AD-A176 256

US Army Corps of Engineers
Construction Engineering Research Laboratory

USA-CERL TECHNICAL REPORT N-87/02, VOL. II
January 1987
Multipurpose Training Ranges

Development of Environmental Guidelines for Multipurpose Range Complexes

Volume II: Description of Field Tests, Sediment Yields, and Option Analysis

by
Robert E. Riggins
Steven Apfelbaum
William D. Goran
Anthony J. Krzysik
Timothy J. Ward

This report provides information on the field tests, sediment yields study, and management option analysis conducted to supply data for a natural resources management demonstration test conducted at Fort Riley, KS. The purpose of the test was to reduce the effects of training activities from the new Multipurpose Range Complex on the installation.

Volume I of this report describes the test results.

DTIC
ELECTE
JAN 2 9 1987
S D
E

DTIC FILE COPY

Approved for public release; distribution unlimited.

20030131196

87 1 28 056

The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official indorsement or approval of the use of such commercial products. The findings of this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

DESTROY THIS REPORT WHEN IT IS NO LONGER NEEDED
DO NOT RETURN IT TO THE ORIGINATOR

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188
Exp. Date: Jun 30, 1986

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBERS CERL TR N-87/02, VOL. II	5. MONITORING ORGANIZATION REPORT NUMBERS
6a. NAME OF PERFORMING ORGANIZATION U.S. Army Construction Engr Research Laboratory 6b. OFFICE SYMBOL (If applicable): USA-CERL	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) P.O. Box 4005 Champaign, IL 61820-1305	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION DOD SACE 8b. OFFICE SYMBOL (If applicable): DAEN-ZCF-B	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER Facility Technology Applications Tests
8c. ADDRESS (City, State, and ZIP Code) 20 Massachusetts Ave., N.W. Washington, D. C. 20314-1000	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO / PROJECT NO / TASK NO / WORK UNIT ACCESSION NO

11. TITLE (Include Security Classification)
Development of Environmental Guidelines for Multipurpose Range Complexes Volume II: Description of Field Tests, Sediment Yields, and Option Analysis (Unclassified)

12. PERSONAL AUTHOR(S) Riggins, Robert E.; Apfelbaum, Steven; Goran, William D.; Krzysik, Anthony J.; Ward, Timothy J.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM ____ TO ____	January 1987	64

16. SUPPLEMENTARY NOTATION
Copies are available from the National Technical Information Service Springfield, VA 22161

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
FIELD	GROUP	SUB-GROUP	Fort Riley	ecology
12	2		Multipurpose Range Complex	training
			environmental management	tracked vehicles

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This report provides information on the field tests, sediment yields study, and management option analysis conducted to supply data for a natural resources management demonstration test conducted at Fort Riley, KS. The purpose of the test was to reduce the effects of training activities from the new Multipurpose Range Complex on the installation.

Volume I of this report describes the test results.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL E. P. Mann	22b. TELEPHONE (Include Area Code): (217) 373-2773 22c. OFFICE SYMBOL: Chief-IMT

DD FORM 1473, 83 APR — All previous editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

FOREWORD

This research was conducted for the Office of the Assistant Chief of Engineers (OACE), under Project Facility Technology Applications Tests (FTAT); Work Unit, "Multipurpose Training Ranges." The work was performed by the Environmental Division (EN), U. S. Army Construction Engineering Research Laboratory (USA-CERL). Mr. Don Bandel (DAEN-ZCF-B) was the OACE Technical Monitor.

The assistance of S. Apfelbaum, K. A. Heiman, C. Sams, and N. Thomas (Applied Ecological Services) and T. J. Ward (New Mexico State University) in conducting the field tests, sediment yields study, and management option analysis is acknowledged.

Dr. R. K. Jain is Chief of USA-CERL-EN. COL Norman C. Hintz is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

CONTENTS

		Page
	DD FORM 1473	1
	FOREWORD	3
	LIST OF TABLES AND FIGURES	5
1	ECOLOGICAL CONDITION OF THE LAND AND WILDLIFE IN AND ADJACENT TO THE MULTIPURPOSE RANGE COMPLEX, FORT RILEY, KANSAS	7
	Introduction	7
	The Study Region and Study Areas	7
	Topography and Climate	8
	Soils	9
	Vegetation	10
	The Study Sites	11
	Methods	11
	Disturbance History	12
	Vegetation Studies	12
	Avian Studies	14
	Small Mammals Studies	14
	Vegetation Mapping	14
	Results	15
	Discussion	38
	Ecological Implications	40
	Reclamation, Ecological Monitoring, and Management	42
2	ESTIMATES OF TRAINING IMPACTS ON SEDIMENT YIELD AT THE FORT RILEY, KS, MPRC	44
	Introduction	44
	Approach	44
	Results	48
	Conclusion	48
3	ENVIRONMENTAL IMPACTS, MAINTENANCE, AND MANAGEMENT PERSPECTIVES AND OPTIONS FOR THE FORT RILEY MPRC	49
	Introduction	49
	The Fort Riley MPRC	49
	Summary of Technical Presentations	50
	Summary of Discussions	50
	REFERENCES	61
	DISTRIBUTION	

TABLES

Number		Page
1	Total and Mean Intercept of Woody Vegetation in the Riparian Control Study Areas	16
2	Total and Mean Intercept of Woody Vegetation in the Riparian Test Areas	17
3	Frequency Distribution of Live and Dead Woody Stems in the Riparian Test Study Areas	18
4	Frequency Distribution of Live and Dead Woody Stems in the Riparian Control Study Areas	19
5	Density of Live and Dead Woody Plants	20
6	Total and Mean Canopy Intercepts	20
7	Tree Heights and DBH Reading From Selected Large Trees	21
8	Totals, Means, and Standard Deviations for Relative Cover, Frequency, and Importance Values of Plants Sampled in the Control Study Areas	23
9	Totals, Means, and Standard Deviations for Relative Cover, Frequency, and Importance Values of Plants Sampled in the Test Areas	29
10	Average Percent Cover for All Plants Less Than 1 m Tall	35
11	Results of Emlen Bird Surveys	36
12	Small Mammal Trapping Data and Analysis	37
13	Geometric Characteristics of Drainage Units	47

FIGURES

1	General Location of Fort Riley, KS	8
2	Location of the Multipurpose Range Complex and the USA-CERL Geographical Information System High-Resolution Window	13
3	Drainage Units	45
4	Schematic of Drainage Units	46

DEVELOPMENT OF ENVIRONMENTAL GUIDELINES
FOR MULTIPURPOSE RANGE COMPLEXES,
VOLUME II: DESCRIPTION OF FIELD TESTS,
SEDIMENTS YIELDS, AND OPTION ANALYSIS

1 ECOLOGICAL CONDITION OF THE LAND AND WILDLIFE IN AND ADJACENT TO THE MULTIPURPOSE RANGE COMPLEX, FORT RILEY, KANSAS*

Introduction

Federal environmental mandates require that impacts associated with changes in military training activities be assessed. This study was designed to determine the ecological impacts of construction, use, maintenance, and operation of the proposed Multipurpose Range Complex (MPRC) at Fort Riley, KS. This is a newly designed facility for conducting training activities on Abrams and Bradley tracked vehicles. The facility will encompass 4500 by 1000 m with additional acreage for a control facility, vehicle holding, several shelters, and a safety fan.[1]

The goals of this study were to: (1) establish a program of scientific investigation using standardized techniques of data acquisition and analysis and (2) evaluate the baseline ecological condition of the proposed MPRC system grounds and establish a program capable of monitoring long-term ecological dynamics and impacts of military activities.

The Study Region and Study Areas

Fort Riley is located in northeastern Kansas (Figure 1) in Riley and Geary Counties. The main post is just north of the confluence of the Republican and Smoky Hill Rivers.[2] The Fort contains more than 100,000 acres (40 914 hectares) and occupies historic range and crop acreage, including native prairie and riparian forest systems. Some land is currently used for agriculture and for plantings to enhance wildlife habitat. Most of the facility is managed for several wildlife species, with emphasis on game animals.[3] Major crops grown in and around the facility include wheat, grain sorghum (milo), corn, alfalfa, and soybeans. The MPRC and the study areas are located in the northwestern sector of Fort Riley.

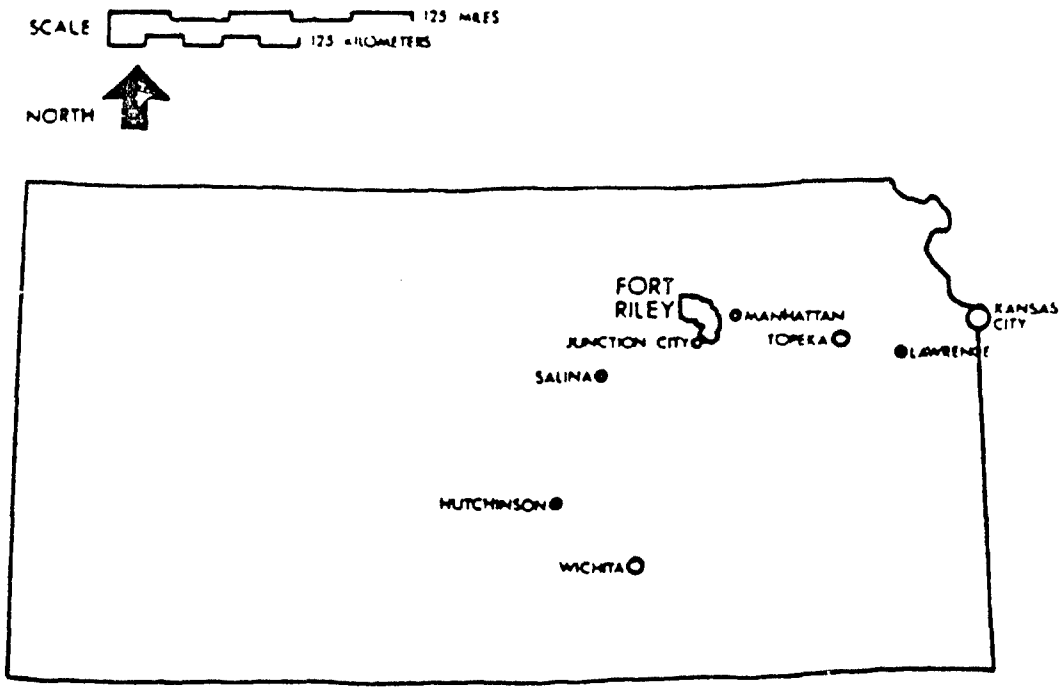
---

*Prepared by Karin A. Heiman, Chuck Sams, and Neil Thomas, *Applied Ecological Services*, Juda, WI.

[1] *Fort Riley Multi-Purpose Range Complex Erosion Control Manual* (U. S. Army Engineer Waterways Experiment Station, 1982).

[2] *Draft Environmental Assessment: Multipurpose Training Range Complex* (MCA Project Number T519 (Fort Riley, KS, 6 August 1982).

[3] *Five Year Wildlife Management Plan, Fort Riley Military Reservation, KS* (Fort Riley, March 1982).



KANSAS

Figure 1. General location of Fort Riley, KS.

Topography and Climate

At Fort Riley, the Flint Hills are dissected by numerous streams cutting down to the bottoms of the Smoky Hill and Kansas Rivers. Rock outcrops border some steeper hillsides and some river floodplains. North and west of the Flint Hills region is an area of undulating upland prairie with deeper soils and fewer outcrops. About 35 percent of the post is upland prairie, 55 percent broken hilly country, and 10 percent riparian and river valley. Elevations range from 1025 ft (312 m) in the bottomlands of the Kansas River to 1350 ft (411 m) on hilltops.[4]

Climate greatly influences the vegetation of Kansas. Mean annual rainfall is 20 in. (51 cm) in western Kansas and increases to 40 in. (102 cm) to the east. Precipitation is heaviest in early summer, with about 75 percent of the annual 33 in. (838.2 mm) occurring during the growing season. Summer precipitation frequently occurs as thundershowers. Winters are generally clear and dry with snowfall averaging from 22 to 36 in. (558.8 to 914.4 mm) annually. Slightly greater precipitation falls in the eastern areas of Riley and Geary Counties. Mean monthly temperatures range from 25°F (-4°C) in winter to more than 80°F (27°C) in summer. Fort Riley has moderately cold winters and hot summers.

---

[4] *Draft Environmental Assessment: Multipurpose Training Range Complex.*

Soils

Soils on Fort Riley include river bottom soils, terrace and stream valley soils, upland prairie soils, and soils on hilly, often rocky areas.[5] River bottom alluvial soils were carried from the high plains to the west and northwest and range from pure sand through sandy and silty loams. These soils support woodlands and grasslands. Terrace soils are formed from materials eroded from limestone, shale hills, and ancient river sediments, and they occur in bottomlands. These soils are variable, ranging in texture from sandy loams to silty clays to clay loams. Upland prairie soils were formed on loess deposits by the natural breakdown of the stone hills. In the Flint Hills, soils are relatively thin and "cherty"; away from these hills, upland prairie soils are thicker, with a heavier texture and more clay in the subsoils.

The study sites have six general soils types. Although they vary, they have some characteristics in common. Because of their high montmorillonite clay content, the soil structure is blocky, and soils may have a high shrink-swell potential that may create instability. Permeability is slow, and erosion potential is usually high. On some soils, water availability is very low, which favors drought-tolerant plants. Most topsoils are slightly acidic, except the Clime-Sogn soil complex, which is quite alkaline.

The loamy upland soils (Wymore) are generally deep loess soils. When in good condition, they produce an average of 5000 lb/acre of air-dried herbage. This is contrasted with shallow limy uplands (Clime-Sogn complex), which average about 2500 lb/acre or the alluvial lowlands, which can average 8000 lb/acre. The loamy upland soils generally have low shear strength and are very susceptible to compaction and compression. They have good potential for agriculture and for wildlife use.

Wymore silty-clay loam comprises most of the prairie test and control site soils and some of the riparian test area. These are generally dark soils with topsoil 13 in. deep and subsoil 25 in. deep. Tilling and perhaps military use has eroded the topsoil over most of the area, so there is a mixture of top and subsoils.

Reading silt loam on 0 to 3 percent slopes, and Irwin silty clay loams, which was formed from clay shales, occur on gently sloping soils in the study areas. Both have subsoils at 11 in. that extend to more than 40 in. deep. Irwin soils have a blocky structure that increases their susceptibility to washing and runoff.

Areas with Clime-Sogn complex soils are calcareous and are found on 5 to 20 percent slopes. Clime soils usually occur below limestone outcrops, while Sogn soils have thin topsoils and occur directly on bedrock. Both soils have high erosion potential.

Alluvial lowland soils are a mixture of soils from adjacent uplands and upstream areas; their use is restricted due to frequent flooding. An associated type of soil--the Breaks Alluvial complex--occurs in V-shaped drainages associated with tilled land. Because slopes range from 0 to 50 percent and soil water permeability is poor, most of these areas are not suitable for cultivation.

Prairie test and control sites were mainly Wymore soils in various erosional conditions. The prairie control site encountered Ready soils on the western section of one transect, and was bordered to the south by Clime-Sogn Series. The other transects

---

Soil Conservation Service, *Soil Survey of Riley County and Part of Geary County*,(U. S. Department of Agriculture, June 1975).

may have had patches of Irwin Series. The prairie test portion also had patches of Break-Alluvial, Irwin, and the Clime-Sogn Series.

The riparian control sites were made up of Reading (and on occasion Wymore) soils in level areas, Irwin soils on some slopes, alluvial soils in creek bottoms, and break-alluvial soils along two transects that followed drainages toward Madison Creek. The riparian test site was covered by Wymore soil, some Reading soil, and patches of Alluvial, Irwin, and Clime-Sogn soils.

Vegetation

The presettlement vegetation of Fort Riley was "tallgrass" prairie on uplands and deciduous forests in drainages, floodplains, and adjacent hillsides.[6] The prairie is a part of the "bluestem" prairie that covers the Kansas Flint Hills and makes up 75 percent of numerous species, including big and little bluestem (Andropogon gerardii and Andropogon scoparius), Indiangrass (Sorghastrum nutans), and others. Riparian forests are dominated by oak (Quercus macrocarpa), elms (Ulmus rubra), maple (Acer saccaharinum), ash (Faxinus spp.), and common hackberry (Celtis occidentalis).

Fort Riley has five natural and four cultural vegetation types.[7]

This study focused on two of the natural classes: the riparian system and the adjacent grasslands. Agriculture is the predominant use of adjacent lands.

Ecological impacts of tracked vehicles can best be understood in the context of vegetation succession after disturbances. These impacts include modifications of the vegetation from land clearing, direct contact between vegetation and military vehicles, and indirect impacts such as erosion.

Potential study sites for this investigation had to have a representative mix of vegetation associations in the MPRC and adjacent areas. Most prairie study areas were disturbed prairie and fallowed agricultural lands. Riparian areas had been timbered and showed secondary growth. Most woody plants in riparian areas were less than 90 years old, with the majority less than 30. Shrubs and saplings were most abundant in a fringe of woody vegetation encroaching on the prairies from the riparian areas. Based on tree ring analysis, most shrubs were also less than 25 years old.

Plant succession generally follows agricultural abandonment of lands. This includes the initial establishment by annual plants in recently disturbed areas, and their gradual replacement by biennials, and then short- and long-lived perennials, including trees and shrubs. At Fort Riley, asters (Aster spp.), goldenrods (Solidago spp.), thistle (Cirsium spp. Cardus nutans), and several other plants occurred in recently fallowed lands. Unlike areas in the eastern deciduous forest, where most secondary successional studies have been done,[8] woody vegetation may not be as important in prairie succession because of

---

[6] A. W. Kuchler, "A New Vegetation Map for Kansas," *Ecology*, Vol 55 (1974), pp 586-604.

[7] D. L. Williams, *Report To Accompany Vegetation Maps of Selected Portions of Fort Riley, KS* (1978).

[8] D. W. Johnson and E. P. Odum, "Breeding Bird Populations in Relation to Plant Succession on the Piedmont of Georgia," *Ecology*, Vol 37, No. 1 (1956), pp 50-61; J. R. Karr, "Habitat and Avian Diversity on Strip Mined Land in East Central Illinois," *Condor*, Vol 70, No. 4 (1968), pp 348-357.

the reduced importance of woody vegetation in this region. Where planted, wood species were important only in stream courses and in several areas that were being invaded by trees from the riparian systems.

The Study Sites

The prairie study sites were extensive, disturbed areas dominated by exotic plant species, with several small, relatively natural, native prairie communities. Most prairie study sites had been farmed. Based on woody plant ages, most farmed areas were fallowed 15 to 25 years ago. Several areas were more recently fallowed and had a weedier vegetation that included thistles (Ambrosia artemisiifolia) and ragweed (Ambrosia psilostachya). Madison Creek and some larger tributaries were the only areas with continuous riparian vegetation. Prairie dominated the uplands. There was often a very abrupt boundary between prairie and riparian, possibly indicating wildfire. In some cases, this was related to farming activities. Narrow riparian corridors were on the western side of Madison Creek, while better developed systems were on the eastern banks. This is likely the effect of wildfires that burned from a predominantly westerly direction until encountering natural firebreaks such as Madison Creek. Many older trees on the west bank had multiple fire scars. Small reentrants in the prairie were dominated by prairie plants and low-growing shrubs (Symphoricarpos, Cornus sp.), with occasional cottonwoods, ash, willow, and osage orange.

Several areas with standing water had growths of sedges, rushes, and some rooted aquatic plant species. Prairie cord grass (Spartina pectinata) was often associated with such areas. In general, prairie grasses occurred along moisture- and soil-type gradients, with side-oats gramma (Bouteloua curtipendula) and little bluestem on highest, driest areas, especially on rock exposures; bluestem and indiangrass occupied intermediate moisture soils; cord grass (Spartina pectinata) was found only in wetter areas.

Small patches of upland prairie, usually on shallow soil over exposed rock, were not plowed and perhaps were only grazed or hayed in the past. These parcels retained an appearance and a plant species composition that were probably similar to the prairie before farming disturbances. All prairie transects contained small, undisturbed prairie, recently fallowed farm fields, and land that was plowed in the early 1900s. The recently disturbed areas had an abundance of annual weed species; older plowed grounds had fewer and less productive growths of these weed species and were dominated by native prairie grasses. However, the widespread presence of ironweed (Vernonia spp.), bluegrasses (Poa spp.), Japanese brome grass (Bromus japonicus), ragweeds (Ambrosia spp.), and thistles suggested that the historic prairie disturbances had been extensive and the prairie soil significantly disturbed to select for disturbed-site plants. Tank ruts in the prairies were vegetated by plants that were also found in recently fallowed lands. Ruts were usually being invaded by vegetation from alongside the tracks. Production and stature of plants in the ruts were suppressed, and plant species richness may have declined. Some ruts were bare for several growing seasons based on ages of tree saplings in the tracks.

Methods

Sixteen sites (eight test and eight control) were chosen in and adjacent to the MPRC to study riparian and prairie vegetation types. The test sites for both vegetation types were located in areas expected to receive impacts from the MPRC. The condition of the control areas was to be left relatively undisturbed by military activities. Four control and four test transects, 800 m long, were established and flagged in each study

area. Transect locations chosen in various representative areas were the locations for all ecological studies, and were permanently marked with 1/4-in.-diameter rebar (Figure 2). Field reconnaissance, aerial photographs, and maps were used to ensure that the study areas were similar physiographically and vegetationally, and had relatively similar anthropogenic and natural disturbance histories. An additional criterion for site selection was that all areas had to be within USA-CERL's Geographical Information System (GIS) study area. Because of the relatively narrow MPRC area, some test areas were located on adjacent land that will likely be modified only by MPRC use, and not by construction.

Disturbance History

Historic uses of land in the study areas were investigated to determine their influence on the existing ecological systems. Anthropogenic and natural disturbances in and around the study areas were investigated using 1956 aerial photographs (1:20,000). Ages of woody plants (determined with an increment core sampler) were used to determine when agricultural fields may have been fallowed; woodland tree ages were used to date major disturbances.

Vegetation Studies

Woody Plants

Woody vegetation was sampled using four 100- by 2-m belt transects (800 m square) for each riparian study area. Sixteen transects (four along each 800-m transect) were sampled. A combination of riparian edge and interior was sampled along each transect. Woody vegetation data consisted of tree and shrub stem counts, diameters, and canopy cover to the nearest 0.1 m. Woody species in each sample transect were identified, and those with stems taller than 1 m or diameters greater than 1 in. (25.4 mm) were measured for diameter at breast height (DBH). Stem-size class frequency distributions were prepared with these data. Woody species canopy cover was measured in two ways: (1) by canopy intercept--a measurement of woody plant cover that intercepts each 100-m transect and (2) by using a sighting tube with cross hairs and tallying the number of tree stems intercepted above 80 sampling points along each 800-m transect. The heights and diameters of the tallest trees along but not necessarily in each riparian study transect were measured with a Leitz abney level and DBH tape. The ages of these and representative smaller-diameter trees were determined by increment core sampling techniques. These data were used to investigate the disturbance history, successional status, and recuperative potential of the forested areas. Transects for the study of woody vegetation were not established in prairie areas.

