KANSAS ACADEMY OF SCIENCE GUIDEBOOK

12TH ANNUAL MULTIDISCIPLINARY FIELDTRIP

OCTOBER 23, 1999

THE WICHITA STATE UNIVERSITY NINNESCAH
RESEARCH STATION
AND
NATURAL HISTORY RESERVATION

Kansas Geological Survey
Open-file Report 99-39

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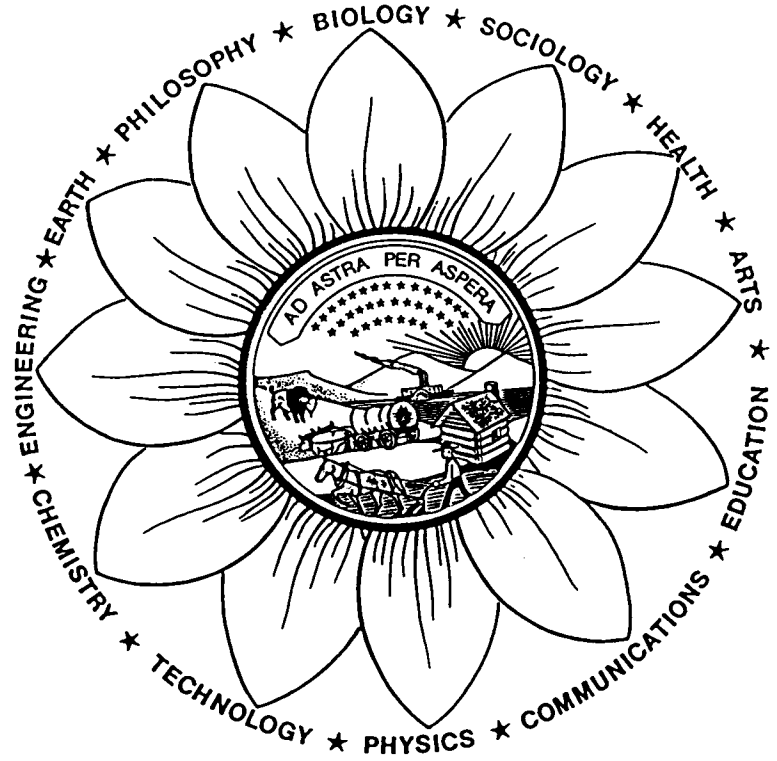


THE WICHITA STATE UNIVERSITY NINNESCAH RESEARCH STATION AND NATURAL HISTORY RESERVATION

Compiled and edited by L. H. Skelton
Kansas Geological Survey

ERRATA

PP. 13 & 21:
THE TWO QUARTER
SECTIONS DELINEATED
FOR THE WSU FIELD
STATION ARE MISLOCATED.
THEY ARE 0.5 MILES TOO
FAR NORTH. THE AREA IS
PROPERLY IN THE SE QUARTER
OF SEC. 7 & THE SW QTR OF
SEC. 8.

CONTENTS

COVER

Scanned image (x1) of malachite encrusted dolomitic limestone slab from outcrop at WSU Ninnescah Field Station.

INTRODUCTION AND WELCOME

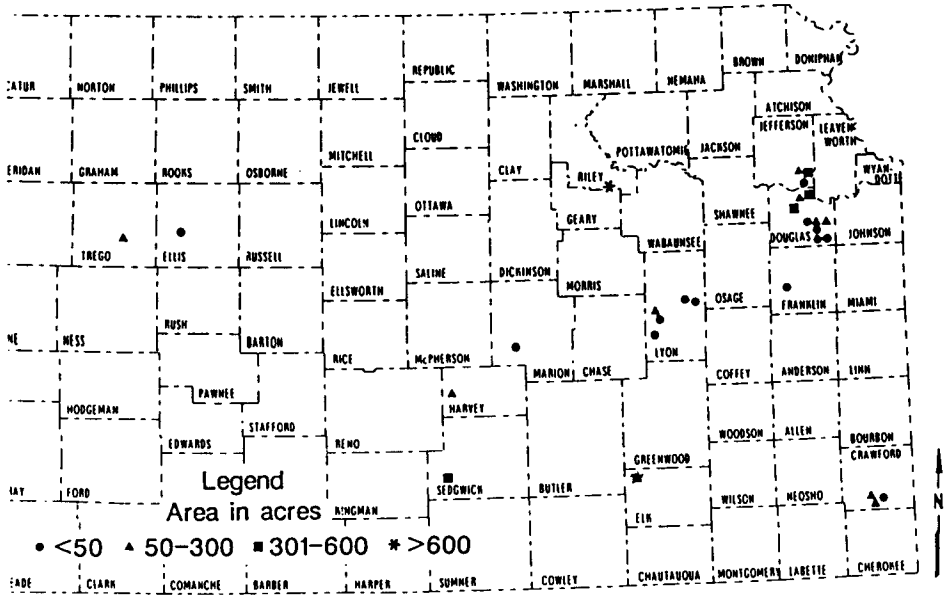
Welcome to the last Kansas Academy of Science Field Trip of the Millenium. If we opt for the popular definition of "millenium", the Academy will have entered the 21st Century by the next trip, not too bad for an organization that began in the 19th Century. When the number and impact of scientific discoveries made during the Academy's 127 years of existence, is considered, it is overwhelming from medical miracles to planet-destroying weapons to trips to Mars. Today, however, this 23rd day of October, 1999, we will travel over topics long studied by Academy members: our solar system and the natural history of the Great Plains. We will visit the Lake Afton Public Observatory and Wichita State University's Biological Field Station.

This multi-disciplinary field trip is the twelfth of a series of such trips to the Natural Areas of Kansas which were established by the Natural and Scientific Areas Act enacted by the Kansas legislature in 1974. The 1999 trip is a return to the site of the first such excursion which was conducted on October 9th of 1988. The types of areas considered for preservation are outlined in the Act and consist of biological, geological and archaeological areas.

Twenty-five such areas, used for research and education, are shown below and are managed by the academic community in the state. Other Natural Areas are managed by private agencies (Nature Conservancy shares management with universities in two areas), the State Department of Wildlife and Parks, county and urban governments and school districts. The 24 areas administered by colleges an universities are shown on the map (Figure 1). They total approximately 17,000 acres (6880 hectares) and range in area from 5.5 acres (2.23 hectares) to approximately 4900 acres (1983 hectares).

This guidebook is an updated version of the guidebook used for the 1988 field trip. The section on geology has been completely rewritten and the other sections edited and updated where desired by the original authors. Titles of the edited versions are marked with an asterisk on the contents page.

You are urged to plan now to attend KAS "Field Trip of the Millenium" to be held October, 2000, in the region of Hays, Kansas.



ons of university and college natural areas in Kansas.

LAKE AFTON PUBLIC OBSERVATORY

W. Scott Kardel
Fairmount Center for Science & Mathematics Education
The Wichita State University
Wichita, Kansas 67208
and
Lawrence H. Skelton
Kansas Geological Survey
Wichita, Kansas 67209

The Lake Afton Public Observatory with its 16-inch telescope was created in 1979 through the cooperation of four local governmental units. Construction and equipment costs were divided equally between Sedgwick County and the City of Wichita. Through 1994, the majority of the operating costs of the Observatory were shared equally by the Wichita Board of Education (U.S.D. 259) and The Wichita State University. Since then, the Observatory has been operated by the university's Fairmount Center for Science and Mathematics Education with additional funds for facilities from Sedgwick County. All programs, exhibits and school outreach materials are designed, prepared and presented by the Observatory staff and volunteers.

The Lake Afton Public Observatory offers programs for the general public on weekend evenings throughout the year. School classes can reserve an Observatory program on Wednesday and Thursday evenings and on Thursday during the day. The Observatory's programs extend beyond its walls through portable editions of exhibits, instructional astronomy games, video tapes and astronomy activities for use in the classroom. A unique outdoor display is a true-scale solar system in which the sun is two inches in diameter and the nine planets are proportionately sized and spaced. Skill, thinking and a bit of luck may be required to find them all.

The Observatory is located 20 miles southwest of downtown Wichita on MacArthur Road (39th Street South) and 247th Street West in Lake Afton County Park.It is immediately north of the lake, just off MacArthur Road. Up-to-date program information is available in a recorded message by phoning 316-WSU-STAR (978-7827) or by visiting the Observatory's Website at: http://www.twsu.edu/~obswww/

The 1999 Kansas Academy of Science field trip is fortuitously timed in that this visit to Lake Afton Observatory coincides with an approaching peak of sunspot activity. During this visit, you will have an opportunity to safely view sunspots, solar prominences and the bubbling nature of the sun's surface (which has been compared to the appearance of a pot of rice boiling in slow motion). There will be a demonstration of the hazard of direct visual observation of the sun without the benefit of optical filters. The observatory's exhibit hall contains an extensive collection of meteorites and exhibits on the solar system and general astronomy. There are astronomy-oriented computer games available. Try your hand at landing a spacecraft on the moon (if you are an aircraft pilot, remember to compensate for the lesser gravity and lack of atmosphere). Or you may want to engage in a game of space trivia.

A brief review of solar data: The sun, the nearest star from earth is an average 93,000,000 miles (157,170,000 km) distant, ranging from 91,500,000 miles (147,223,500 km) at its closest (perihelion) on January 3rd each year to 94,500,000 miles (152,050,500 km) at its most distant (aphelion) on each July 4th. Comprehension of the distance is facilitated with realization a photon of light leaving the solar surface has traveled for about 8.33 seconds before it strikes one's eye.

Kansas summers have taught us to respect the sun's heat. Its temperature ranges from about 5000°C (9932°F) at the surface to a possible 15,000,000°C (27,000,000°F) in the interior. These temperatures are achieved through a sustained fusion reaction wherein about 564 million tons of hydrogen are converted into

approximately 560 million tons of helium each second. The difference of four million tons of matter is represented by energy¼heat and light.

The sun's mass, about 745 times greater than the totaled mass of all the planets, is so great that the fusion reaction can continue for five billion years, a bit more than the estimated total time the earth has existed. Its diameter is nearly 858,000 mile (1,380,000 km), big enough to contain more than a million earths.

The sunspots occur in roughly eleven year cycles and we presently are entering a period of maximum activity. The spots are magnetic storms which erupt on the sun's surface. They occur in pairs, each spot forming a magnetic pole. The spots contain a dark center, the umbra, surrounded by a lighter-colored rim, the penumbra. The duration of individual pairs may be from a few hours to several months. Some storms create solar prominences which are great arcs of solar matter extending in a loop perhaps several million miles from the sun's surface. The magnetic storm activity at peak periods of the cycle cause electromagnetic disturbances on the earth. These disturbances affect our communications and other electromagnetic activities. They may intensify aurora borealis in our hemisphere and cause it to form in more southern latitudes than usual. Since the volume of human-created electromagnetic activity on the earth has increased by several orders of magnitude during the past 75 years, the next several months may find us, paraphrasing a Chinese expression, "living in interesting times".

Reference

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INTRODUCTION TO THE WICHITA STATE UNIVERSITY NATURAL AREA

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In 1983, The Wichita State University Endowment Association acquired 330 acres south of and adjacent to a one mile portion of the Ninnescah River in southwestern Sedgwick County, Kansas. The area is located principally in the southeast quarter of section 7 and the southwest quarter of section 8 of Township 29 South, Range 3 West, Sixth Principal Meridian. At the time of acquisition, much of the Ninnescah Tract (Research Station and Natural History Reservation) was under cultivation to wheat and milo and occasionally alfalfa and oats. In addition to the agricultural land, the Ninnescah Tract consists of two original prairie segments of 40 and 26 acres (16.2 and 10.5 hectares), a 17 plus acre (6.9 hectares) riparian woodland on the east quarter-section, and an intermittent stream having two tributaries that periodically flow through both prairie segments and the woodland.

The prairie was grazed heavily during the 100 years before acquisition but not to the total loss of native species. By removing livestock, burning and tree removal, native grasses and forbs have become reestablished over much of the area. The area is fenced except along the Ninnescah River. Management by burning and removal of woody vegetation will continue and the spread of native species monitored. At present, about 100 acres (40.5 hectares) have been removed from cultivation and returned to native grasses. Because the prairie segment is lowland, there are many wallows or temporary marsh habitats. Much of the prairie region is subject to flooding.

The Ninnescah River is a typical sandy plains river. It is cutting away the banks along the west half mile and mostly depositing along the east half mile. A large sandbar developing on the east edge of the property holds vegetation in early stages of succession by alternation of scouring and deposition. Levees are raised periodically along the east half mile of the river during major floods. The 10-year flood of October 1985 cut about ten feet (3.05 m.) of bank to the west and deposited up to one meter of new sand on the levees to the east.

The riparian woodland overlies three river terraces and at least two lateral ponds hold water much of the year in abandoned river channels on the terraces. The 17 acre (6.9 ha) woodland is an island separated from other woodland both east and west by about a half-mile of herbaceous vegetation.

