BLUESTEM PRAIRIE

MANAGEMENT PLAN

Section 15,
E½ of Section 22,
W½ of Section 23,
and portions of SE¼ of Section 10, south of the Buffalo River
Township 139 North, Range 46 West
Downer Quadrangle
Riverton Township
Clay County
Minnesota

MINNESOTA CHAPTER

THE NATURE CONSERVANCY

AND

SCIENTIFIC AND NATURAL AREAS PROGRAM

AUGUST 1981

Draft Copy

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Scope and Organization of the Management Plan

The purpose of this management plan is to outline the longterm goals and specific actions to be used in management of Bluestem Prairie. A major information source used in preparation of the plan was the 1980 preserve inventory, a cooperative project of the Minnesota Department of Natural Resources and The Nature Conservancy which described and documented the site's physical and biological resources. Other sources included scientific literature, preserve files at The Nature Conservancy, and personal communication with persons who have worked on or studied the preserve and experts in various fields.

The introductory section of the management plan provides a brief summary of the preserve's most significant resources, a concise, comprehensive management goal for the preserve (the "unit goal"), an outline of general management objectives, and finally a summary of the specific actions themselves. A note on review of the plan concludes this section.

The central section of the plan contains the actions and descriptions of their justification and suggested methodologies. The actions are divided into two categories: resource management actions, which are concerned mainly with proper stewardship of the resources themselves, and use management actions, which regulate and inform human users of the tract.

Following the actions are sections concerning recommended boundary adjustments (areas to be acquired or otherwise given protected status), a tentative arrangement of actions in priority groups, and a list of

literature sources used in preparation of the plan. Figures and appendices follow; the appendices cover a variety of subjects including management policy and methodologies.

Most Significant Resources

Bluestem Prairie is a 1200 acre tract of grassland in Clay County adjacent to Buffalo River State Park. One of its most important characteristics is the diversity of its plant communities; over 300 plant species are known from the tract, and it includes wet prairie, sedge meadow, fen-like areas, mesic tallgrass prairie, and dry upland prairie. This diversity is partly accounted for by the presence of 21 different soil series in the preserve, as well as the topographic features of the Campbell and Norcross strandlines of glacial Lake Agassiz. In turn, the diversity of plant communities supports a much greater variety of animal species than can be found on more homogeneous preserves; for example, 70 species of birds were recorded during the 1980 inventory. Another valuable characteristic of Bluestem Prairie is its size; it is one of the very few prairies left in Minnesota where a visitor can sense some of the vastness of the sea of grass that once covered western Minnesota, and where one can look over a grassland vista in which man's influence is quite inconspicuous.

The preserve supports a number of rare plants and animals, including the greater prairie chicken, a threatened species in Minnesota (Minnesota Natural Heritage Program 1981). Parts of Bluestem Prairie are used as booming grounds by the prairie chickens, and it also provides nesting and loafing habitat for these rare birds. Other unusual birds which may nest on the preserve are the eastern meadowlark (Sturnella magna, on the western edge of its range at Bluestem Prairie); Henslow's

sparrow (Ammodramus henslowii, classified as rare by the Minnesota Natural Heritage Program 1981), and upland sandpiper (Bartramia longicauda, a species of special concern). In addition, the sandhill crane (Grus canadensis, threatened in Minnesota) migrates through the preserve, and its seasonal presence adds to the value of the tract. Rare mammals include the plains pocket mouse (Perognathus flavescens), prairie vole (Microtus ochrogaster), and northern grasshopper mouse (Onychomys leucogaster), all of which are classified as rare by the Heritage Program.

Bluestem Prairie's plant communities harbor three rare plant species. These documented rare plants are Carex scirpiformis Mackenz. (rare in Minnesota) (Minnesota Natural Heritage Program 1980), Tofieldia glutinosa (Michx.) Pers. (also rare), and Spartina gracilis (endangered in Minnesota). A number of botanists have studied the vegetation of the preserve; many of their observations of rare plants are undocumented, but their work suggests that about sixteen other rare plant species are probably growing on the preserve.

Besides its biological elements, Bluestem Prairie contains portions of two strandlines (beaches) of glacial Lake Agassiz, which once covered much of western Minnesota and eastern North Dakota. Since many miles of these and similar beachlines have been leveled or radically altered by gravel operations, the presence of these two unaltered beach ridges makes Bluestem Prairie a site of geological interest as well as biological value.

Unit Goal

The management goals for Bluestem Prairie are to maintain viable, diverse native prairie communities; to re-establish such communities where they have been disturbed; and to maintain populations of rare animals and plants described on pages 3 and 4, especially the greater prairie chicken. An additional goal is to provide an opportunity for people to learn about the prairie through interpretation, research, informal visits, and other forms of use where such use is appropriate and does not impair the quality of the preserve.

Management Organization

Management of this SNA will be a cooperative effort of the SNA Program, TNC and the Division of Parks and Recreation. Already TNC and Parks cooperate extensively, exchanging labor and equipment to carry out prescribed burns and other management activities. The SNA Program will assure that management actions on Bluestem SNA, both on TNC and Parks' lands, are consistent with the SNA management plan and policies. An annual work schedule will outline planned management activities and identify agreed upon responsibilities.

Management Objectives

The following management objectives were derived directly from TNC and SNA policy; the policy sources (Appendices A and B) are listed after each objective. The actions that will implement each objective are listed in abbreviated form on the right, along with a number referring to the Management Actions section.

Management objectives	Actions and action numbers
1. Re-establish fire (TNC policies 2,3a; SNA policy 3).	Prescribed burns (2) Conservation easements (23) Culverts (9)
2. Minimize damaging human impact (TNC policies 2,3b, 4,9; SNA policies 3,7,8, 15,16,17,19,22).	Wildfire containment (1) Ditches (4) Refuse removal (11) Parking (19) Gravel pile (3) Maintain fencing (20) Dead elms (5) Cottonwood removal (6) Culverts (9) Control booming ground access (21) Hiking trails (22,26) Herbicide study (18)
3. Monitor condition of preserve (TNC policies 1,2,3b,4; SNA policies 1,2,5,19,24).	Vegetation monitoring (15) Volunteer managers (24) Inspections (32) Annual report (35) Fen investigation (10) Rare species monitoring (16,17) Prairie invaders monitoring (7)
4. Minimize safety hazards to visitors (TNC policy 7; SNA policy 17).	Refuse removal (11) Parking (19) Maintain fencing (20)
5. Complete collection of base-line data (TNC policy 6; SNA policies 1,2,15b).	Plant collections (13) Rare plant search (14) Herpetological inventory (12) Fen investigation (10)

Management objectives	Actions and action numbers
6. Inform local citizens of the nature and features of the preserve (TNC policies 5,6; SNA policies 4,12,18).	Brochure (28) Field walks (29) School use (31) Registration box (34) Volunteer managers (24) Fen observation deck (25) Local meetings (37) Prairie chicken blinds (21) Local group contacts (27)
7. Maintain contact with resource professionals and educators (TNC policies 5,10; SNA policies 4,9,13, 14,15b,26).	Encourage research (30) Encourage school use (31) Professional contacts (27) C.O. contact (36) Monitor research (33)
8. Control non-native species (TNC policy 3; SNA policies 2,3,6c).	Control spurge (8) Prescribed burns (2)

Summary of Management Actions -- Bluestem Prairie

RESOURCE MANAGEMENT ACTIONS

1. Implement a wildfire containment program that will protect the prairie from damage by fire-fighting equipment.
2. Implement a prescribed burning program at Bluestem Prairie.
3. Reshape the gravel discard pile in the southwest quarter of Section 23 to blend in with surrounding topography.
4. Prevent filling or dredging of ditches on the preserve.
5. Leave standing dead elms along the Buffalo River within the proposed Scientific and Natural Area.
6. Fell cottonwoods and other large trees along the ditch that runs north-south through the center of Section 15.
7. Monitor populations of brome, leafy spurge, sweet-clover, willow, buckbrush, and aspen.
8. Control leafy spurge populations on the preserve.
9. Install culverts at perimeter drainage pathways to facilitate mowing of firebreaks.
10. Investigate the fen-like areas and their water regime, and restore natural drainage if necessary.
11. Remove refuse from the preserve.
12. Conduct a more thorough inventory of reptiles and amphibians on the preserve.
13. Complete collections for inventoried plant species.
14. Attempt to locate the rare plant species which have been reported to occur on or near Bluestem Prairie.
15. Monitor the plant community at Bluestem Prairie.
16. Monitor populations of rare animals at Bluestem Prairie.
17. Map and monitor populations of Tofieldia glutinosa, Spartina gracilis, and Carex scirpiformis.
18. Investigate herbicide use on cultivated fields adjacent to the tract.

USE MANAGEMENT ACTIONS

19. Develop a parking area for preserve visitors.
20. Maintain fencing and repair as necessary.
21. Control visitor access to prairie chicken booming grounds during booming season, and provide observation blinds.
22. Encourage hiking and cross-country skiing on the mowed firebreaks on the preserve.
23. Acquire conservation easements around the preserve.
24. Recruit local volunteer managers, preferably living within three to four miles of the tract.
25. Construct an observation deck at one of the fen areas (if appropriate).

26. Limit off-trail hiking on the river banks at the preserve's north edge.
27. Develop and maintain a close relationship with local and regional government officials, natural resource managers, community groups, and other appropriate people.
28. Develop a brochure on Bluestem Prairie and distribute it to users, Buffalo River State Park visitors, interested neighbors, and other interested groups.
29. Conduct guided field walks on Bluestem Prairie.
30. Encourage nondestructive research on Bluestem Prairie.
31. Encourage local middle and secondary schools and regional higher education institutions to use the site for field trips, if appropriate.
32. Periodically inspect the site.
33. Maintain close contact with all scientists who are using the site for educational purposes.
34. Erect a registration box and maintain the box and its supplies.
35. Submit an annual written report to TNC and the SNA program.
36. Contact the local DNR conservation officer (C.O.) and request his or her assistance in managing the site.
37. Hold periodic meetings for the local residents.

Review of the Plan

The actions outlined in this plan must be considered provisional, not definitive, and should be reviewed periodically to see that they are still relevant in light of current conditions. Changes in the site's resources, users, and other management considerations are bound to occur. If warranted, the plan's management actions can and should be modified so that they more effectively and/or efficiently implement TNC guidelines and SNA policies (if appropriate). All proposed actions should be primarily directed at protecting and preserving elements which are a significant part of Minnesota's natural diversity. In any event the plan should be thoroughly reviewed and updated at intervals of no longer than every ten years.

1. Implement a wildfire containment program that will protect the prairie from damage by fire-fighting equipment.

At Bluestem Prairie, wildfire containment is especially important because of the proximity of many acres of flammable pasture land. The wildfire threat to this neighboring land should be minimized, preferably using techniques which anticipate wildfire danger rather than responding to emergency situations. Emergency responses can be destructive to the prairie, both through the use of heavy vehicles on the preserve and because of sod-breaking firebreak construction techniques. For example, in October 1978, a wildfire starting northwest of the preserve burned 445 hectares of the prairie. Control of the fire resulted in some damage to the prairie in the form of disked and plowed firebreaks (Fig. 1, page 61). To prevent further damage from wildfire containment and to protect neighbors from property damage, The Nature Conservancy constructed mowed-and-burned firebreaks around the entire perimeter of Bluestem Prairie in 1980. These firebreaks should be reconstructed each year. Possible procedures for their construction include mowing and burning, disking, plowing, and stripping sod. Fire retardants may be used in combination with mowing. Disking, plowing, and sod stripping are undesirable, although effective, because exposure of bare prairie soil will lead to weed invasion.

Whatever break-construction technique is used, care should be taken to avoid populations of rare plants, especially the Spartina gracilis occurrence on the west boundary of the SW 1/4 section 15. Even a mowed

break should be routed to go around this and other rare plant occurrences. (Another Spartina gracilis occurrence may be found on the west side of the east half, section 22; similar precautions should be taken there.) In addition, firebreaks should meet the following criteria whenever possible: they should be placed on high, dry ground to facilitate access and minimize damage to prairie sod; and they should cross plant community boundaries and should separate occurrences of a given rare plant species, since different treatment within a community or species population ehances diversity and lessens the chances of eliminating an entire species from the preserve.

If the perimeter firebreaks are wide enough and properly maintained, wildfire will probably not spread to adjacent land. Local fire authorities should be contacted annually (see also Action 27, page 43) to request that they refrain from running vehicles on the prairie to control wildfire except in extreme conditions when perimeter breaks are inadequate for the task. If a wildfire threatens to jump the break (e.g. at a narrow point in the break, or late in the season after regrowth of a mowed break) control efforts should be directed at the preserve's edge where the fire is likely to cross its boundary. In such a case, breaks should be burned or fire retardant applied; plowing or disking should not be used except as a last resort, and then only on the perimeter of the prairie. If it appears necessary to control a wildfire in the preserve's interior (e.g. if winds are high and unpredictable and perimeter breaks are clearly inadequate), fire

retardant and burned breaks should again be used in preference to the destructive methods of plowing and disking.

Once the danger of wildfire spreading onto adjacent property is past, or if there is no such danger to begin with, the fire should be allowed to burn itself out. Local fire officials, neighbors, and the local volunteer manager should be kept aware of this policy. They should be provided with names and telephone numbers of the volunteer manager and TNC and SNA personnel concerned with fire management to speed notification in case of wildfire.

2. Implement a prescribed burning program at Bluestem Prairie.

Fire is a natural part of the prairie ecosystem. It occurred frequently in Western Minnesota grasslands before white settlement Curtis 1959; Dubenmire 1968) and prairie plants evolved in response to its frequency. Prescribed burning allows these fire-adapted species to retain dominance over certain exotic species. It helps to maintain the open character of the prairie by suppressing growth of woody species, and restores old fields and other disturbed areas. Fire removes built-up fuel, consequently reducing wildfire hazard to adjacent lands and ehnancing nutrient cycling. In addition, it improves the habitat for certain animals.

At Bluestem Prairie, fire will play an important role in management. On such a large preserve, use of fire is more practical than are more labor-intensive management practices like hand weeding and

seeding of desirable species. Goals of fire management at Bluestem Prairie are maintenance of native species populations (especially a diversity of forbs and warmseason grasses, both of which suffer through lack of fire), control of sweetclover and other exotic species, and control of woody species like willow, buckbrush (Symphoricarpos occidentalis or wolfberry), and aspen.

Prescribed burning at Bluestem Prairie began in 1977, when staff at Buffalo River State Park lit a prescribed fire on the park land in the north half of the northeast quarter of section 15. A wildfire burned most of the preserve in 1978; in 1981 the second prescribed fire burned the southeast and southwest quarters of section 15 (Figure 1, page 61).

During the first stages of fire management at Bluestem Prairie (including the 1981 burn), emphasis will be on maintaining a recovery phase schedule for all areas on which burning has been initiated. The recovery phase must include three consecutive spring burns or suitable alternatives; if a year is skipped, sweetclover may appear in large numbers that spring. Alternatives to the three-year recovery phase include summer mowing and summer burning; the timing of these alternatives is tricky and very important. Advice on sweetclover management is found in Appendix G, page .

Second priority during the first few years of fire management will be on getting the whole preserve into a fire rotation. Achievement of this goal will necessarily be slow because of the necessity of burning each new unit for three consecutive years. Personnel and time

limitations will determine how large an area can be burned each year and thus whether new units can be added to the fire program in a given year.

A detailed burning plan for Bluestem Prairie has been prepared for the Buffalo River State Park Management Plan (DNR 1980). This schedule uses irregularly-shaped burn units of about 200 acres and variably timed spring and fall burns. It will serve as a flexible model for a maintenance-phase burning program at Bluestem after completion of the early, recovery phase described above. For the sake of achieving the early phase goals (three years of consecutive burns and rapid inclusion of the whole preserve into a fire program), burn units during the first few years may be larger than 200 acres, and fire breaks may not necessarily follow the pattern described in the state park plan. However, the fire plan that is finally used should meet the criteria below. Fire management units should cross plant community boundaries and should separate occurrences of rare plant species when possible, since different treatments within a community or population enhance diversity and minimize chances of eliminating a small rare-species population. Firebreaks should be placed on high, dry ground to avoid damage to wet sod. Fire plans should take account of sweetclover populations; considerable experimentation in different combinations of summer burns, summer mowing, fall mowing, and early and late spring burns may be necessary to find a combination that will keep this aggressive biennial in check.

Some old haystacks are found on Bluestem Prairie (Figure 2, page 62). Since these haystacks are good sites for invasion of weedy plants, they should be removed. Prescribed burns are a good opportunity to burn out the old stacks. Large stacks should be allowed to burn around the edges each year to gradually reduce their size (burn crews should be careful to extinguish the smoldering bales after each burn); smaller haystacks should be spread out and thoroughly burned.

3. Reshape the gravel discard pile in the southwest quarter of section 23 to blend in with surrounding topography.

The 1974 gravel extraction operation in the southwest quarter of section 23 left a discard sand and gravel pile about 20 meters tall (Figure 2, page 62). This pile is visually intrusive on the otherwise rolling prairie; because of its steep slope and coarse material, it is bare of vegetation and probably will remain so for years. Its presence detracts from the aesthetic pleasure of the prairie, and it should be recontoured.

After extraction of the gravel, a small depression remained which is now an intermittent pond. This pond supports certain species which would not naturally be found on this area of the preserve, and probably concentrates deer populations in the area. Since the purpose of the preserve is to maintain the original native grass prairie, this pond should be filled with the material from the discard pile during the process of levelling. According to TNC policy, management will "maintain

or restore selected plant communities as near as possible to the conditions they would be in today had natural processes not been disrupted." SNA policy, too, advises the removal of "existing developments ... unless they are unobtrusive and not detrimental to the purposes for which the area was designated ..." The excavated pond disrupts natural drainage patterns and affects the water balance on the surrounding prairie. It may also serve as a location for invasion of some species that would not otherwise become established on the prairie. It is also a visual intrusion on an area of prairie that does not normally have ponds of this sort.

Once the gravel pit area is restored to more natural contours, reseeding with native species would be desirable. Due to the material's sandy texture, it may be difficult to establish nonweedy native species. Seeding with an annual cover crop may help prevent colonization of the area by weeds which could spread onto adjacent native grassland.

4. Do not modify ditches on the preserve.

These ditches, such as the one running north-south through the center of section 15, have replaced natural drainageways. However, they prevent flooding of adjacent farmlands, and filling them could create water balance problems for neighbors. The process of filling or dredging the ditches would disturb vegetation along their banks and would expose large areas of fresh dirt, inviting invasion by weeds. Dredging would dry out the prairie and alter plant community composition.

For these reasons the ditches should be left in their present condition.

5. Leave standing dead elms along the Buffalo River within the proposed scientific and natural area.

The Buffalo River State Park plan calls for removal of dead elms along the river at the north edge of the proposed SNA. These trees provide valuable wildlife habitat; although they may pose a slight safety hazard to preserve users, standing dead trees are a natural part of the riverine forest ecosystem. A more appropriate alternative, allowing both preservation of the natural system and elimination of major safety hazards, is to remove only those branches of dead trees that seem likely to fall on heavy use areas.

6. Fell cottonwoods and other large trees along the ditch that runs north-south through the center of section 15.

These trees are visually intrusive on the rolling prairie especially since they form a straight line. Under natural conditions on the prairie cottonwoods would be found along meandering river floodplains, but not along a minor drainage like this ditch. Many are dead or dying in 1981; as they fall naturally the open vista will gradually be restored. However, faster removal is desirable for the sake of the preserve's aesthetic value. These dead trees should be cut on a short length of ditch at a time so that they fall into the ditch; the wood should not be removed, since use of heavy equipment would be necessary and would damage

the prairie. The live trees should be girdled to kill them; over the years they too can be cut to fall into the ditch. In order to minimize disturbance, only short lengths of ditch should be cleared each year. As of 1981, personnel from Buffalo River State Park are starting to remove some of the trees from the north half of the ditch; the park's cooperation should be sought in further work as well.

7. Monitor populations of brome, leafy spurge, sweetclover, willow, buckbrush, and aspen.

All of these species tend to invade native prairie; brome, leafy spurge and sweetclover are exotic, while the others are native woody species which move into unburned and unmowed prairie. Monitoring is desirable to determine population status (increasing versus decreasing) and to evaluate success of management programs.

Of the above species, the greatest threats to the prairie are from sweetclover (Melilotus spp.) and leafy spurge (Euphorbia esula). Suggested monitoring techniques for spurge are described in action 8 (control of spurge, page 21. Similar techniques can be used for sweetclover, including permanent marking of size and location of selected sweetclover patches, and measurements of frequency (Appendix F1) and/or absolute density. Notes should be kept on its phenology, since sweetclover is biennial and management techniques depend on whether a given area is dominated by first-year or second-year plants (see action 2, page 13). Since there are many patches of sweetclover on the preserve, monitoring may be conducted on a few representative areas.

For willow and aspen, a combination of aerial infrared photo monitoring and ground level field work would serve best to determine population changes. Aerial photos for 1962 (black and white) and 1976 (color infrared) indicate slight increases in extent of woody vegetation over that 14 year period, noticeable on the eastern edge of the southwest quarter of section 15 (next to the ditch). Aerial infrared photos will serve to indicate major changes in extent of woody vegetation, but they can not show small changes, nor can they indicate changes in density within a woody patch. Therefore, permanent ground markers and a cover-analysis method like point-quarter transects (Appendix F3) should be used in addition to aerial photos. After a prescribed burn, observations should be recorded and markers placed to show the extent of top-kill or total kill of woody species, and followup observations during subsequent seasons will indicate the success of fire management.

Since there are many woody patches on Bluestem Prairie, monitoring of each would be impractical. A few representative patches in burn rotation areas should be monitored, and aerial photos used to estimate changes in the others.

Brome grass (Bromus inermis) is found in the plowed area of the southeast quarter of section 22, in the manured area of the northeast quarter of section 22, and in patches in the southwest 1/4 of section 15. This introduced rhizomatous species tends to form a continuous sod and is a threat to the native plant community. Extent of representative brome patches should be marked and size and density of the patches

monitored from year to year to determine whether the brome sod areas are expanding or retreating. If possible, separate patches in portions of the prairie under different management practices should be monitored for comparison (true for brome as well as for other species of concern).

