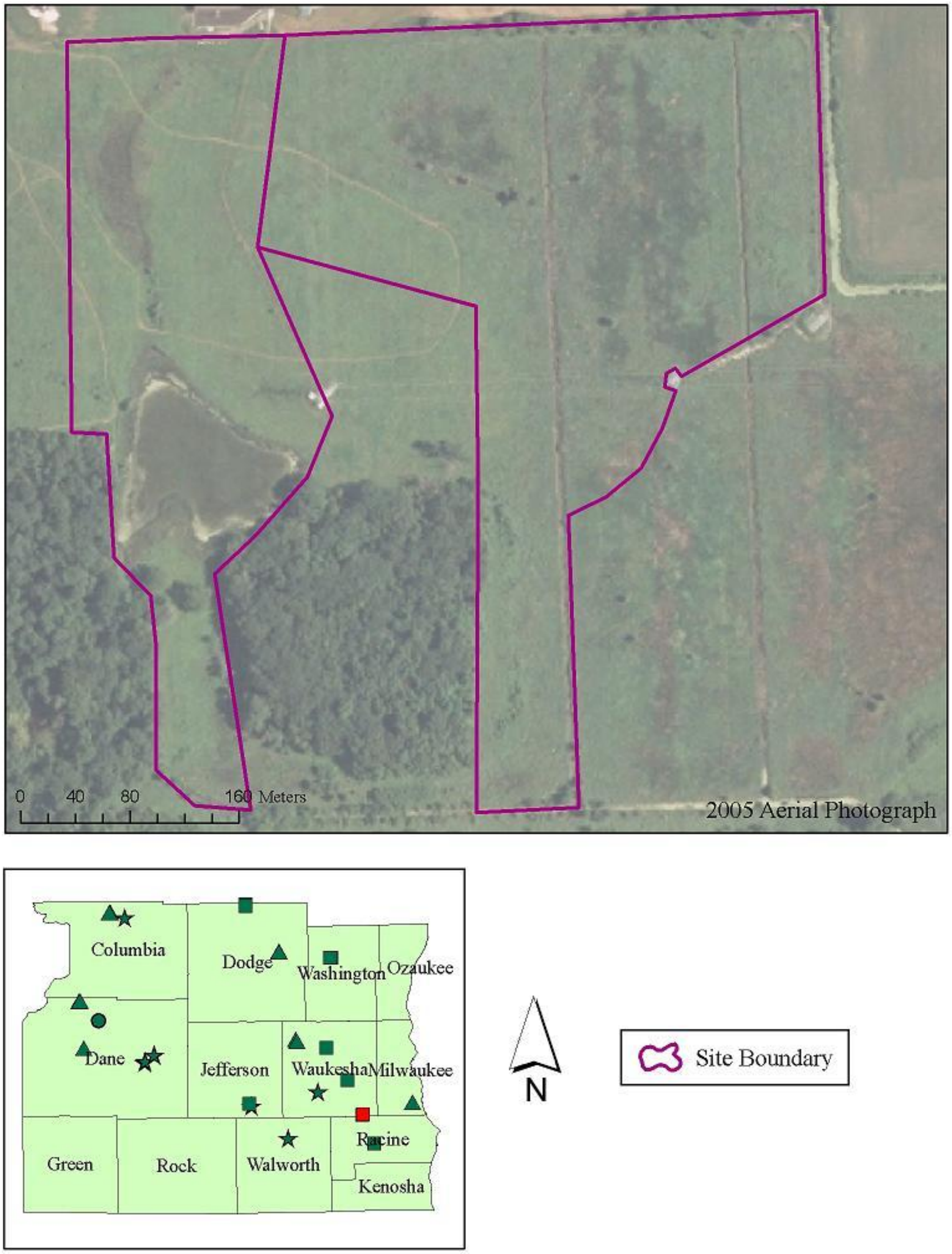
Peters East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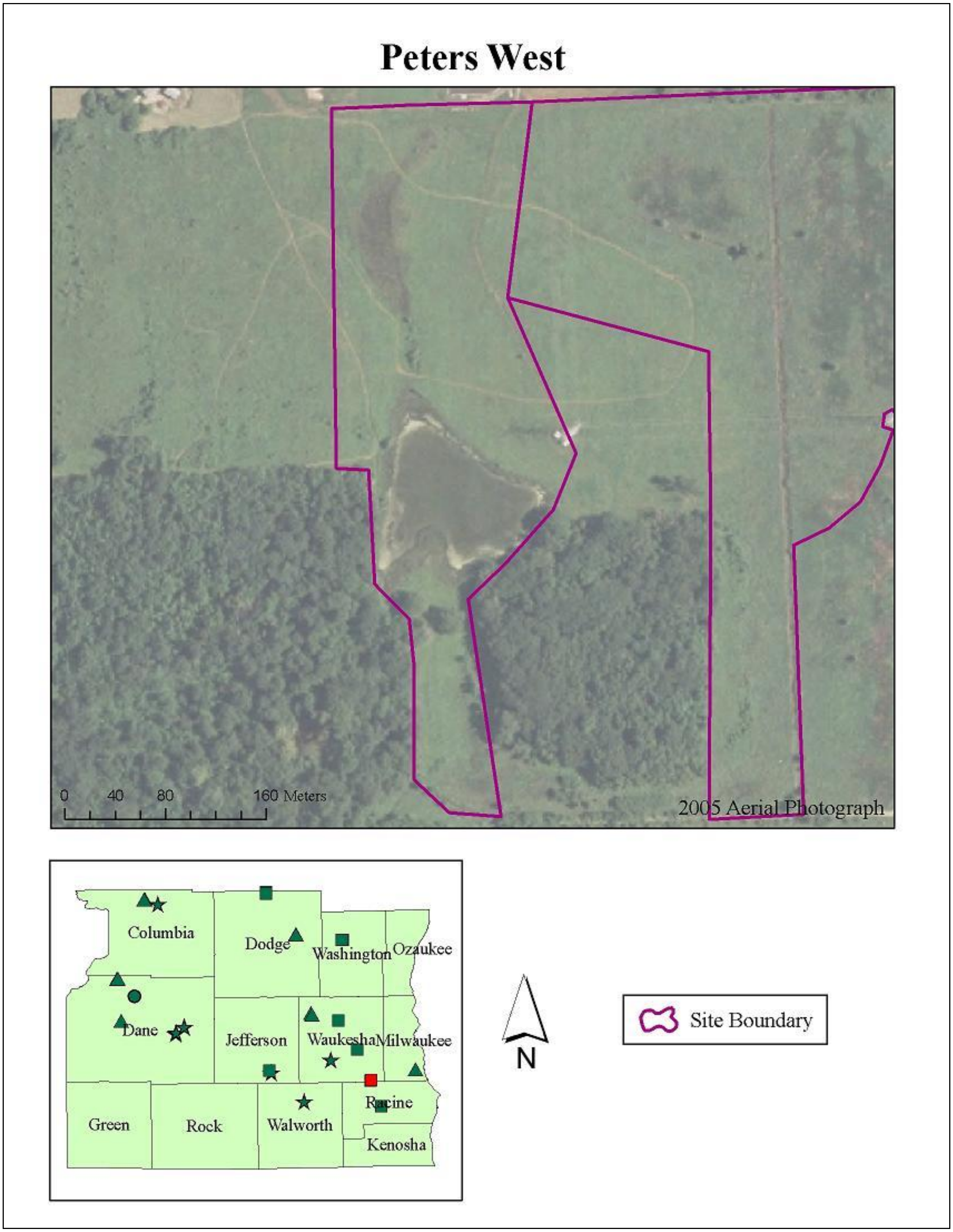
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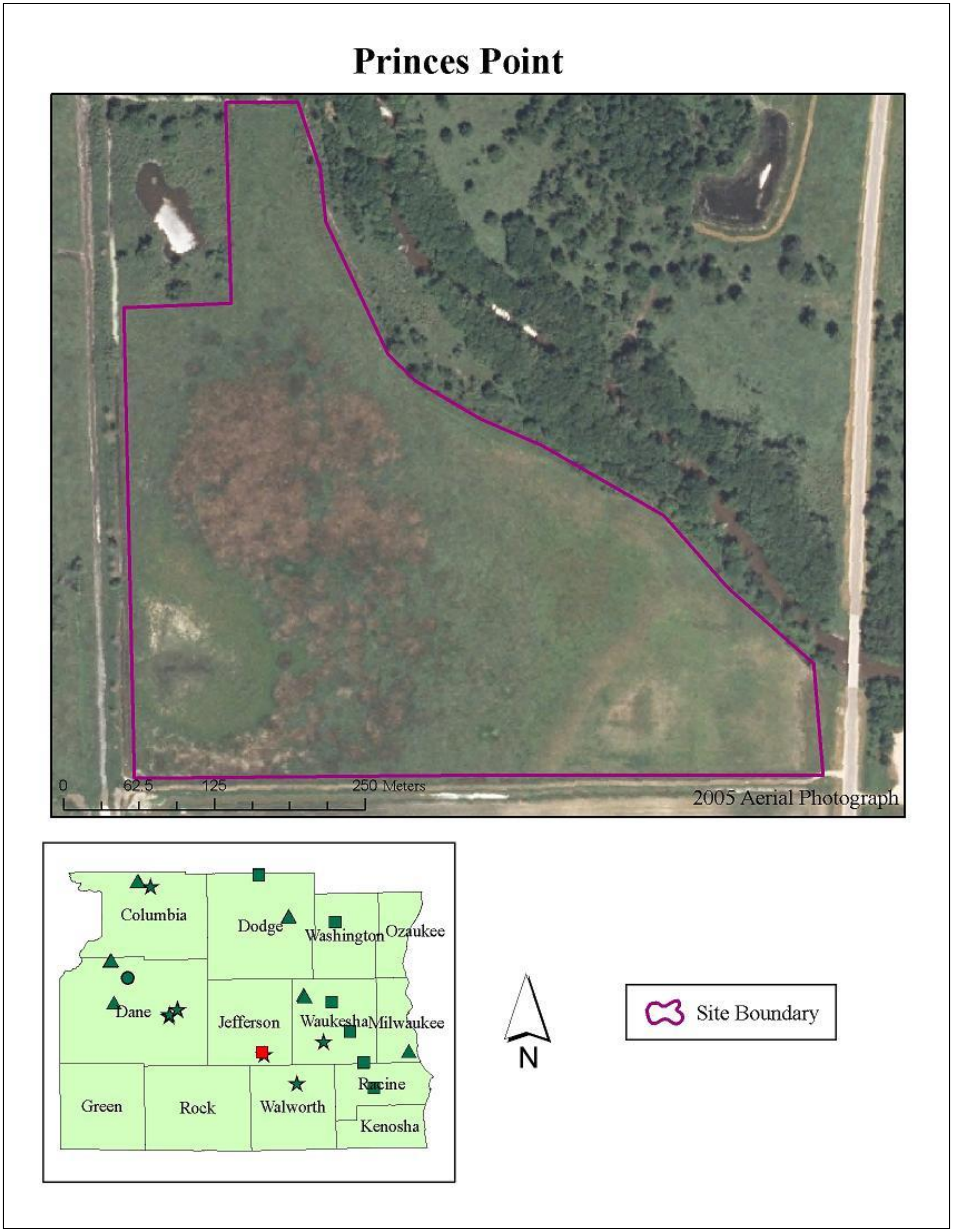
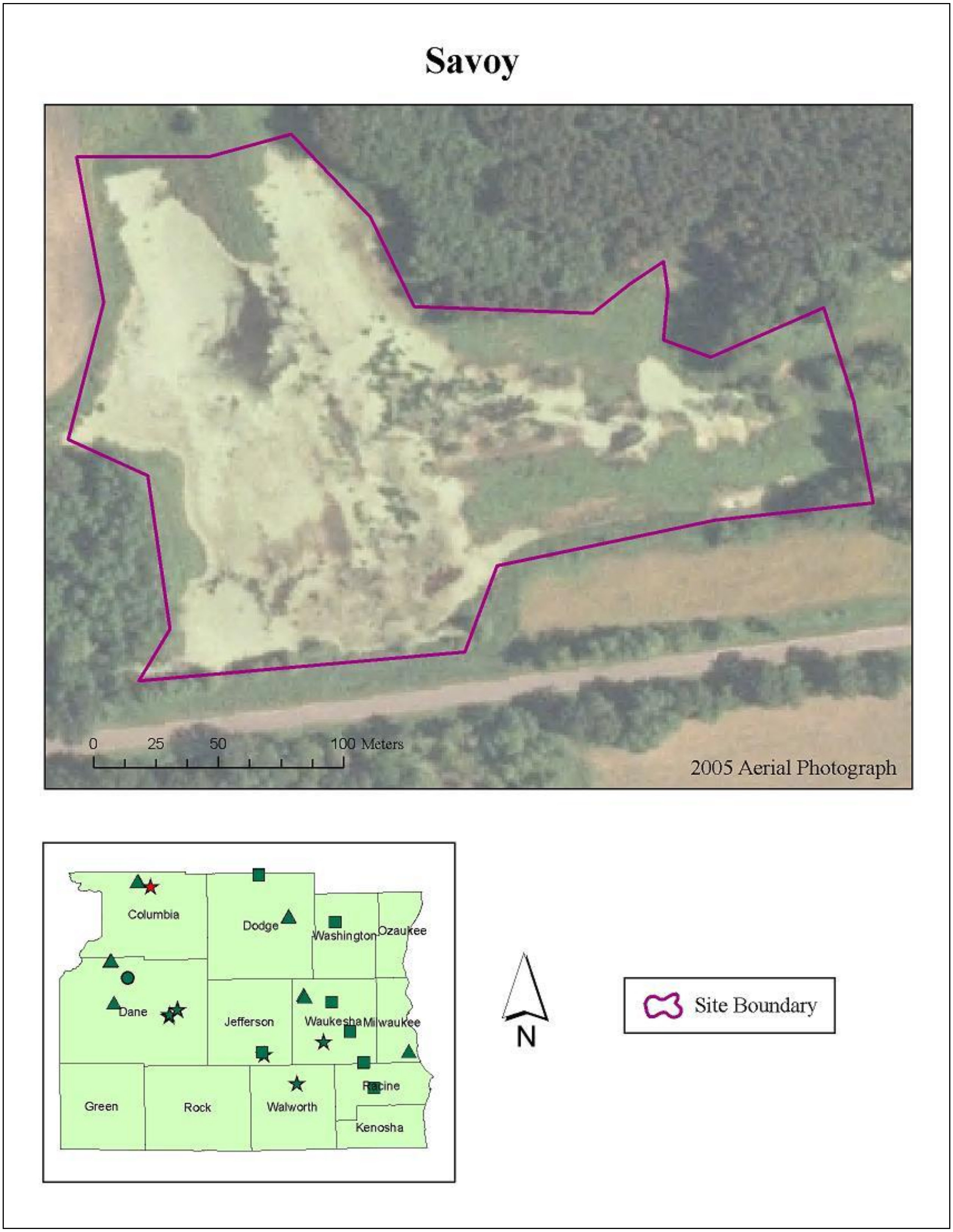
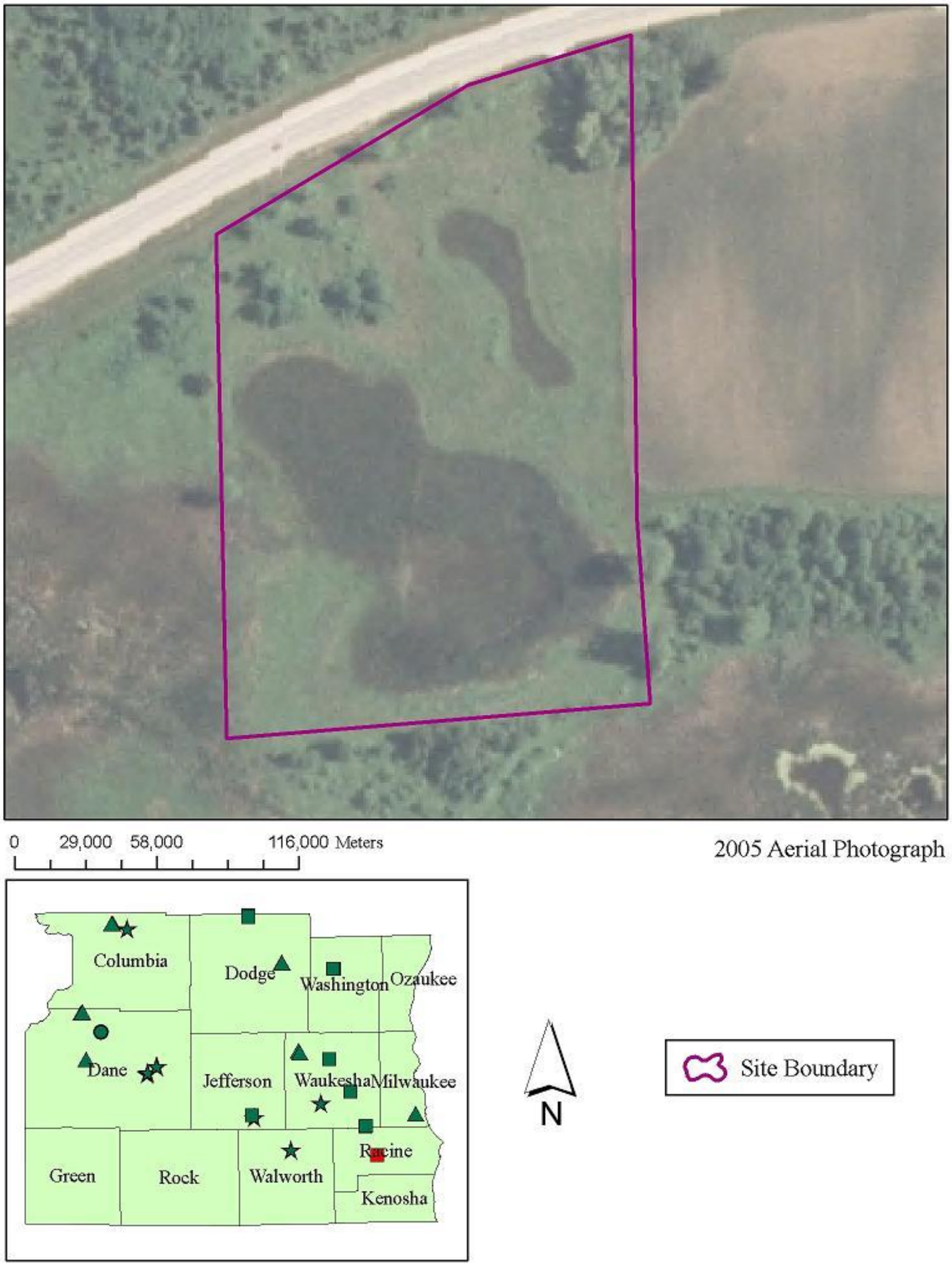
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Site Boundary


Princes Point
0
62.5
125
250 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Racine
Green
Rock
Walworth
Kenosha
N
Site Boundary

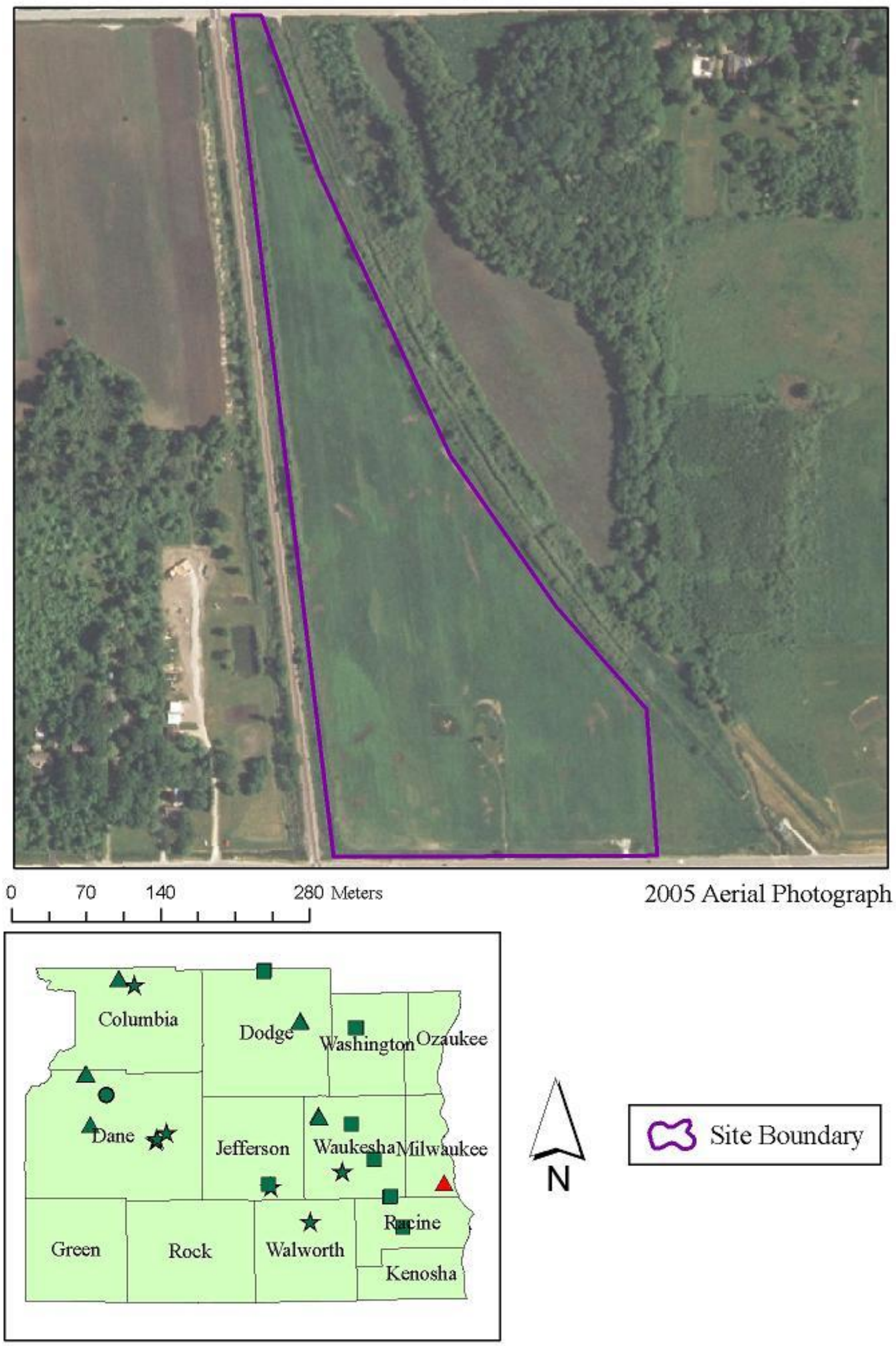

Savoy
0
25
50
100 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Site Boundary

STH 20

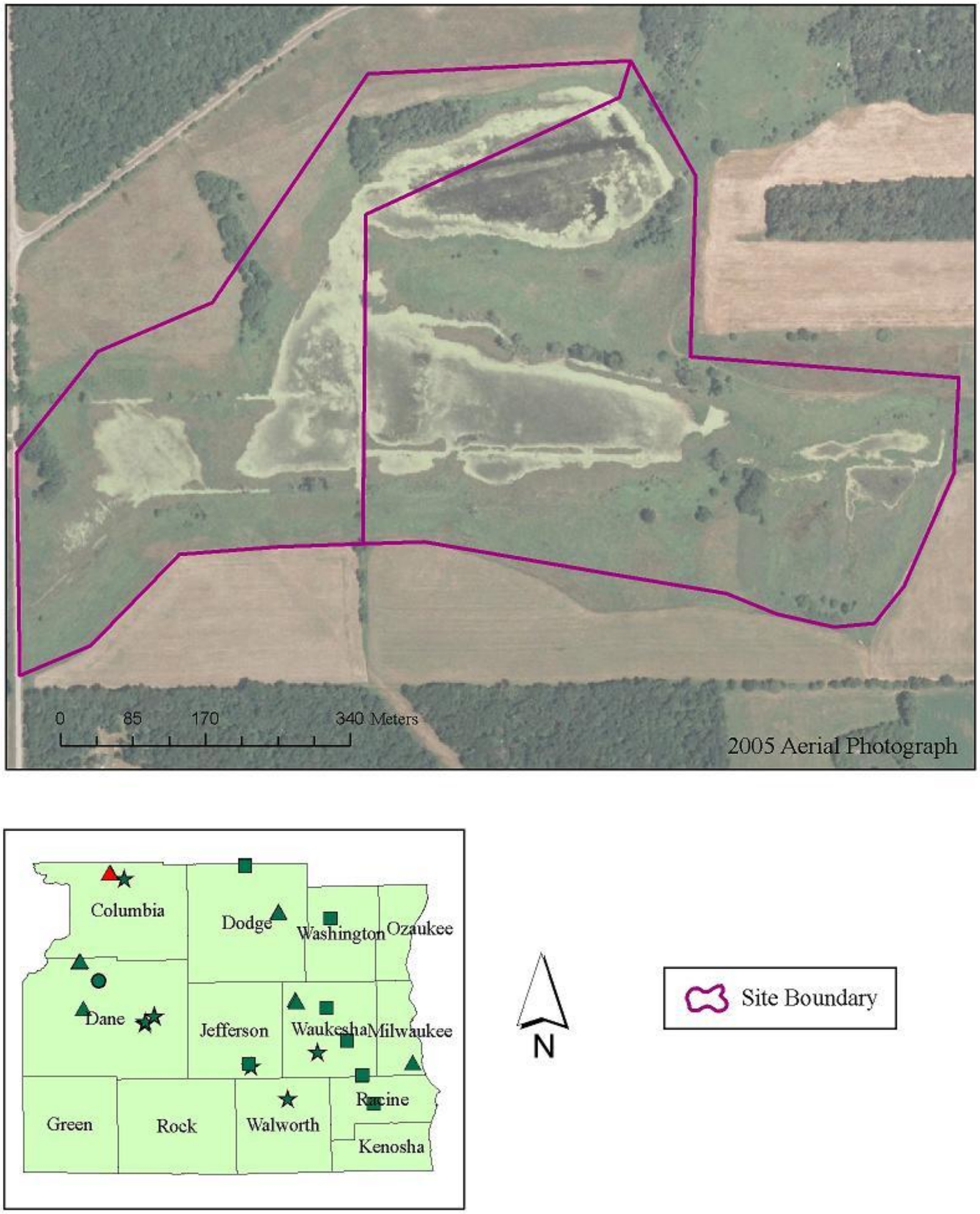


0
29,000
58,000
116,000 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Site Boundary