Geologically, an extensive member of the Ninnescah Shale is exposed along the cutting side of the river near the headquarters and at several sites along the intermittent streams. The shale exhibits standard fractures as well as oxidized and reduced zones. The east prairie tributary exhibits a unique pattern of complex meanders and cutoffs that geology classes use for mapping exercises. The soils of the Ninnescah Tract are: Elandco silty loam, Renfrow silty clay loam, Tabler silty clay loam and Shellabarger sandy loam.

The only structures on the site are the headquarters (167 ft. by 70 ft. mobile home), a small Butler-type building for housing a tractor and maintenance implements, and a weather station containing a hydrothermograph and wind set. The headquarters can accommodate one or two investigators or a small class and instructor. For larger educational groups, the director or assistant may serve as guides. Primitive group camping is available at selected sites. Walking trails are under development in the

woodland and driving trails follow the perimeter of most of the prairie sites. Potable water is not available because groundwater aquifers contain waters high in calcium, sodium, iron, manganese and chloride. Plans are to develop a classroom building and outbuildings for equipment, and to rejuvenate two hand-dug wells.

Use of the Ninnescah Tract is dedicated to both education and research and the tract is used by all levels of students and teachers from several disciplines (sciences, education and arts). Long-term studies on prairie recovery and woodland succession have been initiated, including graduate studies on: rodent composition on burned and unburned prairie sites, interstitial fauna in sandbars along the Ninnescah River, and macrobenthos of temporary streams. Short-term studies are being conducted on prairie succession by undergraduate students and students enrolled in special topics courses (biology, geology and anthropology). A faunal and floral checklist is being developed. Investigators, classes, ideas, and suggestion are always welcome.

Reference

Distler, D. A.,1988, Wichita State University Natural area:
Kansas Acad. Science Trans., v. 91, no.1-2, p.46-47.

Addendum:

NINNESCAH EXPERIMENTAL TRACT
ACTIVITIES SINCE THE 1988 KAS MEETING

All former crop land was planted to grasses and forbs native to the region.

The entire property was divided into 33 ten-acre units marked by steel poles in order to locate more closely species assemblages.

Work began in the early 1990's to restore wetlands compromised by former management practices.

In late 1998, a 14 by 60 foot mobile building was received as a gift. It is being converted into a lecture-laboratory facility, a small library and office space.

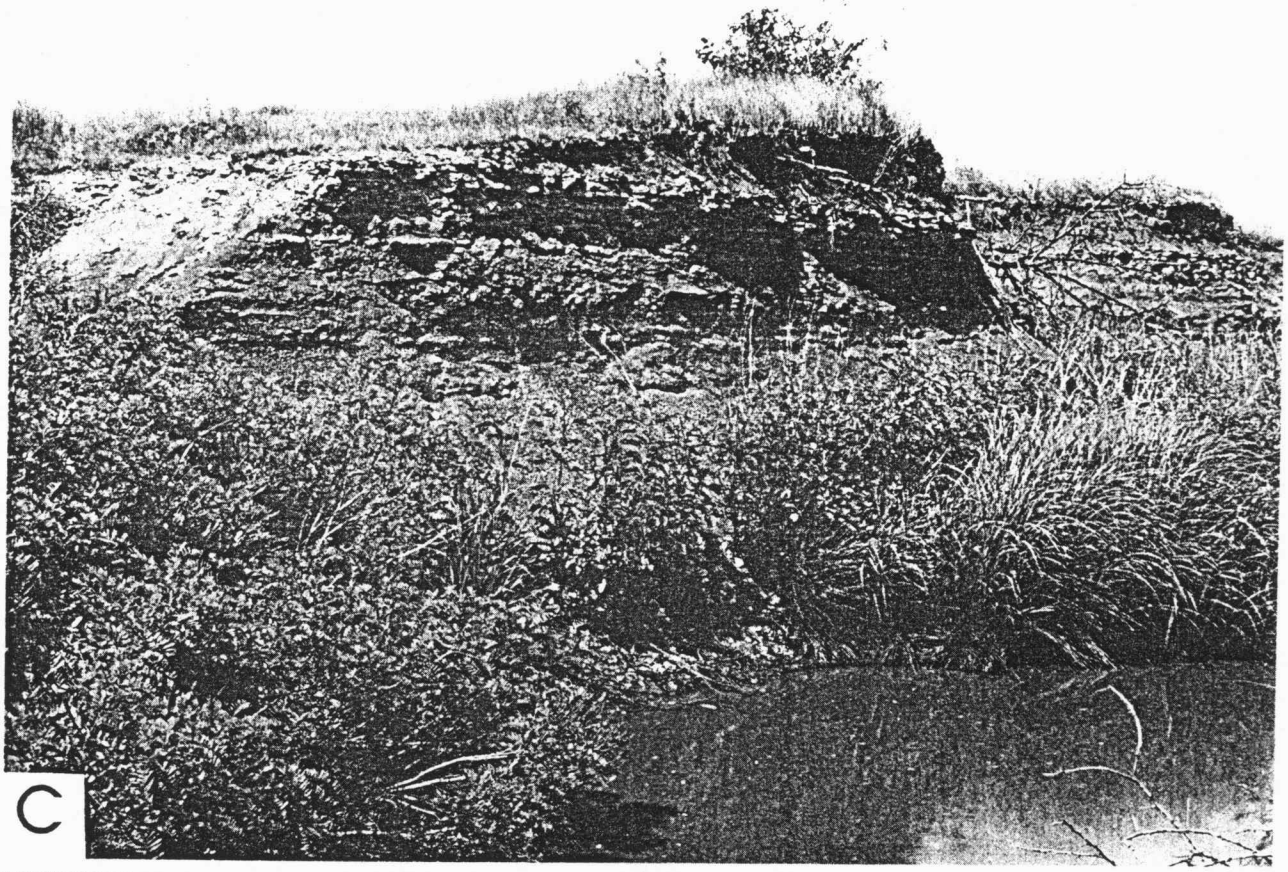
Severe erosion of the south bank of the Ninnescah River necessitated moving the original headquarters building to a safer location away from the river's edge. This was accomplished in the late Summer of 1999.

Figure Captions

A. Native prairie, advanced stage of succession (view east)
B. Gray wolf skull found on NET
C. Palisade area showing thin upland soils and outcrop of Ninnecah Shale
D. Creek in wooded area with outcrop of limestone bed in Ninnescah Shale
E. Ninnescah Experimental Station-1999
F.Ninnescah Experimental Station-1988

A

B



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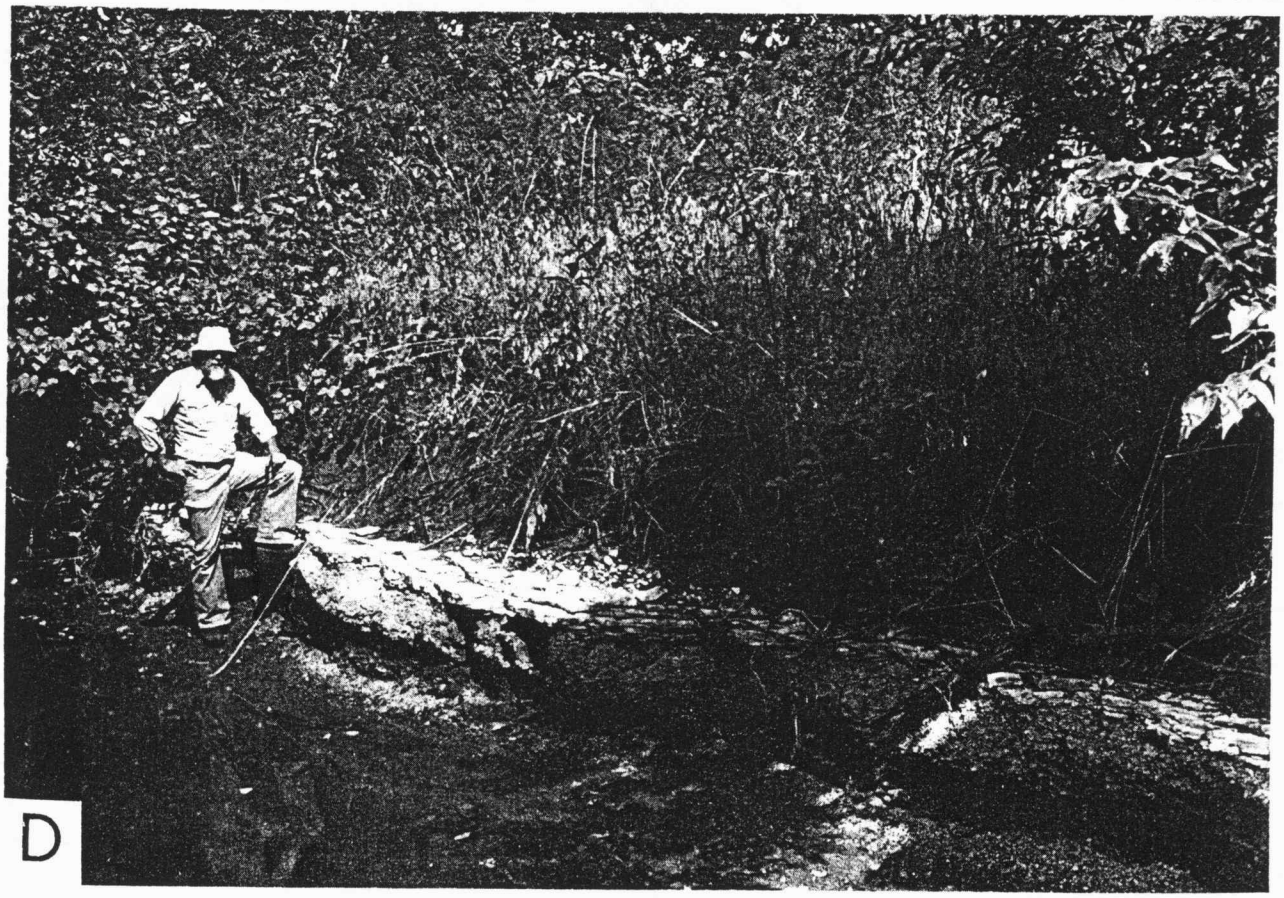

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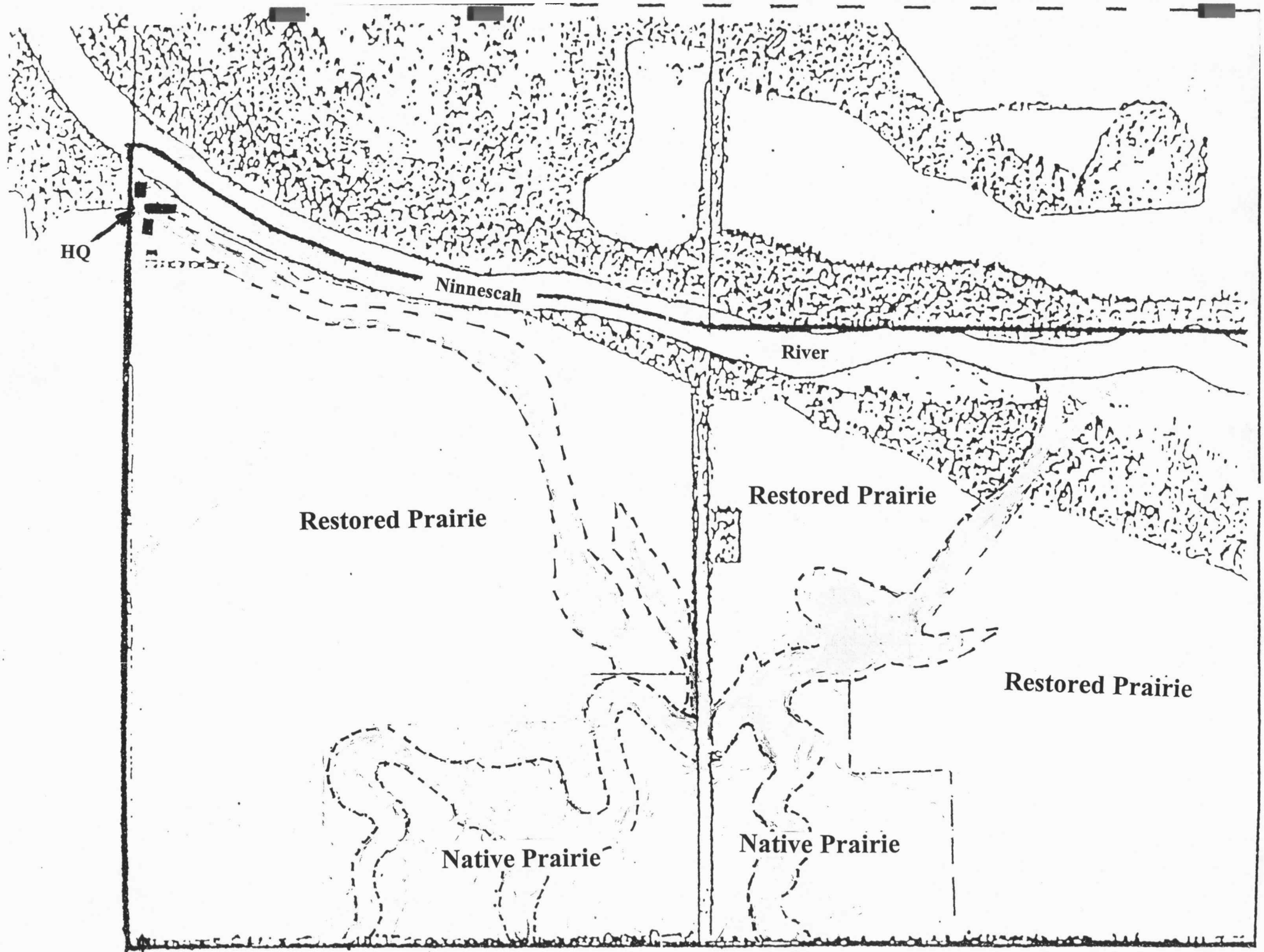

Fig. E. NINNESCAH TRACT - 1000

SCALE: 1 in. = 528 ft.

