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In January of 1988 the Nebraska Natural Heritage Program initiated a systematic natural-areas inventory of Pawnee County, Nebraska, the first of its kind in the state. The inventory had two primary objectives: 1) to test the effectiveness of methods for conducting county-based natural area inventories, developed in other Midwestern states, in the eastern Nebraska landscape, and 2) to locate, classify, and evaluate natural areas of statewide and national significance in Pawnee County. Color infrared photo analysis, aerial reconnaissance, and ground surveys were used to identify, classify, and evaluate natural areas. Though Pawnee County proved to be a difficult county for an initial inventory, the methods used were effective in identifying natural areas in an eastern Nebraska landscape. [This is the final report from the survey, dated December 19, 1990—Editor.]

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INTRODUCTION

The Nebraska Natural Heritage Program (NENHP) was created in September of 1987 with the signing of a two-year cooperative agreement between The Nature Conservancy and the Nebraska Game and Parks Commission. The purpose of the program is to maintain a dynamic, computer-assisted database containing information on the status and distribution of the elements of natural diversity in Nebraska. The elements include plants, animals, and natural communities. In July of 1989, full administration of the program was transferred to the Nebraska Game and Parks Commission.

In January of 1988, the NENHP initiated a systematic natural-areas inventory of Pawnee County, Nebraska, the first of its kind in the State. Pawnee County was selected for the inventory because it has a large number of remnant tallgrass prairies and its relatively small size was suitable for a pilot inventory. Color infrared photo-analysis, aerial reconnaissance, and ground surveys (White and Madany, 1978) were used to identify, classify, and evaluate natural areas. Similar systematic county-based natural-area inventories have been conducted by heritage programs in other midwestern states, including Kansas, Missouri, Indiana, Michigan, and Minnesota.

A natural area was defined as a tract of land or water that reflects as nearly as possible the natural conditions occurring on the site prior to European settlement. Natural areas contain one or more relatively undisturbed natural communities. A natural community is a distinct and recurring assemblage of populations of organisms (plants and animals) normally associated with each other and their physical environment. Examples of natural communities in Nebraska include tallgrass prairie, Sandhills alkaline marsh, and western coniferous forest.

The inventory had two primary objectives: 1) to test the effectiveness of methods for conducting county-based natural-area inventories, developed in other Midwestern states, in the eastern Nebraska landscape; 2) to locate, classify, and evaluate natural areas of statewide and national significance in Pawnee County. Secondary objectives included: 1) to locate populations of rare plants and animals associated with the natural areas identified during the inventory and identify potential rare species habitat; 2) to collect ecological information that can be

incorporated into the Nebraska Natural Heritage Database and increase the effectiveness of the database in the environmental review process.

The information collected regarding natural areas during the inventory has been incorporated into the Nebraska Natural Heritage Database. Inclusion of the information in the database allows for efficient ranking of the natural areas for conservation purposes on a statewide and regional scale. The most significant sites can be targeted for registration with the Nebraska Natural Areas Register, conservation easements, or acquisition by public and private conservation groups. Incorporation of the information into the database makes it easily accessible to local, state, and federal government agencies and private consulting groups who use such information for making environmentally-informed planning decisions. The result is that the information gathered during this inventory, and any future county-based natural areas inventory, can be used in a variety of ways to preserve the biological diversity of Nebraska. This report summarizes the methodology and results of the inventory and presents recommendations for future systematic natural-area inventories in Nebraska.

STUDY AREA

Pawnee County, occupying 1,123 sq km (432 sq mi), lies within the Eastern Lowlands Region of Nebraska (Fig. 1). Underlying bedrock consists of Pennsylvanian and Permian formations primarily of limestone and shale. Glacial advances have left till and outwash deposits overlying most of the bedrock. Subsequent erosion has exposed the bedrock in valleys. Wind-deposited loess occurs as a thin mantle overlying the glacial deposits on many of the ridgetops. The topography is characterized by rounded ridges, intervening hillsides, and entrenched drainageways, with relief varying from nearly level to very steep (Sautter, 1976). Drainage is to the southeast; the primary rivers are the North Fork and South Fork of the Big Nemaha River.

