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Restoration of Riparian Habitat and the Recovery of Avian Diversity in Agricultural Landscapes

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Introduction

Riparian areas – defined as the transitional zone between terrestrial and aquatic ecosystems – occupy only a fraction of total land area in the U.S. yet contain a significantly greater diversity and abundance of species than are found in surrounding landscapes. Avian species, in particular, are dependent on riparian areas, which provide habitat for breeding, nesting, migration and dispersal (NRC 2002). As habitat availability is the most important factor influencing the distribution and abundance of avian species (Best et al. 1978), restoration of riparian areas is fundamental to the conservation of avian diversity.

Since European settlement, the majority of riparian areas have been degraded or converted to other land uses. It is estimated that approximately two-thirds of the nation's riparian areas have been destroyed; today, riparian areas represent less than five percent of total land area in the U.S. In some regions, loss of riparian habitat has been in excess of 95 percent – indicating that riparian areas are one of the most endangered ecosystems in the country (NRC 2002). Humans impact riparian areas through several land use practices; agriculture, however, is considered the greatest cause of riparian loss in the U.S. Agricultural practices that threaten riparian areas include livestock grazing, row-cropping, tillage, drainage, irrigation, and channelization (Knopf et al. 1988; NRC 2002).

Riparian areas typically support a greater diversity and abundance of avian species than are found in surrounding upland areas – this distinction is particularly evident in both the relatively arid western U.S. and the tallgrass prairies of the eastern Great Plains. However, riparian areas are also significantly degraded in both regions, with major declines occurring in bird populations dependent on riparian habitat (Best et al. 1995; NRC 2002; Scott et al. 2003). By looking more closely at the leading sources of degradation and the impact of these sources on riparian plant and avifaunal communities, opportunities for restoration may be identified and prioritized according to the different biological and social factors influencing the two regions.

Characteristics of Riparian Communities

Riparian areas are typically dominated by woody plants, grasses, and emergent herbaceous plants, but plant communities vary substantially between riparian areas. Significant variations in riparian plant communities exist between the Pacific coastal region, the arid and semi-arid West, the Great Plains and the temperate East, which are attributable to variations in climatic, hydrologic and geomorphic conditions between ecological zones throughout the U.S. However, a uniform characteristic of native riparian communities is a dependence on the fluctuating cycles of wetness and dryness that typify terrestrial-aquatic transitional zones. Such extreme conditions of environmental disturbance promote species dispersal and regeneration, which leads to vegetative structural complexity in the form of staggered successional patterns and large-scale heterogeneity in plant community types (NRC 2002). The inherent complexity of riparian plant communities creates a variety of niches for a diverse assemblage of avian species within a limited area (Askins 2000; Scott et al. 2003). Therefore, alteration of natural disturbance

regimes or degradation of habitat complexity negatively impacts the fitness and survival of avian species associated with the altered riparian systems.

Riparian Vegetation and Avian Diversity in the Arid and Semi-Arid West

In the western U.S., riparian areas constitute less than one percent of the landscape (Knopf et al. 1988; Dobkin et al. 1998), yet provide habitat for more avian species than all other ecosystem types combined. Avian diversity and abundance, number of rare species, and number of breeding pairs of birds are extremely high in riparian areas compared to upland habitat (Knopf et al. 1988; NRC 2002). In northern Colorado, for example, 82 percent of avian species depend on riparian habitat for breeding. An even greater diversity and abundance of avian species utilize riparian areas during migration – it is estimated that riparian areas support more than 10 times the number of birds during migration than are supported by upland habitat (Knopf et al. 1988).