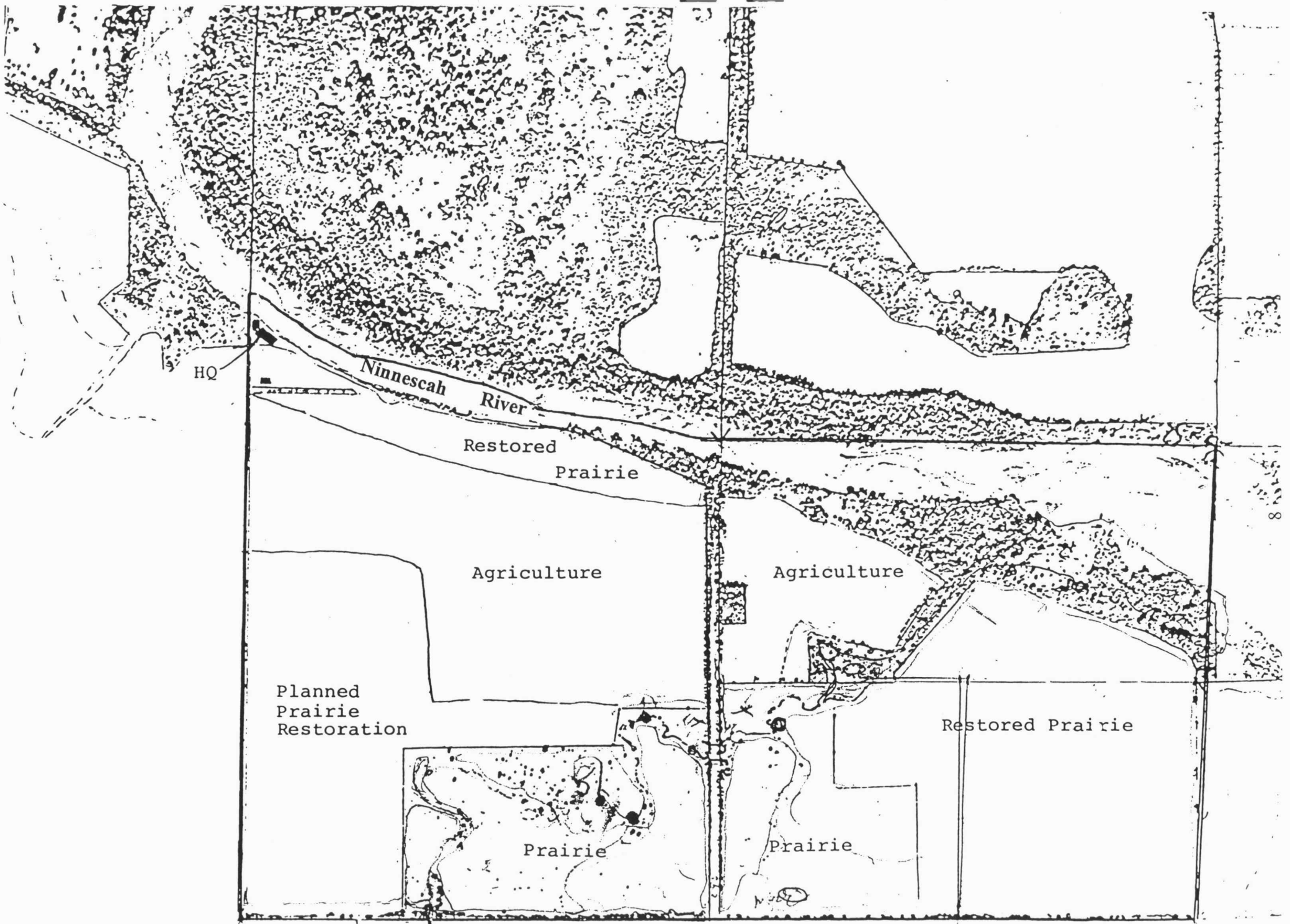

Fig. F. NINNESCAH TRACT – 1988 **SCALE: 1 in. = 660 ft.**

GEOLOGY OF THE WICHITA STATE UNIVERSITY'S SOUTH FORK OF THE NINNESCAH TRACT

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The Ninnescah Tract is located in the northeast quarter of Section 7 and the northwest quarter of Section 8, Township 29 south, Range 3 west in southwestern Sedgwick County, Kansas. It lies within the Wellington Lowland physiographic province (figure 1). Although classified by Schoewe, 298) as "a minor physiographic unit of the Arkansas River Lowlands", it differs from other units by displaying a rolling topography which contrasts the more uniform and flat-lying surfaces found elsewhere in the Arkansas Valley Lowlands. The Wellington Lowland typically ranges between 1140 and 1350 feet (348 m – 411 m) in elevation above sea level. Distler (pers. comm., 1999) estimates that erosion has removed up to four feet (1.22 m) of topsoil from the Ninnescah Tract since it was first broken for agriculture in the 1880's. The Wellington Lowland drains into the Arkansas River via the Ninnescah River, Slate Creek, the Chicaskia River and Bluff Creek and their tributaries.

As shown on the Sedgwick County geologic map (figure 2), most of the area in the tract is covered by Quaternary age alluvium. The alluvium consists principally of silica sand derived principally from the Great Bend Sand Prairie, the largest sand sheet in Kansas, (Arbogast, 1998) and carried downstream by the North Fork of the Ninnescah River from Stafford and western Reno counties. Longitudinal sand dunes formed on the north side of the river in Section 7 are oriented in the same north-south direction as the prevailing wind. The dune sand was not examined for this paper. The river sand consists of angular to well-rounded grains ranging from 0.5mm to slightly more than 2.0mm long axis diameter. Cross, Wells and McHenry (1988) analyzed grain-size distribution and compared the river sand to that of the dunes. Their charts, originally published in the 1988 edition of this guidebook, are reproduced as figure 3. They found the river sand grains to be larger and better sorted. This is due probably to a greater efficacy by water as a sorting agent in addition to sand in the dune area being somewhat stabilized by vegetation. Observation under a standard microscope shows grain composition to be principally silica with perhaps 1 to 2 percent orthoclase feldspar, chert, and possibly rutile grains. Arbogast (4) notes that the surficial geology of the source area "is dominated by unconsolidated Quaternary deposits of eolian and alluvial origin". Composition suggests a Rocky Mountain origin with quartz, feldspar, etc. transported eastward by the Arkansas River. Some of the grains may have originated from Permian and Cretaceous sandstones which outcrop in areas from south-central Kansas to the Rocky Mountains.

The W.S.U. tract is underlain by up to 50 feet (15.24 m) of the Lower Permian (Leonardian) age Ninnescah Shale which is the uppermost member of the Sumner Group of strata in Kansas. Conrad (13) determined that local strata dip 0°15' to the southwest and strike north 10° west. These strata, characterized by interbedded shales and evaporites, are included in the Absaroka II stratigraphic sequence. The Leonardian stage correlates to the European Artinskian stage which began about 280 million years ago (Mugel and Pratt, 1991) and initiated a period of worldwide marine regression.

Other than in the extreme northeast corner, the field station is underlain by the Ninnescah Shale formation (Conrad,14). Conrad reported the Wellington/Ninnescah contact to be south of the field station on 87th Street. The lowermost portion of the Ninnescah Shale seen here is a dolomitic limestone which crops out at the edge of the Ninnescah River where about 5 to 18 inches (13 to 46 cm)of one-half to one inch (1.5 to 2.5 cm)beds are exposed. It is white to gray in color, locally calcareous and contains patchy deposits of malachite ($Cu_2CO_3(OH)_2$on fracture and bedding surfaces. The limestone is jointed at about

12 inch (30.5 cm) intervals with two joint sets, one trending N.53°E. and the other N.50°W. The strike of the joint sets roughly parallels several regional geologic structures and portions of local stream channels. The dolomitic limestone is about the same stratigraphic level as the first limestone encountered in a core drilled in the NW NW of Section 33, Township 28 south, Range 3 west, about 2.25 miles (3.6 km) to the north northeast (Berendsen and Lambert, 24). At the Ninnescah tract, the limestone is overlain with 14 inches (35.6 cm) of laminated red and gray shale, the alternating red and gray layers about one inch (2.5 cm) thick. Above that are 26 inches (66 cm) red and gray laminated shale, the gray weathering to red. It is overlain by a 2 to 3 inch (5 to 7.6 cm) thick nodular gray gypsum layer which grades upwards into 22 to 23 inches (55.9 to 58.4 cm) of weathered, deteriorated red shale which represents the C soil horizon. This C regolith is overlain by five feet (1.5 m) of brown, sandy, silty soil (figure 4).

Previously, a color change from red to gray shale and the presence of cupriferous carbonate beds has been used to distinguish the boundary between the Ninnescah Shale and the underlying Wellington Formation. Norton, in 1939, combined three cupriferous carbonate layers near the transition into a single member which he labeled the Milan Limestone Member of the Wellington Formation, placing it at the top. Berendsen and Lambert (1981) have shown that the Milan Limestone is but one of several such carbonate layers in the lower part of the Ninnescah and perhaps the upper part of the Wellington and should not be considered as a definite boundary. They recommend that the name be discontinued as a stratigraphic unit. Transition from gray to red shale is likewise not valid since there are similar redbeds through the Wellington, even in its lower part in eastern Sedgwick County. Ongoing work by Skelton suggests that sandstone channels incised into the Wellington in eastern Sedgwick County are Permian in age and that thinner, near-surface sandstones in areas near the channels are crevasse splays. A wireline log shows that an apparently similar sandstone channel at the base of the Ninnescah Shale was penetrated by a well drilled at NE NE NW, section 31, Township 27S., Range 4W. in the Bartholemew oil and gas field approximately 10 miles (16 km) northwest of the Ninnescah Tract. Examination of cuttings from wells to the north and south failed to show sandstone at the interface between the Wellington Formation and Ninnescah Shale, but the cuttings did contain isolated, angular, iron-oxide-coated grains of silica sand. Water wells drilled near the town of Sedgwick in Section 33, Township 25 north, Range 1 west also indicated a sandstone at the top of the Wellington Formation. This sandstone where found, seems to be correlative to the Garber sandstone which marks the top of the Wellington Formation in Oklahoma. It is suggested here that the presence of sandstone or isolated sand grains at the base of the Ninnescah Shale be established as marker delineating the top of the Wellington Formation and that beds lying above the sandstone be assigned to the Ninnescah Shale.

The Wellington Formation which Conrad found exposed directly beneath Ninnescah River alluvium at the far northeast corner of the field station, represents a sabkha environment at the edge of a regressive sea. It contains evaporites, principally gypsum and anhydrite in the lower part and contains a thick salt deposit (the Hutchinson Salt Member) in the middle. The upper portion is shaly, contains evaporites and dolomitic carbonates characterized by the presence of malachite. The presence of redbeds seems to increase upward in the Ninnescah Shale.

Summarizing the presence of malachite, Lambert, Berendsen and Ripley noted that the deposits are not structurally controlled nor associated with any hydrothermal or metamorphic activity. They believe that the majority of the sediments, accompanied by diagenetic pyrite (FeS_2), were deposited in a reducing environment. Chalcopyrite ($CuFeS_2$) accompanied and/or replaced the pyrite itself and was altered to bornite (Cu_5FeS_4) and digenite (Cu_9S_5). The source of copper may have been in granitic rocks in the Wichita or Ouachita Mountains in southern Oklahoma or in mafic rocks associated with the Central North American Rift System. Copper found in trace amounts in such rocks could be mobilized by high chlorine concentration in the evaporating ocean and deposited as replacement of organic materials (spores, etc) in the upper Wellington and lower Ninnescah formations. The copper sulfides

subsequently were oxidized to carbonates by oxygenated meteoric water migrating down dip.

