

U.S. FISH AND WILDLIFE SERVICE, DEPARTMENT OF THE INTERIOR

DRAFT ENVIRONMENTAL ASSESSMENT

PROPOSED HUNTING REGULATIONS FOR THE EASTERN POPULATION OF SANDHILL CRANES IN THE MISSISSIPPI FLYWAY

I. PURPOSE AND NEED FOR ACTION

A. AUTHORITY and RESPONSIBILITY

In the United States the preeminent authority and responsibility for migratory game birds reside with the Secretary of the Interior and are derived from international treaties to which the Constitution specifies that only the Federal Government can be signatory. The key instrument defining Federal authority is the Migratory Bird Treaty Act of 1918 (as amended). Among those species designated as "migratory game birds" for which there is Federal management authority is the taxonomic family *Gruidae*, which includes the five or six generally recognized subspecies of sandhill cranes (*Grus canadensis*) found in North America. Authority for establishing hunting seasons for sandhill cranes is provided in the Migratory Bird Treaty Act and appropriate Federal regulations (50 CFR). Regulations governing the establishment of annual regulations for the hunting of migratory birds are specified in *Title 50 Code of Federal Regulations, Part 20, Subpart K*. Any authorization of hunting or taking of cranes or other migratory birds will be done in compliance with the Migratory Bird Treaty Act and associated regulations.

B. NEED FOR ACTION

Greater and lesser (and Canadian) sandhill cranes are presently hunted in other parts of their range and have been divided into management populations based on their geographic distribution during fall and winter. The Eastern Population (EP) of sandhill cranes is the subject of this proposed action.

The Atlantic and Mississippi Flyway Councils recently completed a Management Plan for the Eastern Population of Sandhill Cranes (hereafter called the Management Plan; Van Horn et al. 2010). The Management Plan allows for hunting of this population when the three-year average of the USFWS-coordinated fall population survey exceeds 30,000 cranes. This population level has now been reached and exceeded with latest 3-year average indicating 51,217 cranes (Fig. 1). This environmental assessment considers the action to institute a limited harvest of sandhill cranes from the EP by reviewing current management strategies and population objectives, and examining alternatives to current management programs.

C. SCOPE OF THE ENVIRONMENTAL ASSESSMENT

The geographic scope of this assessment is limited to the range of EP sandhill cranes (Fig. 1). This range includes all or portions of the States within the Atlantic and Mississippi Flyways, (Fig. 1). The temporal scope of this assessment is ongoing, with annual review of applicable

population and harvest information as part of the annual regulations process for the hunting of migratory birds (50 CFR part 20).

II. PROPOSED ACTION AND ALTERNATIVES

A. ALTERNATIVE 1 (PREFERRED ALTERNATIVE) - ALLOW A LIMITED TAKE OF SANDHILL CRANES DURING THE OPERATIONAL FALL AND WINTER HUNTING SEASON FRAMEWORK ESTABLISHED ANNUALLY FOR MIGRATORY BIRDS:

The Service proposes to permit the harvest of a limited number of EP sandhill cranes in the Mississippi Flyway. The season would be regulated by the issuance of State permits beginning with the 2011-12 hunting season. This action is implemented within the context of Section 3 of the Migratory Bird Treaty Act of 1918 (as amended), which authorizes the regulation of migratory bird hunting. The proposed action will provide a unique geographic recreational opportunity for sport hunting of this species on a limited basis.

The regulation of harvest of EP sandhill cranes will vary with population size and follow the harvest strategy outlined in the Management Plan (Van Horn et al. 2010). The season will be considered on an annual basis to permit adjustments pending a review of population status and harvest information. The harvest will be monitored by requiring all harvested sandhill cranes to be registered through a state-run registration system and the population status will be monitored annually by fall inventories conducted at traditional migratory staging areas. Results will be reported annually at the winter meetings of the Atlantic and Mississippi Flyway Council Technical Sections, as well as in the annual USFWS crane population status report and the Federal Register.

Opportunities to harvest EP cranes will be regulated by objectives and permit allocation procedures described in the Management Plan for this population (Van Horn et al. 2010). This plan includes the process to determine the number of permits to be issued in any given year, based on the 3-year average of the fall population index. Special State crane hunting permits, similar to those currently used for harvest regulation of other populations (e.g., Rocky Mountain and Lower Colorado River Valley Populations) of sandhill cranes will be employed by all participating States and other government entities authorized to issue permits by the Service. The Service will approve the maximum numbers of permits to be issued as part of its normal annual regulations process.

B. ALTERNATIVE 2 - NO ACTION:

This alternative will continue the current closure on hunting of EP cranes in the Atlantic and Mississippi Flyways. Without an effective mechanism to limit future population growth, EP sandhill cranes may exceed existing population objectives and lead to depredation problems involving private agricultural interests throughout their range. Lacking a method to preclude

excessive concentrations at specific sites, sandhill cranes may become locally overabundant in specific habitats. Lack of recreational opportunity on these birds may preclude efforts to enhance wetland habitats that directly impact the long-term viability of these birds and many other wetland dependent waterfowl species.