Although the western U.S. encompasses a broad range of ecosystems, the comparatively arid climate plays a significant role in shaping the region's riparian communities. The complex cottonwood-shrub communities characteristic of many riparian areas in the arid climate of the American West provides habitat to greater avian diversity and abundance than either cottonwood forest or treeless shrub-steppe communities, which are often associated with degraded or upland areas (NRC 2002). Populations of avian species dependent on the riparian woodlands of the Southwest have significantly declined in response to habitat degradation – Yellow-billed Cuckoo (*Coccyzus americanus*), Vermilion Flycatcher (*Pyrocephalus rubinus*), Verdin (*Auriparus flaviceps*), Willow Flycatcher (*Empidonax traillii*), Lincoln's Sparrow (*Melospiza lincolnii*), White-crowned Sparrow (*Zonotrichia leucophrys*), Red-shouldered Hawk (*Buteo lineatus*), Yellow-breasted Chat (*Icteria virens*), Bell's Vireo (*Vireo bellii*) and Blue Grosbeak (*Guiraca caerulea*) are all species dependent on riparian habitat (Askins 2000). Restoration of riparian plant communities that support these populations – such as Fremont cottonwood (*Populus fremontii*), Goodding willow (*Salix gooddingii*), Arizona sycamore (*Platanus wrightii*), among others (NRC 2002) – is therefore important.

Riparian Vegetation and Avian Diversity in the Tallgrass Prairies of the Midwest

Tallgrass prairies of the eastern Great Plains support diverse riparian plant communities, including birch (*Betula* spp.), sweetgum (*Liquidambar styraciflua*), water tupelo (*Nyssa aquatica*), sycamore (*Platanus occidentalis*), cypress (*Taxodium distichum*), among many others (NRC 2002). Riparian areas of the tallgrass prairies provide habitat to numerous avian species, including Yellow-billed Cuckoo (*Coccyzus americanus*), Black-billed Cuckoo (*Coccyzus erythropthalmus*), Eastern Wood-Pewee (*Contopus virens*), Wood Thrush (*Hylocichla mustelina*), American Redstart (*Setophaga ruticilla*), Red-headed Woodpecker (*Melanerpes erythrocephalus*), Downy Woodpecker (*Picoides pubescens*), Red-bellied Woodpecker (*Melanerpes carolinus*), Brown Thrasher (*Toxostoma rufum*), Rose-breasted Grosbeak (*Pheucticus ludovicianus*), Indigo Bunting (*Passerina cyanea*), in addition to many others (Best and Stauffer 1980; Stauffer and Best 1980).

Best et al. (1995) discovered that many avian species found in the agricultural landscapes of the eastern Great Plains are highly dependent on riparian woodlands, which provide critical nesting habitat and support higher avian diversity than all other habitat types (Best et al. 1995). Likewise, in a study on habitat selection by breeding birds found in riparian areas, Stauffer and Best (1980) found that riparian woodlands support four times the diversity of breeding birds found in upland grassland habitat. The authors also found that although both riparian and upland woodlands support a high diversity of breeding birds, riparian woodlands sustain a greater abundance of these species (Stauffer and Best 1980).

Livestock Grazing in the West
Agricultural Impacts on Bird Diversity in Riparian Areas

In the arid and semi-arid lands of the western U.S., the greatest source of riparian degradation is the intensive grazing of domestic livestock, primarily cattle (Knopf et al. 1988; Dobkin et al. 1998). While the landscape across the western Great Plains is well-adapted to historical levels of grazing by wildlife such as bison, riparian systems in the region are unable to tolerate the more intense levels of livestock grazing occurring today. In the arid climate, cattle – which concentrate in riparian areas for shade, forage and water (NRC 2002; Askins 2000) – spend a disproportionate amount of time inhabiting riparian woodlands, estimated at five to 30 times longer than in surrounding upland areas (Askins 2000). In other regions of the western U.S., where grazing had not occurred prior to introduction of domestic livestock grazing to the system over a century ago, riparian areas tend to be intolerant of even minor levels of livestock grazing, lacking the resiliency to adjust to the environmental impacts from foraging or trampling by cattle. In these regions, livestock grazing has led to the decline, endangerment, and loss of a wide variety of avian species (Scott et al. 2003) – it is estimated continued loss of riparian habitat will lead to the extirpation of nearly 50 percent of the species of breeding birds from the region (Knopf et al. 1988).