8. Control leafy spurge populations on the preserve.

Leafy spurge (Euphorbia esula) has invaded the prairie in the northwest quarter of section 23, near the fence line on the east side, and other populations are reported from the west side, E 1/2 Sec. 22, and the NW 1/4 Sec. 15 (Figure 3, page 63). Since this plant is a state-classified noxious weed, spreads rapidly, and is difficult to control, it is important to begin attempts at its elimination soon. First, permanent markers should be placed on the fence row or in the ground to mark the size and position of the current infestation; density of the spurge should be determined systematically, e.g. by using quadrats along a transect between two points which can be accurately relocated in subsequent years. Depending on the amount of spurge present, the quadrats may be used for either frequently (Appendix F1) or absolute density measurements. The size of the spurge population should then be traced from year to year by noting changes in its areal extent and frequency or density.

Little is known about control of spurge. Herbicides such as Round-up and Tordon are frequently used; repeated mowing may also help to eliminate the species by depleting its reserves. If time and personnel

are available, experimentation on control techniques for spurge would be desirable, since herbicides are inappropriate on a natural area. Numerous clones of spurge are available at Bluestem Prairie and other TNC preserves; some could be mowed every month, some more frequently, and some less often. If herbicides must be used due to time limits or ineffectiveness of other control methods, hand application (using a wick and touching each individual plant, or using a herbicide which translocates through the root system) should be used to prevent damage to other species. Herbicides should be as specific as possible. Results of any control-method experimentation should be kept on file and used in determination of appropriate techniques for use on this and other preserves.

9. Install culverts at perimeter drainage pathways to facilitate mowing of firebreaks.

Several drainageways cross the preserve boundaries, making mowing of perimeter firebreaks difficult in spring. Culverts need to be installed at four of these drainage pathways (Figure 2, page 62). Although installation of culverts will cause some disturbance, it will be beneficial in the long run since use of a tractor and mower on these wet areas would otherwise damage the sod repeatedly. Before beginning construction, the sites should be searched for rare plants, and alternative sites chosen if rare plants are found. During installation, sod should be saved if possible and replaced to minimize weed invasion at the culvert sites.

10. Investigate the fen-like areas and their water regime, and restore natural drainage if necessary.

Two areas, one on the west edge of the southeast quarter, section 22, and one on the east edge of the southwest quarter, section 23, appear to be fens (Figure 3, page 63). These sites should be visited by a person with knowledge of fens, and their vegetation should be documented. Two particularly rare species, Triglochin palustris and Oxypolis rigidor, may occur in the areas and should be searched for. If one of the areas is determined to be a good example of a fen, an observation deck should be construction (Action 25, page 42).

A drainage tile (or possibly two) emerges from the fen area on the west side of the preserve (SE 1/4 section 22), and empties into a ditch just across the fenceline. The ditch and the tile have probably influenced water levels in the fen by speeding outflowing drainage. Although the visible tile is currently plugged (1981), someone who has knowledge of fens and their hydrology should examine the site and determine possible benefits of filling the ditch. If such a measure appears desirable, the landowner should be contacted and the action requested, or permission should be requested for TNC or the SNA program to take the action.

11. Remove refuse from the preserve.

Garbage (old fence wire, cans, bottles, etc.) has been dumped on the preserve in two places. One dump is on the north edge of the

northeasternmost aspen stand in the southeast quarter of section 15, and the other is located in the northwest corner of the northeast quarter, section 22 (Figure 2, page 62). Both trash piles should be removed, as they detract from the preserve's aesthetic value and user safety.

12. Conduct a more thorough inventory of reptiles and amphibians on the preserve.

The 1980 inventory used a drift fence to capture reptiles and amphibians, but it was not set up until July, and was entirely unsuccessful. A spring starting date (late April through early June) is likely to improve results from the drift fence. Amphibians and reptiles breed, congragate, and move about from hibernation sites to summer habitat most actively in the early spring, and they are easier to locate and identify in their vocalizations at that time. In early fall, too, herps are active as they move back to hibernation sites. Drift fences would be useful at this time (mid- to late September) as well as in the spring.

Location of drift fences is important. A few mima mounds are found on Bluestem Prairie (inventory, page 27); such mounds are often used as hibernation sites for amphibians and reptiles. To increase chances of capturing herps on the preserve, drift fences should be placed in rings around likely mima mounds. Openings in the drift-fence circles, and funnel traps below the openings, should be near low, wet areas toward which herps move in the spring. Abandoned ant hills

are also used as hibernation sites by herps, and if large ant hills can be found on Bluestem Prairie, they would also make good drift fence locations.

13. Complete collections for inventoried plant species.

Of the plant species recorded by the 1980 inventory team, all but nineteen were deposited as voucher specimens. Vouchers for these nineteen (listed below) should be collected at the preserve and deposited at the University of Minnesota herbarium (St. Paul campus). The specimens will be useful for verification of species identification and for systematic placement of the plants in the event of taxonomic revision.

Collections of rare plants should be made with regard to the size of the species' population. Although none of the species listed below are considered rare in Minnesota, some rare plants are expected to be found on the prairie (Action 14, page 26). If at the time of collection these species' populations are small, collection should be limited to one sample of those plant parts necessary for species identification -- for instance, one flower or one shoot.

Plant species observed but not collected at Bluestem Prairie:

Acer saccharum	Equisetum laevigatum
Ambrosia artemisiifolia	Euphorbia esula
Amorpha canescens	Galium boreale
Artemisia frigida	Medicago sativa
Aster junciformis	Oenothera biennis
Astragalus crassicarpus	Plantago eriopoda
Cirsium arvense	Pycnanthemum virginianum

Quercus borealis	Solidago gigantea
Rosa suffulta	Sporobolus heterolepis
Solidago altissima	

14. Attempt to locate the rare plant species which have been reported to occur on or near Bluestem Prairie.

A number of rare plant species are likely to occur on Bluestem Prairie. The species, each with its status as classified by the Minnesota Natural Heritage Program (1980) are described below.

Oxypolis rigidior (endangered) and Triglochin palustris (rare) are fen species which should be searched for during investigation of the fen-like areas (Action 10, page 23). Carex hallii (threatened) is often found in association with Carex scirpiformis, which is documented from calcareous swales at Bluestem Prairie. Orobanche fasciculata (rare) is an epiphyte on sage roots and was documented on the preserve in 1947; its persistence there should be verified. Calamagrostis montanensis (rare) and Helianthus nuttallii spp. rydbergii (rare) were collected on the prairie in 1962 and may still occur there; C. montanensis is found on dry, sandy habitat and H. nuttallii prefers moist, often sandy areas. Other rare species reported on or near the preserve, but not documented, include:

Astragalus flexuosus Dougl.
Antennaria aprica Nutt.
Carex obtusata Lilj.
Chamaernodes nuttallii Pick.
Helictotrichion hookeri
Juncus gerardi Loisel.
Mirabilis linearis
Monolepis nuttalliana (Schultes) Greene.

Orobanche ludoviciana Nutt.
Poa arida Vasey
Puccinellia nuttalliana (Schultes) Hitchc.
Rumex occidentalis Wats.
Triglochin palustris L.

15. Monitor the plant community at Bluestem Prairie.

Changes in vegetation can significantly affect the quality of a preserve as a whole. Monitoring can help give advance warning of changes and, if the changes are undesirable, allow management actions to be taken before the changes become irreversible. A minimal level of monitoring consists of ground photo points to be photographed yearly; such photo points were set up in 1980 on Bluestem Prairie, and are located at all four corners of each releve plot facing the center of the plot. Aerial color infrared should be taken every five years; the first set was taken in 1976. Time and personnel limitations will determine the extent of further monitoring. Releve plots set up during inventory will serve as a basis for developing a more objective and sensitive monitoring system. Criteria for selection of techniques shall include objectivity, limited observer bias, efficiency, sensitivity to changes, and statistical validity. For example, a statistically adequate number of quadrats could be placed at random points within the largest available areas of each plant community (perhaps centered around a releve plot) and frequently recorded for all species present (Appendix F1). An alternative requiring less time would be to record frequency only for dominants and a few other indicator species; this method would indicate

major changes in plant community composition. A subdivided quadrat like the one used by Ed Brekke-Kramer in his study at Kasota Prairie (Kramer 1974) would give useful information on relative abundance and aggregation of the prairie plants, and data from such a quadrat are more easily interpreted than data from an undivided quadrat (Appendix F1b).

A second type of analysis which is efficient and informative is step-point cover analysis (Evans and Love 1957; Owensby 1973). In this technique, the botanist walks a randomly-located transect, recording at intervals the species contacted by a systematically-placed sampling point held in a frame (Appendix F2). These data reflect cover; if a properly-sized frame is used, species' frequencies within that frame can be recorded simultaneously, giving more information from the process (Appendix F2). Thus the step-point method can be modified to a step-point/frequency method. (For further information on the step-point/frequency method contact Mark Heitlinger, The Nature Conservancy - Midwest Regional Office, Minneapolis.) A review of these and other monitoring techniques is found in Walker (1970).

To evaluate and plan management, a number of other monitoring projects are recommended. They are described in Actions 7 and 17 (pages 19 and 33), and concentrate on particular species of interest rather than the plant community as a whole.

Possible contacts for further recommendations on monitoring techniques include Gerald Ownbey (University of Minnesota, St. Paul),

Welby Smith (Minnesota Natural Heritage Program), and Mark Heitlinger (The Nature Conservancy, Midwest Regional Office, Minneapolis).

16. Monitor populations of rare animals at Bluestem Prairie.

Rare animals observed on Bluestem Prairie by the 1980 inventory team include the Henslow's sparrow, greater prairie chicken, sandhill crane, upland sandpiper, eastern meadowlark, field sparrow, melissa blue butterfly, and regal fritillary. These species are described below, along with their status as classified by the Minnesota Natural Heritage Program or other experts and suggested monitoring techniques.

The butterflies Speyeria idalia and Plebejus melissa (regal fritillary and melissa blue, respectively) are considered rare (Huber 1979); their populations in Minnesota have declined rapidly with the destruction of their native prairie habitat. Monitoring for these species could consist of either or both of two methods. Since butterfly and skipper populations fluctuate greatly from summer to summer, one year's survey (like that of the inventory) is not likely to produce a complete species list or accurate population estimates for these insects. Repeated surveys, done in the same fashion as that of the inventory, would be useful not only to complete the preserve's butterfly species list, but also to gain an understanding of the population fluctuations of the various species, including Speyeria idalia and Plebejus melissa. Such surveys should be repeated for at least two or three summers, and should consist of weekly visits to at least one

representative of each plant community on the preserve between 9 and 11 a.m. or 2 and 6 p.m., on calm sunny days if possible.

Repeated butterfly surveys would be most useful for the information they would provide on all species present. However, a less time-consuming operation would be to monitor Speyeria idalia and Plebejus melissa specifically. This could be done using a walking-transect method like the one described by Pollard (1977); (Appendix F4); since his method requires in-flight identification of butterflies, it might require modification to allow capture and in-hand identification. A systematized monitoring technique like Pollard's is desirable, as it limits variability in data due to individual observation techniques. However, the great yearly fluctuations in butterfly and skipper populations, along with the scarcity of standardized monitoring methods in the literature, suggest that monitoring of other types of animals should be emphasized.

Of the bird species mentioned above, three are classified as threatened by the Minnesota Natural Heritage Program (1981); the Henslow's sparrow, greater prairie chicken, and sandhill crane. The upland sandpiper is classified by the program as a species of special concern. The other two birds, the eastern meadowlark and field sparrow, are on the edges of their ranges at Bluestem Prairie; the sighting of the field sparrow appears to represent a northward range extension for this species.

Among these rare birds, all but the sandhill crane may be nesting on the preserve; monitoring should be directed at clarifying the

breeding status of these birds. Site records should be kept for each species, consisting of the number of individuals seen, sex if known, activity and date when observed, evidence for nesting (e.g. singing males, nests, adults carrying nesting material), and exact location of sighting. Monitoring should concentrate on the Henslow's sparrow, field sparrow, and prairie chicken since these species are the most unusual ones seem at Bluestem (the other species have been sighted at a number of TNC preserves). The sandhill crane, however, visits the area only during its migration, and thus is not a good subject for monitoring.

One efficient method for collecting monitoring information in a systematic fashion is the Point Count method. Used in the inventory, the technique establishes circular stations at which a trained observer stands for ten minutes. Use of this method would allow direct comparison of results with the inventory. To supplement point-count data, information on prairie chickens should be gathered from booming-ground counts during early spring; booming grounds should also be mapped each year. The help of the Minnesota Prairie Chicken Society and other interested biologists and birdwatchers should be sought in locating and counting booming prairie chickens. A map of known booming grounds over the past five years is found in the inventory (page 86); the 1981 booming ground (11 birds) is shown in Figure 3, page 63 of this plan. Finally, if time permits, use of a trained bird dog to flush nesting females during the early part of the nesting

season could help investigators locate nests of ground-nesting species, count eggs, and thus estimate reproductive success and confirm breeding species.

Ornithologists (e.g. Dan Svedarsky at the University of Minnesota-Crookston), nongame wildlife specialists (e.g. Carrol Henderson, Minnesota Department of Natural Resources), and entomologists (e.g. Bob Dana, University of Minnesota at Minneapolis) can help devise other monitoring techniques. Criteria to be used in selection of such techniques are described in Action 15, page 27.

Three rare mammals have been documented at Bluestem Prairie: the plains pocket mouse (Perognathus flavescens), grasshopper mouse (Onychomys leucogaster), and prairie vole (Microtus ochrogaster). A study by Duffus (1978) indicated that local populations of Microtus species may be reduced or eliminated on burned areas due to the genus' habitat requirements (green vegetation for food, shallow burrows) and habits (diurnal). However, like all rodent species, Microtus reproduces rapidly and will repopulate burned areas. Although additional information on small mammal populations and their responses to fire at Bluestem would be desirable, monitoring of these animals requires trapping, a destructive process at best. Live trapping exposes the animals to often-fatal stress, and in any case certain identification often requires use of skull characteristics for which the animals must be killed. If small mammal monitoring is to be done, it should be done only by experts capable of identifying live specimens in the field,

and should be small-scale. The best recommendation at this time is that monitoring effort be spent on easier subjects, and that precautions be taken to encourage repopulation of burned areas by small mammals. These precautions include use of small burn units (once the initial recovery phase of burning is finished) to allow rapid rodent migration inwards, and placement of firebreaks across plant community boundaries to leave some parts of each habitat unburned as a refuge for the associated species.

17. Map and monitor populations of Tofieldia glutinosa, Spartina gracilis, and Carex scirpiformis.

These species are classified as rare (Tofieldia glutinosa), threatened (Carex scirpiformis) or endangered (Spartina gracilis) by the Minnesota Natural Heritage Program. They are among the most significant species found on the preserve. Documented locations for all three species are shown in Figure 1 (page 61), along with one undocumented possible site for S. gracilis. However, they may also occur at other sites on the preserve.

Monitoring of these plants will provide information essential for proper management of the Preserve. A preliminary level of monitoring could consist of a visual survey of habitats similar to the documented collection sites during the species' flowering periods, and mapping of the plants' locations throughout the preserve. If time limitations permit, a more intensive monitoring program should begin, consisting of placement of permanent quadrats around individual plants or groups of

plants, periodic counts of flowering stalks and/or fruiting stems, and/or records of changes in numbers of stems and amount of cover.

For Spartina gracilis, monitoring must include determination of the areal extent of the population; this information should be used to relocate the firebreak that currently is mowed across the population. Whether the firebreak is relocated to include or exclude the population from the burn program, this species should be carefully monitored, since it is close to the preserve boundary and to a cultivated field and is thus subject to disturbance. For example, use of herbicides on the adjacent field might be damaging the population (Action 18, page 34).

18. Investigate herbicide use on fields adjacent to the preserve.

A population of the endangered species Spartina gracilis is found on the west side of the SW 1/4 section 15 (see inventory, page 63). The population may be damaged by herbicides drifting across the road from the cultivated field to the west, especially if aerial spraying is used to apply herbicides. The farmer of this adjacent land should be approached and asked about specific herbicides currently being used on the field (if any) and application methods used. If necessary, the farmer should be requested to use a method that minimizes drift and/or to avoid spraying when winds are from the west, and to use the most specific (narrow-spectrum) herbicide possible.

Another population of Spartina gracilis is suspected to occur in the NE 1/4 section 22. If it is documented, it will provide a good

comparison of the population in section 15, provided herbicides are not used on the west half of section 22. Monitoring of both of these populations (Action 17, page 33) could help reveal possible effects of drifting herbicides, as long as other environmental factors are similar for the two populations. In addition, if other rare plants are found on the prairie near cultivated fields where herbicides are being used, the measures described above should be taken to minimize effects of herbicides.

Use Management Actions

19. Develop a parking area for preserve visitors.

Currently, visitors park along the township road running through section 15. Since there are already many group outings on the prairie and there are likely to be more in the future, a more adequate parking area is needed. A developed parking area will prevent obstruction of the road and minimize safety hazards to both preserve users and local residents. The best potential parking area is the pullout on the north side of the township road, just east of the ditch that runs north-south through section 15 (Figure 2, page 62). Its vegetation is already slightly disturbed due to annual mowing of the firebreak between the section's northeast and northwest quarters, so minimal damage would be done to the native prairie. The posts which currently prevent access to the prairie via this pullout should be moved back to accomodate one bus and a car or two, and posts should be set east of the pullout to prevent vehicle use on the prairie. Development should also include smooth access from the township road (current access is probably adequate) and a registration box (Action 34, page 52). A small sign should be placed below the preserve's main recognition sign (located about 1/8 mile to the west of the township road), stating that parking space is available 1/8 mile to the east on the north side of the road. The brochure (Action 28) should also mention the parking area and show it on the map.

20. Maintain fencing and repair as necessary.

Barbed-wire fencing borders the preserve on the west and south sides of the east half of section 22 and the south and east sides of the west half, section 23; there is also a section of fence along the east side of the southeast quarter, section 15 (see inventory, page 13). Of these fences, two are currently in need of repair (new fence posts, possibly new wire); these sections are marked in Figure 2, page 62 of this plan. Other parts of the fences should be checked periodically for damage; it is important that they be kept intact since they keep cattle out of the preserve. Eventually the wooden posts in the perimeter fencing should be replaced with metal posts, but this will be necessary only on a spot basis as individual posts deteriorate.

21. Control visitor access to prairie chicken booming grounds during booming season, and provide observation blinds.

Bluestem Prairie offers a good opportunity for watching booming prairie chickens. However, these birds must not be disturbed during their courtship ritual, or they may not return to the prairie to boom. Local preserve managers, Buffalo River State Park personnel, and DNR personnel should all be asked to keep track of visitation levels at the booming grounds during early spring; if visitation is too heavy and there is danger of disturbing the birds, a permit system should be used to limit numbers of users. If this system proves inadequate, signs should be placed at access points (e.g., along roads and mowed

trails) near the ground prohibiting entry. The prohibition should be enforced and people should be informed of the reasons behind the regulation of human use. DNR and park personnel should be asked to help with this regulation.

Small numbers of human observers will probably not disturb the birds, especially if care is taken to use blinds and stay off the actual booming area. For this reason, observation blinds should be available for use by visitors; they could be stored at Buffalo River State Park.

Prairie-chicken observers and interested groups should be contacted every year or two and asked to use blinds, limit their numbers, and register at the registration box when they visit. To allow informed use management, these contacts should be maintained with nearby chapters of Audubon Society, ornithologists at local colleges and universities, educators using the MSU regional science center (see Action 31), and members of the Minnesota Prairie Chicken Society.

22. Encourage hiking and cross-country skiing on the mowed firebreaks on the preserve.

Hiking and cross-country skiing are an ideal way for visitors to experience the prairie. Both forms of recreation are low-impact, especially if users are requested to confine most of their travel to mowed firebreaks. This will minimize trampling of vegetation, and since the firebreaks will be mowed on high ground and away from populations of rare plants (Action 1, page 11) use of the breaks as trails will protect the fens, other vulnerable wet areas, and sensitive rare

plants. When firebreaks are mowed repeatedly in spring they tend to develop a cool-season grass cover, and since such grasses are quite durable under hiking traffic, trails will be less subject to erosion if routed along mowed breaks.

Cross-country skiing is a suitable activity for Bluestem Prairie. However, grooming of trails with snowmobiles is not recommended, since snowmobiles are inappropriate on a natural area. Directional signs on the trails should not be necessary unless many users request them; the prairie is quite flat and navigation by sight is easy.

The brochure on the prairie (Action 28, page 45) should include a request for hikers and skiers to stay mainly on mowed firebreaks, and should show the locations of the breaks.

23. Acquire conservation easements around the preserve.

If houses were to be built near the preserve, fire management would become very difficult. Most winds would preclude burning, due to possible health and property damage to adjacent landowners. Conservation easements barring development on a strip of land a quarter-mile wide surrounding the preserve would be ideal in facilitating continued fire management on the tract, and would also help prevent excessive-human-use problems that might drive wildlife away from the preserve -- especially the sensitive booming prairie chickens. If such extensive easements could not be acquired, a lower level of protection would be provided by easements adjacent to the roads that intersect or border

the tract, since these are the most likely areas for development. Suggested easements are shown in Figure 4, page 64. Highest priority should be given to acquisition of easements adjacent to prairie in good condition; lower-quality areas may serve as buffers for the better portions of the preserve. However, given the potential for restoration of the lower-quality areas, easements should still be considered for these areas, especially to facilitate their restoration through the use of fire.

At this time (1981) such easements are a high priority. The preserve is near a high-traffic road (State Highway 9) and is quite near a major metropolitan area (Fargo-Moorhead). A housing development already containing over 20 houses is expanding less than a mile away from the prairie (Figure 8, page 68). A large (445) hectare wildfire on the preserve in 1978 raised some controversy over prescribed burning at Bluestem; conservation easements would help ease this situation by prohibiting construction immediately adjacent to the preserve.

24. Recruit local volunteer managers, preferably living within three to four miles of the tract.

At a large preserve like Bluestem Prairie, local managers are especially important, since there are many potential problems which can be prevented only by frequent inspection of the tract. Volunteer managers must have the time, interest, and willingness to become intimately involved with the protection and management of the site. The managers' job at Bluestem will be primarily to: (1) monitor the

tract for signs of misuse or management problems and communicate them to TNC and SNA (a "watchdog" function); (2) be informed of land use plans for the areas near the preserve (e.g., housing developments, mining activities, road modification, pipeline or powerline corridors) and communicate potential problems to TNC and SNA; (3) facilitate communications between TNC, local residents, the SNA program, and other parties; (4) aid professional resource managers when requested; (5) maintain the registration box supplies and collect registration sheets and comment cards; and (6) orient new managers to the site and the local community.