III. DESCRIPTION OF THE AFFECTED ENVIRONMENT

A. SANDHILL CRANES

Sandhill Cranes are generally divided into 9 management populations in North America (Tacha et al. 1994). The taxonomy of sandhill cranes is presently being revised based on recent genetic studies and results are still subject to some interpretation (Rhymer et al. 2001). However, most biologists recognize 5 or 6 distinct subspecies of sandhill cranes (The American Ornithologists Union (1957), Walkinshaw 1973, Lewis 1977), Tacha (1992). Three of these subspecies constitute small non-migratory groups of cranes, none of which are hunted: (1) *G. c. pratensis* (Florida Sandhill Crane), (2) *G. c. nesiotus* (Cuban Sandhill Crane), and (3) *G. c. pulla* (Mississippi Sandhill Crane). None of these subspecies would be affected by this proposed action. The subspecies *G. c. rowani* (Canadian Sandhill Crane) is of questionable designation, with the most recent genetic assessment suggesting that this group should be combined with the subspecies *G. c. tabida* (Greater Sandhill Crane) (Rhymer et al. 2001). The greater sandhill crane is the primary subspecies that will be affected by this action. The final subspecies *G. c. canadensis* (Lesser Sandhill Crane) is not expected to occur within the scope of this proposed action.

Greater and lesser (and Canadian) sandhill cranes are presently hunted in other parts of their range and have been divided into management populations based on their geographic distribution during Fall and Winter. These management populations are: (1) the Midcontinent Population, (2) the Rocky Mountain Population, (3) The Pacific Flyway Population of lesser sandhill cranes, (4) The Central Valley Population of greater sandhill cranes, (5) the LCRVP of greater sandhill cranes, and (6) the EP of greater sandhill cranes. It is the EP population of sandhill cranes that is the subject of this proposed action. The first three populations are presently hunted in Canada and/or the United States. The Central Valley Population and Lower Colorado River Valley Populations are presently not hunted. All of these populations have approved Flyway management plans.

Tacha et al (1992) describes the general biology of sandhill cranes as follows:

“Sandhill Cranes do not breed until they are 2 to 7 years old, depending on subspecies and population. They are perennially monogamous and provide extended biparental care of their young, families usually staying together 9 to 10 months (Tacha 1988, Nesbitt 1992). They are normally long-lived (up to 20+ years) and lay 2-egg clutches once a year, but rarely raise more than one young to fledging. Their primary social units are pairs and families that combine (in migratory populations) into large, socially unstable flocks during migration and wintering periods. These flocks often concentrate at migratory staging areas and on the wintering grounds, making this species particularly vulnerable to loss of strategic wetlands.”

B. THE EASTERN POPULATION OF SANDHILL CRANES

The Eastern Population (EP) of sandhill cranes has rebounded from near extirpation in the late 1800's (Walkinshaw 1949, 1973; Leopold 1949). Management actions, such as regulating take and the protection and restoration of habitat, have allowed this population to increase to a level that exceeded 30,000 cranes by 1996 (Meine and Archibald 1996). The majority of EP cranes breed across the Great Lakes region (Wisconsin, Michigan, Ontario, and Minnesota); however, the range of this population is currently expanding in all directions. By early fall, EP cranes leave their breeding grounds and congregate in large flocks on traditional staging areas throughout the breeding range. During migration, EP cranes use traditional stopover areas including the Jasper-Pulaski Fish and Wildlife Area in northwestern Indiana and the Hiawasse State Wildlife Refuge in southeastern Tennessee. Historically, the EP has wintered in southern Georgia and in Florida. More recently some cranes have wintered further north into Kentucky and Tennessee (Walkinshaw 1973, Lewis 1977, Tacha et al. 1992, Meine and Archibald 1996).

Status: The USFWS has coordinated a long-term (1979-present) fall survey of EP cranes in the Mississippi and Atlantic Flyways (Fig. 1). This survey has documented a long-term increasing trend in this population from the lowest count of 11,943 in 1981 to the highest count of 59,876 in 2009 with the most recent count (2010) being 49,666 cranes (Fig. 1). The survey is conducted annually on or about October 31 by volunteers and agency personnel (Sean Kelly, USFWS, pers. com.). During the survey, the number of cranes at historic migratory staging areas is recorded, providing a fall index of the population. This is neither a complete population survey nor a statistically designed population estimate. In addition, some key staging areas were not surveyed in some years. It is recognized that this index does not count the entire fall population and that the actual fall flight of the EP is larger. The survey is timed to count EP cranes when they are concentrated at staging areas in Indiana, Michigan and Wisconsin although the cranes at these locations come from a broader breeding range. The timing of this survey is supported by over 20 years of data at Manitoulin Island in northern Lake Huron, Ontario which is a significant staging area for thousands of Ontario breeding sandhill cranes on their way south (Brook 2008). These data indicate that sandhill cranes move through this area from early to late October with the peak numbers dropping off after mid-October. This suggests that Ontario breeding EP sandhill cranes have moved south into Michigan or Indiana by the time the USFWS survey is conducted. Limited satellite telemetry and survey data support this movement of EP cranes nesting in Ontario into the primary migration corridor covered by this survey (Boyd et al. 2007, Brook 2008, Long Point Waterfowl - Bird Studies Canada 2009).

Annual Recruitment: Recruitment surveys for this population of cranes have been conducted at various times in various locations throughout their known breeding range (Drewein et al. 1995). Reported recruitment rates for EP cranes have ranged from 9.2% to 14.3%, with an average of 12.0%, for the EP (Drewein et al. 1995). This is among the highest reported recruitment for any sandhill crane population (Drewein et al. 1995). More recent analysis suggests that the recruitment rate may be as high as 16% (Tom Cooper, USFWS, unpublished data, Fig. 4).

Determination of the annual sustainable harvest:

We used two methods to assess the effect of harvest on EP sandhill cranes: 1) the potential biological removal allowance method described by Runge et al. (2004); and 2) constructing a simple population model using fall survey data and annual survival rates published in the literature (Tom Cooper, USFWS, pers. com.).

