Prairie Pothole
JOINT VENTURE

2005 Implementation Plan
Section II – Waterfowl Plan

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> ***"The top priority for protection is the prairie pothole breeding habitat for mallards and pintails in both Canada and the United States. Deterioration of habitat in this prairie area has been the principal cause of decline in abundance of these species."***
>
> - The North American Waterfowl Management Plan, 1986.
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> ***"In the future, Plan success or failure will continue to be linked to long-term trends in waterfowl habitat conditions in the Prairie Pothole Region."***
>
> - North American Waterfowl Management Plan, 2004 Strategic Guidance.

Background and Context

Since the inception of the North American Waterfowl Management Plan (NAWMP) nearly 20 years ago, the Prairie Pothole Region (PPR) has been spotlighted as the habitat most critical to North American waterfowl. That priority continues to this day. The millions of wetlands that dot the U.S. Prairie Pothole Region (PPR) make it one of the most unique and productive waterfowl habitats in the world. In 2002, eight species that composed 80% of the U.S. duck harvest were prairie-obligate or prairie-associated species. Of special interest is the role the PPJV plays in the population dynamics of North America's most important duck, the Mallard. Hoekman et al. (2002) investigated the relationship of variation in different vital rates to changes in the mid-continent Mallard population and concluded that nearly 90% of the variation in population change was attributed to events that occur on the breeding grounds, most notably nesting success, brood survival, and hen survival. Most waterfowl biologists believe that other upland-nesting prairie ducks are most affected by variation in the same demographic parameters.

Since 1994, ducks have been particularly productive in the PPJV. As one indicator, the survey strata that make up the eastern Dakotas portion of the U.S. Fish and Wildlife and Canadian Wildlife Services traditional May breeding waterfowl survey area (Smith 1995) comprise only 7% of the land area sampled, yet during 1994-2002 about 21% of the ducks in the surveyed area resided there (R. Reynolds. U.S. Fish and Wildlife Service, personal communication). In recent years, the PPJV has attracted three times the breeding density of ducks as the PPR of Canada. A "production index" (defined as broods observed in the July survey per breeding duck observed in the May survey) further supports the differences in apparent productivity between the U.S. and Canadian prairies. Certainly, much of this productivity was related to the unusually wet conditions in the PPJV during 1993-2002. However, relatively large areas of intact prairie, the addition of 7.8 million acres of idle grassland restored by the Conservation Reserve Program (CRP), wetland basins that have been protected through easements and the "Swampbuster" provision of the Farm Bill, and almost two decades of conservation work by PPJV partners were also important to the duck population rebound.

The PPR is not only about duck production. During spring migration, ducks, geese, and swans funnel through the region on the way to their Parkland, Boreal Forest, and Arctic breeding grounds. The provision of food—including aquatic invertebrates, seeds and tubers of aquatic plants, and agricultural grains—is critically important to these spring migrants. As wetland habitats have been destroyed or degraded, the quantity and quality of some foods may have been reduced to a level that affects the deposition of nutrient reserves needed for migration and breeding. For example, Anteau and Afton (2004) have hypothesized that condition in spring foraging habitats in the PPJV may be contributing to the population decline of lesser scaup.

Arctic nesting geese are not the focus of PPJV conservation programs; however, PPR habitat conditions may play a role in goose population dynamics. The population “explosion” of Lesser Snow Geese is generally attributed to the abundance of waste grain that has become available to this species during spring migration in the central and northern Great Plains, resulting in birds being able to store high levels of fat and protein reserves. In turn, Snow Geese now breed at a younger age and lay larger clutches than they did historically, thus fueling the rapid population growth and associated destruction of their arctic breeding habitat (Batt 1998).

Although spring and fall migrants glean important resources from the PPR, they are generally not limiting to migrating ducks, geese, and swans. Among waterfowl, the PPR is the most important region to prairie-nesting ducks, and the demographic bottleneck for these species occurs during the breeding season. For that reason, this document focuses exclusively on the many complex issues that affect breeding ducks in the U.S. Prairie Pothole Region.

Factors that Limit Duck Populations

Primary factors limiting growth in duck abundance in the PPJV area are (1) wetland habitat, which limits the carrying capacity for breeding ducks; (2) nest success and brood/duckling survival, which limit recruitment and population growth; and (3) hen survival during the breeding season.