Several management problems at Bluestem Prairie will require special attention by the local managers. The size of Bluestem makes it especially significant as habitat for prairie chickens, and it is therefore important that human use be limited during their critical booming season. Excessive disturbance by observers during this period could drive the chickens away from the preserve. The local volunteer managers can be a vital link in monitoring human use in early spring; for this reason it would be helpful if the person(s) recruited have an interest in prairie chickens. Another important role for the managers is watching and listening for humors and other signs if imminent development near the preserve. Housing developments especially pose a potential obstacle to management of the tract, and any advance warning would help prevent problems. Finally, motorized traffic on the preserve deserves some attention; as the population density near Bluestem Prairie increases,

use of off-road vehicles may become more prevalent. Dirt bikes and snowmobiles can be especially damaging to the more sparsely vegetated, sandy parts of the prairie, but could damage any part of the preserve. The local manager should watch for signs of such vehicle use and inform The Nature Conservancy and the SNA program (if appropriate) if problems arise.

Since there are quite a few people living close to the preserve, finding local managers should not be too difficult. The preserve is large enough so that at least two people or couples should probably share the responsibility of serving as local volunteer manager; each could cover a different portion of the preserve. Some possible candidates are Judy and Gary Miller, who live in the southeast corner of section 16; Donald and Lois Vincent (northwest corner, section 22), and the Brunsvolds, who live in the housing development on the west side of section 21. All of these people have shown an interest in Bluestem Prairie and its management.

25. Construct an observation deck at one of the fen areas (if appropriate).

If investigation of the fen-like areas (Action 10, page 23) shows that one of these sites is a good example of a fen community, an observation deck should be built on its edge. The deck would add to the site's interpretive value and would prevent possible damage to the fen which could be caused by hikers. Once internal mowed firebreaks are established and used as a trail system (Action 22, page 38), the

deck could be built on a trail spur. It should be raised a few feet above the surrounding terrain to give a good view of the whole fen, allowing visual interpretation of the hydrological patterns that form fens.

26. Limit off-trail hiking on the river banks at the preserve's north edge.

Soil erosion is rapid on the banks of the Buffalo River, and hiking traffic is relatively heavy on the section of riverbank lying within the proposed SNA. This section is quite near the campgrounds, picnic area and swimming hole, and once the foot bridge (DNR-Division of Parks, 1980) is built, the number of hikers on the south side of the river will increase. Signs should be posted at the south end of the bridge once it is completed, describing the nature of a Scientific and Natural Area, explaining its use restrictions, and requesting no off-trail hiking on the river banks to help limit erosion. The trail up to Bluestem Prairie should be clearly marked, and if erosion becomes a problem it should be reinforced with steps, wood chips, or other natural surfacing material.

27. Develop and maintain a close relationship with local and regional government officials, natural resource managers, community groups, and other appropriate people.

Local and regional resource professionals and government officials should be aware of Bluestem Prairie, its importance, and major management

actions which are planned for or being implemented on the tract. These individuals, if they are aware of the site and interested in its preservation, can provide valuable expertise and manpower, and lend equipment if needed for management. Cooperative management efforts can also sometimes be used to solve problems which affect several sites in the area, including the preserve. Maintaining contact with these people and with community groups can help eliminate public suspicions and misconceptions, build trust and rapport, and increase community support. It is also a way of monitoring what the public feels about the site and the managers.

In general, contact should be maintained with state, county and federal resource personnel (e.g., the county extension agent DNR area wildlife manager, Soil Conservation Service district conservationist, U.S. Fish and Wildlife Service managers) and with such government officials as town board members, mayors of nearby towns, the county assessor, and county commissioners. Specifically, frequent contact has been and should continue to be maintained with personnel at Buffalo River State Park (especially its manager, Bernie Dohlman); with Paul Rundell, DNR Region I Resource Coordinator; with the Clay County Commissioners; with all members of the Riverton Town Board; and with the Glyndon Fire Department (Jerry Greene, fire chief), and with administrators of the MSU regional science center (see Action 31). The Riverton Town Board members and Glyndon Fire Department should be kept informed of dates and plans for any prescribed burning or burning of

firebreaks, and the Town Board should also be kept informed of other major management actions being undertaken on Bluestem Prairie. Contact should be maintained with administrators of the MSU science education center in order to coordinate interpretation and management with their project.

Although media publicity for Bluestem Prairie has been quite good in the Fargo-Moorhead area (including television spots and newspaper articles), more contact is needed with the people of Glyndon. Communications with them should emphasize their role in protecting this unique area and its rare wildlife, especially the prairie. A sense of pride in Bluestem Prairie on the part of the people of Glyndon will help tremendously in the management of the site. TNC and/or SNA staff, or interested scientists who have studied the site and are familiar with TNC and SNA policy, should attempt to speak to the local high school, the Glyndon Jaycees, the local snowmobile club and the local rod and gun club. Each of these presentations should consist of a description of the preserve's unique resources and a request for the group's assistance in the tract's management. Use regulations (including prohibitions on hunting and use of motor vehicles) should be explained, and each group should be helped to gain an understanding of its role in taking care of Bluestem Prairie.

28. Develop a brochure on Bluestem Prairie and distribute it to users, Buffalo River State Park visitors, interested neighbors, and other interested groups.

The brochure should include an accurate map of the preserve,

(including the parking area, hiking trails/firebreaks, and features of Buffalo River State Park), a description of Bluestem Prairie's history, natural features and significance, and a discussion of the impact of human use. It shall describe the Nature Conservancy Program and the SNA Program (if appropriate), note conducted tours and workshops, promote a "pack out what you bring in" litter philosophy, identify people to contact for more information about the site (including the local manager, park personnel, and TNC-SNA personnel), and encourage visitors to register, provide comments, and become involved in management of the area. Mowed firebreaks should be suggested as suitable places for hiking. Finally, the brochure should note The Nature Conservancy's and/or the SNA Program's rules and regulations governing use, including the requirement that all researchers obtain permission prior to conducing research on the area. The brochure should be distributed to visitors at Buffalo River State Park, to users of the MSU science center (see Action 31), to interested neighbors, to groups which use the prairie for field trips (e.g., schools, universities, Audubon Society chapters, and conservation clubs and camps), and to potential supporters and users.

29. Conduct field walks on Bluestem Prairie.

Guided field walks would be helpful in introducing both local residents and others to the resources of Bluestem Prairie. Depending on the group's interests, such walks could visit the fens, geological

points of interest such as the Lake Agassiz strandlines, riverine forest, representatives of different prairie types, etc. Field walks will also help to inform visitors about The Nature Conservancy/SNA Program, obtain visitor feedback on management, and help visitors feel more responsible for stewardship of the site. The number of conducted tours depends on time and money limitations, and the impact of the tours on the area. A suggested limit for total visitation at Bluestem is 2500 visitor-days per year. Late May through October are ideal times to visit the tract; walks on Bluestem might be scheduled in conjunction with visits to other nearby preserves, constituting a tour of area prairies. Field walks might also be coordinated with interpretive activities at the MSU regional science center (see Action 31). News releases should be sent to the local media to publicize the walks, and reporters should be periodically asked to participate. Potential field trip leaders include SNA and TNC personnel, interested scientists, park personnel, and local managers.

30. Encourage nondestructive research on Bluestem Prairie.

Bluestem Prairie is an ideal site for many kinds of field research; it has some nearly undisturbed habitat (section 15 has been mowed and burned only), formerly grazed land, and formerly plowed land. Its variety of plant communities provide interesting comparisons, as does its fire management program. Research will be valuable in evaluating the success of management (e.g., monitoring activities, Actions 7, 15, 16

and 17) as well as in planning for future management. Research in several subjects is needed and should be encouraged -- perhaps by mentioning the need to university faculty at nearby institutions. Research on most of these topics is suggested in management actions in this plan, but given the large size of the preserve and the limitations of funding, personnel and time, outside help should also be sought. However, when outside research is encouraged, emphasis must be placed on the necessity of responsible stewardship during research, and research should only be encouraged if it cannot occur equally well on other less vulnerable areas. Research proposals must be submitted to and approved by both The Nature Conservancy and the Scientific and Natural Area Program; control over research activities is important to prevent harm to the preserve.

Topics in need of research include:

- --effects of fire on small mammals, insects, and rare plant species of the prairie
- --differing effects of head versus back-fires, fires in different seasons (spring, summer, fall), fires of different acreages, etc., including effects on sweetclover
- --longterm vegetation community changes (monitoring) (see Action 15, page 27)
- --synecology and autecology of sweetclover (Melilotus alba) with an eye to possible control methods (Action 7)
- --synecology and autecology of leafy spurge (Euphorbia esula), with an eye to possible control methods (Action 8)
- --community composition and hydrology of fens on the preserve (Action 10)
- --documentation of rare plant species reported by earlier investigators but not vouchered (Action 14)
- --preferred locations for prairie chicken booming grounds and associated environmental factors (Action 16)

Previous research projects on Bluestem Prairie have been described in the inventory (page 19).

31. Encourage local middle and secondary schools and regional higher education institutions to use the site for field trips, if appropriate.

Bluestem Prairie provides an ideal site for school field trips. It is the only prairie close to the Fargo-Moorhead area that is large enough to provide a sense of the vastness of the original grasslands, and it has an unusual variety of plant communities ranging from dry to wet prairie and including riverine forest and fens. However, field trips should be encouraged only in conjunction with responsible use of the prairie and an understanding of the sensitivity of the resources. Use should be encouraged only if it cannot occur equally well on other, less vulnerable areas. All teachers should be aware of site rules and regulations, such as the need to obtain a permit prior to collecting or conducting research in the area, before they step onto the tract. In addition, before a class comes to the tract teacher workshops should be held so that the teachers are trained and well-informed about the preserve. When the class somes to the site, managers or scientists should, if possible, also be present to help.

The Moorhead State University Foundation is currently drawing up plans for a regional science education center to be built on the Foundation's property (currently a golf course) just east of Buffalo River State Park. The Foundation's plans are for an environmental

education center for students of pre-college and college age; activities will include instruction, demonstration, and interpretation. Since this project will have considerable impact on the area due to field trips and possible research use, and since it provides an excellent opportunity for introducing young people to the prairie, contact must be maintained with administrators and teachers who run and/or use the science center. Since there are likely to be large numbers of users at the center, it is important that only appropriate use of the preserve be encouraged: that is, no collecting; small-sized groups; travel on mowed firebreaks only; and most of all, use of the preserve only if other, less sensitive prairie areas (e.g., the prairie within the state park, just north of Buffalo River) cannot be used for the trips or research.

Several faculty members at North Dakota State University and Moorhead State University and Concordia College have made responsible use of the prairie for classes and/or research, including Dr. Richard Pemble (MSU), Dr. Gary Clambey (NDSU), and Dr. Jerry VanAmburg (Concordia College). Contact should be maintained with these people as well as with appropriate individuals at University of North Dakota and the University of Minnesota at Crookston (Dan Svedarsky in particular); such contact will be valuable for their knowledge of the prairie as well as to learn of other potential users.

32. Periodically inspect the site.

The site shall be thoroughly inspected at least once per month by the local volunteer manager or TNC/SNA personnel for human impacts

(e.g., vandalism, unauthorized trails, littering, overuse of sensitive areas like fens and prairie chicken booming grounds, and other disturbances), signs of violations in rules and regulations (e.g., hunting, snowmobiling, horseback riding, and natural changes in the tract (e.g., spurge advance, insect infestations). An inspection log should be suggested as a means of recording observations. If urgent action is required on the site TNC and the SNA program (if appropriate) should be contacted immediately. Otherwise, records should be kept of observations for the annual report (Action 35, page 53).

The inspections are also an opportunity to gather feedback from users in the area concerning the site and its management. Visitors observed violating rules and regulations should be tactfully asked to correct their behavior, e.g., remove rubbish dumped on the site. Serious problems should be referred to the DNR conservation officer or county sheriff. A report should be submitted to TNC and SNA if further action is advisable.

33. Maintain close contact with all scientists who are using the site for educational and research purposes.

Scientists, as trained observers, can provide valuable information and insights on managing the site (see also Actions 30 and 31). Data gathered from scientific studies are also important for monitoring the site. Thus all scientists using the site will be annually contacted and consulted about their studies, data, and conclusions. Researchers should also be consulted about natural changes and human impacts they

discover while on the tract, and be encouraged to offer input into managing the tract. Finally, research information should be accumulated, stored in a site file, and shared with interested parties. Previous research done on Bluestem Prairie is described in the inventory (page 19).

34. Erect a registration box and maintain the box and its supplies.

The registration box should be of standard TNC design. It should be erected in a conspicuous location approximately fifty feet from the suggested parking area (NW 1/4 section 14, near the road). The registration box should be annually touched up with Olympic wood stain; other maintenance actions should be taken as required. During the spring, summer and fall the box should be checked bi-weekly to see that adequate copies of maps, brochures, registration sheets and other relevant information notices (including notices on upcoming special events, the nearest DNA or volunteer information source, the SNA rules and regulations (if appropriate) and/or TNC rules and regulations) are present.

Two sets of 5 x 7 standardized comment cards will also be kept in the box. One set of cards will be available for users to write comments on management and use of the tract (e.g., problems observed on the tract, proposals for management, evaluation of the managers). The other set of cards will be available for users to write observations on the site's natural features. These cards will ask: the observer's name and address; what species were seen; the number of individuals

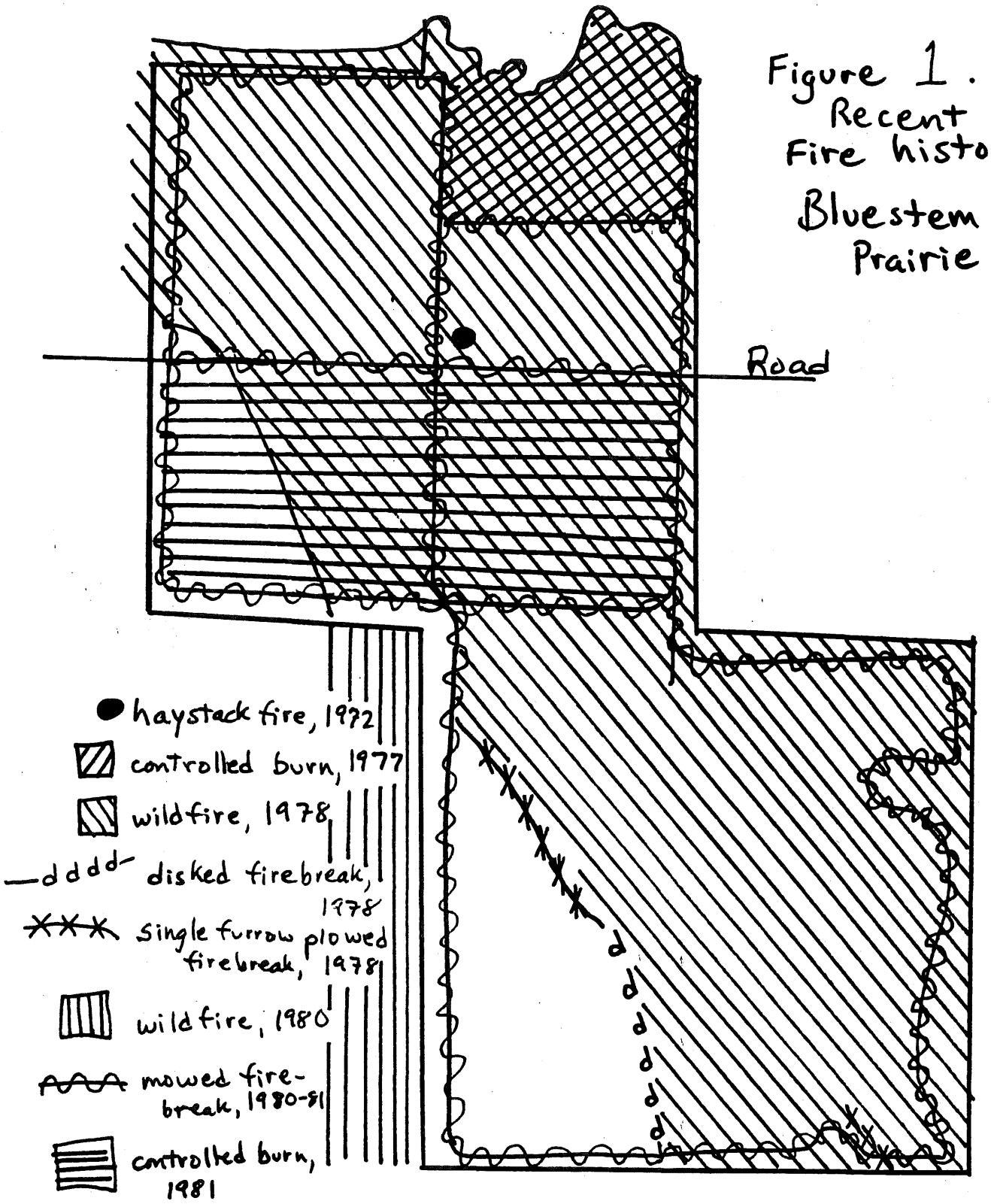
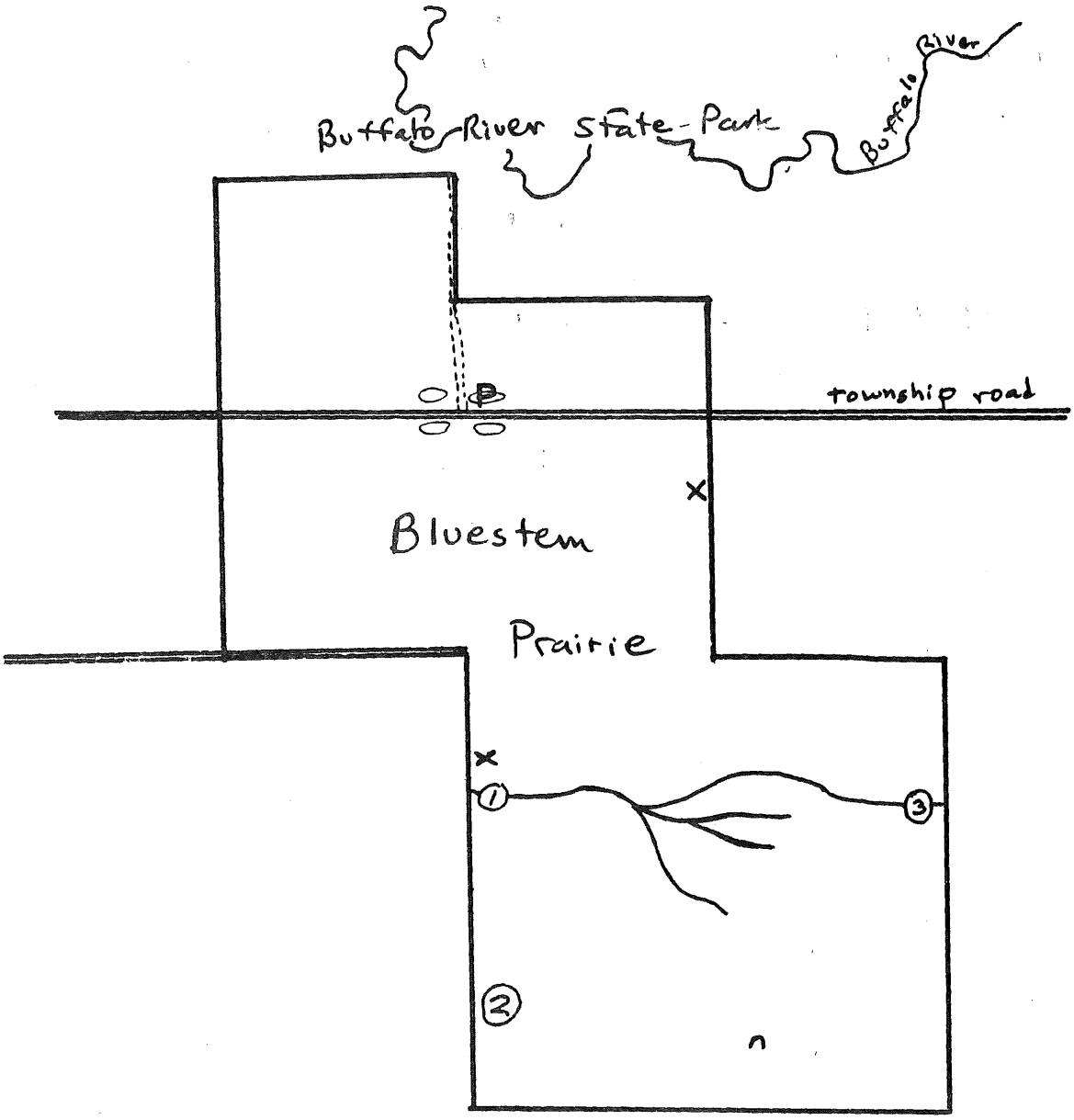


Figure 1. Recent Fire history, Bluestem Prairie

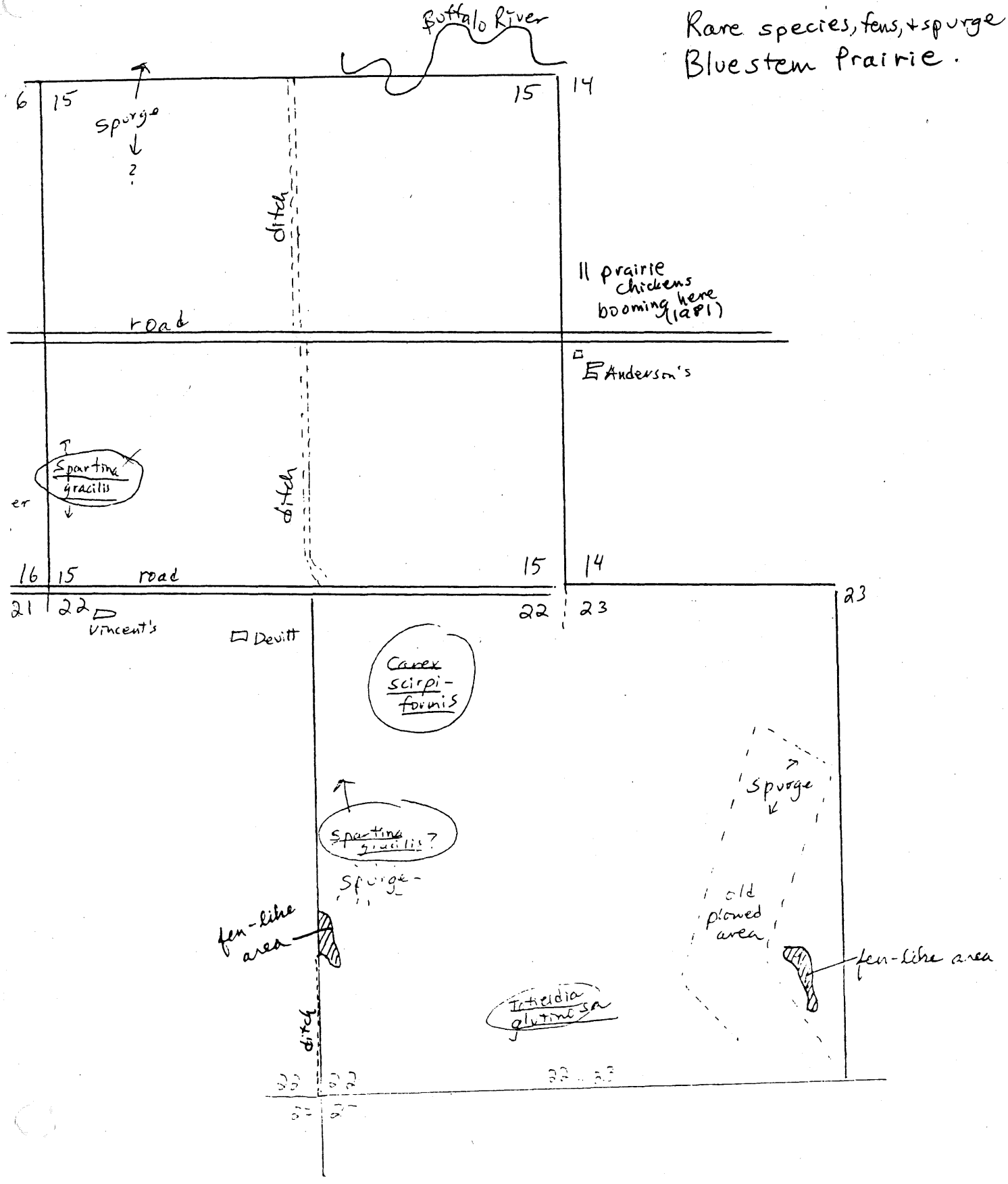


n gravel discard pile
○ old haystack sites
× garbage piles
P potential parking area
①, ②, ③ locations for culverts needed

Figure 2. Physical management needs, Bluestem Prairie

Figure 3.