The majority of upland soils are formed in glacial till and loess, and to a lesser extent in limestone and shale (Sautter, 1976). Lowland soils are formed in alluvium and colluvium. Soils are mainly silty and clayey; very few soils are sandy.

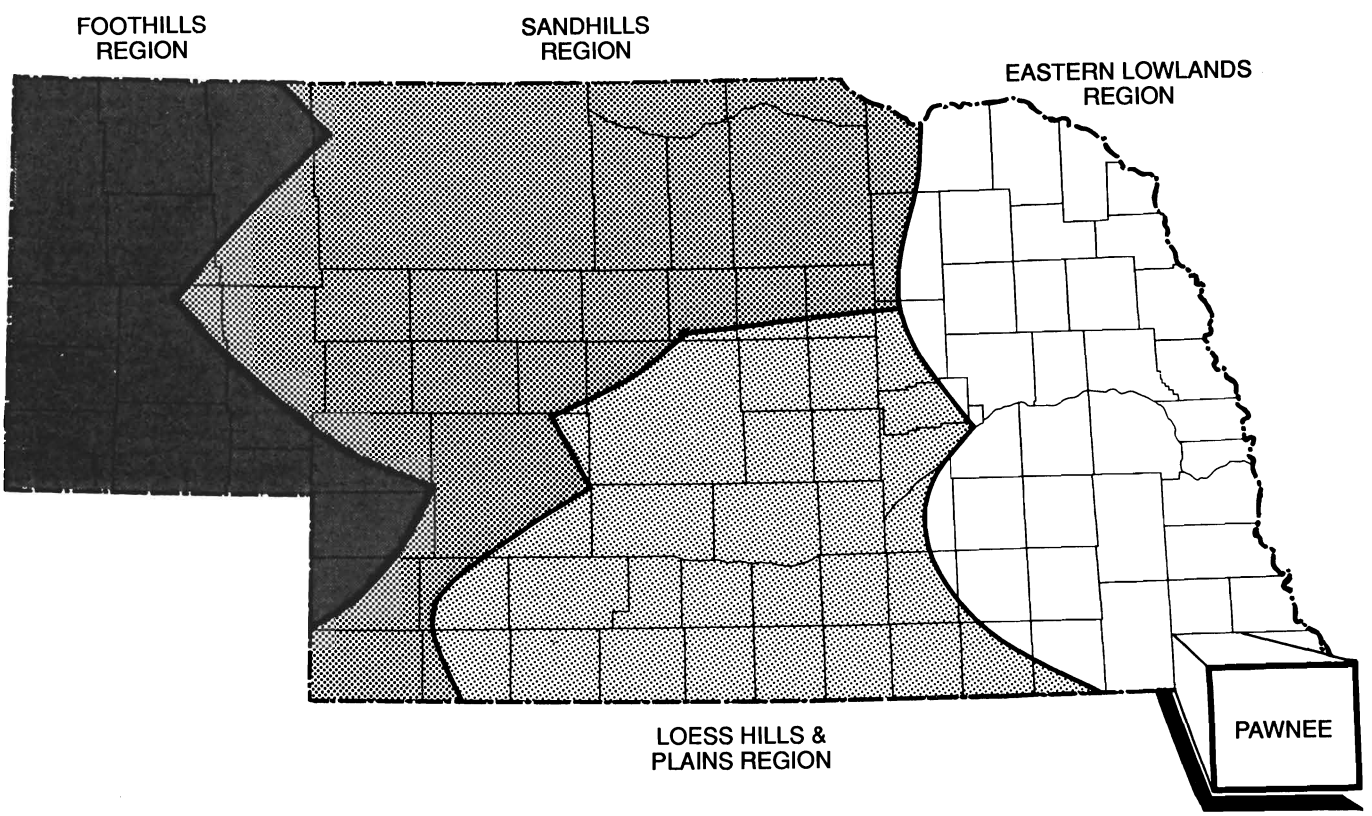

Figure 1. Natural regions of Nebraska, from Clausen et al. (1989).

