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Managing National Wildlife Refuges for Historic or Non-Historic Conditions: Determining the Role of the Refuge in the Ecosystem

ABSTRACT

The 1997 Refuge Improvement Act mandates that National Wildlife Refuges (NWR) develop Comprehensive Conservation Plans and that the Refuge System be administered in a manner that ensures the biological integrity, diversity, and environmental health of the System are maintained. Refuges must determine their role in the landscape and decide if refuge lands will be managed for historic or non-historic conditions. This decision should be based on an understanding of the Refuge Purpose and supported by available science. Case studies for Sherburne NWR and Bosque del Apache NWR illustrate two possible approaches to determining future management.

INTRODUCTION

The U.S. Fish and Wildlife Service (FWS) is developing Comprehensive Conservation Plans (CCPs) for over 500 refuges comprising the National Wildlife Refuge System. These CCPs will determine the management direction for each refuge for a 15-year period. This planning effort is mandated by the 1997 Refuge Improvement Act[1] (Improvement Act), which contains several key provisions guiding the endeavor. The Improvement Act defines the Refuge System mission:

> The mission of the National Wildlife Refuge System is to administer a national network of lands and waters for the conservation, management, and where appropriate,

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1. 16 U.S.C. § 668dd (2000).

> restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans.[2]

The Improvement Act and a Director's Order on National Wildlife Refuge System Mission, Goals, and Purposes[3] state that the achievement of Refuge Purpose(s) is the first and highest obligation of refuge management. Refuge Purpose refers to the justification for the establishment of a particular unit of the Refuge System. The Improvement Act also requires that the Refuge System be administered in a manner that ensures the "biological integrity, diversity, and environmental health of the System are maintained."[4] This mandate has been developed into a full policy, known as the policy on biological integrity, diversity, and environmental health,[5] hereafter referred to as the Integrity Policy.

The Improvement Act and subsequent Integrity Policy represent a legal expression of a shift in emphasis that has been occurring in the Refuge System for several years. An evolution in habitat management has occurred on refuges—"from managing for a few species to managing for many species using more natural processes."[6] This philosophy reflects the contemporary view of the scientific community that natural landscapes are essential for the long-term benefit of humankind.[7]

The Integrity Policy clearly states that management for biological integrity, diversity, and environmental health is best accomplished by management for historic conditions. The policy defines historic conditions as those present "prior to substantial human related changes to the landscape." A guiding principle from the Integrity Policy is: "The highest measure of biological integrity, diversity, and environmental health is viewed as those intact and self-sustaining habitats and wildlife populations that existed during historic conditions."[8] Furthermore, the definition of biological integrity and environmental health in the policy notes that the elements of each must be "comparable with historic

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2. *Id.* § 668dd(a)(2).

3. U.S. FISH & WILDLIFE SERV., DIRECTOR'S ORDER 132 (Jan. 18, 2001), *available at* http://policy.fws.gov/do132.html (last visited Dec. 18, 2004).

4. 16 U.S.C. § 668dd(a)(4)(B).

5. Policy on Maintaining the Biological Integrity, Diversity, and Environmental Health of the National Wildlife Refuge System, 66 Fed. Reg. 3810 (Jan. 16, 2001).

6. U.S. FISH & WILDLIFE SERV., FULFILLING THE PROMISE: THE NATIONAL WILDLIFE REFUGE SYSTEM 13 (1999).

7. *See generally* ECOLOGICAL INTEGRITY: INTEGRATING ENVIRONMENT, CONSERVATION, AND HEALTH (David Pimentel et al. eds., 2000).

8. U.S. FISH & WILDLIFE SERV., U.S. FISH AND WILDLIFE SERVICE MANUAL, 601 FW 3.10, *available at* http://policy.fws.gov/series.html (last visited Feb. 3, 2005).

conditions."[9] Thus, according to the Integrity Policy, to promote biological integrity, diversity, and environmental health is to promote the restoration of historic conditions.

It is important to note, however, that the Integrity Policy does not require restoration of historic conditions in all cases. The policy provides several exceptions, based primarily on the concept of management to improve biological integrity, diversity, and environmental health at larger landscape scales. There are several key sections of the Integrity Policy that discuss options for managing for historic or non-historic conditions.[10] Essentially, the Integrity Policy directs refuges to move toward historic conditions, unless any of the following situations apply:

> (1) Management for historic conditions would conflict with Refuge Purpose;
>
> (2) No feasible alternative exists for accomplishing Refuge Purpose other than management for non-historic conditions;
>
> (3) Management for non-historic conditions on the refuge will make a greater contribution to biological integrity, diversity, and environmental health at a larger landscape scale.

By providing these exceptions, the Integrity Policy provides a large degree of latitude in deciding how to manage refuge lands in order to meet the Refuge Purpose and mandates from the Integrity Policy. How

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9. *Id.* 601 FW 3.6(B).

10. *Id.* 601 FW 3.

> 3.7(C) In pursuit of refuge purposes, individual refuges may at times compromise elements of biological integrity, diversity, and environmental health at the refuge scale in support of those components at larger landscape scales.
>
> *******
>
> 3.10(A)(5) We may find it necessary to modify the frequency and timing of natural processes at the refuge scale to fulfill refuge purpose(s) or to contribute to biological integrity at larger landscape scales.
>
> *******
>
> 3.14(D) On some refuges, including many of those having the purpose of migratory bird conservation, we establish goals and objectives to maintain densities higher than those that would naturally occur at the refuge level because of the loss of surrounding habitats.
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> *******
>
> 3.15(C) We do not allow refuge uses or management practices that result in the maintenance of non-native plant communities unless we determine there is no feasible alternative for accomplishing refuge purpose(s).

Id.

are managers to determine when the above exceptions apply? What logic should be used to make this determination? What scientific information and data are necessary to make an informed decision?

It is difficult to envision circumstances where the determination to manage for historic or non-historic conditions will be unequivocal, with no possibility of legitimate options. Future desired conditions for any refuge are not prescribed in absolute terms. Rather, it is more likely that the decision to manage for historic or non-historic conditions must be thoroughly analyzed and debated. Refuges must assess their Purpose and the Integrity Policy mandates and determine their desired future course of management. Therefore, the question, *"How much land, if any, should be managed in non-historic conditions and how much land, if any, should be maintained in, or restored to, historic conditions?"*, is central to the implementation of the mandates from the Improvement Act and the Integrity Policy. This question is central because the answer affects the most basic of refuge land management decisions—determining what vegetation communities, and resultant wildlife, are to be managed for on specific pieces of land. We provide suggestions on how to answer this central question by encouraging the use of critical thinking, logical decision processes, and scientific information and data. It must be recognized, however, that there is no ecologically correct answer, and that human value judgments will play a role in determining future management directions.[11] Nonetheless, available science should be the foundation for these judgments.