Rare species, fens, + spurge
Bluestem Prairie.



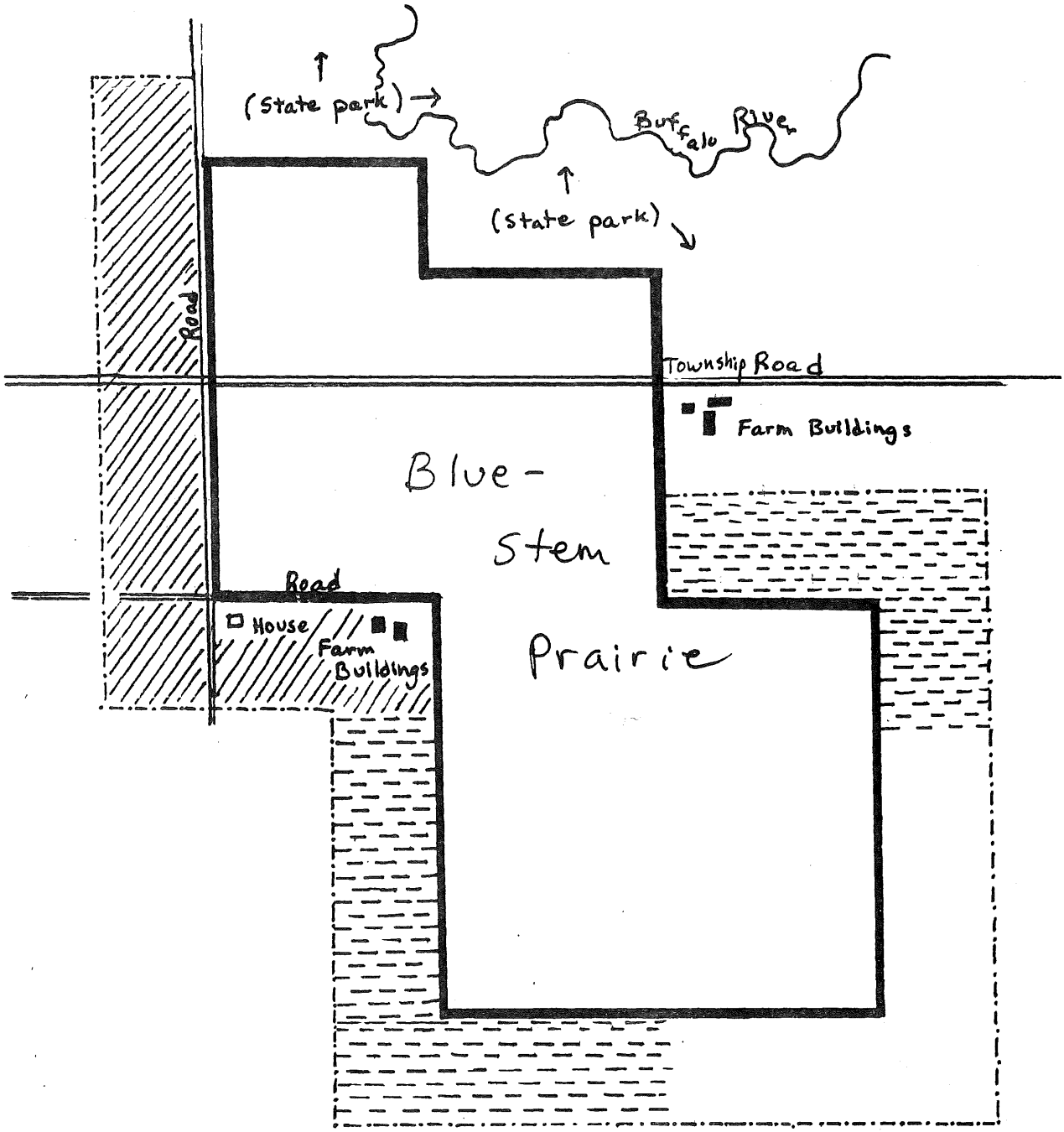


Figure 4.
Proposed conservation easements at Bluestem Prairie.

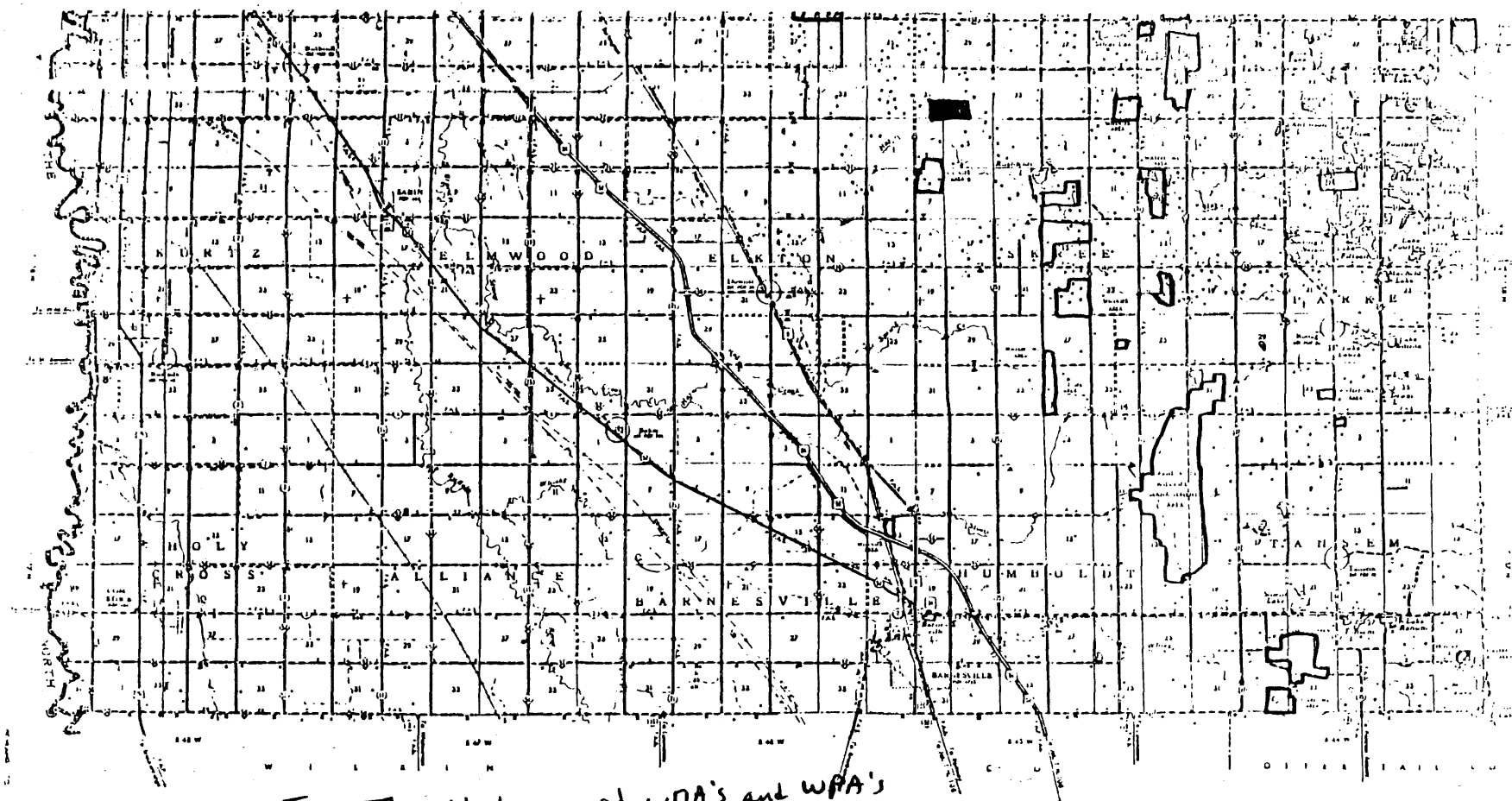
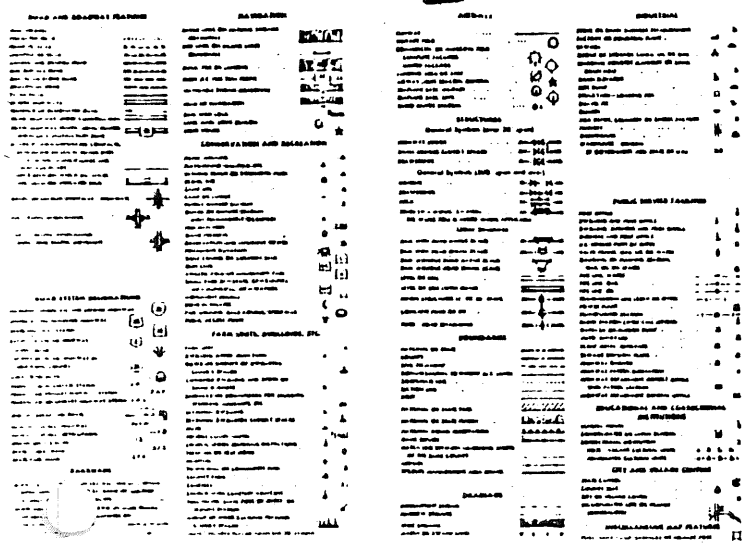


Fig. 5 ☐ Publicly owned WMA's and WPA's

LEGEND ■ or ▨ Privately owned prairie

▨ Bluestem Prairie



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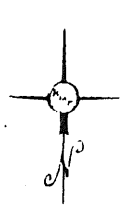
GENERAL HIGHWAY MAP

CLAY COUNTY MINNESOTA

SCALE



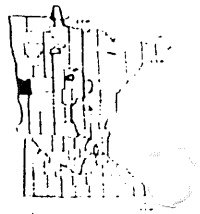
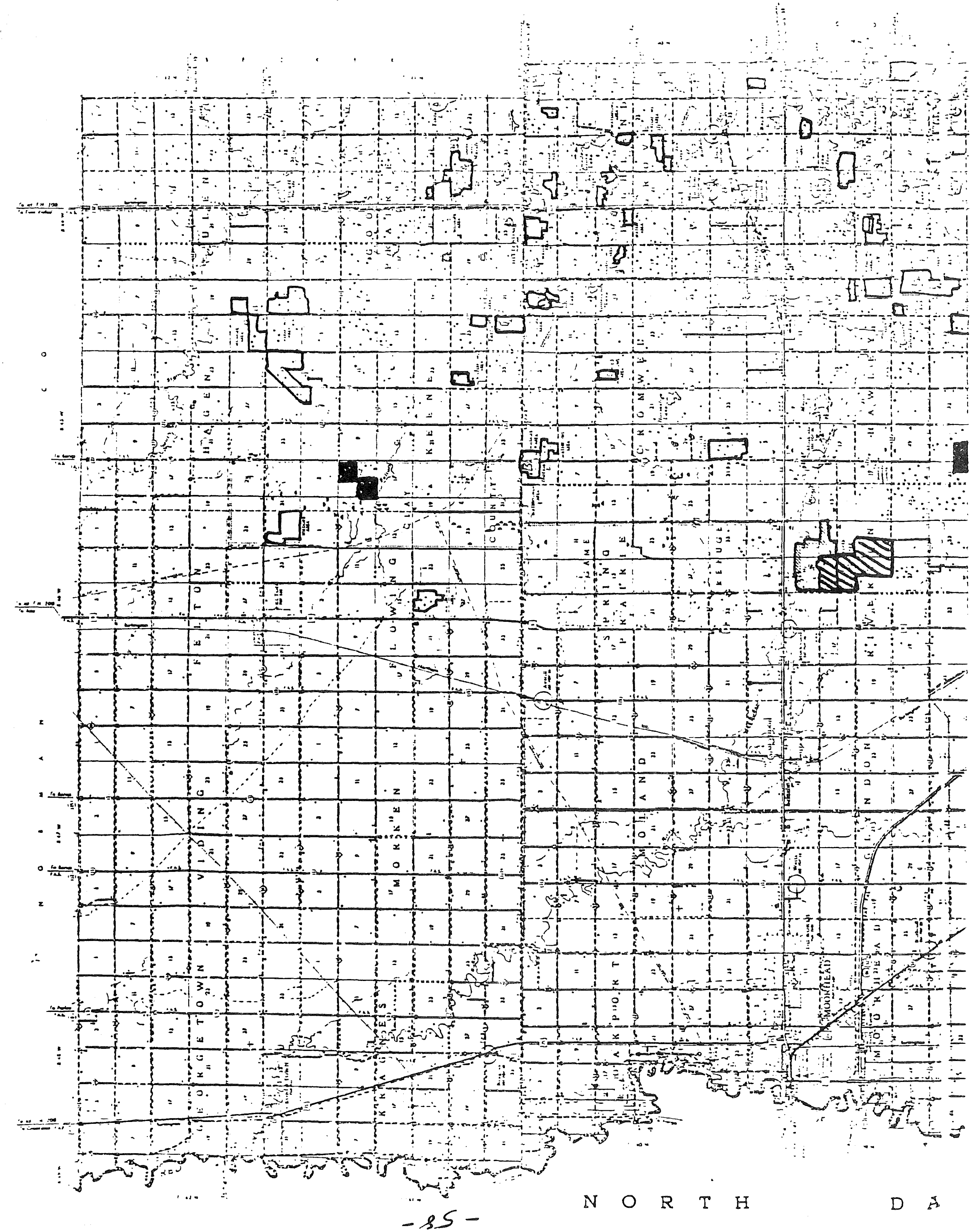


Fig. 5 Publicly-owned wildlife land and privately-owned prairies near Bluestem Prairie.

'53



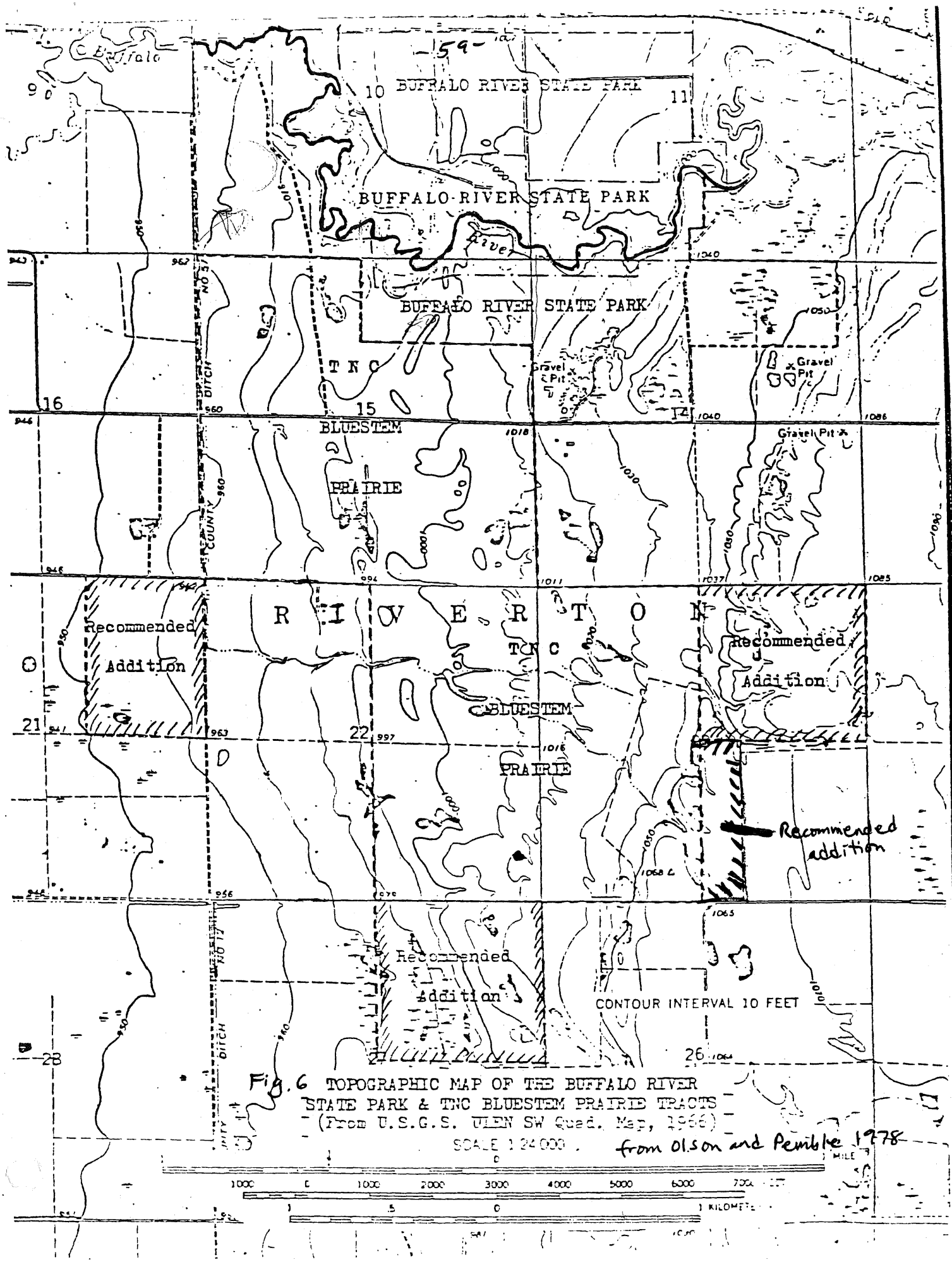


Fig. 6 TOPOGRAPHIC MAP OF THE BUFFALO RIVER STATE PARK & TNC BLUESTEM PRAIRIE TRACTS (From U.S.G.S. ULEN SW Quad. Map, 1966)

from Olson and Pemble 1978

POTENTIAL NATURAL VEGETATION FOR CLAY COUNTY, MINNESOTA[1]