To estimate the potential biological removal (PBR) allowance (Runge et al. 2004), we calculated the average annual growth in the absence of hunting. We estimated the intrinsic rate of growth as

the slope of a simple linear regression of the natural log of the fall survey counts against year (1979-2010; Fig. 3). The estimated annual rate of growth for EP cranes is approximately 4%. Using the mean of the last three fall counts (51,217) as a reasonable minimum estimate of the crane population in 2010, we estimated the PBR for the 2011-12 hunting season as 1,024 cranes ($PBR = 0.04(51,217) \times 0.5$, Runge et. al. 2004:308) or approximately $\frac{1}{2}$ of the expected annual rate of increase.

We also used fall survey data (USFWS, unpublished data) and an estimate of the annual survival rate of EP cranes from the literature (0.88, Tacha et al. 1992) to construct a simple population model for EP sandhill cranes. The best fitting model for fall survey data indicated an annual recruitment rate of 0.16 (Fig. 4). Based on this model, we modeled the effect of various harvest levels ranging from no harvest to 2,500 birds per year. Assumptions of the model included: 1) all harvest was additive to natural mortality, 2) annual survival is 0.88, and 3) annual recruitment was 0.16. Our results indicated that any harvest below 2,000 birds per year would result in a growing population (Fig. 5).

To date, Kentucky is the only state that has submitted a proposal to open a hunting season for EP sandhill cranes. The Kentucky hunt plan follows the guidelines of the Management Plan (Van Horn et al. 2010) and provides for a maximum retrieved harvest of up to 400 cranes. Assuming a crippling rate of 20% (Van Horn et al. 2010), total take could potentially be up to 480 cranes. This level of take would be sustainable based on the results of the PBR method and the population model contained in this environmental assessment. Furthermore, this level of harvest would be substantially less than that experienced by other hunted populations of sandhill cranes. For example, approximately 1,049 birds (recent 3-year average) are harvested from the Rocky Mountain Population of cranes each year. This represents approximately 4.9% of the recent 3-year average population estimate of 21,433 cranes (Kruse et al. 2010). The Mid-Continent Population, comprised of approximately 530,486 birds (3-year average), experiences an annual harvest (3-year average) of approximately 35,792 birds (includes crippling loss and harvest in Mexico and Canada; Kruse et al. 2010). This level of harvest represents approximately 6.7% of the Mid-Continent Population of cranes. Both the Rocky Mountain and Mid-Continent populations of cranes have exhibited positive growth rates in the presence of such harvest levels (Kruse et al. 2010). The proposed action to allow a crane hunt in Kentucky, with a potential take of 480 birds (400 harvested + 80 due to crippling loss), would result in only 1% of the population being harvested, which is lower than either the Rocky Mountain or Mid-Continent Populations. Therefore, we believe the proposed action would still allow positive growth of the EP of cranes.

Provisions for season closure:

According to the EP management plan, hunting seasons for EP cranes would be offered if the three-year average fall survey estimate was above 30,000 cranes. When the three year fall survey average falls below 30,000, the hunting season will be closed and will remain closed until the three year fall survey average exceeds 30,000 (Van Horn et al. 2010). The Service recognizes that utilization of a three year population trend estimate to guide season closures may mask a precipitous one year drop in the EP crane population index. In such cases, the Service will hold discussions with Flyway Councils to assess the biological ramifications of the population index change and consider what options, including season closure, should be considered in such a situation.

C. WHOOPING CRANES

In 2001, the USFWS announced its intent to reintroduce whooping cranes (*Grus americana*) into historic habitat in the eastern United States with the intent to establish a migratory flock that would summer and breed in Wisconsin, and winter in west-central Florida (66 FR 14107; March 9, 2001). We designated this reintroduced population as a nonessential experimental population (NEP) according to section 10(j) of the Endangered Species Act of 1973 (Act), as amended. The geographic boundary of the NEP includes the States of Alabama, Arkansas, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Louisiana, Michigan, Minnesota, Mississippi, Missouri, North Carolina, Ohio, South Carolina, Tennessee, Virginia, West Virginia, and Wisconsin. The objectives of the reintroduction are: To advance recovery of the endangered whooping crane; to further assess the suitability of Wisconsin and west-central Florida as whooping crane habitat; and to evaluate the merit of releasing captive-reared whooping cranes, conditioned for wild release, as a technique for establishing a self-sustaining, migratory population. As of May 2011, there are approximately 105 birds in the eastern NEP of whooping cranes.

Mississippi and Atlantic Flyway states within the NEP area maintain their management prerogatives regarding the whooping crane (66 FR 33910; June 26, 2001). They are not directed by the reintroduction program to take any specific actions to provide any special protective measures, nor are they prevented from imposing restrictions under State law, such as protective designations, and area closures. None of the States within the NEP area have indicated that they would propose hunting restrictions or closures related to game species because of the whooping crane reintroduction. Overall, the presence of whooping cranes is not expected to result in placement of constraints on hunting of wildlife or to affect economic gain landowners might receive from hunting leases. The potential exists for future hunting seasons to be established for other migratory birds that are not currently hunted in some of the States within the NEP area (e.g. EP sandhill cranes). The whooping crane reintroduction program will not prevent the establishment of hunting seasons or conservation orders approved for other migratory bird species by the Mississippi or Atlantic Flyway Councils. The Kentucky Department of Fish and Wildlife Resources has proposed a sandhill crane hunting season in 2011. The season would begin in mid-December and continue for 30 consecutive days until mid-January 2012. The season dates were chosen such that they would begin approximately 3 weeks after whooping cranes are normally migrating through Kentucky. This will reduce the likelihood that sandhill crane hunters would encounter whooping cranes.