Long-term grazing of domestic livestock is correlated with decreased structural complexity of riparian vegetation and decreased bird diversity and abundance within riparian areas (Scott et al. 2003). The consumption and trampling of vegetation by cattle inhibits natural successional processes of riparian areas. Livestock grazing promotes the succession of the structurally complex cottonwood-shrub associations to shrub- or grass-dominated communities by inhibiting the establishment of tree and shrub species such as cottonwoods, willows, and other associated woody species. This loss in the structural complexity of riparian vegetation often leads to an accompanied loss in bird diversity (Askins 2000; Scott et al. 2003).

Livestock Management and Restoration of Riparian Diversity

Although livestock grazing occurs throughout the western U.S., regional variations in the climatic, hydrologic and geomorphic conditions, the occurrence and habitat use of species, and the historical patterns of land-use necessitates a multifaceted approach to the conservation of avian diversity. Depending on landscape characteristics and resource conditions, recommendations for livestock management varies. There are several alternatives to the conventional management of livestock by intensive grazing. Alternative methods include the exclusion of livestock from riparian systems by fencing; extended rest of rotation plots; specialized grazing systems and herding practices; provision of upland sources of water and forage; revegetation of riparian areas with woody species; construction of drift fences; and changing the rotation schedule or stocking intensity of livestock (Dobkin et al. 1998; NRC 2002). Based on the scope of this paper, however, consideration of management alternatives will focus on livestock exclusion from riparian areas and rotational or late-season grazing, with restoration of riparian vegetation as needed.

Livestock Exclusion

Intensive grazing of domestic livestock within the arid and semi-arid western U.S. has been shown to degrade the composition and structural complexity of riparian plant communities, which in turn reduces avian diversity and abundance in these areas. In areas where native riparian vegetation – although degraded – still remains, the removal of livestock from the riparian area will induce re-establishment of native floral and avifaunal communities. Livestock exclusion allows for the regeneration of structural complexity in riparian plant communities, and the restoration of suitable habitat necessary for re-establishment of avifaunal populations to the system. Exclusion may be the best option in some cases: For instance, the removal of lower vegetation layers by cattle (Askins 2000) threatens the persistence of species of ground-nesting birds (Dobkin et al. 1998), which depend on the lower vegetation layers both

for nest-building and shelter. Exclusion may be an important restoration action in heavily degraded areas or areas where endangered ground-nesting species are known to occur.

Of alternatives to current grazing practices, livestock exclusion is considered the most effective means of restoring riparian systems (Dobkin et al. 1998; NRC 2002). Dobkin et al. (1998) investigated the relationship between riparian habitat conditions and avian diversity and abundance in a relatively arid region of the Great Basin. Exclusion of cattle grazing occurred in plots 33 years prior (primary exclosures) and immediately prior (secondary exclosures) to the study. Intensive livestock grazing dominated the study area for nearly 100 years before exclusion occurred, severely degrading native floral and faunal communities through conversion of the native riparian meadow system into a system with upland vegetation associations (Dobkin et al. 1998).

The authors found significant differences in the composition and structural complexity of riparian vegetation between the primary and secondary exclosures. The primary exclosures supported dense, sedge-dominated meadows with a mixture of shrubs, grasses, forbs, and rushes, while the secondary exclosures had a high density of shrubs and bare ground with minimal vegetation. However, a significant decrease in both shrubs and bare ground occurred in the secondary exclosures over the three-year study period due to replacement of the less desirable cover by grasses, rushes and forbs. Similarly, examination of the vertical and horizontal complexity of the exclosures found that foliage height diversity was significantly greater in the primary exclosures compared to the secondary exclosures. However, small but significant increases in foliage height diversity occurred within both primary and secondary exclosures over the study period – herbaceous foliage height diversity increased in both exclosures, while shrub foliage height diversity increased significantly in secondary exclosures, suggesting an initial recovery of the system from livestock grazing stress (Dobkin et al. 1998).