The Improvement Act requires that all refuges complete a CCP by the year 2012. The Integrity Policy requires that its principles be incorporated into all aspects of Comprehensive Conservation Planning. We strongly recommend that during CCP preparation adequate time be devoted to considering and implementing the ideas presented in this article.

The article is divided into several sections. First, we discuss the types of information and data that must be considered and understood prior to deciding the direction of future refuge management. Second, we present suggestions on how to determine the role of the refuge in the larger landscape and the best contribution the refuge can make. Last, we present case studies to provide examples of how these decisions were made for two National Wildlife Refuges (NWR).

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11. Roger A. Powell, *Ecological "Nonarguments" and Human Value Judgments*, 10 WILDLIFE SOC'Y BULL. 141 (1982).

INFORMATION AND DATA NEEDS

Refuge managers have a tremendous amount of information available to them when making decisions. Section 3.9 of the Integrity Policy provides an overview of the types of information that managers should consider when implementing the policy.[12] In the following three sections, we present the basic information needed to make informed decisions on refuge management.

Step 1: Identify and Understand the Refuge Purpose

Identifying and understanding the Refuge Purpose requires careful consideration and deliberation and is not necessarily a straightforward process. In a recent overview of laws and policies related to the National Wildlife Refuge System, Fischman describes the following three levels for understanding Refuge Purposes, from most general to most specific: (1) the broad statutory terms provided in the law or Executive Order establishing the refuge, (2) the intent of the basic authorities as revealed through legislative history, (3) the particular circumstances that led to the approval for each refuge.[13] Fischman goes on to say that the Service's current practice, as defined by Director's Order 132, is to define purposes at level 1, *i.e.*, in the most general way, through broad statutory terms. Appendix 1 of Director's Order 132 spells out a series of steps to follow to identify the Refuge Purpose.[14] Following this guidance, it can be seen that for most refuges the Purpose can be established from the language of the Executive Order or federal law under which the refuge was established. For example, the FWS database on refuge purposes indicates that 295 refuges (or portions of refuges) were established under the Migratory Bird Conservation Act, and, thus, their purpose is "for use as an inviolate sanctuary, or for any other management purpose, for migratory birds."[15]

In practice, an understanding of Refuge Purposes often includes an analysis of the particular circumstances under which the refuge was established (levels 2 and 3 from Fischman). Dan Ashe, Science Advisor to the Director of FWS, notes that determining refuge purposes is a product of all three levels.[16] In a few cases, there may be very specific Refuge

12. U.S. FISH & WILDLIFE SERV., *supra* note 8, 601 FW 3.9.

13. ROBERT L. FISCHMAN, THE NATIONAL WILDLIFE REFUGES: COORDINATING A CONSERVATION SYSTEM THROUGH LAW 79 (2003).

14. U.S. FISH & WILDLIFE SERV., *supra* note 3, app. 1.

15. 16 U.S.C. § 715d (2000).

16. Personal communication from Dan Ashe, Science Advisor to the Director of the Fish and Wildlife Service (Jan. 2004).

Purposes and, thus, only a small degree of latitude in determining future management direction. However, in most cases, the purposes of the refuge are broad enough to allow a considerable degree of latitude in determining on-the-ground management. It is imperative that the purpose of each refuge is analyzed and understood, and that serious consideration be given to how the purpose will be combined with current mandates and new scientific knowledge to guide future management.

Step 2: Assess the Current and Historic Status of Biological Integrity, Diversity, and Environmental Health

FWS policies for Comprehensive Conservation Planning[17] and Habitat Management Planning[18] provide a starting place for narrowing the types of biological information necessary to assess the current and historic status of biological integrity, diversity, and environmental health. In addition, the FWS has published recommendations for the types of baseline inventory data that should be collected on each refuge.[19] Information necessary to assess current and historic conditions should include:

- Distribution, migration patterns, and abundance of fish, wildlife, and plant populations, and related habitats, including information on the location and conditions of resources of special concern, such as rookeries, leks, vernal pools, or roost sites.
- Description of vegetation community types, plant species composition, soil types, water quantity and quality, invasive species, and wildlife habitat relationships.
- Description of ecological processes such as fire and hydrology, as well as erosion problems, contaminant problems, and any other conditions affecting biological integrity, diversity, and environmental health.
- For all species, communities, and processes, determine the degree to which they are of management concern due to factors such as rarity, declines, status as keystone or indicators, or high degree of public interest.

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17. Refuge Planning Policy Pursuant to the National Wildlife Refuge System Administration Act as Amended by the National Wildlife Refuge System Improvement Act of 1997, 65 Fed. Reg. 33,892, 33,910 (May 25, 2000).

18. U.S. FISH & WILDLIFE SERV., *supra* note 8, 620 FW 1.

19. U.S. FISH &WILDLIFE SERV., WH8.1, BASELINE INVENTORY TEAM REPORT 6-7 (2004).

Developing an understanding of the current and historic status of biological integrity, diversity, and environmental health of the refuge and surrounding ecosystem is critical. Acquiring and understanding the necessary information can require a tremendous amount of effort. This information can be obtained from a thorough search of available scientific literature and data, use of on-site refuge data, discussions with local and regional experts, networking with other refuges and partners, and professional judgment and experience.

Step 3: Compare Historic to Current Conditions and Assess the Opportunities and Limitations to Maintaining and Restoring Biological Integrity, Diversity, and Environmental Health

Using the information gathered in Step 2 above, historic and current conditions can be compared and differences can be determined. A useful way to view this information is through detailed vegetation maps and accompanying data tables showing the area of each vegetation type. For example, the Comprehensive Conservation Plan for the Marais des Cygnes NWR specifically notes that the refuge historically contained 1335 hectares (3300 acres) of bottomland hardwood forest, but currently has only 607 hectares (1500 acres) of this forest type.[20] Comparison of differences in ecological processes such as fire or flooding can be described in terms of changes in frequency, intensity, and season.

The next step is to assess the opportunities and limitations to either restoring historic conditions or managing for non-historic conditions. Again, a series of questions may help focus these deliberations:

- Is it possible to return to historic conditions for all wildlife species and vegetation communities, and ecological processes? If not, what are the limits and constraints? For example, if there are upstream dams, how different is the current hydrologic regime from historic conditions? How similar can a current burn regime be to the historic regime?
- Is it possible to restore extirpated animals, especially those such as large carnivores or herbivores, that may have significant effects on ecosystem structure and function?
- Are there ongoing changes, such as climate change, that may alter future conditions regardless of management efforts?

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20. U.S. FISH & WILDLIFE SERV., MARAIS DES CYGNES NATIONAL WILDLIFE REFUGE COMPREHENSIVE CONSERVATION PLAN 16 (1998).