D. HABITATS

Sandhill cranes are a wetland dependent species that feed on aquatic vegetation, small vertebrate and invertebrate animals, and waste grain crops. Nesting habitat is typically on the edge of marshy areas where 1 or 2 eggs are laid in a large, open nest. The majority of EP cranes reproduce from Eastern Minnesota eastward through Michigan and north into southern Ontario. They winter primarily from southern Tennessee into the northern part of Florida. Cranes typically leave breeding areas by late October and arrive in winter habitat by mid-November. Northern migration typically begins in mid to late February.

Throughout their breeding range, EP cranes use wet meadows, bogs, shallow marshes, and pastures for nesting and colt rearing. During migration, they stage in large marshes that have little human disturbance and open shallow water for roosting. Winter roosts are located in slow river backwater areas or shallow marshes where birds can stand in the water. Cranes leave roosts near dawn to locate grassland areas or grain crops for feeding. Preferred feeding areas

are open, with little vegetation that could hide predators. Waste corn or grain left in already harvested fields is preferred for foraging cranes. After feeding, cranes typically loaf in undisturbed open areas. A typical pattern is to leave the roost at dawn for feeding areas, feed for 1 or 2 hours, fly to a loafing area for several hours, return to feed (often in the same field) and return to the roost in late afternoon-early evening.

IV. ENVIRONMENTAL CONSEQUENCES

A. ALTERNATIVE 1 (PREFERRED ALTERNATIVE) - ALLOW A LIMITED TAKE OF SANDHILL CRANES DURING THE OPERATIONAL FALL AND WINTER HUNTING SEASON FRAMEWORK ESTABLISHED ANNUALLY FOR MIGRATORY BIRDS:

1. The Eastern Population of Sandhill Cranes

The EP of sandhill cranes is expected to continue to increase, given the anticipated level of sport harvest. Provision of hunting opportunities is expected to increase the level of interest in the crane population by hunters, leading to additional support for monitoring and habitat conservation efforts.

2. Whooping Cranes

Due to the delayed timing of Kentucky's proposed sandhill crane hunting season, eastern NEP whooping cranes will have already migrated through the state before hunting begins. Additionally, Kentucky will delay shooting hours until sunrise to ensure optimal lighting under any weather conditions and all hunters will also be required to pass an online identification test prior to being issued any permit to hunt sandhill cranes." Therefore, this alternative is not expected to negatively impact the eastern NEP of whooping cranes.

3. Hunters

Monetary expenditures by hunters are associated with goods, services, privileges of hunting, economic values of the food provided, and annual effects on crop depredations by cranes. These benefits will be limited due to the limited harvest opportunities that are expected under the harvest allocation process outlined previously. Additional benefits may include increased support for monitoring and habitat enhancement programs that will benefit cranes and other wetland dependent wildlife species.

4. Non-governmental Organizations and the Public

Organizations opposed to hunting in general will be opposed to the addition of additional hunting opportunity. Organizations that generally support hunting are expected to support the proposal. Members of the public neither opposed nor supportive of hunting programs are expected to support the proposal conditional on the implementation being consistent with the long-term maintenance of the population and its continued growth.

5. Business

Minimal financial benefits of limited additional hunting opportunities would be gained by local businesses in those areas where harvest permits were issued for lodging and support services.

B. ALTERNATIVE 2 - NO ACTION:

1. The Eastern Population of Sandhill Cranes

The population is expected to continue to increase. In the absence of harvest opportunities, the population is expected to reach levels where crop depredation problems continue to become an issue with local agricultural interests.

2. Whooping Cranes

Efforts to increase the eastern NEP of whooping cranes would be unaffected by this alternative.

3. Hunters

Monetary expenditures by hunters are associated with goods, services, privileges of hunting, economic values of the food provided, and annual effects on crop depredations by cranes. These benefits would not accrue if there are no hunting opportunities offered on this population.

4. Non-governmental Organizations and the Public

Organizations opposed to hunting in general will be supportive of this alternative. Such support is not expected to engender additional support for monitoring or habitat improvement projects. Organizations generally supportive of hunting would be disappointed by a decision to continue the existing season closure on this population. Members of the public neither opposed nor supportive of hunting programs would be unaffected by the proposal.

5. Business

Potential financial benefits of additional hunting opportunities would not accrue. No additional revenue attributable to hunting would be gained.

V. CONSULTATION AND COORDINATION

Technical review of the Kentucky crane hunting proposal was conducted by the Webless Committee of the Mississippi Flyway Council and Atlantic Flyway Council Technical Sections. Subsequently, the proposal was endorsed by the Technical Section and recommended for approval by the Mississippi Flyway Council. The Council approved the hunt proposal in March 2011 and forwarded it to the USFWS for consideration during the early seasons regulations meeting in June 2011. Pending USFWS approval the crane hunt plan will be published in the early seasons regulations proposed rule in the Federal Register.

A. ENDANGERED SPECIES

Consultation under Section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.), has not been sought in development of this proposal but will be done during the regulatory process to develop frameworks for the 2011-2012 Migratory Game Bird Hunting Regulations. The proposed action is not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of their critical habitats. Hunting regulations are designed, among other things, to remove or alleviate conflict between seasons for migratory game birds and the protection and conservation of endangered and threatened species and their habitats. The Service's biological opinions resulting from its consultation under Section 7 are considered public documents and are available for inspection in the Division of Endangered Species and the Division of Migratory Bird Management.