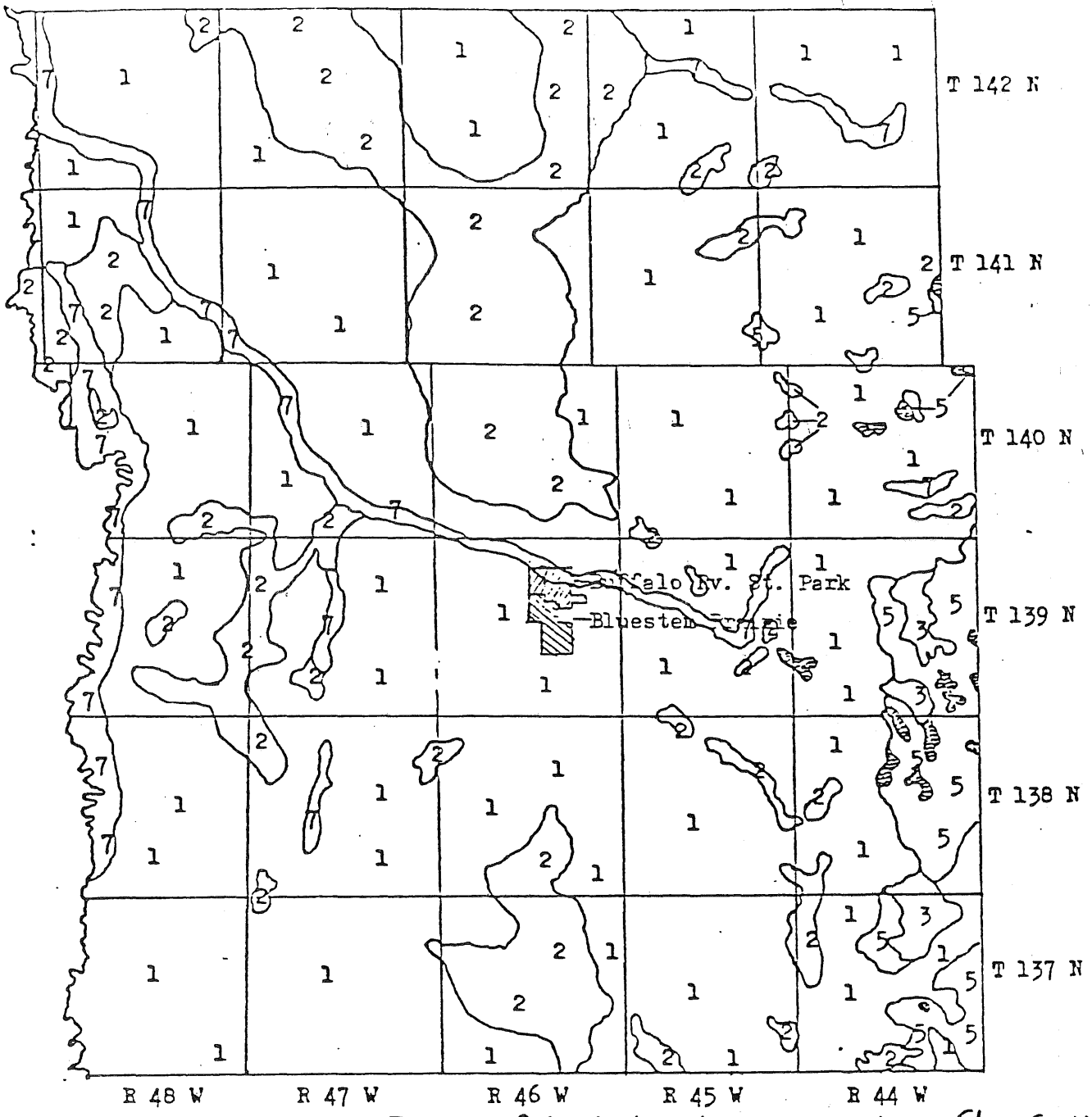


Fig. 7. Potential natural vegetation, Clay Co. M

1 - Prairie

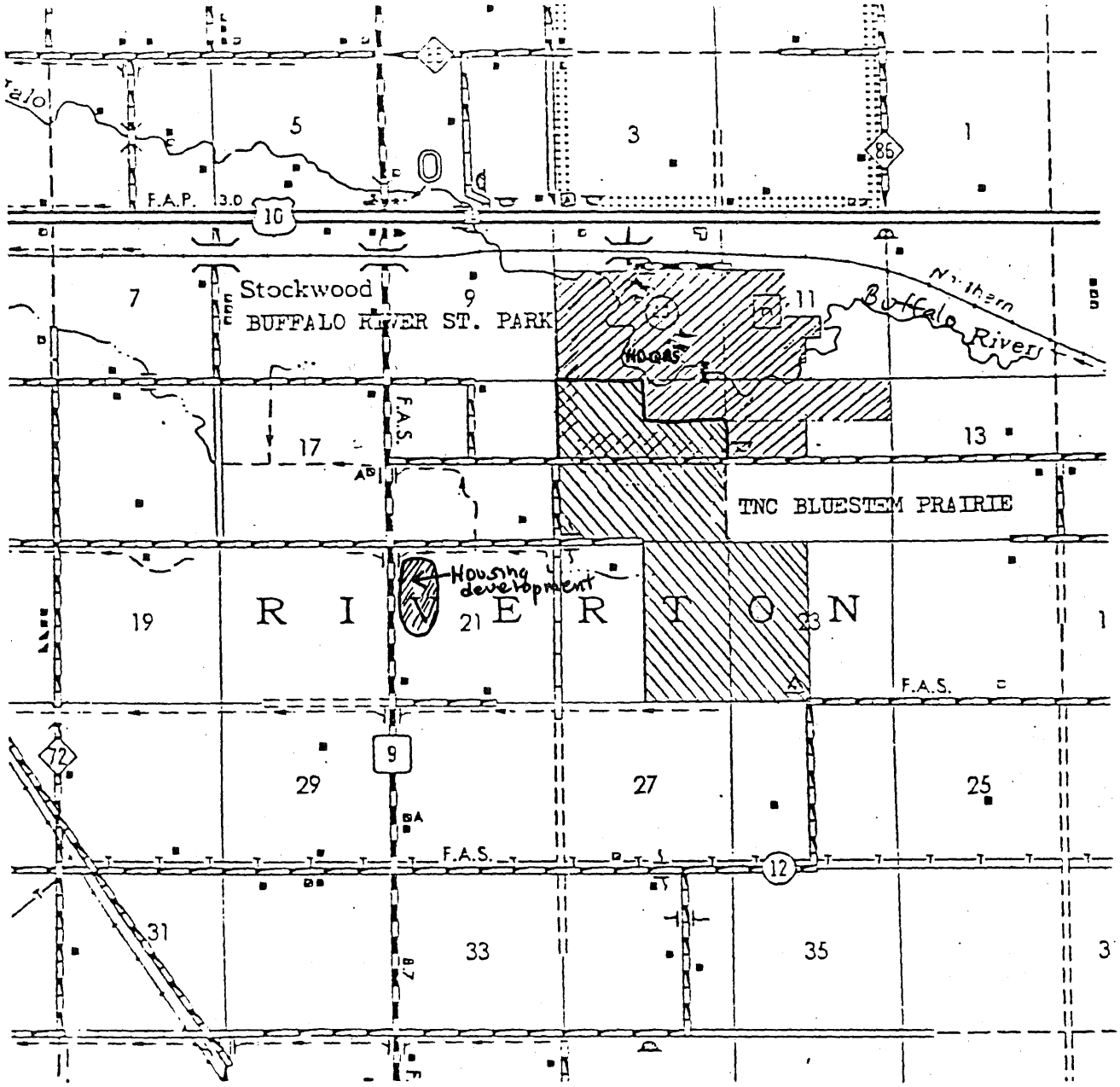
2 - Wet Prairie, Marshes, and Sloughs (marsh-grasses, flags, reeds, rushes, wild rice, with willow and alder brush in places)

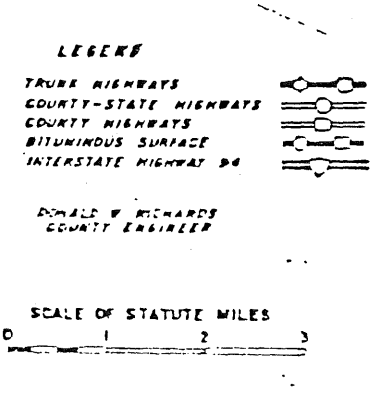
3 - Brush Prairie (grass and brush of aspen, balm of Gilead, oak, and hazel)

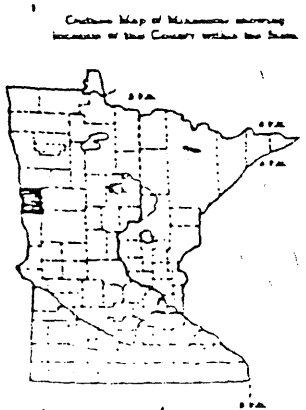
5 - Oak Openings and Barrens (scattered trees and groves of oaks, mostly bur-oak, of scrubby form with some brush and thickets)

7 - River Bottom Forest (elm, ash, cottonwood, box-elder, oaks, basswood, willow, aspen, hackberry, etc.)

[1] Adapted from Marschner, F. J. 1930. The original forests of Minnesota. U. S. Dept. Agric., For. Serv., North Central For. Exp. Stn., St. Paul, Minn. from Olson and Pemble 1971.







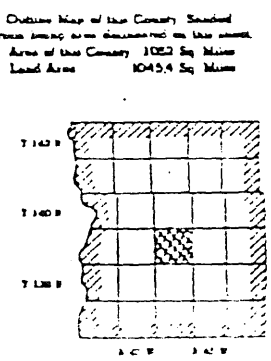


Fig. 8 Riverton township.
Adapted from Olson and Pemble 1978.

seen; where the species were observed (space will be left for a sketch); and other remarks (e.g., presence of nesting activity, territorial behavior, identifying marks of unknown species). The back of the cards will have instructions and note the purpose of the cards. A list of those species which are of particular interest to managers and scientists could also be included here. The observation cards, the management comment cards and the registration sheets can provide valuable monitoring data to managers. It is therefore important to collect the cards and the registration sheets, and keep them for analysis.

35. Submit an annual written report to TNC and the SNA Program.

The annual report shall note completed management actions, progress made in implementing other actions, number of users and violations (compared against preceding years), solicited and unsolicited comments regarding management, research proposals and studies underway, changes in the resources, problems identified by managers, local residents and researchers, and recommendations for changes in the management plan. It should be written by the TNC and/or SNA personnel who manage the site, and should include observations and actions by the local volunteer managers as well as other people involved with management of the site.

36. Contact the local DNR conservation officer (C.O.) and request his or her assistance in managing the site.

This action will become most important if Bluestem Prairie is

designated as a state Scientific and Natural Area, since the C.O. will then have enforcement authority for protection of the tract. The C.O. may also be able to offer useful advice on enforceable management programs.

37. Hold periodic meetings for the local residents.

Public meetings can be used to enlist support for project work (e.g., monitoring) on the preserve; as a forum to discuss management decisions, problems, and actions; to encourage landowners to adopt practices which will help protect the prairie; or to offer information to interested users of the prairie. Meetings might be held in conjunction with a field trip or other activity, or they could be timed to meet the needs and specific interests of local residents, like the May workshop on prescribed burning held in 1981. Ideally, meetings will be held at least every year at a time and place convenient for these planning to attend; for example, a suitable location would be the interpretive buildings at Buffalo River State Park. Publicity for the gatherings should be through distribution of flyers in mailboxes and/or through news releases sent to local media such as newspapers (e.g., Fargo, Glyndon, Hawley, and Barnesville) and radio stations. Reporters might also be asked to attend. Special circumstances or controversies may warrant more extensive publicity or more than one meeting. It is particularly important that adjacent landowners and frequent users be present at these meetings since their actions can have a large impact

on the tract and vice versa, so these people should be notified personally by phone or mail when a meeting is being planned. All comments on management of the preserve should be recorded.

Another method of maintaining contact with the local residents is by securing a place on the agendas of meetings of local organizations, for example, the local rod and gun club, snowmobile club, and Jaycees (Action 27, page 43). The disadvantage of this method is that it does not necessarily involve the preserve's close neighbors, its adjacent landowners. If contact is maintained through existing groups rather than by setting up meetings specifically concerning the preserve and its management (to which neighbors would be invited), deliberate efforts should be made to stay in touch with adjacent landowners through individual contacts. They should be encouraged to aid in stewardship of Bluestem Prairie's unusual natural features and kept informed of major management actions.

Boundary Adjustments

Several tracts of native prairie in good condition are still found adjacent to Bluestem Prairie. These include the NE 1/4 Section 23 and the west part of the SE 1/4 Section 23 (both currently used for pasture); the northeast 1/4 Section 27 (hay and pasture); the west half of Section 22 (of which the eastern portion is reportedly in better condition) (Cross-Cella, 1981); and the NE 1/4 Section 21 (less its W 1/2 W 1/2). All of the proposed additions are shown in Figure 6 (page 59).

A compilation of field notes by Richard Pemble, Richard Johnson, and Tom Morley (TNC files) shows that in 1971 to 1973 the NE 1/4 Section 23 was mostly lightly to moderately grazed, producing some damage to vegetation, but leaving most or all native prairie species. Part of the Norcross strandline of glacial Lake Agassiz runs through the area adding to its value as a natural area and increasing the urgency of its acquisition, since its development for gravel mining is a possibility. The quarter section needed burning in 1973, as a thick layer of dead grass had accumulated and the woody species (aspen and willow) appeared to be expanding onto the prairie. South of this quarter, an area of good prairie covers about the W 1/2 W 1/2 SE 1/4 Section 23. This area has also been lightly to moderately grazed and still has a diverse native flora. Another proposed addition, the NE 1/4 Section 27, has been well-managed by its owner (Alvin Arneson); it is lightly grazed and although it has some Kentucky bluegrass, the community consists

mainly of a good variety of native mesic or dry-mesic prairie grasses and forbs. The previous owner reportedly burned off this property occasionally to maintain good forage; this may have contributed to its present high quality. Because this quarter-section contains part of the Campbell strandline of glacial Lake Agassiz, it would be a valuable addition to the preserve's geological interest as well. The east part of the west half, section 22, has also been lightly grazed, but was reportedly in good condition in 1971, and is still a worthy prospect for acquisition.

The 1980 inventory crew reported that all of the above areas are still in good condition (Cross-Cella 1981). One area they did not investigate is the NE 1/4 Section 21 (less its E 1/2 E 1/2). Although this area is recommended for addition to the preserve by Olson and Pemble (1978) no information on its current condition has been found. This area, as well as all of the others mentioned above, should be thoroughly investigated by experts to determine the desirability of their acquisition. If acquisition is not possible, other options for their protection should be explored; such as easements (see Action 23, page 39) and agreements with landowners regarding grazing intensity levels and protection of the areas from cultivation. Quick action is important in pursuing protection for these areas, since development is occurring nearby and will probably expand to some of these tracts in the near future.

Table 1. Priority listing for management actions, Bluestem Prairie.

CRITICAL	NECESSARY FOR PROPER STEWARDSHIP	SUPPLEMENTARY
Wildfire containment (1)	Gravel pile recontouring (3)	Plant collections (13)
Prescribed burning (2)	Tree removal (6)	Hiking and skiing trails (22)
Leafy spurge control (8)	Prairie invader monitoring (7)	Fen observation deck (25)
Fen study (10)	Culverts (9)	Contacts with city, county, state and federal officials and personnel not listed in column to the left
Rare plant search (14)	Refuse removal (11)	
Conservation easements (23)	Herpetological inventory (12)	
	Plant community monitoring (15)	
	Rare animal monitoring (16)	Encourage school use (31)
	Rare plant monitoring (17)	
	Herbicide study (18)	
	Parking area (19)	
	Fence maintenance (20)	
	Booming-ground access control (21)	
	Local volunteer managers (24)	
	Riverbank hiking control (26)	
	Contacts with state park personnel (27)	
	Contacts with Clay County commissioners (27)	
	Contacts with Riverton Town Board (27)	
	Contacts with Region I Resource Coordinator (27)	
	Contacts with Glyndon Fire Dept. (27)	
	Brochure (28)	
	Guided field walks (29)	
	Research encouragement: critical projects (30)	
	Monthly inspections (32)	
	Contacts with scientists (33)	
	Registration box (34)	
	Annual report (35)	
	C.O. contact (36)	
	Local meetings (37)	

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Appendix A

The Minnesota Scientific & Natural Area (SNA) Program

Since the SNA Program may also be involved in the stewardship of Bluestem Prairie a description of the SNA Program management policies, rules and regulations, and pertinent legislation is included here. If Bluestem Prairie is designated an SNA it will be managed in accordance with these statutes, policies, rules and regulations.

The SNA Program is located in the Minnesota Department of Natural Resource's (DNR) Division of Parks. The Scientific & Natural Areas Act (M.S.A. 84.033) of 1969 created the program. It authorized the Commissioner of the DNR to acquire, designate and maintain SNAs, and to adopt pertinent rules and regulations governing the use of the areas.

The DNR issued rules and regulations governing the SNAs in 1973 (Minnesota Reg. NR 300-303). The rules and regulations, still in effect, cover permitted and restricted uses of SNAs, provide for environmental protection, prohibit certain uses and acts, and establish legal penalties for violations. The rules and regulations also state that the Commissioner of the DNR can restrict: 1) travel within the unit; 2) the hours of visitation; and 3) the number of visitors within the area at any given time.

In 1975 the Scientific and Natural Areas Act was amended by the Outdoor Recreation Act (ORA; M.S.A. 86A.05). This statute further defined and more adequately funded the program. It included SNAs

within the Minnesota Outdoor Recreation System, defined the purpose of SNAs, delineated resource and site qualifications, provided for administration of the units, and classified SNAs into one of three "use designations": Research, Education and Public Use. The law states that only scientific, educational or public uses which do not impair or threaten the preservation objectives are to be allowed. Physical development is limited to facilities absolutely necessary for protection, research and education projects, and when appropriate for interpretive services. Finally, the statute requires plans to be drawn up for each SNA. No development funds can be spent by the DNR until these plans have been approved.

To be designated as an SNA a site must: 1) contain elements of "exceptional scientific and educational value," and 2) "be large enough to preserve their inherent natural values and permit effective research or educational functions." The SNA staff notifies the DNR Commissioner's Advisory Committee (CAC) on SNAs and the Minnesota Natural Heritage Program on all new nominations. The SNA staff then is responsible for conducting a field survey of the site to determine the site's qualities, vulnerability, extent of man-made disturbances and management practices which may be needed. The results of this field survey are forwarded to the Heritage Program which then evaluates the significance of the site's elements. Using the field survey data and the Heritage Program evaluation the CAC assesses the site and sends a recommendation to the SNA Program. Based on the CAC recommendation, the priorities for protection

as established by the Heritage Program, and on other considerations, such as the opportunity to acquire the area, the SNA Program sets a priority for designating the area as an SNA. Recommended proposals are next sent to the Director of the Division of Parks for approval. Finally, the proposal is passed on to the Commissioner of the DNR. If the Commissioner approves the site then the land rights are acquired either by fee simple purchase, lease, donation or conservation easement. Once the Commissioner determines sufficient land rights have been acquired to administer the area as an SNA it is formally designated. The formal designation includes the classification of the site as either a Research, Educational or Public Use unit.

If and when Bluestem Prairie is designated an SNA the Outdoor Recreation Act requires that a master plan for the area be completed and approved. The SNA Program is responsible for completing the SNA plan. After the SNA draft plan is completed the CAC and DNR review and approve it. An announcement is then made to the public and other state agencies regarding the existence of the plan. Interested persons and agencies are invited to review and comment on the plan within thirty days of the announcement. Comments received by the DNR are reviewed and appropriate changes are made in the plan. Finally, the revised plan is submitted to the State Planning Agency for review. After the DNR reviews this agency's recommendations, and makes the necessary changes, the plan is officially approved.

In July, 1979 the DNR issued a policy statement on SNAs. These policies will affect the management of Bluestem Prairie if and when

it is designated. The full text of the policy statement can be found in the Management section, "DNR-SNA Management Policies, Rules and Regulations" (Appendix C).

Appendix B

The Nature Conservancy's Management Guidelines

TNC's management guidelines govern what management actions will be implemented on Bluestem Prairie. The two primary TNC stewardship objectives are as follows:

> The primary objective is to maintain areas so that they sustain species, communities, and natural features that make significant contributions to the preservation of natural diversity. The secondary objective is to determine and promote land uses compatible with the preservation of natural diversity on the preserve, in order to foster local support for individual preserves and recognition by the general public of the values of natural diversity preservation.
>
> (Stewardship Guide for Preserve Committees, 1978)

The primary objective, the ecological objective, is closely tied to determining which of the preserve's resources are most significant for preservation. The Minnesota Natural Heritage Program will play a major role in identifying which elements of the preserve are most significant. This assessment in turn determines how the preserve will be managed. For example, if an endangered species is the most significant element on the tract and that species requires a successful plant community, then management should be directed at perpetuating this successional stage in order to preserve the endangered species. If, on the other hand, the most significant element on the tract is a climax community then a different management program is necessary.

Management may be directed at species, communities, natural features, etc. In January, 1978 the Minnesota Chapter of TNC developed a Manual for Stewardship of Nature Conservancy Lands in Minnesota. The following guidelines are taken from this document.

If the occurrence of one or more species are determined to be significant on a preserve TNC will:

1. MAINTAIN POPULATION LEVELS SO THAT THE SPECIES CHANCES OF LONG TERM SURVIVAL ON THE TRACT REMAIN STABLE OR ARE IMPROVED.

Management to increase the population of any species should be integrated with perpetuating other native species and maintaining the tract as a diverse and naturally functioning system. There may be important ecological factors regulating the population size of significant species and it may not be desirable in all cases to attempt to increase populations.

2. MANAGEMENT OF SPECIES POPULATIONS WILL BE ACCOMPLISHED PRINCIPALLY THROUGH MANAGEMENT OF THE SPECIES' NATURAL HABITAT AND THROUGH PROTECTION OF THE SPECIES FROM VANDALISM, POACHING AND SIMILAR THREATS.

Thus managers generally will not use artificial means, such as direct control of natural predation, manipulation of food supply through food plots, or improvement of nesting habitat through plantings or artificial shelters to manage populations. Exceptions to this guideline should only be made in certain circumstances when special actions

are necessary for the survival of a species or to redress an imbalance due to a factor such as predator extinction.

Management of plant communities should also be guided by an assessment of the preserve's communities. Where management is directed toward plant communities TNC will:

3. MAINTAIN OR RESTORE SELECTED PLANT COMMUNITIES AS NEAR AS POSSIBLE TO THE CONDITIONS THEY WOULD BE IN TODAY HAD NATURAL ECOLOGICAL PROCESSES NOT BEEN DISRUPTED. THIS GUIDELINE WILL BE ACHIEVED, TO THE EXTENT FEASIBLE, BY:
   A) PERPETUATING AND AS NECESSARY RE-ESTABLISHING NATURAL ECOLOGICAL PROCESSES; AND
   B) MINIMIZING IMPACTS OF CHEMICAL, MECHANICAL AND SIMILAR ARTIFICIAL PROCESSES ASSOCIATED WITH HUMAN INFLUENCES.

Some preserves will be protected because they contain significant geological, hydrological or other natural features. The same Heritage Program methodology used to evaluate species and plant communities should be used to assess the importance of these features. TNC will:

4. MAINTAIN NATURAL FEATURES IN PRISTINE CONDITION AND PROTECT THEM FROM UNNATURAL CORROSION AND DETERIORATION. THIS WILL BE ACCOMPLISHED PRIMARILY THROUGH REGULATING THE LEVELS AND TYPES OF HUMAN USE AND IMPACTS THAT ACCELERATE CORROSION AND DETERIORATION.

In special instances steps may be taken to prevent or diminish even natural processes of deterioration in order to perpetuate significant natural features and other natural elements.

TNC' secondary objective, the social stewardship objective, is to foster local support for preserves and recognition by the general

public of the value of natural diversity preservation. The future preservation of natural areas depends upon a constituency of users and supporters. TNC should foster the development of such a constituency by encouraging the appropriate use of preserves by educators, students, researchers, and other members of the general public. The management plan should identify appropriate types and levels of use, and specify programs to facilitate such use.