Wetland Habitat –Availability of wetlands is the primary factor determining the number of breeding ducks that settle in the PPJV area (Kantrud et al. 1989). Wetlands available at any given time are a function of precipitation and the number of basins that will pond water. Wetlands that have been drained or filled for agriculture or other purposes will no longer pond water and are incapable of attracting breeding ducks. Wetland losses in the PPR vary geographically from about 35% in South Dakota to greater than 90% in Iowa (Dahl 1990). Wetlands degraded by disturbance to the basin or surrounding land-use may also affect duck use. Anecdotal evidence suggests that breeding pair use of wetlands in the eastern portions of the PPR has declined over time.

Nest Success – Nest success for upland nesting ducks underwent a system-wide decline across the PPR of North America between the mid-1930s and the mid-1980s (Drever et al. 2002). Nest success has been identified as the most important component influencing the reproductive output for Mallards in the PPR (Johnson et al. 1992) and North Dakota (Cowardin et al. 1985). Recent sensitivity analyses by Hoekman et al. (2002) showed that nest success was the single most important life cycle factor influencing population change in mid-continent Mallards.

Hen Survival – Hoekman et al. (2002) reported that survival of Mallard hens during the breeding season was second to nest success in determining the annual change in population size of mid-continent Mallards. Hens are at increased risk to predation during egg laying and incubation (Cowardin et al. 1985, Sargeant et al. 1984), and increased nesting effort has been associated with decreased survival of Mallard hens in the PPR. Management treatments that increase nest success can be expected to increase Mallard hen survival during the spring/summer period.

Brood/Duckling Survival – Hoekman et al. (2002) concluded that duckling survival was an important component influencing temporal variation in the size of Mallard populations from the PPR. Krapu et al. (2000) found that variation in the survival rate of Mallard broods was influenced by rain events and availability of seasonal wetlands. Therefore, conservation of small, shallow wetlands is considered critical for capitalizing on increased capacity for ducks to produce young in wet years.

Biological Models

In the early years of the North American Waterfowl Management Plan (NAWMP), the PPJV adopted a biological model-based approach to decision support for waterfowl programs in the joint venture. Selected models are based on research that demonstrates a strong linkage between habitat characteristics and changes in demographics.

The "Four Square Mile Survey" (FSM survey), designed by the Northern Prairie Wildlife Research Center (NPWRC) in Jamestown, North Dakota, is the primary PPJV tool for monitoring waterfowl populations and for developing models that are used to predict the results of landscape level changes in the relationship of breeding waterfowl to habitat quantity and quality. This survey began in 1987 and was originally developed to assess the impact of the U.S. Fish and Wildlife Service (FWS) Small Wetlands Acquisition Program in the U.S. Prairie Pothole Region. The survey is designed to monitor temporal and geographic variation in wetland and upland habitats and to measure relationships between breeding waterfowl and habitat characteristics. The survey is coordinated by the FWS Region 3 and Region 6 Habitat and Population Evaluation Team (HAPET) offices and is conducted by FWS Refuge Division personnel in the PPR of Montana, North Dakota, South Dakota, and Minnesota, and by Iowa DNR personnel in Iowa. Details of this survey can be found in Cowardin et al. (1995).

Duck productivity models developed by the NPWRC are the key tools used to monitor duck population performance, establish population objectives, and develop treatment prescriptions for the PPJV (Cowardin and Johnson 1979, Cowardin et al. 1988, Cowardin et al. 1995) . These models follow two forms: (1) deterministic models for five upland nesting duck species (Mallard, Gadwall, Blue-winged Teal, Northern Shoveler, and Northern Pintail); and (2) a stochastic model for Mallards. Deterministic models are used primarily to estimate annual duck recruitment in the PPJV area (Cowardin et al. 1995) and the stochastic Mallard model is used in planning exercises to simulate the effect of applying various treatments to the landscape (e.g, restoring cover, creating nesting islands). Both model types have been used extensively throughout the history of the PPJV to support research, planning, and assessment. These tools were selected because they provide a critical and measurable link between biological performance and landscape/habitat characteristics that can be at least partially controlled by managers and agencies responsible for the success of the plan (Reynolds et al. 1996). Productivity models have always been considered integral to address the dynamic temporal and geographic nature of the land area and are used in an adaptive process for plan implementation in the JV. Traditional surveys of spring abundance and productivity such as those conducted by the

FWS Division of Migratory Bird Management are valuable for tracking PPR-wide population trends, but are too coarse-grained to be useful for assessing how management actions affect biological responses by the birds.