- Is the refuge within the historic geographic range for the species or vegetation types to be managed for? If not, how distant is the historic range? Based on sensitivity to fragmentation or dispersal concerns, does this distance make a difference in the likelihood of success?
- Are there natural or anthropogenic threats that might have a long-term negative effect on the viability of plant and animal populations or vegetation communities?
- How feasible is it that any necessary intensive management can be achieved and sustained over time?
- If there are constraints, can they be ameliorated? How far along the trajectory toward restoration of historic conditions is it possible to move? What is the minimum amount of change that is acceptable?

All of the above opportunities and limitations are related to biological issues. In practice, there will likely be management constraints arising from public concerns. These issues are beyond the scope of this article, but potentially will influence future management direction on a refuge.

An example illustrates how opportunities, or limitations, might affect future management direction. Assume that declining grassland birds are a resource of concern within a specific refuge ecosystem and that management for them would not be in conflict with the Refuge Purpose. The refuge is considering its potential contribution to improve habitat for these birds. This consideration should be based on a careful evaluation of the historic conditions on the refuge. If grasslands and the birds of concern were historically present on the refuge, then it would probably be appropriate to manage for the declining grassland birds, if there were no other management constraints or limitations. However, if grasslands and the birds of concern were not historically present, then the refuge must carry out a more detailed analysis prior to deciding to manage for the grassland birds and their habitats.

The refuge must consider what current habitat would be converted to grassland, and what the implications are of eliminating the existing habitat and precluding a return to historic habitat. One implication of precluding a return to historic habitat is the loss of value for the plants and animals that occupied the historic habitat in favor of those that occupy the grassland. Another concern is the potential difficulty in creating and maintaining a grassland habitat in an area where it did not naturally occur. If the natural, historic habitat was a shrub or forest type, then significant management effort will be required to keep such areas in a grassland stage. It may be difficult to mimic native grass and forb species diversity and to recreate the desired habitat structure.

In addition, the refuge must consider if there are any management constraints, such as the inability to burn or maintain native grazing animals, which would preclude proper grassland habitat management. For example, are there ecological considerations, such as minimum grassland patch size, that cannot be achieved? If the grassland birds of management concern require large, contiguous patches, does the refuge have the ability to provide these? Are there other biological requirements that may diminish the value of managing for grasslands?

In assessing the opportunities and limitations of managing for historic or non-historic conditions, it is important to acknowledge any tradeoffs. Management for a specific vegetation community and resultant wildlife will invariably preclude management for other vegetation associations and wildlife. In the case of restoration of historic conditions, in almost all instances it will be impossible to completely restore conditions to those that existed prior to substantial human related changes to the landscape. In the case of management for non-historic conditions, it is unlikely that such management will completely compensate for losses at the larger landscape scales. It is important to understand and acknowledge what cannot be accomplished and any tradeoffs that are made.

DETERMINING THE ROLE OF THE REFUGE IN THE ECOSYSTEM AND FUTURE MANAGEMENT DIRECTION

Section 3.9.D. of the Integrity Policy requires consideration of the refuge's importance to refuge, ecosystem, national, and international landscape scales of biological integrity, diversity, and environmental health.[21] The refuge's roles and responsibilities within regional and system administrative levels also must be identified. The subsequent section of the Integrity Policy requires consideration of the relationships among refuge purpose(s) and biological integrity, diversity and environmental health, and the resolution of conflicts among them.[22] The Policy notes that through the comprehensive conservation planning process and other planning and management activities it is necessary to determine the appropriate management direction to maintain and, where appropriate, restore, biological integrity, diversity, and environmental health, while achieving refuge purpose(s).[23] These are

21. U.S. FISH & WILDLIFE SERV., *supra* note 8, 601 FW 3.9(D).
22. *Id.* 601 FW 3.9(E).
23. *Id.* 601 FW 3.9(G).

very complicated tasks, and the Policy provides little specific guidance on how to accomplish them.

Determining the possible roles of a refuge in the ecosystem is at the core of determining future possible management direction for the refuge. Determination of the refuge's possible roles should be based upon the foundation of information concerning current and historic conditions, both on the refuge and in the surrounding ecosystem. Future refuge management must meet the refuge purpose and help to maintain the biological integrity, diversity, and environmental health of the entire refuge system. As we have shown, most refuges have some degree of management flexibility, and the basic question that must be answered is, *"What is the most important contribution the refuge can make?"* Although there is no "cookbook" approach to determining the role of the refuge in the ecosystem or its best contribution, following a logical process and using available science are necessary steps for making informed decisions. There are a number of factors that can help focus the deliberations about the role of the refuge in the ecosystem.

- What is the appropriate landscape scale to assess the importance of refuge resources? What ecosystem boundaries (Bird Conservation Regions, FWS Ecosystems, etc.) should be used to analyze the refuge context?
- What are the important resources (species, vegetation communities, ecological processes) that should be considered for management, given the context of the refuge within the chosen ecosystem boundaries?
- What is the relative priority of these resources, based on factors such as rarity, importance, and extent of occurrence?
- Are there critical species, vegetation types, or processes within the ecosystem that the refuge should manage for, even if they require non-historic conditions?
- What other protected areas exist within the ecosystem, and how might the refuge complement or supplement these areas?
- What is the land capability based on where the refuge sits in the ecological landscape, *i.e.*, what is most sustainable?

We believe that refuges should compile and understand the information and data needs presented in the first section of this article and then answer the above questions. Our final suggestion is that refuges ask this critical question for each current vegetation type, *"Why is the land currently in this vegetation type or condition?"* What is the contribution the lands make to refuge purpose and/or system-wide biological integrity, biodiversity, and environmental health? For those areas where the current vegetation types do not correspond to the historic types, the original management intent for creating or maintaining the non-historic vegetation type should be determined. For each area currently in a non-historic vegetation type, determine the reasons for, and benefits of, continuing current management. Those current vegetation types most different from historic (*e.g.*, croplands, exotic grasses, exotic trees) need the most justification from the perspective of the Integrity Policy if they are to remain. For each area that is currently in a historic vegetation type, determine the reasons for, and benefits of, continuing current management. And for all areas, consider any reasons why the current vegetation type (historic or non-historic) might be changed to a different type (historic or non-historic) in the future.

The above deliberations should reflect any limitations or constraints that might affect future management options. The logic and rationale for all of the above steps should be documented, including citations and data sources used in making the decisions. By following this process, refuges will make future management decisions based on available science and a thorough consideration of the role of the refuge in the ecosystem.

We present the following two case studies to provide examples of how these decisions were made for two NWRs. The Sherburne NWR case study explains the decision to restore the historic vegetation community type on refuge uplands. The Bosque del Apache NWR case study explains the decision to manage parts of the refuge for historic conditions and other parts for non-historic conditions.