Herbaceous Vegetation

All vegetation less than 1 m tall was sampled in 1-m circular quadrats, located every 15 m along each 800-m transect in the riparian and prairie study areas. Plant species were identified in each of the 50 quadrats of every transect, and their percent cover estimated and recorded. The data were used to analyze relative plant cover and frequency (percent of sample quadrats in which each plant species occurred) in each study transect. Fifty quadrats were established in each 800-m transect. Plant voucher collections of most plant species in the study transects were made. Plant specimens were pressed, labeled, and mounted on herbarium paper. All identification and

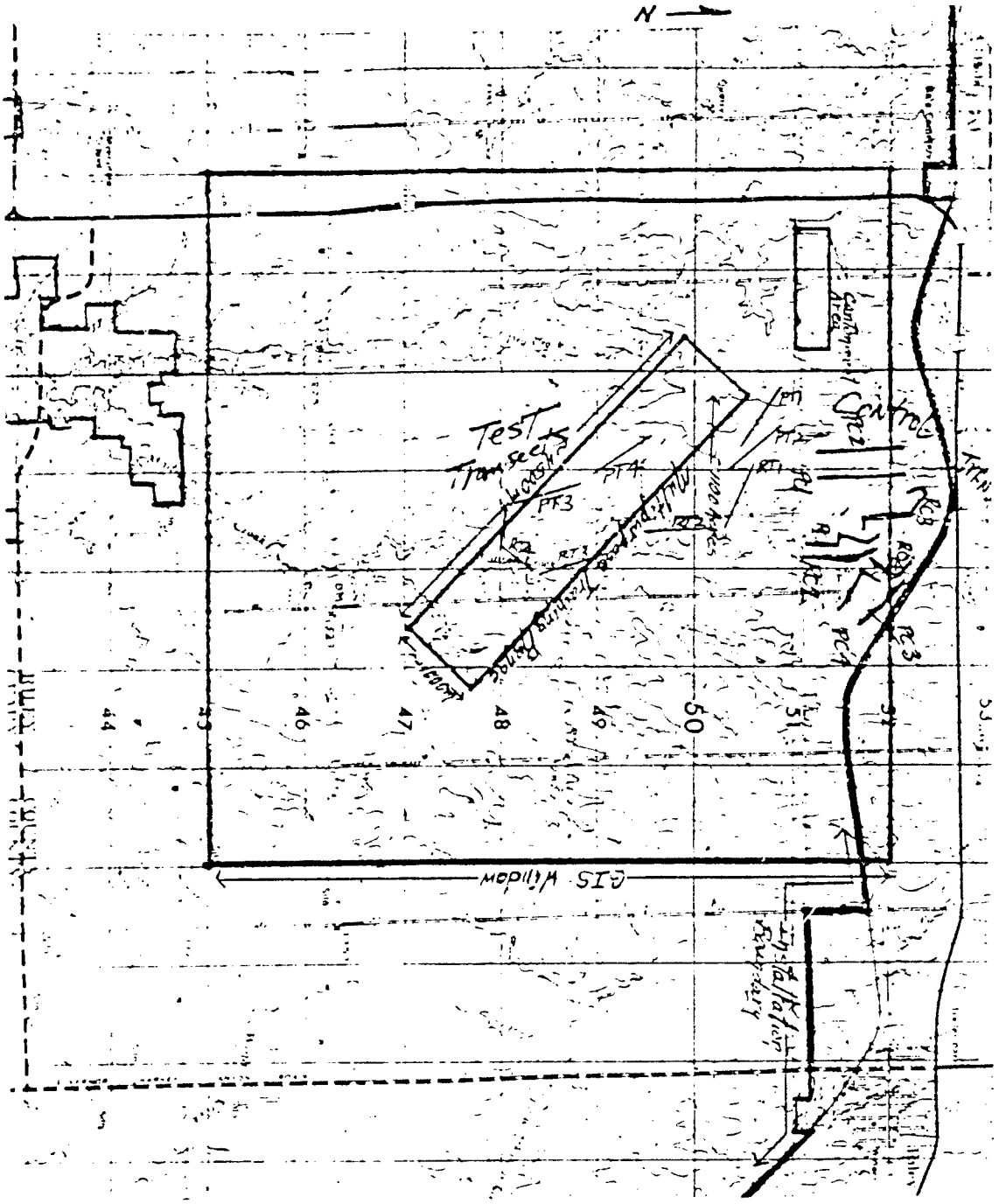


Figure 2. Location of the Multipurpose Range Complex (outlined in the central area of the map) and the USA-CERL Geographical Information System high-resolution window. Locations and identification of the 16- to 800-meter study transects in the prairie and riparian control and test study sites are shown (scale 1:50,000).

nomenclature follow Bare and Gleason.[9] Herbarium specimens (153 species) were deposited at the USA-CERL and Fort Riley Herbariums. Searches for Federal and Kansas special-status plant species were conducted during all field studies.

Avian Studies

Birds were studied using Emlen[10] transect techniques. Surveying was done daily for 3 to 4 hours by two independent observers at a slightly slower speed than suggested by Emlen, because of the noise created from moving through the vegetation. Locations of all birds observed or heard were plotted on prepared survey forms. Plotting and analysis were done within 25-m-wide belts parallelling both sides of the 800-m study transect to a distance of 100 m. The number of individuals for each species was determined, and then averaged over the four 800-m transects in each study area. For standardization with other studies, bird density has been reported as the number of birds in 100 ha. Surveying along each study transect was terminated when all or most of the individual birds were consistently replotted in the same areas during multiple surveys. three surveys were conducted in each study transect. Bird nomenclature follows the U. S. Fish and Wildlife Service *Bird Banding Manual.*[11]

Small Mammals Studies

Small mammals were sampled using 60 traps (four rat traps, 23 museum specials, and 33 mousetraps) for four consecutive days (960 trapdays) along each of the sixteen 800-m transects for a total of 3840 trapdays. Traps were baited with peanut butter and oatmeal and set at 5-m intervals. Traps were checked each morning, rebaited, and reset. Most captures were submitted as voucher specimens to USA-CERL. Mammal nomenclature follows Hall and Nelson.[12]

Vegetation Mapping

Vegetation in the MPRC and peripheral acreage included in the GIS high-resolution window was mapped on 1:24,000, color, infrared aerial photographs provided by USA-CERL. Classification of vegetation generally follows Williams.[13]

---

[9] J. A. Bare, *Wildflowers and Weeds of Kansas* (Regents Press of Kansas, 1976); H. A. Gleason, *The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada* (Hafner Press, 1952).

[10] J. T. Emlen, "1971 Population Densities of Birds Derived From Transect Counts," *Auk.* Vol 88(1971), pp 232-342.

[11] *North American Bird Banding Manual, Vols 1 and 2* (U. S. Department of the Interior, Fish and Wildlife Service, 1976).

[12] E. R. Hall and K. R. Nelson, *The Mammals of North America, Vols I and II* (Ronald Press, 1959).

[13] D. L. Williams.

Results

Vegetation Studies

Woody Vegetation. There was no measurable woody vegetation in the prairie test or control study areas. Based on canopy intercept along 2- by 100-m belt transects (Tables 1 and 2), plant species composition and total intercept (canopy cover) measure in the riparian test and control were very similar. The percent of the 1600-m transects covered by woody vegetation in these study areas was also similar, with both having 60 to 80 percent canopy intercept. Slippery elm (Ulmus rubra) dominated the test areas, followed by hackberry (Celtis occidentalis). Ash (Fraxinus pennsyvlanica) and black walnut (Juglans nigra) were co-dominants along the riparian test transects. Based on total intercept, hackberry also dominated the control, followed by slippery elm, dogwood (Cornus spp.), honeylocust (Gledistsia triacanthos), and coralberry (Symphoricarpos orbiculatus). Based on species richness, the riparian control site was slightly more diverse, having 22 species compared to 20 in the riparian test area. Two of the dominant species in the test area--walnut and burr oak (Quercus macrocarpa)--were not found in the control transects.

Stem-size class frequency distributions of woody plants (Tables 3 and 4) showed that the study areas had very similar total densities of smaller live woody plants (0 to 5 cm DBH), with 1400 to 1632 stems noted in an area of 1600 m^2. The number of dead, smaller-size stems was higher in the test study area, with 177 compared to 75 in the control. The largest tree, whose diameter was 65 to 70 cm, was in the riparian test area. Woody plant density in the riparian test site was slightly more variable, based on standard deviation of mean densities. This suggests that the test area was better-developed riparian, having a larger, older component, and that it was a slightly patchier forest than the control areas.

Density for tree and shrub species along the same study transects (Table 5) showed slight species dominance shifts from the cover data. However, these data generally support an assessment similar to the stem frequency distribution analysis. The test area had slightly higher live and much higher dead stem density than the riparian control. The clonal shrubs, coralberry (Symphoricarpos orbiculatus), dogwood (Cornus spp.), and leadplant (Amorpha fruticosa) showed higher densities in the controls. Slippery elm (Ulmus rubra), elders (Sambuscus canadensis), smooth sumac (Rhus glabra), plum (Prunus americana), walnut (Juglans nigra), Kentucky coffee tree (Gymnnocladus), and green ash (Fraxinus) had higher densities in the riparian test area.

The riparian test area had almost 100 more intercepted branches (Table 6), but slightly more viable intercept among sample points. The mean number of intercepted branches (based on 294 sampling points) was also slightly higher in the riparian test than in the control area. A total of 291 samples were taken in the control area.

In the riparian test area, average tree diameter was slightly larger (Table 7), while tree heights were slightly smaller. The average tree height and diameter were about 10 m and 40 cm, respectively.

Table 1

Total and Mean Intercept of Woody Vegetation (in meters) Along Four 2- by 100-m Transects Along Each of the four 800-m-Long Study Transects in the Riparian Control Study Areas (13-25 June 1984)

	RC1			RC2			RC3			RC4			ROW TOTALS			REL. % COVER STUDY TRANSECT
SPECIES	TOTAL	MEAN	STD	TOTAL	MEAN	STD	TOTAL	MEAN	STD	TOTAL	MEAN	STD	TOTAL	MEAN	STD	
Acer negundo	9.0	4.5	0.7				0.8	0.8					9.8	2.5	3.8	0.6
Acer saccharinum							35.8	11.9	10.6				35.8	9.0	15.5	2.2
Amorpha fruiticosa	15.7	3.1	2.1	5.1	2.6	2.1	9.6	1.2	1.2				30.4	7.6	5.8	1.9
Catalpa speciosa							19.0	9.5	7.8				19.0	4.8	8.2	1.2
Celtis occ.				50.8	16.9	15.2	70.6	3.9	3.8	72.1	12.0	9.2	193.5	48.4	29.2	12.1
Cornus spp.	27.9	1.9	1.1	20.6	3.4	2.5				63.1	5.7	9.3	111.6	27.9	22.8	7.0
Fraxinus pena.	55.3	5.0	4.2	20.0	4.0	3.9							75.3	18.8	22.6	4.7
Gleditsia tri.	5[illegible].4	2.6	2.9	9.4	3.1	3.9	26.1	2.6	3.2				91.9	23.0	21.4	5.7
Gymnocladus dio.	6.3	6.3											6.3	1.6	2.7	0.4
Juglans nigra													0.0	0.0	0.0	0.0
Juniperus vir.										4.7	1.2	0.2	4.7	1.2	2.0	0.3
Maclura pomifera	9.5	3.7	0.7	2.3	1.2	0.6	11.8	5.9	0.8	6.7	6.7		30.3	7.6	3.5	1.9
Morus alba													0.0	0.0	0.0	0.0
Morus rubra	20.1	4.0	2.4				4.1	2.1	1.9	10.4	10.4		34.6	8.7	7.6	2.2
Parthenocisus qui.													0.0	0.0	0.0	0.0
Populus deltoides				4.0	4.0					25.9	13.0	17.0	29.9	7.5	10.8	1.9
Prunus americana										10.5	1.2	1.5	10.5	2.6	4.5	0.7
Quercus macrocarpa													0.0	0.0	0.0	0.0
Rhus glabra	7.1	0.9	0.9	1.6	0.8	0.1				7.7	7.7		16.4	4.1	3.4	1.0
Ribes missouriense	5.1	1.3	0.4				2.9	1.0	0.9	0.8	0.8		8.8	2.2	2.0	0.6
Salix nigra	12.0	12.0											12.0	3.0	5.2	0.8
Sambucus can.	45.4	3.8	1.9				5.1	0.5	0.2	5.3	0.8	0.3	55.8	14.0	18.3	3.5
Symphoricarpos orb	43.7	2.9	2.5	10.6	1.3	1.1	21.2	1.0	1.0	13.9	3.5	2.7	89.4	22.4	12.9	5.6
Ulmus rubra	25.4	1.5	1.2	35.4	1.5	1.9	38.0	2.7	2.8	34.7	4.3	4.1	133.5	33.4	4.8	8.3
Vitis sp.	5.9	2.0	2.0										5.9	1.5	2.6	0.4
unknown vine				1.3	1.3		0.6	0.6					1.9	0.5	0.5	0.1
TOTAL	344.8			161.1			245.0			255.8		COLUMN TOTAL	1007.3			63.1
												MEAN	38.7			
												STD	48.2			

Table 2

Total and Mean Intercept of Woody Vegetation (in meters) Along Four 2- by 100-m Transects Along Each of the Four 800-m-Long Study Transects in the Riparian Test Areas (13-25 June 1984)

	RT1			RT2			RT3			RT4			ROW TOTALS			STUDY TRANSECT
SPECIES	TOTAL	MEAN	STD	TOTAL	MEAN	STD	TOTAL	MEAN	STD	TOTAL	MEAN	STD	TOTAL	MEAN	STD	%
Acer negunde							1.3	1.3		0.9	0.9		1.3	0.3	0.6	0.1
Acer saccharinum													0.0	0.0	0.0	0.0
Amorpha fruiticosa				1.0	1.0								1.0	0.3	0.6	0.1
Catalpa speciosa										1.0	1.0		1.0	.3	0.0	0.0
Celtis occ.	131.3	14.6	17.9	35.1	5.9	3.8	41.8	2.8	2.0	69.4	3.9	5.0	208.2	52.1	48.4	13.0
Cornus sp.	14.7	2.9	3.0	31.7	4.0	3.8	5.8	2.9	2.7	4.1	1.0	0.7	52.2	13.1	12.0	3.3
Fraxinus penn.				42.8	3.9	3.9	56.7	8.1	11.6	64.5	5.4	4.0	99.5	24.9	25.4	6.2
Gleditsia tri.				7.3	2.4	2.2	28.6	2.9	3.1	7.2	1.4	0.5	35.9	9.0	11.7	2.2
Gymnocladus dio.				14.1	4.7	3.6				26.6	26.6		14.1	3.5	6.1	0.9
Juglans nigra				37.9	3.8	2.5	61.2	3.6	3.0	38.1	4.7	3.3	99.1	24.8	26.1	6.2
Juniperus vir.													0.0	0.0	0.0	0.0
Maclura pomifera				73.7	12.3	15.1	4.2	4.2					77.9	19.5	31.4	4.9
Morus alba													0.0	0.0	0.0	0.0
Morus rubra	9.5	2.4	1.8	7.0	7.0		3.9	2.0	1.5	5.9	3.0	3.9	20.4	5.1	3.6	1.3
Parthenocissus qui.				0.8	0.8					0.4	0.4		0.8	0.2	0.3	0.1
Populus deltoides													0.0	0.0	0.0	0.0
Prunus americana	55.1	3.1	3.1	1.0	0.5	1.4	5.8	0.8		18.2	3.6	4.7	61.9	15.5	23.0	3.9
Quercus macrocarpa										34.7	5.8	5.5	34.7	8.8	0.0	0.0
Rhus glabra	10.1	5.1	6.3	17.6	17.6		46.1	5.8	7.7	8.1	2.0	1.6	73.8	18.5	17.1	4.6
Ribes missouriense	1.1	1.1		0.9	0.9		2.5	2.5		0.5	0.5		4.5	1.1	0.9	0.3
Salix nigra													0.0	0.0	0.0	0.0
Sambucus can.	17.6	3.5	3.8				3.5	0.9	0.5	9.3	4.7	5.7	21.1	5.3	7.3	1.3
Symphoricarpos orb	65.1	6.5	12.1	6.0	1.5	1.0				4.2	0.7	0.8	71.1	17.8	27.4	4.4
Ulmus rubra	176.4	6.5	7.1	34.6	6.9	5.4	46.8	2.3	1.7	22.3	3.2	1.7	257.8	64.5	66.9	16.1
Vitis sp.							1.4	1.4					1.4	0.4	0.6	0.1
unknown vine							1.5	0.8	0.2	1.6	1.6		1.5	0.4	0.6	0.1
TOTAL	480.9			311.5			311.1			317.0		COLUMN TOTAL	1184.8			69.0
												MEAN	45.6			
												STD	65.9			

Table 3

Frequency Distribution (Number of Stems) of Live and Dead Woody Stems Greater Than 1 m Tall or 2.5 cm in Diameter, Measured Along Four 2- by 100-m Transects Along Each of Four 800-m Study Transects (13-26 June 1984)

RIPARIAN TEST STUDY AREA

AREA	RT1	RT2	RT3	RT4	Total	Tot/dead	MEAN	STD
SIZE CL.								
2.5 to 5								
Total	549.0	236.0	466.0	381.0	1632.0		408.0	115.7
Mean	274.5	118.0	233.0	190.5				
Dead	40.0	11.0	26.0	90.0		177.0		
5 to 10								
Total	28.0	28.0	6.0	19.0	81.0		20.3	9.0
Mean	14.0	14.0	3.0	9.5				
Dead	3.0	1.0	0.0	1.0		5.0		
10 to 15								
Total	10.0	15.0	3.0	5.0	33.0		8.3	4.7
Mean	5.0	7.5	1.5	2.5				
Dead	3.0	2.0	0.0	0.0		5.0		
15 to 20								
Total	7.0	8.0	0.0	7.0	22.0		5.5	3.2
Mean	3.5	4.0	0.0	3.5				
Dead	1.0	1.0	0.0	2.0		4.0		
20 to 25								
Total	0.0	0.0	0.0	1.0	1.0		0.3	0.4
Mean	0.0	0.0	0.0	0.5				
Dead	0.0	0.0	0.0	0.0		0.0		
25 to 30								
Total	1.0	0.0	1.0	2.0	4.0		1.0	0.7
Mean	0.5	0.0	0.5	1.0				
Dead	0.0	0.0	0.0	0.0		0.0		
30 to 35								
Total	1.0	1.0	1.0	1.0	4.0		1.0	0.0
Mean	0.5	0.5	0.5	0.5				
Dead	0.0	0.0	0.0	0.0		0.0		
35 to 40								
Total	2.0	1.0	0.0	0.0	3.0		0.8	0.8
Mean	1.0	0.5	0.0	0.0				
Dead	0.0	0.0	0.0	0.0		0.0		
40 to 45								
Total	0.0	0.0	0.0	1.0	1.0		0.3	0.4
Mean	0.0	0.0	0.0	0.5				
Dead	0.0	0.0	0.0	0.0		0.0		
45 to 50								
Total	0.0	0.0	0.0	0.0	0.0		0.0	0.0
Mean	0.0	0.0	0.0	0.0				
Dead	0.0	0.0	0.0	0.0		0.0		
50 to 55								
Total	0.0	0.0	0.0	0.0	0.0		0.0	0.0
Mean	0.0	0.0	0.0	0.0				
Dead	0.0	0.0	0.0	0.0		0.0		
55 to 60								
Total	0.0	0.0	0.0	0.0	0.0		0.0	0.0
Mean	0.0	0.0	0.0	0.0				
Dead	0.0	0.0	0.0	0.0		0.0		
60 to 65								
Total	0.0	0.0	0.0	0.0	0.0		0.0	0.0
Mean	0.0	0.0	0.0	0.0				
Dead	0.0	0.0	0.0	0.0		0.0		
65 to 70								
Total	0.0	0.0	0.0	1.0	1.0		0.3	0.4
Mean	0.0	0.0	0.0	0.5				
Dead	0.0	0.0	0.0	0.0		0.0		
70 to 75								
Total	0.0	0.0	0.0	0.0	0.0		0.0	0.0
Mean	0.0	0.0	0.0	0.0				
Dead	0.0	0.0	0.0	0.0		0.0		
75 to 80								
Total	0.0	0.0	0.0	0.0	0.0		0.0	0.0
Mean	0.0	0.0	0.0	0.0				
Dead	0.0	0.0	0.0	0.0		0.0		
80 to 85								
Total	0.0	0.0	0.0	1.0	1.0		0.3	0.4
Mean	0.0	0.0	0.0	0.5				
Dead	0.0	0.0	0.0	0.0		0.0		
TOTALS	598.0	289.0	477.0	419.0	1783.0	191.0		
MEAN	38.2	17.0	28.1	24.6	74.3			
STD	132.6	56.9	112.9	92.0	325.3			

Table 4

Frequency Distribution (Number of Stems) of Live and Dead Woody Stems Greater Than 1 m Tall or 2.5 cm in Diameter, Measured Along Four 2- by 100-m Transects Along Each of Four 800-m Study Transects (13-26 June 1984)

RIPARIAN CONTROL STUDY AREA

AREA	RC1	RC2	RC3	RC4	Total	Tot/dead	MEAN	STD
SIZE CL.								
2.5 to 5								
Total	379.0	193.0	283.0	553.0	1408.0		352.0	133.4
Mean	189.5	96.5	141.5	276.5				
Dead	6.0	4.0	5.0	60.0		75.0		
5 to 10								
Total	21.0	7.0	9.0	22.0	59.0		14.8	6.8
Mean	10.5	3.5	4.5	11.0				
Dead	0.0	0.0	2.0	2.0		4.0		
10 to 15								
Total	6.0	6.0	6.0	4.0	22.0		5.5	0.9
Mean	3.0	3.0	3.0	2.0				
Dead	1.0	0.0	1.0	0.0		1.0		
15 to 20								
Total	0.0	2.0	1.0	2.0	5.0		1.3	0.8
Mean	0.0	1.0	0.5	1.0				
Dead	0.0	0.0	0.0	0.0		0.0		
20 to 25								
Total	0.0	0.0	1.0	0.0	1.0		0.3	0.4
Mean	0.0	0.0	0.5	0.0				
Dead	0.0	0.0	0.0	0.0		0.0		
25 to 30								
Total	0.0	1.0	0.0	0.0	1.0		0.3	0.4
Mean	0.0	0.5	0.0	0.0				
Dead	0.0	0.0	0.0	0.0		0.0		
30 to 35								
Total	0.0	0.0	0.0	0.0	0.0		0.0	0.0
Mean	0.0	0.0	0.0	0.0				
Dead	0.0	0.0	0.0	0.0		0.0		
35 to 40								
Total	0.0	0.0	0.0	1.0	1.0		0.3	0.4
Mean	0.0	0.0	0.0	0.5				
Dead	0.0	0.0	0.0	0.0		0.0		
40 to 45								
Total	0.0	1.0	0.0	0.0	1.0		0.3	0.4
Mean	0.0	0.5	0.0	0.0				
Dead	0.0	0.0	0.0	0.0		0.0		
45 to 50								
Total	0.0	0.0	0.0	0.0	0.0		0.0	0.0
Mean	0.0	0.0	0.0	0.0				
Dead	0.0	0.0	0.0	0.0		0.0		
50 to 55								
Total	0.0	0.0	0.0	2.0	2.0		0.5	0.9
Mean	0.0	0.0	0.0	1.0				
Dead	0.0	0.0	0.0	0.0		0.0		
55 to 60								
Total	0.0	0.0	0.0	2.0	2.0		0.5	0.9
Mean	0.0	0.0	0.0	1.0				
Dead	0.0	0.0	0.0	0.0		0.0		
60 to 65								
Total	0.0	0.0	0.0	0.0	0.0		0.0	0.0
Mean	0.0	0.0	0.0	0.0				
Dead	0.0	0.0	0.0	0.0		0.0		
65 to 70								
Total	0.0	0.0	0.0	0.0	0.0		0.0	0.0
Mean	0.0	0.0	0.0	0.0				
Dead	0.0	0.0	0.0	0.0		0.0		
70 to 75								
Total	0.0	0.0	0.0	0.0	0.0		0.0	0.0
Mean	0.0	0.0	0.0	0.0				
Dead	0.0	0.0	0.0	0.0		0.0		
75 to 80								
Total	0.0	0.0	0.0	0.0	0.0		0.0	0.0
Mean	0.0	0.0	0.0	0.0				
Dead	0.0	0.0	0.0	0.0		0.0		
80 to 85								
Total	0.0	0.0	0.0	0.0	0.0		0.0	0.0
Mean	0.0	0.0	0.0	0.0				
Dead	0.0	0.0	0.0	0.0		0.0		
TOTALS	[illegible]	210.0	300.0	586.0	1502.0	31.0		
MEAN	[illegible]	[illegible]	[illegible]	34.5	62.6			
STD	91.7	[illegible]	68.4	133.7	280.8			