The climate is continental and is characterized by extremes in temperature and frequent changes in weather. Tornados, thunderstorms, hailstorms and blizzards occur occasionally. Mean annual precipitation is 74–84 cm (29–33 in), the majority occurring between April and September (Elder, 1969). The mean length of the frost-free period is slightly less than 180 days.

Presettlement vegetation of Pawnee County consisted primarily of tallgrass prairie on uplands. Deciduous forest occurred on valley slopes of major streams and to a lesser extent on adjacent uplands. Lowlands (floodplains) were dominated by wet-mesic and wet prairies, freshwater marshes, and deciduous floodplain forests.

The first settlers arrived in Pawnee County after the Kansas Nebraska Bill opened the area to settlement in 1854. Increased settlement occurred after the passage of the Homestead Act in 1862. Since settlement, the landscape and natural veetation of Pawnee County has undergone drastic changes. By the early 1900s, vast areas of native prairie were plowed and converted to cropland or fenced and heavily grazed; forests were logged, grazed, and cleared for cropland; and wetlands were drained and farmed. The major streams and rivers have been channelized and their banks stabilized, greatly altering the natural hydrology of the floodplain. Settlement also brought a halt to the natural disturbance processes, such as fire, large-scale bison grazing, and floods, that were important in maintaining the ecological integrity of the native landscape.

The population of Pawnee County in 1980 was 3,937 (Sasso, 1984) with an average of 3.5 people per square kilometer. As of 1977, Pawnee County consisted of 63,072 ha (155,790 ac) of cropland, 19,856 ha (49,045 ac) of rangeland, 16,836 ha (41,584 ac) of pastureland or hayland, 6,534 ha (16,139 ac) of woodland, and 6,222 ha (15,368 ac) of urban or other land-uses (Bose, 1977).

METHODS

Classification and ranking systems

The natural community classification for Nebraska developed by Clausen et al. (1989) was used to classify natural communities located during the inventory. This classification recognizes 4 basic categories of natural communities: terrestrial (upland), palustrine (wetland), lacustrine (lake), and riverine (stream). Lacustrine and riverine communities were not surveyed during this inventory. Each natural community identified by the inventory was evaluated and given an element-occurrence rank as defined by Clausen et al. (1989). Element-occurrence ranks reflect the degree of anthropogenic disturbance that has occurred in a community and how closely the community resembles its presettlement condition (i.e. the community's natural quality). Because this inventory sought relatively undisturbed communities, natural quality was an important factor in determining a site's significance and whether it was classified as a natural area. Natural communities were given 1 of 4 possible element-occurrence ranks: A-,B-,C-, and D-grade, or a combination of grades (e.g. AB or BC). Combination grades represent sites of intermediate quality (e.g. AB-grade sites were between A- and B-grade quality). A-grade communities were the highest quality and relatively undisturbed. D-grade communities were the lowest quality and severely disturbed. Sites harboring only D-grade natural communities or relatively small C-grade communities were not considered natural areas in this inventory. During the inventory, sites thought to have the potential for containing a natural community were referred to as a potential natural area (PNA).

Inventory procedures

A systematic methodology was followed during the inventory to ensure that the landscape within the study area would be thoroughly searched for natural areas. Color infrared photo analysis, aerial reconnaissance, and ground surveys (White and Madany, 1978) were used to identify, classify, and evaluate natural areas.