During 1991-96, partners in the PPJV conducted model-based planning exercises for each FWS Wetland Management District in Minnesota, North Dakota, South Dakota, northeast Montana, and north-central Iowa. The planning process, "Multi-Agency Approach to Planning and Evaluation" (MAAPE), involved participation from over 300 individuals representing more than 30 conservation and land-use agencies. Key components of these plans included (1) identifying treatments; (2) developing guidelines for each treatment; (3) setting breeding population and recruitment rate goals; and (4) developing prescriptions for habitat and other management treatments. Biological models were used to estimate the (then) current capability of the landscape to attract ducks during the breeding season and recruit young into the fall flight. Simulation modeling was conducted to predict the response of populations to treatment applications. The results were summarized in "Duck Management Plans for Waterfowl Management Districts, 1996" (copies available from the North Dakota Game and Fish Department and Region 3 HAPET office).

The MAAPE was based on a sample of the PPJV landscapes (Cowardin et al. 1995), and although this approach was suitable for estimating the amount of a particular treatment or treatment mix that would be needed to achieve a specific population response, it did not allow for identification of geographic areas where different treatments should be applied. This is especially important considering that treatment guidelines were mostly developed to target areas which met certain landscape characteristics. Since the original MAAPE planning process was completed, additional biological and landscape information has become available. Much of this new information has been used to develop and apply spatially explicit models across large land areas.

Population and Habitat Trends

Duck Abundance – Two surveys are used to monitor changes in duck abundance in the PPJV. The May Breeding Waterfowl and Habitat survey (Smith 1995), conducted annually in part of the PPJV area by the FWS, Canadian Wildlife Service, and cooperating state agencies, is arguably the finest example of a long-term wildlife survey in the world. Since this survey began in 1955, duck abundances in major breeding areas of the U.S. and Canada have experienced three "peaks" and two "valleys", with indices ranging from about 25 million to 43 million birds. Given the extensive landscape changes that have occurred in the PPR, the magnitude and periodicity of the peaks and valleys are remarkably similar (Fig. 1).

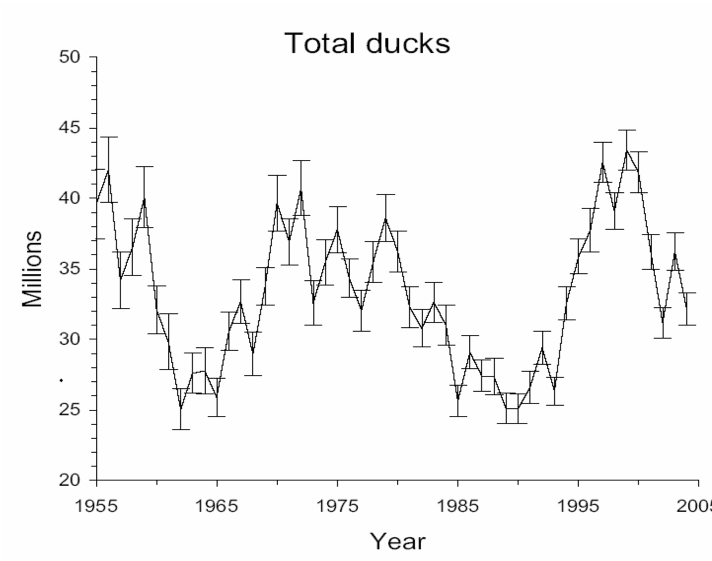

Figure 1. Breeding duck indices for the traditional survey area, 1955-2004 (see Wilkins and Otto, 2005).

The 1995 revised PPJV Implementation Plan set a numerical objective of 6.8 million breeding ducks "under average environmental conditions", as measured by the May habitat and population survey. That objective was equaled or exceeded during nine consecutive years, 1994-2002. Within the PPJV (survey strata 41 and 45-49), several elements came together to produce an explosive growth in duck abundance, from 1.8 million ducks in 1990 to 10.5 million in 2000, a 492% increase (Fig. 2). However, during this 10-year period, precipitation was well above the long-term average, so population goals were not achieved under what were envisioned (but not explicitly defined) as average environmental conditions. Other factors related to this high population level were the nearly 8 million acres of grassland that were restored through the CRP and, to a lesser degree, hundreds of habitat restoration projects completed by the PPJV. Another important factor was the extant grasslands coupled with intact wetland basins "set the table" for the duck recovery of the 1990s.