Table 5

Density (Stems/3200m^2) of Live and Dead Woody Plants Greater Than 1 m Tall or Greater Than 2.5 cm DBH as Measured in Four 100-by 2-m Wide Transects Along Each of the 800-m Study Transects (13-26 June 1984)

		RIPARIAN CONTROL		RIPARIAN TEST	
SPECIES		LIVE	DEAD	LIVE	DEAD
Acer negundo		4		3	
Acer saccharinum	(present)				
Amorpha fruiticosa		107		7	
Catalpa speciosa		5	3		
Celtis occidentalis		51	7	122	9
Cornus spp.		470	59	118	
Fraxinus pennsylvanica		15	1	44	7
Gleditsia triacanthos		38	3	22	4
Gymnocladus dioicus		3		20	1
Juglans nigra				49	3
Juniperus virginiana		6			
Maclura pomifera		10		65	11
Morus alba	(present)				
Morus rubra		6	1	18	
Parthenocisus quinquefolia				2	
Populus deltoides		4			
Prunus americana		22		214	12
Quercus macrocarpa				4	
Rhus glabra		29		319	36
Ribes missouriense		31	1	15	5
Salix nigra		2			
Sambucus canadensis		29	5	119	93
Symphoricarpos orbiculatus		516		237	
Ulmus rubra		67	1	199	10
Vitis sp.		5		3	
unknown vine		2		12	
TOTAL		1421	81	1592	191
MEAN		67.7	9	79.6	17.4
STD		140.5	17.8	92.1	25.5

Table 6

Total and Mean Canopy Intercepts (Number of Branches Using Sighting Tube) for Riparian Control and Riparian Test Areas (13-25 June 1984)

TRANSECT	TOTAL	MEAN	STD	N VALUE
Riparian Control 1	58.0	0.7	1.4	80.0
Riparian control 2	12.0	0.2	0.6	59.0
Riparian control 3	91.0	1.1	0.6	80.0
Riparian Control 4	28.0	0.4	1.0	72.0
Riparian Control Total	189.0	0.6	1.3	291.0
Riparian Test 1	145.0	1.8	2.3	80.0
Riparian Test 2	32.0	0.5	1.1	65.0
Riparian Test 3	53.0	0.8	1.4	70.0
Riparian Test 4	54.0	0.7	1.3	79.0
Riparian Test Total	284.0	1.0	2.5	294.0

Table 7

Tree Heights and DBH Reading From Selected Large Trees in the Riparian Test Area (13-26 June 1984)

a. Test Area.

SPECIES	DBH (cm.)	TREE HEIGHT (meters)
Celtis occidentalis	30.50	7.90
Celtis occidentalis	20.30	8.10
Celtis occidentalis	27.90	8.80
Celtis occidentalis	30.50	7.90
Fraxinus pennsylvanica	22.40	9.20
Fraxinus pennsylvanica	35.60	12.00
Gleditsia triacanthos	33.00	8.30
Juglans nigra	40.60	9.00
Quercus macrocarpa	71.10	12.70
Quercus macrocarpa	25.40	10.10
Quercus macrocarpa	76.20	12.00
Quercus macrocarpa	63.50	12.20
Quercus macrocarpa	76.20	8.60
Mean + St. D.	42.6 + 21.	9.6 + 1.8

b. Control Area.

SPECIES	DBH (cm.)	TREE HEIGHT (meters)
Celtis occidentalis	25.40	9.40
Celtis occidentalis	25.40	9.20
Celtis occidentalis	15.20	8.60
Celtis occidentalis	35.60	9.00
Celtis occidentalis	30.50	7.40
Celtis occidentalis	40.60	9.40
Celtis occidentalis	35.60	8.60
Celtis occidentalis	81.30	9.90
Fraxinus pennsylvanica	45.70	7.90
Fraxinus pennsylvanica	35.60	9.90
Fraxinus pennsylvanica	38.10	13.50
Fraxinus pennsylvanica	83.80	16.40
Fraxinus pennsylvanica	38.10	13.70
Fraxinus pennsylvanica	35.60	13.70
Fraxinus pennsylvanica	35.60	12.50
Populus deltoides	48.30	12.50
Mean + St. D.	40.6+ 18.2	10.7 + 2.6

Herbaceous Vegetation. Eight hundred quadrat samples were analyzed along the study transects in the prairie and riparian control and test sites. Calculations were made of plant species relative cover, relative frequency, sum (an importance value), and the mean and standard deviations for these three indices (Tables 8 and 9). Total quadrat vegetation cover values (Table 10) were similar in both the prairie and riparian test and control sites and averaged more than 100 percent because of the multilayered vegetation usually present. Based on cover and importance values, the riparian study areas (Table 8) were dominated by several species: Japanese brome grass (Bromus japonicus), sunflower (Helianthus annuus), bluegrass (Poa spp.), European brome grass (Bromus inermis), and coralberry (symphoricarpos) Other species that codominated only in the riparian test area included crown-beard (Verbisian alternifolia), nettle (Urtica dioica), and wild rye (Elymus canadensis). Brome grasses had a higher importance in the riparian test transects, which were close to fallowed farm fields. These species were also present and important in the riparian control. The riparian test study area was slightly more diverse than the control area, with 72 vs. 63 quantitatively sampled species.

In the riparian test area, vegetation had a more equitable distribution of importance values and more species were dominant; no species had an importance value of greater than 57, in comparison to a value of 82 for the control area. These two areas, which shared more than 50 percent of their species, had 45 species in common. This represented 62.5 percent and 71.4 percent of the species in the riparian control and test areas, respectively. Virtually all dominant species were important in both areas, except for crown-beard, which was not sampled in the control area.

The prairie control and test areas (Table 9) each had 68 sampled species, most of which were common to both areas. Based on mean relative cover, the prairie control was dominated by bluegrasses (Poa spp.), brome grass (Bromus inermis), big bluestem grass (Andropogon gerardii), and western ragweed (Ambrosia psilostachya). These species had an average quadrat cover of 9.3 percent. Yellow sweet clover (Melilotus officinalis) and small ragweed (Ambrosia artemisiifolia) also had high cover values. An average of 32 percent big bluestem grass cover dominated the prairie test area. On the average, about 6 percent of the cover was bluegrass, western ragweed, and quack grass (Agropyron repens). Bare soils covered about 2 percent of both areas.

The most frequent species in the prairie control was western ragweed, which occurred in more than 7 percent of all quadrats, followed by 6 percent bluegrass. Big bluestem and yarrow (Achillea millefolium) accounted for about 5 percent. Several other species, including sage (Artemisia ludoviciana), small ragweed, sedge (Carex spp.), fleabane (Erigeron strigosus), yellow sweet clover (Melilotus officinalis), and prairie panic grass (Panicum leibergii) occurred in 3 to 4 percent of the quadrats. Big bluestem, western ragweed, sage, bluegrass, and sedges were the most frequently noted species in the prairie test area.

Based on importance value, the prairie control was dominated by western ragweed and bluegrasses; big bluestem grass followed, with a value of 14. Brome grass had a value of 12, and yarrow and small ragweed had values of about 9. Based on importance value, most of the same plant species dominated the prairie test site. Big bluestem grass was most prevalent, followed by western ragweed and bluegrasses. A total of 216 plant species were sampled or observed along the study transects; 153 species were collected for voucher specimens.

Table 8

Totals, Means (x), and Standard Deviations (STD) for Relative Cover, Frequency, and Importance Values of Plants Sampled

a. Riparian Control Study Area (13-26 June 1984)

	COVER			FREQUENCY			IMPORTANCE VALUE		
SPECIES	TOTALS	$\bar{x}$	STD	TOTALS	$\bar{x}$	STD	TOTALS	$\bar{x}$	STD
Abutilon theophrasti									
Acalypha sp.									
Acalypha virginica									
Acerates angustifolia									
Achillea millefolium	0.0	0.0	0.0	2.0	0.5	0.6	2.0	0.5	0.6
Agropyron repens	8.0	2.0	2.2	4.0	1.0	0.8	12.0	3.0	2.9
Alisma plantago-aquatica									
Allium canadense									
Amaranthus retroflexus									
Ambrosia artemisiifolia	1.0	0.3	0.5	5.0	1.3	1.3	6.0	1.5	1.7
Ambrosia psilostachya	10.0	2.5	2.6	12.0	3.0	3.2	22.0	5.5	5.8
Ambrosia trifida	21.0	5.3	5.0	16.0	4.0	1.4	37.0	9.3	6.1
Amorpha canescens									
Amorpha fruticosa	3.0	0.8	1.0	3.0	0.8	1.0	6.0	1.5	1.9
Andropogon gerardii	9.0	2.3	3.2	7.0	1.8	1.5	16.0	4.0	4.7
Andropogon scoparius	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Androsace occidnetalis									
Antennaria neglecta									
Apocynum cannabinum									
Artemisia ludoviciana	11.0	2.8	1.7	13.0	3.3	1.3	24.0	6.0	2.7
Asclepias hirtella									
Asclepias purpurascens									
Asclepias syrica	1.0	0.3	0.5	5.0	1.3	1.0	6.0	1.5	1.3
Asclepias tuberosa									
Asclepias verticillata									
Asclepias viridiflora									
Aster ericoides									
Aster pilosus									
Aster sp.	1.0	0.3	0.5	1.0	0.3	0.5	2.0	0.5	1.0
Aster sericeus									
Astragalus crassicarpus									
Baptisia australis									
Barbarea vulgaris									
Bare soil	5.0	1.3	2.5	2.0	0.5	1.0	7.0	1.8	3.5
Bidens frodosa									
Boehmeria cylindrica									
Bromus inerais	7.0	1.8	2.1	2.0	0.5	0.6	9.0	2.3	2.6
Bromus japonicus	23.0	5.8	4.9	15.0	3.8	1.7	38.0	9.5	6.6
Bromus tectorum									
Buchloe dactyloides									
Cacalis tuberosa									
Callirhoe alcaeoides									
Callirhoe involucrata									
Cannabis sativa	0.0	0.0	0.0	1.0	0.3	0.5	0.0	0.0	0.0
Carduus nutans									
Carex sp.									
Carex sp.	3.0	0.8	1.0	13.0	3.3	1.3	16.0	4.0	1.4
Carex triangularis	6.0	1.5	1.7	14.0	3.5	0.6	20.0	5.0	2.2
Carex vulpinoidea									
Cassia fasciculata									
Celtis occidentalis	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Chaeaesyce sp.									
Chenopodium album									
Cirsium altissimum	5.0	1.3	1.0	11.0	2.8	1.3	16.0	4.0	2.2
Cirsium discolor									
Cirsium undulatum									
Convolvulus arvensis	1.0	0.3	0.5	2.0	0.5	1.0	3.0	0.8	1.3
Convolvulus sepium									
Cornus spp.	6.0	1.5	1.7	5.0	1.3	1.3	11.0	2.8	3.0
Croton sp.									
Cuscuta sp.	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Cyperus esculentus									
Delphinium carolinianum									
Desmodium sp.									
Echinacea pallida									
Echinochloa muricata									

Table 8 (Cont'd)

Echinocystis lobata									
Eleocharis palustris									
Elymus canadensis	12.0	3.0	3.2	11.0	2.8	1.7	23.0	5.8	4.4
Eragrostis spectabilis	0.0	0.0	0.0	2.0	0.5	0.6	2.0	0.5	0.6
Erigeron annuus	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Erigeron strigosus	0.0	0.0	0.0	2.0	0.5	0.6	2.0	0.5	0.6
Euonymus americanus									
Euphorbia sp.									
Festuca elatior									
Festuca octoflora									
Fragaria virginiana									
Fraxinus americana									
Galium aparine	1.0	0.3	0.5	6.0	1.5	1.7	7.0	1.8	2.2
Galium circaezans									
Geranium carolinianum									
Geum sp.	4.0	1.0	0.8	9.0	2.3	1.7	13.0	3.3	2.5
Gleditsia triacanthos	1.0	0.3	0.5	2.0	0.5	0.6	3.0	0.8	1.0
Glycyrrhiza lepidota									
Gymnocladus dioica									
Hedeoma hispida									
Hedyotis nigricans									
Helianthus annuus	55.0	13.8	6.6	27.0	6.8	3.0	82.0	20.5	9.1
Helianthus grosseserratus									
Heliopsis helianthoides									
Hibiscus trionum									
Hieracium longipilum									
Hordeum jubatum									
Hordeum pusillum									
Hypericum perforatum	1.0	0.3	0.5	1.0	0.3	0.5	2.0	0.5	1.0
Iva scoparia									
Juglans nigra									
Juncus kansanus									
Juncus torreyi									
Juniperus virginiana									
Kochia scoparia									
Koeleria cristata	0.0	0.0	0.0	2.0	0.5	0.6	2.0	0.5	0.6
Krigia oppositifolia									
Kuhnia eupatorioides	1.0	0.3	0.5	2.0	0.5	0.6	3.0	0.8	1.5
Lactuca canadensis	1.0	0.3	0.5	7.0	1.8	1.0	8.0	2.0	1.2
Lactuca sp.									
Laportea canadensis									
Lepidium densiflorum									
Lespedeza capitata									
Liatris pycnostachya									
Linum sulcatum									
Lycopus americanus									
Maclura pomifera									
Medicago lupulina									
Medicago sativa									
Melilotus alba									
Melilotus officinalis	2.0	0.5	0.6	3.0	0.8	0.5	4.0	1.0	0.8
Mentha sp.									
Mirabilis nyctaginea	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Monarda fistulosa									
Morus alba									
Morus rubra									
Moss									
Muhlenbergii spp.	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Oenothera speciosa	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Onosmodium molle	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Opuntia polycantha									
Oxalis stricta	0.0	0.0	0.0	6.0	1.5	1.3	6.0	1.5	1.3
Oxalis violaceae									
Panicum capillare									
Panicum lanuginosum									
Panicum leibergii	0.0	0.0	0.0	5.0	1.3	0.5	5.0	1.3	0.5
Panicum virgatum	10.0	2.5	3.3	6.0	1.5	1.9	16.0	4.0	5.2
Parietaria pennsylvanica	3.0	0.8	1.0	9.0	2.3	2.5	12.0	3.0	3.4
Parthenocissus quinquefolia									
Penstemon cobaea									
Petalostemon candidum									
Petalostemon purpureum	1.0	0.3	0.5	1.0	0.3	0.5	2.0	0.5	1.0
Petalostemon sp.									
Phyla cuneifolia									
Physalis sp.	0.0	0.0	0.0	2.0	0.5	1.0	2.0	0.5	1.0
Physalis sp.									
Phytolacca americana									
Plantago purshii									

Table 8 (Cont'd)

Plantago sp.									
Plantago virginica	0.0	0.0	0.0	2.0	0.5	0.6	2.0	0.5	0.6
Poa sp.	26.0	6.5	2.6	21.0	5.3	2.1	47.0	11.8	4.3
Polygala verticillata									
Polygonum aronastrum									
Polygonum persicaria									
Polygonum ramosissimum									
Polygonum sp.									
Prunus americana	4.0	1.0	2.0	3.0	0.8	1.5	7.0	1.8	3.5
Psoralea argophylla									
Psoralea sp.	2.0	0.5	0.6	5.0	1.3	1.3	7.0	1.8	1.7
Ptilimnium nuttallii	0.0	0.0	0.0	2.0	0.5	1.0	2.0	0.5	1.0
Quercus macrocarpa									
Rhus glabra									
Rhus radicans	6.0	1.5	2.4	4.0	1.0	1.4	10.0	2.5	3.8
Ribes missouriense	3.0	0.8	0.5	5.0	1.3	0.5	8.0	2.0	0.0
Rorippa sp.									
Rosa arkansana	4.0	1.0	2.0	4.0	1.0	2.0	8.0	2.0	4.0
Rubus strigosus									
Ruellia strepens									
Rumex altissimus	0.0	0.0	0.0	2.0	0.5	1.0	2.0	0.5	1.0
Rumex crispus	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Sagittaria latifolia									
Sambucus canadensis	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Sanicula gregaria	3.0	0.8	1.5	4.0	1.0	1.2	7.0	1.8	2.4
Schrankia nuttallii									
Schroghularia sp.									
Scirpus atrovirens									
Scirpus cyperinus									
Scrophularia marilandica									
Scutellaria resinosa									
Senecio pauperculus									
Setaria sp.									
Silene antirrhina									
Silphium speciosum									
Sisyrinchium sp.	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Smilax sp.									
Smilax tamnoides									
Solanum carolinense	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Solanum rostratum									
Solanum triflorum									
Solidago canadensis	25.0	6.3	4.0	17.0	4.3	2.6	42.0	10.5	6.6
Sonchus asper									
Sorghastrum nutans									
Spartina pectinata	7.0	1.8	2.4	5.0	1.3	1.5	12.0	3.0	3.8
Sphenopholis intermedia									
Sphenopholis obtusata	7.0	1.8	3.5	6.0	1.5	1.9	13.0	3.3	5.2
Sporobolus heterolepis									
Stachys tenuifolia	1.0	0.3	0.5	4.0	1.0	0.8	5.0	1.3	1.3
Stipa sp.	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.3	0.5
Symphoricarpus orbiculatus	63.0	15.8	7.0	26.0	6.5	1.9	89.0	22.3	8.8
Taraxacum officinale									
Teucrium canadense									
Thlaspi arvense	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Tradescantia ohiensis									
Tragopogon dubius									
Trifolium pratense									
Triodanis leptocarpa									
Triodanis perfoliata	1.0	0.3	0.5	1.0	0.3	0.5	2.0	0.5	1.0
Typha angustafolia									
Typha latifolia									
Ulmus rubra	6.0	1.5	2.4	4.0	1.0	1.4	10.0	2.5	3.8
Urtica dioica	9.0	2.3	2.2	5.0	1.3	1.0	14.0	3.5	3.1
Verbascum blattaria									
Verbascum thapsus									
Verbena hastata	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Verbena stricta	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Verbisina alternifolia									
Vernonia sp.	6.0	1.5	0.6	14.0	3.5	1.7	20.0	5.0	2.2
Veronica peregrina									
Vicia americana									
Viola sp.									
Xanthium strumarium									
TOTALS	386.0	98.0		385.0	98.4		770.0	194.2	
Species	72								

Table 8 (Cont'd)

b. Riparian Test Study Area (13-16 June 1984)

	RIPARIAN TEST								
	COVER			FREQUENCY			IMPORTANCE VALUE		
SPECIES	TOTALS	X	STD	TOTALS	X	STD	TOTALS	X	STD
Abutilion theophrasti									
Acalypha sp.									
Acalypha virginica									
Acerates angustifolia									
Achillea millefolium									
Agropyron repens									
Alisma plantago-aquatica									
Allium canadense									
Amaranthus retroflexus									
Ambrosia artemisiifolia	3.0	0.8	1.0	4.0	1.0	1.4	7.0	1.8	2.4
Ambrosia psilostachya	12.0	3.0	2.2	12.0	3.0	2.2	24.0	6.0	4.2
Ambrosia trifida	12.0	3.0	3.6	19.0	4.8	4.3	31.0	7.8	7.8
Amorpha canescens									
Amorpha fruicosa	1.0	0.3	0.5	1.0	0.3	0.5	2.0	0.5	1.0
Andropogon gerardii	9.0	2.3	3.3	7.0	1.8	2.1	16.0	4.0	5.2
Andropogon scoparius	1.0	0.3	0.5	1.0	0.3	0.5	2.0	0.5	1.0
Androsace occidnetalis									
Antennaria neglecta									
Apocynum cannabinum									
Artemisia ludoviciana	5.0	1.3	1.5	5.0	1.3	1.5	10.0	2.5	3.0
Asclepias hirtella									
Asclepias purpurascens									
Asclepias syrica	2.0	0.5	0.6	11.0	2.8	1.7	13.0	3.3	2.2
Asclepias tuberosa									
Asclepias verticillata									
Asclepias viridiflora									
Aster ericoides									
Aster pilosus									
Aster sp.									
Aster sericeus									
Astragalus crassicarpus									
Baptisia australis									
Barbarea vulgaris									
Bare soil									
Bidens frodosa									
Boehmeria cylindrica									
Bromus inermis	37.0	9.3	11.4	14.0	3.5	3.7	51.0	12.8	15.0
Bromus japonicus	28.0	7.0	4.5	25.0	6.3	3.5	53.0	13.3	6.9
Bromus tectorum									
Buchloe dactyloides									
Cacalis tuberosa									
Callirhoe alcaeoides									
Callirhoe involucraca									
Cannabis sativa									
Carduus nutans									
Carex sp.									
Carex sp.	3.0	0.8	1.5	6.0	1.5	1.3	9.0	2.3	2.6
Carex triangularis	1.0	0.3	0.5	3.0	0.8	1.5	4.0	1.0	2.0
Carex vulpinoidea									
Cassia fasciculata									
Celtis occidentalis	2.0	0.5	1.0	5.0	1.3	1.3	7.0	1.8	2.2
Chamaesyce sp.									
Chenopodium album	0.0	0.0	0.0	2.0	0.5	1.0	2.0	0.5	1.0
Cirsium altissimum	2.0	0.5	0.6	10.0	2.5	1.7	12.0	3.0	2.3
Cirsium discolor									
Cirsium undulatum									
Convolvulus arvensis	0.0	0.0	0.0	2.0	0.5	0.6	2.0	0.5	0.6
Convolvulus sepium									
Cornus spp.	12.0	3.0	1.8	7.0	1.8	1.0	19.0	4.8	2.8
Croton sp.									
Cuscuta sp.									
Cyperus esculentus									
Delphinium carolinianum									
Desmodium sp.	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Echinacea pallida									
Echinochloa muricata									

Table 8 (Cont'd)

