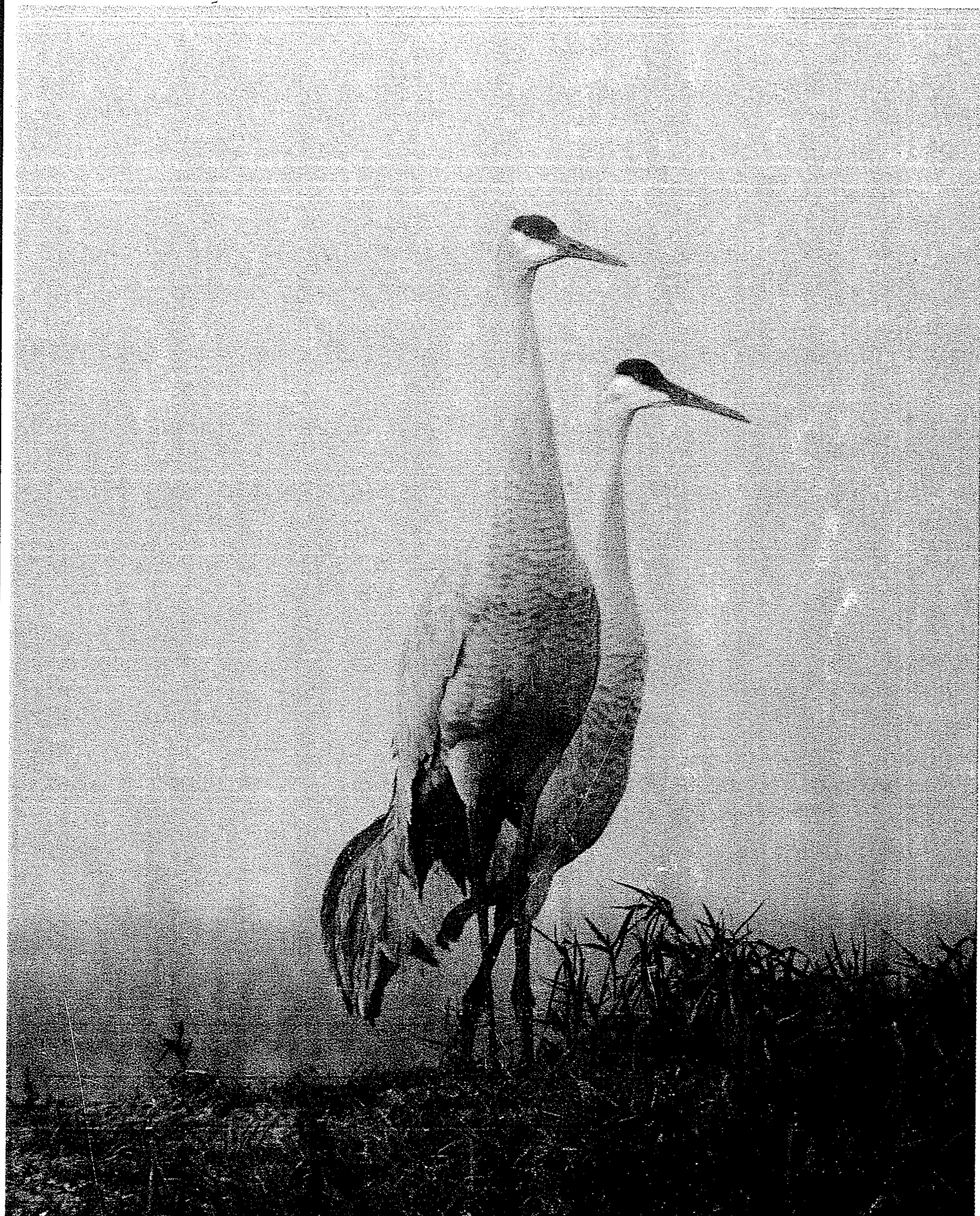
PROCEEDINGS
1988 NORTH AMERICAN CRANE WORKSHOP



State of Florida Game and Fresh Water Fish Commission
Nongame Wildlife Program Technical Report #12
1992

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Cover photograph: Florida sandhill crane (*Grus canadensis pratensis*), by Stephen A. Nesbitt

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WHOOPING CRANE RIVERINE ROOSTING HABITAT SUITABILITY MODEL

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Abstract: Water development interests on the Platte River in Nebraska and recognition of the importance of this river as migratory bird habitat have prompted studies to determine how much water is needed to maintain wildlife habitat values. The whooping crane (*Grus americana*) is one of many species that use the Platte. A model was developed to quantify the relationship between river discharge and roosting habitat suitability for whooping cranes, designed to accommodate the data collection and hydraulic simulation techniques of the Instream Flow Incremental Methodology. Results of the model indicate that optimum roosting habitat conditions in the Big Bend reach of the Platte River are provided by flows of approximately 56.7 m^3/s to 60.0 m^3/s.

Proc. 1988 N. Am Crane Workshop

Each spring the Platte and North Platte river valleys host the world's largest concentration of cranes. More than 500,000 sandhill cranes (*Grus canadensis*) amass in preparation for their northward migration to breeding grounds in Canada, Alaska and Siberia (U.S. Fish & Wildlife Service 1981). Among the other migratory bird species that use the Platte are 4 threatened and endangered species—the piping plover (*Charadrius melodus*), the interior least tern (*Sterna antillarum*), the bald eagle (*Haliaeetus leucocephalus*) and the whooping crane. The entire natural flock of whooping cranes crosses the Platte each spring and fall during its migration between Wood Buffalo National Park, Northwest Territories, and Aransas National Wildlife Refuge, Texas. The migration corridor that crosses the Platte was designated as critical habitat for whooping cranes under regulations pursuant to the federal Endangered Species Act (FR 43:20938-20942).