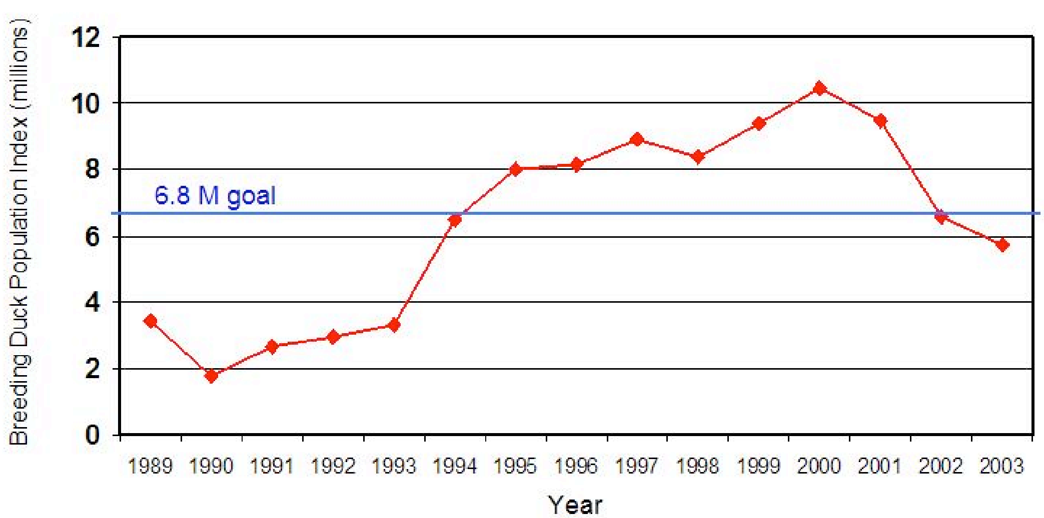

Figure 2. Breeding population index for the ten principal species of ducks in the PPJV survey strata (excluding Minnesota and Iowa).

A second source of duck abundance information, the FSM survey (page 5), also is used for evaluating the number of the breeding ducks and species composition in the PPJV area (Table 1). This survey also detected a rapid growth in duck abundance during the 1990s.

Table 1. Average number and distribution of breeding duck pairs in the U.S. PPR during 1987-98, based on USFWS models and the FSM survey sampling framework.

Species	FWS Region 3	FWS Region 6	Totals
Mallard	474,000	943,000	1,417,000
Gadwall	16,000	686,000	702,000
Blue-winged Teal	243,000	1,484,000	1,727,000
Northern Shoveler	12,000	381,000	393,000
Northern Pintail	10,000	478,000	488,000
Wood Duck	222,000	n/a	222,000
Totals	977,000	3,972,000	4,949,000

Note: It is assumed that wetland protection strategies targeted to meet the population objectives of these species will be sufficient to conserve populations of other duck species that occur in the PPJV area.

Thus, based on the FSM survey, the PPJV supported an average of nearly 5 million breeding duck *pairs*, or 10 million breeding ducks, during 1987-98. The discrepancy between breeding duck estimates derived from the May survey versus the FSM survey reflects a different sampling frame and methodologies, but both surveys affirm the population boom witnessed during 1994-2002.

Duck Recruitment Rates

The updated (January 1995) PPJV Implementation Plan had one waterfowl objective, which contained both a population and recruitment rates components:

Objective 1: By the year 2001, conserve habitat capable of supporting 6.8 million breeding ducks that achieve a recruitment rate of 0.6 under average environmental conditions, with all managed areas achieving a minimum recruitment rate of 0.49.

Overall PPJV Recruitment Rates – In the PPJV area, Mallards are used as a representative species for indexing recruitment rates for all upland nesting ducks. The Mallard productivity model indicated that a recruitment rate of about 0.50 units was needed to result in a stable abundance (finite growth rate = 1.0). Results from model applications for the MAAPE process estimated the average recruitment rate of Mallards was about 0.53 units with average wetland conditions and land-use that existed at that time. More recent analysis associated with an evaluation of duck nesting in CRP during the period 1992-97 (Reynolds et al. 2001) indicates the average recruitment rate during that period was about 0.66 in the combined area of the

Dakotas and northeast Montana. The difference between the two model applications is primarily due to increased nesting success and brood survival during the later period. The period 1992-1997 was associated with peak acres of CRP resulting from the 1985 Farm Bill. Fortunately, most of these CRP acres still exist today. We therefore use the results from the analysis of Reynolds et al. (2001) as a new benchmark for PPJV Mallard recruitment rates under the current landscape conditions.

