

# Geologic Resource Evaluation Scoping Summary

## Tallgrass Prairie National Preserve, Kansas

Prepared by Katie KellerLynn  
September 19, 2008

Geologic Resources Division  
National Park Service  
US Department of the Interior



The Geologic Resource Evaluation (GRE) Program provides each of 270 identified natural area National Park System units with a geologic scoping meeting and summary (this document), a digital geologic map, and a geologic resource evaluation report. The purpose of scoping is to identify geologic mapping coverage and needs, distinctive geologic processes and features, resource management issues, and monitoring and research needs. Geologic scoping meetings generate an evaluation of the adequacy of existing geologic maps for resource management, provide an opportunity to discuss park-specific geologic management issues, and if possible include a site visit with local experts.

On May 14, 2008, the National Park Service held a GRE scoping meeting for Tallgrass Prairie National Preserve at the Prairie Coffee House in Cottonwood Falls, Kansas. Participants at the meeting included NPS staff from the preserve and the Geologic Resources Division, and cooperators from the Kansas Geological Survey and Colorado State University (see table 3). Superintendent Stephen Miller welcomed the group and provided some background information about the national preserve. Heather Brown (Tallgrass Prairie National Preserve) provided information about the interpretive opportunities and themes. Tobin Roop (Tallgrass Prairie National Preserve) discussed some archaeological-geological connections. Bob Sawin (Kansas Geological Survey) highlighted the successful collaboration between staff members at the survey and preserve, the about-to-be-released geologic map, and the geology and geoarchaeology of the preserve. Tim Connors (Geologic Resources Division) facilitated the assessment of map coverage, and Lisa Norby (Geologic Resources Division) led the discussion regarding geologic processes and features.

On May 15, 2008, cooperators and preserve staff participated in a field trip at Tallgrass Prairie National Preserve. Rolfe Mandel (University of Kansas and Kansas Geological Survey) kicked off the trip with a discussion of Quaternary landscape evolution, in particular the Fox Creek valley. In 2006 the Kansas Geological Survey published his findings (see Mandel 2006). In addition, Bob Sawin and Rex Buchanan (Kansas Geological Survey) discussed bedrock geology and highlighted exposures (e.g., Cottonwood, Schroyer, Threemile, and Florence limestones). They also pointed out springs and various cultural uses of geologic resources. Tobin Roop (Tallgrass Prairie National Preserve) showed participants an archaeological site in the Palmer Creek area and provided general information about past human occupation.

## Preserve and Geologic Setting

Depending a viewer's mindset, vantage point, and motive for recording an observation, the midcontinental plains have been "alternately disparaged as an inhospitable desert and rhapsodized as a verdant garden" (Conard and Hess 1998). The vast treelessness and lack of recognizable landmarks may indeed feel disquieting or even inhospitable, yet a thousand species of plants, including four archetypal grasses—switch (*Panicum virgatum*), Indian (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparium*), and big bluestem (*Andropogon gerardii*)—comprise the tallgrass prairie. In the rich soils of the bottomland, the leaves of grasses often reach 0.6 m (2 ft) in length, while the seed stems of big bluestem can exceed 3 m (9 ft). These grasses do not grow as tall in the thinner upland soils, but their roots extend many feet below the surface, exploiting water in the cracks of limestone (Hoy 2006).

In the 1920s natural scientists became increasingly alarmed at how little tallgrass prairie remained undisturbed (Conard and Hess 1998). Hence, in the 1930s, a long struggle began to preserve a national prairie. Finally in 1996, Congress proclaimed Tallgrass Prairie National Preserve. The national preserve (vs. national park) designation allowed the National Park Service greater flexibility in carrying out the proposed public-private partnership (Conard and Hess 1998). The Nature Conservancy owns the majority of the 4,050-

ha (10,000-ac) preserve, which represents a portion of the less than 4% of remaining tallgrass prairie in the world. Tallgrass prairie once covered more than 643,720 km<sup>2</sup> (400,000mi<sup>2</sup>) of North America (National Park Service 2004). The National Park Service administers the entire preserve but can only “own” 73 ha (180 ac). The land owned by the National Park Service surrounds and includes the Spring Hill Farm and Stock Ranch and Lower Fox Creek Schoolhouse.