Chinocystis lobata									
Eleocharis palustris									
Elymus canadensis	33.0	8.3	6.9	34.0	8.5	4.2	67.0	16.8	11.0
Eragrostis spectabilis	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Erigeron annuus	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Erigeron strigosus	2.0	0.5	0.6	3.0	0.8	1.0	5.0	1.3	1.5
Euonymus americanus									
Euphorbia sp.									
Festuca elatior									
Festuca octoflora									
Fragaria virginiana									
Fraxinus americana	2.0	0.5	0.6	1.0	0.3	0.5	3.0	0.8	1.0
Galium aparine									
Galium circaezans									
Geranium carolinianum									
Geum sp.	9.0	2.3	3.9	9.0	2.3	3.3	18.0	4.5	7.1
Gleditsia triacanthos	1.0	0.3	0.5	1.0	0.3	0.5	2.0	0.5	1.0
Glycyrrhiza lepidota									
Gymnocladus dioica									
Hedeoma hispida									
Hedyotis nigricans									
Helianthus annuus	29.0	7.3	7.4	21.0	5.3	4.1	50.0	12.5	11.4
Helianthus grosseserratus	11.0	2.8	5.5	4.0	1.0	2.0	15.0	3.8	7.5
Heliopsis helianthoides									
Hibiscus trionum									
Hieracium longipilum									
Hordeum jubatum									
Hordeum pusillum									
Hypericum perforatum									
Iva scoparia									
Juglans nigra	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Juncus kansanus	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Juncus torreyi									
Juniperus virginiana									
Kochia scoparia									
Koeleria cristata									
Krigia oppositifolia									
Kuhnia eupatorioides									
Lactuca canadensis	0.0	0.0	0.0	5.0	1.3	1.5	5.0	1.3	1.5
Lactuca sp.									
Laportea canadensis									
Lepidium densiflorum	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Lespedeza capitata									
Liatris pycnostachya									
Linum sulcatum									
Lycopus americanus									
Maclura pomifera									
Medicago lupulina									
Medicago sativa									
Melilotus alba	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Melilotus officinalis	4.0	1.0	0.8	10.0	2.5	1.0	14.0	3.5	1.7
Mentha sp.									
Mirabilis nyctaginea									
Monarda fistulosa									
Morus alba									
Morus rubra									
Moss									
Muhlenbergia spp.									
Oenothera speciosa	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Onosmodium molle									
Opuntia polyacantha									
Oxalis stricta	0.0	0.0	0.0	3.0	0.8	0.5	3.0	0.8	0.5
Oxalis violacea									
Panicum capillare									
Panicum lanuginosum	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Panicum leibergii	0.0	0.0	0.0	5.0	1.3	1.0	5.0	1.3	1.0
Panicum virgatum									
Parietaria pennsylvanica	3.0	0.8	1.5	10.0	2.5	1.7	13.0	3.3	2.9
Parthenocissus quinquefolia	1.0	0.3	0.5	2.0	0.5	1.0	3.0	0.8	1.5
Penstemon cobaea									
Petalostemon candidum									
Petalostemon purpureum									
Petalostemon sp.									
Phyla cuneifolia									
Physalis sp.									
Physalis sp.									
Phytolacca americana									
Plantago purshii									

Table 8 (Cont'd)

Plantago sp.									
Plantago virginica									
Poa spp.	31.0	7.8	4.1	26.0	6.5	1.7	57.0	14.3	5.4
Polygala verticillata									
Polygonum aromastrum									
Polygonum persicaria	1.0	0.3	0.5	1.0	0.3	0.5	3.0	0.5	1.0
Polygonum ramosissimum									
Polygonum sp.									
Prunus americana	2.0	0.5	1.0	2.0	0.5	1.0	5.0	1.3	2.5
Psoralea argophylla									
Psoralea sp.									
Ptilimium nuttallii									
Quercus macrocarpa	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Rhus glabra	7.0	1.8	2.9	3.0	0.8	1.0	10.0	2.5	3.8
Rhus radicans	13.0	3.3	3.9	8.0	2.0	1.8	21.0	5.3	5.6
Ribes missouriense	1.0	0.3	0.5	4.0	1.0	0.8	5.0	1.3	1.0
Rorippa sp.									
Rosa arkansana									
Rubus strigosus	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Ruellia strepens									
Rumex altissimus	2.0	0.5	1.0	2.0	0.5	1.0	4.0	1.0	2.0
Rumex crispus									
Sagittaria latifolia									
Sambucus canadensis	2.0	0.5	1.0	2.0	0.5	1.0	4.0	1.0	2.0
Sanicula gregaria	2.0	0.5	1.0	4.0	1.0	1.4	6.0	1.5	2.4
Schrankia nuttallii									
Schrophularia sp.									
Scirpus atrovirens									
Scirpus cyperinus									
Scrophularia marilandica									
Scutellaria resinosa									
Senecio pauperculus									
Setaria sp.									
Silene antirrhina									
Silphium speciosum									
Sisyrinchium sp.									
Smilax sp.									
Smilax tamnoides									
Solanum carolinense									
Solanum rostratum									
Solanum triflorum									
Solidago canadensis	18.0	4.5	5.3	15.0	3.8	2.1	33.0	8.3	7.1
Sonchus asper	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Sorghastrum nutans									
Spartina pectinata									
Sphenopholis intermedia									
Sphenopholis obtusata	0.0	0.0	0.0	2.0	0.5	0.6	2.0	0.5	0.6
Sporobolus heterolepis									
Stachys tenuifolia	1.0	0.3	0.5	1.0	0.3	0.5	2.0	0.5	1.0
Stipa sp.									
Symphoricarpus orbiculatus	18.0	4.5	2.5	12.0	3.0	1.4	30.0	7.5	3.7
Taraxacum officinale									
Teucrium canadense									
Thlaspi arvense									
Tradescantia ohiensis									
Tragopogon dubius	0.0	0.0	0.0	2.0	0.5	1.0	2.0	0.5	1.0
Trifolium pratense									
Triodanis leptocarpa									
Triodanis perfoliata									
Typha angustafolia									
Typha latifolia									
Ulmus rubra	5.0	1.3	1.3	6.0	1.5	1.0	11.0	2.8	2.1
Urtica dioica	19.0	4.8	5.7	13.0	3.3	3.4	42.0	8.0	9.1
Verbascum blattaria									
Verbascum thapsus	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Verbena hastata	0.0	0.0	0.0	2.0	0.5	0.6	2.0	0.5	0.6
Verbena stricta	0.0	0.0	0.0	2.0	0.5	1.0	2.0	0.5	1.0
Verbisina alternifolia	33.0	8.3	6.7	17.0	4.3	3.9	49.0	12.3	10.1
Vernonia sp.	0.0	0.0	0.0	4.0	1.0	1.2	4.0	1.0	1.2
Veronica peregrina									
Vicia americana									
Viola sp.									
Xanthium strumarium									
TOTALS	380.0	96.2		383.0	97.6		780.0	19.6	
Species	63								

Table 9

Totals, Means ($\bar{x}$), and Standard Deviations (STD) for Relative Cover, Frequency, and Importance Values of Plants Sampled

a. Prairie Control Area (13-26 June 1984)

	COVER			FREQUENCY			IMPORTANCE VALUE		
SPECIES	TOTALS	$\bar{x}$	STD	TOTALS	$\bar{x}$	STD	TOTALS	$\bar{x}$	STD
Abutilion theophrasti									
Acalypha sp.									
Acalypha virginica									
Acerates angustifolia									
Achillea millefolium	13.5	3.3	2.1	23.0	5.8	1.3	36.0	9.0	1.4
Agropyron repens	2.0	1.0		3.0	1.0		5.0	1.7	0.6
Alisma plantago-aquatica									
Allium canadense									
Amaranthus retroflexus									
Ambrosia artemisiifolia	22.0	5.5	4.1	15.0	3.8	1.9	37.0	9.3	5.7
Ambrosia psilostachya	37.0	9.3	3.2	29.0	7.3	1.5	66.0	16.5	2.0
Ambrosia trifida	9.0	2.3	2.2	3.0	0.8	1.0	9.0	2.3	3.3
Amorpha canescens									
Amorpha fruticosa									
Andropogon gerardii	37.0	9.3	7.4	19.0	4.8	2.8	56.0	14.0	10.1
Andropogon scoparius	8.0	2.0	1.8	6.0	1.5	1.0	14.0	3.5	2.4
Androsace occidnetalis									
Antennaria neglecta									
Apocynum cannabinum									
Artemisia ludoviciana	11.0	2.8	1.3	14.0	3.5	1.3	25.0	6.3	2.1
Asclepias hirtella									
Asclepias purpurascens	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Asclepias syrica	1.0	0.3	0.5	4.0	1.0	0.8	5.0	1.3	1.3
Asclepias tuberosa									
Asclepias verticillata	1.0	0.3	0.5	2.0	0.7	1.2	3.0	0.8	1.5
Asclepias viridiflora	1.0	0.3	0.5	1.0	0.3	0.5	2.0	0.5	1.0
Aster ericoides	4.0	1.0	1.4	7.0	1.8	1.0	11.0	2.8	2.4
Aster pilosus	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Aster sp.	1.0	0.3	0.5	3.0	0.8	1.5	4.0	1.0	2.0
Aster sericeus									
Astragalus crassicarpus									
Baptisia australis									
Barbarea vulgaris									
Bare soil	10.0	2.5	5.0	2.0	0.5	1.0	12.0	5.0	6.0
Bidens frondosa									
Boehmeria cylindrica									
Bromus inermis	37.0	9.3	15.2	11.0	2.8	3.5	48.0	12.0	18.7
Bromus japonicus	7.0	1.8	2.2	11.0	2.8	2.4	28.0	7.0	6.6
Bromus tectorum									
Buchloe dactyloides									
Cacalia tuberosa									
Callirhoe alcaeoides									
Callirhoe involucrata									
Cannabis sativa									
Carduus nutans									
Carex sp.	1.0	0.3	0.5	4.0	1.0	0.0	5.0	1.3	0.5
Carex sp.	1.0	1.5	6.0	15.0	3.8	2.6	21.0	5.3	3.6
Carex triangularis	2.0	0.5	1.0	5.0	1.3	1.3	7.0	1.8	2.2
Carex vulpinoidea	8.0	2.0	1.8	5.0	1.3	2.5	9.0	2.3	4.4
Cassia fasciculata									
Celtis occidentalis									
Chamaesyce sp.									
Chenopodium album									
Cirsium altissimum	2.0	0.5	0.6	5.0	1.3	1.0	7.0	1.8	1.5
Cirsium discolor									
Cirsium undulatum	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Convolvulus arvensis									
Convolvulus sepium									
Cornus spp.									
Croton sp.									
Cuscuta sp.									
Cyperus esculentus									
Delphinium carolinianum									
Desmodium sp.									
Echinacea pallida									
Echinochloa muricata									

Table 9 (Cont'd)

Echinocystis lobata									
Eleocharis palustris	1.0	0.3	0.5	1.0	0.3	0.5	2.0	0.5	1.0
Elymus canadensis	1.0	0.3	0.5	4.0	1.0	0.8	5.0	1.3	1.3
Eragrostis spectabilis	7.0	1.8	1.7	10.0	2.5	1.7	17.0	4.3	3.3
Erigeron annuus	0.0	0.0	0.0	2.0	0.5	0.6	2.0	0.5	0.6
Erigeron strigosus	4.0	1.0	0.5	15.0	3.8	2.1	19.0	4.8	2.9
Euonymus americanus									
Euphorbia sp.									
Festuca elatior									
Festuca octoflora	0.0	0.0	0.0	3.0	0.8	1.0	3.0	0.8	1.0
Fragaria virginiana									
Fraxinus americana									
Galium aparine	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Galium circaezans									
Geranium carolinianum	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Geum sp.									
Gleditsia triacanthos									
Glycyrrhiza lepidota									
Gymnocladus dioica									
Hedeoma hispida									
Hedyotis nigricans									
Helianthus annuus	6.0	1.5	1.0	9.0	2.3	1.0	15.0	3.8	0.5
Helianthus grosseserratus									
Heliopsis helianthoides									
Hibiscus trionum	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Hieracium longipilum									
Hordeum jubatum									
Hordeum pusillum									
Hypericum perforatum	1.0	0.3	0.5	1.0	0.3	0.5	2.0	0.5	1.0
Iva scoparia									
Juglans nigra									
Juncus kansanus	1.0	0.3	0.5	4.0	1.0	1.2	5.0	1.3	1.5
Juncus torreyi									
Juniperus virginiana									
Kochia scoparia									
Koeleria cristata	1.0	0.3	0.5	4.0	1.0	0.0	5.0	1.3	0.5
Krigia oppositifolia									
Kuhnia eupatorioides	0.0	0.0	0.0	2.0	0.5	0.6	2.0	0.5	0.6
Lactuca canadensis	1.0	0.3	0.5	8.0	2.0	1.8	9.0	2.3	2.2
Lactuca sp.									
Laportea canadensis									
Lepidium densiflorum	0.0	0.0	0.0	8.0	2.0	0.8	8.0	2.0	0.8
Lespedeza capitata	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Liatris pycnostachya									
Linum sulcatum	2.0	0.5	1.0	6.0	1.5	1.3	6.0	1.5	1.3
Lycopus americanus									
Maclura pomifera									
Medicago lupulina	1.0	0.3	0.5	1.0	0.3	0.5	2.0	0.5	1.0
Medicago sativa									
Melilotus alba									
Melilotus officinalis	29.0	6.0	5.0	13.0	3.3	2.1	35.0	8.8	6.2
Mentha sp.									
Mirabilis nyctaginea									
Monarda fistulosa									
Morus alba									
Morus rubra									
Moss									
Muhlenberg.. spp.									
Oenothera speciosa									
Onosmodium molle									
Opuntia polycantha									
Oxalis stricta	0.0	0.0	0.0	5.0	1.3	0.5	5.0	1.3	0.5
Oxalis violaceae									
Panicum capillare									
Panicum lanuginosum									
Panicum leibergii	4.0	1.0	0.0	13.0	3.3	1.0	17.0	4.3	1.0
Panicum virgatum	10.0	2.5	5.0	4.0	1.0	2.0	14.0	3.5	7.0
Parietaria pennsylvanica									
Parthenocissus quinquefolia									
Penstemon cobaea									
Petalostemon candidum	0.0	0.0	0.0	4.0	1.0	1.4	5.0	1.3	1.9
Petalostemon purpureum	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Petalostemon sp.									
Phyla cuneifolia									
Physalis sp.	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Physalis sp.									
Phytolacca americana									
Plantago purshii									

Table 9 (Cont'd)

Plantago sp.									
Plantago virginica	1.0	0.3	0.5	6.0	1.5	2.4	7.0	1.8	2.9
Poa sp.	40.0	10.0	9.9	24.0	6.0	4.2	64.0	16.0	13.7
Polygala verticillata									
Polygonum aronastrum									
Polygonum persicaria									
Polygonum raeosissimum									
Polygonum sp.									
Prunus americana									
Psorea argophylla									
Psoralea sp.	2.0	0.5	0.6	6.0	1.5	1.3	8.0	2.0	1.8
Ptilimnium nuttallii	2.0	0.5	0.6	4.0	1.0	1.2	6.0	1.5	1.7
Quercus macrocarpa									
Rhus glabra	1.0	0.3	0.5	1.0	0.3	0.5	2.0	0.5	1.0
Rhus radicans									
Ribes missouriense									
Roriopa sp.									
Rosa arkansana									
Rubus strigosus									
Ruellia strepens									
Rumex altissimus									
Rumex crispus									
Sagittaria latifolia									
Sambucus canadensis									
Sanicula gregaria									
Schrankia nuttallii	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Schrophularia sp.									
Scirpus atrovirens									
Scirpus cyperinus									
Scrophularia marilandica									
Scutellaria resinosa									
Senecio pauperculus	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Setaria sp.									
Silene antirrhina	2.0	0.5	0.6	6.0	1.5	1.0	9.0	2.3	1.5
Silphium speciosum									
Sisyrinchium sp.									
Smilax sp.									
Smilax tamnoides									
Solanum carolinense	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Solanum rostratum									
Solanum triflorum									
Solidago canadensis	5.0	1.3	1.9	9.0	2.3	1.7	12.0	3.0	3.6
Sonchus asper									
Sorghastrum nutans									
Spartina pectinata	3.0	0.8	1.5	1.0	0.3	0.5	4.0	1.0	2.0
Sphenopholis intermedia									
Sphenopholis obtusata	1.0	0.3	0.5	3.0	0.8	1.5	4.0	1.0	2.0
Sporobolus heterolepis									
Stachys tenuifolia									
Stipa sp.	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Symphoricarpus orbiculatus	5.0	1.3	1.5	2.0	0.5	0.6	4.0	1.0	1.4
Taraxacum officinale									
Teucrium canadense									
Thlaspi arvense									
Tradescantia ohiensis									
Tragopogon dubius									
Trifolium pratense									
Triodanis leptocarpa									
Triodanis perfoliata	5.0	1.3	2.5	9.0	2.3	1.9	15.0	3.8	4.3
Typha angustafolia									
Typha latifolia									
Ulmus rubra									
Urtica dioica									
Verbascum blattaria									
Verbascum thapsus									
Verbena hastata	0.0	0.0	0.0	2.0	0.7	0.6	2.0	0.7	0.6
Verbena stricta									
Verbesina alternifolia									
Vernonia sp.	4.0	1.0	1.2	11.0	2.8	2.1	12.0	3.0	3.6
Veronica peregrina									
Vicia americana									
Viola sp.									
Xanthium strumarium									
TOTALS	355.5	90.6		401.0	103.0		750.0	192.1	
Species	68								

Table 9 (Cont'd)

b. Prairie Test Area (13-26 June 1984

	PRAIRIE TEST								
	COVER			FREQUENCY			IMPORTANCE VALUE		
SPECIES	TOTALS	$\bar{X}$	STD	TOTALS	$\bar{X}$	STD	TOTALS	$\bar{X}$	STD
Abutilion theophrasti									
Acalypha sp.									
Acalypha virginica									
Acerates angustifolia									
Achiliea millefolium	5.0	1.3	1.0	9.0	2.3	1.3	14.0	3.5	2.1
Agropyron repens	24.0	6.0	7.0	9.0	2.3	1.7	33.0	8.3	8.5
Alisma plantago-aquatica									
Allium canadense									
Amaranthus retroflexus									
Ambrosia artemisiifolia	11.0	2.8	3.1	7.0	1.8	1.7	13.0	3.3	5.3
Ambrosia psilostachya	27.0	6.8	4.1	27.0	6.8	1.7	54.0	13.5	5.8
Ambrosia trifida									
Amorpha canescens	1.0	0.3	0.5	2.0	0.5	0.6	2.0	0.5	0.6
Amorpha fruticosa									
Andropogon gerardii	128.0	32.0	11.8	35.0	8.8	1.7	163.0	40.8	13.2
Andropogon scoparius	14.0	3.5	2.1	10.0	2.5	1.3	24.0	6.0	3.2
Androsace occidnetalis									
Antennaria neglecta	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Apocynum cannabinum	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Artemisia ludoviciana	12.0	3.0	0.8	20.0	5.0	0.8	32.0	8.0	1.4
Asclepias hirtella									
Asclepias purpurascens									
Asclepias syrica	2.0	0.5	1.0	5.0	1.3	1.9	11.0	2.8	2.5
Asclepias tuberosa									
Asclepias verticillata	2.0	0.5	0.6	5.0	1.3	1.0	7.0	1.8	1.5
Asclepias viridiflora	1.0	0.3	0.5	1.0	0.3	0.5	2.0	0.5	1.0
Aster ericoides	6.0	1.5	1.9	7.0	1.8	1.0	13.0	3.3	2.9
Aster pilosus									
Aster sp.									
Aster sericeus									
Astragalus crassicarpus									
Baptisia australis									
Barbarea vulgaris									
Bare soil	8.0	2.0	4.0	3.0	0.8	1.5	11.0	2.8	5.5
Bidens frodosa									
Boehmeria cylindrica									
Bromus inermis	8.0	2.0	2.8	3.0	0.8	1.0	11.0	2.8	3.8
Bromus japonicus	17.0	4.3	7.2	10.0	2.5	3.1	27.0	6.8	10.2
Bromus tectorum									
Buchloe dactyloides	1.0	0.3	0.5	1.0	0.3	0.5	2.0	0.5	1.0
Cacalis tuberosa									
Callirhoe alcaeoides									
Callirhoe involucrata									
Cannabis sativa									
Carduus nutans									
Carex sp.	3.0	0.8	1.5	5.0	1.3	1.9	8.0	2.0	3.4
Carex sp.	13.0	3.3	3.8	14.0	3.5	4.1	27.0	6.8	7.8
Carex triangularis	0.0	0.0	0.0	2.0	0.5	0.6	2.0	0.5	0.6
Carex vulpinoidea	1.0	0.3	0.5	4.0	1.0	2.0	5.0	1.3	2.5
Cassia fasciculata	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Celtis occidentalis									
Chamaesyce sp.	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Chenopodium album	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Cirsium altissimum									
Cirsium discolor									
Cirsium undulatum	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Convolvulus arvensis	1.0	0.3	0.5	3.0	0.8	1.0	7.0	0.9	1.1
Convolvulus sepium									
Cornus sop.									
Croton sp.									
Cuscuta sp.									
Cyperus esculentus									
Delphinium carolinianum									
Desmodium sp.									
Echinacea pallida									
Echinochloa muricata	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5

Table 9 (Cont'd)

Echinocystis lobata	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Eleocharis palustris	6.0	1.5	1.0	8.0	2.0	2.0	14.0	3.5	3.0
Elymus canadensis	2.0	0.5	1.0	3.0	0.8	1.0	5.0	1.3	1.9
Eragrostis spectabilis									
Erigeron annuus	6.0	1.5	0.6	11.0	2.8	0.5	17.0	4.3	1.0
Erigeron strigosus									
Euonymus americanus	1.0	0.3	0.5	7.0	1.8	1.5	8.0	2.0	2.0
Euphorbia sp.									
Festuca elatior	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Festuca octoflora									
Fragaria virginiana									
Fraxinus americana									
Galium aparine									
Galium circaezans	4.0	1.0	0.8	12.0	3.0	1.6	16.0	4.0	2.4
Geranium carolinianum									
Geum sp.									
Gleditsia triacanthos									
Glycyrrhiza lepidota									
Gymnocladus dioica	0.0	0.0	0.0	2.0	0.5	0.6	2.0	0.5	0.6
Hedeoma hispida									
Hedyotis nigricans	4.0	1.0	1.4	5.0	1.3	1.5	9.0	2.3	2.9
Helianthus annuus	1.0	0.3	0.5	4.0	1.0	2.0	5.0	1.3	2.5
Helianthus grosseserratus									
Heliopsis helianthoides									
Hibiscus trionum									
Hieracium longipilum									
Hordeum jubatum									
Hordeum pusillum									
Hypericum perforatum									
Iva scoparia									
Juglans nigra	5.0	1.3	1.5	9.0	3.0	1.0	14.0	3.5	3.1
Juncus kansanus									
Juncus torreyi									
Juniperus virginiana									
Kochia scoparia	11.0	2.3	2.4	16.0	4.0	2.7	27.0	6.8	5.0
Koeleria cristata									
Krigia oppositifolia									
Kuhnia eupatorioides	3.0	0.8	1.0	6.0	1.5	1.3	9.0	2.3	2.2
Lactuca canadensis									
Lactuca sp.									
Laportea canadensis	1.0	0.3	0.5	12.0	3.0	1.6	11.0	2.8	2.4
Lepidium densiflorum	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Lespedeza capitata									
Liatris pycnostachya	0.0	0.0	0.0	6.0	1.5	1.0	6.0	1.5	1.0
Linum sulcatum									
Lycopus americanus									
Maclura pomifera									
Medicago lupulina									
Medicago sativa									
Melilotus alba	5.0	1.3	1.5	3.0	0.8	1.0	8.0	2.0	2.4
Melilotus officinalis									
Mentha sp.									
Mirabilis nyctaginea									
Monarda fistulosa									
Morus alba									
Morus rubra									
Moss									
Muhlenbergii spp.									
Oenothera speciosa									
Onosmodium molle									
Opuntia polycantha	0.0	0.0	0.0	3.0	0.8	1.0	3.0	0.8	1.0
Oxalis stricta	0.0	0.0	0.0	3.0	0.8	0.5	3.0	0.8	0.5
Oxalis violaceae									
Panicum capillare									
Panicum lanuginosum	6.0	1.5	1.3	16.0	4.0	2.2	22.0	5.5	3.3
Panicum leibergii	5.0	1.3	1.3	6.0	1.5	1.3	11.0	2.8	2.5
Panicum virgatum									
Parietaria pennsylvanica									
Parthenocissus quinquefolia									
Penstemon cobaea	0.0	0.0	0.0	2.0	0.5	0.6	2.0	0.5	0.6
Petalostemon candidum									
Petalostemon purpureum									
Petalostemon sp.									
Phyla cuneifolia	0.0	0.0	0.0	2.0	0.5	0.6	2.0	0.5	0.6
Physalis sp.									
Physalis sp.									
Phytolacca americana	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Plantago purshii									