Over 1,000 direct-diversion irrigation ditches were in place on the Platte and its tributaries in Nebraska, Wyoming and Colorado by 1890 (Eschner et al. 1983). In 1909, Pathfinder reservoir on the North Platte River in Wyoming was among the first of the mammoth U.S. Bureau of Reclamation (USBR) projects to be completed in the west, and several other large reservoirs in the Platte basin followed. The present annual stream flow of the Platte is less than 30% of the pre-development flow (Miller 1985).

In the past, reductions in the water and sediment supply to the Platte have resulted in losses of as much as 90% of the pre-development channel width through vegetative encroachment (Williams 1978). The replacement of wide, open channels with networks of narrow channels separated by densely vegetated islands has been detrimental to several bird species dependent upon the Platte (Currier et al. 1985). New development proposals must consider potential effects to migratory bird habitat on the Platte, particularly to the habitat of the 4 endangered species.

Most attention and controversy have focused on the flows required to render the Platte a suitable roosting site for migrating whooping cranes. The simplest approach to this question is to examine the record of whooping crane use of the Platte and to attempt a correlation of use and discharge. This was the approach taken in a biological opinion issued by the U.S. Fish and Wildlife Service (USFWS) on the Narrows Unit, a large reservoir proposed for construction by the USBR on the South Platte River in Colorado. The USFWS reasoned that because most sightings of whooping cranes on the Platte have occurred at a discharge greater than 31.2 m^3/s (1100 cfs), and Narrows would significantly reduce the occurrence of such flows in the spring and fall, the project would constitute an adverse modification of habitat (U.S. Fish & Wildlife Service 1983). The effects of Narrows on channel morphology also figured into this finding of jeopardy. In a similar decision, the Nebraska Game and Parks

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Commission (NGPC) determined that the Catherland project, a proposed trans-basin diversion from the Platte in south-central Nebraska, would also constitute an adverse modification of whooping crane habitat. NGPC (1985) used a discharge of 48.2 m^3/s (1700 cfs) as the acceptable minimum for the spring and fall in its evaluation.

The Narrows and Catherland opinions did not satisfy the water development community or the wildlife conservation community. A new approach to the wildlife/water questions that might better satisfy the parties concerned was sought in the Instream Flow Incremental Methodology (IFIM), developed by the USFWS. IFIM is a process of riverine habitat assessment designed to evaluate changes in riverine systems, notably changes in discharge (Bovee 1982). It is ordinarily applied to fish and other strictly aquatic species, but it can be applied to more terrestrial species if pertinent flow-related habitat requirements can be identified.

This paper describes a whooping crane riverine roosting habitat suitability model based on the IFIM, and presents the results of this model as it was applied to the Big Bend reach of the Platte River in central Nebraska. The purpose of the model was to quantify the relationship between river discharge and whooping crane roosting habitat suitability in this reach, which is situated between Lexington and Chapman, Nebraska (Fig. 1). The model was not designed to predict changes in channel morphology given long-term changes in discharge. Instead, given recent measurements of channel morphology in the Big bend, the model evaluated the short-term effects of varying discharge on roosting habitat.

The author gratefully acknowledges the editorial assistance of his wife, Kathryn Ziewitz, in the preparation of this manuscript.

METHODS

Habitat Suitability Criteria Workshops

The habitat suitability criteria that were the biological basis of the model were developed during a workshop held in Grand Island, Nebraska, November 6, 1986. The workshop was organized by the Grand Island office of the USFWS, which required an assessment tool for almost immediate use in Endangered Species Act consultations with the sponsors of water development projects in Colorado and Wyoming. A previous workshop had identified a wide range of roosting habitat suitability criteria (Shenk & Armbruster 1986). This workshop narrowed the focus to flow-related criteria, and direct incorporation into an operational IFIM model was a primary objective. Participants in the workshop included individuals experienced either with whooping cranes, the Platte River, or both; David Blankinship, Kenneth Strom (National Audubon Society), Ross Lock, John Dinan (NGPC), James Lewis, David Bowman, Wallace Jobman, David Carlson (USFWS), Delmar Holz, Duane Woodward (USBR), Gary Lingle (Platte River Trust) and the author. Michael Armbruster and Pat Nelson (National Ecology Center, USFWS) acted as facilitators.

The workshop participants were specifically concerned with the effects of river discharge during the migration seasons on whooping crane roosting habitat quantity and quality, all other factors being equal. This narrow focus was taken intentionally to isolate the role of discharge. The participants identified measurable habitat variables that appeared to explain observed use of riverine roosting sites by whooping cranes. Following an approach common to IFIM studies, the variables identified were then interpreted as indices with assumed suitability values ranging from 0.0 to 1.0. The participants eventually agreed upon 3 criteria: unobstructed width, water width and percent water width shallow.

Unobstructed width is the distance across a channel between either a bank or an occurrence of woody vegetation over 1 m tall. Although unobstructed width does not vary with discharge (except in the long-term), it establishes the context within which the other criteria apply, and serves to distinguish wider sites from narrower sites in the final analysis. The suitability index for unobstructed width is provided in Fig. 2.