Tallgrass Prairie National Preserve is in the Flint Hills region of the Central Lowlands Physiographic Province. Formed by erosion of westward-dipping strata, the Flint Hills cross east central Kansas from the north near Nebraska and extend south into Oklahoma, where they are called the Osage Hills. The Flint Hills region derives its name from the abundance of flint (i.e., chert) scattered across its surface. The Permian rock units, primarily limestone and shale, contain many bands of chert. Because chert is less soluble than the limestone that surrounds it, weathering of the softer rock causes differential erosion of topographic features and forms clay-rich soil that contains a large volume of chert fragments (Wilson 1984). This gravel-rich soil armors the rocky uplands and causes slower erosion than in adjacent areas where the limestone does not contain chert (Mandel 2006). These geological characteristics saved the Flint Hills from widespread plowing that would have destroyed the native prairie.

## Geologic Mapping Plan for Tallgrass Prairie National Preserve

During the scoping meeting, Tim Connors (Geologic Resources Division) showed some of the main features of the GRE Program’s digital geologic maps, which reproduce all aspects of paper maps, including notes, legend, and cross sections, with the added benefit of being GIS compatible. The NPS GRE Geology-GIS Geodatabase Data Model incorporates the standards of digital map creation for the GRE Program and allows for rigorous quality control. Staff members digitize maps or convert digital data to the GRE digital geologic map model using ESRI ArcGIS software. Final digital geologic map products include data in geodatabase and shapefile format, layer files complete with feature symbology, FGDC-compliant metadata, a Windows HelpFile that captures ancillary map data, and a map document that displays the map and provides a tool to directly access the HelpFile. Final products are posted at <http://science.nature.nps.gov/nrdata/>. The data model is available at <http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm>.

When possible, the GRE Program provides large scale (1:24,000) digital geologic map coverage for each unit’s area of interest, which is generally composed of the 7.5-minute quadrangles that contain NPS-managed lands. Maps of this scale (and larger) are useful to resource managers because they capture most geologic features of interest and are spatially accurate within 12 m (40 ft). The process of selecting maps for management begins with the identification of existing geologic maps in the vicinity of the National Park System unit. Scoping session participants then discuss mapping needs and select appropriate source maps for the digital geologic data (table 1) or, if necessary, develop a plan to obtain new mapping.

**Table 1. Source Maps for Tallgrass Prairie National Preserve**

| GMAP ID <sup>1</sup> | Reference                                                                                                                                                                                                 |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 74912                | Sawin, R. S. 2008. <i>Surficial geology of the Tallgrass Prairie National Preserve, Chase County, Kansas</i> . Scale 1:12,000. Map M-119A. Lawrence, KS: Kansas Geological Survey.                        |
| 74913                | Sawin, R. S., and R. C. Buchanan. 2008. <i>Water-bearing units of the Tallgrass Prairie National Preserve, Chase County, Kansas</i> . Scale 1:12,000. Map M-119B. Lawrence, KS: Kansas Geological Survey. |

<sup>1</sup>GMAP numbers are identification codes for the GRE Program’s database

Tallgrass Prairie National Preserve has nine 7.5-minute quadrangles of interest: Diamond Springs, Wilsey SE, Lake Kahola, Hymer, Strong City, Saffordville, Elmdale, Cottonwood Falls, and Gladstone (fig. 1). The preserve is situated entirely within the Strong City 7.5-minute quadrangle. During scoping, preserve staff deemed the Kansas Geological Survey map that covers just the preserve acreage as sufficient for resource management. This publication—*Surficial Geology of Tallgrass Prairie Preserve, Chase County, Kansas*—graphically shows the distribution, rock type, and age of bedrock near the surface and can be used to (1)

identify surface and subsurface lithologic units and their stratigraphic relationships, (2) show geologic structures, (3) delineate thick surficial materials such as alluvium, and (4) show the spatial orientation of these features (Sawin 2008). Preserve staff also plans to use this map for interpretive purposes and sell it in the visitor center. The hydrologic map (i.e., Sawin and Buchanan 2008) delineates water-bearing limestone associated with springs.