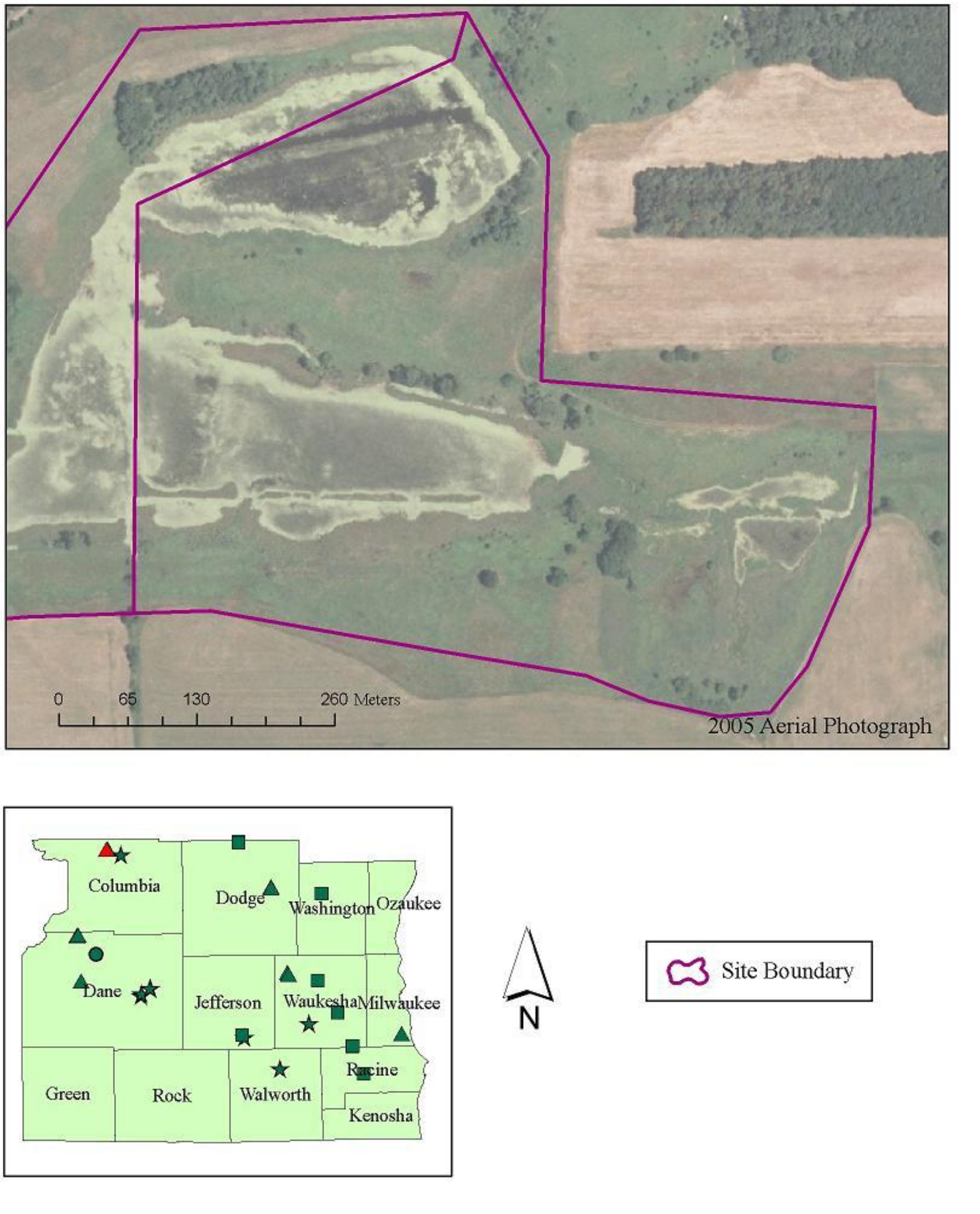
Target


0
70
140
280 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Site Boundary

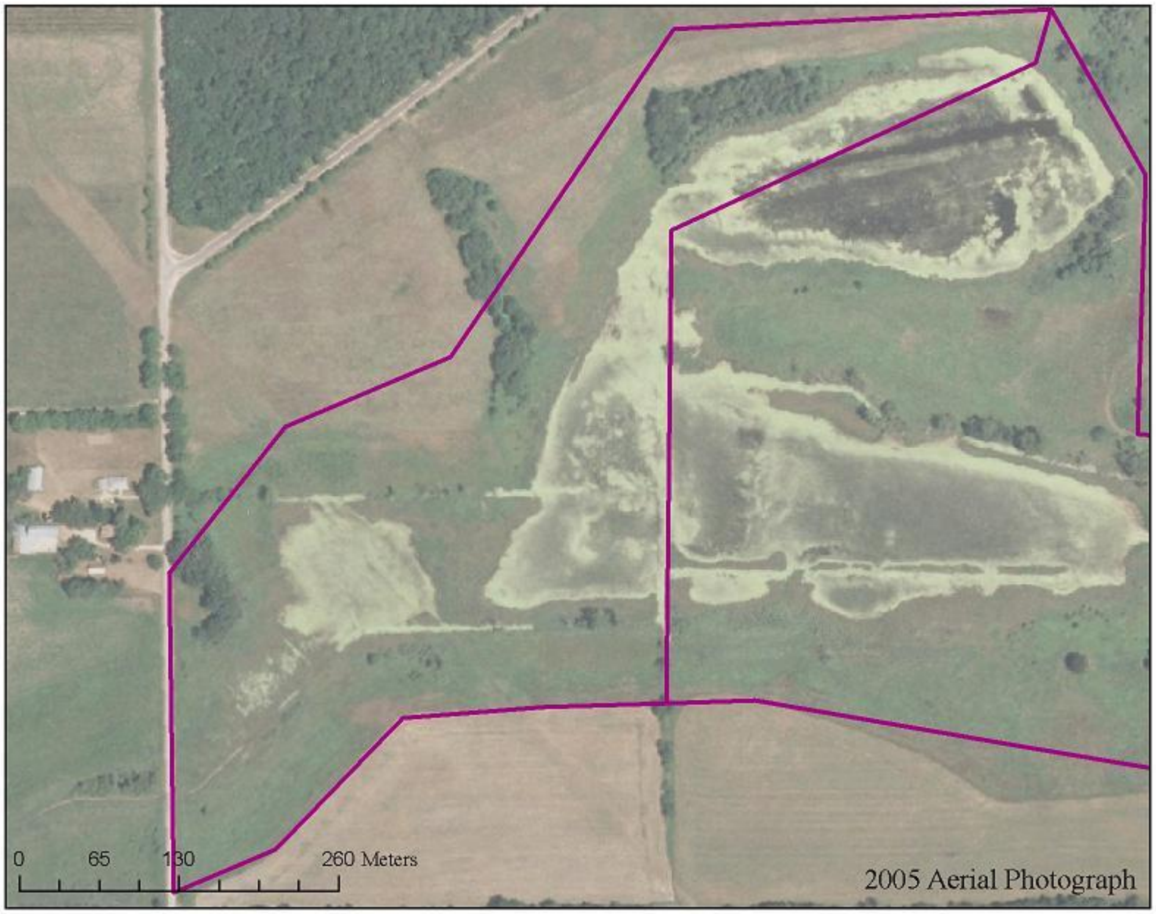
Walkerwin

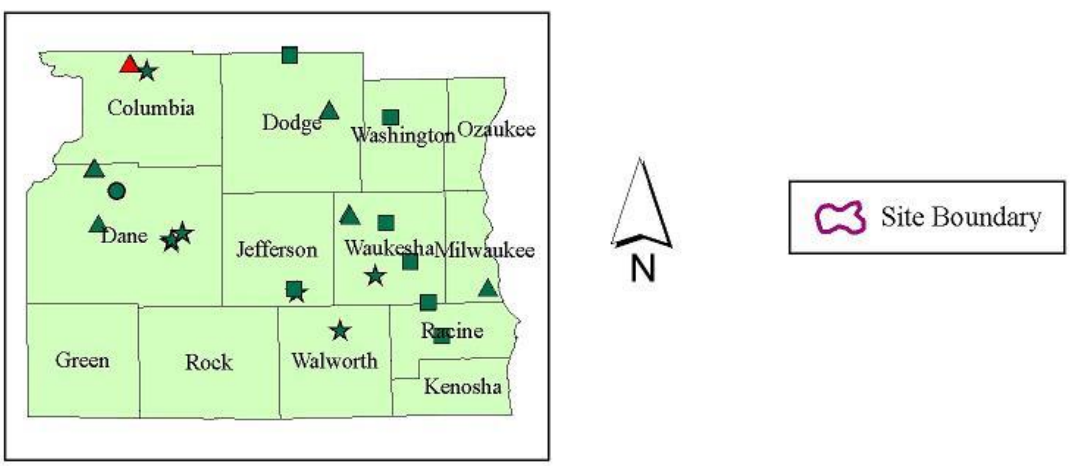

0
85
170
340 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Racine
Green
Rock
Walworth
Kenosha
N
Site Boundary

Walkerwin East

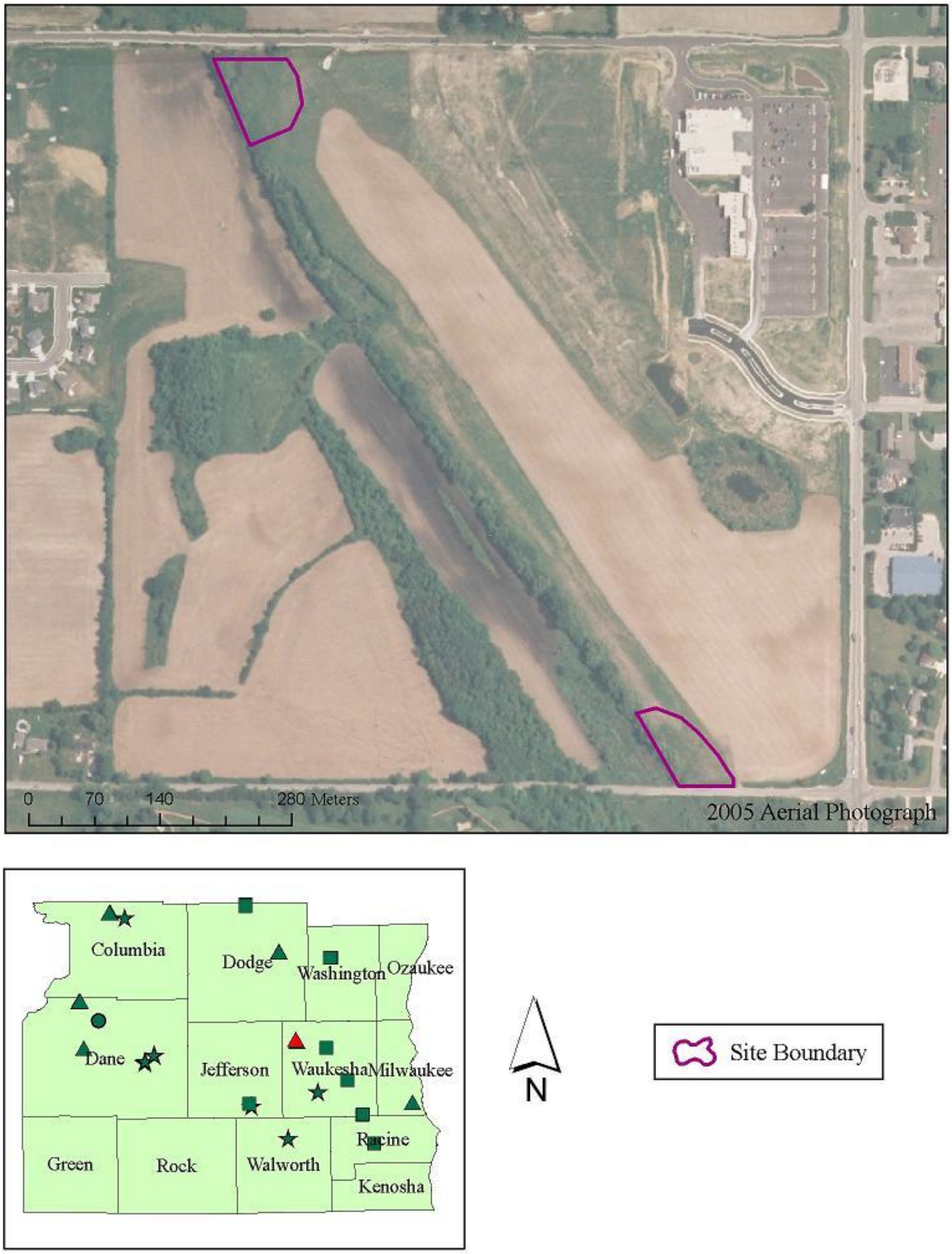


Walkerwin West





Wangard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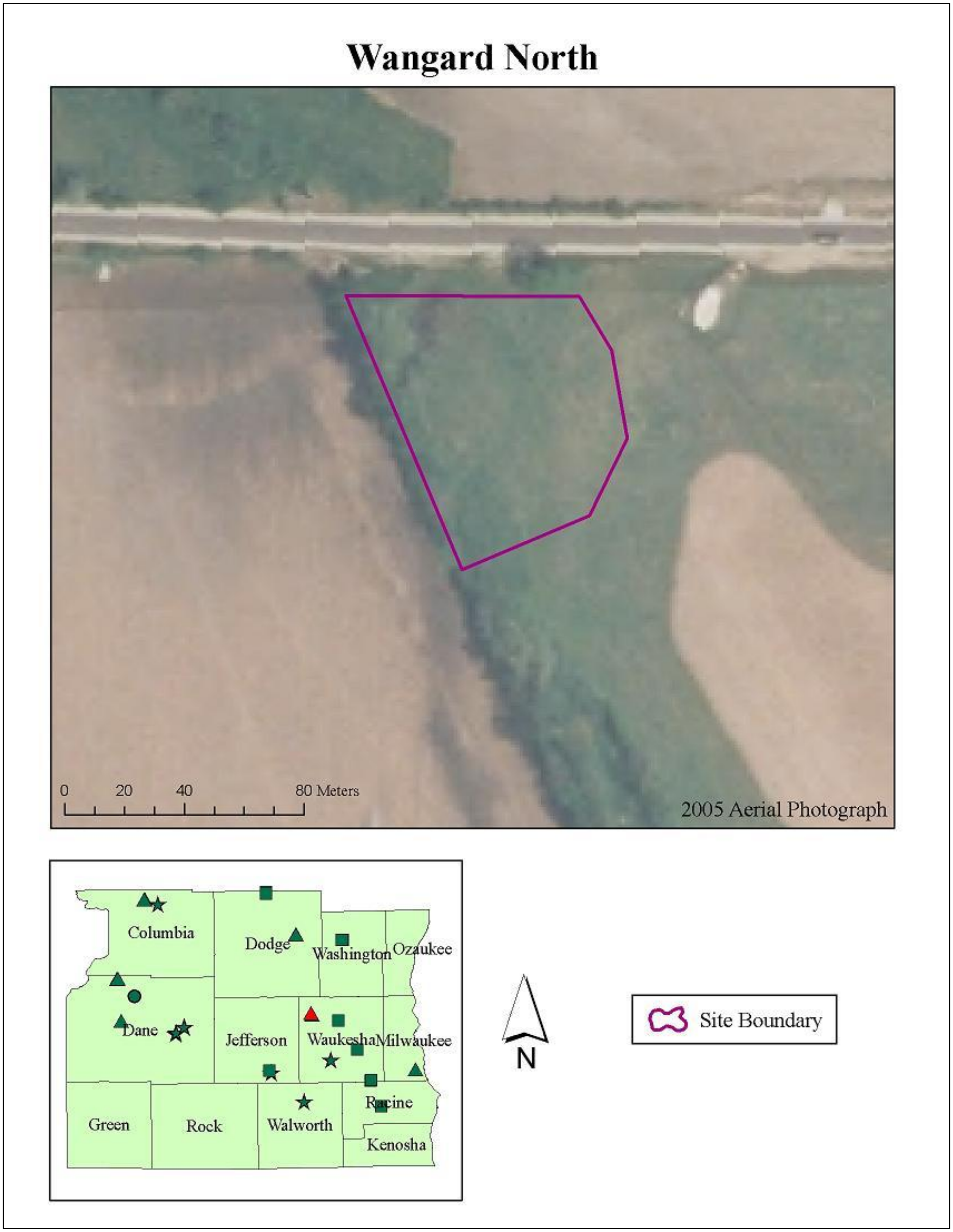
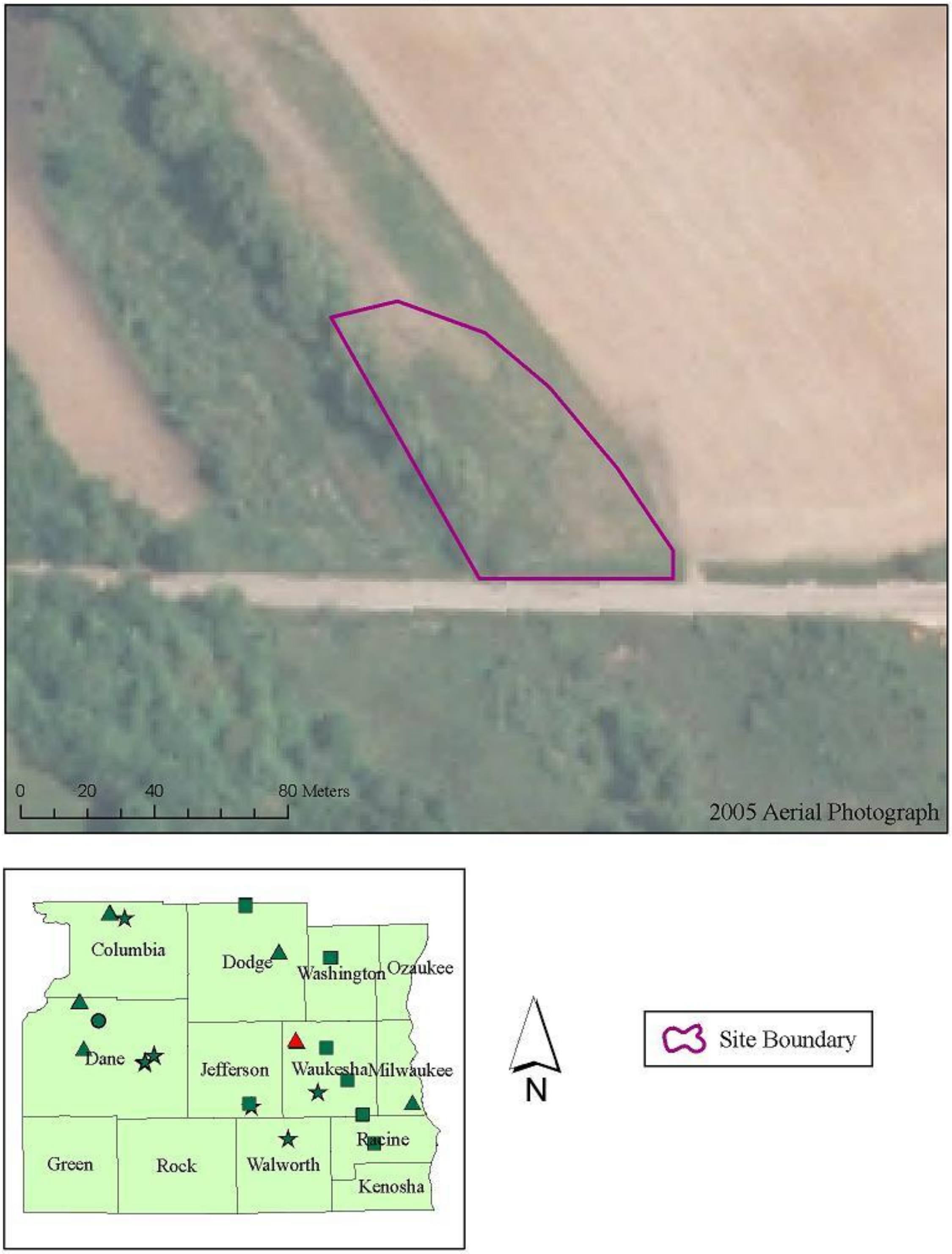
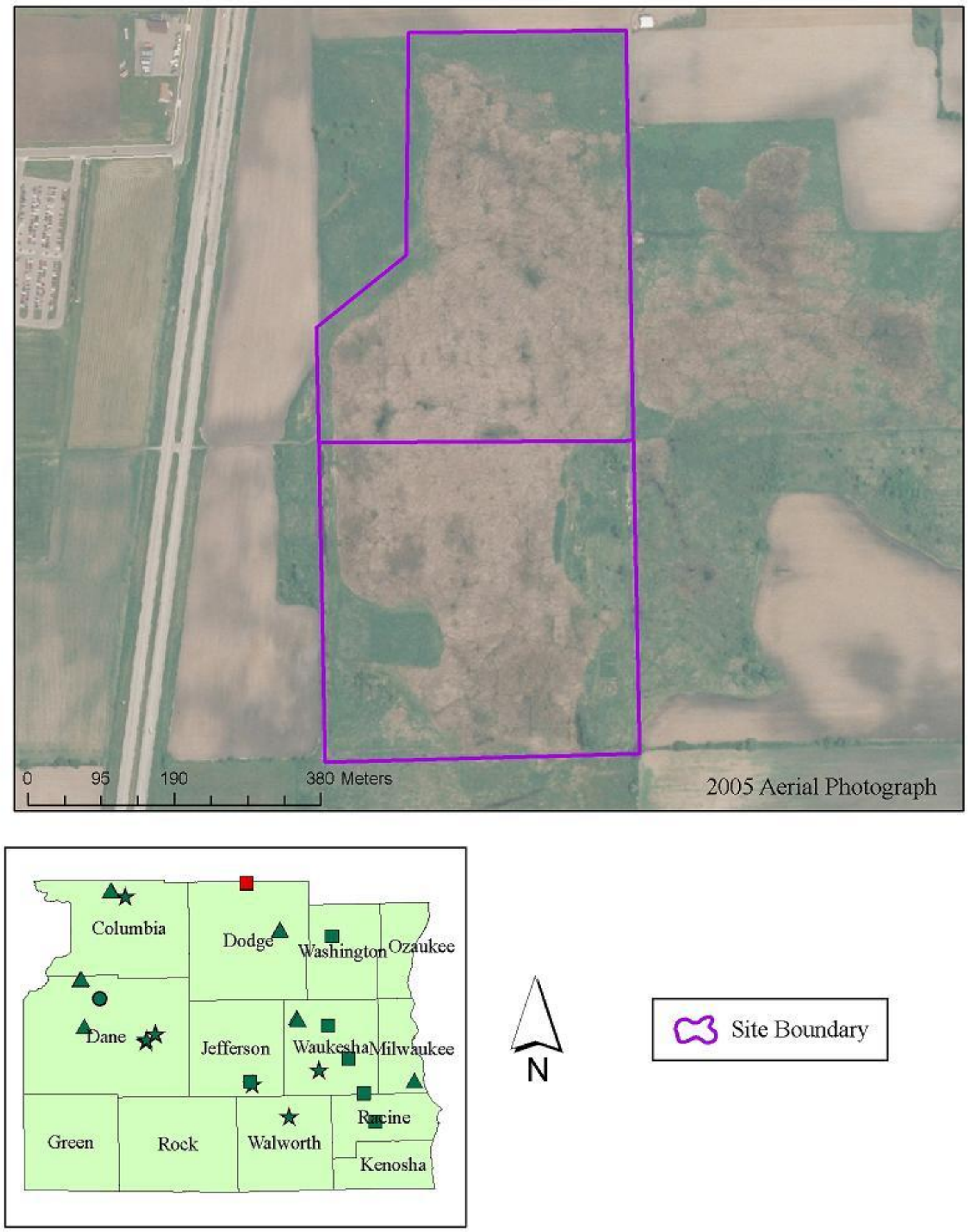
70
140
280 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Racine
Green
Rock
Walworth
Kenosha
N
Site Boundary