Color Infrared Photo Analysis—The first stage of the inventory involved examining U.S. Geological Survey (U.S.G.S.) National High Altitude Photography (NHAP) color-infrared photographs (film negatives) to identify PNAs. The photos, taken May 14, 1981, were 1:58,000 scale. Each mile section on a photo was systematically reviewed for PNAs. Previously identified natural areas were used as reference sites to aid in photo identification of PNAs. All PNAs identified on the photographs were mapped onto USGS topographic maps (7.5') and given an identification number. Brief notes describing the types of natural communities thought to occur on a PNA and possible disturbances were recorded for each PNA. PNAs ranging in size from 1–777 ha (2.5–1920 ac) were identified in this manner.

Aerial Reconnaissance—The second stage of the inventory involved low-level aerial reconnaissance. Four flights were flown during the fall of 1988 with a total flight time of approximately 6–7 hours. Flight transects followed county roads and included a total width of 3.2 km (2 mi). Observers were located on each side of the plane and were responsible for a distance of 1.6 km (1 mi) on their respective side. Brief notes on the quality of each PNA and disturbances present were recorded during the flights. If PNAs were observed to have been destroyed or contain major disturbances they were no longer considered PNAs and eliminated from further evaluation. Some PNAs were missed during the flights and others could not be adequately evaluated from the air (e.g. some forest stands and recently hayed grasslands).

Ground Surveys—Initial intentions were to ground survey all PNAs remaining after the aerial reconnaissance. However, due to limited manpower and time, this was not possible. Forty-five of the larger 8–40.5 ha (20–100 ac) PNAs thought to be A- or B-grade and some very large (>130 ha) C-grade PNAs were chosen for ground surveys during the summers of 1989 and 1990. Only PNAs where landowner permission was obtained were surveyed. A few PNAs where landowner permission was not received were partially surveyed from road right-of-ways.

During ground surveys, determinations were made whether to classify a PNA as a natural area. Determinations were based on the presence or absence and quality of natural communities on the site. If a PNA was rejected during this stage, it was surveyed only long enough to determine the rejection criteria. For sites determined to be natural areas, information was recorded on the types of natural communities present and their plant species, element-occurrence ranks, size, type and degree of disturbance, and boundaries. The information was recorded on a field form designed for the inventory. The locations of rare plants and animals observed during ground surveys were mapped on 7.5'-topographic maps and information on their populations recorded. Rare species were those considered rare by the NENHP (Clausen et al., 1989). All natural community and rare-species occurrences identified during the inventory were entered into the manual map and computer file of the Nebraska Natural Heritage Database.

Table I. Summary of PNAs, rejected PNAs, and confirmed natural communities during inventory stages.

PNA Status	Inventory Stage		
	Photo-analysis	Aerial reconnaissance	Ground survey[1]
Prairie			
PNAs	715	400[2]	361
Rejected PNAs	--	372	14
Confirmed Natural Areas	--	--	25
Forest			
PNAs	53	42	36
Rejected PNAs	--	9	--
Confirmed Natural Areas	--	--	6

[1]Only 45 total sites ground surveyed
[2]57 new PNAs identified

RESULTS

Color infrared photo-analysis identified 715 prairie PNAs and 53 forest PNAs in Pawnee County. Most prairie PNAs, 687 (96%), were on uplands, 28 (4%) were on lowlands. Twenty-nine (55%) forest PNAs were on uplands, 24 (45%) were on lowlands.

Of the 768 total PNAs identified from photo analysis, 399 (52%) were rejected as natural areas through aerial reconnaissance (Table I). Rejected prairie PNAs include 42 (6%) determined to be cropland, 55 (8%) exotic cool-season pastures, 275 (38%) grazed native prairie infested with exotic cool-season grasses or showing other disturbance. Fifty-seven prairie PNAs, not identified during photo analysis, were located during the flight transects. Of the 400 (48%) prairie PNAs remaining after the aerial reconnaissance, the status of 101 sites could not be judged accurately either because they were missed during the flights or they were recently-hayed grasslands which showed no distinct characteristics useful in evaluation.