To achieve the above stewardship objective TNC will:

5. INVOLVE LOCAL RESIDENTS, USERS, AND OTHER INTERESTED MEMBERS OF THE PUBLIC IN DISCUSSIONS ABOUT STEWARDSHIP PLANNING AND IMPLEMENTATION.

6. PROVIDE INFORMATION ABOUT THE PURPOSE AND NATURAL QUALITIES OF THE PRESERVE TO THE LOCAL COMMUNITIES AND PRESERVE USERS.

7. KEEP THE PRESERVE AS FREE FROM HAZARDS TO USERS AS POSSIBLE.

8. CONDUCT STEWARDSHIP ACTIVITIES IN A WAY THAT MINIMIZES UNNECESSARY ANNOYANCES AND HAZARDS TO RESIDENTS NEAR THE PRESERVE.

9. UTILIZE PRESERVE DESIGN, SUCH AS THE PLACEMENT OF TRAILS, PARKING AREAS AND SIGNS, TO BOTH OPTIMIZE ACCESSIBILITY OF THE PRESERVE AND MINIMIZE UNDESIRABLE HUMAN IMPACTS TO THE EXTENT THAT SUCH DESIGN MEASURES DO NOT CONFLICT WITH OTHER PRESERVE OBJECTIVES.

10. PROMOTE APPROPRIATE RESEARCH AND EDUCATIONAL USE OF THE PRESERVE.

Two major stewardship objectives -- ecological and social -- may at times conflict with each other. People crush vegetation, erode and compact soil, alter the behavior of wildlife and transport onto

preserves the seeds of unwanted plants that stick to shoes and clothing.

It is the Nature Conservancy's position that:

11. ECOLOGICAL CONSIDERATIONS SHOULD BE WEIGHED MORE HEAVILY THAN HUMAN CONSIDERATIONS WHEN THERE IS A THREAT THAT SIGNIFICANT NATURAL ELEMENTS ON A PRESERVE WILL BE ALTERED OR SIGNIFICANTLY DAMAGED.

Appendix C

DNR-SNA Management Policies, Rules, and Regulations

To ensure the preservation of the SNA's elements of natural diversity it is the DNR's policy to:

1. IDENTIFY AND CATALOG THE NATURAL FEATURES OF THE AREA.

2. ENSURE THAT RESOURCE MANAGEMENT IS DIRECTED TOWARD PRESERVATION AND MAINTENANCE OF ALL SIGNIFICANT ELEMENTS OF THE AREA.

3. MANAGE THE AREA IN SO FAR AS POSSIBLE, TO PERPETUATE OR ESTABLISH NATURAL PROCESSES AND LIMIT THE EFFECTS OF HUMAN ACTIVITIES.

4. PROMOTE WISE STEWARDSHIP WITH USERS, LOCAL RESIDENTS AND SPECIAL INTEREST GROUPS.

To fulfill these general policies the DNR will:

5. MONITOR AND EVALUATE SNA MANAGEMENT PERIODICALLY TO DETERMINE IF MANAGEMENT OBJECTIVES ARE BEING ACHIEVED.

6. USE MANAGEMENT METHOD(S) CONSIDERED MOST NATURAL AND APPROPRIATE TO THE TOTAL ENVIRONMENT OF THE AREA AND:
   A) NOT USE COST ALONE TO DICTATE SELECTION OF THE APPROPRIATE MANAGEMENT METHODS;
   B) DESIGN MANAGEMENT PLANS TO ADDRESS THE ECOLOGICAL INTEGRITY OF THE AREA TO PREVENT MISMANAGEMENT;
   C) REMOVE EXISTING DEVELOPMENTS OR UNNATURAL OBJECTS UNLESS THEY ARE UNOBTRUSIVE AND NOT DETRIMENTAL TO THE PURPOSES FOR WHICH THE AREA WAS DESIGNATED OR OF HISTORIC VALUE.

7. PROHIBIT THE FOLLOWING:
   A) CUTTING OF GRASS, BRUSH, OR OTHER VEGETATION, THINNING TREES, REMOVAL OF DEAD WOOD AND WIND-FALLS, OPENING OF SCENIC VISTAS OR PLANTING EXCEPT AS PROVIDED FOR IN THE MANAGEMENT PLAN;

B) INTRUSIONS OF DEVELOPMENT ON, THROUGH OR OVER SNAs UNLESS ESSENTIAL TO THE MANAGEMENT OF THE UNIT;
C) MINERAL EXTRACTION, PEAT HARVESTING AND WATER INUNDATION OR APPROPRIATION;
D) COLLECTION OF PLANT, ANIMAL, HISTORICAL OR GEOLOGICAL SPECIMENS (EXCEPT BY PERMIT) OR ANY CONSUMPTIVE USE OF NATURAL RESOURCES;
E) INTRODUCTION OF PLANT, ANIMAL, OR OTHER OBJECTS, INCLUDING LIVE SEEDS OR DISEASE ORGANISMS, UNLESS EXPRESSLY PROVIDED FOR IN THE MANAGEMENT PLAN.

8. PROVIDE THE FOLLOWING:
A) SPECIAL MANAGEMENT TO TRANSIENT SPECIES ONLY WHEN THERE IS A WELL DEFINED NEED;
B) SPECIAL MANAGEMENT FOR BALD EAGLE NESTS AND COLONIAL WATER BIRD NESTING SITES WHERE APPROPRIATE;
C) REVIEW OF DNR PERMITS AND ACTIONS TO MINIMIZE ADVERSE EFFECTS ON A DESIGNATED SNA.

9. INVOLVE USERS, LOCAL RESIDENTS, AND SPECIAL INTEREST GROUPS IN THE MANAGEMENT OF THE SNA AND ENFORCEMENT OF RULES.

10. ESTABLISH A WORKING RELATIONSHIP WITH ADJACENT LANDOWNERS SO AS TO MINIMIZE OR ELIMINATE THOSE LAND USE PRACTICES HAVING AN ADVERSE IMPACT ON THE SNA.

To ensure the preservation of SNA resources and provide for use of the area it is the DNR's policy to:

11. LIMIT HUMAN USE ON SNAs TO THE AMOUNT THE RESOURCE CAN TOLERATE WITHOUT DAMAGE TO SPECIAL FEATURES.

12. PROVIDE FOR THE INTERPRETATION OF THE SPECIAL FEATURES AND THEIR MANAGEMENT.

13. SEED INPUT FROM USERS, LOCAL RESIDENTS AND SPECIAL INTEREST GROUPS IN DECISIONS REGARDING MOST SUITABLE USE(S).

14. REQUIRE USERS ENGAGED IN SCIENTIFIC STUDY TO MAKE INFORMATION OBTAINED ON THE SNA AVAILABLE TO THE DNR AND ENCOURAGE USERS TO MAKE THEIR STUDIES AVAILABLE TO THE SCIENTIFIC COMMUNITY THROUGH REPORTS OR PUBLISHED ARTICLES.

To fulfill these general policies the DNR will:

15. ENCOURAGE:
    A) ACTIVITIES WHICH CAN OCCUR EQUALLY WELL ON LESS VULNERABLE OUTDOOR AREAS TO BE CONDUCTED ELSEWHERE;
    B) SCIENTIFIC STUDIES, PHOTOGRAPHY, AND KEEPING OF PHENOLOGICAL RECORDS AND FAUNAL AND FLORAL LISTS FOR LONG TERM RESEARCH EDUCATIONAL BENEFITS;
    C) APPROPRIATE USERS AND PUBLIC SUPPORT RATHER THAN UNRESTRICTED PUBLIC USE.

16. PROHIBIT THE FOLLOWING ACTIVITIES UNLESS NECESSARY FOR MANAGEMENT PURPOSES OR SPECIFICALLY AUTHORIZED BY THE MANAGEMENT PLAN: COLLECTING PLANTS AND ANIMALS, HUNTING, FISHING, CAMPING, PICKNICKING, HORSEBACK RIDING, MOTORIZED VEHICLE USE WITH THE EXCEPTION OF PARKING FACILITIES AND SIMILAR ACTIVITIES.

17. ASSURE STRUCTURES, TRAILS AND SIGNS ARE AS SPECIFIED IN THE MANAGEMENT PLAN AND IN KEEPING WITH THE NATURAL SURROUNDINGS AND PRESENT ONLY SO FAR AS REQUIRED FOR RESOURCE PROTECTION AND PROVISION OF BASIC USER NEEDS.

18. ADAPT INTERPRETIVE TECHNIQUES AND MATERIALS TO THE USER.

19. LIMIT OR EXCLUDE USE FROM AN AREA FOR AN APPROPRIATE PERIOD OF TIME WHEN IMPORTANT NATURAL FEATURES ARE THREATENED AS A RESULT OF SUCH USE.

20. CLEARLY POST THE PROCESS FOR OBTAINING A VISITOR USE PERMIT WHEN REQUIRED, AT THE ENTRANCE TO THE SNA.

21. NOTIFY ADJACENT LANDOWNERS AND INTERESTED PARTIES PRIOR TO IMPLEMENTING MAJOR MANAGEMENT ACTIONS.

22. ERECT BOUNDARY SIGNS AS SPECIFIED IN THE MANAGEMENT PLAN TO DISCOURAGE ENCROACHMENT AND TRESPASS ONTO THE SNA AND ONTO ADJACENT PROPERTY BY SNA USERS.

23. REQUIRE A "PACK OUT WHAT YOU BRING IN" LITTER PHILOSOPHY AND ENFORCE LITTER REGULATIONS.

24. FENCE ONLY WHEN NECESSARY TO CORRECT PERSISTENT ENCROACHMENT OR TRESPASS PROBLEMS TO THE SNA OR ADJACENT PROPERTY.

25. REGULATE USE OF EMPLOYING, SINGLY OR IN COMBINATION, METHODS THAT INCLUDE BUT ARE NOT LIMITED TO THE FOLLOWING:
    A) NO ACCESS RESTRICTIONS;
    B) ACCESS BY PERMIT ONLY;
    C) ACCESS ON DESIGNATED TRAILS ONLY;
    D) TEMPORAL OR SPATIAL ZONING.

26. REQUIRE:
    A) REVIEW OF ALL RESEARCH PROPOSALS FOR THE SNA WITH EMPHASIS ON THE PROPOSED RESEARCH METHODOLOGY;
    B) IF NECESSARY, BONDING OF RESEARCHERS TO GUARANTEE CLEAN-UP FOLLOWING COMPLETION OF THE PROJECT(S).

Appendix D

SNA Deed/Lease Considerations

If and when Bluestem Prairie is designated an SNA the lease will influence the management of the tract. The lease states:

1. Management planning is a joint and cooperative responsibility of the DNR and the Nature Conservancy.

2. The DNR will notify TNC thirty days prior to any proposed change in the rules and regulations. The Conservancy will then notify the DNR within thirty days if the change is acceptable or not.

3. The DNR will not cause or permit to be caused any act constituting harm or destruction of the unit.

4. The DNR shall not apply or permit application of any chemicals, including herbicide and insecticide, unless it has been provided for in the management plan or unless written permission has been first obtained from the Conservancy.

5. If consistent with the management plan a permanent recognition sign will be erected by the DNR on the unit.

6. Upon request the DNR shall provide TNC with an annual report on use management of the unit.

7. The Conservancy shall have access to the unit at any time.

8. TNC may, with the consent of the DNR, lease all or any portion of the unit for purposes consistent with the management plan.

9. Both TNC and the DNR can terminate the lease when there is a breach of the contract.

Appendix E

Relevant State and Local Land-use Laws

Finally, several Minnesota statutes may affect the management of Bluestem Prairie. They include:

1. Collecting and taking of wild animals:

   Under state law (M.S. 98.48) special permits are required from the DNR, Division of Fish and Wildlife, for the collection or taking of protected wild animals.

2. Endangered species:

   The Endangered Species Act (M.S.A. 97.488, as amended in 1981) states that no endangered wild animal or plant or parts thereof may be taken except under special circumstances. The DNR, Division of Fish and Wildlife, may undertake programs or promulgate rules and regulations which also affect the management of endangered or threatened species.

3. Conservation of certain flowers:

   Under state law (M.S. 17.23) no member of the Orchid or Trillium families, or any species of Lotus (Nelumbo lutea), Gentian (Gentiana), Arbutus (Epigaea repens) or Lily (Lilium) can be taken or gathered in any manner from public

land without the permission of the Commissioner of Agriculture and then only for scientific and herbarium purposes.

4. Control of noxious weeds:

It is the duty of all land owners, according to state law (M.S. 18.181), to eradicate or otherwise destroy all noxious weeds. Section 18.315 also states that towns and cities may take steps to control noxious weeds on state lands within the territorial limits of the towns or cities provided that the managing agency fails to take action within fourteen days of receiving notice to cut or control the weeds. The following plants are considered noxious weeds statewide: field bindweed; hemp; poison ivy; leafy spurge; perennial sowthistle; bull thistle; canada thistle; musk thistle; and plumeless thistle. In addition, in Becker County hoary alyssum, cockleburr, wild sunflower, giant foxtail, wormwood, redroot pigweed, and kochia are classified as noxious weeds.

Appendix F-1a
Frequency sampling. From Heitlinger 1979.

To collect frequency data one simply notes the presence or absence of a species in a sampling unit (quadrat). Frequency is usually expressed as a percentage. If a species is observed in half of the quadrats in a sample, for instance 40 out of 80 quadrats, the frequency of the species is 50%.

The number of stems and biomass are disregarded in frequency sampling. All judgements are reduced to a yes or a no decision, which is objective and determined quickly.

The methods to be used are slightly modified from those of Hyder (1963, 1966, 1975a, 1975b). Frequency data will be used for monitoring grassland vegetation over time.

1. Determine which SNAs and which homogeneous areas (identified for relevé studies) will also be sampled with frequency analysis. Only grasslands will be sampled with frequency techniques. **Check with supervisor** about the choice. Lay out and mark the corners of the frequency plot using the same method as for relevé plots.

2. Frequency sampling will be conducted once, between August 15 and 30.

3. The frequency plot will be 100 feet by 75 feet (30.5m x 23m). It is placed near the center of the homogeneous area, near but not contiguous to the relevé plot (see figure 5, **page 60**).

4. Locate transects along the base line. Use graph paper to plot locations. The 100 foot baseline is divided into five 20 foot segments. Within each segment, two transect locations are chosen through random selection. Use a table of random numbers to select five pairs of two digit numbers between 01 and 20. Each pair must be different numbers but otherwise duplicate numbers are permitted.

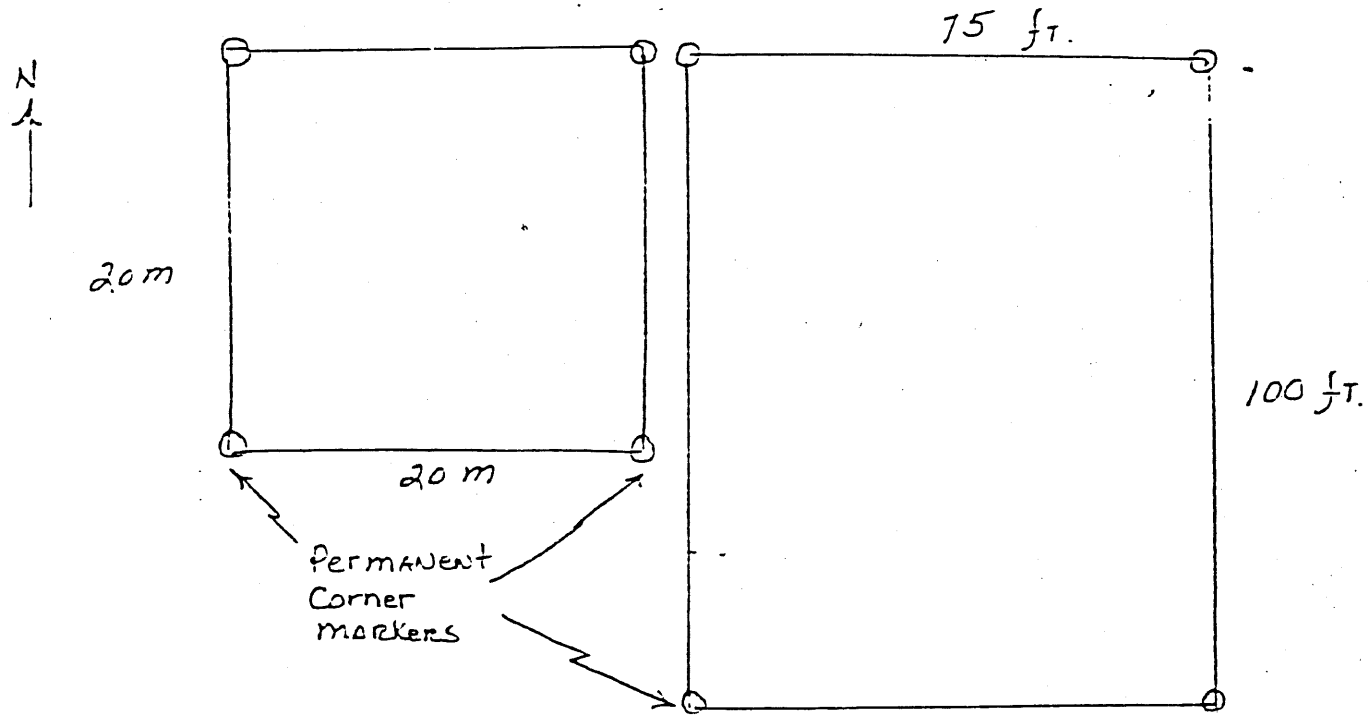


Fig. 5. Releve and frequency plots.

Each pair of numbers is used to locate two transects in each 20 foot segment. See figure 6.

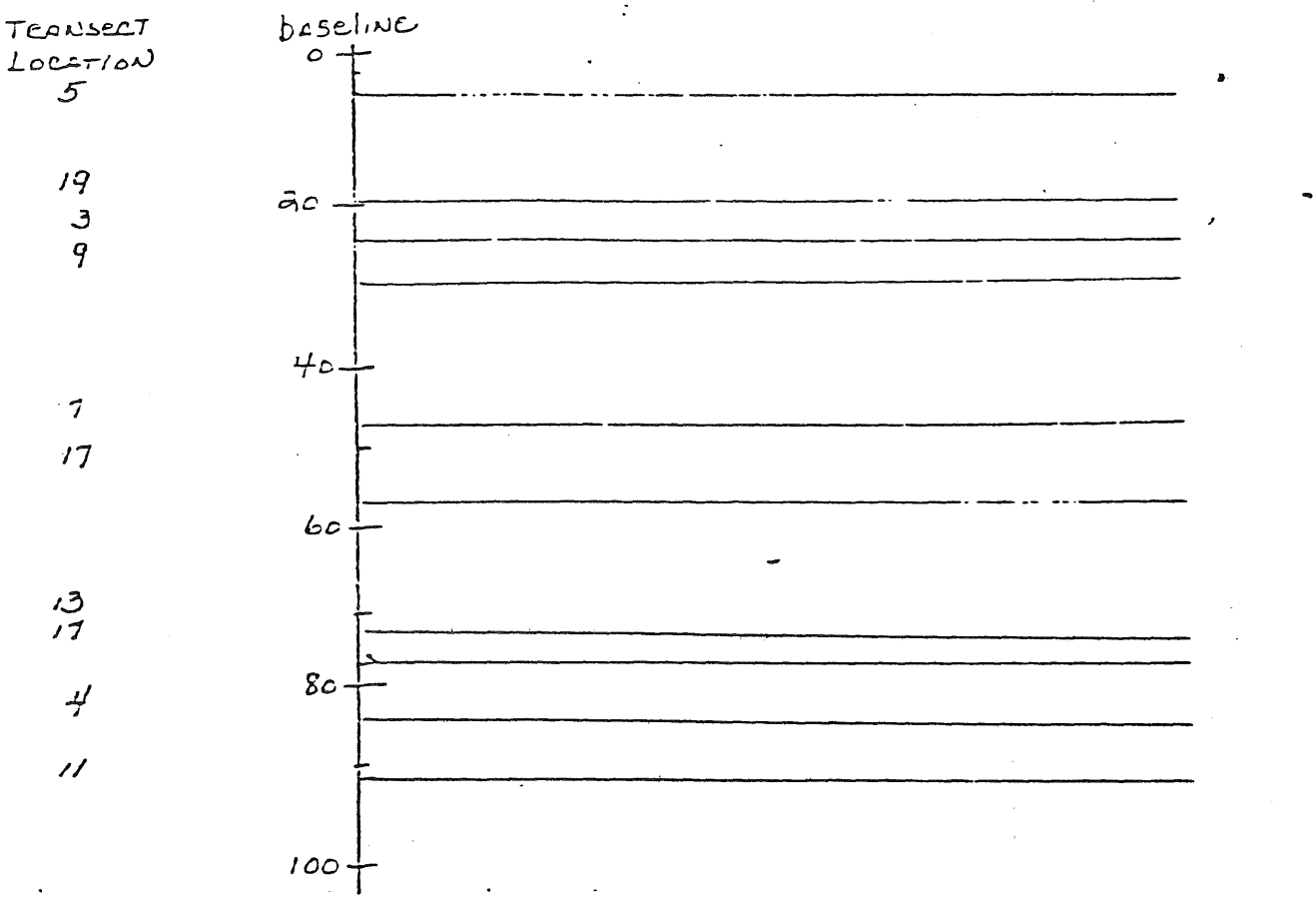


Fig. 6. Transect locations along the baseline. Pairs of randomly selected numbers between 01 and 20 are converted to numbers of feet to locate two transects in each 20 foot segment of the baseline.

5. Locate quadrat placements along each transect. Use graph paper to plot locations. Using a table of random numbers, select 20 numbers between 00 and 89. Each number in a set must be different. Multiply each of the 20 numbers by 10. These numbers are transposed to inches along a 75 foot (900 inch) transect, and indicate where the side of the quadrat closest to the baseline is located. Repeat random selection for quadrat placements ten times, so that each of the ten transects has a total of 20 quadrat locations, making a total of 200 quadrat locations per plot. Repeat the entire process for each plot.

6. After locating on graph paper the transect and quadrat placements for each plot, locate transects in the field and ~~map~~ mark each transect

with a pair of 5' lengths of electrical conduit driven three feet into the ground. Quadrat placements need not be marked in the field.