Wangard North
0
20
40
80 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Racine
Green
Rock
Walworth
Kenosha
N
Site Boundary

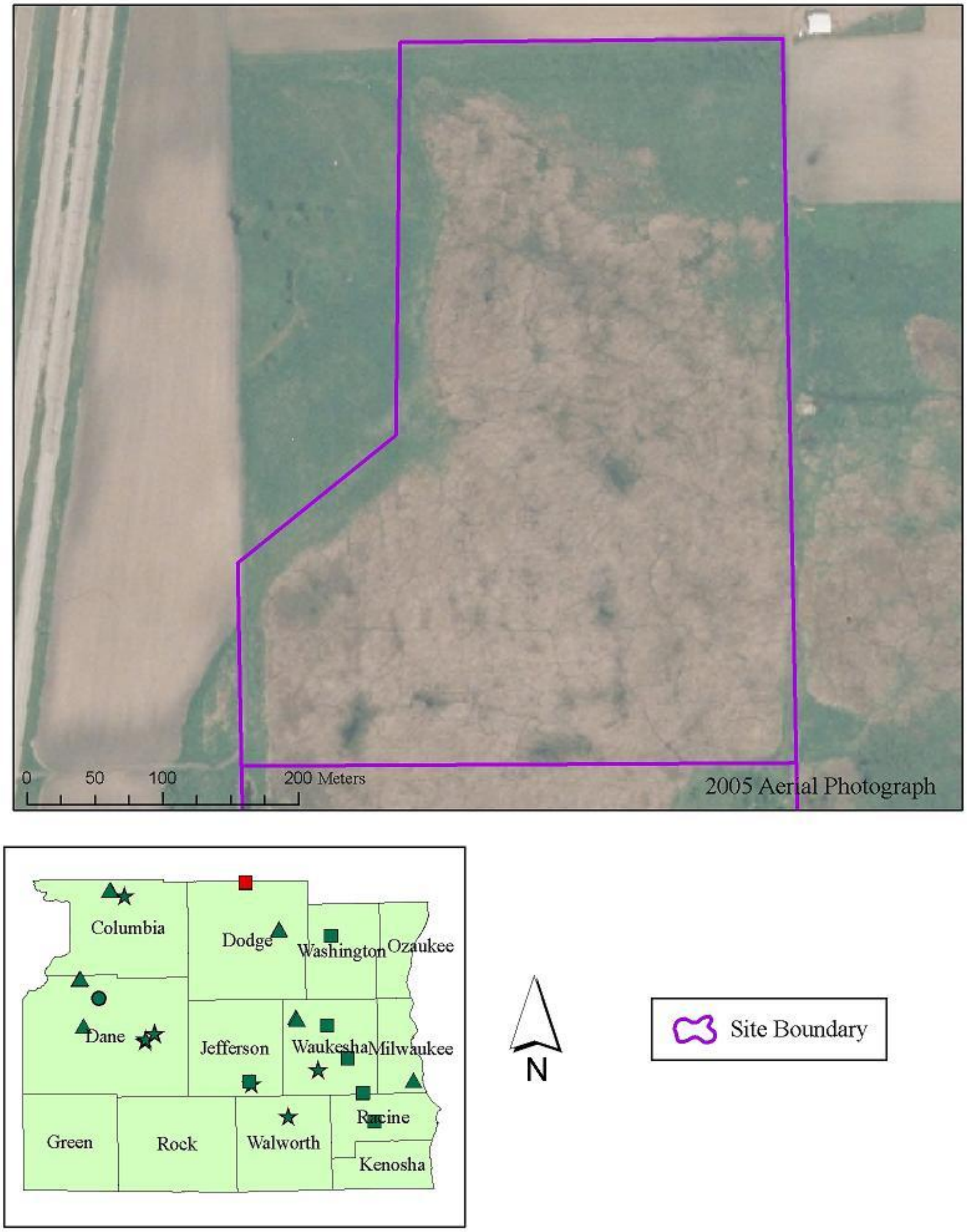
Wangard South



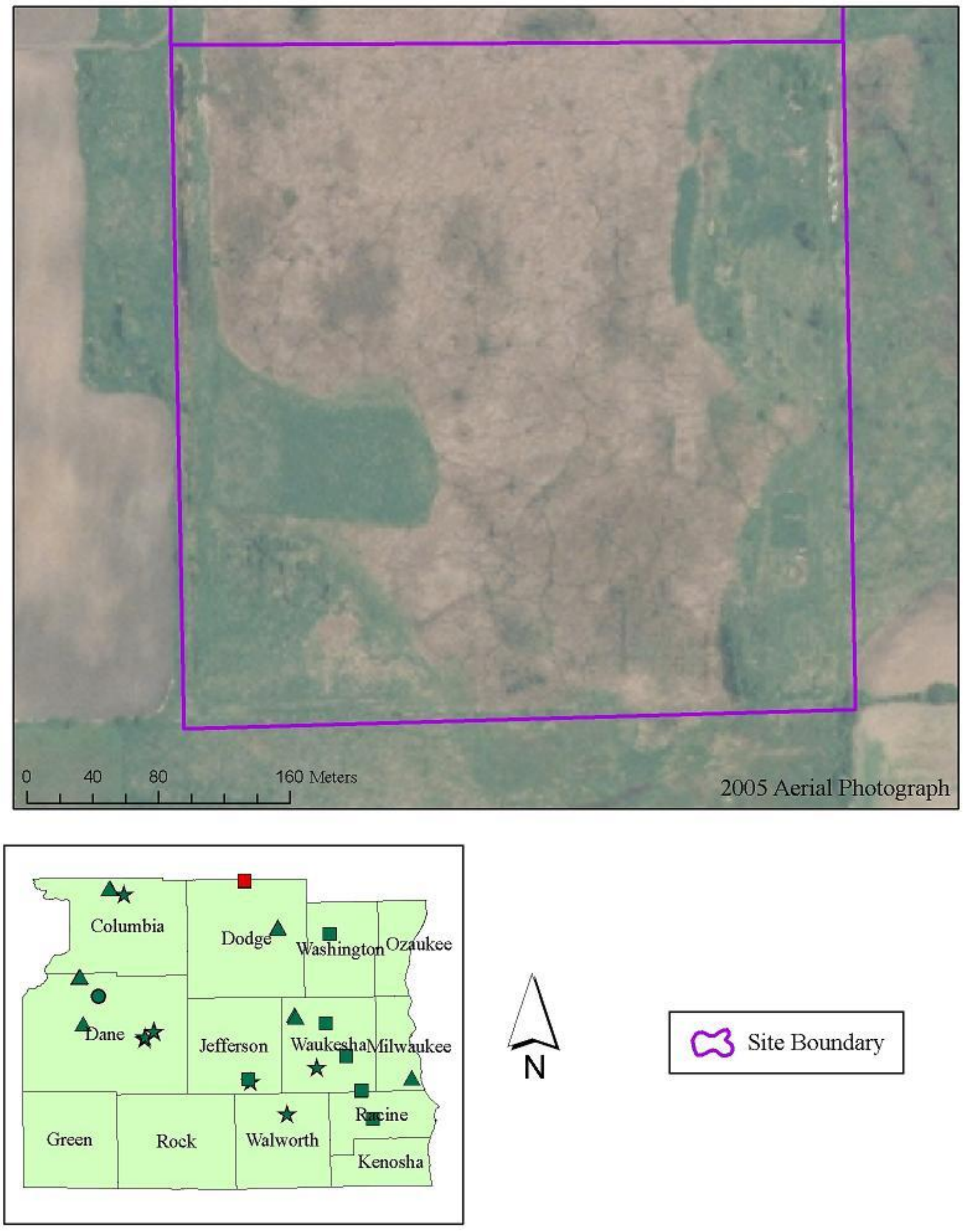
Waupun


0
95
190
380 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Racine
Green
Rock
Walworth
Kenosha
N
Site Boundary

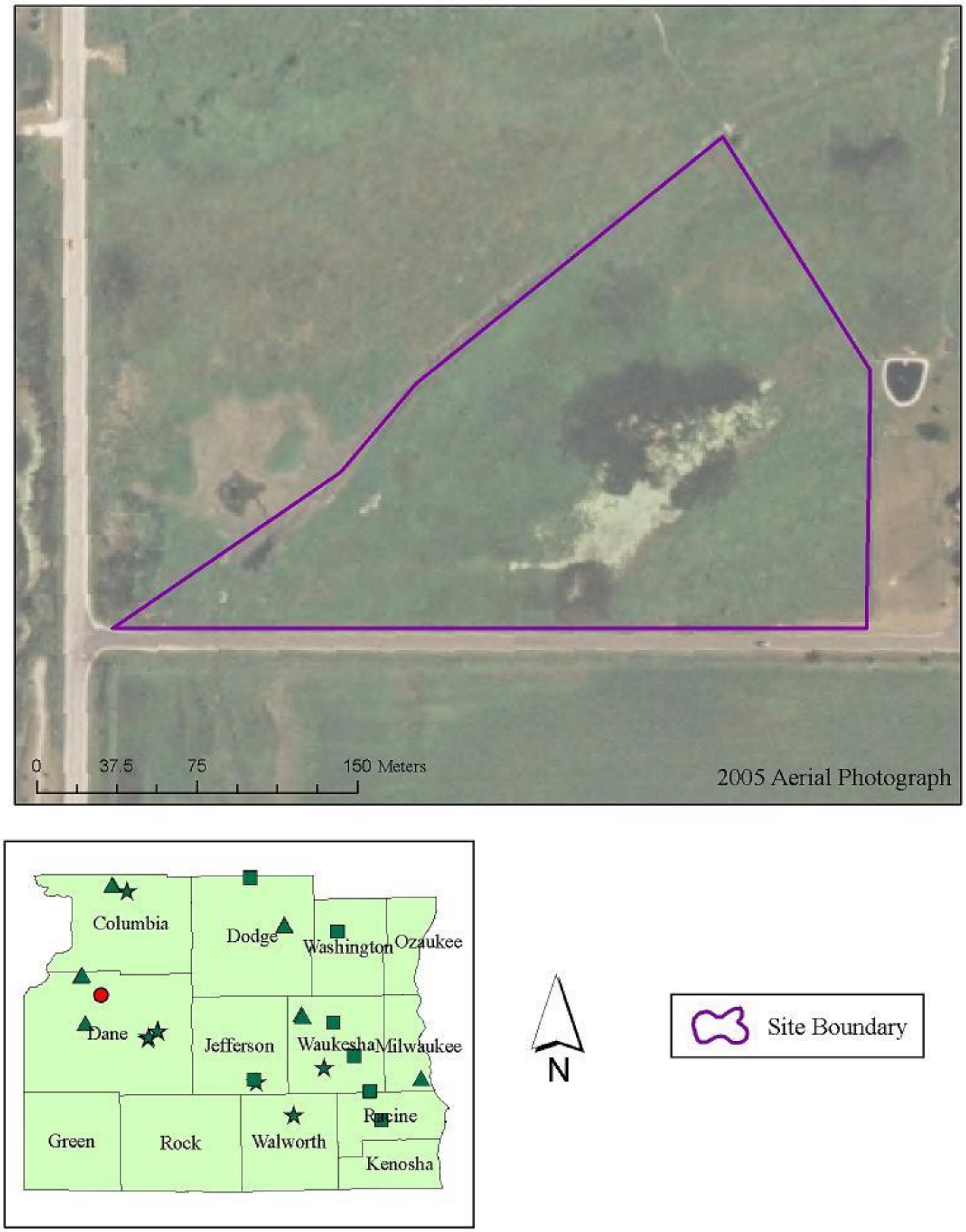
Waupun North



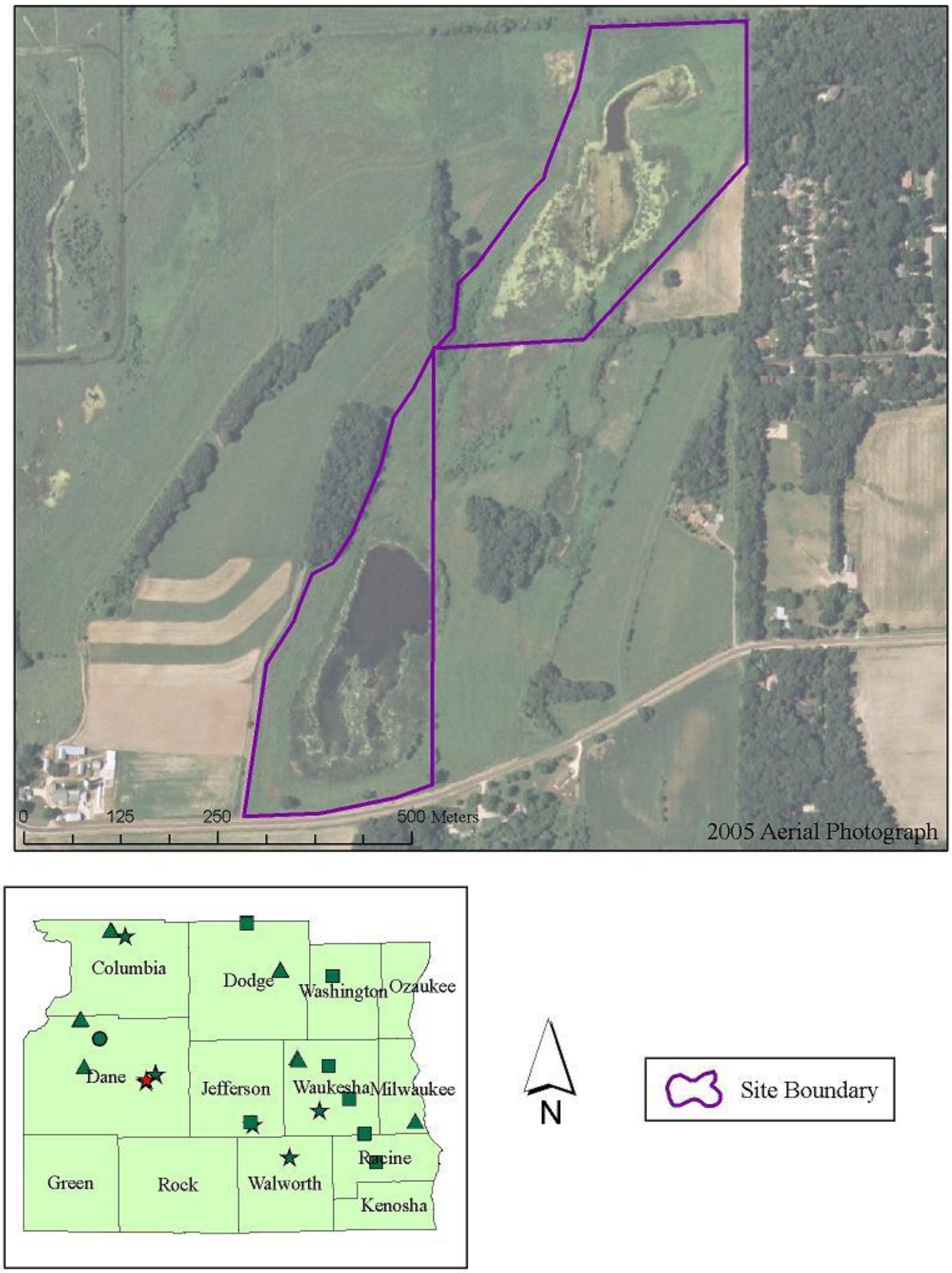
Waupun South



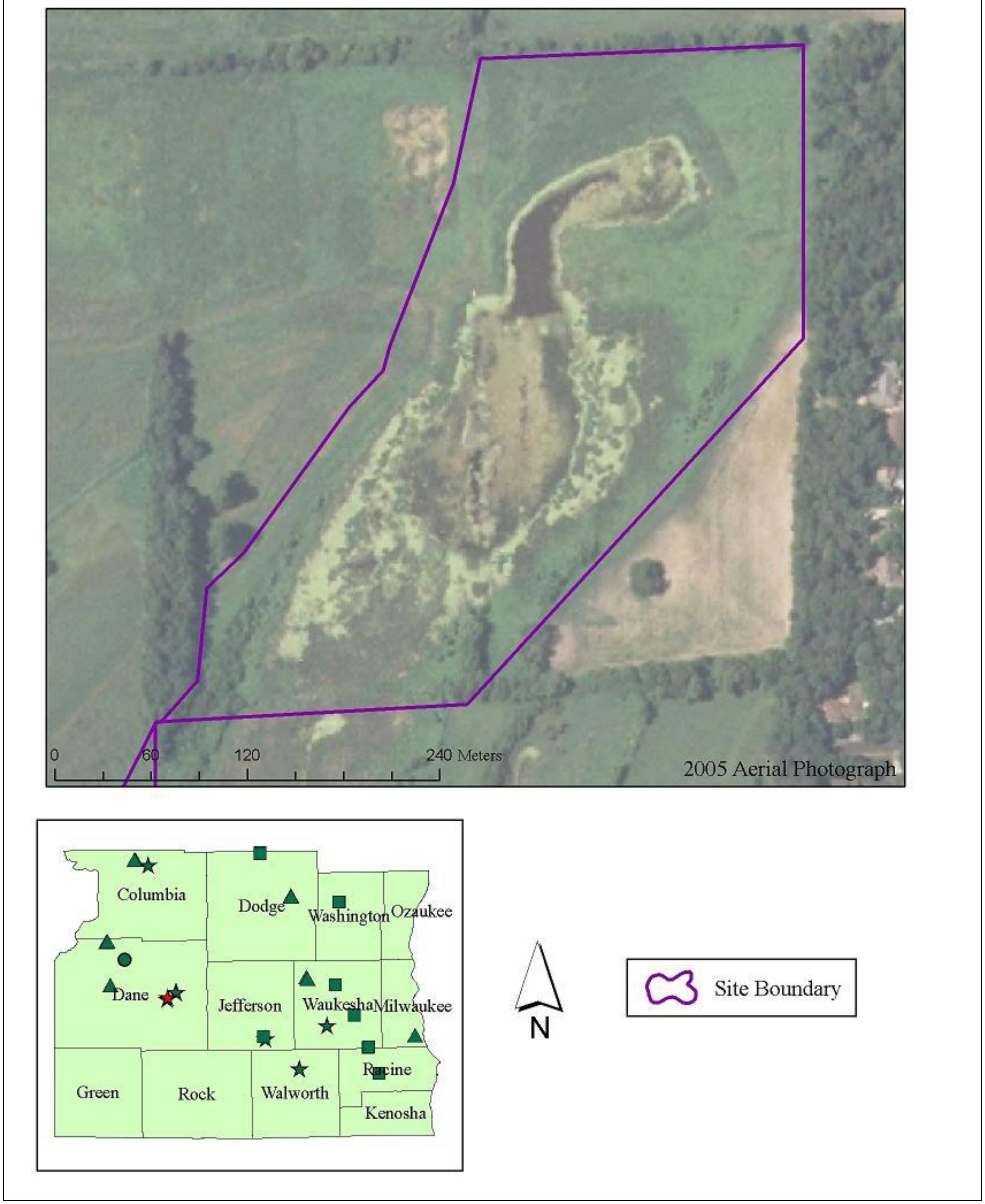
Wilke

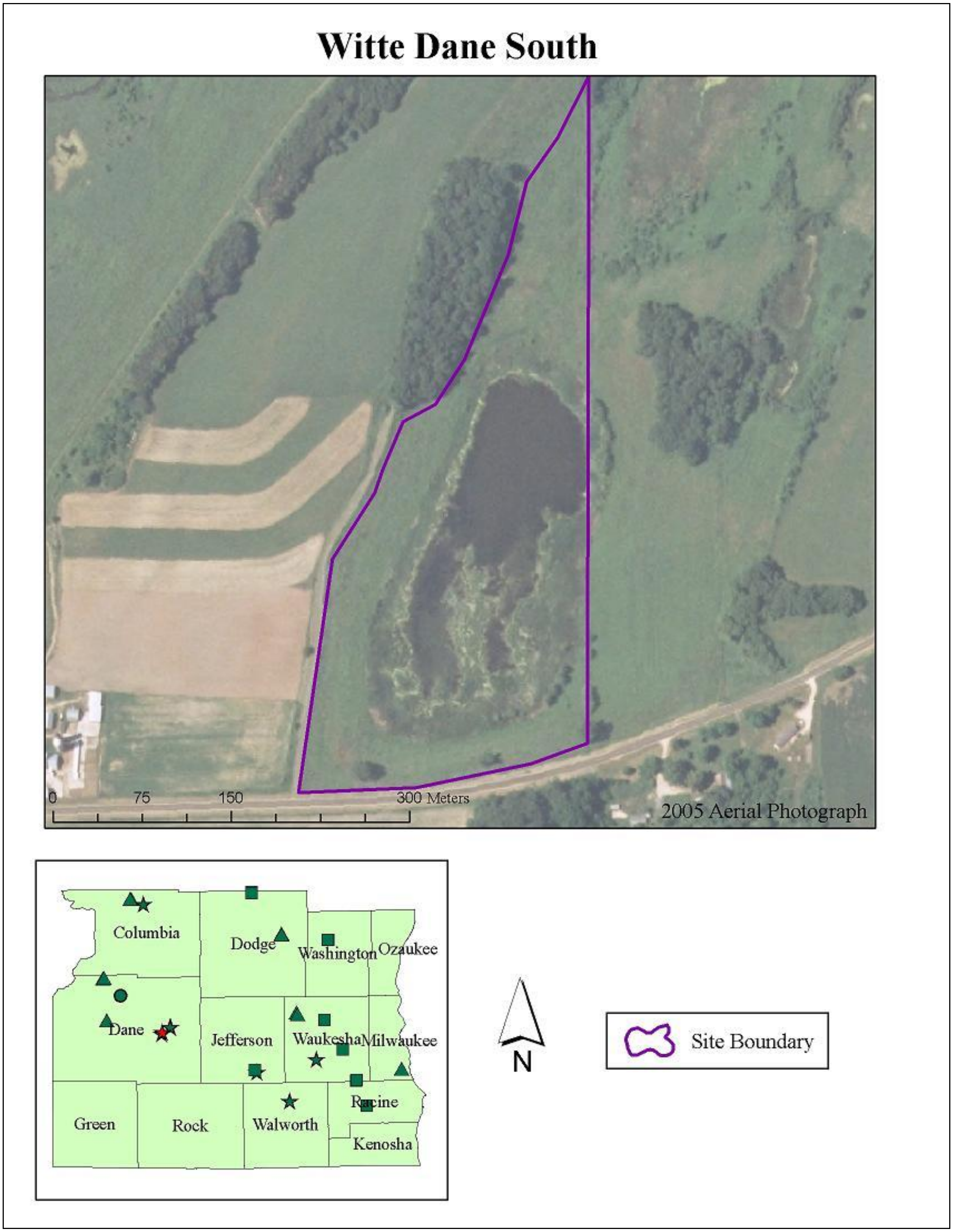

0
37.5
75
150 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Racine
Green
Rock
Walworth
Kenosha
N
Site Boundary

Witte Dane

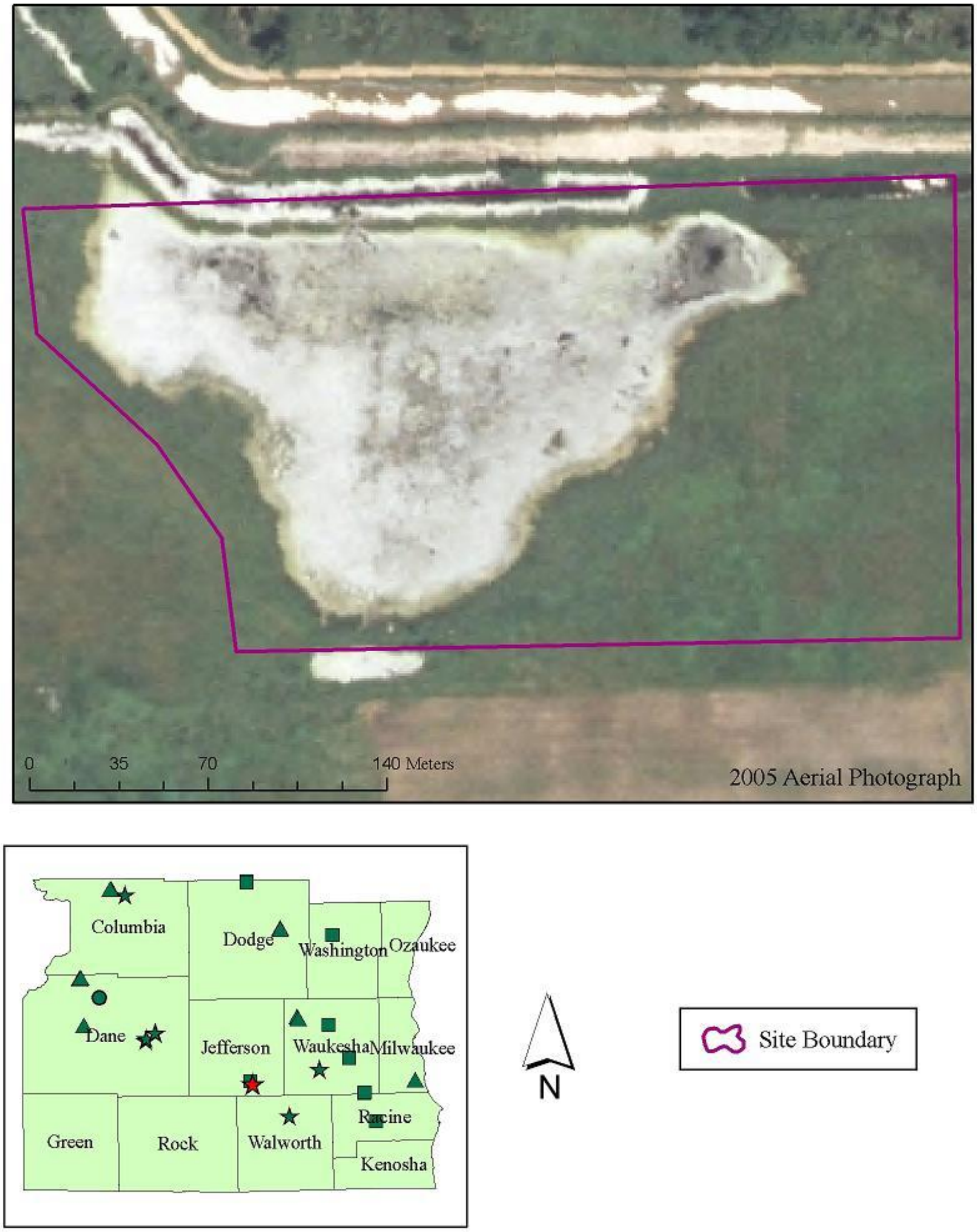

0
125
250
500 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Racine
Green
Rock
Walworth
Kenosha
N
Site Boundary