Corresponding to variances in vegetation quality between exclosures, avian abundance and species richness was consistently greater in the primary exclosures than in the secondary exclosures. Associations of specific species corresponded to vegetation types dominant in the exclosures – species typically associated with wetland and riparian habitats, such as the Song Sparrow (*Melospiza melodia*), were found only in the primary exclosures, while avian species consistent with grassland or upland habitat, such as American Kestrel (*Falco sparverius*), Horned Lark (*Eremophila alpestris*), and Vesper Sparrow (*Pooecetes gramineus*), were found only in the secondary exclosures. However, the appearance of avian wet-meadow species in the secondary exclosures in the latter years of the study may serve as indication of initial restoration of the native riparian meadow floral and aviafaunal communities. Most notably, avian species known to be highly dependent on riparian meadow habitat with declining population levels across the region, such as Western Meadowlarks (*Sturnella neglecta*), had stable or increasing numbers in the primary exclosures, indicating the significant benefits derived from livestock exclusion in preserving avian diversity and abundance in riparian habitats (Dobkin et al. 1998).

Rotational or Late-Season Grazing

Total exclusion may not be necessary in all restoration cases: regeneration of native floral and avifaunal communities may occur by decreasing the intensity of grazing on the system, although restoration will likely occur more slowly. Specifically, the negative impacts from livestock grazing can be greatly reduced if grazing is restricted during the summer – summer grazing tends to reduce vegetation density and decrease avian abundance – and permitted only during the late fall or winter. This allows for establishment of higher densities of riparian vegetation during the spring and summer, which provides important cover to avian populations during breeding and nesting periods (Askins 2000).

According to Stanley and Knopf (2002), exclusion of livestock from some riparian areas is not required for restoration of native riparian plant and avian populations. In a study of degraded riparian systems in

northern Colorado, the authors found that by instituting a rotational late-season grazing management system, the negative effects of cattle on riparian communities were substantially reduced. The late-season grazing system involved two months of intensive cattle grazing in the late summer followed by 34 months of rest from grazing. The authors found that after two cycles of late-season grazing, there was no statistical difference in vegetation between grazed and ungrazed pastures. However, while increases in bird densities occurred on both grazed and ungrazed pastures, the magnitude of the increase was less on grazed pastures, leading the authors to conclude that while a light-intensity late-season grazing system improved avian habitat, in cases where priorities for restoration involve maximizing avian recovery, greater restrictions on cattle grazing may be required. Therefore, late-season grazing can be used when the need to balance conflicting land uses is important (Stanley and Knopf 2002).

Rotational grazing or grazing management has also been recommended for riparian areas in the western Great Plains. The western Great Plains were once dominated by shortgrass prairie, but unlike the eastern Great Plains where the majority of the tallgrass prairie has been removed for crop cultivation, large expanses of the native grasslands remain and are used predominately for livestock grazing. Historically, grazing by roaming herds of bison occurred across the western shortgrass prairies of the Great Plains – restoration of riparian habitat, therefore, should include managed levels of grazing to mimic historical disturbance regimes. However, grazing must be managed to preserve the complex patchwork of disturbance patches, supporting diverse assemblages of grassland communities in different successional stages and ensuring the provision of a full range of habitat types for the diversity of avian species occurring in the region (Askins 2000).

Restoration of Riparian Vegetation

In regions where native riparian communities have been severely degraded, however, the exclusion or seasonal-grazing of domestic livestock is not sufficient to restore native plant and avifaunal communities. In these cases, active recolonization of native vegetation – by planting or seeding – is needed. According to Askins (2000), while restoration of severely degraded riparian systems requires greater upfront investment, it may be the only option remaining for the conservation of endangered avian species. In many areas of the arid Southwest, for instance, few remnant patches of riparian woodlands remain, most of which are highly modified by livestock grazing. Avian species endemic to these areas, therefore, will soon disappear if large-scale restoration of riparian habitat does not occur in this region (Askins 2000).