Of the 53 forested PNAs identified during the photo analysis, 9 (17%) were eliminated during the aerial reconnaissance stage because of young age class structure or evidence of heavy grazing or logging. Forty-two forest stands remained as PNAs after the aerial reconnaissance.

A list of natural areas confirmed during ground surveys is presented in Table III. Of the thirty-nine prairie PNAs ground-surveyed, 25 were determined to be natural areas (Table II): 22 tallgrass prairies on upland sites and 3 wet-mesic prairies on lowland sites. The other 14 PNAs were rejected as natural areas because they were either 1) cool-season pastures, 2) native prairies heavily invaded by exotic cool-season grasses or weeds, or 3) reseeded warm-season grasslands. Six of the larger forest PNAs were ground-surveyed. All were classified as natural areas, three as eastern floodplain forest and three as southeastern upland forest. Of these six sites, only one 8 ha (20 ac) floodplain forest was ranked as a high quality (AB-grade) community. The other stands were ranked C-grade due to disturbance from overgrazing and logging.

Two rare-species populations were discovered during ground surveys, including three populations of western buckeye (*Aesculus glabra* var. *arguta*) growing in eastern floodplain forests and two populations of rattlesnake master (*Eryngium yuccifolium*) in tallgrass prairies. Rattlesnake master is known from only 2 other sites in the State. Also identified during the survey was a nesting colony of great blue herons (*Ardea herodias*) in several sycamore (*Platanus occidentalis*) trees within an eastern floodplain-forest. This is one of only two heron-nesting colonies known from southeastern Nebraska.

Table II. The number and average size of natural communities by community type ground-surveyed during the county natural areas inventory of Pawnee County, Nebraska.

Natural community	Number of sites	Average size (acres)	Total acreage
Tallgrass prairie	24	54[1]	2296
Wet-Mesic prairie	3	15	45
Eastern flood-plain forest	3	33	99
Southeastern upland forest	3	100	300
Total	33[2]		2740

[1]One large C-Grade 1000-acre prairie was not figured in the calculation, all other sites were ≥ BC-Grade.

[2]Since two sites contained more than one natural community, the total number of sites listed here exceeds the number of confirmed natural areas listed in Tables I and III.

DISCUSSION

Although Pawnee County proved to be a difficult county for an initial inventory, the methods used were effective in identifying natural areas in an eastern Nebraska landscape type. During photo-analysis, identification of high-quality prairies was difficult because of their resemblance to and interspersion among 1) lower-quality native prairies with an abundance of cool-season grasses, 2) reseeded warm-season pastures, and 3) cool-season pastures. Inexperience in identifying the tones and color patterns of the various grassland types was also partially responsible for the large number of lower quality (C-grade) prairies and cool-season pastures classified as PNAs during photo-analysis. A minimum-size restriction was not placed on PNAs, adding greatly to the number identified during the inventory. A minimum-size restriction of 4 ha (10 ac) may have been reasonable.

Several prairie PNAs missed during photo analysis were detected during aerial reconnaissance due to the distinct red-orange color of the dormant warm-season grasses that dominated such sites at the time of the flights. Aerial reconnaissance was also effective in eliminating 52% of the PNAs originally identified during photo analysis. Photos used in the photo analysis were taken in May, 1981. Flight transects were flown in 1988. During the period between 1981 and 1988, land use changed on many of the PNAs (e.g. conversion to cropland or initiation of livestock grazing) resulting in the large number of rejections as natural areas. Rejected areas included: 1) cropland, identified by the presence of crops, crop residue, or plowed soils; 2) exotic cool-season dominated pastures, identified by the greenish tone of the actively growing cool-season grasses; and 3) grazed native prairies identified by the presence of cool-season grasses, cattle trails, and tree and shrub encroachment. Aerial reconnaissance was not particularly effective in identifying disturbance in forested PNAs. Flights were conducted prior to leaf-fall, making identification of understory disturbance (i.e. grazing) and trunk diameter (for determining

Table III. Natural areas identified during the Pawnee County natural-area inventories, with natural community-types and rare species.