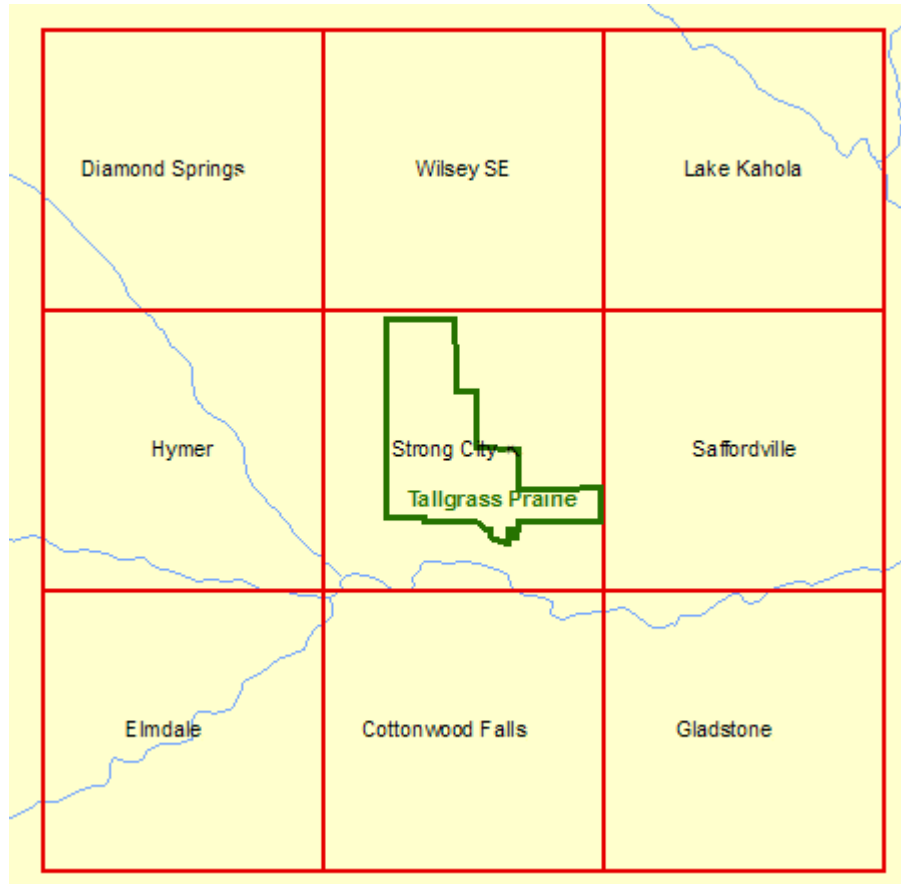


**Figure 1. Area of Interest for Tallgrass Prairie National Preserve.** Tallgrass Prairie National Preserve, outlined in green, is situated in the Strong City 7.5-minute quadrangle. The 7.5-minute quadrangles surrounding the preserve are outlined in red and labeled in black.

On September 15, 2008, the GRE Program announced the completion of the digital geologic map for Tallgrass Prairie National Preserve. The digital map is available on the NPS Data Store at <http://science.nature.nps.gov/nrdata/quickoutput.cfm?type=ds&cat=geology&key=GRE&parkcode=TAPR>. As discussed during scoping the source for the digital data is Sawin (2008) and Sawin and Buchanan (2008) (see table 1). The 9.2 ArcMap document (.mxd) has a HelpFile button that launches the GRE HelpFile. The GIS data are in the NPS 2.0 geodatabase data model and are available in ESRI 9.2 personal geodatabase and shapefile formats.

For extended coverage, the Kansas Geological Survey is currently mapping (scale 1:24,000) Morris County to the north of the preserve and has digitized a 1:50,000-scale map of Chase County (originally published in 1951). The Kansas Geological Survey will make these maps and digital data available to preserve staff. The Data Access and Support Center (DASC) provides many options of data at <http://www.kansasGIS.org>.