Although cattle trampling of bird nests has been cited as a problem in areas of livestock grazing, most cite the loss of riparian vegetation as the greatest threat to avian persistence in areas where intensive livestock grazing is practiced. Recommendations to protect the diversity and abundance of avian species, therefore, often involve restoration of the diversity and structural complexity of riparian vegetation. Conservation of bird diversity and abundance in the riparian woodlands of arid regions, for example, involve both the management of livestock grazing and the restoration of woody vegetation communities (Scott et al. 2003).

In a study by Rice et al. (1984), they found that tree species composition was more important in determining avian presence or absence than vertical and structural complexity of the vegetation. In this study, the authors found that avian populations utilizing riparian habitat in the arid desert of the Southwest selected habitat based on tree species composition. Because avian species have shown affinities to specific tree or plant species, tree species composition is one of the most important attributes involved in riparian community habitat selection by birds. The majority of the time avian habitat preferences were based on selection of particular tree species – increasing the diversity of tree species occurring in an area, therefore, increases the potential niches for avian species with tree-specific adaptations (Rice et al. 1984).

Row-Cropping in the Tallgrass Prairies of the Midwest
Agricultural Impacts on Bird Diversity in Riparian Areas

In the eastern Great Plains of the Midwest, agriculture has reduced the extent of native vegetation throughout the region (Stauffer and Best 1980). Pre-European settlement, the uplands of the eastern Great Plains were dominated by tallgrass prairie. Today, however, very little remains: For instance, the total extent of native tallgrass prairie remaining in Illinois, Indiana and Iowa is only 0.01-0.02 percent of historical levels. Recent population declines in avian species that inhabit tallgrass prairie are the result of the expansion of row-cropping in the Midwest (Askins 2000).

Native riparian woodlands throughout the Midwest have been removed or degraded for the purposes of increasing drainage and decreasing crop-shading for row-crop agriculture (Osborne and Kovacic 1993). The shift to monoculture farming and the consolidation of farms into larger units has reduced both the diversity of plant communities and the extent of non-farmed land in agricultural areas, in turn diminishing the extent of suitable habitat available to avian populations (Best et al. 1995; Patterson and Best 1995). According to Best et al. (1995), decreased avian abundance is due to repeated habitat disturbance from agricultural practices in the region, such as tillage, planting and cultivation, leading to poor nesting success and the disruption of site fidelity behavior (Best et al. 1995).

Land Conservation and Restoration of Riparian Diversity

In regions with intensive row-crop agriculture, such as in the Midwest, riparian areas provide important refuge for avian species. Because little native habitat remains and the remaining habitat continues to be depleted at a rapid rate (Best et al. 1978; Stauffer and Best 1980), the primary goal for avian conservation in the eastern Great Plains should be the preservation of remaining native riparian habitat and the restoration of degraded habitat. The spatial context of restoration issues is important when considering restoration actions – focus should be not only on specific riparian habitats, but also on the larger landscape mosaic within which the particular habitat occurs. Avian diversity and abundance within riparian areas are affected by habitat size, the type and amount of edge habitat, the quantity and quality of available resources, and land-use practices (Askins 2000).