Recruitment Rates in Managed Habitats – The MAAPE planning process was used to address the sub-objective of all managed areas achieving a minimum recruitment rate for Mallards of 0.49. During the MAAPE process, recruitment rate objectives were set for each of the 14 Waterfowl Management Districts in the Dakotas and Montana. Table 2 summarizes the recruitment rates for Mallard estimated at the time of MAAPE planning (without CRP), the objectives that were established, and a current estimate of recruitment rates with the inclusion of CRP in the landscape.

Table 2. Mallard recruitment rates in Waterfowl Management Districts of North and South Dakota at "baseline", projected MAAPE planning, and estimated currently.

Waterfowl Management District	Baseline Recruitment Rate (without CRP)	Recruitment Rate Objective After MAAPE Planning[1]	Current, Estimated[2] Recruitment Rate
Medicine Lake, MT	0.80	0.79	0.67
Sand Lake, SD	0.62	0.65	0.65
Audubon, ND	0.40	0.61	0.71
Arrowwood, ND	0.40	0.71	0.71
Kulm, ND	0.44	0.63	0.66
Madison, SD	0.46	0.68	0.50
Waubay, SD	0.43	0.63	0.64
Long Lake, ND	0.42	0.58	0.66
Land Andes-Huron, SD	0.44	0.63	0.53
Tewaukon, ND	0.32	0.63	0.64
Crosby-Lostwood, ND	0.35	0.67	0.60
Valley City, ND	0.29	0.62	0.58
J. Clark Salyer, ND	0.26	0.54	0.58
Devil's Lake, ND	0.26	0.58	0.59

[1]To achieve these recruitment rate objectives, each Waterfowl Management District set objectives for a mix of habitat treatments. Objectives for each treatment type, summed across all Waterfowl Management Districts, are presented in Waterfowl Plan Appendix A.

[2]These estimates are based on FSM survey results for the period 1989-2002 (Wangler and Reynolds 2003) adjusted upward by a factor of 1.245 to reflect differences in model results from the MAAPE plans and those of Reynolds et al. (2001). The differences were largely attributable to CRP acres, which were not considered in the original MAAPE plans.

Biological Foundation

During 1994-2004, the U.S. PPR experienced a boom in duck abundance unlike any that had been previously documented. This event provided a new perspective on the potential of the area to support and recruit ducks. During a run of several years, the U.S. PPR far exceeded goals established by the PPJV. Obviously, the sequence of wet years that began in 1994 was a major force behind this boom. However, there is reason to believe that the potential of the PPR landscape to recruit ducks actually increased before and during this period (Fig. 3).