Witte Dane North



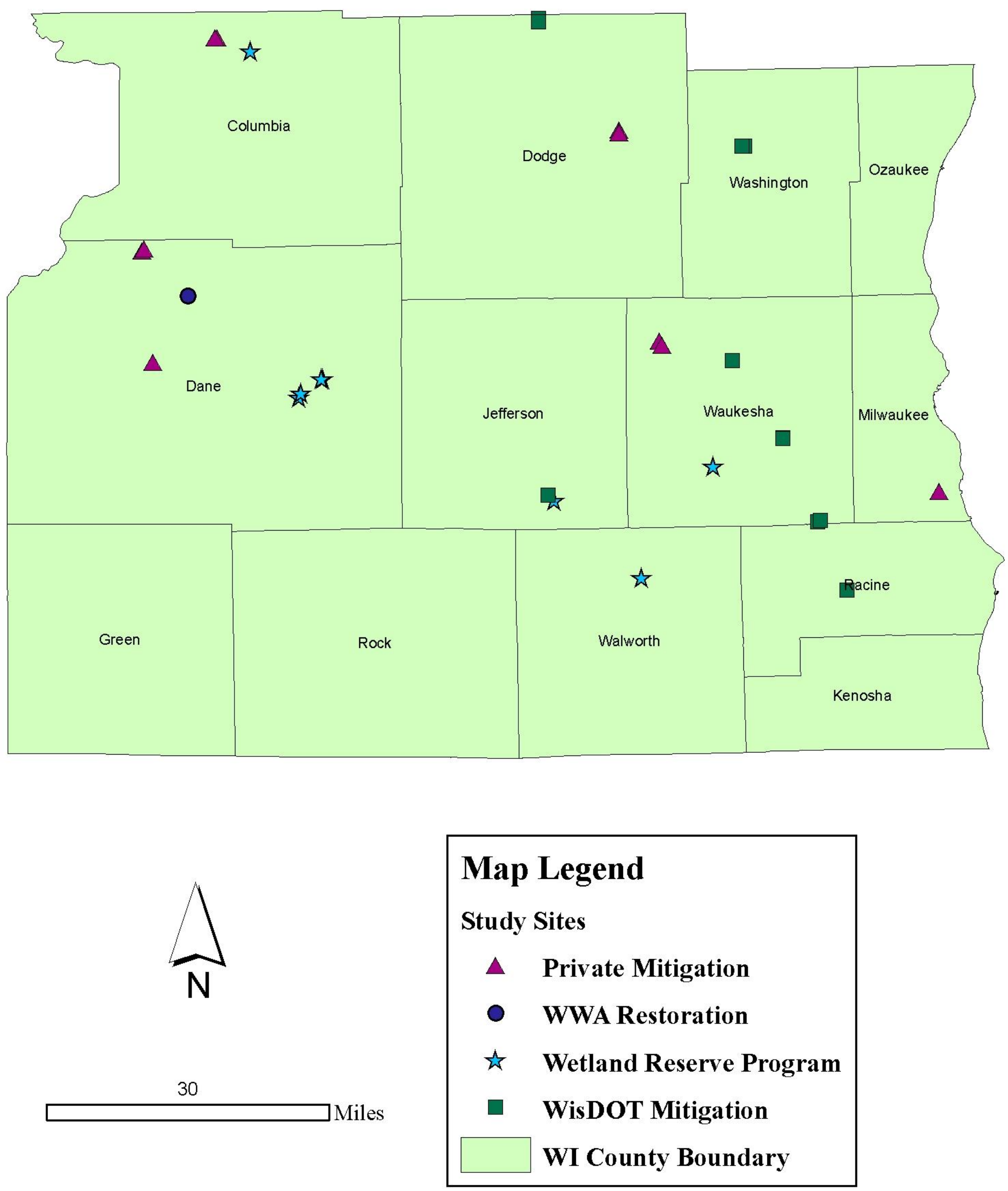

Witte Dane South
0
75
150
300 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Site Boundary

Witte Jefferson

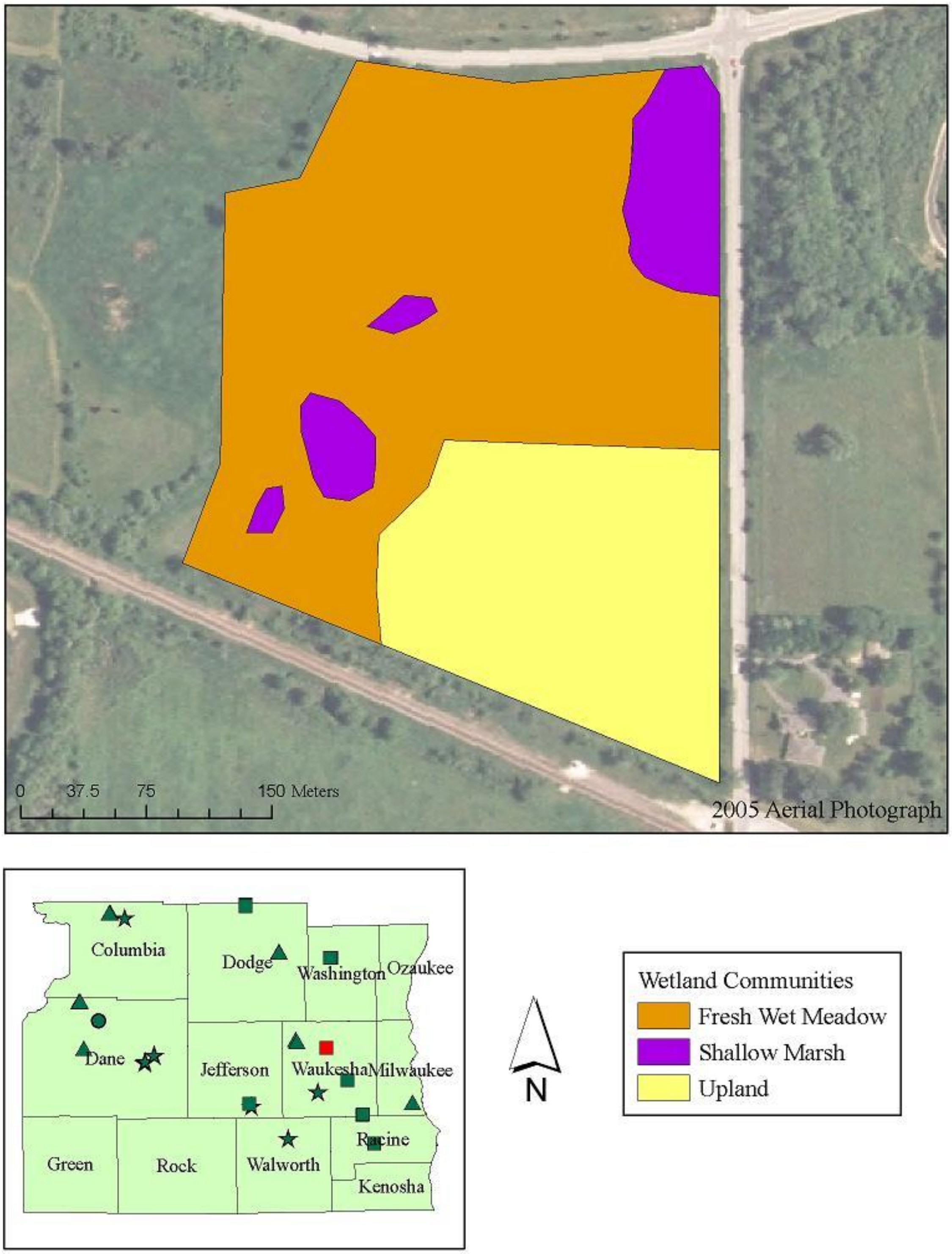


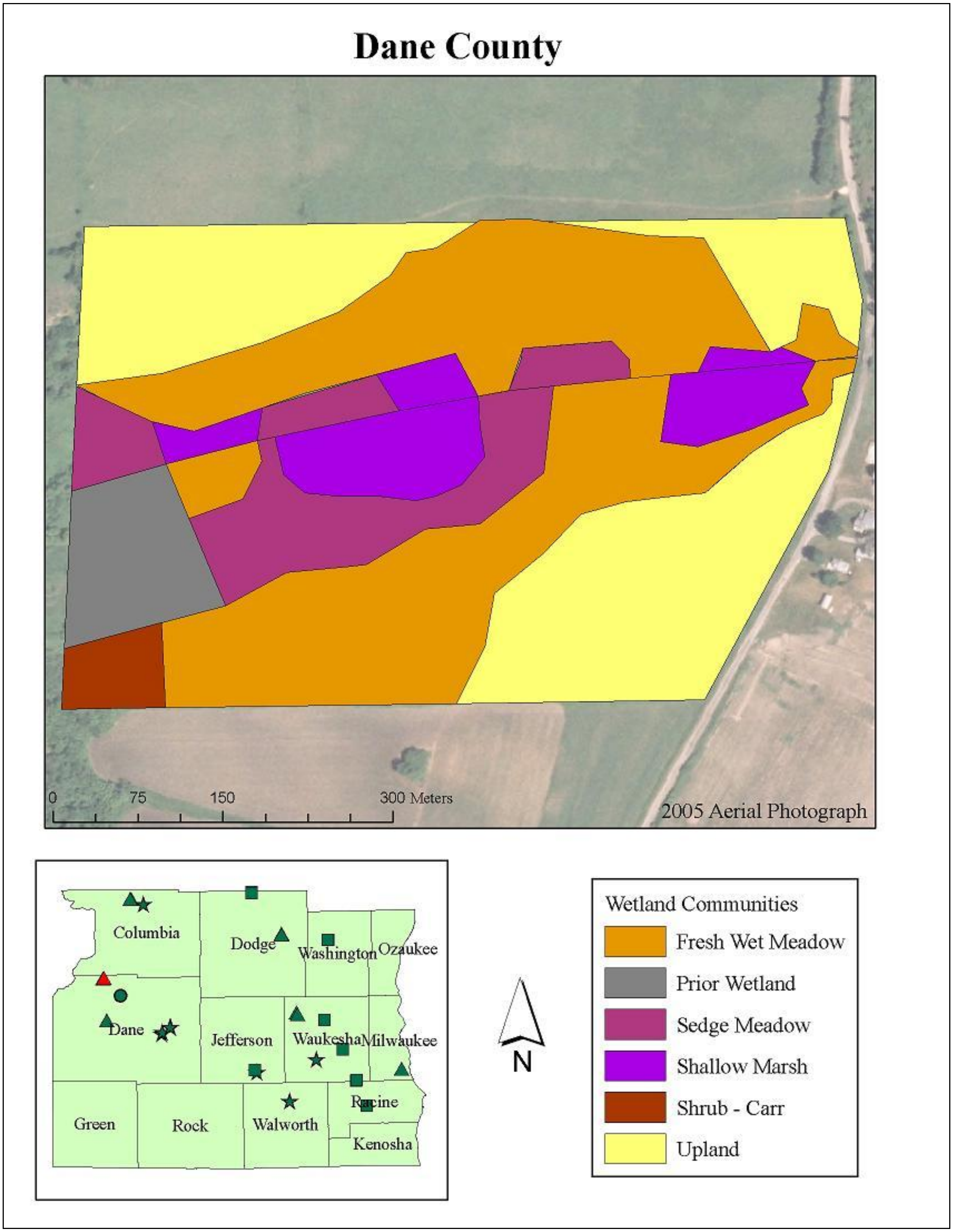
Appendix B: Community types within each of the study sites

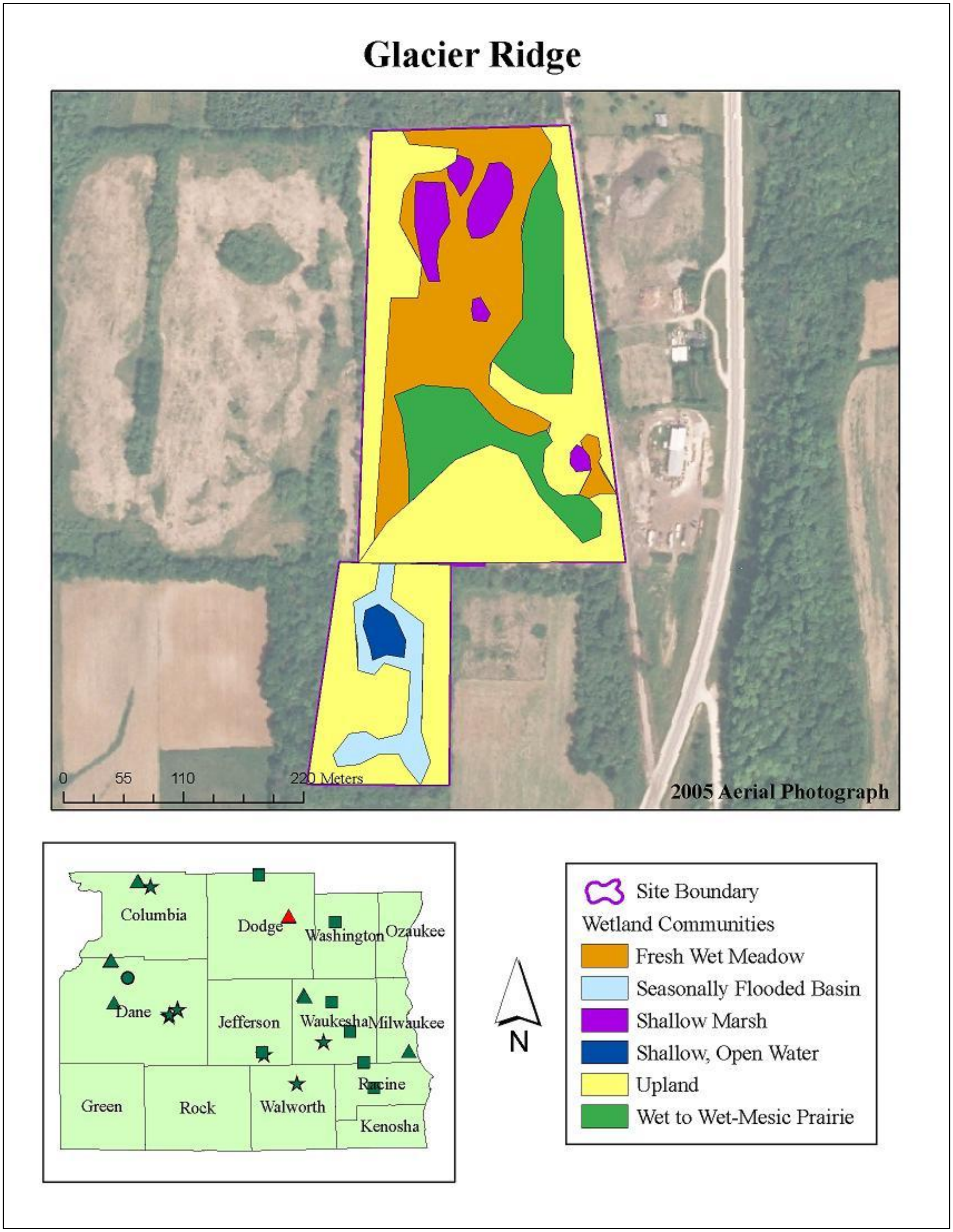
Location of wetland restoration study sites



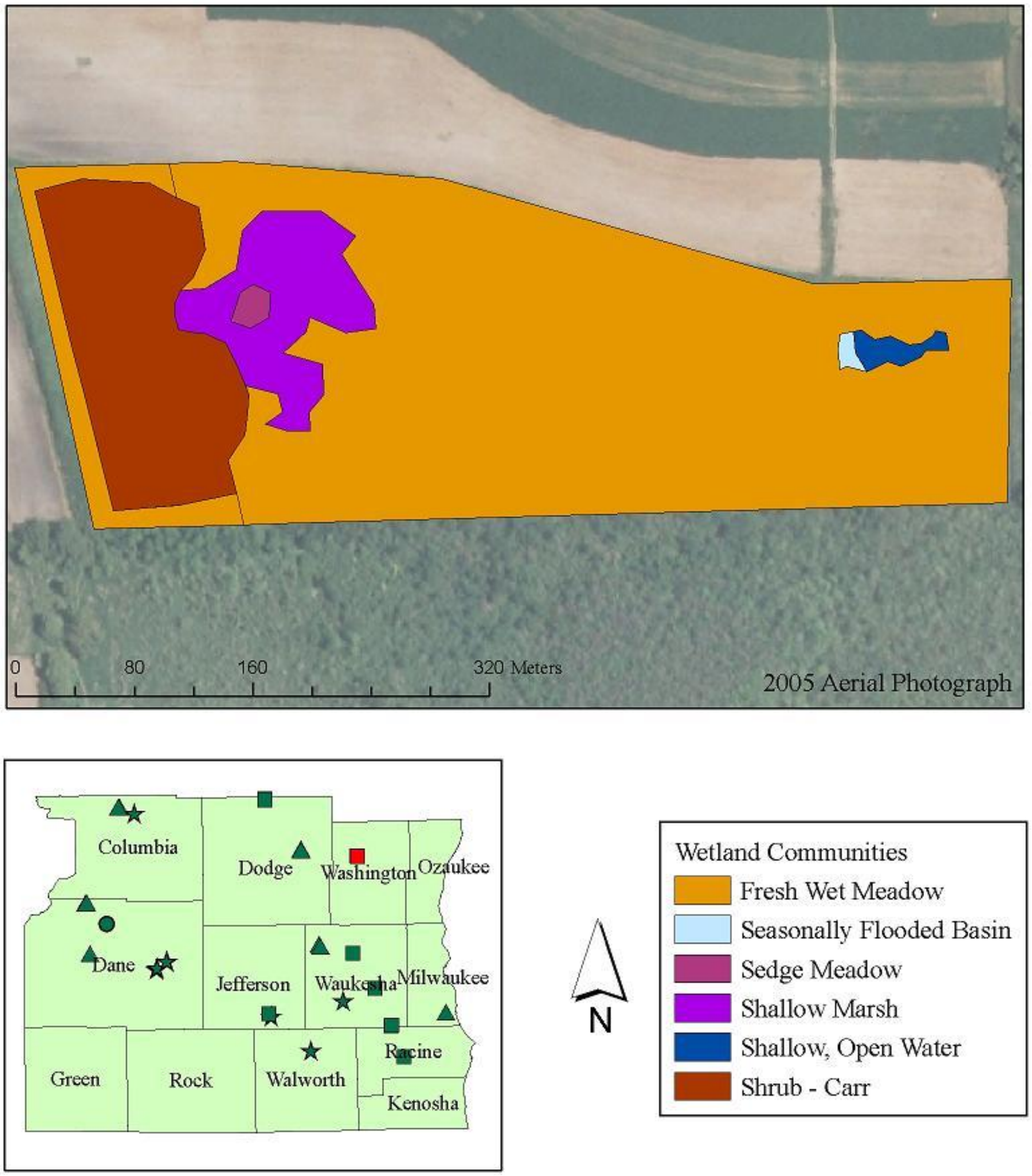
Cull


0 37.5 75 150 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Wetland Communities
Fresh Wet Meadow
Shallow Marsh
Upland

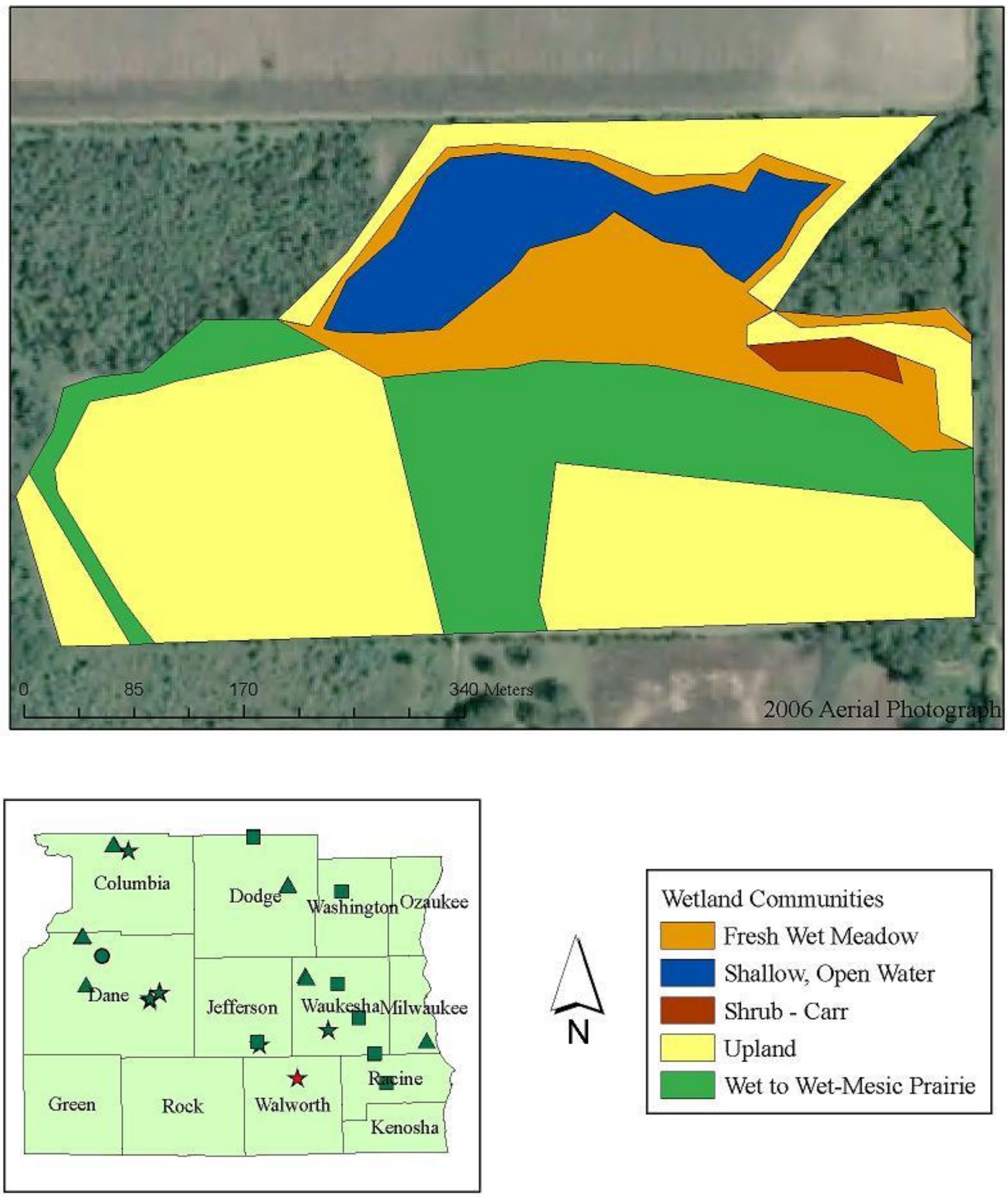

Dane County
0
75
150
300 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Racine
Green
Rock
Walworth
Kenosha
N
Wetland Communities
Fresh Wet Meadow
Prior Wetland
Sedge Meadow
Shallow Marsh
Shrub - Carr
Upland


Glacier Ridge
0 55 110 220 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Site Boundary
Wetland Communities
Fresh Wet Meadow
Seasonally Flooded Basin
Shallow Marsh
Shallow, Open Water
Upland
Wet to Wet-Mesic Prairie