Based on whooping crane sightings, minimum value was assigned to ≤ 152 m (Johnson 1981) and maximum value to 351+ m (Lingle et al. 1984). Rather than drawing a straight line between the minimum and maximum points, the shape of the index between these 2 extremes was designed to attribute lower weight to this criterion than to the other water-related criteria. The nearly vertical line between 0.0 and 0.5 on the suitability axis in the vicinity of 152 m on the horizontal axis had the effect of reducing the influence of this criterion in the final results by a factor of 2. This somewhat counter-intuitive curve reflected the judgment of the workshop participants that the water-related criteria were more important determinants of roosting habitat quality than unobstructed width.

Water width is the summation of all water widths on a transect within the unobstructed width. The consensus of workshop participants was that whooping cranes use aquatic sites for roosting because they seek the physical isolation a water barrier provides. They believed that, generally, the greater the expanse of water, the better for whooping cranes. The suitability index for water width is provided in Fig. 3. Minimum value was assigned to ≤ 37 m (Johnson unpubl. data, referenced in Shenk & Armbruster 1986) and maximum value to 252+ m (Lingle et al. 1986).

Percent water width shallow was the percentage of the water width, as defined above, less than or equal to 20 cm deep. Most depth measurements taken at riverine roosting sites have been ≤ 20 cm (Shenk & Armbruster 1986). Although whooping cranes roost in shallow water, the river channel they use may contain water deeper than 20 cm. At the time of the workshop, stream bed profiles measured at the 3 most recent confirmed sightings of whooping cranes on the Platte showed that the birds used channels when an average of 42.9% of the water width was ≤ 20 cm deep (Lingle et al. 1984; Lingle et al. 1986; Currier unpubl. data). From this data, it was apparent that only some portion of the water width in a channel needed to be shallow for roosting whooping cranes. The suitability index for percent water width shallow is provided in Fig. 4. The optimum range of values, 30% to 50%, was based roughly on the calculation of this criterion from the profiles mentioned above. The minimum values were the consensus product of discussions. The physical relationship of the 3 criteria is diagramed in Fig. 5.

The participants discussed water velocity, which is often used in IFIM studies, as a possible fourth criterion, but did not achieve any consensus regarding the shape of the suitability index. Velocity was not included in the model for two reasons: 1) no data had been collected on water velocity at whooping crane roosting sites, 2) within the range of depths that whooping cranes actually stand in while roosting it seemed unlikely that water velocity could become too great to prohibit roosting on the Platte.

The participants combined the 3 criteria into a single quantity using an approach common to most IFIM studies. A measure of habitat quantity was multiplied by the 3 index values to compute a weighted usable area (WUA) for each discharge examined at each of the study sites by the following equation:

WUA = AREA * S(UW) * S(WW) * S(PWWS)

where

AREA = wet surface area S(UW) = suitability based on unobstructed width

S(WW) = suitability based on water width

S(PWWS) = suitability based on percent water width shallow

In order to compare and combine the results of study sites of different length, WUA was reported per 305 m of stream length.

The author wrote the computer programs that calculated WUA based on the results of hydraulic simulations, described below, and documented them in an unpublished report dated 8 January 1987.

Instream Flow Data Collection

In the determination of the relationship between discharge and habitat, the model uses physical measurements of the river collected according to field techniques of the IFIM (Bovee & Milhous 1978). The Big Bend of the Platte River was the focus of 4 years (1983-1986) of study employing this methodology. The Grand Island office of the USBR was primarily responsible for the study, with assistance from several federal, state and private organizations.

The Big Bend study area (approximately 145 river km) was initially divided into 12 reaches based on differences in channel morphology and other hydrologic characteristics. Within each of these reaches, 1 to 4 study sites were selected to represent the reach as a whole. Eight of these sites represented reaches that contain active channels more than 152 m wide, a common characteristic of most riverine roosting sites used by whooping cranes (Johnson 1981; Lingle et al. 1984; Lingle et al. 1986). The locations of the 8 sites are provided in Fig. 1, and the names of the sites, the reach length each represents, and other information about them is provided in Table 1.

The study sites were from 305 m to 1234 m in length. Three to 10 permanent transects (survey lines crossing the river approximately perpendicular to the flow of water) were situated to represent stream conditions in the immediate vicinity. At intervals of 3 m, or where the stream bed abruptly changed along a transect, the elevation of the stream bed and the velocity of the stream flow was measured. At less frequent intervals the elevation of the water surface was measured. The occurrence of important channel features, such as vegetated islands, was recorded. These measurements were repeated at least 3 times at different discharges to partially account for changes in the stream bed as a function of discharge.

A part of IFIM called the Physical Habitat Simulation (PHABSIM) system (Milhous et al. 1984) was used to predict the water surface elevation at discharges above and below the measured discharges. Fig. 6 depicts a hypothetical cross section of a river, the measurements made along an instream flow transect and the water surface elevations predicted by PHABSIM. The measurements depicted in Fig. 6, plus measurements of the upstream-downstream distance that each transect represented, constituted all of the physical data required by the habitat model.

RESULTS

The model evaluated only the short-term consequences of varying discharge on whooping crane roosting habitat. The results presented here must be regarded as valid only under present river channel conditions. For each measurement at a study site, PHABSIM was used to predict a stage vs. discharge relationship within a range of 40% to 250% of the measured discharge (refer to Table 1 for the measured discharges). The stream bed profile data and the predicted stage vs. discharge relationship for each measurement of each study site were used as inputs to the computer programs that implement the habitat model. Results from the multiple measurements of each site were examined individually and then averaged to produce a single WUA vs. discharge curve. Fig. 7 depicts the average curves for the 8 study sites.