Conservation of some species – such as those with large home ranges or sensitive to habitat disruption – may require the conservation of large, interconnected areas of natural habitat (Askins 2000). For instance, several avian species of the eastern Great Plains are intolerant of riparian habitat disturbance. Therefore, conservation of these species, including the Western Meadowlark (*Sturnella neglecta*), Blue-gray Gnatcatcher (*Polioptila caerulea*), Ovenbird (*Seiurus aurocapillus*), Scarlet Tanager (*Piranga olivacea*), Wood Thrush (*Hylocichla mustelina*), Dickcissel (*Spiza americana*), Warbling Vireo (*Vireo gilvus*), Yellow Warbler (*Dendroica petechia*) and Field Sparrow (*Spizella pusilla*) (Stauffer and Best 1980), requires that riparian areas inhabited by these species are adequately buffered from surrounding land-use practices, such as row-crop agriculture. Also, Stauffer and Best (1980) found that the diversity of breeding birds in riparian woodlands increases as the width of the riparian woodlands increases. Therefore, focusing agricultural efforts in areas where restoration investments can be maximized, either by regional landowner interest or by connectivity of enrolled lands, should be a high priority of future programs.

Several federal, state and local agricultural conservation programs currently exist that have successfully advanced the conservation of both riparian habitat and avifaunal populations. Refining these programs and increasing appropriations to these programs, however, is greatly needed in order to achieve large-scale restoration objectives such as the recovery of North American avifaunal populations. The Conservation Reserve Program (CRP), which provides financial incentives to farmers to voluntarily retire marginal land from production, is one of the most successful federal conservation programs. Studies have shown that CRP lands support a greater avian abundance than surrounding croplands (Askins 2000).

Although birds frequent croplands, relatively few species can successfully nest there. In a study by Patterson and Best (1995), the authors found that total mean avian abundance in CRP lands was four times that in row-crop fields. This difference was largely due to the greater diversity in vegetation structure and complexity. Avian abundances in different CRP plots varied in accordance with variations among plots – those plots with greater vertical cover, canopy cover of grasses and forbs and vertical and horizontal heterogeneity had greater bird abundance. CRP has contributed to an increase in abundance of many avian species because the row-crop habitat it replaces supports both lower bird abundances and fewer nesting species. The more complex structure and composition of vegetation present on CRP lands, the large tracts of land set-aside in the program, as well as reduced human activity on these land parcels, are believed to account for these differences. However, in order to derive the greatest benefit to avian species occurring in agricultural landscapes, consideration of certain aspects of CRP is important: For instance, the quality of habitat provided by CRP is as dependent on how CRP is managed and administered as it is on associated environmental factors (Patterson and Best 1995).

Key to improving avian diversity across the Midwest is to increase riparian coverage within agricultural landscapes, increase habitat diversity by restoring the natural disturbance regimes (or managing in such a way as to mimic natural disturbances) and habitat patchiness, and increasing the amount of woody vegetation in riparian areas. A combination of land conservation and restoration actions, therefore, is necessary to restore avian diversity and riparian habitat in this region.

Conclusion

Restoration of riparian areas is defined by the National Research Council as the reestablishment of pre-disturbance conditions to riparian areas and the facilitation of self-sustaining natural functions and processes within the system (NRC 2002). Successful restoration of riparian ecosystems necessitates the establishment of clear goals and objectives. A comprehensive understanding of the physical, biological and social interactions influencing riparian systems allows for better management of conflicting land uses (Kershner 1997). According to Kentula (1997), the development of systematic methods to evaluate and prioritize sites in restoration planning is necessary to ensure that the ecological benefits of restoration and the probability of project success are maximized. Prioritization of restoration actions gives the restoration practitioner the ability to focus limited resources on sites of highest priority (Kentula 1997; Palik et al. 2000).

Development of a multi-step process, based on a combination of existing restoration models, may aid the establishment of priorities for avian conservation and restoration of riparian habitat within a regional landscape. An understanding of the following six major factors influencing riparian areas may improve identification and implementation of restoration actions: 1) reference (or pre-disturbance) and existing conditions of the riparian area, 2) regional context of the restoration problem, 3) sources of degradation, 4) species-specific and community characteristics, 5) the social, political and economic landscape, and 6) prioritization of restoration actions.