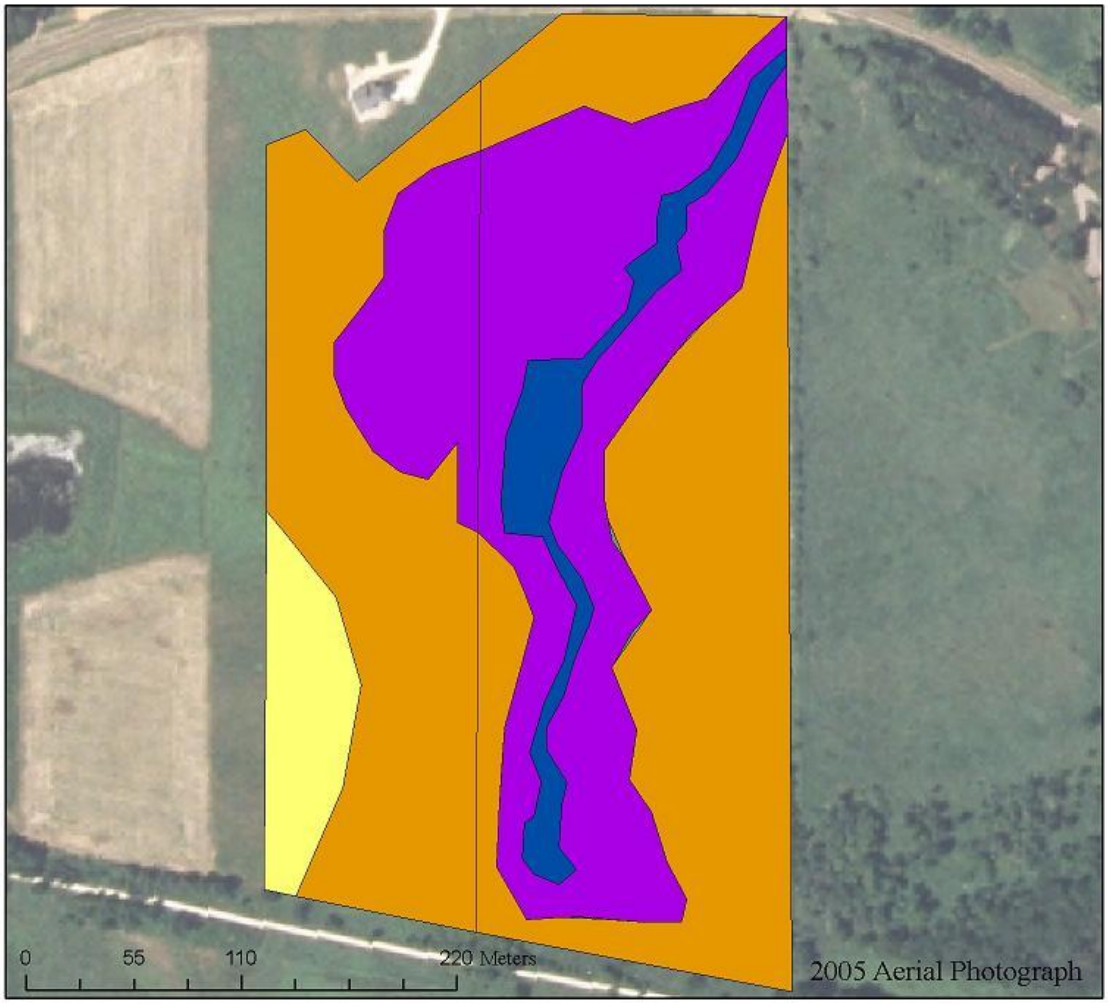
Gundrum

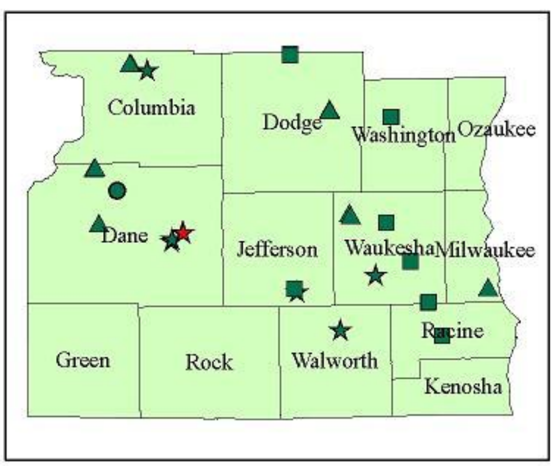

0
80
160
320 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Wetland Communities
Fresh Wet Meadow
Seasonally Flooded Basin
Sedge Meadow
Shallow Marsh
Shallow, Open Water
Shrub - Carr

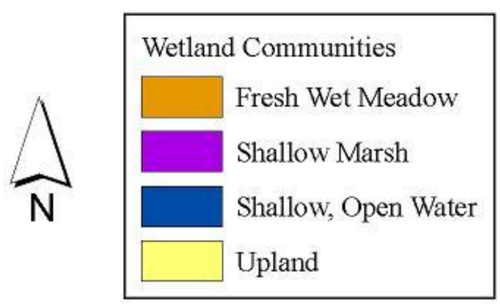
Mann

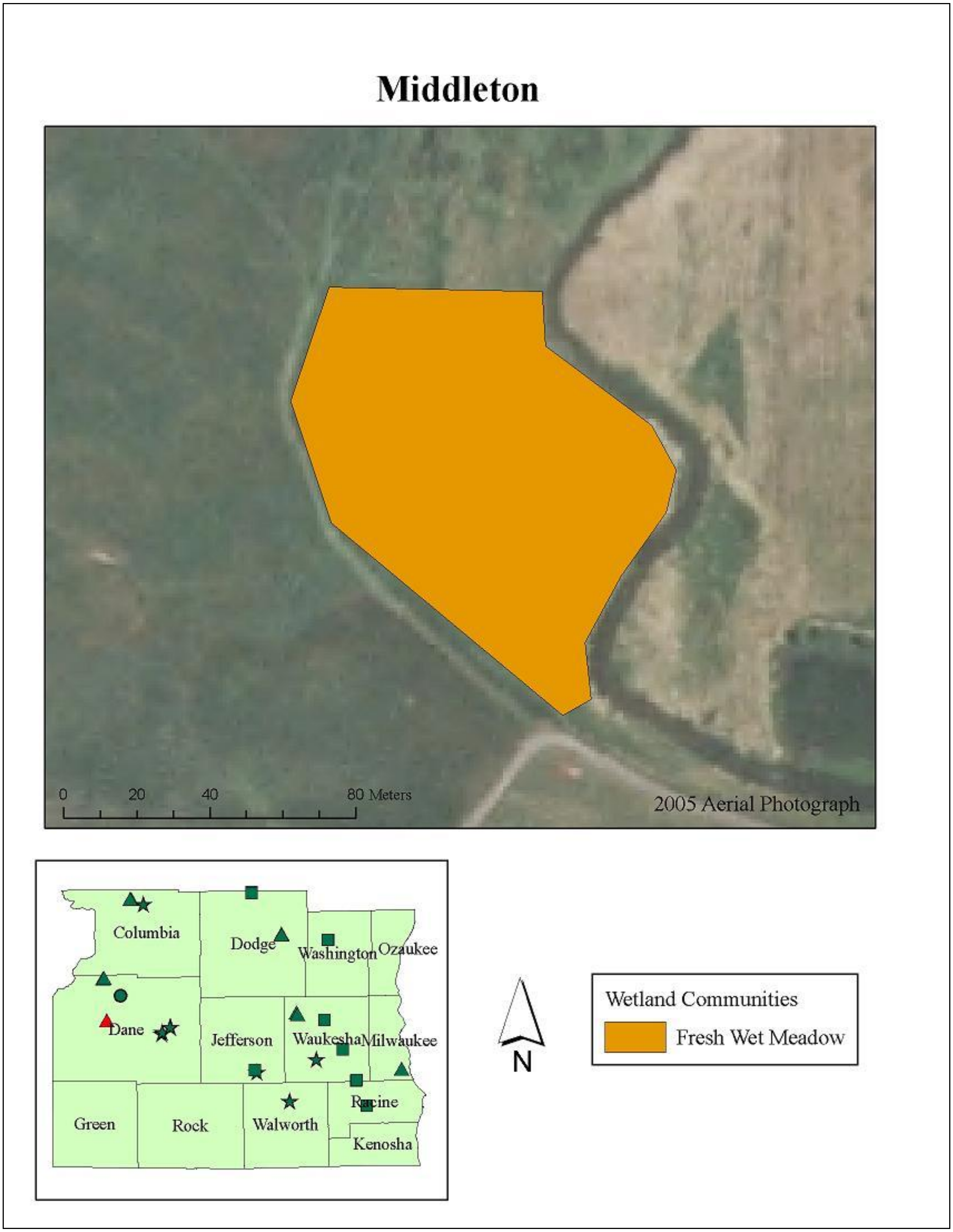

0
85
170
340 Meters
2006 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Wetland Communities
Fresh Wet Meadow
Shallow, Open Water
Shrub - Carr
Upland
Wet to Wet-Mesic Prairie

Martinelli

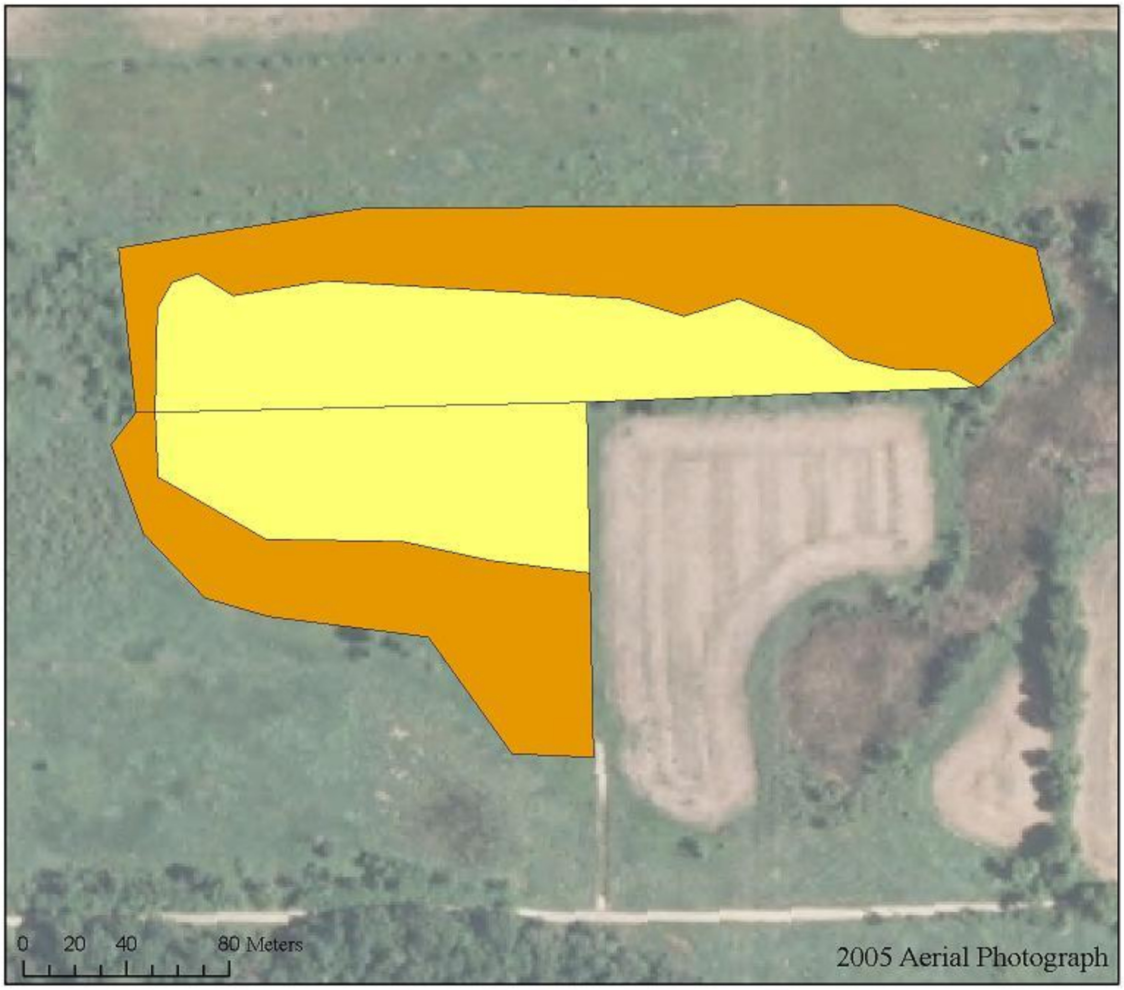

0
55
110
220 Meters
2005 Aerial Photograph

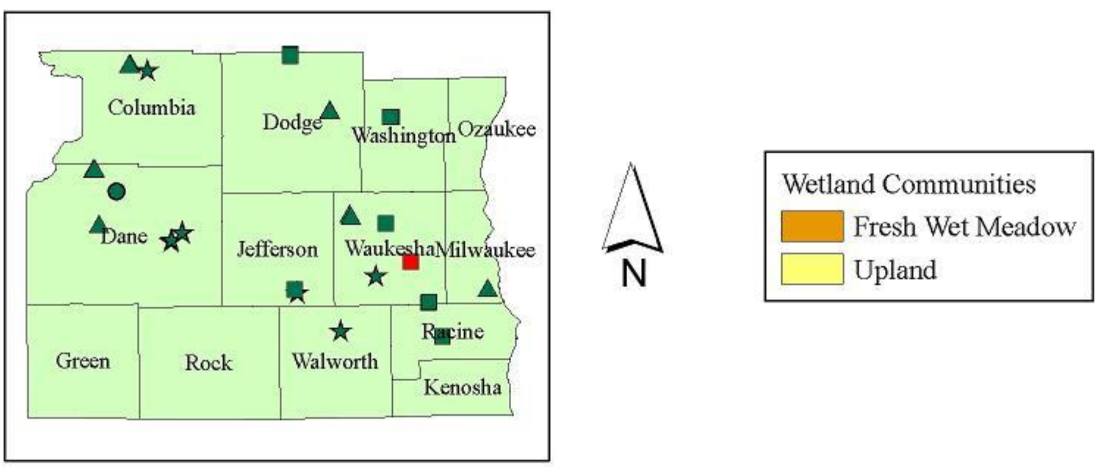

Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Racine
Green
Rock
Walworth
Kenosha

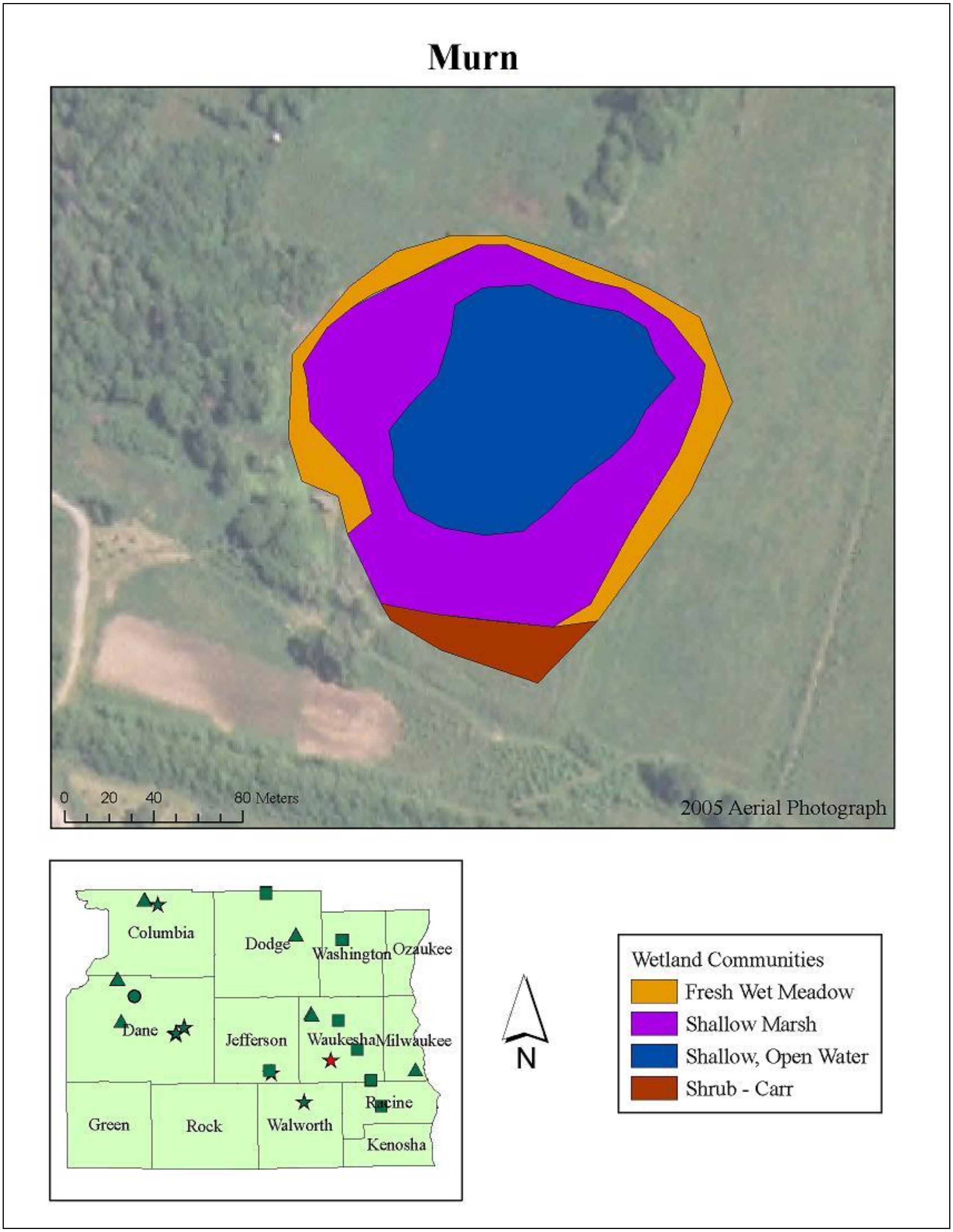

N
Wetland Communities
Fresh Wet Meadow
Shallow Marsh
Shallow, Open Water
Upland

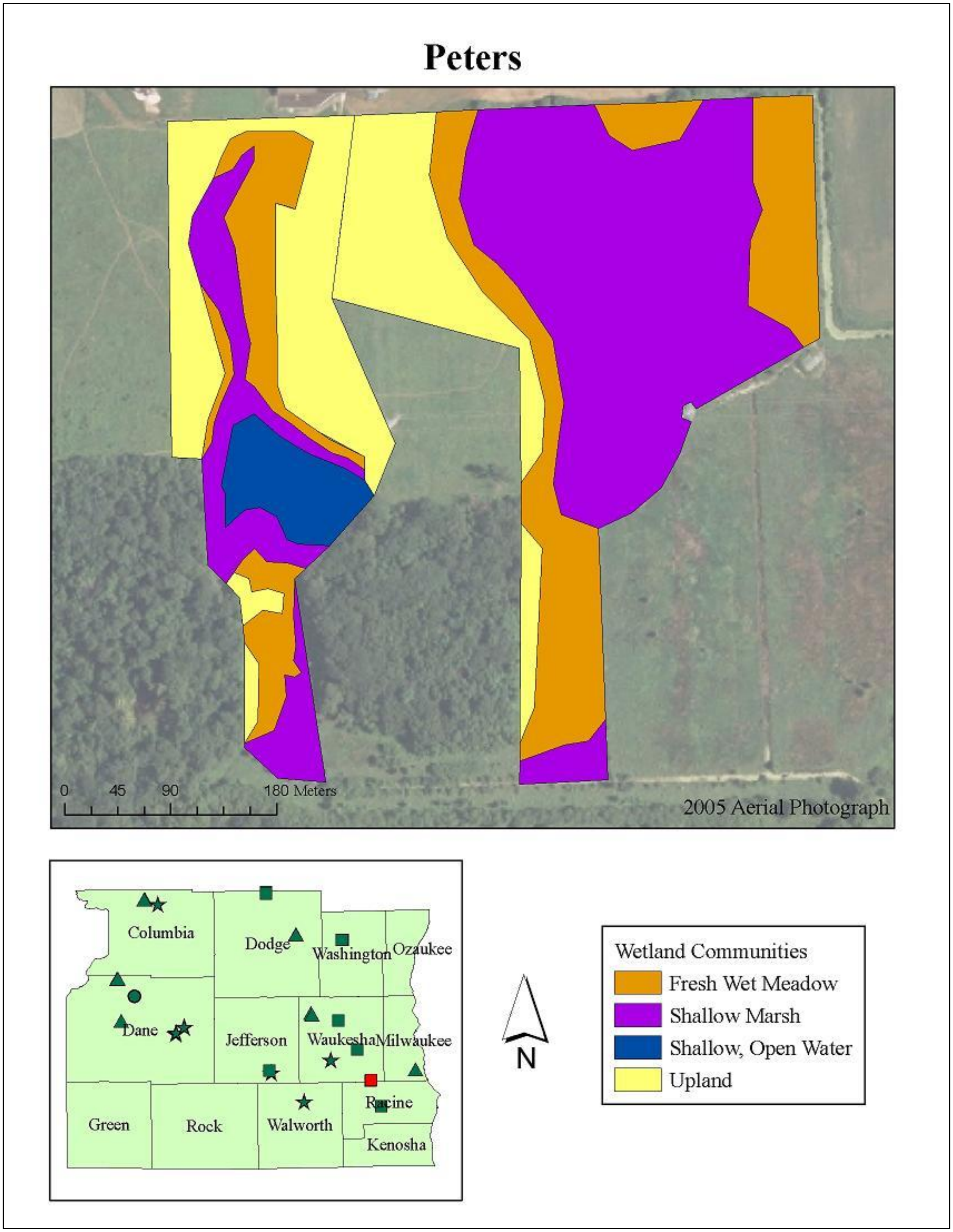

Middleton
0
20
40
80 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Wetland Communities
Fresh Wet Meadow

Moyer

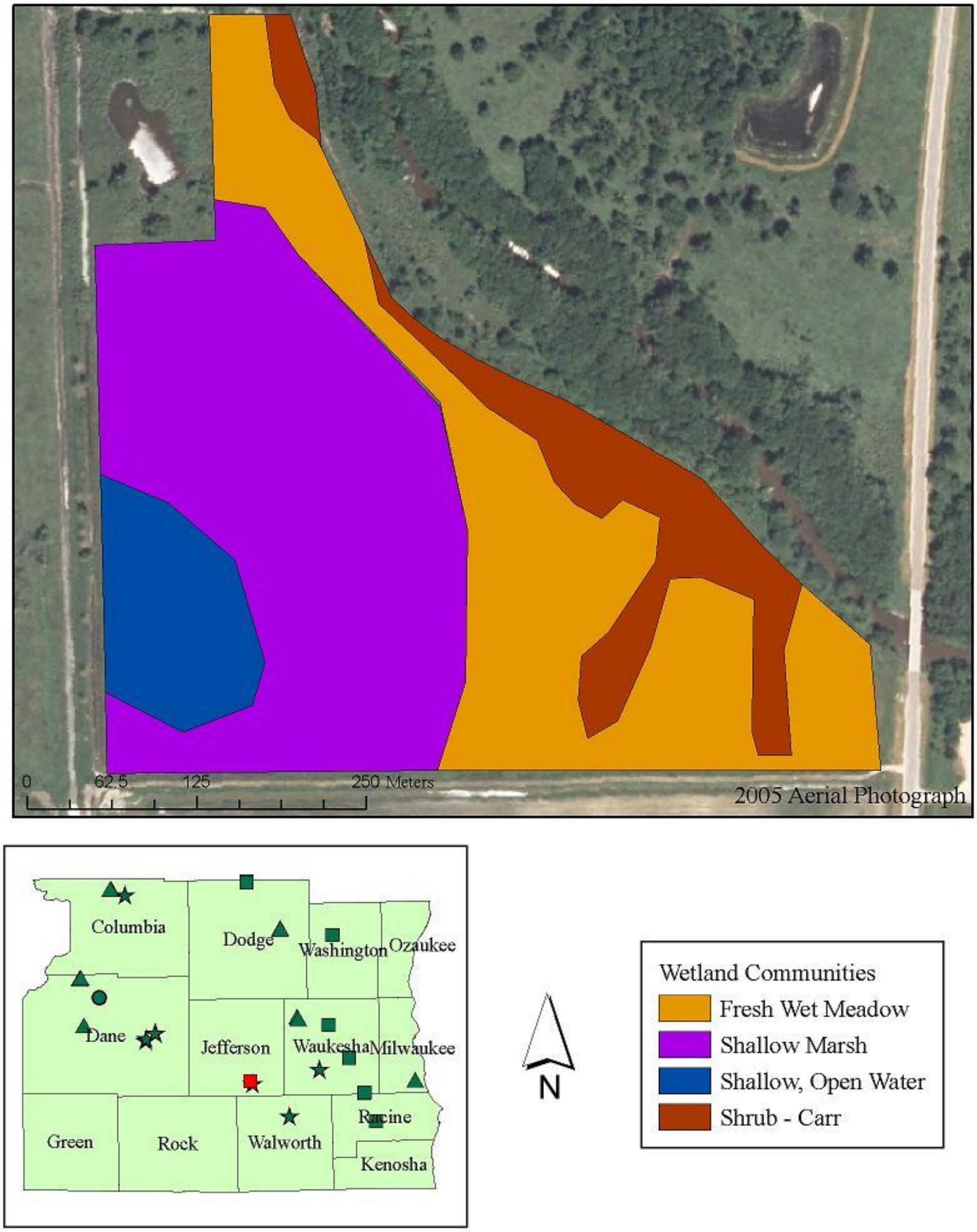

0 20 40 80 Meters
2005 Aerial Photograph


Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Wetland Communities
Fresh Wet Meadow
Upland