Most of the sites exhibited a bell-shaped relationship between WUA and discharge. Generally, less WUA was provided by flows less than 28.3 m^3/s (1000 cfs) and greater than 85.0 m^3/s (3000 cfs) than was provided by flows around 56.7 m^3/s (2000 cfs). The most notable exceptions to this trend were the Elm Creek site (2) and the Rowe Sanctuary site (6). The curve for the Elm Creek site suggested that the greatest WUA was provided by flows between 16.1 m^3/s (570 cfs) and 31.2 m^3/s (1100 cfs), although compared to other sites the magnitude of WUA even at these optimum flows was relatively small. An unusually flat relationship was produced for the Rowe Sanctuary site with maximum WUA occurring at discharges greater than 85.0 m^3/s (3000 cfs). This largest of the study sites contained a greater diversity of channel sizes than the other sites, and habitat was available over a greater range of flows.

The great divergence in the amplitude of the curves in Fig. 7 was a direct consequence of the differences in channel morphology between the study sites. Those with the fewest wooded islands and widest channels (sites 6, 8B, 9BW, 9BE and 12) provided orders of magnitude more habitat at a given discharge than those with many wooded islands and narrow channels.

Some of the curves in Fig. 7 exhibited discontinuities, i.e., sudden increases or decreases in WUA at certain discharges (e.g. the Wood River site). This occurred when the lowest or highest discharge predicted for a given measurement produced a large difference in WUA compared to the other measurements at that discharge. When the multiple measurements were averaged, a nearly vertical line in the WUA vs. discharge relationship shown in Fig. 7 was the result. To produce a single WUA vs. discharge relationship for the Big Bend of the Platte, the average curves in Fig. 7 were combined. The 2 Mormon Island sites represent the same reach of the river, therefore the curves for these sites were averaged apart from the rest to produce a single curve, reducing the number of curves from 8 to 7. The 7 curves were weighted by the length of the reach they represented, i.e., the WUA values at a given discharge were multiplied by the appropriate reach length. Altogether, the 7 curves represented 58.6 km of the 145 km in the Big Bend. In the determination of the representative reach lengths for each site (Table 1), the USBR subtracted lengths where the most obvious human disturbances to whooping cranes were present, such as bridges and roads, from the original reach lengths determined by morphological and hydrological characteristics only. In this way, results combined from different sites would more closely reflect the WUA vs. discharge relationship for only those parts of the Big Bend that are potential whooping crane roosting habitat.

In the final step, the 7 weighted curves were summed (Fig. 8), producing a roughly bell-shaped curve with maximum WUA occurring at 56.7 m^3/s (2000 cfs). Values closely comparable to the maximum were available in a range of 56.7 m^3/s (2000 cfs) to 68.0 m^3/s (2400 cfs).

DISCUSSION AND CONCLUSIONS

Flows of approximately 56.7 m^3/s (2000 cfs) to 68.0 m^3/s (2400 cfs) provide optimal conditions for whooping crane roosting in the Big Bend of the Platte River. Most of the study sites exhibit a relationship between WUA and discharge similar to the aggregate relationship, but some sites provide much more habitat than others with flows of this magnitude. Maximum WUA is achieved at the Rowe Sanctuary site with much higher flows and at the Elm Creek site with much lower flows, but 56.7 m^3/s (2000 cfs) provides the greatest roosting habitat value at all of the sites collectively.

Following the November 1986 workshop, 6 additional whooping crane roosting sites on the Platte were measured that corroborate the idea that maximum shallow area is not necessarily most attractive to whooping cranes, but which raised questions regarding the percent water width shallow approach. The new measurements increased the range of the observed values of this criterion from 35.5%-51.3% to 12.8%-54.0%, but were not sufficient to determine whether the 30% to 50% range considered optimum is preferred. However, the facts that 5 of the 6 new data points did not fall within this range and that all 6 sites conformed quite well to the picture of "good" habitat based on the other criteria suggest that new approaches to a depth criterion should be investigated.

Although the model should still be improved, questions regarding flows and whooping cranes can now be addressed using a relative measure, rather than a fixed threshold, as in the past. The model enables users to estimate the percentage loss or gain in habitat suitability, as measured by WUA, given a proposed change in flows during the migration periods. This capability is desirable from both water development and wildlife conservation perspectives. The impacts of proposed projects can be more easily evaluated and desirable flow management alternatives more easily formulated.

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Table 1. The 8 study sites examined in this paper.