First, identification of both the reference and existing condition of a given riparian system is important in establishing restoration goals and objectives. Comparison of the distribution of pre-disturbance conditions with the distribution of existing levels of disturbance will establish the conservation status of riparian habitats or species of concern (Kentula 1997). For example, preservation of the rare cottonwood-willow and honey mesquite woodlands of the southwestern U.S. should take precedence over the continued practiced of intensive livestock grazing in areas where these two management objectives conflict (Askins 2000).

Second, understanding the regional context within which the species or ecosystem of concern occurs is important in identifying restoration issues. Avian conservation depends on a clear understanding of both

their habitat requirements and how their habitats are sustained by natural processes (Askins 2000). For instance, several avian species – including the Mountain Plover (*Charadrius montanus*), Baird's Sparrow (*Ammodramus bairdii*), Lark Bunting (*Calamospiza melanocorys*), McCown's Longspur (*Calcarius mccownii*), and Chestnut-collared Longspur (*Calcarius ornatus*) – are endemic to the western Great Plains region (Askins 2000). Regional restoration efforts, therefore, should focus on maintaining habitat critical to the persistence of these species, regardless of whether habitat for these species is threatened within the regional landscape.

Third, recognition of the sources of degradation allows for investigation of alternative management practices. For instance, one of the greatest threats to riparian habitat is disruption of the natural disturbance regime (Askins 2000), which, when altered, may result in the devastation of local communities adapted to site-specific conditions present in a site's pre-disturbed state. Alternative management practices may include restoration of the natural disturbance regime, or something less extreme, such mitigation.

Fourth, characteristics of community assemblage demonstrate habitat requirements at the ecosystem or community level, while species-specific characteristics demonstrate habitat requirements of specific species of concern. In determining the relative tolerance to habitat alterations by nesting bird species, Stauffer and Best (1980) found that most species nesting primarily in trees were habitat specialists, meaning these species would be intolerant of habitat disruption. All cavity-nesting species also specialized in their selection of habitat due to their requirement of nesting only in live or dead trees. Species preferring shrub or herbaceous vegetation as nesting habitat were much more generalized in their habitat requirements, exhibiting a higher tolerance to habitat alterations – the only exception to this was the Common Yellowthroat (*Geothlypis trichas*), which was highly specialized to nesting in grass habitat (Best et al. 1978; Stauffer and Best 1980). Results of this study illustrate the importance of protecting and restoring native riparian woodland communities in the conservation of avian species. Other species considerations important in setting restoration objectives include the regional occurrence of rare or endangered species, the preservation of which will take precedence over other restoration needs. For example, total exclusion of livestock grazing may be recommended for riparian areas sheltering rare or endangered species of ground-nesting birds (Jensen et al. 1990).

Fifth, identification of the social, political, and economic context within which the degraded riparian system occurs allows for incorporation of non-biological factors into the restoration analysis. Exclusion of domestic livestock is considered the most effective method for restoring riparian habitat, but may not be a feasible restoration option due to social constraints within the regional landscape. Although recovery of riparian systems occurs more slowly and is at greater risk of failure when employing alternative methods to total exclusion, these methods may be the only publicly-acceptable option. According to Askins (2000), it is necessary to discover ways in which ecological processes and species diversity can be maintained and economic development can continue.

Lastly, prioritization of restoration actions should be based on the conservation status of the system or species of concern and the feasibility of achieving restoration goals. According to Askins (2000), the highest priority in the eastern Great Plains is the preservation of tallgrass prairie remnants and the restoration of native prairies. Similarly, but specific to riparian areas, however, would be the preservation of remaining riparian woodlands and the restoration of woodland habitat within the region. Restoration management actions in a landscape dominated by row-crop agriculture, therefore, may include implementation of a voluntary land conservation program that provides landowners financial incentives to retire cropland in floodplain areas. Conservation buffers, which are increasingly recognized as serving an important role in the conservation of avian species, are a common management technique for restoring riparian areas that had been degraded by row-crop agriculture (NRC 2002).