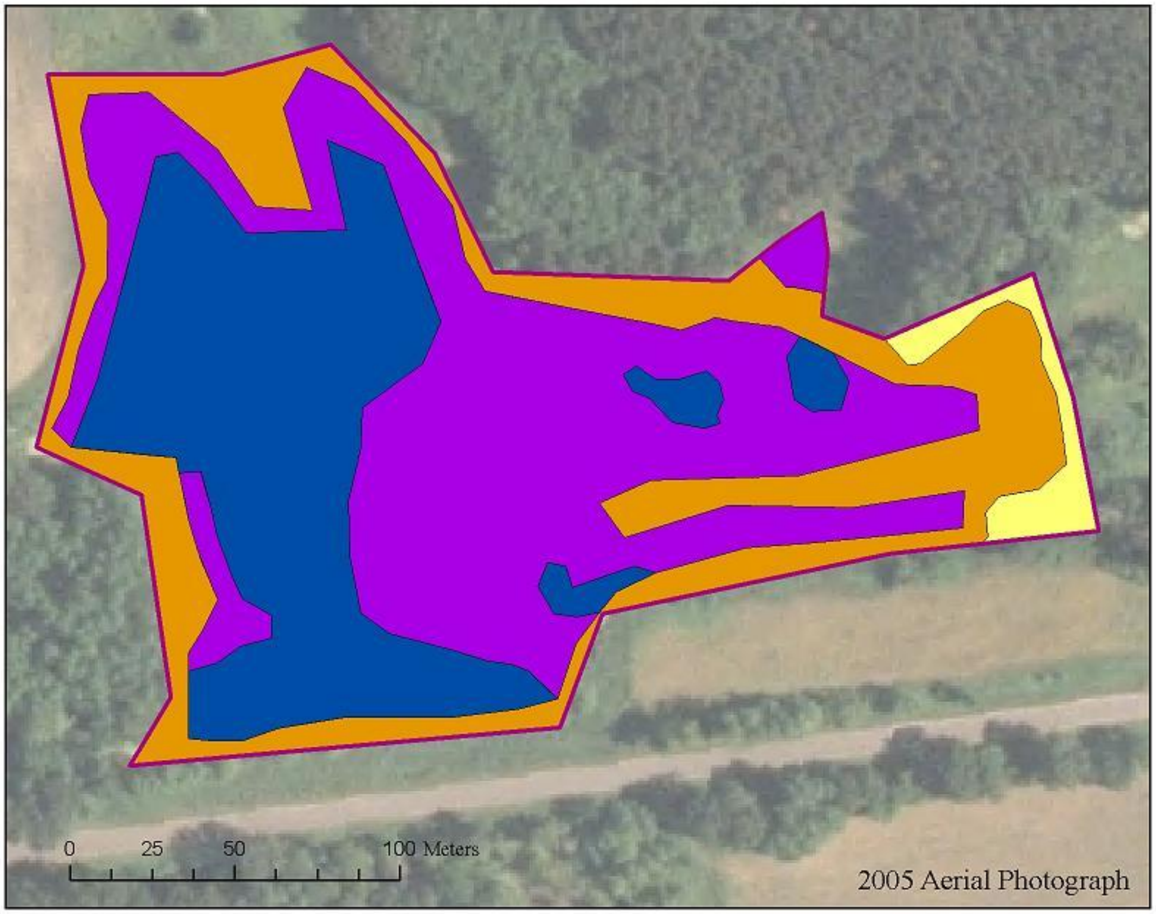

Murn
0 20 40 80 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Racine
Green
Rock
Walworth
Kenosha
N
Wetland Communities
Fresh Wet Meadow
Shallow Marsh
Shallow, Open Water
Shrub - Carr

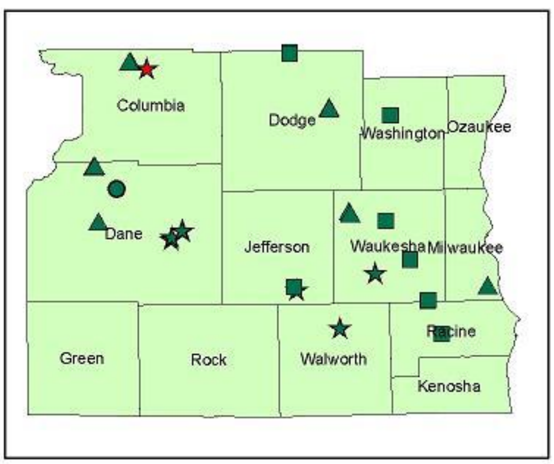

Peters
0 45 90 180 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Racine
Green
Rock
Walworth
Kenosha
N
Wetland Communities
Fresh Wet Meadow
Shallow Marsh
Shallow, Open Water
Upland

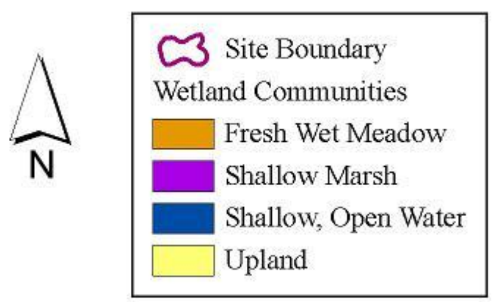
Princes Point

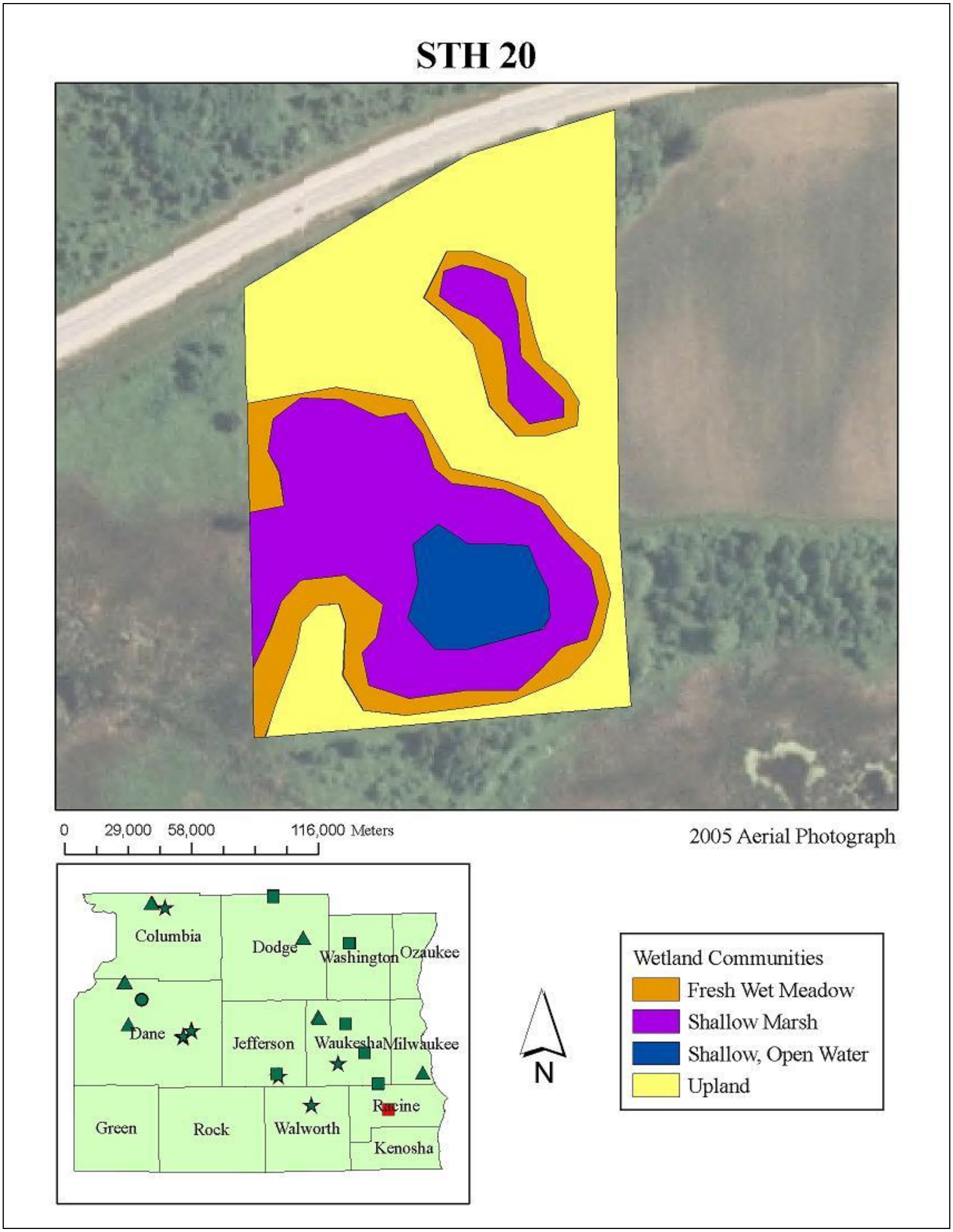


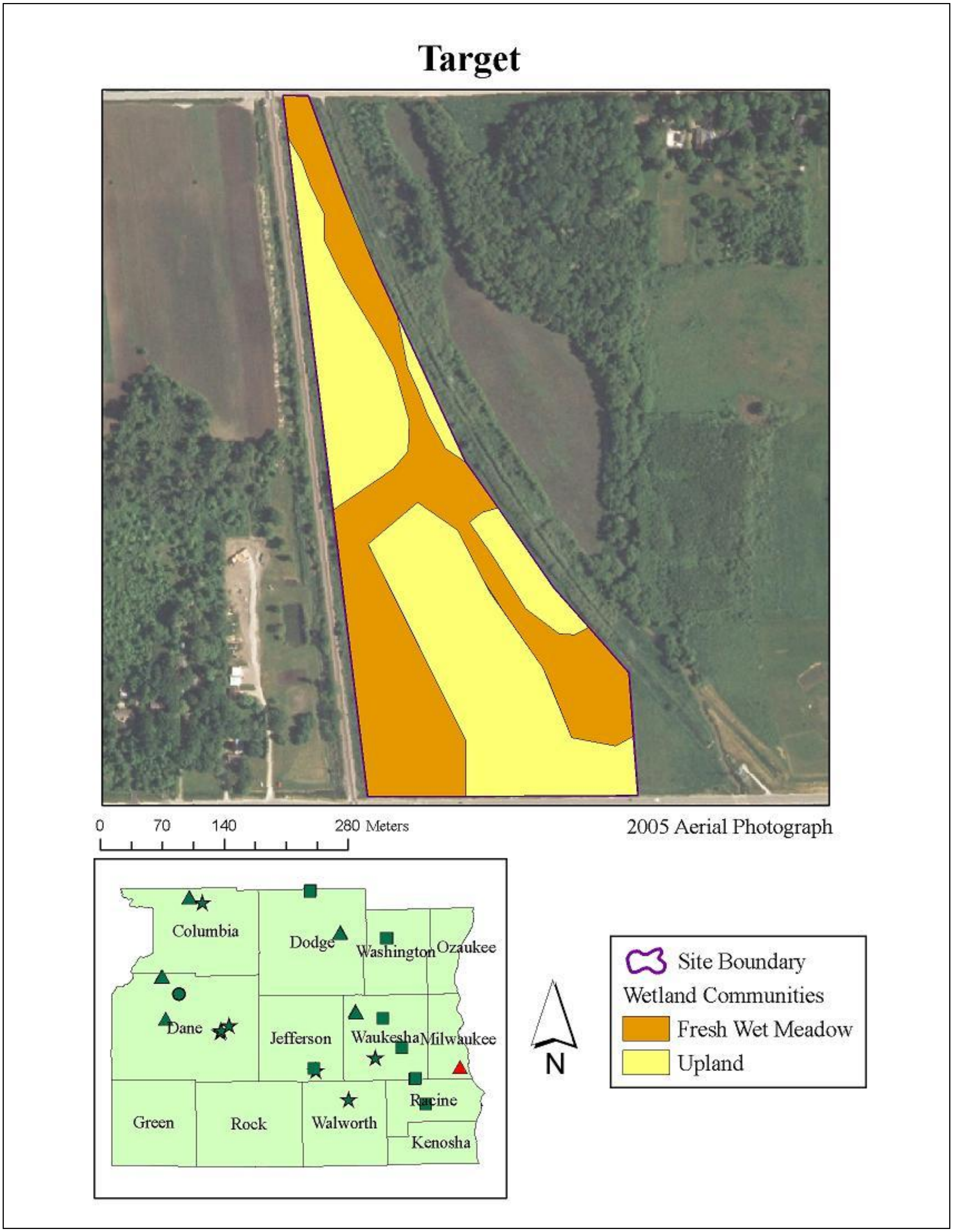
Savoy


0
25
50
100 Meters
2005 Aerial Photograph

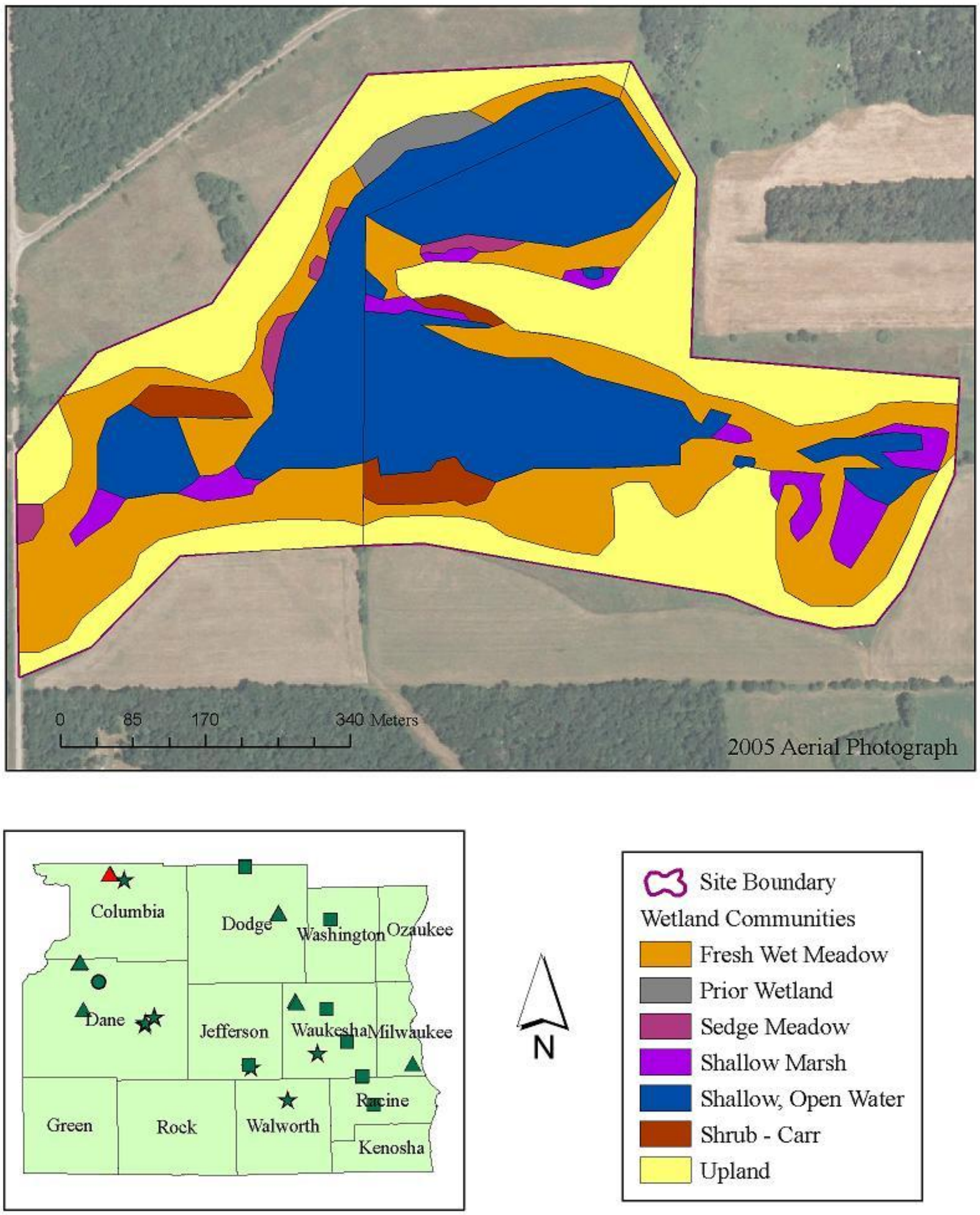

Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha


N
Site Boundary
Wetland Communities
Fresh Wet Meadow
Shallow Marsh
Shallow, Open Water
Upland

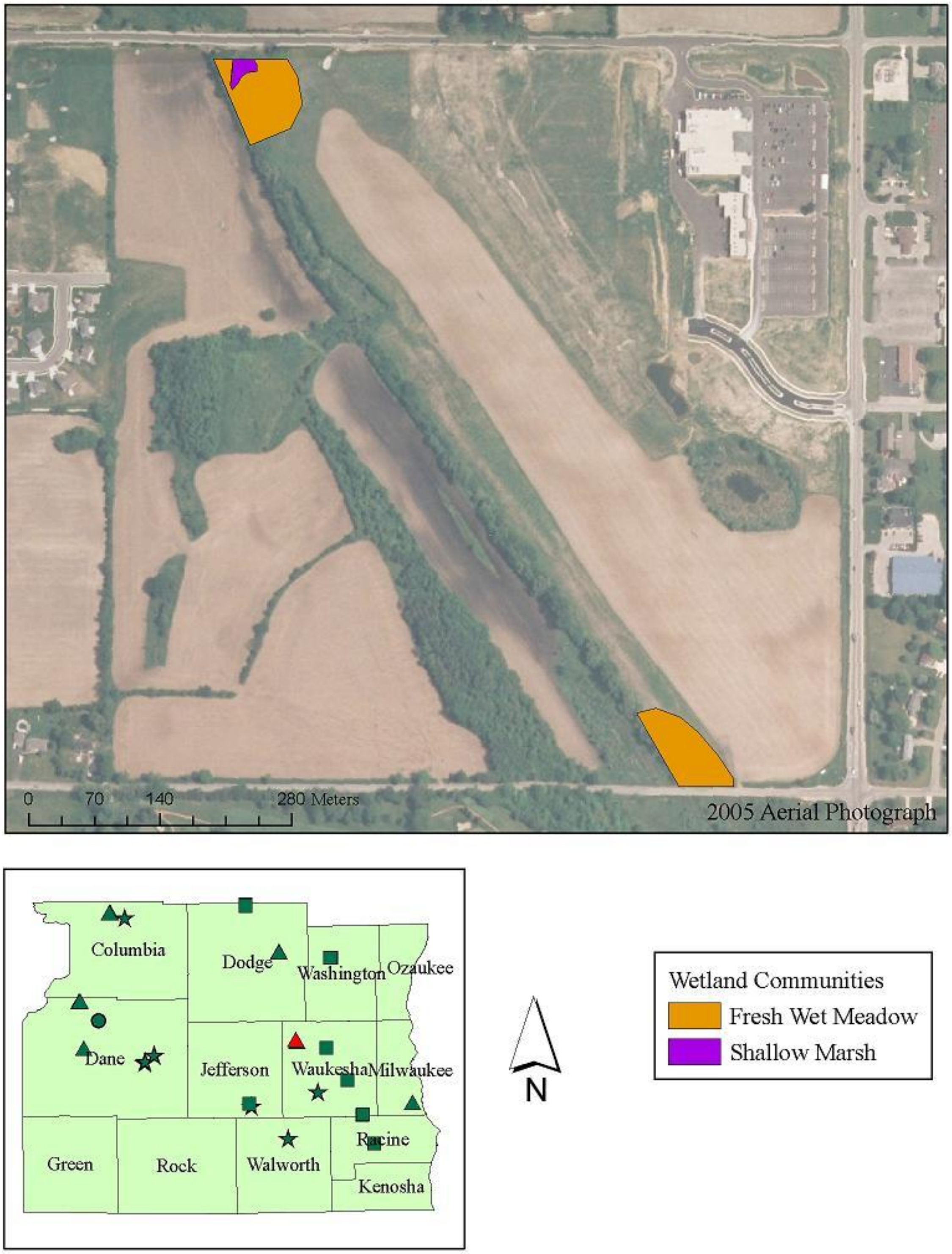

STH 20
0
29,000
58,000
116,000 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
Wetland Communities
Fresh Wet Meadow
Shallow Marsh
Shallow, Open Water
Upland
N

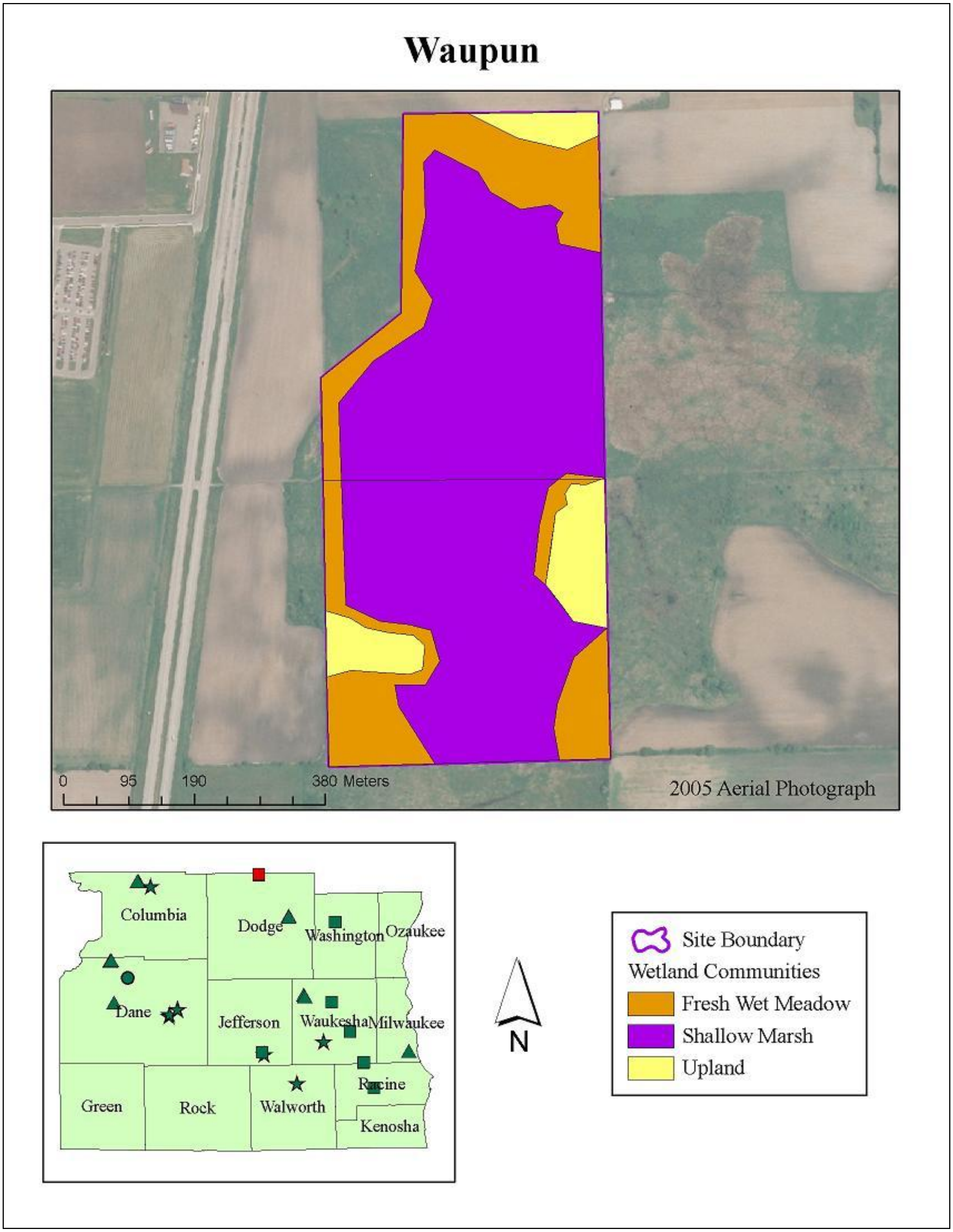

Target
0
70
140
280 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Site Boundary
Wetland Communities
Fresh Wet Meadow
Upland