Site Number/ Measurement	Name of site and reach length site represents	Date measured	Measured discharge m³/s	(cfs)
Site 2	Jeffrey's Island, 6.3 km			
1	(3.9 mi)	10/10/84	57.5	(2030)
2		4/10/85	64.9	(2290)
3		7/22/85	18.1	(640)
Site 4A	Elm Creek, 4.8 km (3.0 mi)			
1		3/26/85	53.0	(1871)
2		7/08/85	6.4	(227)
Site 6	Rowe Sanctuary, 12.2 km			
1	(7.6 mi)	10/03/84	40.5	(1430)[a]
2		4/03/85	56.0	(1977)
3		7/07/85	8.2	(290)
4		6/09/86	15.6	(549)
Site 8C	Denman, 4.8 km (3.0 mi)			
1		10/15/84	121.0	(4270)
2		4/18/85	38.7	(1372)
3		7/19/85	15.3	(540)
Site 8B	Wood River, 3.7 km (2.3 mi)			
2		3/21/85	94.5	(3336)
3		7/12/85	11.8	(415)
4		5/21/86	51.0	(1802)
Site 9BW	Mormon Island West, 19.6 km			
1	(12.2 mi)[b]	3/24/83	29.6	(1045)[c]
2		3/31/83	44.4	(1568)
3		10/19/83	20.7	(730)
4		4/02/85	36.8	(1299)
5		7/10/85	3.1	(110)
6		10/02/85	24.3	(858)
7		4/03/86	31.5	(1113)
8		6/12/86	17.1	(604)
Site 9BE	Mormon Island East[d]			
1		3/23/83	31.2	(1100)
2		4/01/85	37.0	(1305)
3		7/11/85	2.7	(96)
4		10/03/85	26.9	(950)
6		6/11/86	15.0	(530)
Site 12A	Chapman, 7.1 km (4.4 mi)			
1		10/12/84	63.0	(2225)
2		4/15/85	52.0	(1837)
3		7/16/85	6.1	(215)
4		6/13/86	30.3	(1068)

a The channels measured at Site 6 do not include all river channels. Reported discharges are approximately 68% of the total flow in the river.

b Sites 9BW and 9BE were originally intended to represent 16.9 mi. of the river, but clearing of vegetation in these sites has reduced the miles represented to 12.2 (Duane Woodward, USBR, pers. comm.).

c The channels measured at Sites 9BW and 9BE do not include all river channels. Reported Discharges are related to total river flow by the following relationship: Total Flow = (Site 9B flow * 1.79) + 348.0 cfs

d Site 9BE represents the same river reach as site 9BW.

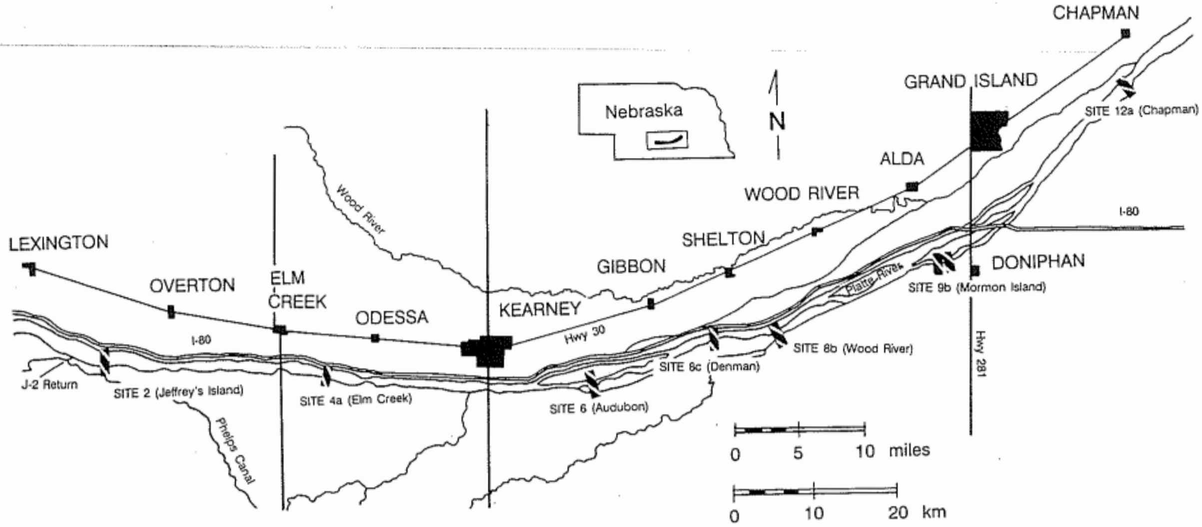

Figure l. Locations of the 8 study sites in the Big Bend of the Platte River.