CASE STUDY I—SHERBURNE NATIONAL WILDLIFE REFUGE

Refuge Purpose

Sherburne NWR consists of 12,410 hectares (30,665 acres) in east central Minnesota, situated in the transition zone between tallgrass prairie and forest. Sherburne NWR was established in 1965 under the authority of the Migratory Bird Conservation Act of 1929.[24] That Act states that lands may be acquired "for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." The original intention of the Migratory Bird Conservation Commission in establishing

24. 16 U.S.C. § 715d (2000).

the Refuge was primarily to provide habitat for migratory waterfowl. During the initial stages of the CCP process for Sherburne NWR, the refuge purpose was discussed at length. It was determined through this process that, considering the wording of the establishing legislation together with recent policy and legislation, the Refuge Purpose is currently interpreted to include all migratory birds as provided for in the Migratory Bird Treaty Act, which includes hundreds of species other than waterfowl.[25] This interpretation of the migratory bird purpose of the refuge was the first consideration in determining future management direction. In addition, the CCP specified that the refuge is also considering the full diversity of native species that make up and depend upon healthy ecosystems.

Historic Conditions

Sherburne National Wildlife Refuge lies within the deciduous forest-woodland zone of Minnesota on the Anoka Sandplain, a large, flat, sandy outwash area now thought to be lacustrine in origin. The predominant presettlement vegetation on the uplands throughout the Anoka Sandplain was oak savanna.[26] Before European settlement, oak savanna was widely distributed in the Midwest. It occupied up to half of the Midwestern landscape, especially along the prairie-forest border, and extended over portions of Minnesota, Iowa, Missouri, Illinois, Wisconsin, Indiana, and Ohio, covering 11 to 13 million hectares (27.5 to 32.5 million acres).[27] These places have become fragmented and lost entirely in many areas. A 1985 survey found about 0.02 percent of the pre-European oak savanna remained, in scattered remnants.[28] Losses of oak savanna were due to timber cutting, fire suppression, and conversion to homesteads and/or farming. Today, oak savanna and open oak woodlands are among the world's most threatened plant communities. The Nature Conservancy ranks Midwest savannas as "globally endangered" and the U.S. Environmental Protection Agency chose Midwestern oak savanna for its first Ecosystem Recovery Project.[29]

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25. List of Migratory Birds, 50 C.F.R. § 10.13 (2004).

26. MINN. DEP'T NATURAL RES. AD HOC WORKING GROUP, UPPER LEVELS OF AN ECOLOGICAL CLASSIFICATION SYSTEM FOR MINNESOTA (1996) (working draft).

27. V.A. Nuzzo, *Extent and Status of Midwest Oak Savanna: Presettlement and 1985*, 6 NAT. AREAS J. 6, 6 (1986).

28. *Id.*

29. THE NATURE CONSERVANCY, MIDWEST OAK ECOSYSTEM RECOVERY PLAN: A CALL TO ACTION 71, 73 (Mark L. Leach & Laurel Ross eds., 1995), *available at* http://www.epa.gov/glnpo/ecopage/upland/oak/oak95/call.htm (last visited Jan. 14, 2005).

Francis J. Marschner reviewed and interpreted the notes from the first land surveyors and prepared a map of Minnesota's pre-European settlement vegetation.[30] He called this the "Original Vegetation of Minnesota" because the surveys were usually made just ahead of settlement and described the vegetation before it was directly altered by cultivation, commercial logging, or land clearing. The Refuge refined Marschner's interpretation of pre-European settlement vegetation within its boundary with the aid of a Cooperative Education Student, Kevin Kenow, in 1978. Kenow performed an independent review of the surveyor's records and other sources of information on the distribution of vegetation before European settlement and developed a map specific to the Refuge. From these sources we estimate that prior to European settlement 63 percent of the Refuge was oak savanna (95 percent of the upland), 3 percent was big woods, and the remaining 34 percent was wetland, lake, or river.

Current Conditions

When Sherburne NWR was established, much of the upland area was being farmed. As was the case throughout the midwest, the historic landscape, consisting of primarily oak savanna on the uplands, had been lost in two ways: through conversion to agricultural fields or through fire exclusion, which facilitated its conversion to oak woodland and forest. Upland management on the refuge began with the reestablishment of native grasses and forbs in the old crop fields and the removal of non-native species across the refuge, including conifer plantations and other non-native trees planted around old homesteads. Some large areas of native grasslands were created where the old fields had been. There was also selective cutting in some of the oak woodlands to open the canopy and begin the restoration of oak savanna in these areas. In addition, prescribed fire was introduced as a major management tool. This helped open the canopy in the wooded areas and facilitated the restoration of the planted native grasslands. Refuge goals for wetlands were to restore a complex of historic wetland basins that could be manipulated via water control structures to benefit wildlife, and to use the ditches, once used to drain the wetlands, to convey water between wetlands and allow drawdowns and reflooding.

30. Francis J. Marschner, The Original Vegetation of Minnesota (1974) (a map compiled in 1930 by F.J. Marschner under the direction of M.L. Heinselman of the U.S. Forest Service, on file at the Cartography Laboratory of the Department of Geography, University of Minnesota, St. Paul, Minn.).

Land Management Decisions

Several factors were considered to help determine if the refuge should move toward historic vegetation conditions. Even though this direction was implied in some early refuge documents and from past management decisions, the CCP process allowed the refuge to step back and take a fresh look at this question with present-day knowledge and past lessons learned. This made the decision process more transparent and the decisions more explicit.

The refuge considered its geographic context within its originally legislated purpose by asking how it can best serve migratory birds in this location and considering the natural history of these birds. It was affirmed that although Sherburne NWR is located within the Mississippi Flyway, it is not within the major duck production areas of Minnesota or the Midwest (*i.e.*, the prairie pothole region). In light of this fact, Sherburne NWR can best serve waterfowl by providing habitat for those birds during migration. In addition, for other migratory birds, we consulted the FWS Region 3 list of Resource Conservation Priorities (RCP).[31] This list was designed to help FWS Region 3 prioritize management decisions in light of the reality of limited resources. A portion of this list addresses migratory birds. Part of the rationale for developing a species-based RCP list, especially from the migratory bird perspective, was the idea that declining species would be surrogates for declining habitats. This rationale works well for prairie birds; however, it falls short in terms of migratory land birds and oak savanna. Although midwestern oak savanna as a vegetation type has been ranked as a critically endangered ecosystem,[32] it contains few rare or declining migratory birds due to its ecotonal nature.

A second factor that was considered in determining the return to historic vegetation at Sherburne NWR is its location within the ecological land types of the Midwest and Minnesota. To reiterate, the refuge lies in the transition zone between tallgrass prairie and deciduous forest. Soil surveys and pre-European records show that this land is best suited to oak savanna/barrens as a natural habitat. A further extension of this concept is the idea of land capability. Land capability considers what is sustainable on the site based on soils, climate, and ecological context.