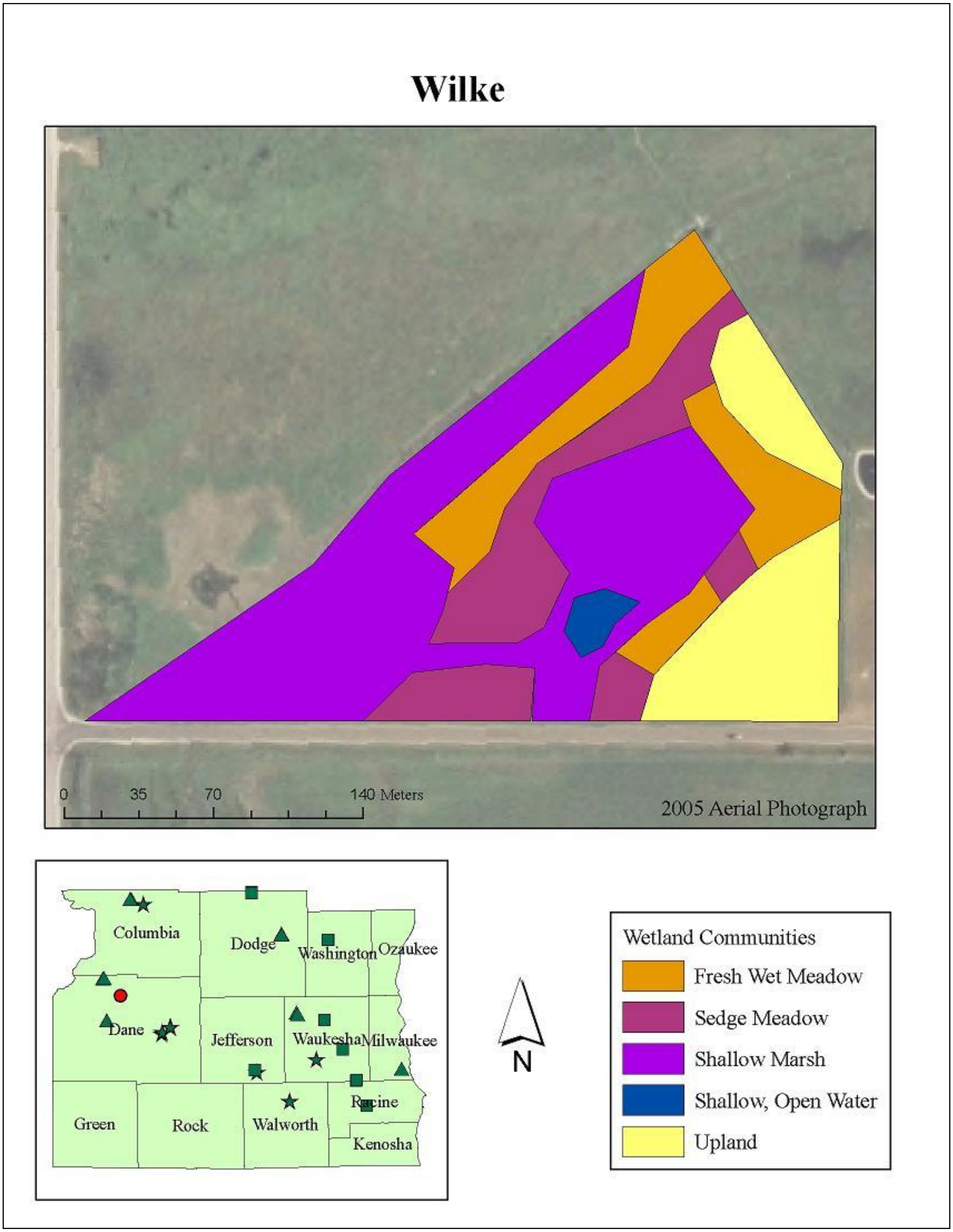
Walkerwin

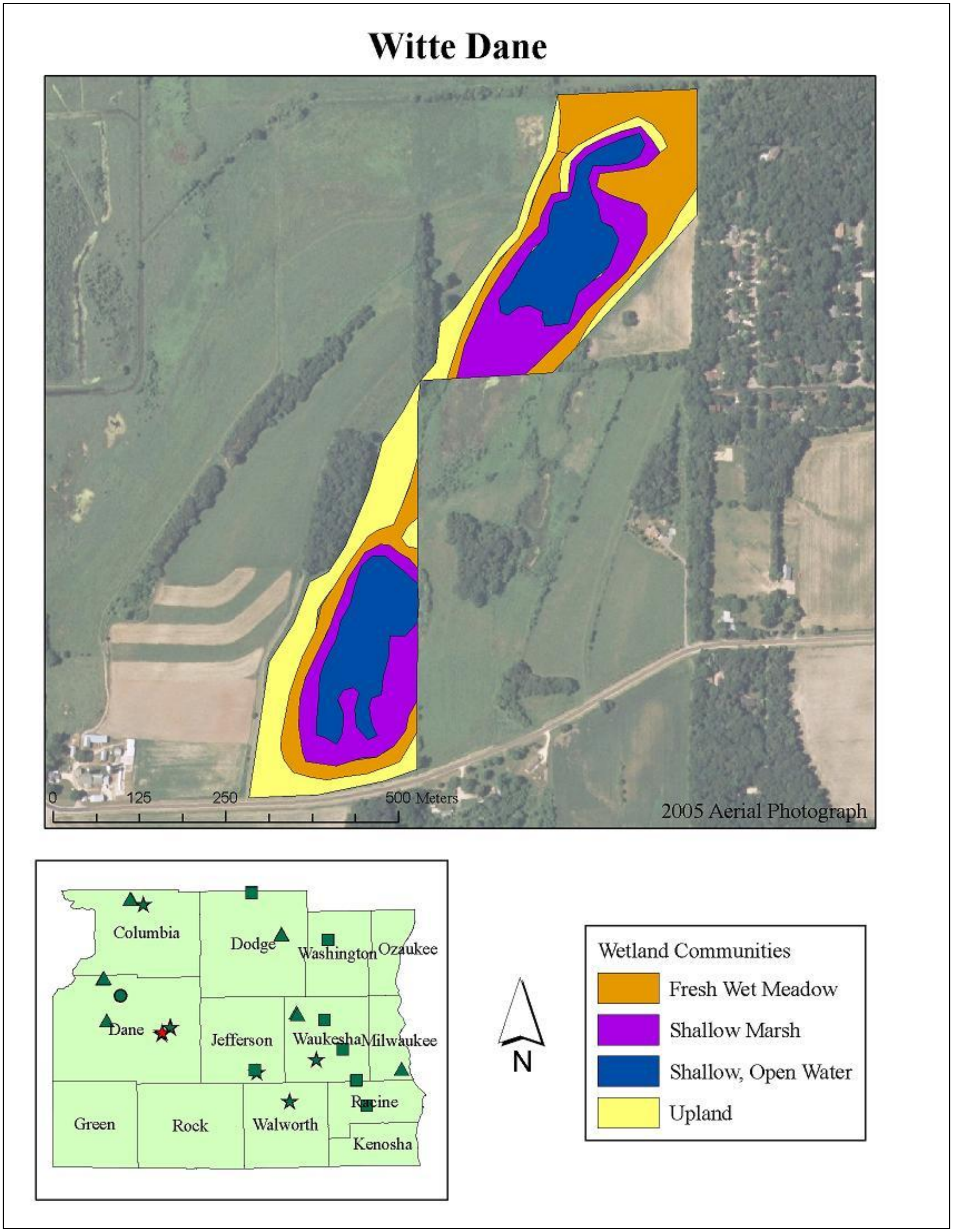

0
85
170
340 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Site Boundary
Wetland Communities
Fresh Wet Meadow
Prior Wetland
Sedge Meadow
Shallow Marsh
Shallow, Open Water
Shrub - Carr
Upland

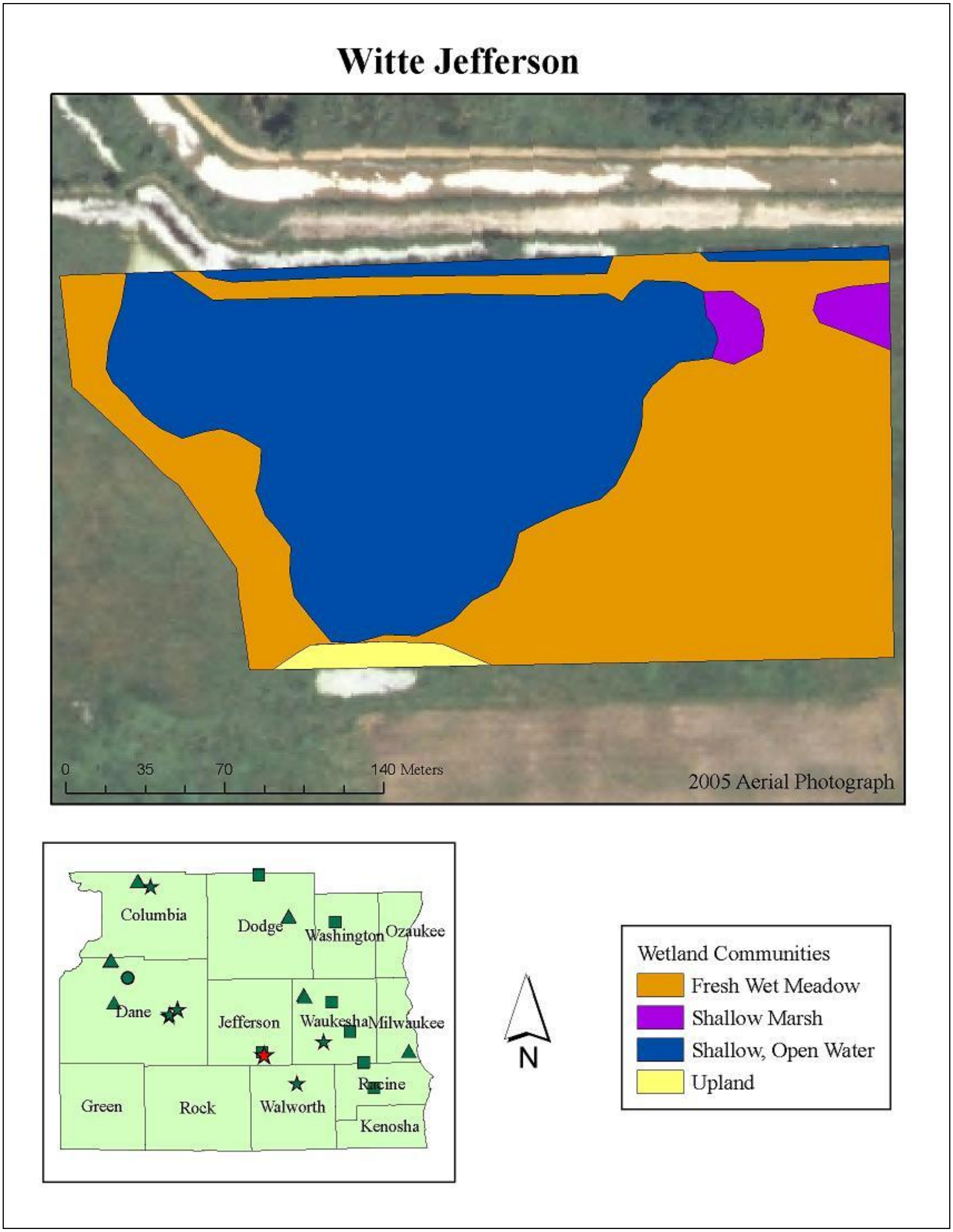
Wangard


0 70 140 280 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Wetland Communities
Fresh Wet Meadow
Shallow Marsh

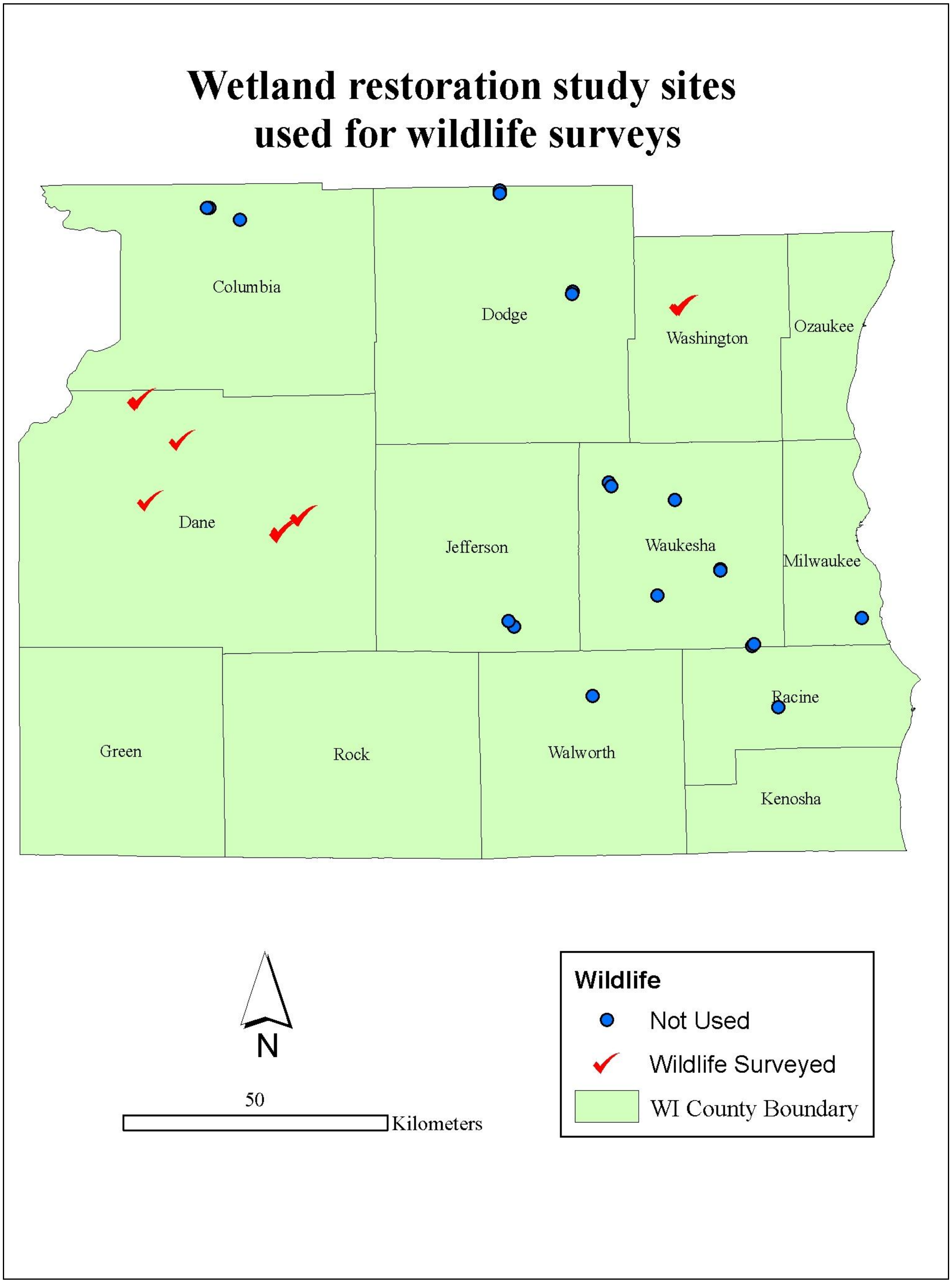

Waupun
0
95
190
380 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Site Boundary
Wetland Communities
Fresh Wet Meadow
Shallow Marsh
Upland

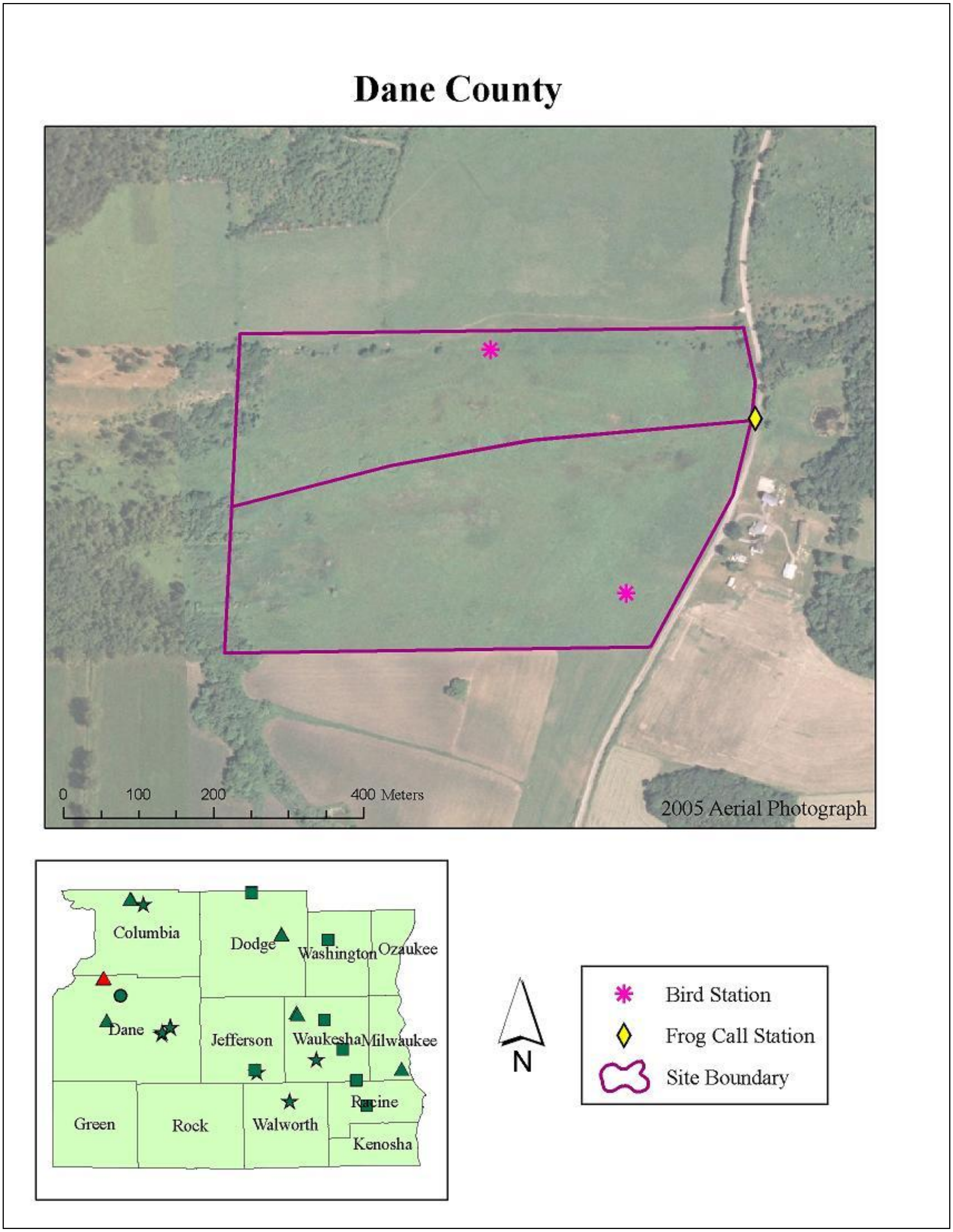

Wilke
0
35
70
140 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Wetland Communities
Fresh Wet Meadow
Sedge Meadow
Shallow Marsh
Shallow, Open Water
Upland


Witte Dane
0
125
250
500 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Racine
Green
Rock
Walworth
Kenosha
N
Wetland Communities
Fresh Wet Meadow
Shallow Marsh
Shallow, Open Water
Upland

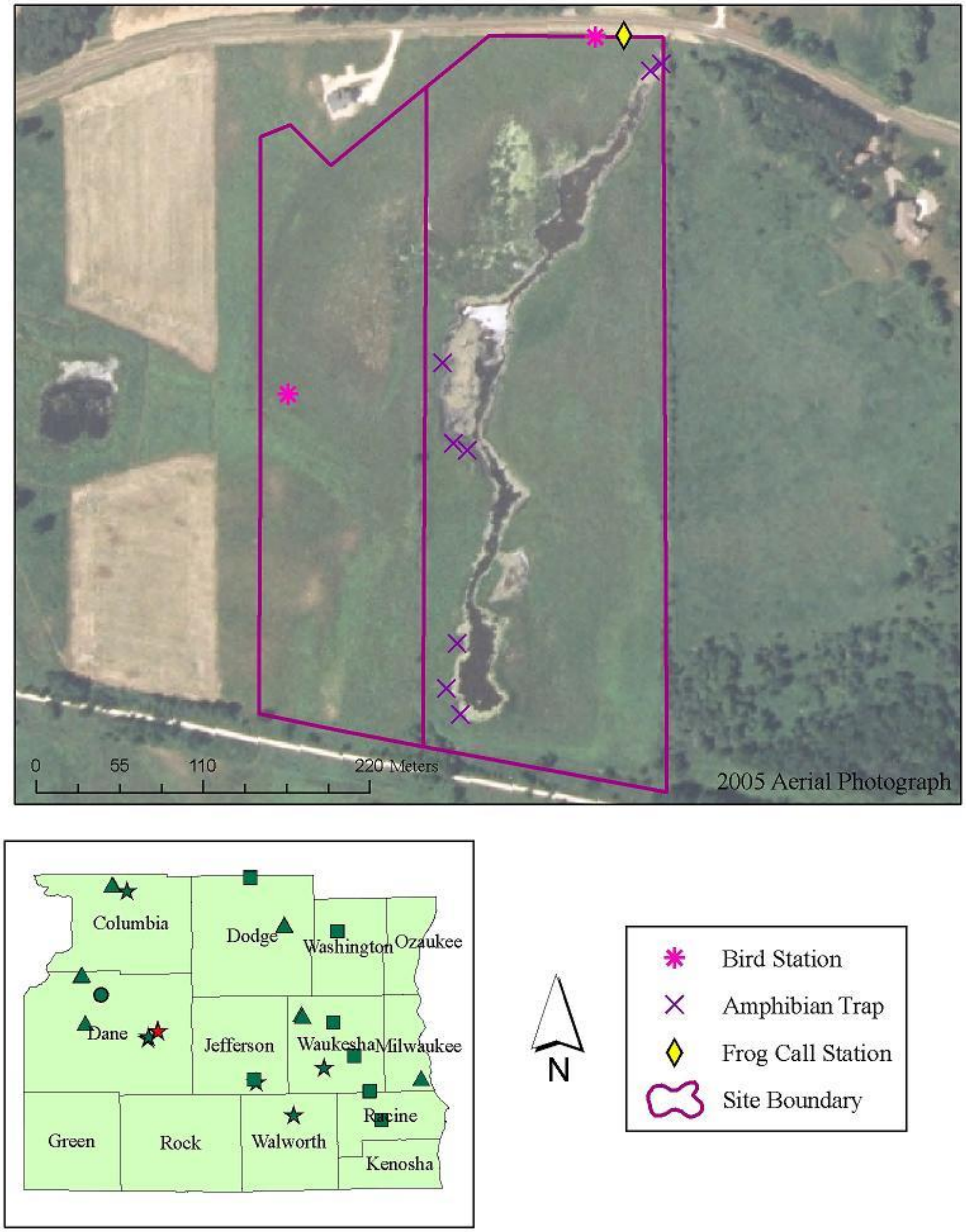

Witte Jefferson
0 35 70 140 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Wetland Communities
Fresh Wet Meadow
Shallow Marsh
Shallow, Open Water
Upland

Appendix C: Study sites used for wildlife monitoring


Wetland restoration study sites
used for wildlife surveys
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
50
Kilometers
Wildlife
Not Used
Wildlife Surveyed
WI County Boundary

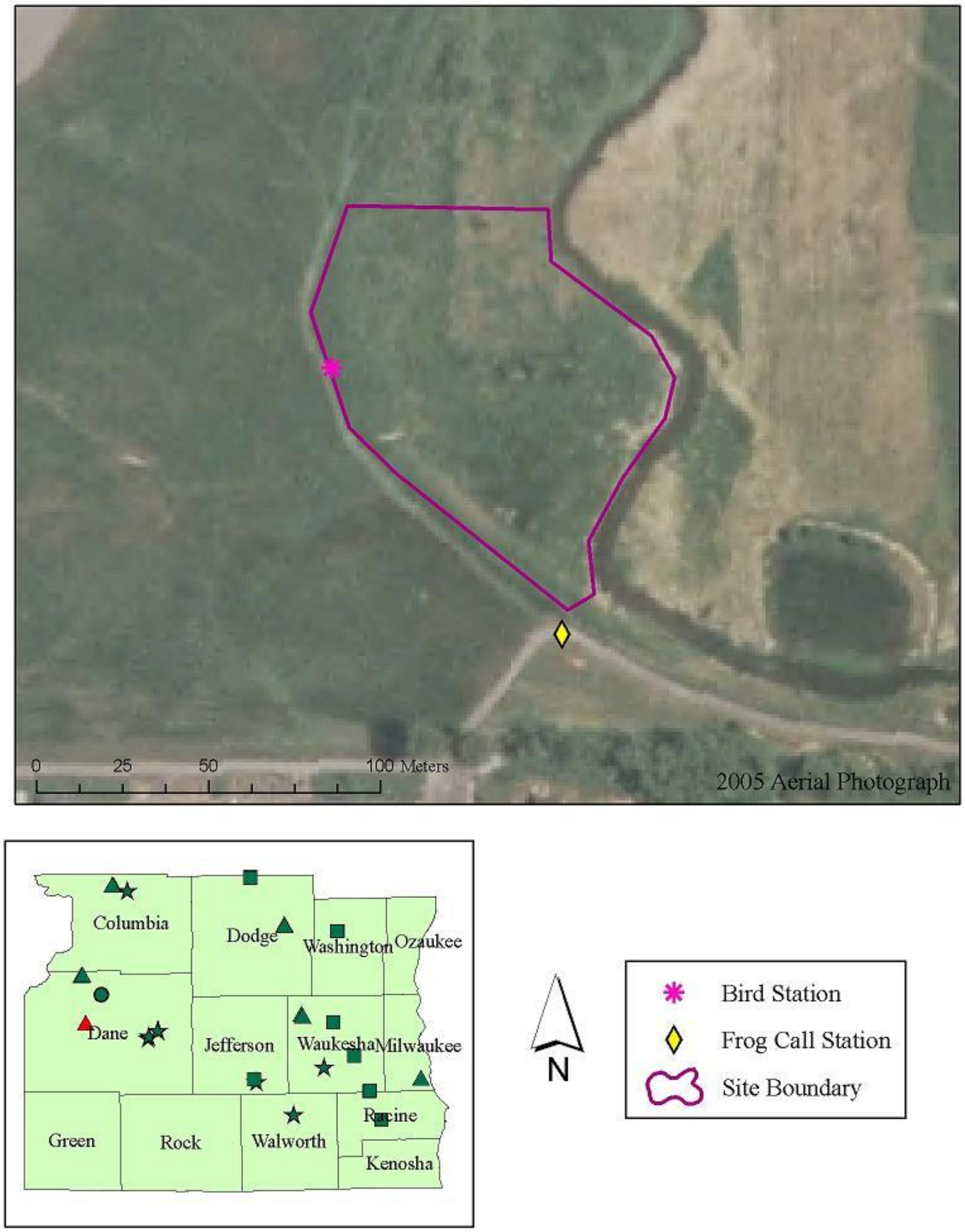

Dane County
0
100
200
400 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Bird Station
Frog Call Station
Site Boundary