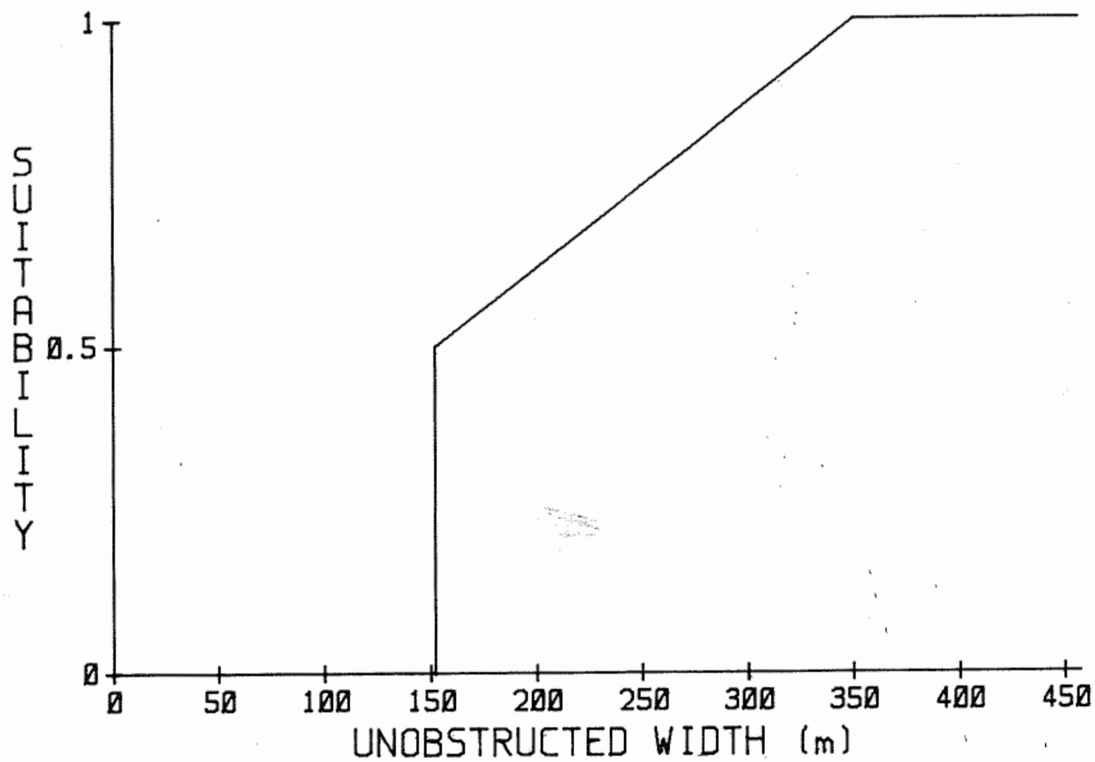

Figure 2. *Habitat suitability index for unobstructed width.*

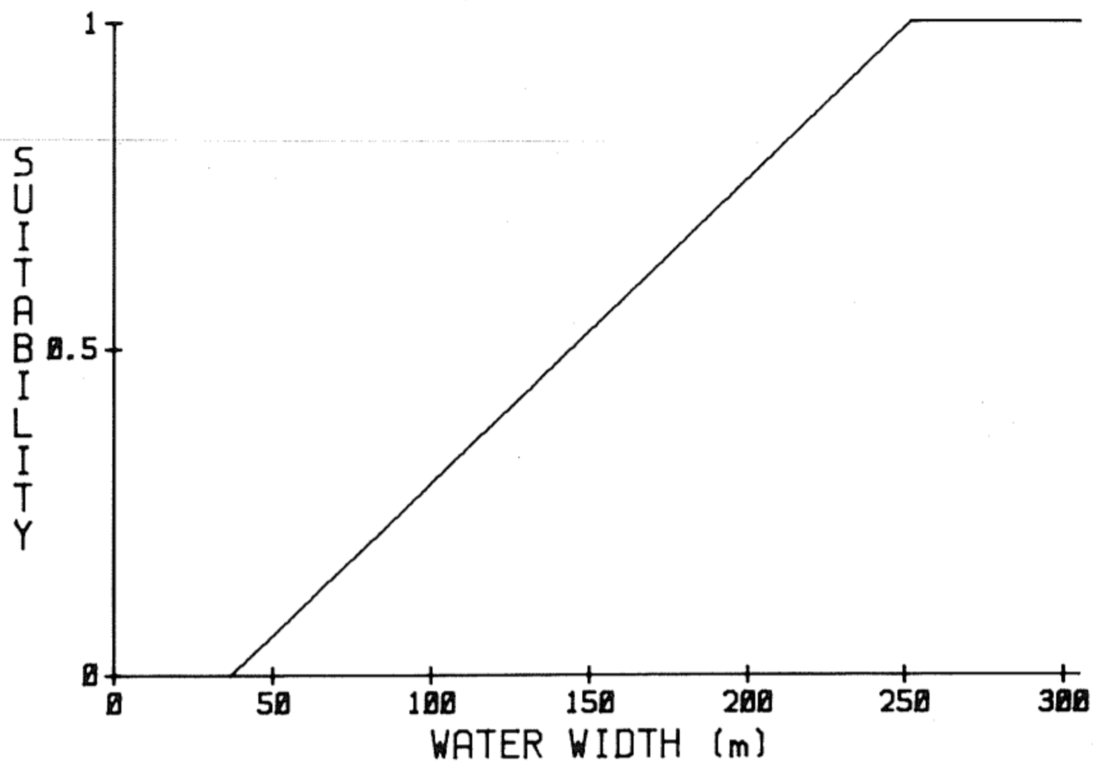

Figure 3. Habitat suitability index for water width.