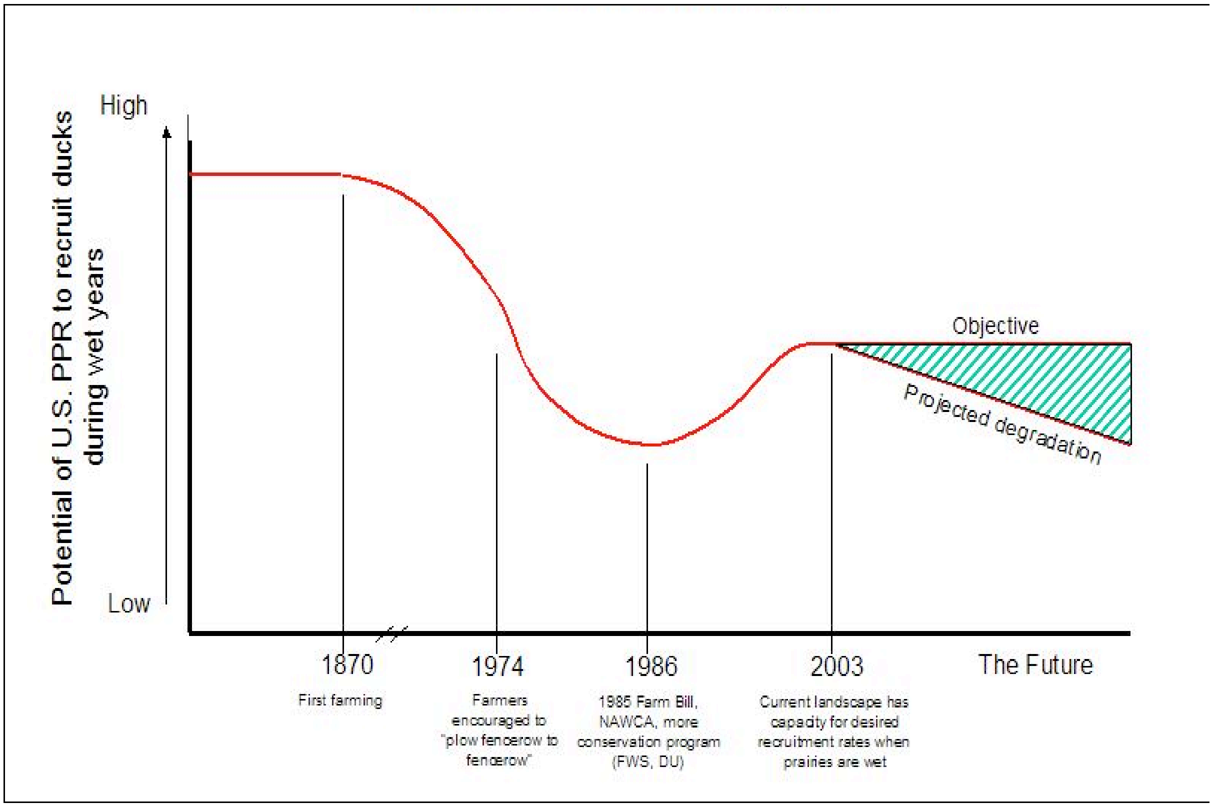

Figure 3. Conceptual diagram of the past and future duck production capacity of the U.S. PPR. Projections of future loss (cross-hatching) are used to assist in setting restoration objectives.

This boom of 1994-2004 (hereinafter the "boom years") had a profound effect on the design and content of this revised implementation plan. In 1995, when the PPJV implementation plan was last updated, no one imagined that duck populations would increase like they did in the decade following. Nor did many even suspect that the landscape of the U.S. PPR had the capability to fuel such an increase. This demonstrated capability suggests the need to revisit some fundamental conservation philosophies about the region.

First and foremost, the dramatic change in abundance of ducks underscores the dynamic nature of the PPR and suggests that setting objectives based on "average environmental conditions" may be inconsistent with the prairie environment and the way duck populations respond to the dynamic conditions that occur there. Indeed, over 50 years ago Lynch (1984) and others recognized the boom and bust nature of prairie duck populations. We believe that a more appropriate paradigm for the PPJV is one that acknowledges that precipitation will fluctuate, at times dramatically (both spatially and temporally), and those changes are beyond our control. However, we can manage wetland basins and grasslands that are vital to fueling population growth during wet periods and sustaining a reservoir of birds during drought. Thus, we propose a revised implementation plan that has as its foundation the goal of "keeping the table set" for population increases. We propose to do this through a focus on maintaining the integrity and health of the wetland basins and grasslands, complemented by restoration and enhancement projects that improve duck recruitment potential and offset potential losses due to future degradations of the landscape.

Thus, we propose a revised implementation plan that has as its foundation the goal of "keeping the table set" for population increases.

While this foundation underscores the importance of habitat protection, it also recognizes the need and opportunity for restoration and enhancement (R&E) of habitat. In all likelihood, habitat loss will continue in many parts of the PPJV, and pro-active habitat R&E can be applied to counteract these losses. Moreover, some jurisdictions of the PPJV have substantial R&E potential but far less opportunity for habitat protection. Our ability to capitalize on these opportunities whenever possible is important to success of this plan.