7. Frequency sampling procedure.

   a) Prepare (or obtain copies of) data sheets. See figure 7. Obtain a quadrat frame (10 inches square).

Frequency Data

SNA _____ Cover Type _____

Frequency plot # _____ Soil series _____

Location _____ Date _____

_____ Surveyor(s) _____

_____

Transect #

Species	1	2	3	4	5	6	7	8	9	10	Sum	%
Andropogon gerardi											99	49
Andropogon scoparius												
etc.												

Fig. 7. Design of frequency data sheet showing data tallies for Andropogon gerardi which occurred in 7 quadrats in transect 1, 4 in transect 2, 15 in transect 3, etc.

   b) Use the relevé data to make a list of all the species you may expect to encounter in the frequency plot adjacent to where the relevé was made. List the grasses alphabetically, and then all other species alphabetically.

   c) Tightly stretch a measuring tape along a transect line. Refer to graph paper for positions of quadrats along the transect.

   c) Conduct sampling. Two people are needed for sampling. One inspects the quadrat's contents and calls the names

of the species present. The other carries the data sheet, pencil and a ruler, and tallies data by a diagonal slash, one slash for each quadrat placement in which a species occurs. Overhangs do not count; the plant must be rooted in the quadrat. Tallies are kept separate by transect. A dot counter is used for tallying data. Double check all tallies.

Bare soil from pocket gopher or other ground disturbance is recorded as if it were a species.

Put a ? before any species name for which identification is in doubt. Describe unknowns under categories such as "unidentified grasses," " unidentified forbs," etc.

8. Record frequency data for an SNA using exactly the same format and method species arrangement as in the relevé synthesis table, but instead of using an x to simply record presence of the species write in the frequency percent.

9. Submit all data sheets with a map showing location of the frequency plot attached to the data sheet for that plot. Also submit "notes" mentioning any special problems, time spent in conducting sampling in the field, and any additional observations not recorded in the data that may be significant. Do not abbreviate species names and use only scientific names. Data sheets and tables need not be typed, but writing must be clear and spelling carefully proofed.

10. References for Frequency Method

Hyder, D.N., C. E. Conrad, P.T. Tueller, L. D. Calvin, C. E. Poultou, and F. A. Shera. 1963. Frequency sampling in sagebrush-bunchgrass vegetation. Ecology 44:740-746.

Hyder, D.M., R. E. Bement, E. E. Remmenga, and C. Terwilliger, Jr. 1966. Vegetation - soils and vegetation - grazing relations from frequency data. J. Range Mangt. 19:11-17.

Hyder, D.R., W.R. Houston, and J.E. Burwell, 1975. Tally equipment for frequency sampling of herbaceous vegetation. U.S.D.A., Agric. Res. Service, Western Region. 21p.

Hyder, D.R., R.E. Bement, E.E. Remmenga, and D.F. Hervey. 1975. Ecological responses of native plants and guidelines for management of shortgrass range. U.S.D.A., Agric. Res. Service, Technical Bul. 1503. 87p.

11. Materials for Frequency Method.

Maps and aerial photos as for relevé method
Measuring tapes, 100 feet or longer
½" steel conduit (corners and transect positions)
Compass
Post pounder and stepladder
Quadrat frame -- 20 inches × 10 inches square, one side open, with handle
Grid paper, data sheets
Dot counter

Appendix F-1b: Frequency analysis, subdivided quadrats From Kramer 1975.

Frequency Analysis

Frequency analysis was based on fifty 0.5M (1 X 0.25M) sample sites. All sample sites were determined by a restricted randomization method. The grid map (Figure 5) was used as the base for the ordered restriction. The restriction required that each 50M block would be sampled at one site. The randomization was accomplished by selecting sample site coordinates in each block from a random numbers table (Cox, 1972).

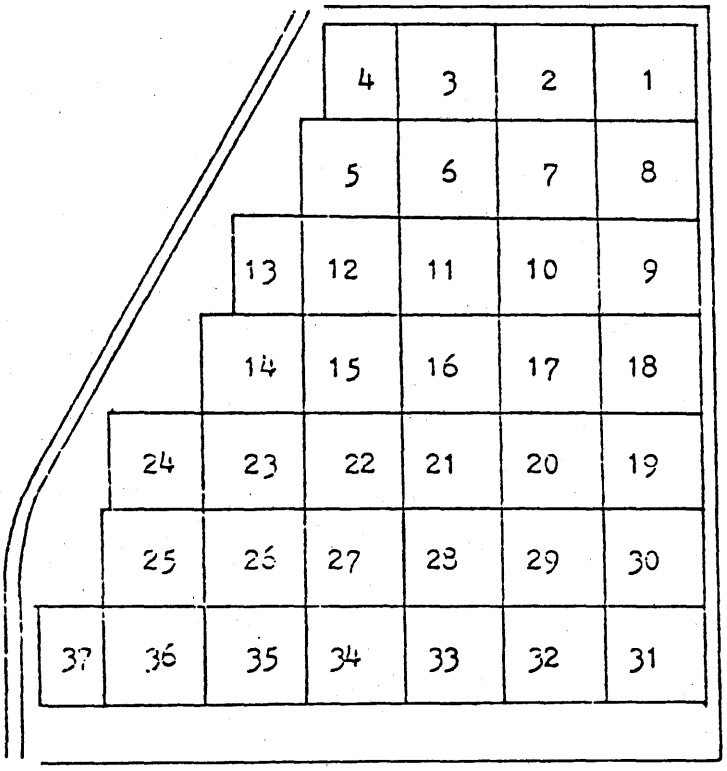


Figure 5. Grid map. Numbered blocks are 50M sq except 4, 13, 24, & 37.

Three grid blocks, each having 25% or more of its area in a buffer zone (Nos. 4,13, & 37), were not considered in the sample site selection. The remaining 34 blocks were treated equally. Sixteen additional sample sites were selected at random, one per randomly selected 50M block.

Each sample site was located by triangulation from block corners and 25M midpoints along the east-west boundary lines. Each site was marked with a flag.

A 0.25 X 1M sampler was constructed of 1in angle aluminum. Three-sixteenth in diameter holes were drilled at decimeter intervals along the 1M sides to accomodate 12-strand stainless steel crosswires affixed to three-sixteenth in bolts. Two taut crosswires were positioned between the sides and were marked with solder drops at decimeter intervals to delimit each square decimeter within the 0.5M sampler.

The 0.5M sampler was placed with the marker flag abutting its northeast corner. The sampler was positioned randomly in a north-south or east-west direction and alligned by magnetic compass. Vegetation growing along the edges of the sampler was carefully parted to position the sampler. Vegetation growing immediately outside the sampler edges was cliped at ground level to permit better viewing of the edge and to allow precise repositioning of the sampler at a later date. Additional corner flags were used to aid in establishing the sampler position. Loose debris from previous seasons was removed to aid viewing at ground level. Crosswires were positioned by threading them through the vegetation (Figure 6).

Basal frequency was recorded for each decimeter. All sites were sampled from 4 July through 29 August 1974 with most sites revisited several times in 1974 and some sites checked in 1975.

Field analysis of composition was limited to methods meeting the following requirements: the time required for each sample must not preclude making numerous replications; each site must be precisely relocatable to verify identifications; data should include a large number of the species present; data should be comparable to other studies; and the data should reflect composition of the entire site.

The assessment of population values or community structure by frequency analysis was the most commonly applied quantitative measure for the analysis of herbaceous communities in North American descriptive studies (Muller-Dombois, 1974).

Walker (1970) considered frequency to be the only method to provide acceptable estimates of all species without expenditure of excessive amounts of time. Because of the difficulty in counting individuals or estimating basal area, Curtis (1955) believed that "quadrat frequency is perhaps the best method of gaining information on the quantitative relations of the prairie plants." Greig-Smith (1957) also considered quadrat frequency the easiest of quantitative measures to determine.

Becker and Crockett (1973) compared various sampling techniques in grassland vegetation and found the quadrat an advantage over other methods when time was considered. They also found that frequency values determined by quadrat and line transect methods best reflected dispersion of the major species or species groups.

The selection of a modified quadrat system seemed appropriate but questions remained concerning size (area) of samples and number of sample replications. The vast majority of reported studies selected the most traditional size, 1sq M. Cain and Castro (1959) suggest a 1 to 2 sq M frame size for sampling a herb layer. Some recent studies have used smaller sizes (Smeins & Olsen, 1970; Becker & Crockett, 1973).

To provide ease of sampling and to permit using a greater number of samples, a sample unit size of 1 X ½M was selected. The resulting data indicated this size was suitable for this site. Only one species was recorded with 100% frequency. A 100% value indicates a plot size larger than the maximum size of the gaps between individuals of that species (Daubenmire, 1968). If several species had reached 100%, the sample could be too large and values for these species would not indicate relative distances between individuals.

Evans (1952) demonstrated that changes in frequency were not directly proportional to changes in the size of the sampling unit. He also stated that

> the size of quadrat was found to affect the resulting values of frequency and abundance, as well as the frequency distributions of the number of individuals per quadrat. It was also shown to have a marked effect upon various measures of dispersion.

The data presented here is thus most directly comparable to those studies using a sampler of the same dimensions.

Frequency may be defined as the estimate of the chance of an individual occurring in any sample (Greig-Smith, 1957) or as Daubenmire (1968) defined it

> frequency . . . provides information about the uniformity of distribution with out necessarily indicating how many or how much. It is defined as the percentage of occurrence of a species in a series of samples of uniform size contained in a single stand, the numbers and sizes of plants in each sample being ignored.

It has been noted repeatedly that frequency is dependent on density and distribution (Dice, 1948; Greig-Smith, 1957; Goodall, 1952). Goodall stated that

> certainly the frequency found reflects certain absolute characteristics of the vegetation, as well as the size and distribution of the quadrats used; but it combines so many

> (density, distribution, and in many cases size of individuals) and unites them in so complex a fashion, that it is not possible to argue back from the frequency to the features of the vegetation on which it depends.

Dice has shown that

> the calculation of the population density of a species from the frequency of its occurrence in samples of any kind may give erroneous figures when the distribution of the form is non-random . . . therefore, frequency should not be used as an indication of population density.

Simple frequency data therefore does not deal comprehensively with the importance of a species in a community. As an example, Poa pratensis has a 0.5M frequency of 100% at this site. Does it also have a high value of cover? Apparently not. Drew (1947) reported that in domestic prairies, this species had a high frequency value (79%) but low cover value (6.5%). Smeins and Olsen (1970) reported on three community types in Minnesota tall-grass prairie. In a Stipa community, Poa had a 14% cover value for a 100% frequency value. In an Andropogon gerardi community, it had 12% cover for 85% frequency. In a Spartina community it had 5% cover for 40% frequency. All three of these communities were catagorized by high frequency and cover values for the named species.

Simple frequency may tell us that a species has wide distribution, such as Poa, Carex, Andropogon gerardi, and Helianthus rigidus in this study. However, it relates little about other characteristics of dominance such as great abundance, comparatively large size (height and volume), long life span, and good vigor (Weaver, 1954). Indications of relative abundance and aggregation are possible if the frequency sample contains several sub-samples. Table 2 lists sub-sample frequency at two levels. The first considers total decimeter frequency (TDF). If this value is high compared to the corresponding 0.5M frequency (THF), then that species clearly is more abundant than the species with a low

TDF and a similar THF. Curtis (1959) stated that species behavior analysis based on this type of frequency was identical to that based on density values.

The second level considers decimeter frequency in only those 0.5M samples occupied by the species (DF/OM). This value will exceed the TDF for all species except those with THF of 100%. The TDF value, if relatively high, may indicate aggregation, but it is the ratio between THF and TDF that is of importance. This is more apparent when converted to DF/OM. If both DF/OM and TDF values are high, no aggregation is apparent and a sod forming grass is indicated. If the THF value is high with low TDF and DF/OM values, a frequent but widely dispersed species is indicated. As the DF/OM value rises and approaches or exceeds twice the TDF value, a bunch grass or otherwise aggregated grass or forb is indicated. Extreme aggregation occurs where the DF/OM value exceeds the THF.

The validity of the number of samples taken was tested by application of the species-area curve as employed by Cain, Nelson & McLean (1937) and Cain (1938).

The cumulative number of species sampled is plotted against the number of samples taken. The minimum number of samples needed is found where the resulting curve begins to level out or where a 10% increase in the total sample area results in a 10% increase in the total number of species. The curve levels at approximately 21 samples and the 10% relationship is satisfied at approximately 15 samples (Figure 11). Twenty samples as minimum was selected for data comparison.

Frequency values for these samples are listed in Table 2. Species of less than 10% frequency in the 50 sample total are not included.

Appendix F-2. Step-point plus frequency method. -29/-

Pilot Study to Test Step-point and Step-point plus Frequency Sampling for Prairie Vegetation Monitoring

Heitlinger 1980

Vegetation relevé plots (20m x 20m and 10m x 10m) have been permanently located on several Minnesota prairies. While useful in classifying vegetation, this system is inadequate for long-term vegetation monitoring. It requires estimates of cover which are subjective and hence can vary by observer, cover is recorded in broad cover classes which hampers identification of small changes and statistical treatment, and the relevé plot is not necessarily representative of the community in which it occurs. Alternative methods should be tested.

The step-point method is a "rapid, accurate, and objective method of determining the botanical composition and total cover of herbaceous vegetation." (Evans and Love 1957). Cook et al 1962 state "The technique is most suitable for measuring major characteristics of the vegetation of an area... . Often the technique is useful to determine features of the plant composition and density rapidly as a preliminary step toward more refined and detailed appraisal." A method for decreasing subjectivity in point placement was developed by Owensby (1973). Step-point is a common sampling method in tallgrass range management studies. Evans and Love (1957) used 100 points per acre (30 minutes per acre for one person); Owensby recommends about 60 points per acre (6-7 minutes per acre for a three-person crew). The standard approach is to use a regular distribution of sampling points.

Step-point sampling avoids the problems of estimating cover and tedious stem-counts. The main drawback is that it does not sample the less frequent plants and forbs as well as the dominant grasses.

A test is needed to determine if some modifications will significantly increase the number of species recorded, and to apply the step-point technique in classifying vegetation to identify representative areas which may be sampled more intensively.

A. Modifications to be tested are:

1. Varying the points per acre. By a greater density of points more species may be sampled. One application would be to sample at low density generally and higher density selectively in areas where rarer species occur.

2. Sampling in two seasons. By sampling once in the cool and once in the warm season we may pick up many additional species.

3. Combining step-point and frequency sampling. In frequency sampling the species present in a quadrat are recorded, regardless of size or number, as present. This type of binomial (yes or no) technique is quick but requires a relatively high number of observations. Byder (no date) found that 150 or more quadrats were needed to detect as significant

(at $p < .05$) a 20 percent change in density. No other method is as efficient for obtaining valid information about a large number of subdominant and relatively rare species. By combining step-point for common species and a $0.5m^2$ quadrat for less frequent plants we may pick up many additional species. One application would be to sample with step-point generally to measure dominant grasses, and use $0.5m^2$ quadrat frequency measurements in selected areas to record less common species.

B. Vegetation classification.

1. After conducting the studies listed above and determining the optimal method, it will be tested to quantitatively map vegetation. Data will be tabulated per unit area (e.g., per acre or hectare) and units with closely similar values lumped into a cover type. The questions to be resolved are 1) how much time per acre does it require to use the optimal method, and 2) is the data useful in generating a vegetation map which can then be used to select representative sites for long-term monitoring?

Method

Sites and study areas. The site or sites (preserves) selected should have fairly complete species inventories, so that the number of species recorded in the trials can be compared to the total number of species. The preserve should be small enough so that 10 percent of the preserve area can be included in the study of method modifications without having an inordinately large area for study. The preserve should be diverse enough so that a test is provided in dry-to-wet prairie communities. Schaefer Prairie would be a good test site (120 acres not including formerly cultivated land, 275 vascular plants including 188 wet-to-dry native prairie species).

For the study of method modifications, 1-acre study plots totaling 10% of the sit acreage will be randomly selected. Selections qualify for study if they are less than 50 percent in wetland, woodland, and other non-native prairie communities. The corners of study plots will be marked with stakes, and located with a tape measure and compass.

Data collection points. To increase the speed of sampling, transect and data collection points will be located in the field by paces and steps. The researcher will have to determine the average length of his/her pace (two steps) and how many paces equal one side of a square one-acre area (approximately 209 feet). The variability of measuring with paces should increase the randomness factor each time data is sampled in an area, as well as greatly reduce the time required.

Transects will be located by restricted randomization of one transect per one-tenth of the baseline length. The researcher will randomly select one among numbers from 1 to the number of paces per 20.9 feet rounded to the nearest whole number. For example, if a step equals 2.25 feet, there are 9.3 steps per

Table 1. Variations in sampling method.

	Sampling density (per acre)	Method (sampling area)	Season	Species		
				total #	# grasses	# recorded wi 60-90% freque
1.	50	point	spring			
2.			summer			
3.			both			
4.		.25m^2	spring			
5.			summer			
6.			both			
7.	100	point	spring			
8.			summer			
9.			both			
10.		.25m^2	spring			
11.			summer			
12.			both			
13.	200	point	spring			
14.			summer			
15.			both			
16.		.25m^2	spring			
17.			summer			
18.			both			
19.	400	point	spring			
20.			summer			
21.			both			
22.		.25m^2	spring			
23.			summer			
24.			both			

20.9 feet. Round this to 9 and randomly select a number from 1-9 to locate the base of the transect. Repeat ten times, once every 20.9 feet. The 20.9-foot interval also should be measured by pacing.

The data collection points along transects will be 'located' at randomly selected one-step intervals. For example, if a step equals 2.25 feet, there are 93 steps per transect length (209 feet), and 40 of the 93 will be randomly selected for each transect for placement of the point and quadrat frame. The date need only be collected at the highest density of points to be studied (400) since results at lower densities can be determined through sub-sampling the data set. The easiest way to make this selection is to number cards from 1-93 (or whatever the number of paces per 209 feet), shuffle and select without replacement 40 cards, each card read as the number of steps along the transect where data is collected. The same method may be used for sub-sampling the data set for results at different densities of data collection points.

Materials and personnel. A cover type map or aerial photo will be needed for locating study areas and classification mapping. An overlay grid will be used for random selection of study areas within a site. A tape measure and lengths of steel conduit are needed for measuring and marking study plots. Wire flags can be used for marking transect bases. A quadrat frame will be constructed incorporating a single point for step-point data and a three-sided quadrat frame. Determining the optimal size of a quadrat is rather complicated. Hyder et al (1963) recommended 9-inch square quadrats for frequency sampling in sagebrush-bunchgrass vegetation. Curtis and McIntosh (1950) suggest a quadrat should be one to two times as large as the mean area per individual of the most common species. The greatest precision in detecting changes occurs when percent frequency falls between 60-90 percent (Hyder, no date), so the ideal size would record species of greatest interest within this range. Since dominant species will be sampled with the step-point method, a fairly large quadrat of 50cm by 50cm ($0.25m^2$) will be used for this study. A data sheet is attached.

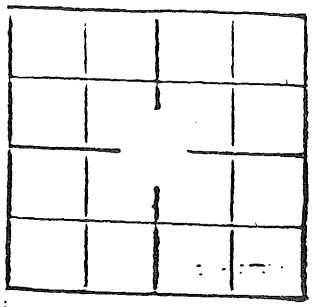
Field procedures. After locating transect bases with flags, a compass is used to sight a straight line. As a sampling point is reached the back of the quadrat frame is placed against the boot and leaned forward until contact is made with the ground. For point data, plants are recorded if the point strikes the base of the plant. If no plant base is hit then the plant nearest the point and within a forward 180° arc is recorded. For frequency all species identifiable will be recorded as present if rooted within the quadrat. The procedure will be repeated twice: mid-June and late August. Unknowns will be recorded as unknown seedling, grass, sedge spp. forb, or shrub.

Analysis of methods. Species area curves for total species, dominant grass species, and number of species recorded with frequency of 60-90% will be drawn for 24 variations in sampling method (Table 1). This will graphically depict the relation between completeness and utility of the sampling variation,

and increased number and size of the sample. For a general picture of the dominant species it is anticipated that step-point at 50-100 points per acre will be adequate. Additional points probably won't add a proportional amount of information about dominant grasses. For sub-dominants we would look for a sharper climb in the species area curve with increased number of frequency quadrats. If we see a flattening of the curve at a certain number of quadrats, that would provide a rationale for sampling at that density. The number of species recorded with frequencies between 60-90% is of interest because in this range the detection of change is best.

Mapping and classification. The selected method should be used in late August or early September on the entire preserve. Data should be recorded so that it can be analyzed per acre. One-acre blocks can then be characterized quantitatively, e.g., by the species occurring above a given frequency. Such a map would be useful as a quantitative baseline for the entire preserve and as a systematic way to identify plots for long-term study which are representative of communities on the preserve. By mapping several preserves in this way, we would increase our confidence in generalizing treatment responses from one preserve to another. The purpose of the pilot trial would be to determine the time per acre to use this system on a large scale, and the time and other constraints in generating maps from the data.

Field time. It is estimated to take 1 hour for set-up and 4 hours to collect data per 1-acre study plot. If Schaefer Prairie is used, we would have 6-12 study plots, requiring 3-6 long field days in spring and in summer. If step-point is used at 100 points per acre for mapping, it would take 50-60 field hours to collect mapping data. Required time might be reduced considerably if more than one person was involved in data collection. Analysis and writing might take an additional 4 days. The total commitment for one person would be 10 to 16 days.



Sect ____ Preserve _____, _____ Co, S

Plot # ☐ By _____ Date _____

Location = X

Transect (N-S or E-W) = ☐ . = step-point ✓ = frequ

-- Data Collection Points 1-40 per transect

Code	Species
	Graminoids
?	grass
?	sedge
Andropogon ger.	
A.	scop.
Bouteloua curt.	
Bromus inerm.	
Bromus kal.	
Koeleria crist.	
Panicum spp.	
P.	virg.
Poa comp.	
Sorghastrum nut.	
Sporobolus het.	
Spartina pect.	
Stipa spart.	
	Forbs & Shrubs
?	forb

Appendix F-3.

Point-centered quarter sampling. From Mueller-Dombois and Ellenberg 1974.