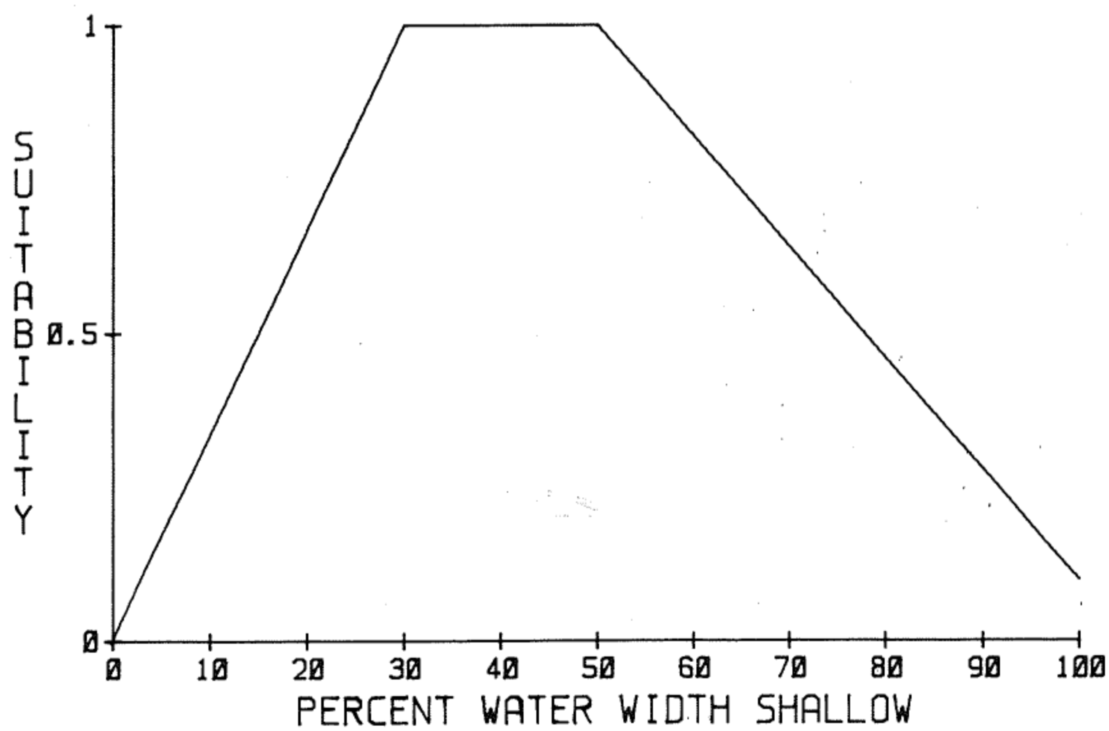

Figure 4. Habitat suitability index for percent water width shallow.

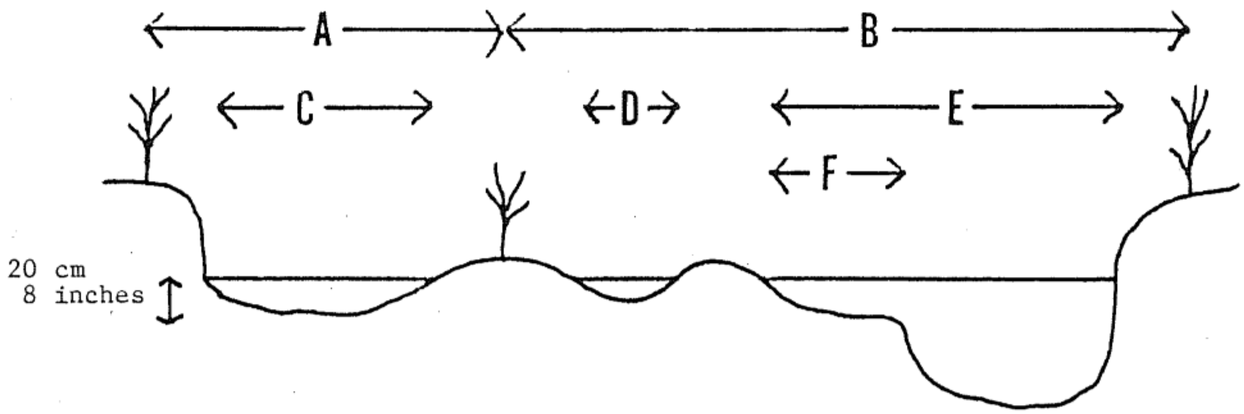

*Figure 5. Hypothetical cross section of stream bed along a transect illustrating the physical relationship between unobstructed width, water width, and percent water width shallow. Two unobstructed segments occur on this transect having unobstructed widths of A and B. Within segment A, the water width is C. Within segment B, the water width is D + E. Within segment A, the percent water width shallow (less than or equal to 20 cm or 8 in deep) is 100%. Within segment B, it is ((D + F) / (D + E)) * 100.*

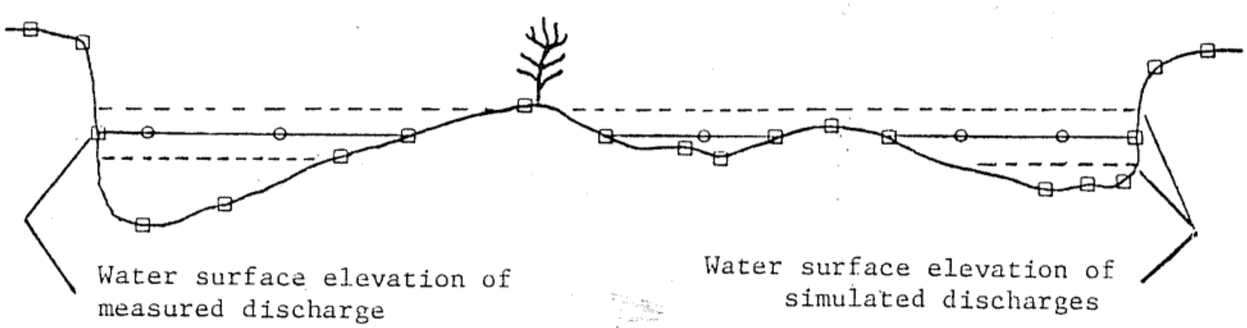

Figure 6. Hypothetical cross section of stream bed along a transect showing measurements taken in instream flow data collection. The squares represent locations at which bed elevation and water velocity are measured. The circles represent locations at which water surface elevation is measured. The occurrence of woody vegetation over 1 m (3 ft) tall is also recorded.