31. U.S. FISH & WILDLIFE SERV., FISH & WILDLIFE RESOURCE CONSERVATION PRIORITIES: REGION 3 (2002), *available at* http://midwest.fws.gov/pdf/priority.pdf (last visited Jan. 17, 2005).

32. REED F. NOSS ET AL., ENDANGERED ECOSYSTEMS OF THE UNITED STATES: A PRELIMINARY ASSESSMENT OF LOSS AND DEGRADATION, app. B at 61 (1995), *available at* http://el.erdc.usace.army.mil/emrrp/emris/EMRIS_PDF/ec.pdf (last visited Jan. 17, 2005).

Based on these factors, it would be a continuous battle to keep all trees out of the grasslands at Sherburne NWR. The presence of trees severely reduces the contribution the refuge can make toward viable populations of declining migratory grassland bird species, most of which are area dependent and intolerant of trees.

A final factor in the refuge's decision to return to historic vegetation was the contribution Sherburne NWR could make to the NWR System. Sherburne NWR is in the unique situation of being able to serve as a showcase and demonstration area for the restoration of oak savanna. This is based on other factors such as its ecological location and land capability. There are no other refuges within the system that could undertake the restoration of oak savanna on such a large scale.

Following this thinking, the decision was made for Sherburne NWR that its best contribution to the wildlife conservation effort and the NWR System is the restoration and maintenance (as close as possible with present constraints) of the historic upland landscape, including the globally endangered oak savanna ecotype, while providing migratory habitat for waterfowl.

Challenges and Constraints

Having made the decision to restore the majority of the refuge uplands to oak savanna, the refuge acknowledges that there are many potential limitations to achieving the complete restoration of oak savanna at Sherburne NWR. There has been a loss of herbivory by the large ungulates (*i.e.*, bison and elk) that historically played a large role in maintenance of savanna. Today, bison are extirpated from Minnesota and free-ranging elk survive only as a small re-introduced herd in northwestern Minnesota. It will likely be difficult to reintroduce these animals on a historic scale due to concerns about public safety. Even if these species could be reintroduced, the grazing patterns would not be able to accurately mimic historic events and timing. Other considerations are the need for vaccinations of bison to prevent the potential spread of brucellosis to domestic cattle and the need to keep both the elk and bison herds within the carrying capacity of the site.

Fire was a major force for shaping and maintaining oak savanna. Currently, the windows of opportunity to apply fire create a skewed seasonal application of this tool—usually the rainfall, humidity, wind conditions, and staffing necessary to ensure a safe and effective burn only allow the application of spring burns. Therefore, current fire management methods do not match historic conditions. In addition, with lands around the refuge experiencing rapid residential growth, there are added constraints and challenges placed on the application of fire as a management tool. These concerns include smoke management, lack of understanding of fire as a management tool, and fear of wildfire. Fire within an urban setting is generally perceived as a devastating event, and urban residents moving to the area around the refuge have an understandable fear of wildfire.

Invasive species are a growing concern on the refuge. It will be difficult to control the spread of invasive species that threaten the restoration of historic savanna. Exotic species often out-compete native grasses in grassland restoration areas. Other species such as box elder (*Acer negundo*) can take over a site being prepared for oak savanna restoration due to their rapid spread on exposed soils being prepared for grassland seeding. It may be necessary to recognize that some exotic species, *e.g.*, hoary allysum (*Berteroa incana*) and Kentucky bluegrass (*Poa pratensis*), do not pose a major threat, may be too prolific to eliminate, or cannot be effectively controlled. Species such as these, which were not historically part of the oak savanna community, may have to be accepted as part of the modern savanna community.

There are concerns that the water table on the refuge has risen due to the establishment of the refuge impoundments. The hydrologic regime of these wetlands may have been altered by changing what were historically flow-through wetland basins to storage basins.[33] In addition, in some of the upland areas where the grassland understory has been restored in preparation for oak savanna, the elevated water table appears to be favoring aspen (*Populus tremuloides*) over oak species as the pioneering species, possibly due to increased soil moisture conditions. It will be necessary to study and determine the impact of the water table and the ability to restore the full extent of the oak savanna.

The areas surrounding the refuge are experiencing urban encroachment, which poses challenges and constraints to future refuge management. Physically, the refuge is becoming a disjunctive piece of native habitat within a sea of residential development. In addition, many actions that are common on now-adjacent suburban lands, such as application of lawn herbicides and allowing cats to roam freely outdoors, can be detrimental to wildlife. Another effect is the potential that exotic plants will spread into the refuge and negatively impact native habitat restoration efforts. These insidious threats further reduce the effective area of the refuge.

There will be a need to work within these potential constraints as much as possible. Any restoration of oak savanna will never be able to

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33. R.G. Brown, Hydrologic Effects of Impoundments in Sherburne National Wildlife Refuge, Minnesota 15 (1984) (U.S. Geological Survey, Water-Resources Investigation Report 84-4175).

completely recreate the conditions that existed prior to European settlement. However, ecological restoration should be viewed as movement along a trajectory toward the ideal condition while acknowledging that complete restoration is not possible.[34]

The key management decisions that will guide future management at the refuge are (1) the phrase "migratory birds" from the Refuge Purpose is considered to mean all migratory birds as noted in the Migratory Bird Treaty Act, (2) Sherburne NWR is not in the major duck producing area of the prairie potholes, and (3) the historic upland vegetative community of oak savanna has inherent value as a rare vegetation type.

CASE STUDY II – BOSQUE DEL APACHE NATIONAL WILDLIFE REFUGE

Refuge Purpose

The Bosque del Apache NWR comprises 23,136 hectares (57,168 acres) in Central New Mexico, along the Rio Grande. Vast Chihuahuan desert scrublands and semidesert grasslands dominate this arid landscape bisected by the most salient feature of the refuge, the Rio Grande.[35] The area was established in 1939 as a National Wildlife Refuge whose purpose is to serve as "a refuge and breeding ground for migratory birds and other wildlife." In reviewing the historical record since 1939, it is clear that Refuge management programs have focused on the welfare of the Rocky Mountain Population (RMP) of greater sandhill cranes (*Grus canadensis tabida*), and that concerns for this population were a driving force for refuge establishment.[36] The recovery of the population, which numbered only 14 individuals in 1939, has been attributed to management programs on the Refuge and adjacent state refuges in the Middle Rio Grande Valley. The population remains sensitive to habitat loss and alteration and is currently the subject of landscape research to assess habitat conditions across its range.[37]