Table 9 (Cont'd)

Plantago sp.									
Plantago virginica									
Poa spp.	25.0	6.3	0.6	17.0	4.3	1.7	42.0	10.5	7.0
Polygala verticillata									
Polygonum aronastrum									
Polygonum persicaria									
Polygonum ramosissimum	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Polygonum sp.									
Prunus americana									
Psoralea argophylla									
Psoralea sp	7.0	1.8	1.7	11.0	2.8	2.2	18.0	4.5	3.9
Ptilimium nuttallii	0.0	0.0	0.0	2.0	0.5	0.6	2.0	0.5	0.6
Quercus macrocarpa									
Rhus glabra									
Rhus radicans									
Ribes missouriense									
Rorippa sp.									
Rosa arkansana									
Rubus strigosus									
Ruellia strepens	1.0	0.3	0.5	4.0	1.0	0.8	5.0	1.3	1.0
Rumex altissimus	1.0	0.3	0.5	1.0	0.3	0.5	2.0	0.5	0.1
Rumex crispus									
Sagittaria latifolia									
Sambucus canadensis									
Sanicula gregaria									
Schrankia nuttallii	1.0	0.3	0.5	4.0	1.0	0.0	5.0	1.3	0.5
Schrophularia sp.									
Scirpus atrovirens									
Scirpus cyperinus									
Scrophularia marilandica									
Scutellaria resinosa									
Senecio pauperculus									
Setaria sp.									
Silene antirrhina	0.0	0.0	0.0	4.0	1.0	0.8	4.0	1.0	0.8
Silphium speciosum									
Sisyrinchium sp.									
Smilax sp.									
Smilax tamnoides									
Solanum carolinense									
Solanum rostratum									
Solanum triflorum									
Solidago canadensis	1.0	0.3	0.5	4.0	1.0	1.4	5.0	1.3	1.9
Sonchus asper									
Sorghastrum nutans	3.0	0.8	1.0	3.0	0.8	1.0	6.0	1.5	1.7
Spartina pectinata									
Sphenopholis intermedia									
Sphenopholis obtusata	1.0	0.3	0.5	1.0	0.3	0.5	2.0	0.5	1.0
Sporobolus heterolepis									
Stachys tenuifolia	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Stipa sp.									
Symphoricarpus orbiculatus	0.0	0.0	0.0	2.0	0.5	0.6	2.0	0.5	0.6
Taraxacum officinale									
Teucrium canadense									
Thlaspi arvense									
Tradescantia ohiensis									
Tragopogon dubius									
Trifolium pratense									
Triodanis leptocarpa	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Triodanis perfoliata	2.0	0.5	0.6	9.0	2.3	1.0	11.0	2.8	1.5
Typha angustafolia									
Typha latifolia									
Ulmus rubra									
Urtica dioica									
Verbascum blattaria									
Verbascum thapsus									
Verbena hastata									
Verbena stricta									
Verbisina alternifolia									
Vernonia sp.	4.0	1.0	0.0	14.0	3.5	0.6	18.0	4.5	0.6
Veronica peregrina	0.0	0.0	0.0	1.0	0.3	0.5	1.0	0.3	0.5
Vicia americana									
Viola sp.									
Ianthium strumarium									
TOTALS	391.0	98.6		409.0	105.1		799.0	200.9	
Species	69								

Table 10

Average Percent Cover for All Plants Less Than 1 m Tall (From 50-m-square Sample Quadrats, 13-26 June 1984).

CONTROL			TEST		
STUDY AREAS	$\bar{X}$	STD	STUDY AREAS	$\bar{X}$	STD
RC1	131.2	40.2	RT1	121.1	35.3
RC2	110.5	43.9	RT2	101.3	36.0
RC3	147.4	49.8	RT3	145.6	66.7
RC4	142.6	51.2	RT4	154.1	47.0
PC1	141.0	47.9	PT1	126.8	29.5
PC2	109.4	32.8	PT2	122.8	53.8
PC3	132.4	46.5	PT3	122.6	40.7
PC4	143.2	46.7	PT4	126.2	42.0

Avian Studies

The number and species of birds in the riparian and prairie control and test areas showed that these areas were very similar (Table 11). Based on species richness, both riparian areas averaged 30 species. The prairie had 18 to 22 species per transect in the test and control areas, respectively. Breeding bird species richness in the riparian areas was 25 and 26 for the control and test sites, respectively. Eighteen species were recorded in the prairie control, and 13 in the prairie test. Visiting species were fewest in the prairie control (three or four species), while the prairie test had six species. Four to six species visited the riparian areas.

The house wren was the most abundant breeding bird in the riparian control. The dickcissel, a prairie species, was very abundant, since it visited riparian edges extensively. Habitat edge was important to many bird species in the riparian areas. Some species that used riparian interior and edge were important in both prairie and riparian study areas, including common yellowthroats, brown thrashers, goldfinches, northern orioles, eastern kingbirds, and visiting species. Visitors included dickcissels, grasshopper sparrows, brown-headed cowbirds, swallows, and other species. Dickcissels were far more abundant and important in the prairies, with an estimated 97 to 110 individuals in 100 ha. Dominant breeding species of the prairie were common to both prairie study sites, and had very similar densities in each area. This included meadowlarks, grasshopper sparrows, and dickcissels; visiting brown-headed cowbirds were observed parasitizing nests of these three important species. Consequently, the cowbird was an abundant but variable visitor in the prairies. Upland plovers were observed nesting only in the prairies, with similar densities in both the test and control areas (10 to 13 individuals per 100 ha). Several habitat edge species occupied even the smallest growth of shrubs or trees in the prairies. Thus, both edge and riparian species were recorded in the prairies. Species included brown thrashers, catbirds, yellowthroats, kingbirds, rosebreasted grosbeaks, warbling vireos, chickadees, robins, indigo buntings, cardinals, and field and chipping sparrows.

Table 11

Results of Emlen (1974) Bird Surveys in Riparian and Prairie Control and Test Study Areas (13-26 June 1984). (Mean and Standard deviations [STD] for bird density are calculated from three surveys along each of the four 800-m transects in each study area. Mean density of birds has been equated to other studies by standardizing sample areas. Density has been presented as numbers of individuals of each bird species in 100.

SPECIES	RIPARIAN CONTROL		RIPARIAN TEST		PRAIRIE CONTROL		PRAIRIE TEST	
	MEAN	STD	MEAN	STD	MEAN	STD	MEAN	STD
BLUE WING TEAL							P	
GREAT BLUE HERON			6	0				
GREEN HERON	6	0					8^	0
UPLAND PLOVER	6^	0	13^	0	10	4	13	8
KILDEER	8	0	7	1	10	5	13	0
BOBWHITE QUAIL	8	3	15	5	8	4	10	3
RING NECK PHEASANT	6	0	6	0	10	8	7	1
MORNING DOVE	20	4	15	7	22.0^	13	25.0^	18
TURKEY VULTURE			7.0^	1	6.0^	0		
RED-TAILED HAWK					6	0		
BARRED OWL	P		P					
GREAT HORNED OWL	P		P					
YELLOW BILLED CUCKOO	14	6	15	7	6	0	13	10
DOWNY WOODPECKER	13	0	8	0				
RED-HEADED WOODPECKER	13	0	15	10				
FLICKER	11	3	13	9	6	0		
COMMON NIGHTHAWK	10^	3	9^	5	21	14	12	6
SCISSOR-TAIL FLYCATCHER							13^	0
EASTERN KINGBIRD	27	6	23	4	20	6	13	0
WESTERN KINGBIRD	13^	0			25	0		
GREAT CRESTED FLYCATCHER	25	0	19	10				
EASTERN WOOD PEWEE	17	7	15	9				
BLUEJAY	27	18	14	8	25^	0	6^	0
COMMON CROW	19	0	7	1				
BROWN-HEADED COWBIRD	28	11	27	11	43^	30	32^	16
RED-WING BLACKBIRD	19	8	20	4	13	7	33^	21
WESTERN MEADOW LARK	16	3	16	2	22	19	34	3
ORCHARD ORIOLE			29	29				
NORTHERN ORIOLE	24	5	24	19	10	6	13	0
GRACKLE	13	0					19^	7
GOLDFINCH	28	9	33	11	22	6	17	9
GRASSHOPPER SPARROW	12^	3	7^	1	16	7	30	22
CHIPPING SPARROW	25	0						
FIELD SPARROW	20	5	12	3	8	0		
CARDINAL	15	8	16	7	18	9		
ROSE-BREASTED GROSBEAK	22	19	18	5	27	20		
INDIGO BUNTING	17	9	19	8	11	4		
DICKCISSEL	57^	25	75^	25	97	15	110	42
BARN SWALLOW	13	0	25	0	6^	0	19^	8
TREE SWALLOW	21	7	11	4	19^	8	6^	0
ROUGH-WING SWALLOW			15	9			20^	9
LOGGERHEAD SHRIKE	7	3			7	3		
WARBLING VIREO	11	3	8	0	13	0	17	12
YELLOW WARBLER	25	0			8	0		
COMMON YELLOWTHROAT	16	14	29	17	18	13	16	4
CATBIRD	14	2	17	7	9	3		
BROWN THRASHER	16	7	31	16	13	5	20	20
HOUSE WREN	51	17	23	9	22	4		
BLACK-CAPPED CHICKADEE	16	6	8	0				
ROBIN	13	0	13	0			13	0
EASTERN BLUEBIRD	25	0						
CHIMNEY SWIFT	25	0						
TOTAL SPECIES	30.8	3.1	30.8	2.2	22.0	1.5	18.0	1.7
VISITING SPECIES^	4.8	1.0	5.8	1.3	3.5	1.3	5.5	0.6
BREEDING SPECIES	26.0	2.6	25.0	2.4	18.3	1.7	12.8	2.5

Small Mammal Studies

The prairie deer mouse (Peromyscus maniculatus bairdii) was the most abundant prairie small mammal, accounting for more than 82 and 39 percent of the captures in the prairie control and test areas, respectively (Table 12). Except for two Blarina in the prairie test site, and one least shrew (Cryptotis) in the prairie control, all other captures in these areas were similar, both in composition and number. Although density of some mammal species was higher in the prairie test area, the total captures (51 and 33, respectively, in the control and test) suggested slightly elevated populations in the control.

The white-footed mouse (Peromyscus leucopus) dominated the riparian test and control areas and accounted for well over 50 percent of the captures. The total numbers and richness of captured small mammals were virtually identical (90 and 98 individuals in the control and test, respectively). Slightly fewer prairie voles (Microtus) and no Peromyscus maniculatus were captured in the riparian study areas, but the meadow jumping mouse Zapus was captured only in the riparian sites. The prairie areas were also very similar; however, trap successes of 3.4 to 5.3 percent in the prairies compared to 9.4 to 10.2 percent in the riparian areas may suggest fundamental differences between small mammal populations in prairie and riparian vegetation types.

Table 12

Small Mammal Trapping Data and Analysis Based on Four Trap Days (60 traps [960 trapdays] in each study area, 13-26 June 1984).

	STUDY AREAS			
SPECIES	PRAIRIE CONTROL	PRAIRIE TEST	RIPARIAN CONTROL	RIPARIAN TEST
Blarina brevicada	0	2	0	9
Cryptotis parva	1	0	2	0
Mircotus ochrogaster	3	9	5	5
Peromyscus leucopus	2	8	80	79
Peromyscus maniculatus	42	13	0	0
Reithrodontomys sp.	3	1	2	3
Zapus hudsonius	0	0	1	2
TOTALS	51	33	90	98
TRAP SUCCESS	5.3	3.4	10.2	9.4

Discussion

Riparian forest habitats generally support higher bird and small-mammal populations than adjacent nonriparian habitats. Riparian systems in the western and southwestern United States have the highest-density bird populations of all North America forests of equivalent area.[14] Compared to the adjacent grasslands, avian density in the riparian study areas was high. This may suggest similar general conclusions regarding the importance of Fort Riley's riparian areas for maintaining local and perhaps regional avian diversity. Consequently, the manipulation or loss of riparian habitat may extend several hundred meters beyond the edge of the streamside vegetation. In the desert southwest, it is questionable whether riparian areas are a renewable resource that can sustain damage and exploitation.[15]

The riparian habitats in and adjacent to the MPRC are successional communities resulting from farming and logging during the late 1800s to the 1940s. No baseline data were available on the riparian system's condition during presettlement times. Most of the tree species occurring in these areas reproduce vegetatively, and are not eliminated completely by logging (for example, processes such as stump suckering occur). Thus, the existing riparian habitat plant species mix is similar to that of the presettlement condition. Structural aspects of the habitat have likely been modified and have undoubtedly influenced the avifauna. This is especially true if correlations between avian communities and habitat structure found elsewhere apply at the study areas.[16] The avian communities at Fort Riley are probably similar to presettlement communities, since the historic riparian habitat was also perturbed by disturbances that created edge habitat between riparian and prairie. Fire, winter exposure, drought, insect infestations,windthrow of trees, ice storms, and other perturbations enriched edge habitats. Most birds in the present riparian systems either breed or feed in edges. Thus, disruption of edge habitat can greatly reduce avian and other populations. If edges are left intact, and the riparian core modified, there will be fewer changes in avian communities; if riparian systems are left intact and the edges modified, greater changes may be expected.

Riparian systems are not only important breeding and water areas for birds and mammals, but also serve as migratory habitat. They often contain 10 times as many migratory animals as nonriparian habitats.[17] Complete destruction of riparian area in the MPRC would greatly modify avian communities. Sustained heavy use of these areas might cause less, but still substantial declines, because many of the vocally reliant breeding and avian courtship behaviors may not succeed above military noise. Construction and use of the MPRC may cause loss of birds in the prairie areas because the predominant vegetation (perennial prairie grass and forb) will change to plant forms dominated by weed species, possibly with areas of bare soil, or the site may become dominated by monocultures of nonnative vegetation.

Construction and use of the MPRC area are likely to cause vegetation shifts. If riparian vegetation is bulldozed, some riparian species may be eliminated locally in the

---

[14] J. R. Lacey, P. R. Ogden, and K. E. Foster, *Southern Arizona Riparian Habitat: Spatial Distribution and Analysis* (University of Arizona, Tucson, 1975).

[15] J. R. Lacey, P. R. Ogden, and K. E. Foster.

[16] J. R. Karr; M. F. Wilson, "Avian Community Organization and Habitat Structure," *Ecology*, Vol 55 (1974) pp 1017-1029; R. H. MacArthur, "Environmental Factors Affecting Bird Species Diversity, "*Amer. Nat.*, Vol 98 (1964), pp 387-398

[17] Lacey, Ogden, and Foster.

short term. The duration of this impact is determined by the time necessary for natural dispersal mechanisms to bring seeds in and for the plants to become established. Some species, including ragweed, sunflowers, poison ivy, elders, and coralberry, may flourish with construction and MPRC use. Thirty to 50 years may be required to reestablish larger woody vegetation with forest structural aspects that are attractive to wildlife. If soils are disrupted significantly or lost during construction or use, this amount of time may be prolonged. If the riparian core is left intact and edge habitat is lost, restoration of edge habitat would be greatly accelerated by the adjacent intact riparian core, which can serve as a source of plant propagules.

Species whose habitats are disturbed by construction of the MPRC will likely cause the immediate replacement of existing prairie plants. Many prairie plant species that have reestablished over the years in the fallowed MPRC lands would be reduced or eliminated. Their reinvasion and establishment in the MPRC may be slower than during the reinvasion after farming, especially if soils are significantly modified. The seed source for prairie plants that could potentially reinvade may become more removed from the MPRC due to increased destruction of vegetation and soils by tracked vehicle use on adjacent lands. Plant succession could be initiated after construction of the MPRC. Loss of soil, intact vegetation, and soil-seed banks (seeds preserved in the soils that resprout with disturbances) could cause poor regrowth of native prairie plants and could reduce the importance of the prairie community. Weedy plant species that respond quickly to disturbance will replace the prairie plants. Several plants that are already present and are likely to invade and increase in the MPRC land are considered noxious species, and their increased importance would be undesirable. These include thistles, bindweed, and poison ivy. If soil disturbances are severe, even establishment of disturbed-site plant species may be slowed.

A shift toward weedy plant species may shift mammals toward greater dominance by deermice (Peromyscus spp.), with reductions in shrews, voles, moles, and perhaps other species. Mammal populations at Fort Riley have been found to be higher than those on adjacent lands.[1] This is thought to result from the patchy vegetation mosaic present, including intact, undisturbed native prairies and successional farmlands. If native prairie grasses and riparian vegetation reestablish after construction, small-mammal populations may return to existing levels or at least to naturally fluctuating populations. However, with construction and persistent use of the MPRC, small-mammal populations may decline (as much as 20 percent has been measured) and may shift in species composition and diversity.

With increased weediness of the existing prairies, avian communities may also decline, and some prairie bird species may leave the area. However, a lush regrowth by invading weed species might favor quail, pheasants, prairie chickens, doves, grackles, and red-winged blackbirds. Avian visits may increase with increased weediness. If disturbed prairies are gradually replaced by prairie grasses, a shift toward upland plovers, grassnopper sparrows, dickcissels, and meadowlarks is likely. These species would be especially attracted and invasive when the insects they feed on return or are accessible. Meadowlarks and plovers eat mostly beetles, while dickcissels and grasshopper sparrows use lepidoptera and orthoptera insects and prairie grass seeds for food.[2] However, persistent military use could substantially reduce prairie bird populations.

---

[1] *Five Year Wildlife Management Plan.*

[2] P. G. Risser, E. C. Birney, H. D. Blocker, S. W. May, W. J. Parton, and J A. Wiens, *The True Prairie Ecosystem* (Academic Press, 1981).

The data of this study concur with those of a study by Johnston on the relative numbers of birds using riparian and prairie habitats in Kansas.[20] Johnston found that 23 bird species, or 13 percent of the 176 species in the state, used only the prairies. Risser, et. al.,[21] found that 13 to 15 bird species used the prairies. The data for the current study also concurred with Risser on bird species that are important in prairies. Prairie bird species make up about 5 percent of all North American bird species. In Kansas, about 58 percent of all birds are woodland species; some were at their range limits in the Fort Riley study region. This included the scissor-tailed flycatcher at the northern edge of its range, the black-capped chickadee at its southern limit, and several species at their western range limits in Kansas riparian systems. Included were the orchard oriole, yellow-billed cuckoo, and chipping sparrow.[22] Numerous active nests (containing eggs) found during this project suggested the study period was good for analyzing avian communities; this was supported by Johnston as being the period when most birds breed during an average year.

Some mammal species were also close to their range limits in the study region. For example, the meadow jumping mouse (Zapus hudsonius) is limited to wooded portions of Kansas because of affinities with the deciduous forests. No captured mammal species was indigenous only to grasslands. In general, mammal community composition was typical[23] for this area of Kansas. The region is located in or near the edge of several biotic provinces. No endemic mammals were collected (or occur); however, 27 to 43 mammal species are found in this region, depending on the relative importance of deciduous forest and prairie in an area.

Ecological Implications

Woody plants may actually increase in some areas because of tracked vehicle damage to prairie sod.[24] Establishment of woody vegetation in the prairie could increase the effective habitat edge. However, since soils in the study area are very susceptible to compaction, the potential for establishing wood vegetation in tracked vehicle ruts may be reduced. The tracked vehicle use per acre is already high.[25] With development of the MPRC, it would be expected to increase substantially and become intensely localized. The road improvements that accompany MPRC development might also increase use because they would provide better access to the MPRC area.

Historic grazing and farming of the property has likely been responsible for reducing prairie forbs and grasses. Many plant species known to increase with grazing

---

[20] R.F Johnson, *The Breeding Birds of Kansas*, Vol 12, No. 14 (University of Kansas, Museum of Natural History, 1964), pp 575-655.

[21] Risser, et al.

[22] D. W. Johnson and E. P. Odum.

[23] E. L. Cockrum, *Mammals of Kansas*, Vol 7. No. 1 (Univeristy of Kansas Publications, Museum of National History, 1952), pp 1-303.

[24] T. B. Bragg and L. C. Hulbert, "Woody Plant Invasion of Unburned Kansas Bluestem Prairie", *Jo Range Management*, Vol 29, No. 1 (1977), pp 19-24.

[25] W. D. Goran, L. L. Radke, and W. D. Severinghaus, *An Overview of the Ecological Effects of Tracked Vehicles on Major U.S. Army Installations*, Technical Report N-142/ADA126694 (U.S. Army Construction Engineering Research Laboratory [USA-CERL], 1983).

and agricultural disturbances were found to be widespread and relatively abundant (Table 9) in the prairie study areas.[26] This suggests either that farming and grazing were widespread, or that farming followed by military activities had an effect on plant species composition that was similar to the effect of grazing and agriculture in other areas. Most land in the MPRC has been subjected to recurring disturbances by tracked vehicles. Only a small part of the area has been exposed to constant, intense, or frequent repeated tracked vehicle use. Single drive-through events by tracked vehicles were frequent around the proposed MPRC property and in parts of the control study areas.

Although not exhaustive, the following lists several tracked vehicle impacts that were observed and some that are likely to occur in the MPRC area.

1. Tracked vehicle impacts can cause or initiate soil compaction, reduce soil permeability, and increase erosion potential.

2. Shearing of soils with exposed cuts can increase soil erosion potential. The reduced albedo of exposed soils can raise soil temperatures, which can reduce successful establishment and survival of vegetation.

3. Soil ruts can occur and can concentrate runoff and lead to gullying.

4. Vehicle tracks can initiate stream bank erosion by destroying bank vegetation or by modifying in-stream flow patterns and rates.

5. Dust generation can reduce vegetation production and eliminate intolerant plants.

6. Direct elimination of vegetation by shearing and scraping can select for plant species that can survive these disturbances.