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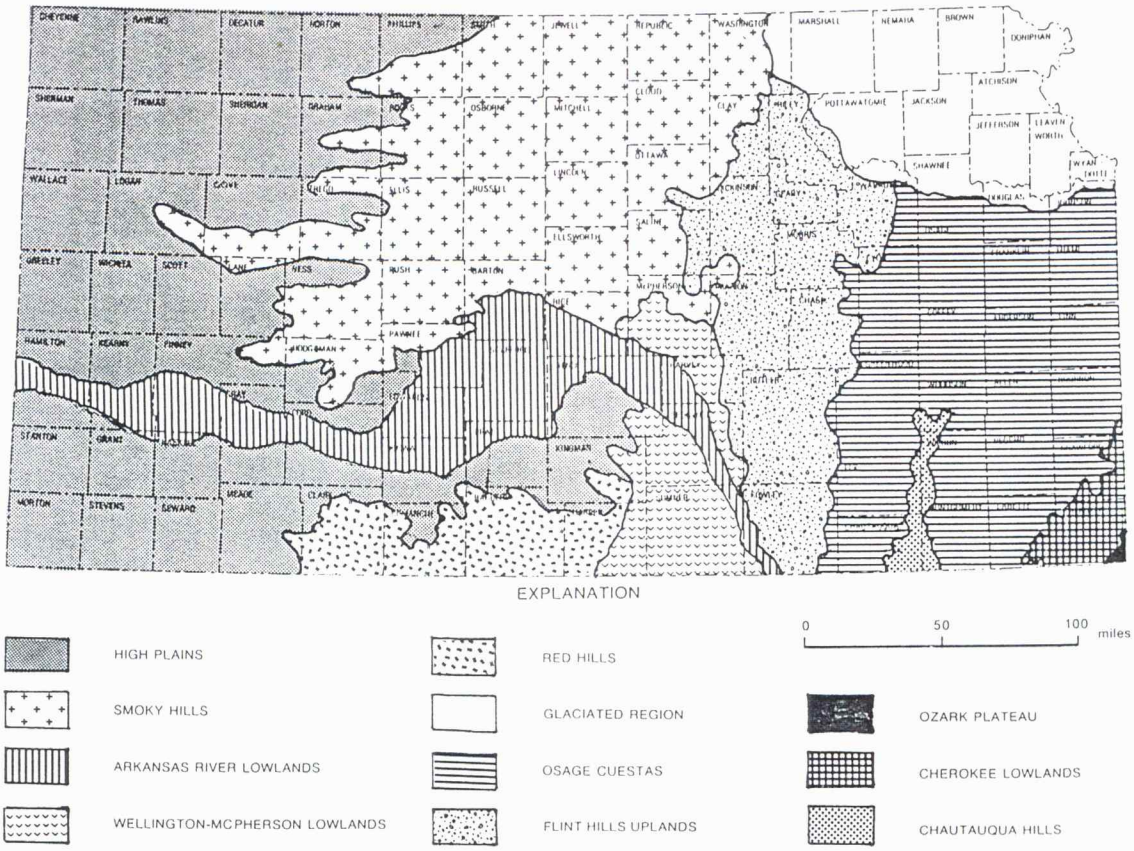


Fig. 1. Generalized physiographic regions of Kansas.

Fig. 4. Ninnescah Shale outcrop at river bank, WSU Ninnescah Field Station.

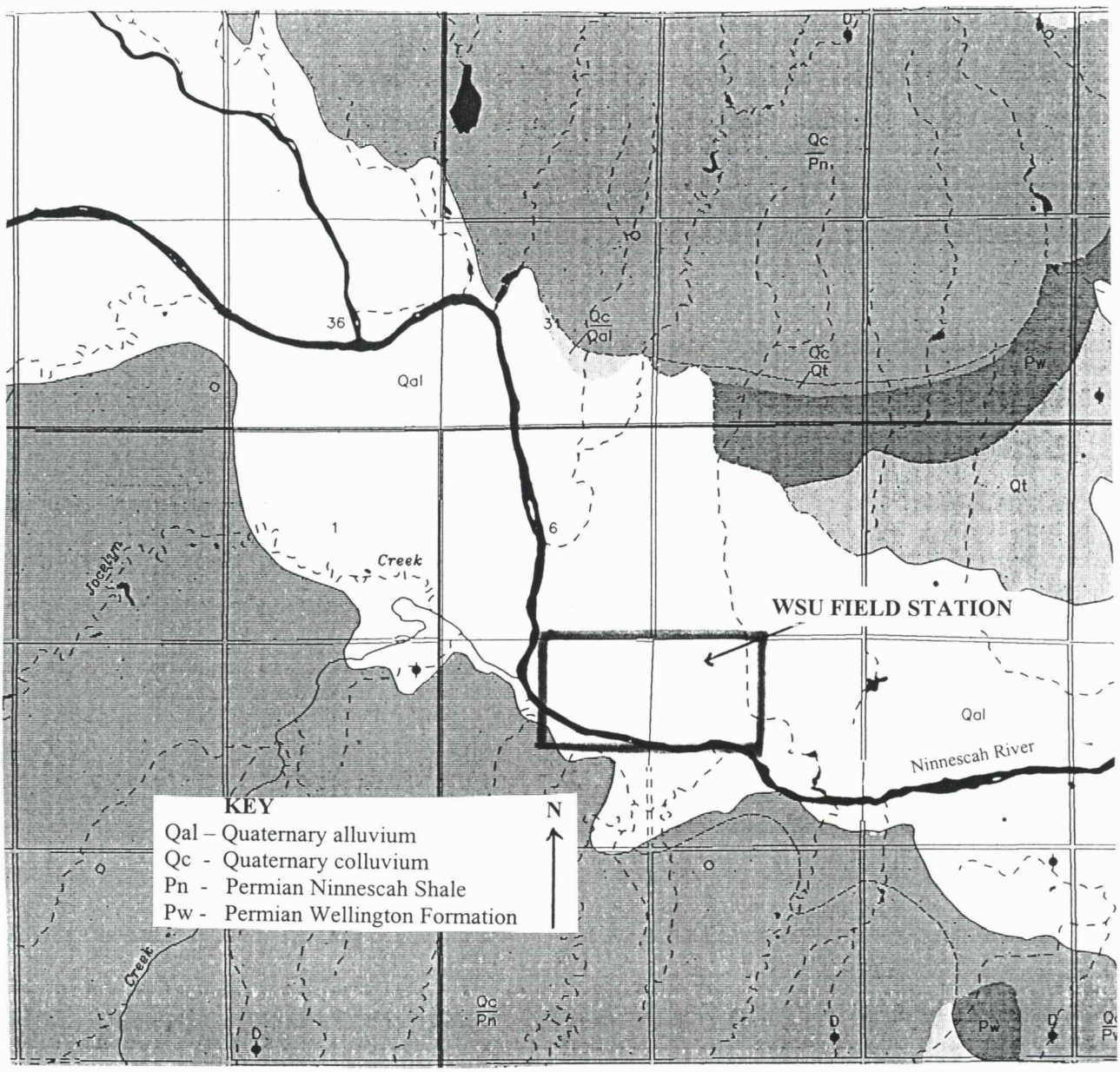
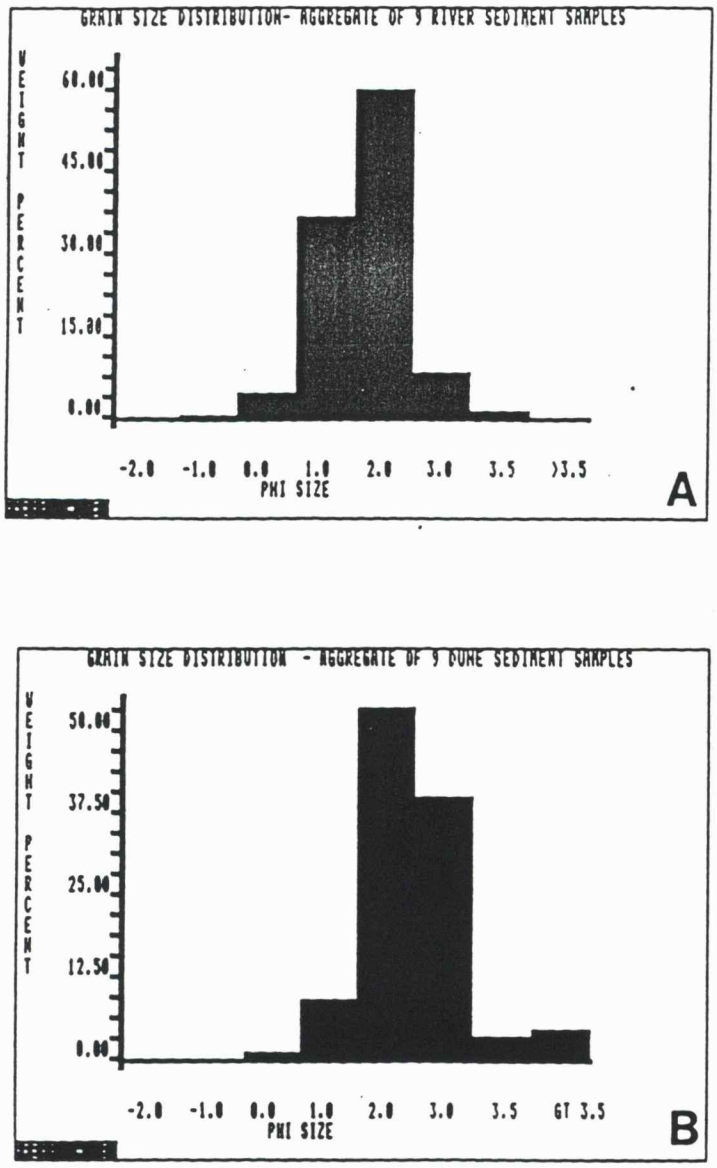


Fig. 2. Generalized geologic map of WSU Ninnescah Field Station area.



Grain-size analysis of sediment taken from the Ninnescah River (A) compared with samples taken from dune deposits located on the north side of the river (B). Results indicate that sand grains deposited in a fluvial (river) environment are larger and better sorted than sand deposited in an eolian (dune) environment.

$$\emptyset = -\log_2 S$$

Where S= size of grains in mm

Fig. 3. Grain size distribution of sand from WSU Ninnescah Field Station (from: Cross, Wells and McHenry, 1988 KAS Field trip Guidebook).

PRAIRIE NOTES

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The Ninnescah Experimental Tract (NET) is located in the southwest corner of Sedgwick County in the Wellington Lowland physiographic province of Kansas. NET occupies the southeast one-quarter of Section 7 and the southwest one-quarter of Section 8, Township 29S and Range 3W. Elevation is approximately 1312 feet (400m) above mean sea level. Annual precipitation is approximately 29 inches (73.7cm), an average annual temperature of 54 F (12.2 C), and an average frost-free period of 210 days. Soils, derived from both Permian and Quaternary deposits, are of both upland and lowland types. The main upland soil at NET is Renfrow silty clay loam. whereas Tabler silty clay loam, Farnum loam, Elandco silt loam, Canadian sandy loam and Shellabarger sandy loam are the primary lowland type soils. Deeply cut stream channels are common throughout the native prairie areas with stream beds lying as much as ten feet below the adjacent prairie.

The prairie area at NET occurs on both upland and lowland soils. The main upland soil, Renfrow silty clay loam, is either currently under wherat cultivation (100 acres/40.5 ha) or has recently been removed from cultivation and planted to native prairie grasses and forbs (100 acres/40.5 ha). Native Prairie sites, which account for 66 acres (26.7 ha), are found on both upland and lowland sites. Upland prairie sites support vegetation dominated by blue grama (*Bouteloua gracilis*) and sideoats grama (*Bouteloua curtipendula*). Lowland prairie sites are dominated by big bluestem (*Andropogon gerardi*), indiangrass (*Sorghastrum avenaceum*), switchgrass (*Panicum virgatum*), sideoats grama and annual bluegrass (*Poa annua*). Wallows in these native prairie sites are dominated by western wheatgrass (*Agropyron smithii*).

Some portions of the native prairie area of NET previously were broken for crops and other portions were overgrazed heavily during the past 100 years. Much of the area is in early to middle seral stages of mixed and tallgrass prairie. Grazing ceased in 1983 and the only management practice now in effect is annual or biannual burning. Frequency of burning is dependent upon the amount and moisture content of the fuel in spring when burning is initiated. On the basis of rainfall and soil type, that if and when climax is reached, decreasers will be composed approximately of 25-50% big bluestem, 10-25% indiangrass and up to 20% Canada wildrye and eastern gammagrass on much of the lowland sites and in addition, there should be 10-25% little bluestem on upland sites. Common increasers expected in climax vegetation are switchgrass, western wheatgrass and sedge on lowland sites and in addition, blue, hairy and sideoats gramas, as well as tall and sand dropseed on upland sites. Based on projected climax, a comparison of two areas of lowland prairie indicates that range conditions were poor for overgrazed sites to excellent for sites that had not been impacted by intense grazing. A comparison of soil characteristics associated with successional stages indicates that soils under late-successional prairie have higher organic matter, nitrogen and phosphorus contents than do early-successional old-field sites.

AQUATIC NOTES

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The Ninnescah River defines the northern boundary of the field station. During periods of low water, the pattern of flow is braided. Some sandbars are contiguous with the shore and others occur as ever-changing islands. Zones of erosion and deposition occur in almost any small section of the river. The positions of point-bars are relatively constant and seem to be correlated with the width of the riverbed. Prior to the development of agriculture in the region and the elimination of prairie fires, herbaceous vegetation extended to the river's edge. At present, there is a discontinuous, narrow riparian border of cottonwood, willow, hack-berry, box elder and mulberry. Several introduced species have invaded this border since the 1930's: Osage-orange, catalpa, Siberian elm, maple, locust and juniper. With trees stabilizing the channel width, floods and periodic discharges of a large reservoir on the North Fork have degraded the channel to a depth of I to 1.5 meters. This degradation has exposed much of the fauna buried in earlier aggradational cycles (late Pleistocene or early Holocene). More than 20 species of molluscs live in the mainstream and a half-dozen more in the muddy substrate of confluent tributaries.