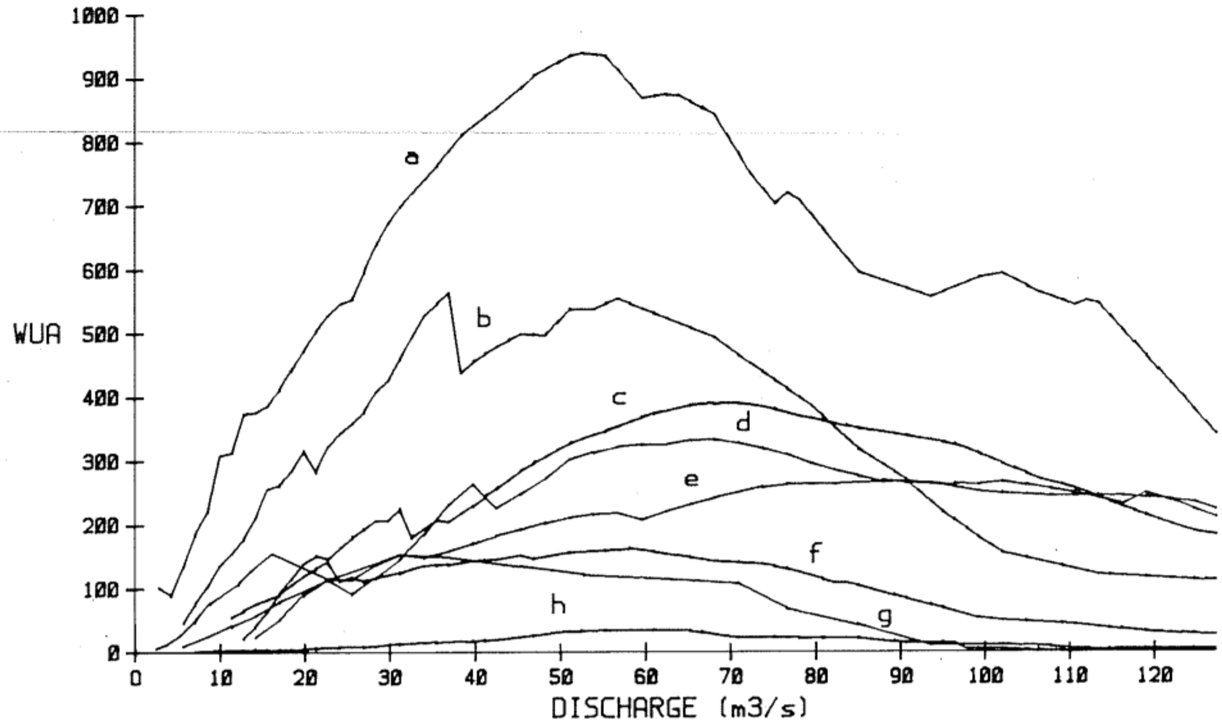

Figure 7. Weighted usable area (WUA) vs. discharge curves for the 8 study sites examined in this paper. Each curve is an average of the results of 2 to 8 separate sets of results of the habitat model using separate instream flow field measurements of the site. The letter immediately above each curve identifies the site: a = Chapman, b = Wood River, c = Mormon Island East, d = Mormon Island West, e = Rowe Sanctuary, f = Jeffrey's Island, g = Elm Creek, h = Denman.

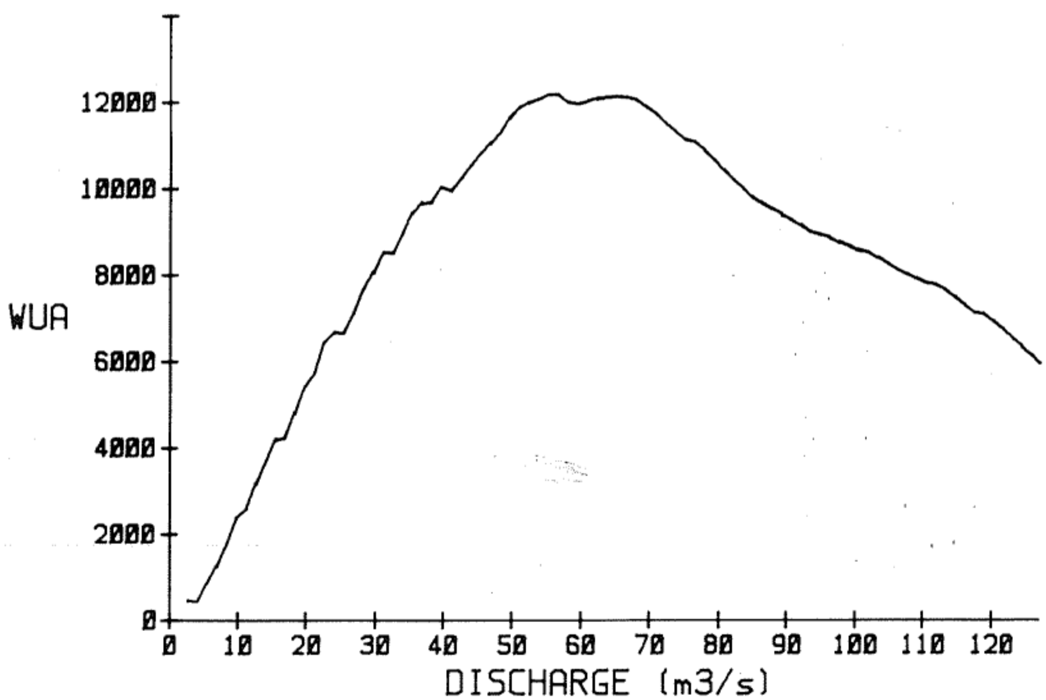

Figure 8. Weighted usable area (WUA) vs. discharge curve for all 8 study sites combined.