7. Damage or removal of tree canopies can eliminate subvegetation that requires shade.

8. Damage to tree roots and branches can allow infections to enter plants.

9. Reduction of woody vegetation cover, forest structure, and complexity of ground cover vegetation can modify avian and small-mammal populations.

Generally, construction activities can be expected to have similar impacts, including:

1. Complete removal of topsoil (which contains soil-seed banks) and destruction of wildlife habitat are often likely in the short term.

2. Widespread soil compaction, disruption to soil structure, and loss of all vegetation may occur.

Many other impacts are associated with tracked vehicle use and construction activities. Critical considerations in designing tracked vehicle use areas (e. g., locating trails along land contours and considering seasonality and frequency of training area use)

---

[26] Risser, et al.

are important. Properly designed training ground accesses and stream and slope crossings can minimize tracked vehicle impacts. However, a tracked-vehicle training program must also have feedback mechanisms for informing land managers about how effective their management strategies are. Monitoring the impacts and effectiveness of mitigation and reclamation is required; however, it can also serve as an important feedback mechanism.

Reclamation, Ecological Monitoring, and Management

An ecological monitoring program would greatly facilitate use of the MPRC for sustained, long-term training activities. The period of time over which the MPRC can be used for effective training will be governed partly by the management strategy for the land, which is closely linked to reclamation and site stabilization, and ultimately to a strong monitoring or feedback program. After a construction zone is reclaimed by introducing vegetation cover and modified surface hydrologic strategies, it is also important to maintain a relevant, effective system. This depends on having a good monitoring program.

Reclamation becomes increasingly difficult with the increase of slope, substrate erodibility, toxicity/soil nutrient relationships, and frequency and persistence of success-reducing agents. It is difficult to reclaim a heavily used tracked-vehicle training area. Rotation of training activities away from reclaimed belts or, at least minimizing the use of selected areas, such as buffers or vegetation plantings, would be desirable; however, this may not be compatible with intended military land uses.

Reclamation strategies must consider the varying intensity of military training activities. A variety of plant species with different tolerances to training activities should be used. For example, use of tolerant buffalo grass (Buchloe dactyloides) or blue grama (Bouteloua gracilis) is recommended over introduced species (e.g., Festuca elatior, Bromus inermis, etc.) or even some native, soil-compaction-intolerant species, like big and little bluestem grasses (Andropogon gerardii and A. scoparius). Native, locally adapted genetic stock should be used for reclamation. Fort Riley is ideally located for collecting locally grown seed for reclamation.

Localized High-Risk Erosional Areas

Localized high-risk erosional areas occur along road corridors, in construction corridors, along tank trails, in association with targets, and in slope and stream crossings and other areas receiving persistent heavy tracked-vehicle traffic. Reclamation of these areas should try to control surface water flow and minimize erosion. Establishment of vegetation cover could be the cheapest long-term solution; however, this may not be possible in the most heavily impacted areas. An alternative would be to establish biological sediment traps that use plants to filter and catch eroded materials[27] before they enter Madison Creek or its tributaries. These catchment basins and filtration systems should be planted with wetland plant species, including cattails (Typha spp.), reeds (Scirpus spp.) rushes (Cyperus spp.), sedges (Carex spp.), and rooted submerged aquatic plant species (Potamogeton spp., Elodea spp., Certophyllum sp., etc.). Collected sediments could be removed from primary catchment areas and placed in upland areas

[27] *Environmental Impact Statement: Fresh Water Wetlands for Wastewater Management*, Technical Report #904/9-83-107 (U. S. Environmental Protection Agency [USEPA], March 1983).

for revegetation. Minimizing of erosion in upslope areas would reduce the maintenance demands of the sediment traps and, if entirely effective, would minimize the need to use the traps. Contour vegetation belts and low-use areas that are removed from heavy military activity could also be useful.

Expansive High-Risk Erosional Areas

Expansive, high-risk erosional areas include large areas from which topsoil is removed for berm construction, where slope contouring has occurred, or where vehicles are held temporarily. They are expansive, disturbed areas that may span several drainage systems. It is recommended that sediment traps be used in critical areas and that slope contour plantings be emplaced. Vegetative belts in conjunction with surface water runoff regulators could be used to effectively minimize movement of soils from construction areas to downstream environments such as Madison Creek and Milford Reservoir. It is also recommended that the belts be planted with native prairie species and a fast-growing, soil-stabilizing cover crop. Disturbed sites would then be reestablished as prairie. The cover crop (e. g., barley, oats, wheat, sweet clover) can effectively minimize erosion, cool soils, and invite insect, avian, and small-mammal use of the property. It can also promote growth and establishment of native prairie plants. In the autumn, local prairie hay should be cut and spread over areas to be reclaimed shortly after winter wheat (cover crop) has been planted at high seeding rates. Germination of the wheat and its growth through the prairie hay in both the fall and spring will help stabilize the hay during windy periods and promote its contact with soil. If other plants are to be introduced, they should be seeded at the same time as the winter wheat, or the seed broadcasted after the wheat has become established. This technique, coupled with applications of site-specific fertilizer (based on soil sampling) will get the seed into the soil at the best time for establishing native grasses. It will also mulch the system with long, fibered material at minimum cost (compared to commercially bagged wheat hull mulch), and should result in a low-maintenance vegetation cover. Because of the generally positive response of prairie grasses and forbs to fire, it may be desirable to include these areas in the burning program at Fort Riley. This may favor wildlife species associated with prairie. It is important to time the haying operation so that the seed is in the correct stage for harvest. Reducing the time that hay is held before being spread may be desirable for maximum seed viability.

Riparian and Edge Habitat

Traditional forestry practices--planting of trees and shrubs--might be desirable for reclaiming habitat edges. Seedling stock can be purchased (or perhaps grown in a nursery at the installation) and then reintroduced. Planting black walnut seed, branch cuttings of willow and hybrid poplar species (into muddy moist soil areas), and root cuttings from dogwoods, elders, and wild plum could accelerate natural successional processes.

2 ESTIMATES OF TRAINING IMPACTS ON SEDIMENT YIELD AT THE FORT RILEY, KS, MPRC*

Introduction

The Fort Riley MPRC trains personnel in a dynamic battle situation, and has several advantages over static firing situations. However, there will be environmental problems associated with this concept, since it requires continuous movement of personnel and armor across the land. One problem is the possibility of increased soil erosion caused by the anticipated disturbance to vegetation and soils. This chapter assesses the potential erosion impacts of the MPRC to help land managers at Fort Riley prevent degradation of the complex to an unusable condition.

Approach

The potential erosion problems of the MPRC were assessed using a mathematical model to predict water and sediment yield from watersheds. The model is currently part of the U. S. Army's Environmental Technical Information System,[28] available through USA-CERL. In general, the model simulates the movement of water and sediment from rainfall, across the soil surface, and through channels systems. The model is based on actual physical processes and is the best state-of-the-knowledge representation of the important controlling phenomena responsible for erosion.

Because of budget constraints, on-ground data collection consisted of only a field inspection and bulk soil sampling. The other data needed to run the model were gathered from published sources, such as maps, construction drawings, soil surveys, scientific literature, and previous reports on the area.

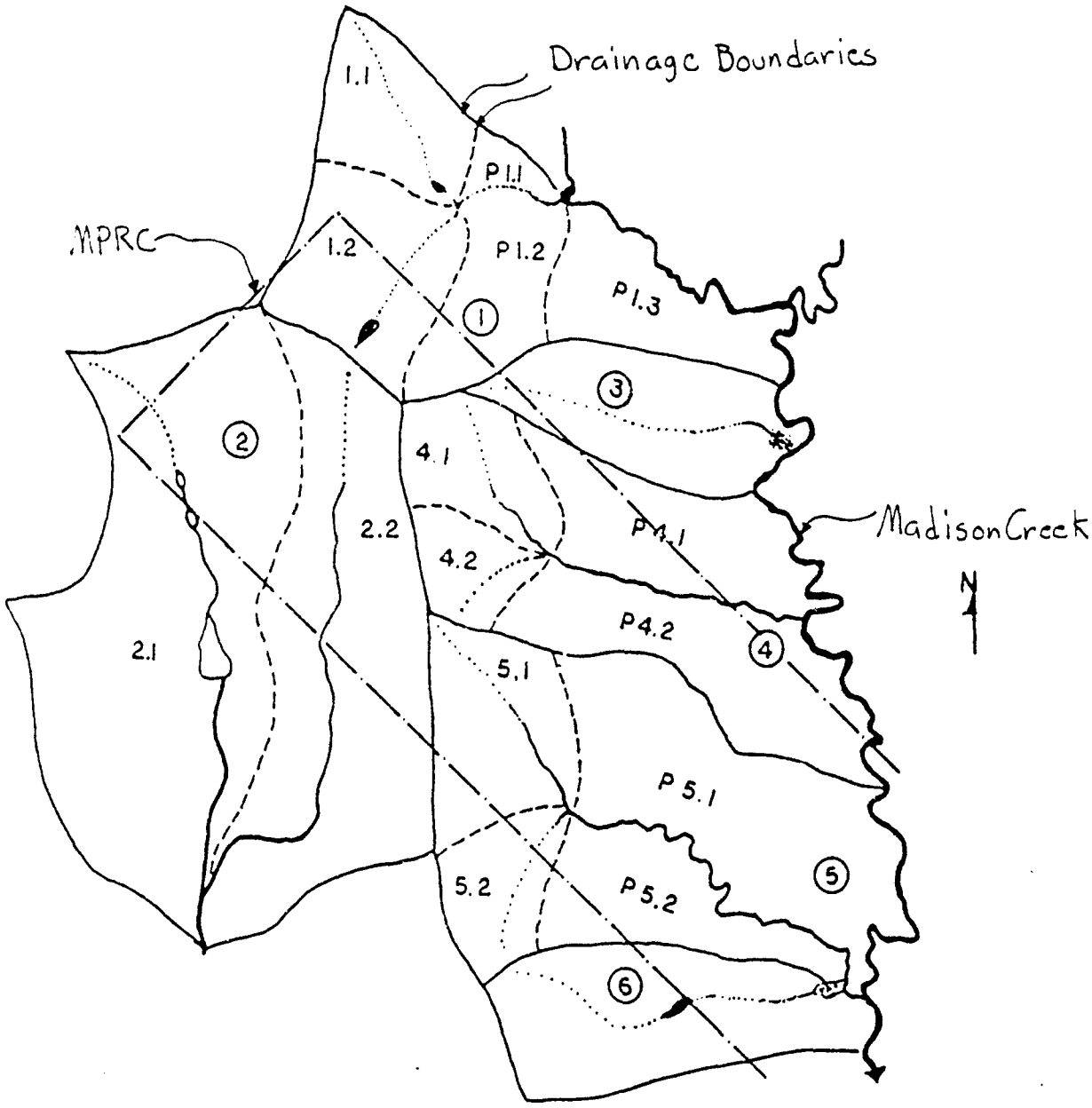
The MPRC was modeled with respect to: (1) its role as an impacting agent on watersheds draining the area and (2) a sediment source via the proposed road network. The first part was approached in "before and after" scenarios. The base rainfall event was a 25-year-return-period, 1-hour-duration storm of 3 in. total depth distributed in time following U. S. Bureau of Reclamation suggested fractions of 0.48, 0.71, 0.88, and 1.0 for the 15-, 30-, 45-, and 60-minute depths, respectively.

Six drainages were modeled as shown in Figure 3. All drainages except number 2 in Figure 3 contribute to Madison Creek near the MPRC. For the model, the drainages were broken down into 10 small watershed units, seven planar units, and eight channels (Figure 4). Information on infiltration rates, soil particle size, vegetative cover, and geometric characteristics was developed for all these units. Table 13 summarizes the geometric characteristics. Soils in the MPRC are predominantly silt loams and silty clay loams. Published infiltration characteristics from the literature were used in the model. The hydraulic conductivity of the soil was assumed to be 0.3 in. per hour. The bulk soil samples were sieved, resulting in a distribution that was 18 percent in the silt

---

*Prepared by Tim J. Ward, Associate Professor of Civil and Geological Engineering, New Mexico State University, Las Cruces, NM.

[28] R. D. Webster, et al., *Modification and Extension of the Environmental Technical Information System (ETIS) for the Air Force*, Special Report N-8/ADA079441 (USA-CERL, 1979).



Width = 1000m (3280 ft)
Length = 4500m (14,760 ft)

Figure 3. Drainage units.

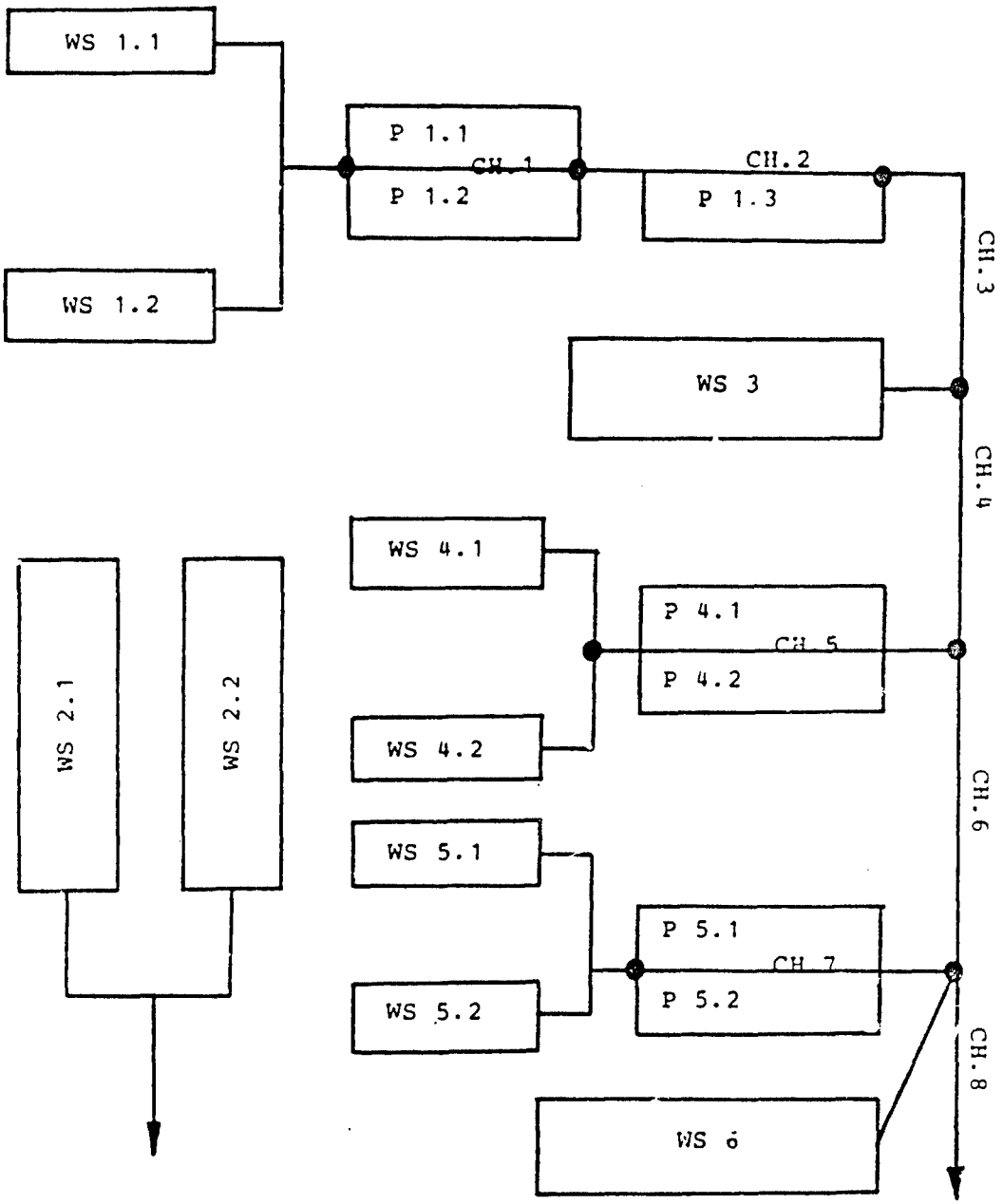


Figure 4. Schematic of drainage units.

Table 13

Geometric Characteristics of Drainage Units

Unit	Part*	Area (acres)	Flow length (feet)	Slope, decimal
WS1.1	L	18.5	343	0.054
	R	27	500	0.042
	C	--	2344	0.030
WS1.2	L	45.5	1035	0.039
	R	19.5	443	0.041
	C	--	1912	0.018
P1.1		9	333	0.045
P1.2		47	1740	0.031
CH1		--	1175	0.017
P1.3		51.5	682	0.042
CH2		--	3289	0.006
CH3		--	2160	0.005
WS2.1	L	100	677	0.025
	R	159.5	1080	0.038
	C	--	6428	0.016
WS2.2	L	123.5	810	0.030
	R	66	433	0.029
	C	--	6620	0.016
WS 3	L	42.5	528	0.028
	R	33	410	0.038
	C	--	3500	0.023
CH4		--	3000	0.003
WS4.1	L	16.5	378	0.025
	R	23.5	540	0.027
	C	--	1896	0.022
WS4.2	L	19	657	0.032
	R	7	242	0.026
	C	--	1258	0.029
P4.1		64	934	0.032
P4.2		85	1244	0.032
CH5		--	2970	0.016
CH6		--	5040	0.002
WS5.1	L	20	364	0.020
	R	38.5	700	0.032
	C	--	2390	0.021
WS5.2	L	26	650	0.030
	R	9.5	238	0.032
	C	--	1738	0.023
P5.1		125.5	1211	0.034
P5.2		12.5	603	0.030
CH7		--	4516	0.010
WS6	L	33	388	0.037
	R	65.5	760	0.035
	C	--	3700	0.023
CH8		--	720	0.003

* L - left side when looking downstream.
R - Right side when looking downstream.
C - Channel common to both sides.

and clay range and 15 percent in the gravel range. These values seem to be a bit higher than the published values, but were used in lieu of better data. Ground cover was estimated to vary between 80 and 100 percent, but the more conservative 80 percent was used for the modeling.

Results

Four scenarios were simulated. The key variables changed were the hydraulic conductivity and the ground cover. Scenario 1 was base conditions. Scenario 2 was a 75 percent reduction in the hydraulic conductivity and a reduction to 30 percent of the ground cover. Scenario 3 was a reduction of the ground cover to 10 percent, and scenario 4 was a mixed scenario, in which the variables were modified according to how much of the drainage unit was in the MPRC. As expected, the worst scenario was number 3. Here, onslope sediment yields increased by factors exceeding 100 on some planes, and the overall sediment yield at the mouth of channel 8 increased by a factor of 5.0. Scenario 4 produced a 3.5 increase, and scenario 2 produced a 2.1 increase.

Road sediment yield was analyzed using slopes of 2 and 6 percent and lengths of 100 and 500 ft. The yield per unit area was much greater for the roads than for the baseline offroad areas, but as the scenarios tended toward decreased stability, the offroad areas often exceeded the lower-slope road values.

Conclusion

Given the physical environment and potential impacts to the soil and vegetation in the area, it appears that the MPRC would increase sediment yields by a factor of 2 to 5.

3 ENVIRONMENTAL IMPACTS, MAINTENANCE, AND MANAGEMENT PERSPECTIVES AND OPTIONS FOR THE FORT RILEY MPRC*

Introduction

In August 1984, USA-CERL hosted a 2-day workshop to review technical information and discuss environmental impacts and management options for the land in and around the new Fort Riley MPRC. This chapter summarizes the finding of the workshop. Details of the technical presentations are reported elsewhere.[23]

The immediate goal of the workshop was to present a forum for discussing environmental and operational concerns related to MPRC construction, use, maintenance, management, monitoring, and conceptual design. Discussions focused on the land needed for training activities, the types of training activities proposed, and the weapon systems to be used at the MPRC. The ultimate goal of the workshop was to prepare a guidance document and a training program for managing and designing MPRC areas for use by other posts installing this type of range. The product would help post engineers develop "scopes of work" for MPRC design, development, and maintenance contracts and for scientific investigations. Discussion focused on the land needed for training activities, the types of training activities proposed, and the weapon systems to be used at the MPRC.

The Fort Riley MPRC

The MPRC, which encompasses 4500 by 1000 m, consists of a block of land with three nonlinear lanes that enter the complex on one end and move roughly two-thirds of the total length of the range to turnaround locations. Tanks will exit at the same place they enter the range. Training will be geared toward various types of weapons and their uses, including infantry. More than one lane will be used concurrently, and day and night training activities will receive nearly equal priority. The expected annual training period is 320 days, with 45 days allotted for maintenance.

Firing lanes will be guided by billboard-sized panels that direct shooters to aim within the margins of the safety fan. The firing lanes and perhaps some critical roadways within the range will be illuminated for night maneuvers. The size of the safety fan will change with the type of weapons being used. Because of the longer axis of the new range and the additional margin of safety needed for many of the new weapons, the fan will be larger than normal. Although training and land management of much of the fan will be possible when coordinated with activities on the range, the off-limits area in the new fan will be larger than for the previous range.

Vehicle travel within the MPRC is to occur only on established roadways. Cross-country and road travel will occur on peripheral acreage and on the approach to the complex.

---

*Prepared by Steven I. Apfelbaum, Karin A. Heiman, Chuck Sams, and Neil Thomas, Applied Ecological Services, Juda, WI.

[23] *Environmental Impact Statement: Fresh Water Wetlands for Wastewater Management*; J. A. Bare.

Construction of the complex involves moving massive quantities of earth over about 75 percent of the MPRC. Two-thirds of the construction project involves moving earth, emplacing berm systems, and developing the target sites and associated approach lanes. Construction of the MPRC had begun at the time of the workshop and the construction itinerary, design plan, and revegetation plans were discussed briefly.

Summary of Technical Presentations

Technical information was presented that described the current condition of select physical and ecological attributes of the MPRC and adjacent areas. Surface hydrological studies and modeling established existing soil loss rates by erosion; they also facilitated prediction of potential losses under different land management strategies as they affect the key determinants of erosion control.[30] A major conclusion was that soil erosion will increase two to five times during construction. However, additional studies will be necessary after construction, final landscaping, and road layout have been completed. Soil losses were directly related to potential degradation of water quality in streams originating or passing near the MPRC. The vulnerabilty of the soil types in the MPRC was discussed. Subsequent presentations detailed the existing ecological condition in areas to be disturbed by MPRC construction and use and in adjacent areas that would remain unmodified. The study team characterized the present condition of vegetation, birds, and small mammals, and discussed potential impacts of the MPRC. The team has installed a permanent ecological monitoring system that can reliably assess the impacts of MPRC construction and use.

Summary of Discussions

Discussions that followed the technical presentations were of four general topics: (1) impacts of MPRC construction and use, (2) land management design, maintenance needs, and suggested mitigations, (3) environmental monitoring and additional research needed to determine impacts and guide maintenance, and (4) design and construction recommendations. The following sections summarize the discussions of each topic. The numerous questions on specific concerns that were raised during the workshop have been summarized as further research needs.

Impacts of MPRC Construction and Use

Significant environmental impacts are associated with MPRC construction, use, and maintenance. Use includes vehicular use of the roads or off-road travel, weaponry use, and impacts within watersheds that are used.

1. Construction-Related Impacts--Ecological:

   a. Construction activities will virtually denude about 75 percent of the MPRC.

   b. Depauperization of the existing flora is expected; this may result in the local short-term and possibly long-term loss of many prairie species in areas within and adjacent to the MPRC.