B. NEPA

NEPA considerations associated with the annual regulation-setting process are covered by the programmatic document, "Final Supplemental Environmental Impact Statement: Issuance of Annual Regulations Permitting the Sport Hunting of Migratory Birds (FEIS 88-14)", filed with EPA on June 9, 1988. Notice of Availability was published in the *Federal Register* on June 16, 1988 (53 FR 22582). The Service's Record of Decision was published on August 18, 1988 (53 FR 31341). However, this programmatic document does not prescribe year-specific regulations; those are developed annually based on year specific estimates of population status. These assessments are presented annually in the Federal Register for public review and comment

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VI. REFERENCES

- American Ornithologists Union. 1957. AOU Checklist of North American birds. Lord Baltimore Press. Baltimore, MD.
- Braun, C. E. R. C. Drewin, C. D. Littlefield, and L. H. Walkinshaw. 1975. Conservation Committee on status of sandhill cranes. *Wilson Bull.* 87(2):297-302.
- Boyd, M., S. Petrie, S. Badzinski, T. Barney. 2007. Movement Patterns, Habitat Use, and Landowner Opinion of a Rapidly Expanding Sandhill Crane Population in Central Ontario. Long Point Waterfowl Research proposal. 2 pp.

- Brook, R. 2008 Manitoulin Island Cooperative Sandhill Crane Survey. Ontario Ministry of Natural Resources Report. 13 pp.
- Drewien, R. C., J. C. Lewis. 1987. Status and distribution of cranes in North America, pp. 469 - 477 in Proc. 1983 Int. Crane Workshop (G. W. Archibald and R. F. Pasquier, Eds.). Dist. by Int. Crane Found., Baraboo, WI.
- Drewien, R. C., W. M. Brown and W. L. Kendall. 1995. Recruitment in Rocky Mountain Greater Sandhill Cranes and comparisons with other crane populations. J. of Wildl. Manage. 59(2):339-356.
- Kruse, K.L., D.E. Sharp, and J.A. Dubovsky. 2010. Status and harvests of sandhill cranes: Mid-Continent, Rocky Mountain and Lower Colorado River Valley Populations. Administrative Report, U.S. Fish and Wildlife Service, Denver, Colorado. 11pp.
- Lewis, J. C. (Chairman). 1977. Sandhill Crane, pp. 4-53 in Management of migratory shore and upland game birds in North America (G. C. Sanderson, Ed.). Int. Assoc. Fish Wildl. Agencies, Washington, D.C.
- Leopold, A. 1949. A Sand County Almanac and Sketches Here and There. Oxford University Press, New York. 228 pp.
- Long Point Waterfowl – Bird Studies Canada (BSC). 2009. BSC – LPW home page <http://www.bsc-eoc.org/research/lpwrf>. Accessed November 16, 2009.
- Meine, C. D. and G. W. Archibald (Eds). 1996. The cranes: - Status, survey and conservation action plan. IUCN, Gland, Switzerland, and Cambridge, U.K. 294pp. Northern Prairie Wildlife Research Center Online. <http://www.npwrc.usgs.gov/resource/birds/cranes/index.htm>(Version 02MAR98).
- Nesbitt, S. A., C. T. Moore, K. S. Williams. 1992. Gender prediction from body measurements of two subspecies of Sandhill Cranes. Pp. 38-42 in Proc. 1991 N. Am. Crane Workshop (D. W. Stahlecker, Ed.). Dist. by Int. Crane Found., Baraboo, WI..
- Pacific Flyway Council. 1983. Pacific Flyway Management Plan for the Greater sandhill crane population wintering along the lower Colorado River Valley. Lower Colorado River Population of Greater Sanhill Cranes subcomm., Pacific Flyway Study Comm. [c/o USFWS Portland, OR. Unpubl. Rept. 26pp. + Appendices.
- Pacific Flyway Council. 1995. Pacific Flyway Management Plan for the Greater sandhill crane population wintering along the lower Colorado River Valley. Lower Colorado River Population of Greater Sanhill Cranes subcomm., Pacific Flyway Study Comm. [c/o USFWS Portland, OR. Unpubl. Rept. 26pp. + Appendices.
- Rhymer, J. M., M. G. Fain, J. E. Austin, D. H. Johnson, and C. Krajewski. 2001. Mitochondrial phylogeography, subspecific taxonomy, and conservation genetics of sandhill cranes (*Grus canadensis*, Avers: Gruidae). Conservation genetics 2:203-218.
- Runge, M. C., W. L. Kendall, and J. D. Nichols. 2004. Exploitation. Pages 303-328 in Sutherland, W.

J., I. Newton and R. E. Green, eds. Bird Ecology and Conservation. Oxford University Press, Oxford, UK.

Tacha, T. C. 1988. Social organization of Sandhill Cranes from mid-continental North America. Wildl. Monogr. 99.

Tacha, T. C., S. A. Nesbit, and P. A. Vohs. 1992. Sandhill Crane (*Grus canadensis*). In The Birds of North America, No. 31 (A. Poole, P. Stettenheim, and F. Gill, eds.). Philadelphia: The Academy of Natural Sciences; Washington, DC: The American Ornithologist's Union.

Tacha, T. C., S. A. Nesbit, and P. A. Vohs. 1994. Sandhill crane. Pages 71-94 in T. C. Tacha and C.E. Braun, eds. Migratory Shore and Upland Game Bird Management in North America. International Association of Fish and Wildlife Agencies, Washington, D.C.