Almost all the families of fishes represented in Kansas are present in the river but the most numerous large fish is the introduced carp. Although somewhat difficult to net, large numbers of 3 to 5 pound carp can be seen when turbidity is low.

Amphibians of the sandy floodplains include the Great Plains toad, spade-foot toad, Woodhouse's toad, Blanchard's cricket frog, plains leopard frog and bullfrog. Reptiles of the river include the snapping turtle, yellow mud turtle, Ouachita map turtle, western painted turtle, red-eared slider and spiny softshell. The ornate box turtle inhabits woodland and prairie sites.

Lizards of the floodplain and riparian border include the eastern fence lizard and the prairie-lined race-runner. The northern water snake is abundant in the river, especially in early summer. Snakes of the prairie and woodland include the eastern yellowbelly racer, black rat snake, bull-snake, prairie king-snake, red-sided garter snake, lined snake and Texas brown snake.

Bird and Mammal lists currently are being developed. Bald eagles and osprey migrate through annually. Great blue herons over-wintered in 1986 and 1987 suggesting open water was present throughout both winters. Rare mammal sightings include: red fox, armadillo and mink. The unnamed creek that divides the property is intermittent much of the summer and at present is completely dry. The lower course of this stream meanders about three-fourths through prairie and the lower fourth through woodland. Above the field station, the stream drains approximately eight square miles of agricultural land. Although the bed has degraded to about the same depth as the river, black mud dominates the pools and raceways and alternate with shale outcrops in the erosion zones. The stream mouth is mainly a nursery for fishes of the mainstream, but pools throughout the creek are dominated by yellow bullheads, black bullheads, small channel catfish, green sunfish and mosquitofish. In addition to the chimney-building crayfish, six species of molluscs have been collected from the creek.

On submerged solid substrate such as shale, woody vegetation and anthropogenic debris and many orders of insects can be found. These include the immature stages of mayflies, stoneflies, dragon and damsel flies, true bugs, true flies and beetles. Some larvae of aquatic insects (bloodworms and club-tailed dragonflies) are well adapted to the unstable sand substrates of the river and many small

invertebrate species are adapted to the interstitial spaces between sand grains. Most of the insects adapted to the mud substrate of the stream have short life cycles because of the impermanence of the habitat.

Addendum: Donald Distler reports these additional fauna observed on the field station during the period 1988 – 1999:

Mammals:
Hispid Cotton Rat
Wood Rat
Cotton Rat
Norway Rat
Ord's Kangaroo Rat
Plains Harvest Mouse
White-Footed Mouse
Deer Mouse
Western Harvest Mouse
Hispid Pocket Mouse
Northern Grasshopper Mouse
Plains Pocket Mouse
House Mouse
Prairie Vole
Thirteen-lined Ground Squirrel
Fox Squirrel
Plains Pocket Gopher
Black-tailed Prairie Dog
Beaver
Least Shrew
Elliot's Short-tailed Shrew
Eastern Mole
Eastern Cottontail
Black Tailed Jackrabbit
Virginia Opossum
Mink
Striped Skunk
Raccoon
Red Fox
Bobcat
Coyote
White-tailed Deer
Nine-banded Armadillo
Bats (unidentified)

Amphibians:
Western Chorus Frog
Smallmouth Salamander

Reptiles:
Western Ribbon Snake
Graham's Crayfish Snake
Eastern Hognose Snake
Plains Blackhead Snake

Large Fishes:
Short-nosed Gar
Walleye
Bigmouth Buffalo
Wiper or White Bass
Black Crappie

LIMNOLOGIC ANALYSIS OF TWO PONDS AT THE WICHITA STATE UNIVERSITY BIOLOGICAL FIELD STATION

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The Ninnescah Research Station and Natural History Reservation (Biological Field Station) is located south of Goddard and northwest of Viola, Kansas. On the grounds of the station are two permanent ponds which are the focus of this project. Other ephemeral ponds exist on a seasonal basis; however, this preliminary limnologic analysis of the field station is concentrated on the two permanent ponds. As the study of limnologic aspects of water bodies necessitates a multi-disciplinary scientific approach, we provide an overview of the biogeochemical characteristic of these ponds, and report on the chemical and biological analyses conducted on water samples collected in Fall and Summer, 1988.

GEOGRAPHIC AND GEOLOGIC SETTING

Three ponds are located within the confines of the Field Station (Figure 1). Pond One is positioned in the SE SW SE of section 7, Township 29 south, Range 3 west, Sedgwick County. Located on a meander loop of an unnamed ephemeral stream, Pond One seems to be a possibly man-made enlargement of the original stream channel and drains into the Ninnescah River. The stream meanders through six square miles (15.54 sq. km) of Sedgwick County and may down-cut a relarively shallow, perched aquifer approximately two miles (3.22 km) upstream from Pond One. The pond is reniform in shape and, when full, is approximately three feet (0.91 m) deep. During July of 1988, the water in Pond One was two feet (0.61 m) deep, whereas during August, the depth was nine inches (22.9 cm) and the pond's dimensions were 25 x 75 feet (7.62 x 22.9 m).

Pond Two, which is man-made, is located 0.75 miles (1.2 km) southeast of Pond One in the SW SW SW of Section 8, Township 29 south, Range 3 west, and is dammed on the north so that open drainage to the Ninnescah River is impeded (Figure 1). Run-off from a farm pond located approximately 200 feet (60.9 m) south is the source of water for Pond Two. The farm pond connects with an ephemeral stream that originates 0.5 mile (0.8 km) south. As a result, both ponds are filled with run-off water during periods of precipitation. Despite a sporadic water source, oval-shaped Pond Two generally contains water because it is deeper than other ponds at the Field Station. Maximum depth may exceed eight feet (2.4 m). During July, however, water depth in Pond Two was six feet (1.8 m). During August, depth was four feet (1.2 m) and the pond's dimensions were 30 x 60 feet (9.1 x 18.3 m). A set of small, shallow ponds is situated between Ponds One and Two. They were not analyzed because they dried by evaporation during the summer.

Geologically, the ponds are located in the Ninnescah Shale, Sumner Group, Lower Permian Series. The Ninnescah Shale is a red to gray, silty shale that contains thin layers of argillaceous limestone and dolomite, and calcareous siltstone. The average thickness of the unit is 300 feet (91.4 m) (Zeller, 1968).

MATERIEL AND METHODS

During July of 1988, five near-shore bottom-water samples were collected from each of the ponds studied. Each water sample was placed in a clean glass jar, labeled, and stored for laboratory analysis. Of the five samples collected, one water sample from each pond was analyzed for cation concentrations that included Ca, Sr, Na, K and Mg. Water analysis was conducted with a Perkin-Elmer 2380 atomic absorption spectrophotometer. The remaining four samples were analyzed microscopically for biota identification to the family level when possible. Depth of water was estimated.

During August, 1988, one water sample from each pond was collected and analyzed for both cation and anion concentrations. In order to ensure proper analytical results, temperature readings were taken from each pond and all alkalinity analyses were completed within 24 hours of sampling. With only 9 inches (22.9 cm) of water remaining in Pond One, its temperature was a relatively homogeneous 86° F. (30° C). Pond Two water was stratified. The upper four to six inches (10.2 to 15.2 cm) of water was 94° F (34.4° C), whereas the bottom water was 84° F (28.9° C). The pH was high for both ponds: Pond One pH was 9.4 and Pond Two pH was 9.1. Spectrophotometric analysis of each water sample was conducted for cations. Standard titration analysis was conducted to determine the concentration of Cl^- and HCO_3^- anions. The sulfate (SO_4) content was determined by plasma emission spectrometry through analysis of sulfur with an inductively coupled plasma spectrometer (ICP). The shallow lake beds were examined visually for macroscopic organisms.

RESULTS AND DISCUSSION

Chemical. Results of spectrophotometric analyses for all samples indicate that Pond One contains higher concentrations of Ca, Mg, Na, Fe and Sr, whereas Pond Two contains higher concentrations of K (Table 1). Alkalinity analyses found higher concentrations of HCO_3 in Pond Two, whereas Cl and CO_3 concentrations are higher in Pond One (Table 1). These results suggest that water from Pond One is enriched with ions compared to Pond Two and that both ponds are enriched with time. Three factors may explain this enrichment.

The water that fills Pond One originates from a stream that drains a larger watershed than that of Pond Two. As a result, erosion processes can effect a larger area and more ions can enter the stream that serves as a source for Pond One. A second consideration is that during the wetter seasons, a substantial portion of the stream flow feeding Pond One may be derived from shallow, temporary aquifers and delayed return flow of percolating rain water. Longer exposure time to the soil and bedrock would allow more time for ion exchange between water and rock. As a result, salinity would be higher in the groundwater-fed pond than in the pond fed solely by storm runoff.

A third and perhaps more important factor leading to the enrichment of ion content in Pond One and through time in both ponds is evaporation. Evaporation tends to concentrate ions in water bodies, In July, 1988. the stream was flowing and Pond One contained approximately 24 inches (61 cm) of water. By August, the stream that feeds Pond One was dry and only nine inches 22.8 cm) remained in the center of the pond. Since rainfall was notably sparse during July and August of 1988, evaporation probably served as the major factor in ionic enrichment. Differences in ionic concentrations in Ponds One and Two may be the result of water depth. Although just as much water evaporated from Pond Two, the man-made pond is nearly twice as deep as Pond One. As a result, more water is present in Pond Two to dilute ionic concentrations.

To determine whether the ionic concentrations in both ponds differ as a result of source water chemistry from weathering, groundwater, or as a result of concentration by evaporative processes requires more frequent water sampling and analyses. These analyses should be made seasonally over a year or more to be valid.

Biological. Results of the biologic census of micro- and macro-organisms indicate that similar taxa inhabit both ponds. Water samples from the two ponds include: abundant Copepods, Ostracodes, sessile and free-living Ciliophora, Rotifers, Cladocera and Odonata. Macro-organisms observed on the lake beds include: Gastropods, shells of Unionidae (Pelecypoda), the aquatic snake *Nerodia erythrogaster* and catfish *Ictalurus melas*. Similarities in taxonomic composition between the two ponds suggest that the widely ranging chemical compositions that characterize the ponds are within the tolerance limits of these taxa.

CONCLUSION

Chemical compositions of both ponds studied at the Biological Field Station increased in ionic concentrations as a result of evaporative processes. Taxonomic of both ponds are similar despite differences in ionic concentrations. Organisms living in the ponds apparently are adapted to fluctuations in water chemistry and have wide tolerance ranges.

The summer of 1988 was characterized by less than normal precipitation; therefore, results from this study may represent extremely stressful environmental conditions. A broader information base is necessary to unscramble the dynamic complexity of pond ecology at the field station.

References

Zeller, D. E. (ed.), 1968, The stratigraphic succession in Kansas: Kansas Geological Survey, Bulletin 189, Lawrence, KS.