---

[30] *Environmental Impact Statement: Fresh Water Wetlands for Wastewater Management.*

c. Vegetation and plant species favored by disturbed soil conditions will become more abundant with construction and use of the MPRC.

d. Amounts of undesirable noxious weed species, such as thistles (Cirsium canadensis, Carduus nutans), will increase following construction activities.

e. Structural aspects of wildlife habitat will be reduced by construction activities that directly or indirectly impinge on riparian and edge habitats with trees and shrubs (e. g., along Madison Creek).

f. Reductions of breeding and visiting birds and perhaps migratory species are likely with loss or modification of riparian and edge habitats.

g. Construction activities will alter prairie bird species richness and populations. Several species are likely to decline for at least the first few years after construction. These include upland plover, dickcissels, and grasshopper sparrows.

h. Small-mammal populations may decrease and become less diverse, and species may shift in relative abundance.

2. Construction-Related Impacts--Soils and Hydrology:

a. Loss of topsoil, labile soil nutrients, modified soils moistures, inversion of horizons, and increased compaction of surface and subsoils will occur to various degrees, depending on soil type, slope, aspect, and erodibility, and may be more pronounced and significant a problem if soils are exposed for longer periods of time during and after construction.

b. Increased soil compaction is expected, which will probably decrease infiltration and increase overland runoff and erosional soil loss.

c Depending on existing topography and watershed layout, erosional soil losses are expected to increase two to five times.

d. In some watersheds, peak surface water flow rates are expected to nearly double. Peak discharge will occur sooner after a storm event.

e. Stream channel degradation and configurational changes are expected to result from sedimentation and changes in surface water movement into and through the water courses. This is expected to destabilize existing channels.

f. Roads within the proposed MPRC generally cut across slope contours, and this layout will both increase erosional problems and destabilize roadways.

g. Berm design and placement will modify drainage patterns and may cause erosion problems of unknown proportion.

3. Use-Related Impacts--Ecological:

a. Continuous disturbance of soils will select for weedy plant species, which can obscure targets and promote increased wildfire frequency and severity. Undesirable noxious weed species are expected to increase in the MPRC, adjacent areas, and the safety fan, especially if maintenance of safety fan land is preempted by "off-limits" status.

b. Degradation and continuous denudation of target areas and locations subjected to frequent drive-throughs are expected to increase the erosion potential and destabilize the areas.

c. Dust generated by vehicle traffic is expected to reduce or eliminate roadside vegetation cover, which could make roadways and adjacent ditch systems vulnerable to erosion. The annual plant species that would be favored by dusting provide little or no soil stabilization benefits.

d. The large amounts of fuel fumes associated with heavily used corridors in the MPRC would reduce or eliminate vegetation for several meters on both sides of the roadways and would destabilize roadways and associated drainage structures. Runoff from deposits of these materials may contribute significant pollutant loads to aquatic systems, including Milford Reservoir.

e. Muzzle blast zones associated with the firing of some weapons is expected to eliminate vegetation 10 to 15 m on both sides of the weapon, and for an equal or longer distance in the line of fire.

f. Explosion byproducts and discarded ammunition materials will be deposited in and around the MPRC. Some byproducts, such as phosphorus and nitrate-based materials, may stimulate plant growth, and may undesirably enrich local and perhaps regional aquatic systems. Heavy metal contamination may occur in local plant and animal populations, and some of these materials may be transported by runoff into aquatic systems.

g. Use of flame-throwers and phosphorus-based ammunitions will likely reduce woody vegetation by increasing wildfire frequency. This would favor fire-tolerant species, including some of the prairie perennial plants and a variety of annual weed species. Disruption and destabilization of soil humus and increased loss of nutrients are expected with increased burning frequency or burn severity.

h. Military debris (ammunition shells, etc.) will make it difficult to mow areas with undesirable weed species, and may make hay leasing of land less attractive. An increase of noxious weed species and plants (e. g., most annuals) that are undesirable for forage would also provide a less nutritious or desirable hay. An increase in the land committed to the MPRC, the safety fan, and roadways and support lands will likely decrease the acreage available for rent.

i. Decreased revenue generated by decreased hay leases may upset the budget of the Post Fish and Game Service and jeopordize the service they provide to Fort Riley.

j. Unless carefully directed and regulated, night training on the MPRC could destroy roadways, culverts, drainageways, berms, targets, and support structures.

k. Frequent soil disruptions around targets are expected to produce continuing problems with weedy plant species obscuring the line of sight from firing positions to targets.

l. New weapon systems and ammunitions are expected to be larger and more destructive. One example is the new Vulcan system, which can dig a 6-ft-deep by 22-ft-long hole when firing a nonexplosive projectile. The new weapons are expected to destabilize target locations and berms more frequently and more severely.

m. The heavy season use of the MPRC will require a trained and dedicated maintenance crew and schedule. A relatively short maintenance period of 45 days per year and heavy demand for use of the MPRC may make maintenance difficult. Poor or untimely maintenance may accelerate degradation of MPRC and adjacent lands.

Suggestions for Land Management Design, Maintenance Needs, and Mitigation

Impact studies suggested that construction and use of the MPRC and adjacent property will primarily upset soils and modify vegetation cover and plant species composition, thus increasing erosion potential. These environmental modifications would promote or cause a variety of impacts. The following section addresses management, maintenance, and mitigation options.

Program Development. It is clear that successful, sustained use of the MPRC and adjacent areas will rely entirely on the efficacy, efficiency, and responsiveness of land management and maintenance. Clearly, the magnitude of the training effort and the potential resulting impacts will require a trained, committed maintenance crew specifically responsible for upkeep of the MPRC and peripheral acreage. Maintenance must be coordinated carefully with MPRC activities and will require daily communication between range operators and maintenance crews. Care must be exercised in procuring maintenance support by outside contractors. Since there is currently no active program for land management (i. e., revegetation) at Fort Riley, an effective program should be developed. This program should be coordinated by range operators, post engineers, and contractors, and should be funded in a manner that will ensure that the allocated money cannot be redirected for other uses.

Erosion Control. Several erosion control measures can be implemented during construction and use.

1. Establish belts or buffers of vegetation to catch and stabilize eroded materials. This should include maintaining at least a 100- to 200-ft.-wide buffer of existing vegetation along principal drainages, such as Madison Creek, within the MPRC.

2. Maintain and design roadways, trail systems, and berm and target structures so they do not serve as direct corridors for runoff to aquatic systems. This should include maintenance of roadside drainageways, and may require limiting tracked-vehicle travel on the road surfaces or in specified areas such as ditch and culvert system crossings.

3. Immediately stabilize and revegetate exposed and erodible substrates during construction and use of the MPRC. Species used should be quick, low-growing, competitive, relatively inexpensive (for seed and management), tolerant of wildfire, and able to survive compaction by military vehicles. During construction, it is desirable to seed and stabilize soils even if they will be moved several months later. Aerial seeding with 60 lb or more per acre of winter wheat or rye should stabilize all but the steepest slopes. This planting could also serve as a nurse crop for growing other plants such as native prairie species. Hydroseeding revegetation techniques could be used on steeper slopes. Spraying 80 to 120 lb of seed per acre along with commercially available wheat hull mulch at a rate of 1500 to 3000 lb per acre should stabilize these areas. Costs associated with revegetation usually vary from $200 to $1500 per acre, depending on the chosen revegetation strategy. It is cheaper and less time-consuming to revegetate than to dredge or to move eroded substrates back upslope.

4. Incorporate sediment trapping and biological filtration pond systems in strategic locations to minimize entry of eroded materials into local aquatic systems. A filtration system could also serve as a location for studying erosion severity, soil nutrient losses, heavy metal and explosion byproducts, and other contaminants from military training activities. Design criteria and literature reviews on filtration system efficiency and maintenance have recently been published.[31] Maintenance of the sedimentation pond systems may include regular checks of the structural integrity of dams, removal of obstructions from emergency spillways or overflow pipe systems, and spotchecks of visually conspicuous problems such as massive vegetation or wildlife mortality. Ponds that fill with sediments may require dewatering and stabilization by revegetation or removal of sediments, with stabilization of the stockpiles. Maintenance should be coordinated with any research projects being done in or around the sedimentation and biological filtration systems.

5. Stabilize all roadways and ditch drainage systems. Roadways might best be surfaced with harder rock materials (if available) than the regionally used limestone. Areas that are difficult to revegetate should be mulched. A number of mulching possibilities are suggested, including use of wood chips (perhaps generated by landscaping operations on the post or in adjacent municipalities), or agricultural products such as straw, hay, cornstalks, or native prairie grass hay mowed from the post. Mulches will help stabilize soils and make the range more attractive. Hay mulches can be applied efficiently and quickly with commercially available spraying units. They may also help reduce roadway erosion and dust generation. Mowed hay (especially when its content is too high in undesirable plants) could be used for erosion control.

6. Suppress all wildfires on the MPRC during the fall to preserve a winter and spring vegetative cover and stabilize soils against erosion. Suppression will require developing a plan, strategically locating firebreaks, and putting together a trained crew with proper equipment.

7. Maintain all stream crossings to minimize channel and stream bank degradation. Minimize the number of crossings and stabilize banks and channels with vegetation, mulches, gravel or riprap if necessary.

Vegetation Islands. Maintain "islands" of vegetation to preserve local native plant species that could invade adjoining disturbed lands. Islands used for concealment during military training activities could also be designed to guide or break wildfire, and might attract and support wildlife species.

Habitat Reclamation. Habitat reclamation with native plant species or preservation of existing vegetation and topographic features could reduce vegetation and wildlife impacts associated with construction and use of the MPRC.

Noxious Weeds. Undesirable noxious weed species may be controlled in several ways.

1. In target locations where targets can be obscured, low-growing, aggressive, and persistent species that respond favorably to frequent disturbances should be planted. These species may be useful in any location where "line of sight" is obscured (e. g., from shooting stations to targets) by taller plants, such as the common weedy species that increase with soil disturbance.

---

[31] T. B. Bragg and L. C. Hulbert.

2. Mowing of areas having noxious weeds or plants that obscure vision may be feasible in areas without large quantities of military debris (ammunition brass, etc.) that would harm mowing units. Mowing in mid-June and again in late July to mid-August would reduce visibility problems, seed production of undesirable species, fall wildfires, and soil erosion. Military tracked vehicles could be used for mowing. Alternatives to mowing include pulling vegetation crushers and choppers over the land using tined harrows or roller chopper units, or flattening or uprooting vegetation by dragging weighted chainlink fences over it. Experimentation will be needed to determine what works.

3. Herbicides can be used to control undesirable species; however, chemicals and application methods should be chosen carefully to prevent buildup of persistent chemicals in soils (which could keep desirable plants from becoming established) and to avoid hazards to health and the environment. A preliminary recommendation made at the workshop is the herbicide ROUNDUP (RODEO) applied by spot application with a direct contact wick applicator system. Broadcast spraying and using more than recommended herbicide volumes or concentrations are undesirable. Herbicides should be applied several weeks before undesirable plants become tall enough to cause line-of-vision problems or several weeks before they produce seeds. Although application times must be adjusted seasonally, early to mid-June may be most appropriate. An advantage of the wick application method is that it is subjects only the tallest weeds directly to herbicide, while leaving the lower-growing plants beneath untreated. This may be an effective way to favor lower-growing desirable species during the time it takes to eliminate undesirable plants. In some areas use of herbicides has actually eliminated desirable plants and selected for weed species; thus, the effectiveness of a herbicide program should be monitored closely.

4. Wildfire (or control of inadvertent fires produced by military training activities) could be used to control undesirable plants. Fires administered in late spring could destroy undesirable plant seeds and seedlings, and select for fire-tolerant native species. Carefully designed firebreaks and guidance systems could be used to guide fire into desirable locations and to control fire at undesirable times of the year. Burnings of the entire box area (4 x 6 km) each spring could minimize dangers of uncontrollable wildfires. After the fires, removal of nonburnable debris will greatly facilitate mowing.

5. Development of integrated mowing and mulching and herbicide and burning programs will best ensure control of undesirable plant species.

Snow and Ice. Winter snow and ice management of the MPRC may be necessary. Targets may have to be deiced so that they stay or return to upright positions. Drifting snow may have to be plowed to allow sightings between shooting positions and targets; snow may also affect a training program's efficiency. Attention should be given to berm placement and relief. A design that takes into account the direction of prevailing winds may cause drifting snow to pass over or through the MPRC. Emplacement of strategically located snow fencing may also guide drift movements.

Management of Dust. Dust generated from roadways may be especially important because of its destructive effects on the tracked vehicles' turbo-charged engines. Vision problems from dust are less of a problem for the newer tracked vehicles because their higher speeds may allow them to outrun dust clouds. However, degradation of roadside vegetation and potential vision obstruction (and thus safety problems) require dust management. Various spray or tackifier substances that have been tried elsewhere have been found to be both expensive and a short-term solution. Oils and tar sprays are also effective only for short times. Alternative strategies, such as the use of mulches, which are relatively inexpensive and easy to apply, may be useful.

Wind. The persistent windy condition of the MPRC requires regular target maintenance. In the past, the wind has dislodged and carried away targets. Cabling stationary targets could keep any dislodged targets in the immediate area, thus allowing easier maintenance.

Guides and Lighting. Firing lane billboard guides and night lighting systems will require upkeep, replacement, etc.

Road and Trail Maintenance. Regular maintenance of roadways and trails within the MPRC is necessary to maintain established drainage systems and ensure the corridors' sustained use. Road and trail maintenance should focus on eliminating water movement on the roadways. The management goal should be to maintain crowned road surfaces and bermed road shoulders in critical locations, especially where runoff from a road surface may initiate gullying or cause a washout on another road.

Weapon-Firing Locations. Management of weapon-firing locations on corridors where vegetation will be or has been denuded by muzzle blast will be required. Areas subjected to frequent flame-thrower weapon training activities will require special management. Firebreaks around these locations may control wildfires. Noncombustible ground cover materials, such as gravel, should be used in these areas.

Gullying. Off-road travel corridors that begin gullying will require special management attention. One sign of gullying is downcutting of tributary confluences with Madison Creek. Downcutting will be followed by movement of gullies away from the creek. Large pieces of rock and large quantities of aggregates will be needed to control gullying and headwall cutting of erosion gullies. A vegetation buffer strip has been proposed along Madison Creek and other major aquatic and stream systems. If off-road tracked-vehicle travel corridors cause runoff to move through the buffer areas, maintenance crews should replant corridors, install diversionary berms, be prepared to apply mulches, and be able to restrict travel through the corridor. Vulnerable areas, which will become obvious to maintenance crews, should be managed carefully; some mechanism for restricting vehicle travel in these areas should be established.

Erosion Problems. Maintenance crews should watch for serious erosion problems that threaten continued use of targets and roadways. Maintenance of problem areas may require seasonal deferral of military training activities in order to rebuild, reconstruct, or stabilize these areas. If erosion becomes a persistent problem, rotation of use and regular maintenance may be necessary.

Stream Channels. Construction of the MPRC will involve modifying stream and drainage systems. Maintenance of stream channels will be necessary to stabilize new and modified natural channels.

Temporary Training Range Maintenance. During construction of the MPRC, the temporary training range (Range 18 Charlie) will receive unprecedented environmentally destructive use. Therefore, a maintenance and management program to help stabilize the substrates should be established.

Shelling Areas. Maintenance crews should reestablish and recontour earth berms associated with targets and areas subjected to shelling. Weekly mulching programs may provide the most effective stabilization.

Environmental Monitoring and Research

Environmental monitoring has already begun at the Fort Riley MPRC. These monitoring projects have established a database on the characteristics of several environmental parameters. Followup studies in the same locations using the same methods will help determine environmental trends caused by natural processes and by MPRC construction and use. Monitoring can also pinpoint where specific management and maintenance strategies are needed. Monitoring, experimentation, and research can also show what management strategies work best for specific circumstances. Having this information will save time and money. The following list provides suggested monitoring subjects and strategies.

1. Changes in existing environmental conditions resulting from MPRC construction and use, and from natural processes, should be monitored. This should include specific programs to monitor:

a. Vegetation, small mammals, birds, and soil conditions using the established study sites and methods. (This will repeat the studies conducted in the summer of 1984.)

b. Erosion problems, sedimentation, gullying, and surface hydrological parameters. Some aspects will require detailed scientific investigations, while others can be done or initiated by range operators and military personnel.

c. Vegetation plantings to determine erosion control success and the benefits offered by different planting strategies.

d. Roadway stream crossings in the MPRC and the condition of stream channels.

e. The status of undesirable plant species and the effectiveness of control or eradication programs.

f. The quality and volumes of water and sediments and the condition of aquatic systems. This should include a program to monitor for nutrient enrichment, heavy-metal toxicity problems, and the effects of hydrocarbons, such as oil, greases, and combustion fumes, that run off the land.

g. The progress of any experimental programs, including:

(1) The effectiveness of sedimentation and biological filtration pond and basin systems. This should include an analysis of water quality and sediment quality, sedimentation determinations, and studies of the systems' biological conditions.

(2) The effectiveness of mulching programs to:

(a) Control roadway dust

(b) Control undesirable plant species

(c) Stabilize target locations and other heavily disturbed areas

(d) Control trackability problems on main roads through use of mulch to reduce mud generated by tracked vehicle use and by precipitation.

(3) The effectiveness of experimental planting strategies designed to:

(a) Determine the best soil-stabilizing vegetation composition and species mixtures

(b) Determine which plants are most tolerant of soil disturbance conditions created by military activities

(c) Determine the most cost- and time-effecitve methods of vegetation and soil management.

Further Research Needs

Workshop discussions identified the need for additional research in several areas:

1. After the final MPRC topography is constructed, conduct additional hydrological and water-sediment yield modeling to pinpoint problems created by changes in topography and drainage systems.

2. Design an experimental planting program to find out which species of plants are best suited for the various situations created at the MPRC.

3. Design and experiment with firebreak and fire guidance strategies.

4. Test the effectiveness of varying widths and configurations of vegetation buffers and vegetation belts along stream courses and in areas believed to be most vulnerable to erosion.

5. Study sediment loads and water quality conditions created by MPRC construction and use in Madison Creek and Milford Reservoir. This should include studies of potential heavy-metal and enrichment problems associated with byproducts of ammunition explosions.

6. Study the ecological effects of vehicle exhaust emissions and fumes on roadside vegetation and aquatic systems.

7. Study the socioeconomics of hay-leasing programs on the post and the effects of the MPRC and safety fan on them. This should integrate the relationship of the MPRC with the post's Fish and Wildlife Office functions.

8. Design a study to test various weed control measures and their compatibility with military training activities. The study should investigate various management strategies, including mowing, herbicide use, the most advantageous administration of fire to control plants, and the use of mulches to smother vegetation.

9. Study the environmental impacts at "Range 18 Charlie," the temporary range being used during MPRC construction.

10. Study MPRC effects on the water quality, sedimentation rates, and biological impacts of the Milford reservoir.

11. Investigate the effectiveness of sedimentation and biological filtration pond and basin systems in minimizing sedimentation in streams, and for capture (adsorption and bioaccumulation) of MPRC-derived pollutants (heavy metals, explosion byproducts, etc.). This program may be able to use existing stock ponds as control sites.

Recommendations

The workshop participants made the following design and construction recommendations:

1. Design an erosion control and maintenance methods manual based on Fort Riley experiences.

2. Develop an integrated maintenance/management and monitoring program for the MPRC.

3. Develop a trained dedicated maintenance crew for the MPRC and adjacent properties.

4. Investigate the feasibility of minimum use of restricted corridors for off-road tracked vehicle use around the MPRC. Since degradation of land around the MPRC may affect the complex's functions, it is advisable to implement a program restricting off-road travel within 1 km from the MPRC perimeter. Additional acreage may be desirable in the most vulnerable areas, such as along Madison Creek.

5. Develop a program to coordinate deferred use of critical eroded areas in and adjacent to the MPRC.

6. Integrate an aerial photography program with the USA-CERL Geographic Information System for monitoring and management of the MPRC and adjacent land. Low-altitude aerial photographs in color or color infrared could be monitored throughout the year to determine erosion problem areas, areas in aquatic systems that are receiving siltation, vegetation establishment problems, etc.

7. Develop and implement a fire management program for the MPRC and adjacent lands, including the entire safety fan areas.

8. Determine if it is possible to partition seasonal use of different areas of the MPRC or the entire range to minimize environmental impacts, especially when the range is most vulnerable to erosion. An example would be using flame-thrower weapons only during wetter times of the year when the chances of creating undesirable wildfires are minimum.

9. Develop an education program and in-field program of displays to minimize damage to the MPRC during night training activities.

10. Store topsoil that is displaced during construction and replace it in areas that will receive minimum impact during MPRC use. Emplace less erodible subsoils in areas that will only receive frequent soil-disrupting impacts. These heavier clay subsoils are less subject to erosion and will remain in place.

11. Start a program to reestablish riparian and edge habitats lost to construction or MPRC use.

12. Establish target locations away from the most sensitive and vulnerable riparian locations and away from stream channels. Establish berms and slopes in areas that may be destabilized by maneuvers away from principal drainages.

13. Reconsider the proposal to use a cement pad in the MPRC lanes for tracked vehicle turnaround locations. These pads will likely be destroyed very quickly and greatly increase MPRC costs.

14. Stockpile rocks, gravels, and mulches for MPRC maintenance.

15. Redesign roads in the MPRC so that they do not cut directly across contours from uplands to lower areas. Consider reducing the length and straightness of steeper roads, because these will contribute to erosion problems.

16. Where possible, investigate and mitigate any potential noise problems created by MPRC operations.

17. To minimize washing and erosion, revegetate all ditch and roadside drainage corridors with wetland plant species, including cattails, sedges, and other locally available plants.

CITED REFERENCES

Bare, J. A., *Wildflowers and Weeds of Kansas* (Regents Press of Kansas, 1976).

Bragg, T. B., and L. C. Hulbert, "Woody Plant Invasion of Unburned Kansas Bluestem Prairie," *Jo Range Management*, Vol 29, No. 1 (1977), pp 19-24.

Cockrum, E. L., *Mammals of Kansas*, Vol 7, No. 1 (University of Kansas Publications, Museum of Natural History, 1952), pp 1-303.

Draft Environmental Assessment: Multipurpose Training Range Complex (MCA Project Number T519, (Fort Riley, KS, 6 August 1982).

Emlen, J. T., "1971 Population Densities of Birds Derived From Transect Counts," *Auk*. Vol 88 (1971), pp 232-342.

Environmental Impact Statement: Fresh Water Wetlands for Wastewater Management, Technical Report #904/9-83-107 (U. S. Environmental Protection Agency [USEPA], March 1983).

Five Year Wildlife Management Plan, Fort Riley Military Reservation, KS (Fort Riley, March 1982).

Fort Riley Multi-Purpose Range Complex Erosion Control Manual (U. S. Army Engineer Waterways Experiment Station, 1982).

Gleason, H. A., *The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada* (Hafner Press, 1952).

Goran, W. D., L. L. Radke, and W. D. Severinghaus, *An Overview of the Ecological Effects of Tracked Vehicles on Major U.S. Army Installations*, Technical Report N-142/ADA126694 (U. S. Army Construction Engineering Research Laboratory [USA-CERL], 1983).

Hall, E. R., and K. R. Nelson, *The Mammals of North America, Vols I and II* (Ronald Press, 1959).