Vegetation Analysis in the Field

7.63 The Point-Centered Quarter Method. In the point-centered quarter method four distances instead of one are measured at each sampling point. Four quarters are established at the sampling point through a cross formed by two lines. One line is the compass direction and the second a line running perpendicular to the compass direction through the sampling point. The line-cross can also be randomly established by spinning a cross over each sampling point. The distance to the midpoint of the nearest tree from the sampling point is measured in each quarter (FIG. 7.4).

The four distances of a number of sampling points are averaged and when squared are found to be equal to the mean area occupied by each tree. COTTAM and CURTIS (1956) tested the reliability of this method on several random populations by checking the result with the plot method. They ranked the four quarter (Q) distances of each sampling point by computing the mean of the shortest (Q1), the second shortest (Q2), the third (Q3) and the longest (Q4) distances. The following estimates of the correct mean area per tree (MA) were found to apply to each of the different sets of mean distance.

Q1 shortest	$=0.5\ \sqrt{MA}$
Q2	$=0.8\ \sqrt{MA}$
Q3	$=1.12\sqrt{MA}$
Q4 longest	$=1.57\sqrt{MA}$
Q mean of 4	$=1.0\ \sqrt{MA}$

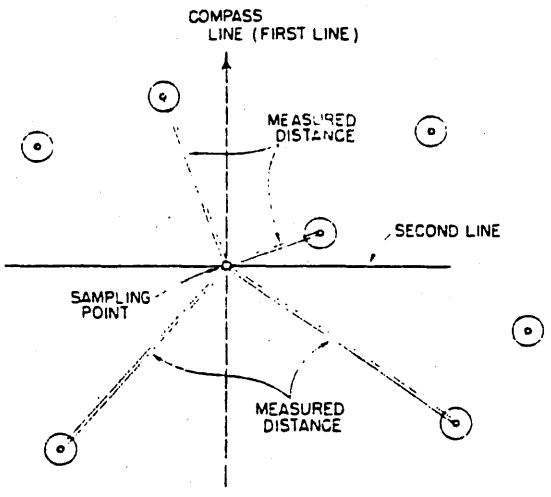


FIGURE 7.4. Point-centered quarter method.

Therefore, no correction factor is needed when the four quarter distances are averaged; and $MA = D^2$, where D = the mean distance of four point-to-nearest-tree distances taken in each of four quarters. Mathematical proof of the workability of this method has been given by MORISITA (1954).

Of course, the accuracy increases with the number of sampling points, and a minimum of 20 points is recommended (COTTAM and CURTIS 1956).

The method has two limitations (NEWSOME and DIX 1968) for field applications. An individual must be located within each quarter, and an individual must not be measured twice. Therefore, stands with wide spacing of individuals present a problem in using this method. The second limitation applies also to the random pairs method.

The parameters obtained in the distance methods are:

1. Species.
2. Density (from mean distance).
3. Diameter (and therefore basal area and dominance).
4. Frequency (as the occurrence of a species at a sampling point).

The same parameters are also obtained from plots. However, the distance methods have an advantage in that they do not require laying out of plot boundaries. This saves considerable time. It also eliminates to a certain extent the personal error from judging whether boundary individuals are inside or outside the quadrat.

7.64 Example of a Point-Centered Quarter Analysis. The following example relates to the same tropical rain forest stand that served for the relevé example (SECTION 5.3) and for the quantitative plot example (SECTION 7.3). The point-centered quarter example is shown only for five sampling points to save space (TABLE 7.4). It is recommended to sample at least 20 points per stand. The adequacy of sampling points can, of course, also be determined by plotting the running mean as described in SECTION 6.42.

In the example analysis in TABLE 7.4, trees with basal diameters less than 3 cm were omitted. These included all woody plants under 2 m height. The small trees could, however, be sampled as a second size category from the same sampling points with each four distances. The objective was to determine (from individuals taller than 2 m):

1. the density for each tree species,
2. the dominance of each tree species, and
3. the frequency of each tree species.

A second objective was to convert these absolute values into relative values as an example for deriving the importance value, which will be discussed in SECTION 7.67.

TABLE 7.4 shows the raw data for five sampling points that were arranged in a transect, one point every 5 m. TABLE 7.5 shows the derivation of the mean basal area by species. This value is needed to determine the dominance of the species, which is a combination of number and basal area.

7.65 Limitations of the Distance Methods. The point-centered quarter method has become well accepted as shown by many vegetation studies (CAPLENOR 1968, HABEK 1968, RISSER and ZEDLER 1968, NEWSOME and DIX 1968, among others). Apart from its less complicated field application and greater information value per sampling point, the method seems more reliable than the random pairs method. This is based on the observation that the distances of trees to sampling points are more truly random than the distances among trees located through sampling points (COTTAM, CURTIS and HALE 1953, PIELOU 1959).

However, the point-centered quarter method is similarly applicable only to random distributions. Plot studies are more reliable where plant individuals are not randomly distributed (SCHMELZ 1969). Yet plots or quadrats are not fully reliable either. The reason is that a plot may also include either aggregations or underdispersed groupings of individuals in contagiously distributed species combinations. Clumping of individuals or contagious distribution applies to nearly all plant life forms, except trees and annuals. But even among the latter life forms nonrandom distributions are the norm for the individuals of single species in mixed-species stands. Therefore, the method should not be applied to single species in mixed stands. Instead, it should be applied only to broad size classes as shown in the preceding example, where the method was applied to tree individuals of all species taller than 2 m. The density of each species is subsequently established by partitioning the total density estimate.

GREIG-SMITH (1964) has cautioned against applying the point-centered quarter method to herbaceous life forms, such as bunch grass vegetation, because the resulting density values are inaccurate where the distribution of individuals occurs in aggregations. This has been supported by RISSER and ZEDLER (1968) who found in Wisconsin grassland that the point-centered quarter method consistently underestimated the number of individuals in contagiously distributed species. This can be explained by the greater probability of a sampling point to fall between the clumps of individuals than within the clumps in contagious distributions in which the clump diameter is small. By falling

TABLE 7.4. *Quantitative Analysis by Point-Centered Quarter Method. Five Sampling Points, One at Every 5 m Along 110°, Starting at End of Convex, Gently Sloping Ridge Below Pauoa Flats Trail Going Upslope Toward the Trail. Raw Data, March 4, 1972.*

SAMPLING POINT	QUARTER NUMBER	DISTANCE (M)	SPECIES	DIAMETER AT BASE (CM)
1	1	0.7	*Psidium guajava*	5.5
	2	1.6	*Acacia koa*	42.5
	3	3.5	*Metrosideros collina*	17.0
	4	2.0	*Metrosideros tremuloides*	25.0
2	1	1.1	*Psidium guajava*	4.0
	2	0.8	*Psidium guajava*	5.0
	3	1.9	*Psidium guajava*	5.0
	4	1.8	*Psidium guajava*	4.0
3	1	1.3	*Acacia koa*	75.0
	2	0.7	*Psidium guajava*	3.0
	3	1.5	*Metrosideros collina*	9.0
	4	2.0	*Metrosideros collina*	23.0
4	1	3.1	*Acacia koa*	14.0
	2	1.7	*Psidium guajava*	6.0
	3	1.1	*Psidium guajava*	5.0
	4	1.9	*Acacia koa*	12.0
5	1	2.5	*Acacia koa*	23.0
	2	2.2	*Acacia koa*	18.0
	3	1.4	*Psidium guajava*	5.0
	4	2.8	*Metrosideros collina*	25.0
		Total 35.6		

Results:

Mean distance (D) = 35.6/20 = 1.78 m

Absolute density = Area/D^2

Where D = mean distance

Number of trees per 100 m^2 = 100/$(1.78)^2$ = 100/3.17 = 31.5

Absolute dominance = mean *ba* per tree × number of trees in species

Where *ba* = basal area

Number of trees in species

SPECIES	NUMBER IN QUARTERS	NUMBER OF TREES IN 100 M^2
Acacia koa	6/20=0.3	0.3 ×31.5= 9.4
Metrosideros collina	4/20=0.2	0.2 ×31.5= 6.3
Metrosideros tremuloides	1/20=0.05	0.05×31.5= 1.6
Psidium guajava	9/20=0.45	0.45×31.5=14.2
		Total 31.5

TABLE 7.5. Mean Basal Area by Species for the 20 Trees Shown in TABLE 7.4.

ACACIA KOA		*METROSIDEROS COLLINA*		*METROSIDEROS TREMULOIDES*		*PSIDIUM GUAJAVA*	
DIAMETER (CM)	BA (CM^2)	DIAMETER (CM)	BA (CM^2)	DIAMETER (CM)	BA (CM^2)	DIAMETER (CM)	BA (CM^2)
42.5	1418	17.0	227	25.0	491	5.5	24
75.0	4418	9.0	64	..	..	4.0	13
14.0	154	23.0	415	..	..	5.0	20
12.0	113	25.0	491	..	..	5.0	20
23.0	415	..	..	..	..	4.0	13
18.0	254	..	..	..	..	3.0	7
..	..	..	..	..	..	6.0	28
..	..	..	..	..	..	5.0	20
..	..	..	..	..	..	5.0	20
Total *ba*	6772		1197		491		165
Mean *ba*	1129		299		491		18

Therefore, dominance of — Dominance rank

Acacia koa	$1129 \times 9.4 = 10613$ cm²	1
Metrosideros collina	$299 \times 6.3 = 1884$ cm²	2
Metrosideros tremuloides	$491 \times 1.6 = 786$ cm²	3
Psidium guajava	$18 \times 14.2 = 256$ cm²	4
	13539 cm²/100m²	

$$\text{Absolute frequency} = \frac{\text{number of points with species}}{\text{total points}} \times 100$$

Acacia koa	$= \frac{4}{5} \times 100 =$ 80 percent
Metrosideros collina	$= \frac{3}{5} \times 100 =$ 60 percent
Metrosideros tremuloides	$= \frac{1}{5} \times 100 =$ 20 percent
Psidium guajava	$= \frac{5}{5} \times 100 =$ 100 percent
	260 percent

between clumps, the point to plant distances will be longer than average. The longer distances result in an overestimate of the mean area per individual and thus in an underestimate of density.

The opposite, namely overestimation of the number of individuals, is true for regularly distributed individuals. This is shown in FIGURE 7.5. In a regular, quadrangular distribution, such as often found in a planted tree stand, the correct mean area is obtained by squaring the shortest distance between any two trees. This result would be obtained only by sampling point 1 in FIGURE 7.5. Such locating may occur once in a very large number of random point placements or not at all. The most

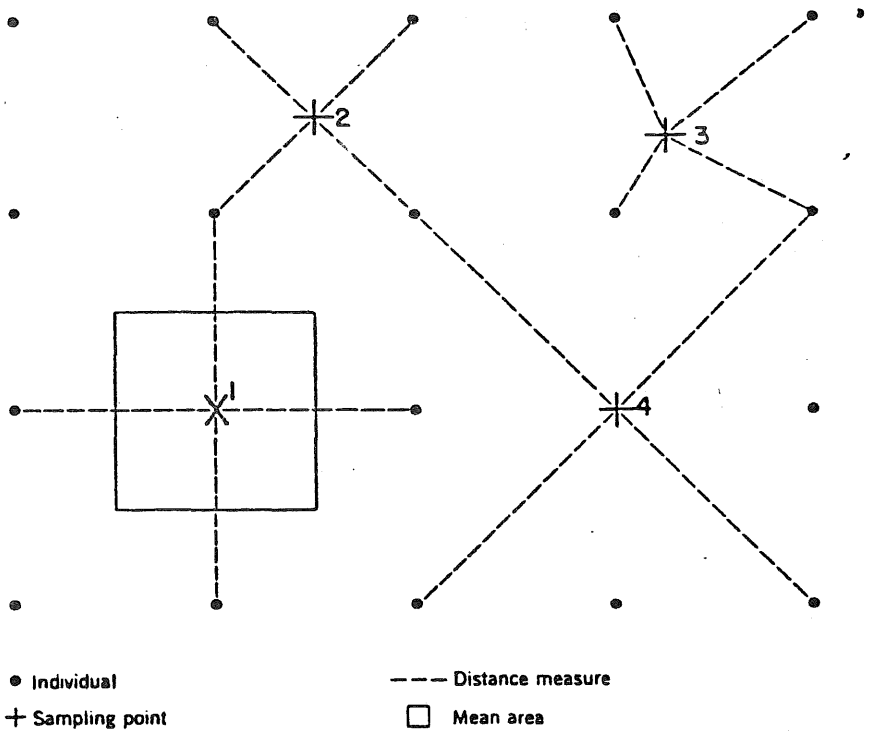


FIGURE 7.5. Application of point-centered quarter method to a regular distribution of individuals. Here only sampling point 1 gives the correct estimate of mean area. Further explanation in text.

common placement would be between trees, such as indicated by points 2 and 3. At these positions the mean distance of four quarters and therefore the mean area will always be underestimated. This will result in a considerable overestimate of tree density. Only position 4 would result in an overestimate of mean distance and thus an underestimate of density, as is found for contagiously distributed individuals. However, for a sampling point to give this result, not only must the point fall directly on a tree, but also the quarter dividing lines must pass through the center of the nearest trees, which would render them invalid for inclusion in the sample. This also shows that the boundary problem, found to be a disadvantage in any plot method, is not entirely eliminated in the plotless methods. However, it is highly improbable that position 4 will occur randomly. Instead, tree density can always be expected to be overestimated by this method when applied to regularly distributed individuals. This is true also for rectangular and rhombic regular distributions.

from Biol. Conserv. 12 (1977):115-134.

A METHOD FOR ASSESSING CHANGES IN THE ABUNDANCE OF BUTTERFLIES

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ABSTRACT

A method based on transect counts has been developed to assess changes in abundance of butterflies from year to year. The method involves weekly walks around a transect route making counts of butterflies seen within defined limits. The transects are divided into sections related to habitat or management units. Walks are made only when weather conditions satisfy specified minimum requirements. The method has been tested for three years at Monks Wood and for two years at a number of other sites.

The basis for annual comparisons is an index of abundance which is produced for each brood of each species, except when separation of broods is not possible. This index is correlated with abundance, although the precise nature of the relationship will vary from species to species. Evidence on this is presented for two species.

The method makes it possible to monitor the abundance of butterflies at selected sites, using recorders, such as nature reserve wardens, who can fit in one or two hours recording each week when the weather is suitable. Such a scheme, based on the methods described in this paper, began in 1976. In addition to the monitoring of fluctuations of abundance, the method provides considerable information on the phenology and ecology of butterflies. The division of the transects into sections makes some assessment of the effects of habitat change, due to management or other factors, possible.

INTRODUCTION

In a previous paper (Pollard *et al.*, 1975) a method was outlined which was considered suitable for recording fluctuations in butterfly abundance. The method is based on transect counts which are used to calculate an index of abundance. Since

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1973 when the preliminary work was done, the study has developed as follows:

(1) A woodland transect in Monks Wood, Cambridgeshire, begun in 1973, has been continued for a further two years.

(2) Another transect route through the two large fields in Monks Wood has been used for recording in 1974 and 1975 to test the method in a more open habitat.

(3) At five other sites, mainly nature reserves, transect recording has been done at a frequency of once a week by wardens or others with similar opportunities for regular recording. This has provided a pilot trial preliminary to a proposed national recording scheme.

(4) Population estimates have been made for two species in Monks Wood to provide data for comparison with the index values.

This paper provides an assessment of the transect recording method and illustrates its use with results from three years' recording in Monks Wood and two years at five other sites in eastern England.

METHOD

The method of transect recording adopted is described here briefly with slight modifications which have been made since the first account (Pollard *et al.*, 1975).

Recording is from the beginning of April until the end of September. The following criteria are observed in order to provide a degree of standardisation:

(1) Counts are started after 1045 h British Summer Time and completed before 1545 h.

(2) Counts are not made when the temperature is below 13°C, from 13°C to 17°C counts are made in sunny conditions (60% sunshine minimum); above 17°C conditions may be sunny or cloudy.

The transect routes are divided into sections, which as far as possible coincide with changes in the nature of the habitat being recorded. Besides simplifying counting this enables some assessment to be made of the occurrence of butterflies in different habitats. It also makes it possible to examine the effect of management of habitats.

The recorder walks at a uniform pace and records all butterflies seen within prescribed limits. It is most convenient to restrict the route to rides and paths, the boundaries of which are generally obvious. The precise width is not important provided the boundaries are permanent, although recording may be difficult if the width is greater than about 5 m. If no established paths are available they may be made by using canes or other markers. In a few cases it may be necessary to gauge distances by eye.

Butterflies are recorded up to about 5 m in front of the recorder. Individual butterflies sometimes fly along ahead of the recorder, in which case only one entry is made provided that there is no doubt that one butterfly is present. If there is any doubt a further record is made. Stops may be made to resolve identification

problems, recording being resumed from the point where the walk was interrupted. If, occasionally, a butterfly cannot be positively identified it is recorded as the commoner of likely alternatives present in the area at that time.

Calculation of the index

As an illustration of the method, the calculation of the index of abundance for hedge brown (*Pyronia tithonus* (L.)) in Monks Wood in 1973, is shown (Table I). The mean count per transect is calculated each week and the index of abundance is the sum of these means. If only one count is made each week, as suggested for routine recording on nature reserves, then the index is simply the total number of individuals seen. A separate index is calculated for each brood of species with more than one generation a year, and for autumn and spring flights of species which overwinter as adults.

TABLE I

CALCULATION OF THE INDEX OF ABUNDANCE FOR THE HEDGE BROWN (*Pyronia tithonus* (L.)) ON THE MONKS WOOD TRANSECT IN 1973. RECORDING WEEKS ARE NUMBERED FROM 1 APRIL

Week	13	14	15	16	17	18	19	20	21
Number of transects	4	7	5	4	3	5	4	7	5
Mean count per transect	0	1·9	34·4	111·8	104·6	79·2	12·1	4·4	0·8
Sum of weekly means	—	Index of abundance = 349·4							

RESULTS

Reliability of counts

The Monks Wood transect route (Pollard *et al.*, 1975) has now been in use from 1973–75 at a frequency of approximately four counts a week. A number of recorders have participated, but the three main ones have been D. O. Elias, E. Pollard and M. J. Skelton. Counts by these recorders for the green-veined white (*Pieris napi* (L.)) and ringlet (*Aphantopus hyperantus* (L.)) illustrate the data obtained (Fig. 1). Counts of green-veined whites are amongst the more variable, those of the ringlet very uniform.

These counts can be examined rather more formally by calculating an index of abundance separately for individual recorders. This has been done for two recorders, D.O.E. and E.P., taking one count made by each recorder each week. If more than one count was available, the one used was selected at random. On the relatively few occasions when no count was available counts made by 'substitute' recorders were used. In almost all cases (Fig. 2) the trend in index value shown by the two recorders is the same, although for many species D.O.E. produced consistently higher values than E.P. The most obvious discrepancy is in the small white (*Pieris rapae* (L.)) data. This may be due to recorder differences in distinguishing green-veined and small whites.

(pages 118-132 omitted)

Appendix G. Sweetclover control methods..

File
Schaefer Prairie
Veg. Mgt.

M E M O R A N D U M

TO: JEFF WEIGEL, PEG KOHRING

cc: Rex Boner

FROM: MARK HEITLINGER MH

DATE: JULY 14, 1981

RE: NOTES ON FIELD TRIP, JULY 8, 1981

SCHAEFER PRAIRIE 8:45 a.m.

We observed vegetation including response of the early May 1981 burn. My subjective evaluation is that the prairie has deteriorated somewhat in the last several years. Sweetclover was more abundant than I recall since the early 1970's. Flowering Kentucky bluegrass was fairly conspicuous. Poison ivy also seems more abundant, though it is hard to assess this.

If pressed, I would speculate that sweetclover seed reserves have gradually built up in the last five or so years to the point where large stands are again possible, particularily in the second year following a fire. Most of the sweetclover now present is in the area burned in spring 1980, although there are sizeable stands elsewhere.

The 1981 May burn seems to have reduced second year sweetclover, although some second year plants survived. The later in spring the burn, the more effective it will be in killing second year plants. As we burn later, however, we will have more impact on the spring flora and birds. Burning in July, after nesting is over but before sweetclover seed set, kills second year and also first year plants. In summary:

April burns - If hot, result in much sweetclover germination; won't effect second year plants; more or less neutral effect on bluegrass and warm season plants; stimulates native cool season plants.

May burns - Mid May burns will kill some but not all second year sweetclover plants; reduces bluegrass and flowering of spring flora, stimulates native warm season plants. May reduce native cool season flowering.

July burns - If there is sufficient fuel to carry the fire, will kill second and first year sweet clover plants, stimulates cool season exotics and suppresses warm season native grasses. May stimulate cool season natives.

The following sequence might be considered.

	UNIT A	UNIT B
Year 1	July burn	Rest
2	May burn	Rest
3	April burn	July burn
4	Rest	May burn
5	Rest	April burn
6	July burn	Rest
7	May burn	Rest
	etc.	etc.

JULY BURN - burn close to but before sweetclover seed set. This should virtually eliminate new seed addition the year of the burn and the following year. Visit prairie and hand pull or mow any second year plants that happen to escape the fire. There may be a significant number of these on mounds, in light fuel areas, and on roadside. The July burn will stimulate cool season exotics.

MAY BURN - This is mostly to reverse the effect on cool season exotics, but may also reduce the number of sweetclover plants that happened to escape as first year plants the July burn, the previous year. I am not sure what the spring fuel load following a July burn will be like. You want to burn later (mid-May) to suppress bluegrass but fuels may require burning before green-up (late April). Any second year plants blooming this year must be hand pulled or mowed.

APRIL BURN - Aim for a hot, dormant season burn. This should result in near-complete germination of any remaining seed, but will not reduce second year plants should any be present. These must be pulled or mowed. There will be a good display of spring flora this year.

Rest - During rest years any observed second year plants should be pulled or mowed. However, if a few plants are over looked and seeds produced, the repetition of the July and May burns should prevent any build up capable of producing very large stands.

As Jeff pointed out, the schedule above calls for burning one unit in April and the other in July in certain years (twice in eight years). I think that is tolerable, but it could be avoided as follows:

	UNIT A	UNIT B
Year 1	July burn	Rest
2	May burn	Rest
3	April burn	Rest
4	Rest	July burn
5	Rest	May burn
6	Rest	April burn
7	July burn	Rest
8	May burn	Rest
9	April burn	Rest
10	Rest	July burn
	etc.	etc.