The other fortunate circumstance related to the boom years is that the event occurred at a time when: (1) scientists were acquiring new insights into duck breeding biology, particularly with regard to relationships between landscape characteristics and duck recruitment rates; (2) new digital, spatial databases were being developed; and (3) the hardware and software (Geographic Information Systems, or GIS) needed to manipulate these spatial databases were becoming available. For example, upland landcover and wetland databases, along with models that predict breeding pair densities, were developed and in widespread use during 1994-2004. Consequently, the PPJV has a record and understanding of the landscape configuration that existed to support the duck boom—a "habitat baseline". We therefore have an unprecedented opportunity to use the change in the PPR's potential to produce ducks (i.e., change in grasslands and wetlands) as one way to gauge our progress towards long-term conservation objectives.

There are several advantages to using this new approach to measure our progress. Most importantly, it affords the opportunity to avoid relying on breeding population estimates as a primary performance metric. Populations vary annually due to forces beyond our control (i.e., water conditions, regional duck distributions, and continental duck population size) in addition to factors that we attempt to influence programmatically (wetland basins, nesting habitat, public policies, and various R&E projects). Also, by monitoring the change in the capacity to attract breeding pairs and produce recruits due to changes in the amount, location, and configuration of wetlands and grasslands, we can begin to quantify the *net* impact of change in habitat (conservation gains minus losses from other causes), as opposed to tallying acreage gains without explicit acknowledgement of the losses that have occurred. Lastly, focusing on the potential of the habitat to attract pairs and produce ducks enables indirect but critical PPJV activities, such as public policy work, to be incorporated under the same performance umbrella as our direct programs.

Implementing an effective conservation program based on this biological foundation requires several elements. First, we must be able to relate important habitat features—wetlands and nesting habitat—to an appropriate measure of population performance, and develop spatial models that quantify how those performance measures vary over time and space. This requires that we are able to periodically and efficiently re-assess the state of the landscape and relate any changes in the PPR's duck population and recruitment potential to landscape changes. We may also choose to monitor some performance measures directly (e.g., nesting success) so that we can independently assess the validity of our models, which in turn will influence the efficacy of our management decisions.

Base Assumptions and Key Uncertainties

Our most fundamental assumption is that nesting ducks respond to habitat characteristics at the local (field or cover type) as well as landscape (percent grassland cover) level (Stephens et al. 2003, Horn et al. 2005). Typically, neither metric, either alone or in combination, accounts for a large portion of the variation in observed nesting success. Interestingly, research conducted in the Drift Prairie region consistently identifies "local" metrics (i.e., height and density of cover) as important covariates related to nesting success, whereas models based on research in the Missouri Coteau region generally do not suggest that these local factors are important, instead pointing to landscape composition (wetland density, percentage grassland) and fragmentation (amount of edge) as significant covariates. This warrants further investigation. It may be that both findings are correct, and the discrepancy reflects different relationships between birds and available habitats in the two regions.

Temporal (year-to-year) variation in duck nesting success is as large as or larger than spatial variation. The few long-term studies to date indicate that on a landscape that outwardly appears unchanged, nesting success may vary by as much as 30 percent from year to year. The causes of this annual variation are largely unexplained but potentially important to management programs. If the forces that drive temporal variation are subject to management intervention, it may be possible to greatly enhance our management effectiveness. Even if the causes are not subject to management intervention, if they are understandable and predictable, they may lead to improved targeting of our programs to match appropriate treatments to specific landscapes.

Another key uncertainty is the form of the relationship between percent grassland in the landscape and duck nesting success. Currently, this is modeled as a linear function (Greenwood et al. 1995), although recent research suggests it may take a non-linear form (Horn et al. 2005), or that there may be a threshold above which the probability of nesting successfully increases markedly (Stephens et al. 2005). There is even evidence that *below* a certain amount of grassland, nesting success *increases* as the predator community becomes suppressed due to poor habitat conditions (G. Zenner, Iowa Department of Natural Resources, personal communications). If confirmed, these alternative functional relationships may have implications for delivery of PPJV programs. We presume a great deal based on data from studies directed toward dabbling ducks, particularly the Mallard. With certain exceptions, it is reasonable that upland-nesting dabbling ducks respond similarly to environmental and ecological relationships that affect their vital rates. However, even though we have a good understanding of diving duck biology, management targeted specifically towards this group of species is rare. Because diving ducks are so heavily dependent on wetlands, which themselves are sensitive to degradation, it's important that we not assume that management actions directed toward puddle ducks will also meet the conservation needs of diving ducks.