Johnson, D. W., and E. P. Odum, "Breeding Bird Populations in Relation to Plant Succession on the Piedmont of Georgia," *Ecology*, Vol 37, No. 1 (1956) pp 50-61

Johnson, R. F., *The Breeding Birds of Kansas*, Vol 12, No. 14 (University of Kansas, Museum of Natural History, 1964), pp 575-655.

Karr, J. R., "Habitat and Avian Diversity on Strip-Mined Land in East Central Illinois," *Condor*, Vol 70, No. 4 (1968), pp 348-357.

Kuchler, A. W., "A New Vegetation Map for Kansas," *Ecology*, Vol 55 (1974), pp 586-604.

Lacey, J. R., P. R. Ogden, and K. E. Foster, *Southern Arizona Riparian Habitat: Spatial Distribution and Analysis* (University of Arizona, Tucson, 1975).

MacArthur, R. H., "Environmental Factors Affecting Bird Species Diversity," *Amer. Nat.*, Vol 98 (1964), pp 387-398.

North American Bird Banding Manual, Vols 1 and 2 (U. S. Department of the Interior, Fish and Wildlife Service, 1976).

Risser, P. G., E. C. Birney, H. D. Blocker, S. W. May, W. J. Parton, and J. A. Wiens, *The True Prairie Ecosystem* (Academic Press, 1981).

Soil Conservation Service, *Soil Survey of Riley County and part of Geary County, Kansas* (U. S. Department of Agriculture, June 1975).

Webster, R. D., et al., *Modification and Extension of the Environmental Technical Information System (ETIS) for the Air Force*, Special Report N-8/ADA079441 (USA-CERL, 1979).

Williams, D. L., *Report to Accompany Vegetation Maps of Selected Portions of Fort Riley, KS* (1978).

Wilson, M. F., "Avian Community Organization and Habitat Structure," *Ecology*, Vol 55 (1974), pp 1017-1029.

UNCITED REFERENCES

Apfelbaum, S. I., K. A. Heiman, C. Sams, and N. Thomas, *Ecological Condition of the Land and Wildlife in and Adjacent to the Multipurpose Range Complex, Ft. Riley, Kansas*, (October 1984).

Eddy, S., and A. C. Hodson, *Taxonomic Keys to the Common Animals of the North Central States* (Burgess Publishing Co., 1961).

Elias, T. S., *The Complete Trees of North America* (Van Nostrand Reinhold Co., 1980).

Emlen, J. T., "Estimating Breeding Season Bird Densities From Transect Counts," *Condor* pp 173-186.

Goran, W. D., *Report of Survey-Visit to Fort Bliss, TX; Ft. Irwin CA; Fort Carson, CO.; and Fort Riley, KS* (University of Illinois, Department of Geography, 1980).

Goran, W. D., and R. E. Riggins, "Geographical Information Systems for Training Land Land Evaluations," *Army Research Development and Acquisition Magazine* (September - October 1983), pp 26-28.

Greig-Smith, P., *Quantitative Plant Ecology* (Butterworths Press, London, 1964).

Importance, Preservation and Habitat Management of Riparian Habitat: A Symposium, General Technical Report RM-43 (U. S. Department of Agriculture, Forest Service, July 9, 1977).

Mueller-Dombois, D., and H. Ellenberg, *Aims and Methods of Vegetation Ecology* (John Wiley and Sons, 1974).

Petrides, G. A., *A Field Guide to Trees and Shrubs* (Houghton Mifflin Company, 1972).

Robbins, C. S., B. Brunn, and H. S. Zim, *A Field Guide to the Identification of Birds of North America* (Golden Press, 1966).

Severinghaus, W. D., *Guidelines for Terrestrial Ecosystem Survey*, Technical Report N-89/ADA086526 (USA-CERL, 1980).

Severinghaus, W. D., R. E. Riggins, and W. D. Goran, *Effects of Tracked Vehicle Activity on Terrestrial Mammals, Birds, and Vegetation at Fort Knox, KY*, Special Report N-77/ADA073782 (USA-CERL, 1979).

Sokal, R. R., and F. J. Rohlf, *Introduction to Biostatistics* (W. H. Freeman and Co., 1969).

The Effects of Wastewater Treatment Facilities on Wetlands in the Midwest, Technical Report #905/3-83-002 (USEPA, March 1983).

The Effects of Wastewater Treatment Facilities on Wetlands in the Midwest, Technical Report #905/3-83-002 (USEPA, September 1983).

Ward, T. J., *Estimates of Training Impacts on Sediment Yield from the Ft. Riley, Kansas Multipurpose Range Complex* (August 1984).

Distribution

Chief of Engineers
ATTN: DAEN-ZCF-B

U.S. Army Engr Div,
ATTN: HNDED-PM, Huntsville

U.S. Army, DEH
Fort Bragg, NC
Fort Leonard Wood, MO
Fort Bliss, TX
Ft. Campbell, KY
Ft. Carson, CO
Ft. Drum, NY
Ft. Irwin, CA
Ft. Ord, CA
Ft. Riley, KS
2nd Inf. APO San Francisco, CA
III Corps, Ft. Hood, TX

U.S. Army Environmental Office
Ft. Stewart, GA
Schofield Barracks, HI

President Army Training Board, Ft. Monroe, VA

USATC, Ft. Eustis, VA 23604

U.S. Govt Print Office 22304
Receiving Sect/Depository Copies (2)

Defense Technical Info. Center 22314
ATTN: DDA (2)

(21)

Selected Examples of Maps Produced by GRASS

These examples are provided on a limited basis to installations that have or plan to have MPRS. They are also provided to selected U.S. Army Corps of Engineers on other Army agencies that are involved in design or construction of MPRS. Refer to Volume I, pages 12-17 for description of the Fort Riley database.

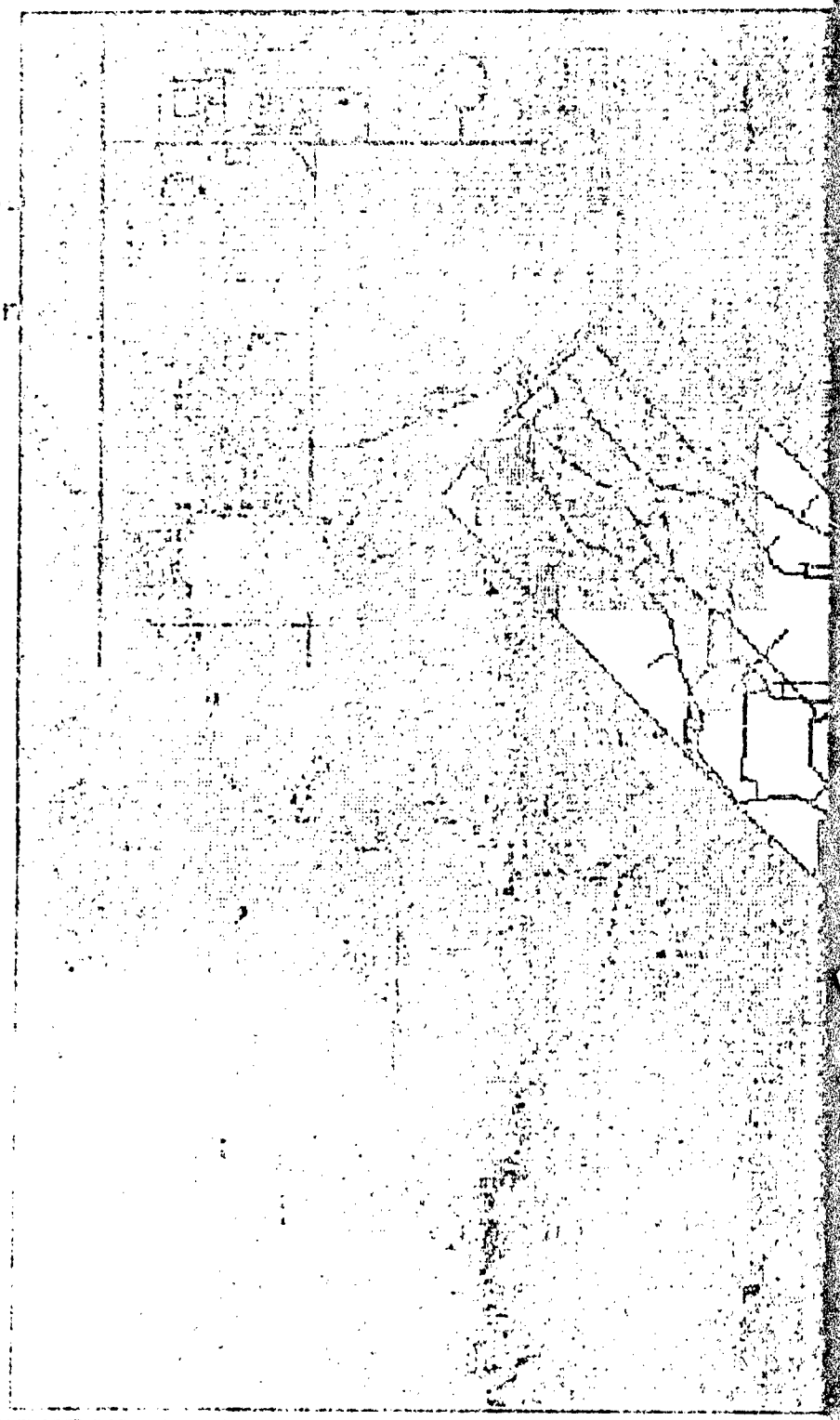
Map 1 is an example of using the GRASS-grid system to combine maps from two different sources. The map includes a LANDSAT image from 7/11/83 derived using the GRASS imagery subsystem. The image simulates a color infrared photo. Next, the digitized boundaries of the installation and the MPRC study area were overlaid on top of the image. To enhance the visibility of water bodies, the GRASS-imagery system was used to classify the LANDSAT image and produce a landcover map. From this, water bodies (lakes, reservoirs, and rivers) were extracted
and overlaid on the new map. Finally, labels and lines representing installation and county boundaries were added. The map was produced by making a copy of the screen and sending the file to an ink-jet printer.

Map 2 is an example use of the Distance program of GRASS-grid, which creates a new map of distance zones based on other maps. Here, the Distance program was asked to create a new map with distance zones of 0 to 50 m and 50 to 125 m from streams. Using the program Paint Map, the new map was printed on the ink-jet printer at a scale of 1:30,000 with streams (blue lines), roads (red lines), the MPRC area (black rectangle), and a 1-km grid.

Map 3 is another example of integrating image data and hardcopy map data. Here, a scanned aerial photo is used to produce a landcover map in the GRASS-imagery system. Then the soils map is reclassified and masked to show erodible soils within the MPRC training area. This is then overlaid on the landcover map, and roads are added to show possible conflicts. The screen image is then saved and printed on the ink-jet printer.

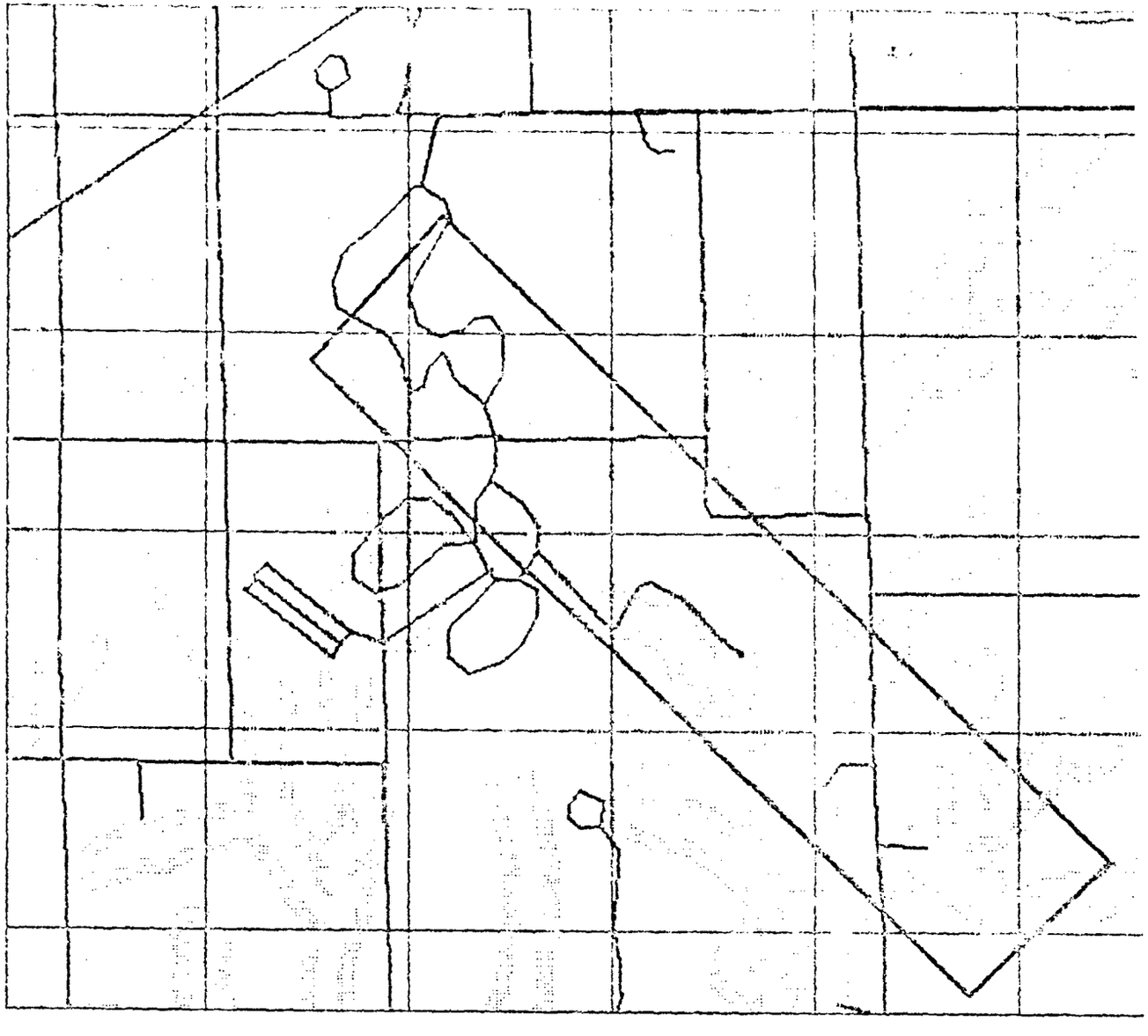
FORT RILEY, KANSAS

Classified NHAP Photo with Erosion Areas

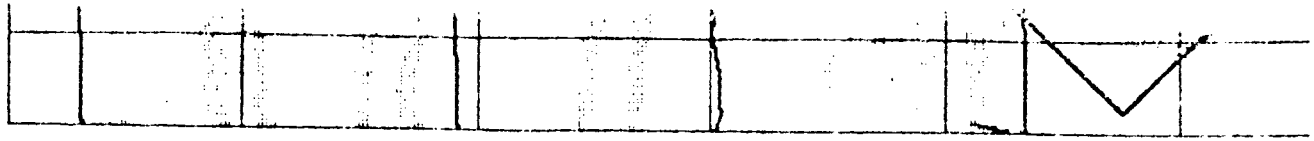


NORTH: 51600.0 WEST: 73000.
SOUTH: 48600.0 EAST: 83000.

2



SCALE: 1 : 30,000



SCALE: 1 : 30,000

UTM: 78000.00 51600.00 83630.00 (grid: 1000 meters)
46600.00

Multi-Purpose Range Complex (rect)

Roads (roads)

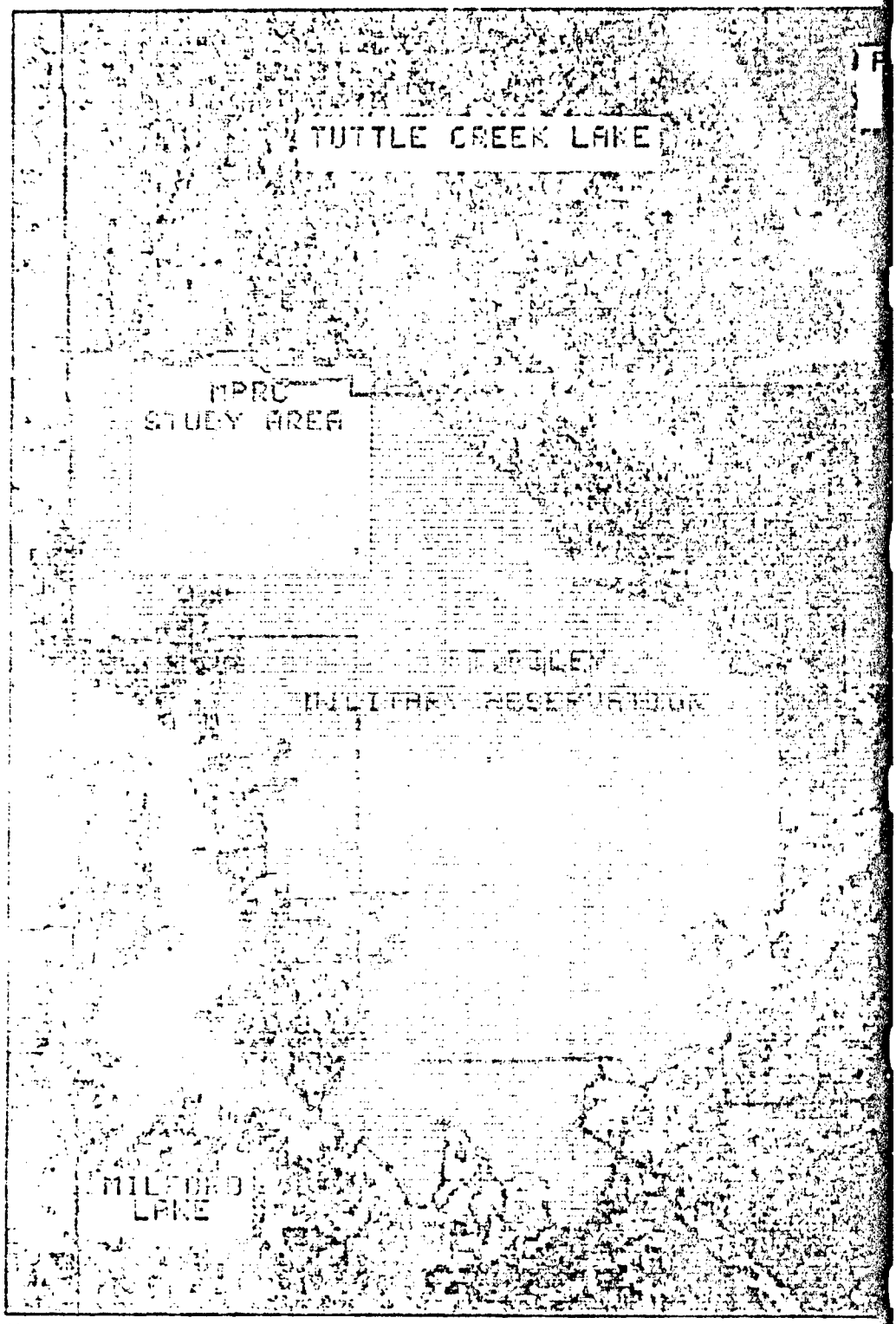
Streams (streams)

1 2

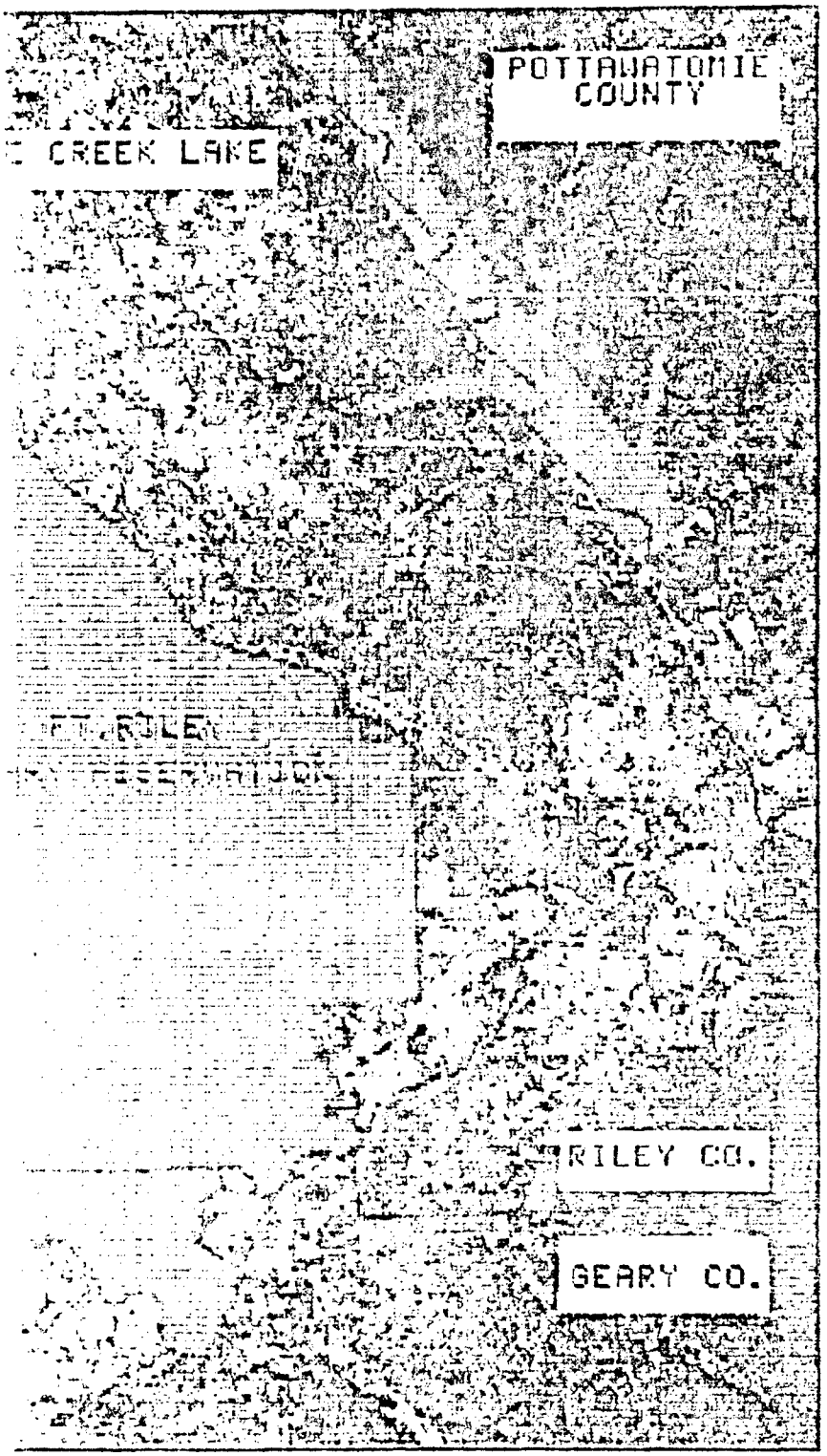
1 0.00 to 50.0 meters zone...(34388)
2 50.0 to 125.0 meters zone..(42316)

FORT RILEY, KANSAS

NOR
SOU



NORTH: 4368975.0 WEST: 674025.0
SOUTH: 4319975.0 EAST: 719025.0



2