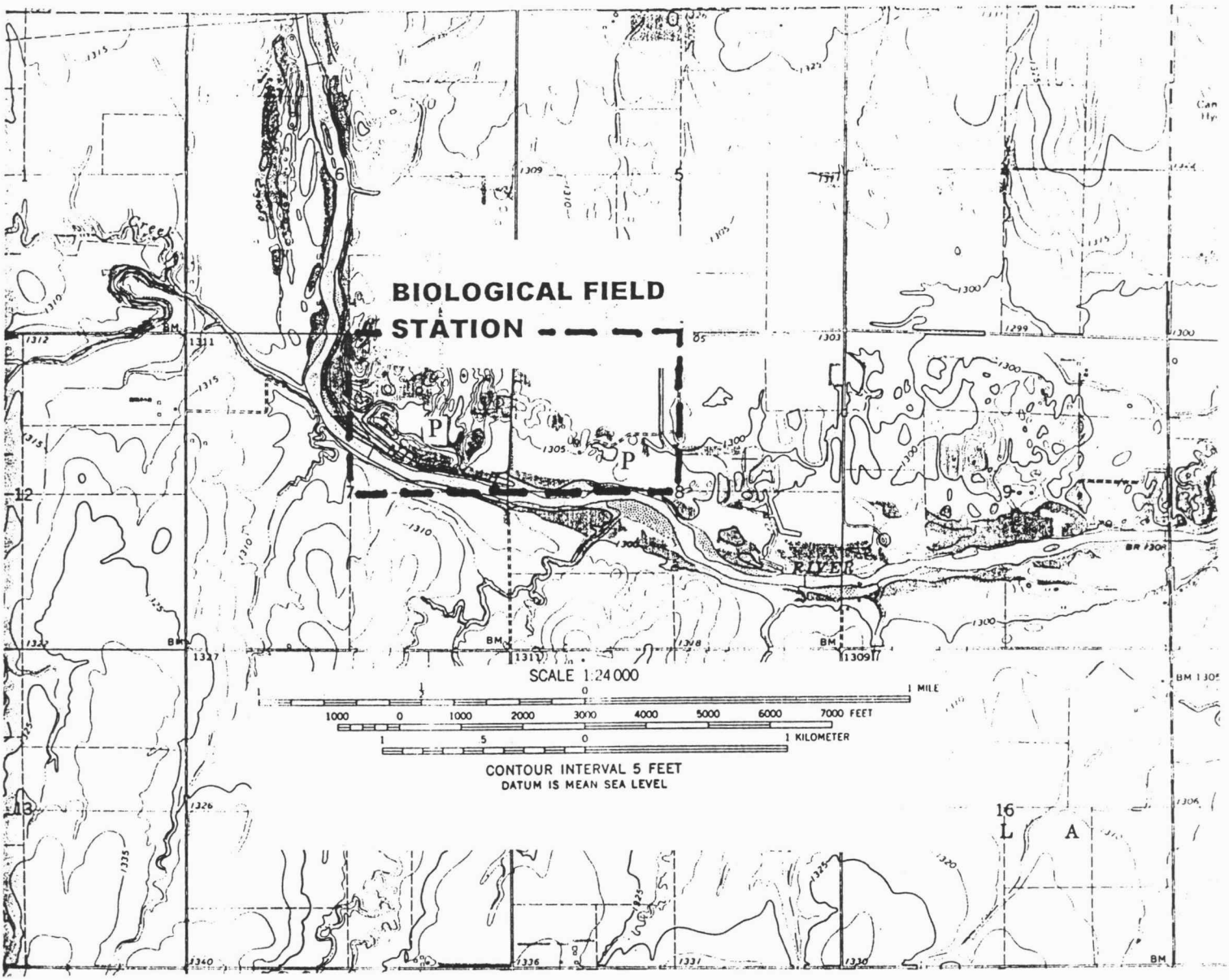

Figure 1. Study area in Sedgwick County, Kansas. The Biological Field Station is labeled. Pond locations are indicated with the notation P.

Ions	July, 1988		August, 1988	
(ppm)	Pond 1	Pond 2	Pond 1	Pond 2
Ca	43.7	23.5	58.8	22.5
Mg	24.9	9.9	31.3	12.1
Na	24.9	7.5	81.9	10.7
K	5.1	5.9	8.3	11.4
Sr	0.2	-	0.3	-
Cl	*	*	95.7	14.2
HCO_3	*	*	74.8	90.9
CO_3	*	*	4.9	2.8
Fe	*	*	4.4	2.2
SO_4	*	*	212.0	9.9

* = analysis not conducted
- = negligible

Table 1. Ionic concentrations of two ponds taken during July and August, 1988.

Ornithology

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The birds of the Ninnescah Research Station and Natural History Reservation have not studied systematically although records have been kept of some of the birds that have been observed there. The following composite list includes those birds that have been observed on the reservation (marked with an asterisk *) plus species that should be common in one or more of its major habitats. Since early October is a time of migratory movements and the timing of migration may vary from year to year, it is impossible to predict what species will be found on the field trip. However, species that are likely to be present in early October are marked with a plus sign (+) after the name. Visitors to the Ninnescah Research Station who sight birds not listed here are requested to report the bird and date observed to Donald Distler.

Pied-billed Grebe (*Podilymbus podiceps*) * +
American White Pelican (*Pelecanus erythrorhynchos*) *
Great Blue Heron (*Ardea herodias*) * +
Little Blue Heron (*Egretta caerulea*) *
Green-backed Heron (*Butoridea striatus*) * +

Snow Goose (*Chen caerulescens*) * +
Canada Goose (*Branta canadensis*) * +
Wood Duck (*Aix sponsa*) * +
Mallard (*Anas platyrhynchos*) * +
Northern Pintail (*Anas acuta*) * +
Blue-winged Teal (*Anas discors*) * +
Northern Shoveler (*Anas clypeata*) * +
Lesser Scaup (*Aythyra affinis*) * +
Common Goldeneye (*Bucephala clangula*) *
Bufflehead (*Bucephala albeola*) *
Common Merganser (*Mergus merganser*) *

Turkey Vulture (*Cathartes aura*) *
Bald Eagle (*Haliaeetus leucocephalus*) *
Osprey (*Pandion haliaetus*) *
Northern Harrier (*Circus cyaneus*) * +
Sharp-shinned Hawk (*Accipiter striatus*) * +
Swainson's Hawk (*Buteo swainsoni*) *
Red-tailed Hawk (*Buteo jamaicensis*) * +
Rough-legged Hawk (*Buteo lagopus*) *
American Kestrel (*Falco sparverius*)* +
Cooper's Hawk (*Accipiter cooperii*) * +

Ring-necked Pheasant (*Phasianus colchicus*) * +
Wild Turkey (*Meleagris gallopavo*) * +
Northern Bobwhite (*Colinus virginianus*) * +

Sora (*Porzana carolina*) *
American Coot (*Fulica americana*) * +
Sandhill Crane (*Grus canadensis*) *

Killdeer (*Charadrius vociferus*) * +
Greater Yellowlegs (*Tringa melanoleuca*) * +
Lesser Yellowlegs (*Tringa flavipes*) +
Solitary Sandpiper (*Tringa solitaria*)
Spotted Sandpiper (*Actitis macularia*) *
Least Sandpiper (*Calidris minutilla*) *
Pectoral Sandpiper (*Calidris melanotos*) +
Upland Sandpiper (*Bartramia longicauda*)
Common Snipe (*Gallinago gallinago*) * +
Franklin's Gull (*Larus pipixcan*) * +
Herring Gull (*Larus argentatus*) *
Ring-billed Gull (*Larus delewarensis*) *
Common Tern (*Sterna hirundo*) *
Black Tern (*Chlidonias niger*) *

Mourning Dove (*Zenaida macroura*) * +
Yellow-billed Cuckoo (*Coccyzus americanus*) *

Eastern Screech-owl (*Otus asio*) * +
Great Horned Owl (*Bubo virginianus*) * +

Common Nighthawk (*Chordeiles minor*) * +
Chuck-will's-widow ((*Caprimulgus carolinensis*) *
Chimney Swift (*Chaetura pelagica*) * +
Belted Kingfisher (*Ceryle alcyon*) * +

Red-headed Woodpecker (*Melanerpes erythrocephalus*) *
Red-bellied Woodpecker (*Melanerpes carolinus*) * +
Yellow-bellied Sapsucker (*Sphyrapicus varius*) * +
Downy Woodpecker (*Picoides pubescens*) * +
Hairy Woodpecker (*Picoides villosus*) * +
Northern Flicker (*Colaptes auratus*) * +

Eastern Wood-pewee (*Contopus virens*)
Least Flycatcher (*Empidonax minimus*)
Eastern Phoebe (*Sayornis phoebe*)
Great Crested Flycatcher (*Myiarchus critinus*)
Western Kingbird (*Tyrannus verticalus*) *
Eastern Kingbird (*Tyrannus tyrannus*) *
Scissor-tailed Flycatcher (*Tyrannus forficatus*) * +
Horned Lark (*Eremophila alpestris*) * +
Purple Martin (*Progne subis*) *
Northern Rough-winged Swallow (*Stelgidopteryx serripennis*)
Bank Swallow (*Riparia riparia*) *
Barn Swallow (*Hirundo rustica*) *

Blue Jay (*Cyanocitta cristata*) * +
American Crow (*Corvus brachyrhynchos*) * +
Black-capped Chickadee (*Parus atricapillus*) * +
Carolina Chickadee (*Parus carolinensis*) * +
Tufted Titmouse (*Parus bicolor*) * +
White-breasted Nuthatch (*Sitta carolinensis*) +
Brown Creeper (*Certhia americana*) *

Carolina Wren (*Thryothorus ludovicianus*) * +
House Wren (*Troglodytes aedon*)
Golden-crowned Kinglet (*Regulus satrapa*) * +
Ruby-crowned Kinglet (*Regulus calendula*) +
Blue-gray Gnatcatcher (*Polioptila caerulea*) +

Eastern Bluebird (*Sialia sialis*) * +
Swainson's Thrush (*Catharus ustulatus*) +
American Robin (*Turdus migratorius*) * +

Gray Catbird (*Dumetella carolinensis*) *
Northern Mockingbird (*Mimus polyglottos*) * +
Brown Thrasher (*Toxostoma rufum*) * +
Cedar Waxwing (*Bombycilla cedrorum*) * +
Loggerhead Shrike (*Lanius ludovicianus*) * +

Bell's Vireo (*Vireo bellii*)
Warbling Vireo (*Vireo gilvus*)
Tennessee Warbler (*Vermivora peregrina*) +
Orange-crowned Warbler (*Vermivora petechia*) +
Nashville Warbler (*Vermivora ruficapilla*) +
Yellow Warbler (*Dendroica petechia*)
Yellow-rumped Warbler (*Dendroica coronata*)
Common Yellowthroat (*Geothlypis trichas*)
Wilson's Warbler (*Wilsonia pusilla*)

Northern Cardinal (*Cardinalis cardinalis*) * +
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)
Blue Grosbeak (*Guiraca caerulea*)
Lazuli Bunting (*Passerina amoena*) *
Indigo Bunting (*Passerina cyanea*)
Dickcissel (*Spiza americana*) *
Rufous-sided Towhee (*Pipilo erythrophthalmus*) +

American Tree Sparrow (*Spizella arborea*) *
Chipping Sparrow (*Spizella passerina*) * +
Clay-colored Sparrow (*Spizella pallida*) +
Field Sparrow (*Spizella pusilla*) +
Vesper Sparrow (*Pooecetes gramineus*) +
Lark Sparrow (*Chondestes grammacus*) *
Savannah Sparrow (*Passerculus sandwichensis*) +

Grasshopper Sparrow (*Ammodramus savannarum*) *
Song Sparrow (*Melospiza melodia*) * +
Lincoln's Sparrow (*Melospiza lincolnii*) +
White-throated Sparrow (*Zonotrichia albicollis*) +
White-crowned Sparrow (*Zonotrichia leucophrys*) * +
Harris' Sparrow (*Zonotrichia querula*) * +
Fox Sparrow (*Passerella iliaca*) *
Dark-eyed Junco (*Junco hyemalis*) * +
Lapland Longspur (*Calcarius lapponicus*) *

Redwinged Blackbird (*Agelaius phoeniceus*) * +
Eastern Meadowlark (*Sturnella magna*) +
Western Meadowlark (*Sturnella neglecta*) * +
Great-tailed Grackle (*Quiscalus mexicanus*) *
Common Grackle (*Quiscalus quiscula*) * +
1. Brown-headed Cowbird (*Molothrus ater*) * +
2. European Starling (*Sturnus vulgaris*) * +
3. Northern Oriole (*Icterus galbula*) *

Pine Siskin (*Carduelis pinus*) *
American Goldfinch (*Carduelis tristis*) * +
House Sparrow (*Passer domesticus*) * +

Donald Distler reports that the following bird species have been sighted during the time between compilation of the above list in 1988 and the present, 1999. An asterisk following the common name indicates that the species was observed near but not on the field station:

136. Long-billed Dowitcher (*Limnodromus scolopaceus*)
137. Woodcock (*Scolopax minor*)
138. Sora Rail (*Porzana carolina*)
139. Common Loon (*Gavia immer*)
140. Least Bittern (*Ixobrychus exilis*)
141. Great Egret (*Casmerodius albus*)
142. Snowy Egret (*Egretta thula*)
143. Cattle Egret (*Bulbulcus ibis*)
144. Ferruginous Hawk (*Buteo regalis*)
145. Peregrine Falcon (*Falco peregrinus*)
146. Prairie Falcon (*Falco mexicanus*)
147. Whooping Crane* (*Grus americana*)
148. Snowy Owl* (*Nyctea scandiaca*)
149. Barred Owl (*Strix varia*)
150. Short-earred Owl (*Asio flammeus*)
151. Ruby-throated Hummingbird (*Archilochus colubris*)
152. Yellow-bellied Sapsucker (*Sphyrapicus varius*)
153. Short-billed Marsh Wren (*Cistothorus platensis*)

PRELIMINARY CHECKLIST OF VASCULAR PLANTS OF THE NINNESCAH EXPERIMENTAL TRACT

Based on collections and field observations of various sources, compiled by Ellie Skokan, September 16, 1988 and supplemented by Donald Distler, September 30, 1999. (Additions marked with *). Nomenclature from The Great Plains Flora Association, 1986. *Flora of the Great Plains*, Lewrence, Kansas, University Press of Kansas

ACANTHACEAE (Acanthus Family)
Ruellia humilis Nutt. (fringeleaf ruellia). Prairie

ACERACEAE (Maple Family)
Acer negundo (boxelder). Woods, river, prairie streams.
Acer saccharinum (silver maple, soft maple). Old homestead.

AMARANTHACEAE (Pigweed Family)
Amaranthus albus L. (tumble weed). Disturbed areas.
Amaranthus graecizans L. (prostrate pigweed). Disturbed areas.
Amaranthus hybridus L. (slender pigweed, green pigweed). Disturbed areas.
Amaranthus retroflexus L. (rough pigweed). Disturbed areas.
Froelichia floridana (Nutt.) Moq. (field snake-cotton). Prairie/woods edge.