Van Horn, K., T. White, W. Atkins, T. Cooper, R. Urbanek, D. Holm, D. Sherman, D. Aborn, J. Suckow, K. Cleveland, R. Brook. 2010. Management Plan for the Eastern Population of Sandhill Cranes. Mississippi and Atlantic Flyway Council Webless Committee. 34pp.

Walkinshaw, L. H. 1973. Cranes of the world. Winchester Press, New York.

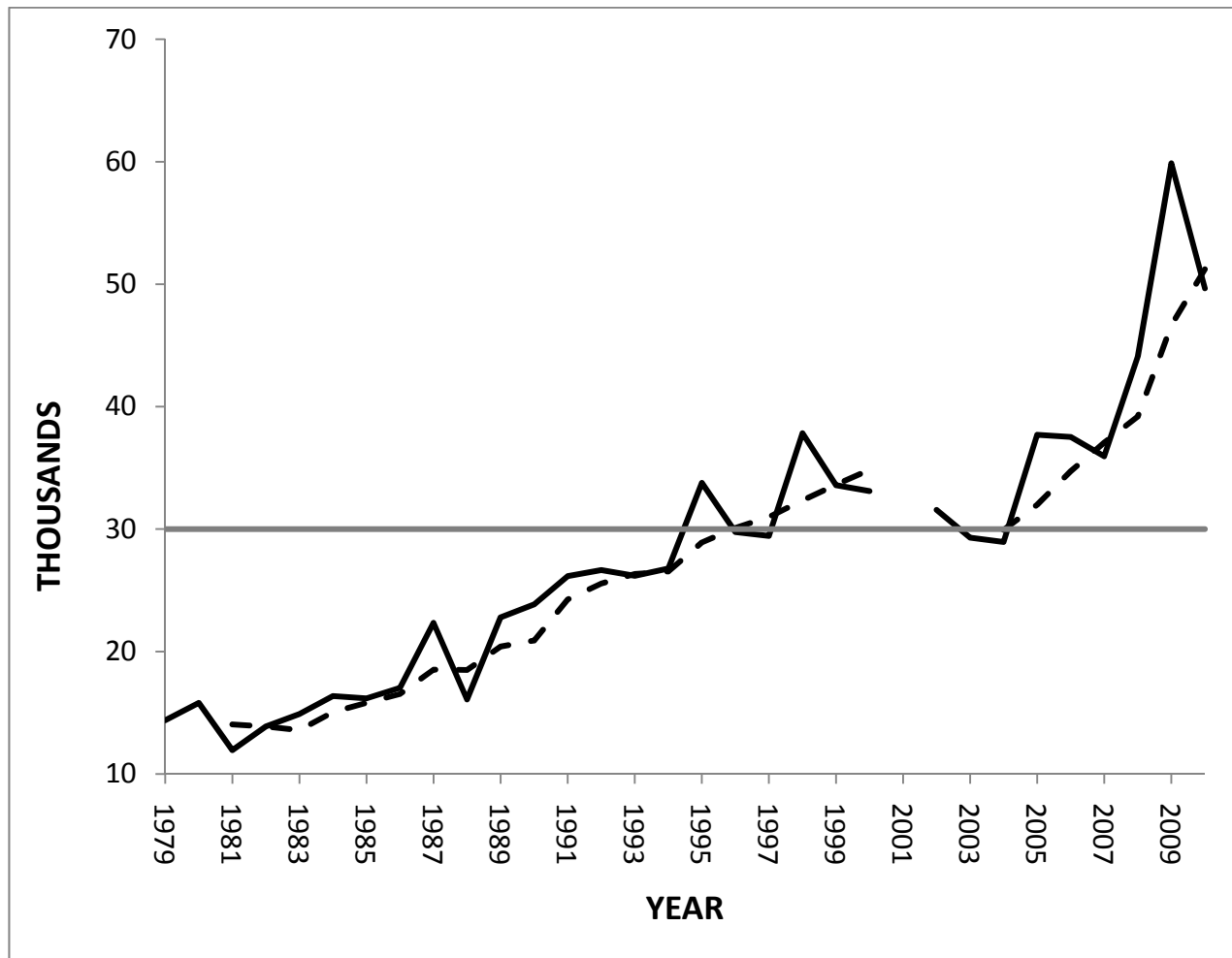


Figure 1. Number of cranes counted during the USFWS-coordinated Fall Eastern Population Sandhill Crane Survey (solid line) and the 3-year average (dashed line). No Survey was conducted in 2001. The solid grey line represents the 30,000 hunting season threshold. The Eastern Population Sandhill Crane Plan (Van Horn et al. 2010) calls for an open hunting season when the 3-year average is above this threshold.