34. GARY K. MEFFE & C. RONALD CARROLL, PRINCIPLES OF CONSERVATION BIOLOGY 421, 422 (1994).

35. David E. Brown, *Biotic Communities of the American Southwest: United States and Mexico*, 4 DESERT PLANTS 1 (1982).

36. MASTER PLAN REPORT: BOSQUE DEL APACHE NATIONAL WILDLIFE REFUGE ANNUAL NARRATIVE REPORTS 5 (1939-2000).

37. L.H. Fredrickson, The Temporal and Spatial Distribution of RMP Sandhill Cranes in Response to Habitat Conditions Determined by Climate, Geomorphology, and Land Use of Public and Private Lands Along an Intermountain Corridor (2003) (unpublished

Historic Conditions

Desert scrublands and grasslands in the region were historically described as thickly covered by luxurious grass but lacking the large herds of grazing ungulates common to prairie grasslands.[38] Periodic fire as influenced by climatic wet and dry patterns may have been the driving force in the maintenance of upland shrubland/grassland mosaics.[39]

The Rio Grande floodplain ecosystem contrasts sharply with the slow moving ecological processes prevalent in adjacent arid uplands. Dynamic flows along this braided, slightly sinuous stream shaped riparian communities fostering a mosaic of vegetative diversity of patchy habitats and rich vertical structure. Flooding was cyclic, generally following an annual pattern of high flows as mountain snows melted in the spring.[40] Flows were perennial in all but the driest times. Vegetative response to flooding was variable depending on flooding intervals and intensity. Floods provided the soil disturbance and moist substrate required for vegetation renewal. Flooding alternately created and destroyed wetlands and meadows. Newly created wetlands supported annual plant communities that moved successionally toward emergent perennial communities. High water tables and saline soils characterized riparian meadows. In the absence of disruptive flooding, wetland/meadow succession advanced forming new woodlands or brushlands.

Significant human influences to Rio Grande riparian communities began 1500 to 2000 years ago by ancestors of present day Pueblo Indians. Forests were used as sources of fuel wood, and openings were created and maintained for low input agriculture.[41] Native Americans also may have intentionally set small fires periodically to aid in vegetation clearing or to drive game. It is estimated that over 10,122 hectares (25,000 acres) of land were irrigated and farmed in the Middle

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proposal to the U.S. Dept. of the Interior, Geological Survey Science Support Program, Albuquerque, N.M., on file with author).

38. Robert R. Humphrey, *The Desert Grassland: A History of Vegetational Change and an Analysis of Causes*, 24 BOTANICAL REV. 193, 209 (1958).

39. Robert R. Humphrey, *Fire in the Deserts and Desert Grasslands of North America*, *in* FIRE AND ECOSYSTEMS 365, 383 (T.T. Kozlowski & C.E. Ahlgren eds., 1974).

40. Michael L. Scott et al., *Hydrograph Characteristics Relevant to the Establishment and Growth of Western Riparian Vegetation*, *in* PROCEEDINGS OF THE THIRTEENTH ANNUAL AMERICAN GEOPHYSICAL UNION HYDROLOGY DAYS 237, 240–41 (H.J. Morel-Seytoux ed., 1993).

41. Dan Scurlock, *The Rio Grande Bosque: Ever Changing*, 63 N.M. HIST. REV. 131, 132 (1988).

Rio Grande Valley prior to the Spanish arrival.[42] Spanish colonization in the sixteenth century brought dramatic landscape changes. Large herds of domestic livestock resulted in wide plant community changes across arid uplands prone to soil erosion.[43] Agricultural development and floodplain grazing accelerated with Spanish and Mexican colonization and continued through American territorial rule. Although European influence through the nineteenth century altered the pristine nature of the floodplain, natural influences, such as flooding, remained dynamic, contributing to diverse habitat communities.

Expansive agriculture, vast wet meadows, and shallow, wide braided river habitats dominated the Middle Rio Grande Valley during pre-European and colonial periods.[44] Although exact numbers of sandhill cranes using these habitats in the Valley during winter periods cannot be ascertained historically, they probably numbered in the thousands. Colonel James W. Abert described populations of large "long-legged" cranes as abundant in his reconnaissance of the area for the U.S. Army in 1847.[45]

Current Conditions

The early twentieth century marked the beginning of irreversible changes for Rio Grande riparian communities. Expanding agriculture prompted the construction of reservoirs to provide a dependable source of irrigation water.[46] Controlled river flows thereafter were directed at meeting agricultural irrigation water demands and marked the beginning of an altered river hydrograph. By 1925, in efforts to improve agriculture still further, the number of river diversions was increased, the river was levied, irrigation canals were added, and a drainage system to lower the water table was developed.[47] Almost immediately, wetland and meadow habitats disappeared and were quickly invaded by woody riparian plant communities.[48]

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42. J.L. BURKHOLDER, MIDDLE RIO GRANDE CONSERVANCY DIST., ALBUQUERQUE, N.M., REPORT OF THE CHIEF ENGINEER 5 (1928).

43. Scurlock, *supra* note 41, at 132-33.

44. *Id.*

45. JAMES W. ABERT, U.S. DEP'T OF WAR, A REPORT AND MAP OF THE EXAMINATION OF NEW MEXICO 12 (1962).

46. THOMAS F. BULLARD & S.G. WELLS, U.S. DEP'T OF INTERIOR, RESOURCE PUB. 179, HYDROLOGY OF THE MIDDLE RIO GRANDE FROM VELARDE TO ELEPHANT BUTTE RESERVOIR, NEW MEXICO 13 (1992).

47. *Id.*

48. VALERIE C. HINK & ROBERT. D. OHMART, U.S. ARMY CORPS OF ENGINEERS, MIDDLE RIO GRANDE BIOLOGICAL SURVEY, FINAL REPORT 7 (1984).

Concurrent to these changes was the introduction of two exotic woody species. Saltcedar (*Tamarix chinensis*) was introduced as an ornamental in New Mexico by 1908[49] and was used to control erosion in the Rio Grande watershed by 1926.[50] The species spread prolifically through flooding events thereafter but did not become established to any extent at the Refuge until after extensive river flooding in 1941. Russian olive (*Eleagnus angustifolia*) was introduced into the valley by 1915[51] and was prevalent in northern New Mexico but less common further south by 1960.[52]

By 1950, remaining wetland and meadow communities were rare. Saltcedar had moved into many forests and brushland communities resulting in a mixed woody community of saltcedar and native forest and brushland. The river hydrograph was further altered through the construction of additional dams to augment water storage for irrigation and to provide flood protection for urban communities in the valley.[53] Gradually, saltcedar has come to dominate or replace native riparian communities in large homogenous stands throughout the region.

Notably absent from the Refuge today are large mammals such as bears (Ursus americanus and Ursus arctos horribilis) and wolves (Canis lupus) and many fish species. Avian species diversity probably continues as high as occurred historically through expansion of woodland habitats normally restricted due to severe river flooding.[54] Mosaics of open and dense habitats, plant species diversity and growth forms, and abundant nest cavities support some of the highest diversities and abundances of birds in all of North America.[55] Current species of concern, including the southwestern willow flycatcher (Empidonax traillii extimus) and the yellow-billed cuckoo (Coccyzus americanus), reflect declining riparian health associated with altered river hydrology and the aggressive invasion by exotic plants. Contrasts in mammal, reptile, and amphibian species diversities in upland and riparian

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49. Scurlock, *supra* note 41, at 137.