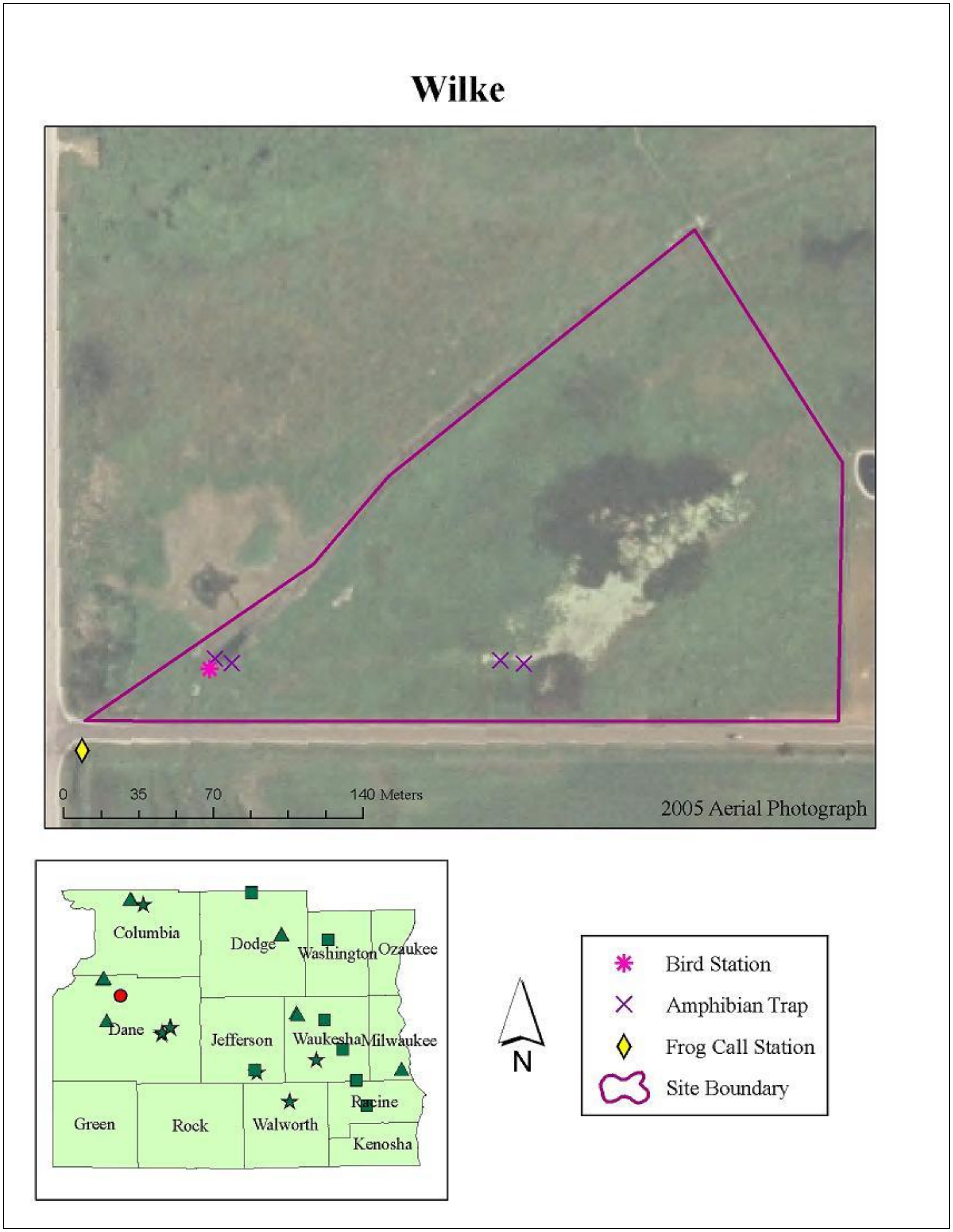
Martinelli



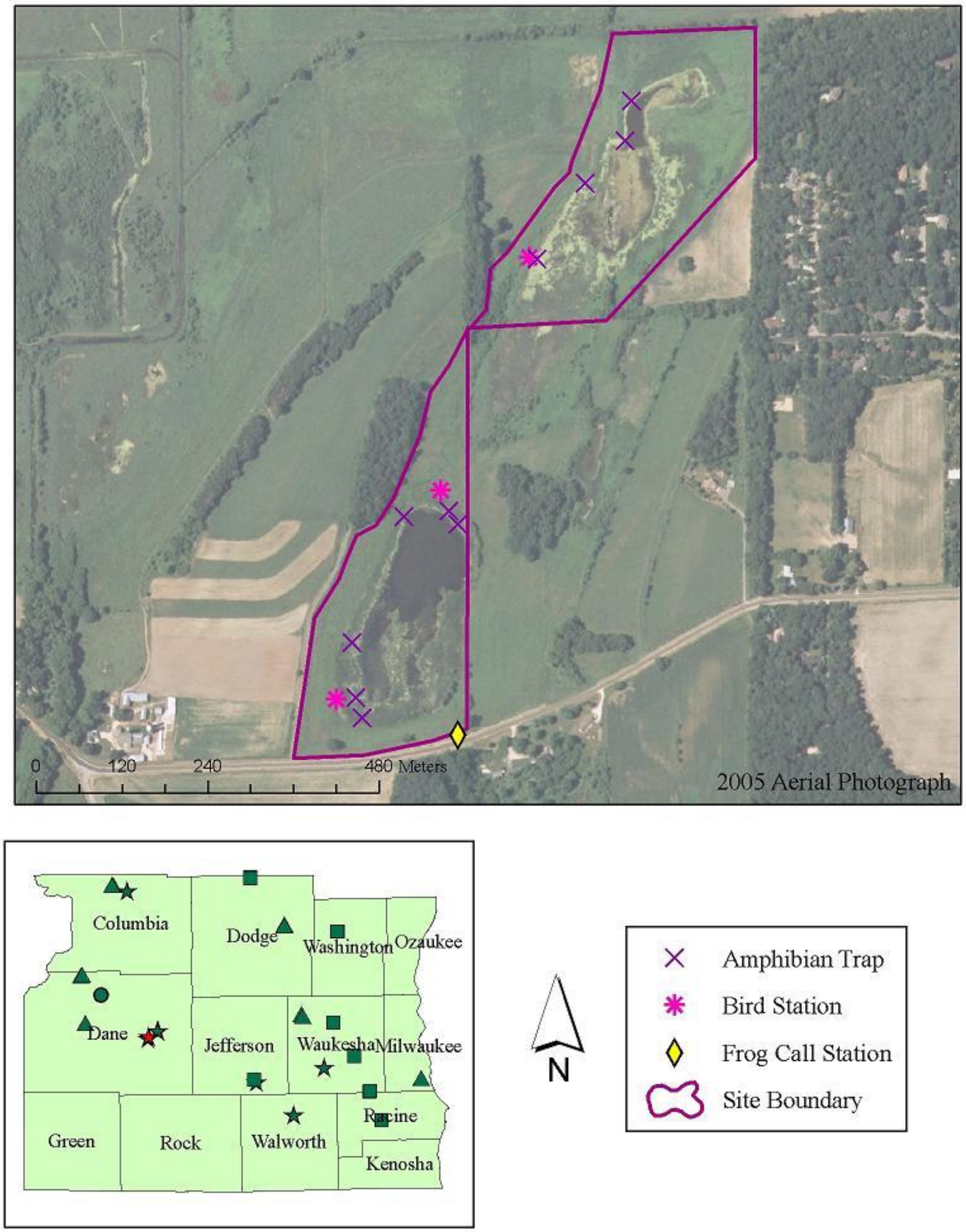
0
55
110
220 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Bird Station
Amphibian Trap
Frog Call Station
Site Boundary

Middleton

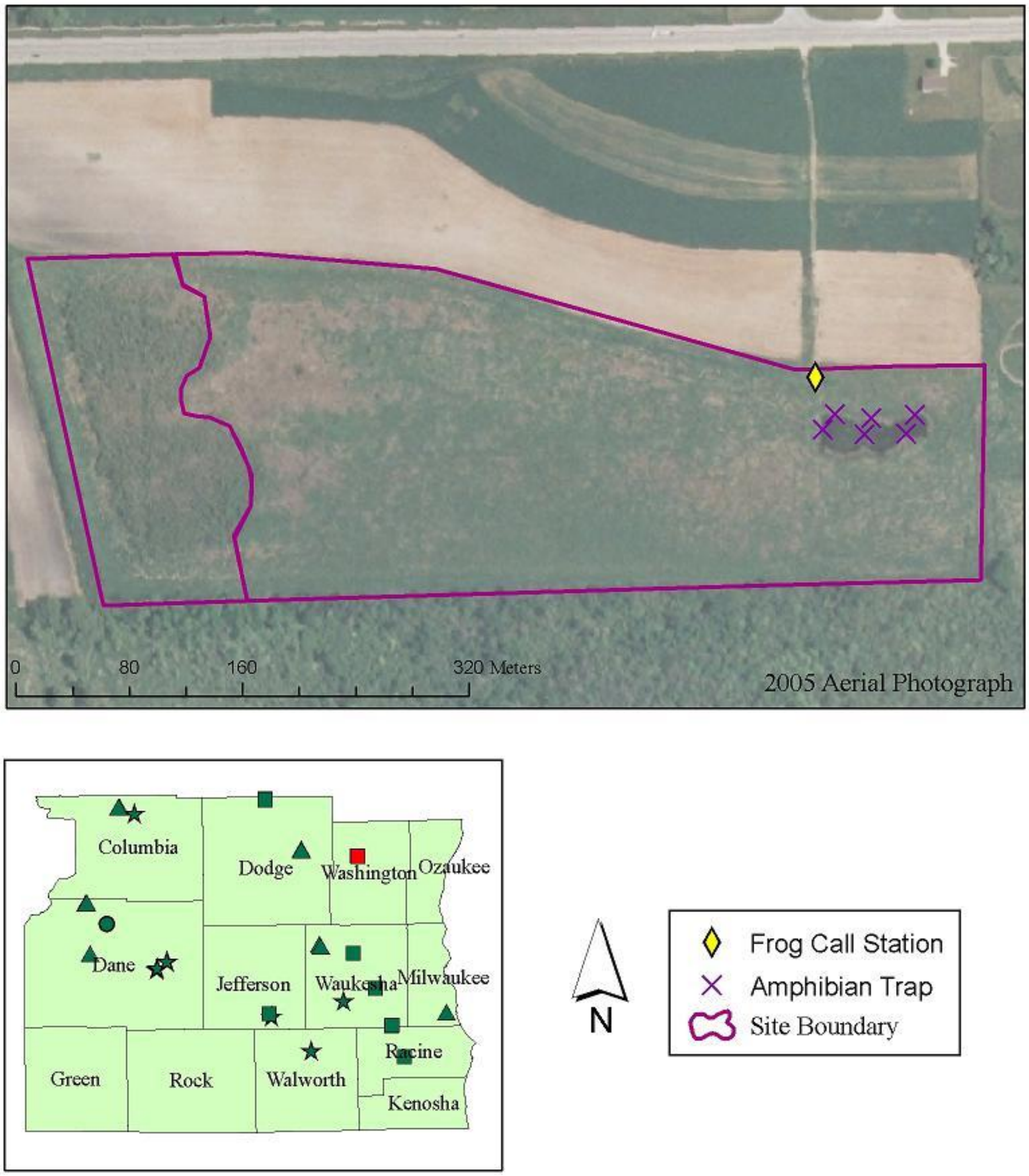

0
25
50
100 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Bird Station
Frog Call Station
Site Boundary


Wilke
0
35
70
140 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Bird Station
Amphibian Trap
Frog Call Station
Site Boundary

Witte Dane


0
120
240
480 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Amphibian Trap
Bird Station
Frog Call Station
Site Boundary

Gundrum


0
80
160
320 Meters
2005 Aerial Photograph
Columbia
Dodge
Washington
Ozaukee
Dane
Jefferson
Waukesha
Milwaukee
Green
Rock
Walworth
Racine
Kenosha
N
Frog Call Station
Amphibian Trap
Site Boundary

Appendix D: Survey sheets used in the field

Southern Wisconsin Vegetation Survey Form

Forb	Present	<2%	2-19%	20-89%	>90%
ABUTHE					
AMBART					
AMBTRI					
ASCINC					
ASTFIR					
ASTLAN					
ASTNOV					
ASTPIL					
ASTPUN					
BIDCER					
BIDFRO					
CIRARV					
CIRDIS					
CIRVUL					
DAUCAR					
EPICOL					
ERIANN					
ERISTR					
EUPMAC					
EUPPER					
EUTGRA					
GEUALE					
HELAUT					
HELGIG					
HELGRO					
IMPCAP					
LACSER					
LYCAME					
LYTSAL					
MELALB					
MENARV					
MIMRIN					
MONFIS					
PLAMAJ					
POLAMP					
POLHYD					
POLLAP					
PYCVIR					
RATPIN					
RUDHIR					
RUMCRI					
SOLCAN					
SOLGIG					
SOLRID					
TAROFF					
TRIHYB					
TRIPRA					
URTDIO					
VERHAS					

Grass	Present	<2%	2-19%	20-89%	>90%
AGRGIG					
AGRSTO					
ANDGER					
BROINE					
CALCAN					
ECHCRU					
ELYCAN					
ELYREP					
ELYVIR					
GLYGRA					
GLYSTR					
HORJUB					
LEEORY					
PANCAP					
PANVIR					
PHAARU					
PHLPRA					
POACOM					
POAPAL					
POAPRA					
SETFAB					
SETGLA					
SETVIR					
SORNUT					
SPAPEC					

Xtr Forb					

Graminoid	Present	<2%	2-19%	20-89%	>90%
CARBEB					
CARCOM					
CARGRA					
CARHYS					
CARLAC					
CARNOR					
CARPEL					
CARSTI					
CARSTR					
CARVUL					
CYPESC					
ELEACI					
ELEERY					
ELEPAL					
EQIARV					
JUNEFF					
JUNTEN					
JUNTOR					
SCHTAB					
SCIACU					
SCIATR					
SCICYP					
SCIFLU					

Aquatic Fb					
ALISUB					
LEMMIN					
SAGLAT					
SPAEUR					
TYPANG					
TYPLAT					
TYPXGL					

Shrub	Present	<2%	2-19%	20-89%	>90%
CORRAC					
CORSTO					
RHACAT					
RHAFRA					
RUBOCC					
SALDIS					
SALERI					
SALEXI					

Tree					
ACENEG					
ACESAC					
FRAPEN					
POPDEL					
QUEBIC					
QUEMAC					
SALNIG					
ULMAME					

Vine					
SOLDUL					
VITRIP					

Site:
Date:

Community: Deep marsh Shallow marsh Wet prairie Fresh wet meadow
Sedge meadow Hardwood swamp Shrub-Carr Flooded Basin Floodplain

Southern Wisconsin Marsh Bird Monitoring Survey Data Sheet

Date *(e.g., 10-May-07)* : Pg ___ of ___

	Before	After
Site # and Name:		
Temperature (°F) :		
Wind speed *(see below)* :		
Observer:		
Cloud cover *(%)* :		
Precipitation *(see below)* :		

Survey replication #:

Put an "S" in the appropriate column if the bird was seen, a "1" if the bird was heard, and "1S" if both heard and seen

Point #	Start Time (military	Background Noise	Species	Responded During:											Call Type(s)	Distance (meters)	Direction	Comments
				Pass 0-1	Pass 1-2	Pass 2-3	Pass 3-4	Pass 4-5	LEBI 5-6	YERA 6-7	SORA 7-8	VIRA 8-9	KIRA 9-10	AMBI 10-11				
																	O	
																	O	
																	O	
																	O	
																	O	
																	O	
																	O	
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																	O	
																	O	

Call Types: YERA: click-click, squeak; SORA: whinny, perweep, keep; KIRA: kek-burr, grunt; VIRA: grunt, ticket, kicker; LEBI: coo, kak, ank; AMBI: pump-er-lunk, kok; COMO: wipeout, giddyup, beep; AMCO: burrup, hickup, cackle; PBGR: owhoop, hyena, ek-ek

If the call type is not one of the above listed types, describe the call in the comments column.

Wind speed: 0 = <1mph 1 = 1-3mph 2 = 4-7mph 3 = 8-12mph 4 = 13-18mph 5 = 19-24mph

Precipitation: light rain, rain, heavy rain, light snow, snow, heavy snow, fog, none

Background noise: 0 no noise 1 faint noise 2 moderate noise *(probably can't hear some birds beyond 100m)* 3 loud noise *(probably can'thear some birds beyond 50m)* 4 intense noise *(probably can't hear some birds beyond 25m)*

Secondary species: Red-n. Grebe, W. Snipe, Black Tern, Forster's Tern, Marsh Wren, Swamp Sparrow, Le Conte's Sp., Yellow-h. Blackbird

Southern Wisconsin All- Bird Monitoring Survey Data Sheet

Date *(eg 10-May-07)* :

Pg ___ of ___

Survery replication # :

Observer(s) *(list all)* * :

	Before	After
Temperature (° F) :		
Wind speed *(scale)* :		
Cloud cover *(%)* :		
Precipitation :		

Wind speed: 0 = <1mph 1 = 1-3mph 2 = 4-7mph 3 = 8-12mph 4 = 13-18mph 5 = 19-24mph

Precipitation: light rain, rain, heavy rain, light snow, snow, heavy snow, fog, none

Background noise: 0 no noise 1 faint noise 2 moderate noise *(probably can't hear some birds beyond 100m)*

3 loud noise *(probably can'thear some birds beyond 50m)* 4 intense noise *(probably can't hear some birds beyond 25m)*

*Put an " **S** " in the "Detected?" column if the bird was seen, a " **1** " if the bird was heard, and "1S" if both heard and seen*

Point #	Start time	Period first detected	**Species**	Detected? (s or 1)	Flyover? (check)	Outside target? (che	Direction	Noise	Comments
							O		
							O		
							O		
							O		
							O		
							O		
							O		
							O		
							O		
							O		
							O		
							O		
							O		
							O		
							O		
							O		
							O		
							O		
							O		
							O		
							O		
							O		
							O		
							O		
							O		
							O		

6 = LEBI 7 = YERA 8 = Sora 9 = VIRA 10 = KIRA 11 = AMBI

Southern Wisconsin Amphibian Trapping Survey Data Sheet

	Before	After
Temperature		
Wind speed		
Cloud cover (%)		
Precipitation		

Date: **Observers:**

Precipitation: light rain, rain, heavy rain, fog, none **Wind speed:** 0 = <1mph 1 = 1-3mph 2 = 4-7mph 3 = 8-12mph 4 = 13-18mph 5 = 19-24mph

				Juveniles															Adults															
Site	Trap #	Time	No amphibians	American Toad	Treefrog	Spring peeper	Chorus frog	Rana sp	Wood frog	Leopard frog	Pickerel frog	Green frog	Bullfrog	Other	Central newt	Blue-spot salamander	Tiger salamander	Other	American Toad	Treefrog	Spring peeper	Chorus frog	Rana sp	Wood frog	Leopard frog	Pickerel frog	Green frog	Bullfrog	Other	Central newt	Blue-spot salamander	Tiger salamander	Other	Comments

Appendix E: Avian primary and secondary species

Primary Species: Wisconsin's avian species of greatest conservation need, as listed in the current Wisconsin Wildlife Action Plan. See http://dnr.wi.gov/org/land/er/wwap/explore/profiles.asp?mode=group&Grp=1 for more information.

Secondary Species: Combination of avian species on the Wisconsin Natural Heritage Working List (available at http://dnr.wi.gov/org/land/er/wlist/index.asp?mode=detail&Grp=7&track=yes), target species in the Marshbird Monitoring Program for Wisconsin (Brady 2008), and Wisconsin species included in the Partners in Flight Landbird Conservation plan (available at http://www.wisconsinbirds.org/plan/species/priority.htm). Species that are also species of greatest conservation need were removed.

Primary species	Secondary Species
Acadian Flycatcher	American Coot
American Bittern	American White Pelican
American Black Duck	Bank Swallow
American Golden Plover	Barn Swallow
American Woodcock	Belted Kingfisher
Bald Eagle	Black Rail
Barn Owl	Blackburnian Warbler
Bell's Vireo	Black-crowned Night-heron
Black Tern	Black-throated Green Warbler
Black-backed Woodpecker	Bonaparte's Gull
Black-billed Cuckoo	Broad-winged Hawk
Black-throated Blue Warbler	Cape May Warbler
Blue-winged Teal	Carolina Wren
Blue-winged Warbler	Cattle Egret
Bobolink	Chestnut-sided Warbler
Boreal Chickadee	Chimney Swift
Brown Thrasher	Clay-colored Sparrow
Buff-breasted Sandpiper	Common Goldeneye
Canada Warbler	Common Loon
Canvasback	Common Moorhen
Caspian Tern	Common Yellowthroat
Cerulean Warbler	Gray Jay
Common Tern	Great Black-backed Gull
Connecticut Warbler	Great Blue Heron
Dickcissel	Great Gray Owl
Dunlin	Greater Yellowlegs
Eastern Meadowlark	Least Bittern
Field Sparrow	Little Gull
Forster's Tern	Long-eared Owl
Golden-winged Warbler	Marsh Wren
Grasshopper Sparrow	Merlin
Great Egret	Mourning Warbler
Greater Prairie-Chicken	Nashville Warbler
Henslow's Sparrow	Northern Flicker
Hooded Warbler	Northern Hawk Owl
Horned Grebe	Northern Pintail
Hudsonian Godwit	Northern Rough-winged Swallow

Primary species	Secondary Species
Kentucky Warbler	Philadelphia Vireo
King Rail	Pied-billed grebe
Kirtland's Warbler	Purple Finch
Lark Sparrow	Purple Martin
Le Conte's Sparrow	Rose-breasted Grosbeak
Least Flycatcher	Ruby-crowned Kinglet
Lesser Scaup	Ruffed Grouse
Loggerhead Shrike	Sedge Wren
Louisiana Waterthrush	Sora
Marbled Godwit	Swainson's Thrush
Nelson's Sharp-tailed Sparrow	Swamp Sparrow
Northern Bobwhite	Virginia Rail
Northern Goshawk	Warbling Vireo
Northern Harrier	Western Grebe
Olive-sided Flycatcher	Western Kingbird
Osprey	White-eyed Vireo
Peregrine Falcon	White-throated Sparrow
Piping Plover	Wilson's Snipe
Prothonotary Warbler	Wilson's Warbler
Red Crossbill	Yellow-bellied Flycatcher
Redhead	Yellow-bellied Sapsucker
Red-headed Woodpecker	Yellow-breasted Chat
Red-necked Grebe	Yellow-headed Blackbird
Red-shouldered Hawk	Yellow-throated Vireo
Rusty Blackbird	
Sharp-tailed Grouse	
Short-billed Dowitcher	
Short-eared Owl	
Snowy Egret	
Solitary Sandpiper	
Spruce Grouse	
Trumpeter Swan	
Upland Sandpiper	
Veery	
Vesper Sparrow	
Western Meadowlark	
Whimbrel	
Whip-poor-will	
Whooping Crane	
Willow Flycatcher	
Wilson's Phalarope	
Wood Thrush	
Worm-eating Warbler	
Yellow Rail	
Yellow-billed Cuckoo	
Yellow-crowned Night-Heron	
Yellow-throated Warbler	

Wisconsin Department of Natural Resources
Bureau of Watershed Management
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