Not all important assumptions and uncertainties are biological. PPJV programs are delivered in a dynamic socio-political environment. As others envision alternative uses for the land, conflicts can arise that impact our ability to deliver conservation programs. For example, how much land does society feel should be dedicated for conservation purposes, and is that amount consistent with our conservation objectives? These are also uncertainties that should be addressed pro-actively.

Research Needs Related to Biological Foundation

A closer examination of key reproductive components needs to be conducted in order to have confidence in predictions from productivity models. These key components include: (1) nest site selection in various landscapes; (2) nest success in major nesting covers; (3) re-nesting propensity; and (4) brood survival. Studies conducted to address these reproductive components should be done within a spatially explicit landscape context. Following are brief descriptions of key information needs for assessing waterfowl recruitment. Additional information about waterfowl research priorities can be found in Waterfowl Plan Appendix B (page 31 of this document) and in Cox et al. (2000).

Determine Mechanisms that Influence Variation in Key Components of Reproductive Rates. – Large variation exists in estimates of most reproductive parameters. Understanding mechanisms that influence variation should improve the predictability of outcomes from management actions. Studies that focus on survival rates of nests, broods, and adult hens should yield the greatest benefit.

Alternative Indices to Recruitment Rates. – Indices such as duckling counts can be informative about reproductive success especially when spatially referenced. Current brood counts conducted from aircraft by the FWS are compromised by unknown, but likely low detection rates, and lack of spatially referenced habitat characteristics. In addition, detection rates vary spatially and temporally, and there is no way to correct either. Thus, the bias is inconsistent, and it is therefore not possible to derive a good index from the data. Brood surveys should be developed that have higher rates of detection, feature better-understood and correctable biases, are spatially referenced, sample all of the major subregions of the PPR, and are associated with breeding population indices.

Brood/Duckling Survival. – After nest success, survival of ducklings is the next most important component of the reproductive cycle determining recruitment rate. Recent studies by Krapu et al. (2000) provide evidence of landscape-level wetland factors that affect brood survival. Further investigations into the influence of landscape characteristics on brood/duckling survival should be conducted in an attempt to improve predictive models about this critical component of recruitment.

Four Square Mile Survey. – Within the PPJV, the FSM survey is critically important for understanding the relationships habitat and waterfowl population size/distribution characteristics.

Virtually all partners in the PPJV use the results of this survey in planning and targeting their conservation programs. An example is the extensive use of the breeding-pair distribution maps (i.e., "thunderstorm maps") developed for several species, which are used daily in decisions about program delivery. Results from the FSM survey have been used to evaluate USDA Farm Bill conservation programs such as the CRP, Wetlands Reserve Program (WRP), and disincentives like the "Swampbuster" provision. The U.S. Congress has used data from the FSM survey in developing proposed modifications to the Clean Water Act. The need to continue the FSM survey throughout the PPJV area cannot be over emphasized

Other Directed Research. – Several information gaps existed in our knowledge of waterfowl biology and the relationship of landscapes to vital rates. In addition, some conservation actions used to restore habitat or enhance duck recruitment have not been fully evaluated. Several of these research needs are described in Waterfowl Plan Appendix B at the conclusion of this section. The list of research needs will continue to evolve as new programs are implemented and old programs are examined for efficacy.

Focal Species

The Mallard has been the traditional focal species by which management programs are designed. The reasons for selecting this species are twofold. First, much research has been conducted on Mallards, and vital rates, habitat selection, and response to management techniques are generally well known. Second, the Mallard is considered representative of an upland-nesting duck insofar as this species selects nest sites in a variety of wetland and upland habitats, depends on both aquatic invertebrates and plant foods during the breeding season, responds to the presence of water (wetlands) and uplands in a manner similar to many other duck species, and is subject to predation rates and pressures typical of those experienced by other upland-nesting ducks.

In addition to Mallards, sufficient information exists in some cases to model the distribution and abundance of four other common duck species (Northern Pintail, Gadwall, Northern Shoveler, and Blue-winged Teal). When possible—and as appropriate—these may also be considered focal species.

Despite the utility of using Mallards and perhaps the other four common dabbling duck species, there remains a need to identify one or more species that can represent the ecology and habitat conservation needs of the diving ducks (*Aythya* spp.). Several species in the group (Lesser Scaup, Canvasbacks, and Redheads) are of management concern, and clearly have habitat requirements and conservation concerns quite different from dabbling ducks. Identification of one or more suitable focal species for diving ducks will be a high priority of the PPJV Technical Committee.