ANACARDIACEAE (Cashew Family)
Rhus aromatica Ait. (fragrant sumac, polecat bush). Woods
Rhus glabra L. (smooth sumac) Edge, fences.
Toxocodendron radicans (L.) O. Ktze (poison ivy). Woods, fences.

APIACEAE (Parsley Family)
Chaerophyllum procumbens (L.) Crantz (wild chervil). Woods.
Conium maculatum L. (poison hemlock). Woods.
Daucus carota L. (wild carrot, Queen Anne's lace). Prairie.
Torilis arvensis (Huds.) Link (hedge parsley). Prairie, disturbed areas.

APOCYNACEAE (Dogbane Family)
Apocynum cannabinum L. (Indian hemp dogbane). Prairie.

ASCLEPIADACEAE (Milkweed Family)
Asclepias incarnata L. (swamp milkweed). Prairie, floodplain.
Asclepias latifolia (Torr.) Raf. (broadleaf milkweed). Prairie.
Asclepias pumila (A. Gray) Vail (plains milkweed). Prairie.
Asclepias speciosa Torr. Showy milkweed). Prairie.
Asclepias stenophylla A. Gray (narrow-leaved milkweed). Prairie.
Asclepias syriaca L. (common milkweed). Prairie.
Asclepias tuberosa L. (butterfly milkweed). Prairie.
Asclepias verticillata L. (whorled milkweed). Prairie.
Asclepias viridis Walt. (spider milkweed). Prairie.
Cynanchum laeve (Michx.) Pers. (sand vine, climbing milkweed).

ASTERACEAE (Aster Family)
Achillea millefolium L. (yarrow). Prairie.
Ambrosia artemisiifolia L. (common ragweed, short ragweed). Prairie, disturbed areas.

Ambrosia psilostachya DC. (western ragweed). Prairie, disturbed areas.
Ambrosia trifida L. (giant ragweed). Disturbed areas.
Artemesia ludoviciana Nutt. (white sagewort). Prairie.
Aster ericoides L. (white aster). Prairie.
Aster oblongifolius Nutt. (aromatic astor). Prairie.
Bidens frondosa L. (beggar-ticks). Disturbed areas.
Cirsium altissimum (L.) Spreng. (tall thistle, roadside thistle). Disturbed areas.
Cirsium undulatum (Nutt.) Spreng. (wavy-leaf thistle). Prairie.
Cirsium vulgare (Savi) Ten. (bull thistle). Prairie.
Conyza canadensis (L.) Cronq. (horse-weed). Prairie, disturbed areas.
Conyza ramosissima Cronq. (spreading fleabane). Prairie, disturbed areas.
Coreopsis tinctoria Nutt. (plains coreopsis). Wet prairie.
Dyssodia papposa (Vent) Hitchc. (fetid marigold). Disturbed areas.
*Eclipta prostrata** (yerba tajo).
Erigeron annuus (L.) Pers. (annual fleabane). Prairie, disturbed areas.
Erigeron strigosus Muhl. ex Willd. (daisy fleabane) Prairie, disturbed areas.
Eupatorium altissimum L. (tall eupatorium). Prairie.
Eupatorium rugosum Houtt. (white snakeroot). Woods.
Gnaphalium obtusifolium L. (fragrant cudweed, fragrant everlasting). Roadside.
Gutierrezia dracunculoides (DC) Blake (broomweed). Prairie.
Haplopappus ciliatus (Nutt.) DC. (goldenweed). Disturbed areas.
Helianthus annuus L. (common sunflower). Disturbed areas.
Helianthus maximilianii Schrad. (Maximilian sunflower). Prairie.
Helianthus petiolaris Nutt. (plains sunflower). Disturbed areas.
Helianthus tuberosus L. (Jerusalem artichoke). Prairie, edge.
Heterotheca latifolia Buckl. (camphorweed). Sandbars.
Iva annua L. (marsh elder). Disturbed areas.
Kuhnia eupatorioides L. (false boneset). Prairie.
Lactuca canadensis L. (wild lettuce). Prairie.
Lactuca ludoviciana (Nutt.) Ridd. (western wild lettuce). Prairie.
Lactuca serriola L. (prickly lettuce). Prairie.
Liatris punctata Hook. (dotted gayfeather). Prairie.
Lygodesmia juncea (Pursh) Hook (skeletonplant). Prairie.
*Pluchea odorata** FW. (marsh fleabane, stinkweed).
Ratibida columnifera (Nutt.) Woot. & Standl. (prairie coneflower). Prairie.
Rudbeckia hirta L. (black-eyed susan). Prairie.
Silphium integrifolium Michx. (showy rosinweed). Prairie.
Solidago gigantea Ait. (late goldenrod). Prairie.
Solidago missouriensis Nutt. (prairie goldenrod). Prairie.
Solidago rigida L. (rigid goldenrod). Prairie.
Sonchus asper (L.) Hill (prickly sow thistle). Prairie.
Taraxacum officinale Weber (common dandelion). Prairie.
Tragopogon dubius Scop. (goat's beard, western salsify). Prairie.
Veronica baldwinii Torr. (Baldwin's ironweed, western ironweed). Prairie.
Xanthium strumarium L. (cocklebur). Disturbed areas.

BIGNONIACEAE (Trumpet Creeper Family)

Catalpa speciosa Warder (northern catalpa, hardy catalpa, Catawba-tree). Woods, river.

BORAGINACEAE (Borage Family)

Lithospermum arvense L. (corn gromwell). Prairie.
Lithospermum carolinense (Walt.) MacM. (puccoon). Prairie.
*Hackelia virginiana.** (beggarlice, stickseed).

BRASSICACEAE (Mustard Family)

Barbarea vulgaris R. Br. (winter cress). Disturbed areas.
Brassica juncea (l.) Czern. (Indian mustard). Disturbed areas.
Capsella bursa-pastoris (L.) Medic. (shepherd's purse). Disturbed areas.
Descurainia pinnata (Walt.) Britt. (tansy mustard). Disturbed areas.
Erysimum repandum L. (bushy wallflower). Disturbed areas.
Lepidium densiflorum Schrad. (peppergrass). Disturbed areas.
Rorippa sinuata (Nutt.) Hitchc. (spreading yellow cress). Disturbed areas.
Sisymbrium altissimum L. (tumbling mustard). Disturbed areas.
Thlaspi arvense L. (field pennycress). Disturbed areas.

CACTACEAE (Cactus Family)

Opuntia macrorhiza Engelm. (plains prickly pear). Prairie.

CAESALPINIACEAE (Caesalpinia Family)

Cassia chamaecrista L. (showy partridge pea). Prairie.
Cassia marilandica L. (Maryland senna). Prairie.
Cercis canadensis L. (redbud). Woods, river, prairie streams.
Gleditsia trancanthos L. (honey locust). Floodplain.

CAMPANULACEAE (Bellflower Family)

Triodanis perfoliata (L.) Nieuw. (Venus' looking-glass). Prairie, disturbed areas.

CAPPARACAE (Caper Family)

Polanisia dodecandra (L.) DC. subsp. *trachysperma* (T. & G.) Iltis. (clammyweed). Riverbank, sandbars.

CAPRIFOLIACEAE (Honeysuckle Family)

Sambucus canadensis L. (common elderberry). Woods, Prairie streams.
Symphoricarpos orbiculatus Moench. (coralberry, buckbrush). Woods.

CARYOPHYLLACEAE (Pink Family)

Cerastium brachypodum (Engelm. ex A. Gray) Robins. (cerastium). Disturbed areas.
Stellaria media (L.) Cyr. (common chickweed). Disturbed areas.

CHENOPODIACEAE (Goosefoot Family)

Chenopodium album L. (lamb's-quarters). Disturbed areas.
Chenopodium gigantospermum Aellen (maple-leaved goosefoot) Disturbed areas.
Cycloloma atriplicifolium (Spreng.) Coult. (tumble ringweed, winged pigweed).

Sandbars.
Kochia scoparia (L.) Schrad. (kochia, fire-weed, summer or mock cypress). Disturbed areas.
Salsola iberica Senn. & Pau. (Russian thistle, tumbleweed). Disturbed areas.

COMMELINACEAE (Spiderwort Family)
Commelina erecta L. (erect dayflower). Sandbars.
Tradescantia sp. L. (Spiderwort). Prairie.

CONVOLVULACEAE (Morning-glory Family)
Calystegia sepium (L.) R. Br. (hedge bindweed). Prairie.
Convolvulus arvensis L. subsp. *angulata* Brummitt (field bindweed). Prairie.
Ipomoea hederacea Jacq. (ivyleaf morning-glory). Edge, disturbed areas.
Ipomoea leptophylla Torr. (bush morning-glory). Prairie.

CORNACEAE (Dogwood Family)
Cornus drummondii C. A. Mey. (roughleaved dogwood). Woods, river, prairie streams.

CUCURBITACEAE (Cucumber Family)
Cucurbita foetidissima H. B. K. (buffalo gourd). Prairie, disturbed areas.

CUPRESSACEAE (Cypress Family)
Juniperus virginiana L. (red cedar). Woods, river and prairie streams.

CUSCUTACEAE (Dodder Family)
Cuscuta cuspidata Engelm. (cusp dodder). Prairie.

CYPERACEAE (Sedge Family)
Carex sp. L. (sedge). Prairie, floodplain, sandbars.
Cyperus esculentus L. (umbrella sedge). Prairie.
Fimbristylis sp. * (sedge).

EQUISETACEAE (Horsetail Family)
Equisetum laevigatum A. Br. (smooth scouring rush). Prairie streams.

EUPHORBIACEAE (Spurge Family)
Acalypha virginica L. (three-seeded mercury). Prairie.
Acalypha ostryaefolia * (three-seeded mercury). Prairie
Croton capitatus Michx. (wooly croton). Prairie
Croton monanthogynus Michx. (one-seeded croton). Prairie.
Croton texensis (Kl.) Muell. Arg. (Texas croton). Prairie.
Euphorbia corollata L. (flowering spurge). Prairie.
Euphorbia cyanthophora Murray (fire-on-the-mountain, painted euphorbia). Prairie, sandbars.

Euphorbia dentata Michx. (toothed spurge). Prairie, disturbed areas.
Euphorbia hexagona Nutt. ex Spreng. (six-angled spurge).
Euphorbia maculata L. (spotted spurge). Prairie, disturbed areas, sandbars.
Euphorbia marginata Pursh (snow-on-the-mountain). Prairie.
Euphorbia missurica Raf. (Missouri spurge, prairie spurge).

FABACEAE (Bean Family)
Amorpha canescens Pursh (lead plant). Prairie.
Amorpha fruticosa L. (false indigo). Prairie stream.
Astragalus crassicarpus Nutt. (ground plum). Prairie.
Baptisia australis (L.) R. Br. var. *minor* (Lehm.) S. Wats. (blue false indigo). Prairie.
Baptisia bracteata Muhl. ex Ell. var. *glabrescens* (Larisey) Isley (plains wild indigo, long
Coronilla varia L. (crown vetch). Riverbank.
Dalea candida Michx. ex Willd. (white prairie clover). Prairie.
Desmodium illinoense A. Gray (Illinois tickclover). Prairie.
Glycyrrhiza lepidota Pursh (wild licorice). Prairie.
Medicago lupulina L. (black medic). Prairie.
Medicago sativa L. ssp. *sativa* (alfalfa). Old homestead, sandbars.
Melilotus alba Medic. (white sweet clover). Prairie.
Melilotus officinalis (L.) Pall. (yellow sweet clover). Prairie.
Psoralea argophylla Pursh (silverleaf scurfpea). Prairie.
Psoralea tenuiflora Pursh (wild alfalfa, scurfy pea). Prairi.
Robinia pseudo-acacia L. (black locust). Old homestead.
Strophostyles leiosperma (T. & G.) Piper (slick-seed bean). Prairie.
Trifolium pratense L. (red clover). Prairie.

FUMARIACEAE (Fumitory Family)
Corydalis curvisiliqua Engelm. subsp. *grandibracteata* (Fedde) G. Ownbey (large-bracted corydalis). Woods.

GERANIACEAE (Geranium Family)
Geranium carolinianum L. (Carolina cranesbill). Disturbed areas.

GROSSULARIACEAE (Currant Family)
Ribes odoratum Wendl. (buffalo currant). Woods, river, prairie streams.

IRIDACEAE (Iris Family)
Sisyrinchium campestre Bickn. (white-eyed grass). Prairie.

JUNCACEAE (Rush Family)
Juncus dudleyi Wieg, (Dudley rush). Prairie.
Juncus sp. *

LAMIACEAE (Mint Family)
Lamium amplexicaule L. (henbit). Disturbed areas.
Lycopus americana * (American bugleweed).

Monarda citriodora Cerv. ex Lag. (lemon beebalm, lemon mint). Sandbars.
Salvia azurea Lam. (blue sage, Pitcher sage). Prairie.
Salvia reflexa Hornem. (Rocky Mountain sage, lance-leaved sage). Disturbed areas.
Teucrium canadense L. (American germander, wood sage). Shaded roadwa.