Natural area name	Township/ Range	Sec.	Natural community/rare species	Size (ha/ac)	EO RANK
Billys Prairie	2N/11E	17	Tallgrass prairie	16/40	BC
Blecha Prairie	2N/11E	7	Tallgrass prairie	16/40	BC
Blecha Prairie	2N/11E	7	Wet-Mesic prairie	2.4/6	BC
Branek Prairie	3N/11E	15	Tallgrass prairie	10/25	BC
Buckeye Woods	1N/10E	12	Southeastern Upland Forest	24/60	BC
Buckeye Woods	1N/10E	12	*Aesculus glabra* var. *arguta*		
Burchard Lake WMA-Site	2N/10E	4	Tallgrass prairie	140/350	BC
Cold Point Prairie	2N/11E	16	Wet-Mesic prairie	6/15	B
East DuBois Forest	1N/12E	25	Eastern Floodplain Forest	12/30	C
Elk Creek Bluffs	3N/11E	6	Southeastern Upland Forest	12/30	BC
Elk Creek Bluffs	3N/11E	6	Tallgrass prairie	12.4/31	BC
Friendly Horse Prairie	1N/10E	28	Tallgrass prairie	4/10	BC
Grey Sky Prairie	3N/10E	01	Tallgrass prairie	22/55	AB
Grey Sky Prairie	3N/10E	01	*Eryngium yuccifolium*	0.4/1	
Hedge Prairie	3N/11E	07	Tallgrass prairie	20/50	BC
Hidden Prairie	2N/10E	33	Tallgrass prairie	9.2/23	AB
Lonesome Cow Prairie	2N/9E	26	Tallgrass prairie	30/75	C
Lores Branch Forest	1N/12E	21	Southeastern Upland Forest	84/210	BC
Mulberry Prairie	2N/11E	21	Tallgrass prairie	20/50	AB
Needlegrass Prairie	1N/10E	16	Tallgrass prairie	11.2/28	B
Nenzil Hill Prairie[1]	3N/10E	1	*Eryngium yuccifolium*		
Pawnee Prairie WMA-Site	1N/10E	20	Tallgrass prairie	400/1000	C
Plum Prairie	3N/11E	10	Tallgrass prairie	4/10	B
Puhalla Prairie	2N/11E	7	Tallgrass prairie	52/130	AC
Quail Prairie	2N/11E	8	Tallgrass prairie	32/80	B
Rain Prairie	3N/9E	8	Tallgrass prairie	6.8/17	BC
Salem Prairie	3N/10E	1	Tallgrass prairie	8/20	B
Schultz Prairie	3N/10E	12	Tallgrass prairie	20/50	B
St. Anthony's Prairie	3N/11E	20	Tallgrass prairie	16/40	B
St. Peter's Prairie	3N/11E	3	Tallgrass prairie	21.2/53	BC
Stateline Forest	1N/12E	34	Eastern Floodplain Forest	10/25	AB
Stipa Prairie	3N/9E	32	Tallgrass prairie	2.4/6	AB
Table Rock WMA Prairie	3N/12E	34	Tallgrass prairie	6/15	AB
Turkey Creek Bottoms	2N/11E	5	Wet-Mesic Prairie	10/25	BC
Turkey Creek Bottoms	2N/11E	5	*Aesculus glabra* var. *arguta*		C
West DuBois Forest	1N/12E	26	Eastern Floodplain Forest	18/45	C
West DuBois Forest	1N/12E	35	*Aesculus glabra* var. *arguta*	6/15	C
Wolf Prairie	3N/9E	22	Tallgrass prairie	14/35	—

[1]This site was not classified as a natural area.

forest age structure) difficult. Aerial reconnaissance of forest stands would have been more effective after leaf fall. The use of a low-winged aircraft caused some problems in evaluating PNAs obstructed from view by the wings.