50. T.W. ROBINSON, PROF. PAPER 491-A, U.S. GEOLOGICAL SURVEY, SPREAD, AND AREA EXTENT OF SALT CEDAR (TAMARIX) IN THE WESTERN STATES 4 (1965).

51. HINK & OHMART, *supra* note 48.

52. C.J. Campbell & W.A. Dick-Peddie, *Comparison of Phreatophyte Communities on the Rio Grande in New Mexico*, 45 ECOLOGY 492, 497 (1964).

53. BULLARD & WELLS, *supra* note 46, at 15.

54. C.S. CRAWFORD ET AL., U.S. DEP'T OF THE INTERIOR, MIDDLE RIO GRANDE ECOSYSTEM: BOSQUE BIOLOGICAL MANAGEMENT PLAN 14 (1993).

55. ROBERT D. OHMART ET AL., U.S. DEPT. OF THE INTERIOR, THE ECOLOGY OF THE LOWER COLORADO RIVER FROM DAVIS DAM TO THE MEXICO-UNITED STATES INTERNATIONAL BOUNDARY: A COMMUNITY PROFILE, BIOLOGICAL REPORT 85, 152 (1988).

communities are less distinct.[56] A variety of mammals, including carnivores, ungulates, and large and small rodents, as well as reptiles and amphibians, utilize both upland and riparian habitats. Mammal and amphibian species of concern include the meadow jumping mouse (Zapus hudsonius luteus) and the Chiricahua leopard frog (Rana chiricahuensis), which are similarly impacted by altered hydrology. Fish species have seen the greatest rate of extirpation of all species groups.

Land Management Decisions

Bosque del Apache NWR is scheduled to begin the Comprehensive Conservation Planning process in the near future. In the absence of CCP planning, the Refuge has evaluated conformance with establishment purposes and the Integrity Policy on an issue-by-issue basis. Two recent issues have laid important groundwork for the preparation of the Refuge's CCP. The first issue involved fire management planning primarily in upland habitats, while the second involved recent water management planning for floodplain habitats at the onset of extended drought in the southwest.

Upland management has been largely passive since the removal of domestic livestock in 1971. In evaluating critical ecological processes in upland areas, fire occurrence was determined essential for the restoration of biological integrity. Therefore, a more active effort to restore native vegetation mosaics was initiated in 2001 with the development of a refuge fire management plan. Prescribed fires will be ignited in upland areas following late spring and summer dry lightning storm patterns at seven-to-twelve year intervals in an effort to augment natural processes. Although large mammals and carnivores such as bear and wolves were once recorded in upland areas, conflicts with humans in urban areas close to the refuge renders their reintroduction unlikely. Such reintroduction issues will await formal CCP development.

Water shortages associated with regional drought required some urgency in setting irrigation use priorities designated by state water law on over half the total 6394 hectares (15,800 acres) encompassing floodplain habitats of the refuge. Analysis used in preparation of the refuge Water Management Plan required close examination of refuge establishment purposes and the Integrity Policy. The restoration of the Rocky Mountain Population of greater sandhill cranes has clearly held primary management emphasis under refuge establishment purposes. Refuge habitat management programs and the establishment of three

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56. Lisa M. Ellis et al., *Rodent Communities in Native and Exotic Riparian Vegetation in the Middle Rio Grande Valley of Central New Mexico*, 42 S.W. NATURALIST 13, 15 (1997).

state refuges in the Middle Rio Grande Valley have restored this population (now numbering 20,000 individuals). As accumulated wetland habitat loss has occurred throughout the Rio Grande corridor and the greater Mexican Highlands wintering area for cranes,[57] the Refuge has expanded wetland management areas to provide essential food resources for this population. Throughout this vast wintering area, Bosque del Apache NWR represents the most reliable location for essential food resources.

Decisions regarding prioritization of state appropriated water resources were based on refuge establishment purposes and the historic primacy of maintaining the RMP of greater sandhill cranes, which at times winters in its entirety in the Middle Rio Grande Valley. In accordance with the RMP sandhill crane flyway management plan, combined state and federal refuges in the Middle Rio Grande Valley must support 17,000-22,000 birds.[58] During cold mid-winter months, cranes require highly digestible energy foods rich in carbohydrates at this higher latitude and elevation. The production of grain corn fills this need through winter months. Through agreements with the New Mexico Department of Game and Fish, the Refuge must support up to 60 percent (13,200) of wintering sandhill cranes by maintaining a minimum of 105 hectares (260 acres) of high quality grain corn.[59] This acreage figure is derived from minimum yields of 5018 kilograms per hectare (4480 pounds per acre) totaling about 544,320 kilograms (1.2 million total pounds). If cranes consume about 0.84 kilograms per hectare (0.75 pounds per acre) per day, then over the course of 120 days total grain corn requirements are 544,320 kilograms (1.2 million pounds) per winter season.[60] Legume crops are also used to maintain soil fertility for high corn production. Combined, about 472 hectares (1170 acres) are used for agricultural production utilizing about 28 percent of available water annually. The decision to maintain 472 hectares (1170 acres) in agricultural lands is intended to enhance biological integrity on the landscape scale by providing for the winter foods needs of the RMP of cranes. It was decided that this was the best use of these lands and that

57. A. Lafon & J.P. Taylor, An Aerial Shorebird Survey of the Interior Highlands in Chihuahua, Durango, and Jalisco, Mexico 7 (Sept. 1994) (unpublished report, U.S. Dept. of the Interior, on file with author).

58. U.S. DEPT. OF THE INTERIOR, MANAGEMENT PLAN OF THE PACIFIC AND CENTRAL FLYWAYS FOR THE ROCKY MOUNTAIN POPULATION OF GREATER SANDHILL CRANES 4 (1997).

59. JOHN P. TAYLOR, U.S. FISH & WILDLIFE SERV., A PLAN FOR THE MANAGEMENT OF WATERFOWL, SANDHILL CRANES, AND OTHER MIGRATORY BIRDS IN THE MIDDLE RIO GRANDE VALLEY OF NEW MEXICO 32 (1999).

60. S.C. Kendeigh et al., *Avian Energetics*, *in* GRANIVOROUS BIRDS IN ECOSYSTEMS 127, 144 (J. Pinowski & S.C. Kendeigh eds., 1977).

returning them to historic conditions would be a less valuable contribution to biological integrity within the larger landscape.