LILIACEAE (Lily Family)
Allium canadense L. (wild onion). Prairie.
Nothoscordum bivalve (L.) Britt. (false garlic). Prairie.

LYTHRACEAE (Loosestrife Family)
Ammannia coccinea Rottb. (toothcup, purple ammannia). Riverbanks.
Lythrum alatum * (winged loosestrife).
Lythrum californicum T. & G. (California loosestrife).

MALVACEAE (Mallow Family)
Abutilon theophrasti Medic. (velvet-leaf). Disturbed areas.
Callirhoe alcaeoides (Michx.) A. Gray (pale poppy mallow). Prairie.
Callirhoe involucrata (T. & G.) A. Gray (purple prairie mallow). Prairie.
Hibiscus trionum L. (flower-of-an-hour, Venice mallow). Prairie.
Malva neglecta Wallr. (common mallow). Prairie.

MIMOSACEAE (Mimosa Family)
Desmanthus illinoensis (Michx.) MacM. (Illinois bundleflower). Prairie.
Schrankia nuttallii (DC.) Standl. (sensitive brier, catclaw sensitive brier). Prairie.

MOLLUGINACEAE (Carpetweed Family)
Mullago verticillata L. (carpetweed).

MORACEAE (Mulberry Family)
Maclura pomifera (Raf.) Schneid. (Osage orange). Woods, river, prairie streams, fencelines.
Morus rubra L. (red mulberry). Woods, river, prairie streams.

NYCTAGINACEAE (Four-o'clock Family)
Mirabilis nyctagineaa (Michx.) MacM. (wild four-o'clock). Disturbed areas, woods edge.

OLEACEAE (Olive Family)
Fraxinus pennsylvanica Marsh. (green ash). Woods, river, prairie streams.

ONAGRACEAE (Evening primrose Family)
Gaura parviflora Dougl. (velvety gaura). Prairie.
Ludwigia peploides * (floating evening primrose).
Oenothera biennis L. (common evening primrose). Prairie, disturbed areas.

Oenothera laciniata Hill. (cut-leaved evening primrose). Disturbed areas.
Oenothera rhombipetala Nutt. ex T. & G. (fourpoint evening primrose). Sandbars.
Oenothera speciosa Nutt. (showy white evening primrose). Prairie.
Oenothera triloba Nutt. (stemless evening primrose). Prairie.
Stenosiphon linifolius (Nutt.) Heynh. (stenosiphon). Prairie.

OXALIDACEAE (Wood Sorrel Family)
Oxalis stricta L. (yellow wood sorrel). Prairie.

PAPAVERACEAE (Poppy Family)
Argemone polyanthemos (Fedde) G. Ownbey (prickly poppy). Woods.

PEDALIACEAE (Unicorn-plant Family)
Proboscidea louisianica (P. Mill) Thell. (devil's claw, unicorn plant). Disturbed areas.

PHYTOLACCACEAE (Pokeweed Family)
Phytolacca americana L. (pokeweed).

PLANTAGINACEAE (Plantain Family)
Plantago patagonica Jacq. (Patagonian plantain).

POACEAE (Grass Family)
Aegilops cylindrica Host (jointed goatgrass). Disturbed areas.
Agropyron smithii Rybd. (western wheatgrass). Prairie wallows.
Andropogon gerardii Vitman (big bluestem). Prairie.
Andropogon saccharoides Sw. var. *torreyanus* (Steud.) Hack. (silver bluestem).
Andropogon scoparius Michx. (little bluestem). Prairie.
Aristida oligantha Michx. (oldfield three-awn prairie three-awn). Disturbed areas.
Bouteloua curtipendula (Michx.) Torr. (sideoats grama). Prairie.
Bouteloua gracilis (H. B. K.) ag. ex Griffiths (blue grama). Prairie.
Bromus inermis Leyss. subsp. *inermis* (smooth brome). Prairie.
Bromus japonicus Thunb. ex Murr. (Japanese brome). Disturbed areas.
Bromus tectorum L. (downy brome). Prairie, disturbed areas.
Buchloe dactyloides (Nutt.) Engelm. (buffalo grass).
Cenchrus longispinus (Hack.) Fern. (longspine sandbur). Disturbed areas, sandbars.
Chloris verticillata Nutt. (windmill grass). Prairie.
Chloris virgata * (showy chloris, feather fingergrass).
Cynodon dactylon (L,) Pers. (Bermuda grass). Driveway.
Dicanthelium oligosanthes (Schult.) Gould var. *scribnerianum* (Nash) Gould (Schribner dicanthelium).
Digitaria ischaemum (Schreb. ex Schweigg) Schreb. ex Muhl. (smooth crabgrass). Disturbed areas.
Digitaria sanguinalis (L.) Scop. (hairy crabgrass). Disturbed areas.
Echinochloa crusgalli (L.) Beauv. (barnyard grass). Disturbed areas.
Eleusine indica (L.) Gaertn. (goosegrass). Disturbed areas.
Elymus canadensis L. (Canada wild rye). Disturbed areas.
Elymus virginicus L. (Virginia wild rye). Prairie/woods edge.

Eragrostis cilianensis (All.) E. Mosher (stinkgrass). Disturbed areas.
Eragrostis reptans * (hairy creeping lovegrass).
Eragrostis spectabilis (Pursh) Steud. (purple lovegrass). Prairie.
Eragrostis trichodes (Nutt.) Wood (sand lovegrass). Sandbar.
Festuca octoflora Walt. (sixweeks fescue). Prairie.
Hordeum jubatum L. (foxtail barley). Disturbed areas.
Hordeum pusillum Nutt. (little barley). Disturbed areas.
Leptochlora fascicularis (Lam.) A. Gray (bearded sprangletop). Prairie.
Leptoloma cognatum * (fall witchgrass).
Muhlenbergia sp Schreb. (muhly). Disturbed areas.
Panicum capillare L. var. *capillare* (common witchgrass). Prairie, disturbed areas.
Panicum dichotomiflorum Michx. (fall panicum). Prairie, disturbed areas.
Panicum virgatum L. (switchgrass). Prairie.
Poa annua L. (annual bluegrass). Prairie.
Schedonnardus paniculatus (Nutt.) Trel. (tumblegrass). Disturbed areas.
Setaria glauca (L.) Beauv. (yellow foxtail). Disturbed areas.
Setaria viridis (L.) Beauv. (green foxtail). Disturbed areas.
Sorghastrum nutans (L.) Nash (Indian grass). Prairie.
Sorghum halepense (L.) Pers. (Johnson-grass). Floodplain, disturbed areas.
Spartina pectinata Link (prairie cordgrass). Prairie streams.
Sporobolus cryptandrus (Torr.) A. Gray (sand dropseed). Sandbar.
Tripsacum dactyloides (L.) L. (eastern gammagrass). Prairie.
Triticum aestivum L. (wheat). Cultivated land.

POLYGONACEAE (Buckwheat Family)
Erigonum annuum Nutt. (annual eriogonum). Prairie edge.
Polygonum amphibium L. (water smartweed). Riverbank.
Polygonum arenastrum Jord. ex Bor. (prostrate knotweed). Prairie, disturbed areas.
Polygonum bicorne Raf. (pink smartweed). Prairie, riverbank.
Polygonum hydropiperoides Michx. (mild waterpepper). Wet prairie.
Polygonum lapathifolium L. (pale smartweed). Riverbank.
Polygonum ramosissimum Michx. (bush knotweed). Disturbed areas.
Polygonum scandens L. (false buckwheat). Riverbank.
Rumex altissimus Wood. (pale dock). Prairie.
Rumex crispus L. (curly dock). Prairie.

RANUNCULACEAE (Buttercup Family)
Anemone caroliniana Walt. (Carolina anemone). Prairie.
Delphinium virescens (prairie larkspur). Prairie.

ROSACEAE (Rose Family)
Geum canadense Jacq. (white avens).
Prunus angustifolia Marsh. (chickasaw plum, sandhill plum). Woods, river, prairie streams.

RUBIACEAE (Madder Family)
Cephalanthus occidentalis L. (common buttonbush). Woods, river, prairie streams.
Galium aparine L. (catchweed bedstraw). Prairie/woods edge.
Hedyotis crassifolia Raf. (small bluets). Prairie.

SALICACEAE (Willow Family)

Populus deltoides Marsh. subsp. *monilifera* (Ait.) Eckenw. (cottonwood). River, woods.
Salix amygdaloides Anderss. (peach-leaf willow). Woods, river, prairie streams.
Salix exigua Nutt. subsp. *interior* (Rowlee) Cronq. (sandbar willow). River, woods.

SCROPHULARIACEAE (Figwort Family)

Lindernia dubia (L.) Penn. (false pimpernel). Moist prairie.
Verbascum thapsus L. (common mullein).
Veronica agrestis L. (field speedwell). Disturbed areas.
Veronica arvensis L. (corn speedwell). Disturbed areas.
Veronica peregrina L. (purslane speedwell). Disturbed areas.
*Leucospora multifida** (sand leucospira). Sand prairie.

SIMAROUBACEAE (Quassia Family)

Ailanthus altissima (P. Mill.) Swingle (tree of heaven, smoke tree). So. fence line.

SMILACEAE (Greenbrier Family)

Smilax hispida Muhl. (bristly greenbrier). Woods, river and prairie streams.

SOLANACEAE (Nightshade Family)

Physalis longifolia Nutt. (common ground cherry). Prairie.
Solanum carolinense L. (Carolina horse nettle). Prairie, disturbed areas.
Solanum ptycanthum Dun. ex DC. (black nightshade). Prairie.
Solanum rostratum Dun. (buffalo bur, Kansas thistle). Disturbed areas.

TYPHACEAE (Cat-tail Family)

Typha latifolia L. (broad-leaved cat-tail). Stream.

ULMACEAE (Elm Family)

Celtis occidentalis L. (hackberry). Woods, river, prairie streams.
Ulmus pumila L. (Siberian elm). Woods, river, prairie streams.

VERBENACEAE (Vervain Family)

Lippia cuneifolia (Torr.) Steud. (wedgeleaf frog-fruit). Riverbank, wet woods.
Lippia lanceolata (Michx.) Greene (northern frog-fruit).
Verbena bracteata Lag. & Rodr. (prostrate verbena). Disturbed areas.
Verbena stricta Vent. (hoary verbena). Prairie.

VIOLACEAE (Violet Family)

Viola pratincola Greene (blue prairie violet). Woods.
Viola rafinesquii Greene (johnny-jump-up, wild pansy). Prairie.

VITACEAE (Grape Family)

Parthenocissus quinquefolia (L.) Planch. (Virginia creeper). Woods, river, prairie streams.

Vitis riparia Michx. (river-bank grape). Woods, river.

ZYGOPHYLLACEAE (Caltrop Family)

Tribulus terrestris L. (puncture vine, goat head). Disturbed areas.

OUTLINE OF THE ARCHAEOLOGICAL SEQUENCE FOR THE REGION OF THE NINNESCAH RESEARCH STATION

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Paleoindian: 11,500 – 7,500 B.P. (before present)

Culture: The first human inhabitants of the continent lived primarily by hunting, with an emphasis on large game – mammoth and bison in this area. Small groups and high mobility seem to have been the norm.

Diagnostics: Fluted and lanceolate spear points, spurred end scrapers, blade tools.

Where found: Most sites have been destroyed or deeply buried by geomorphic processes. Spear points sometimes are found in reworked sediments in this area of the state.

Archaic: 7,500 B.P. – A.D. 1

Culture: The early part of this period saw high temperatures affecting the plains. Few sites have been found, and the extent to which this reflects climate or geomorphology (and hence site visibility) is a moot question. The pattern generally was one of foraging for whatever game was available, supplemented by intensive processing of vegetable foods.

Diagnostics: A large variety of spear point forms are found, many of which also were used as knives; grinding stones, stone-filled hearths.

Where found: Buried in terrace deposits in this part of Kansas.

Early Ceramic: A.D. 1 – 1050

Cultures: This period is marked by the addition of small-scale slash and burn horticulture to the foraging base. A pattern of base camps and special purpose camps is known from the eastern part of the state.

Diagnostics: Conical pottery vessels with thick walls, corner-notched points, arrow points after A.D. 500.

Where found: Near-surface to deeply buried, frequently at the mouths of small streams. Often associated with a well-developed paleosol.

Middle Ceramic: A.D. 1050 – 1500

Cultures: Hamlets of permanent houses supported by an economy more or less evenly divided between maize horticulture and bison hunting.

Diagnostics: Globular and flat-bottomed vessels, side-notched arrow points, shaft smoothers. The bluff Creek complex is the culture found in this region.

Where found: Hamlets are on bluff tops and on terraces.

Late Ceramic: A.D. 1500 – 1720

Cultures: Large villages of grass houses supported by horticulture and bison hunting. This is the culture of the Wichita Indians.

Diagnostics: Flat-bottomed ceramic vessels, plain triangular points, blade tools.

Where found: Major villages at Arkansas City, in Rice County and at Marion; hunting camps widespread.