Crucial to avian conservation is an understanding of both the habitat requirements of avian species and the influence of land-use practices on habitat suitability (Askins 2000; Scott et al. 2003). Conservation of avian diversity and restoration of riparian habitat, therefore, should be based on thorough analysis of the factors influencing the system and determination of how these factors may affect restoration outcome. Restoration goals and objectives will vary according to characteristics of the landscape within which the problem occurs, pressures affecting the landscape, and conservation status of the floral and avifaunal communities. Placing restoration problems within this regional context may aid in the prioritization and successful implementation of restoration actions.

Literature Cited

Askins, R.A. 2000. *Restoring North America's Birds: Lessons from Landscape Ecology*. New Haven: Yale University Press.

Best, L.B., K.E. Freemark, J.J. Dinsmore, and M. Camp. 1995. A review and synthesis of habitat use by breeding birds in agricultural landscapes of Iowa. *The American Midland Naturalist* 134(1):1-29.

Best, L.B. and D.F. Stauffer. 1980. Factors affecting nesting success in riparian bird communities. *Condor* 82:149-158.

Best, L.B., D.F. Stauffer, and A.R. Geier. 1978. Evaluating the effects of habitat alteration on birds and small mammals occupying riparian communities. *In* Strategies for protection and management of floodplain wetlands and other riparian ecosystems. General technical report WO-12. U.S. Forest Service, Washington, D.C.

Dobkin, D.S., A.C. Rich, and W.H. Pyle. 1998. Habitat and avifaunal recovery from livestock grazing in a riparian meadow system of the northwestern Great Basin. *Conservation Biology* 12(1):209-221.

Jensen, H.P., D. Rollins, and R.L. Gillen. 1990. Effects of cattle stock density on trampling loss of simulated ground nests. *Wildlife Society Bulletin* 18(1):71-74.

Kentula, M.E. 1997. A comparison of approaches to prioritizing sites for riparian restoration. *Restoration Ecology* 5(4S):69-74.

Kershner, J.L. 1997. Setting riparian/aquatic restoration objectives within a watershed context. *Restoration Ecology* 5(4S):15-24.

Knopf, F.L., R.R. Johnson, T. Rich, F.B. Samson, and R.C. Szaro. 1988. Conservation of riparian ecosystems in the United States. *The Wilson Bulletin* 100(2):272-284.

National Research Council. 2002. *Riparian Areas: Functions and Strategies for Management*. Washington D.C.: National Academy Press.

Osborne, L.L. and D.A. Kovacic. 1993. Riparian vegetated buffer strips in water-quality restoration and stream management. *Freshwater Biology* 29:243-258.

Palik, B.J., P.C. Goebel, L.K. Kirkman, and L. West. 2000. Using landscape hierarchies to guide restoration of disturbed ecosystems. *Ecological Applications* 10(1):189-202.

Patterson, M.P. and L.B.Best. 1995. Bird abundance and nesting success in Iowa CRP fields: The importance of vegetation structure and composition. *The American Midland Naturalist* 135(1):153-167.

Rice, J., B.W. Anderson, and R.D. Ohmart. 1984. Comparison of the importance of different habitat attributes to avian community organization. *Journal of Wildlife Management* 48(3):895-911.

Scott, M.L., S.K. Skagen, and M.F. Merigliano. 2003. Relating geomorphic change and grazing to avian communities in riparian forests. Conservation Biology 17(1):284-296.

Stanley, T.R. and F.L. Knopf. 2002. Avian responses to late-season grazing in a shrub-willow floodplain. *Conservation Biology* 16(1):225-231.

Stauffer, D.F. and L.B. Best. 1980. Habitat selection by birds of riparian communities: Evaluating effects of habitat alterations. *Journal of Wildlife Management* 44(1):1-15.