Limited manpower prevented ground surveys of all PNAs remaining after aerial reconnaissance. Only PNAs thought to have the greatest potential for conservation action were ground-surveyed.

Natural areas in Pawnee County now occur as scattered remnants in a landscape dominated by cropland, exotic cool-season dominated grasslands, roads and other human developments. Four natural community types were identified in Pawnee County: tallgrass prairie, wet-mesic prairie, southeastern upland forest, and eastern floodplain forest. Tallgrass prairie and southeastern upland forest occur on uplands, while wet-mesic prairie and eastern floodplain forest occur on lowlands (floodplains). Natural areas are composed of one or more natural community types. For example, a tallgrass prairie adjacent to a stand of southeastern upland forest was considered as one natural area.

Tallgrass prairie was by far the most abundant natural community type identified during the inventory. This was expected, considering the majority of uplands in Pawnee County were dominated by tallgrass prairie prior to settlement and the majority of the fertile lowlands have been converted to cropland. The majority of higher quality (A- to B-grade) tallgrass prairies were small (<16 ha) haymeadows. The larger prairies were usually grazed, lower quality (BC- to CD-grade) sites, many with a history of overgrazing. The disturbance of overgrazing reduces the native-species diversity of prairies and leads to exotic cool-season grass and weed invasion. C- or D-grade prairies were not classified as natural areas with the exception of extremely large (>130 ha) C-grade prairies. The large size of the prairies adds to the ecological value of the prairie and compensates somewhat for the higher level of disturbance.

Wetland natural communities are extremely rare in Pawnee County. Drainage and conversion of lowlands to cropland has destroyed the majority of wetlands. Stream channelization and bank stabilization have greatly altered the natural hydrology, further degrading the quality of remaining wetlands. The 3 wet-mesic prairies ground surveyed were all <25 acres as were the other prairie PNAs on lowland sites.

Forested communities in Pawnee County are restricted to river floodplains and bluffs and adjacent uplands. When comparing 1965 U.S.G.S topographic maps to 1981 NHAP color infrared photos it is evident that much floodplain forest has been cleared and converted to cropland in the intervening time period. Upland forests have experienced less clearing. Of the six forest stands ground surveyed, only one high quality stand, an AB-grade 8 ha (20 ac) stand of eastern floodplain-forest, was identified during the inventory. Other ground surveyed stands were either of young age structure or disturbed from grazing or logging.

Though detailed rare-species surveys were not conducted, populations of two rare species were found during the inventory. All identified natural areas are potential rare plant-and-animal habitat. A number of the tallgrass and wet-mesic prairies identified are potential habitat for the western prairie white-fringed orchid (*Platanthera praeclara*), a federal- and state-threatened species.

Three natural areas identified during the inventory occur on wildlife management areas owned and managed by the Nebraska Game and Parks Commission. Other natural areas are of the quality to consider conservation actions, including registration, conservation easements, and acquisition by either public or private conservation groups. The general thinking of many ecologists is that large preserves or complexes of many small preserves have a greater long-term viability than isolated small preserves. Pawnee County contains numerous small prairie tracts. Consideration should be given to designing a tallgrass prairie preserve complex for the county.

FUTURE NATURAL-AREA INVENTORIES

Knowledge of the location of natural areas and the community types and rare species they harbor is necessary to effectively plan for the conservation and management of Nebraska's natural diversity. Without this information, which is severely lacking at the present time (Clausen et al., 1989), many of Nebraska's best natural areas may be unknowingly destroyed. Other Midwestern states have found county-based natural areas inventories an effective method of gathering such information (Lauver, 1989). Data collected during county inventories can be incorporated into the Nebraska Natural Heritage Database, furthering its usefulness in conservation planning.