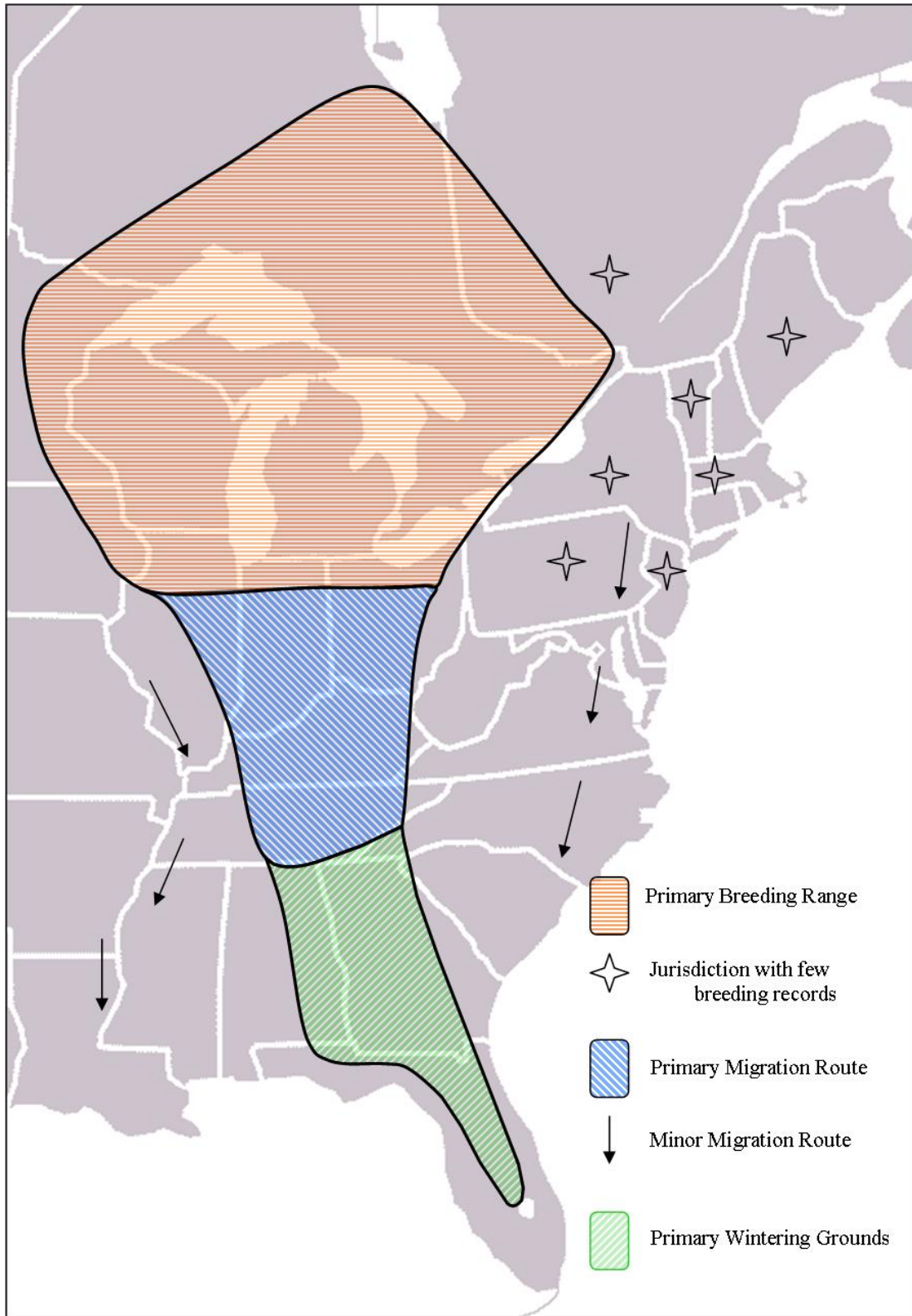


Figure 2. Approximate breeding, migratory, and wintering distribution of the Eastern Population of Sandhill Cranes (Van Horn et al. 2010).

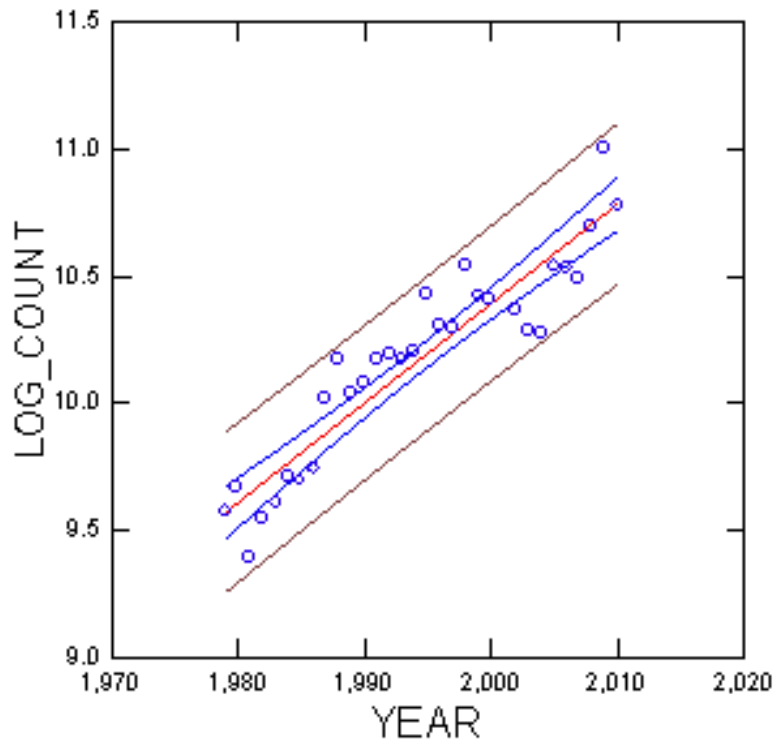


Figure 3. Trend analysis of abundance indices for Eastern Population sandhill cranes (+3.9%/year, $P < 0.001$, $R^2 = 0.869$).