In arid regions of the southwestern United States, many vertebrate wildlife species, particularly birds, are obligated to riparian habitats. The removal of large stands of exotic vegetation through mechanical means simulates the impact of severe flooding which scoured vegetation from the floodplain and created suitable sites for the germination of woody riparian vegetation.[61] Controlled flooding during May and June coinciding with seed dispersal by native riparian plants mimics river flooding events allowing for the regeneration of native forests. The program has successfully restored and enhanced nearly 405 hectares (1000 acres) of native riparian forest since its inception. Where native dominated riparian habitats have been restored, subsequent flooding every six to ten years is necessary to encourage decomposition of ground litter, maintain moderate levels of soil salinity, and generally maintain the natural processes associated with the floodplain environment.

An appreciation of the role of riparian restoration in maintaining biological integrity is a primary focus for converting exotic flora to mosaics of native forests, brushlands, and meadows that historically characterized the floodplain using a portion of the Refuge's water right.[62] On the remaining active river floodplain, the refuge employs similar riparian restoration tools and works aggressively with other government entities and private landowners to manage river flows in accordance with historic hydrographs.[63]

Challenges and Constraints

Water shortages associated with periodic drought and dwindling resources will be the greatest challenges and constraints to achieving goals and objectives developed as part of the Refuge Comprehensive Conservation Plan and Habitat Management Plan. Fortunately, the Refuge water right is well documented and relatively secure when weighed against other legal water uses in New Mexico. It is critical that this water right be used in accordance with state license provisions to assure legal protection in perpetuity. Planning must also

61. John P. Taylor et al., *Soil Disturbance, Flood Management, and Riparian Woody Plant Establishment in the Rio Grande Floodplain*, 19 WETLANDS 372, 380 (1999).

62. John P. Taylor & K.C. McDaniel, *Restoration of Saltcedar (Tamarix sp.)-Infested Floodplains on the Bosque del Apache National Wildlife Refuge*, 12 WEED TECH. 345, 351 (1998).

63. SAVE OUR BOSQUE TASK FORCE, CONCEPTUAL RESTORATION PLAN: ACTIVE FLOODPLAIN OF THE RIO GRANDE—SAN ACACIA TO SAN MARCIAL (Tetra Tech, Inc., Albuquerque, N.M., CD-ROM, Feb. 2004).

take into account the realities of existence in an arid environment where water shortages are the norm rather than the exception. Biotic communities evolved under these constraints and should be adapted to periods of prolonged drought. Refuge management programs developed as part of the planning process must therefore provide windows of latitude that reflect this climatic variation.

The key management decisions that will guide future management at the refuge were (1) the decision to reintroduce fire as a management tool to restore native vegetation mosaics; (2) the determination that management for the winter RMP of greater sandhill cranes is a major purpose of the refuge, and that this requires the maintenance of 473 hectares (1170 acres) in crops to provide adequate food resources; and (3) the desire to restore native riparian stands along the Rio Grande.

SUMMARY

The Improvement Act provides a clear mandate to the National Wildlife Refuge System to manage for the biological integrity, diversity, and environmental health of the System. The Integrity Policy provides further guidance and directs refuges to manage for historic conditions, with certain exceptions. This article considers the basic decision of determining how much of a refuge will be managed for historic versus non-historic conditions and outlines a process by which to make this decision based on available science and critical thinking. The process we recommend begins with the identification and understanding of the Refuge Purpose. Next, refuges must conduct a thorough assessment of the current and historic status of biological integrity, diversity, and environmental health, based on available data and scientific information. Through a comparison of historic to current conditions, refuges must then assess the opportunities and limitations to maintaining and restoring biological integrity, diversity, and environmental health.

Refuges must determine the role of the refuge in the ecosystem and future management direction and consider how the refuge can best meet its purpose and contribute to the biological integrity, diversity, and environmental health of the System. It is important to determine the priority resources for the Refuge and surrounding ecosystem and to question whether current Refuge management practices should be continued or modified.

The case studies for Sherburne NWR and Bosque del Apache NWR serve to illustrate different interpretations possible under the Integrity Policy related to management for historic or non-historic conditions. We believe that the key decision for Sherburne NWR was that oak savanna has inherent value as a plant community type, beyond its value for wildlife. Given the tremendous loss of oak savanna since European settlement, restoration of several thousand acres of this type is very significant. In addition, the land capability at Sherburne NWR is best suited to oak savannas as the natural habitat. However, there are several challenges and constraints that will present difficulties as the Refuge moves toward restoration of oak savanna. We recommend that other refuges openly acknowledge and consider likely challenges and constraints in future restoration efforts.

For the Bosque del Apache NWR, the key decision was that a major contribution the refuge can make is to ensure adequate winter habitat for the sandhill crane population, regardless of whether such habitat consisted of historic or non-historic conditions. This decision considered agreements with the state of New Mexico and the refuge's ability to contribute to biological integrity within the larger landscape for the sandhill cranes.

Both of the refuges for the case studies demonstrate the need to bring scientific information and data to bear in decision making. In addition, these case studies illustrate the need to consider the role of the refuge in the surrounding landscape and to determine the best contribution the refuge can make.

The approach presented in this article and in the case studies is not formulaic, but rather encourages those involved in refuge management to conduct a thorough assessment of available scientific information and to consider a variety of questions related to opportunities, limitations, and priorities. We further recommend that the entire decision-making process be well documented, including logic, assumptions, and reasoning, as well as sources of information. We believe that refuge management decisions based on this approach will add an improved degree of rigor to the process and allow others to understand how decisions were made.

The Improvement Act's requirement that all refuges prepare CCPs provides a significant opportunity for the Refuge System to thoroughly consider the mandates from the law and the Integrity Policy. During the CCP process, refuges must develop a 15-year plan describing future management. It was during this planning process that Sherburne NWR made the key decisions that will affect future management. We strongly urge all refuges to take advantage of the additional time and resources provided during the CCP process to consider the issues presented in this article.

There is both a scientific and institutional challenge to managing refuges in a manner consistent with refuge purposes and meeting new mandates from the Improvement Act to maintain the biological integrity, diversity, and environmental health of the entire refuge system. The scientific challenge stems from the extremely complex nature of ecosystems and imperfect knowledge about many of their components and functions. Institutional challenges include the difficulties of changing management direction, assuring adequate use of available science, and resolving conflicting perspectives.

Following the determination of how much land will be in historic or non-historic conditions, the task remains of describing the desired conditions within these areas, *e.g.*, what vegetation structure, floristic composition, and spatial arrangement is desired? A further necessary step is determination of actual management actions needed to create the desired conditions. These, too, are difficult tasks and are not to be underestimated in terms of their complexity. Nonetheless, the questions considered in this article must come first, before these additional levels of detail can be addressed. We wish to emphasize that critical thinking and the use of available science should serve as the cornerstones of all refuge management decisions. It is our hope that the process we have outlined and the questions posed throughout this article will help in promoting sound land management decisions throughout the Refuge System.