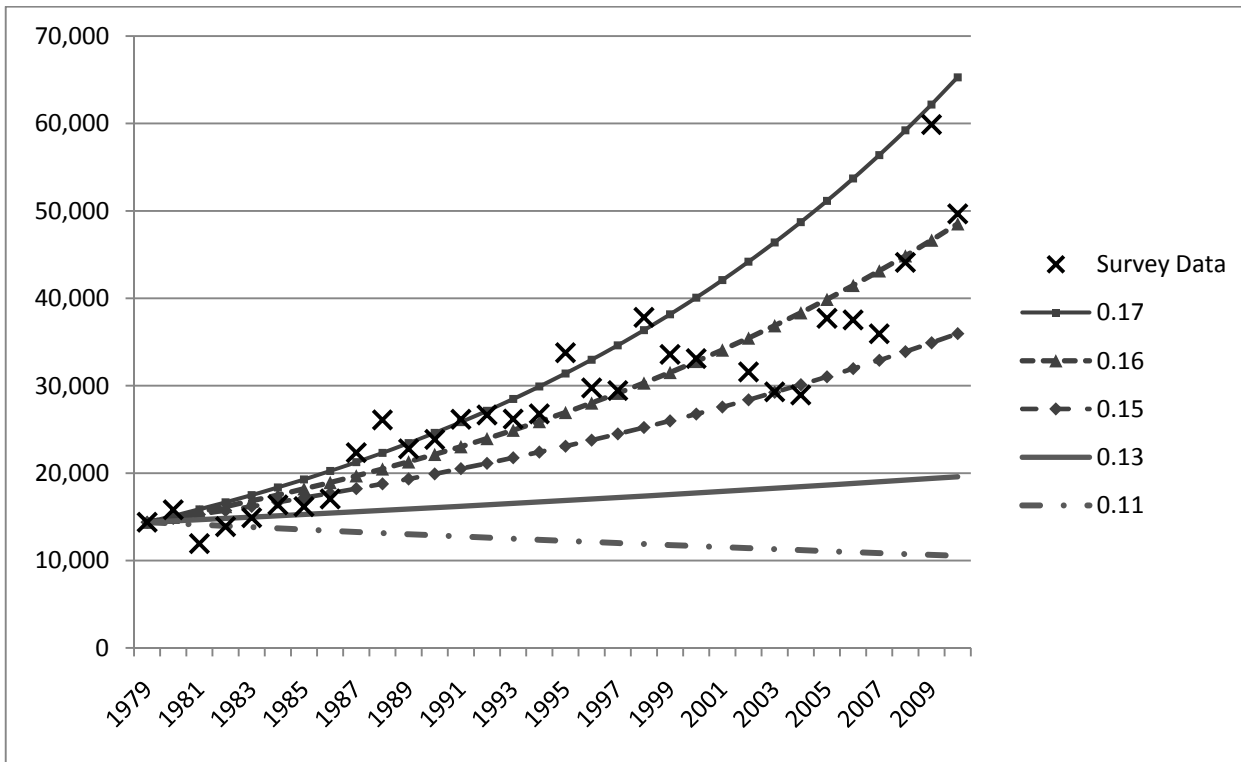


Figure 4. Relationship of different recruitment rates (0.11-0.17) to USFWS fall survey crane counts 1979-2010 (represented by X's) assuming annual survival is 0.88 (Tacha et al. 1992). Results indicated that a recruitment rate of 0.16 produced the best fitting exponential model (USFWS, unpublished data).

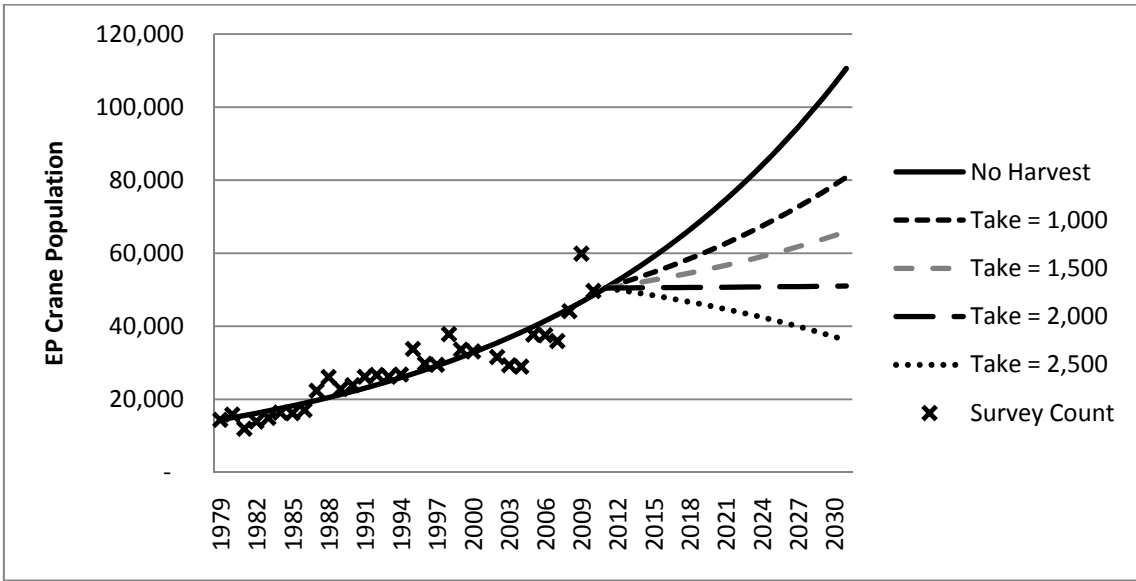


Figure 5. The modeled effect of various harvest levels on Eastern Population sandhill cranes assuming an annual survival rate of 0.88 (Tacha et al. 1992), an annual recruitment rate of 0.16, and all take is additive to natural mortality (USFWS, unpublished data). Actual fall survey data are indicated by X's.