## Geologic Features and Processes and Related Management Issues

The scoping session for Tallgrass Prairie National Preserve provided the opportunity to develop a list of geologic features and processes, which will be further explained in the final GRE report. During the meeting, participants did not prioritize the issues, but discussion made it clear that “geological connections” to the landscape are significant for management, interpretation, and planning. These connections are discussed first, followed alphabetically by other features and processes. For future reference and possible use in compiling the final GRE report, the Kansas Geological Survey may be publishing a bulletin about Tallgrass Prairie National Preserve, which may be completed in 2009. Bob Sawin is the potential author.

### Geologic Connections

According to the brochure about the geology of the Flint Hills, “Few places illustrate the connection between life and landscape better than the tallgrass prairie of Kansas Flint Hills. The region’s geology, unseen yet immensely influential, forms the foundation for life and lifestyle of all plants, animals, and people who lived, currently lived, and will live here in the future.” Lithologically controlled springs such as the one at Spring Hill Ranch influenced siting of buildings and stock ponds. More than 60 stone structures and 60 km (37 mi) of stone fences record the evolution of farming, ranching, and rural life from the mid-19th to mid-20th centuries. More than 100 rock cairns such as those in east Traps pasture have possible archaeological significance; the largest cairns are 1.5 m (5 ft) in diameter. The Schroyer, Threemile, and Florence limestones yield flint, which has geographical and archaeological significance. Paleo-Indians left arrow and dart point, knives, and scrapers, as well as quarry sites where they obtained flint (Hoy 2006). Local Cottonwood Limestone, which weathers into large blocks, was used to build the main ranch house and many of the outbuildings such as the springhouse/smokehouse, outhouse, icehouse, and hen house. A consistent thickness of between 1.5 and 1.8 m (5 and 6 ft) and decorative, fossiliferous (fusulinid) texture made the Cottonwood Limestone ideal building stone. The corners of the three-story barn are also made of Cottonwood Limestone, but the walls are different, possibly Funston or Crouse limestone. In addition, many bridges and culverts in the area are made of local stone.

Present-day quarries are located near Cottonwood Falls, and historic quarries occur within the preserve. Significant quarries, both modern and historic, are shown on the city map; many of these locales are GIS inventoried. Historic and contemporary mining of gravel also occurs in the Cottonwood River.

Kansas Geological Survey geologists used the connections between geology and vegetation to map geologic contacts from aerial photographs: Sharp changes in vegetation indicate the existence of a geologic contact, and subtle changes indicate specific underlying rock units; for example, the sunflower commonly called beggars tick prefers wet areas associated with water-bearing limestones (e.g., Funston Limestone).

Generally speaking, the soils are considerably shallower on the tops of the hills and around rock outcrops. In response to the low moisture and nutrients in shallow soils in these areas, the vegetation is more of a shortgrass “type” with species such as buffalograss (*Buchloe dactyloides*), hairy grama (*Bouteloua hirsuta*), blue grama (*Bouteloua gracilis*), and sideoats grama (*Bouteloua curtipendula*). Going down slope, the soils become less shallow, allowing for more tallgrass species (mixed grass). In the bottomlands, no shortgrass species occur. According to Kristen Hase (Tallgrass Prairie National Preserve), this trend is not entirely consistent across the landscape because tallgrass species occur everywhere, including the hilltops, but shortgrass species do not grow in the lower areas (Kristen Hase, Tallgrass Prairie National Preserve, e-mail correspondence, May 16, 2008).

Kelly Kindscher (Kansas Biological Survey) is studying the vegetation communities on the preserve. He has separated communities based primarily on locations of rock outcrops and shallow soils. His work will document and clarify trends (Kristen Hase, Tallgrass Prairie National Preserve, e-mail correspondence, May

16, 2008). Kristen Hase also suspects that accurate predictions of the distribution of vertebrates, most notably amphibians and reptiles, may be based on geologic features within the preserve.

During scoping, Heather Brown (Tallgrass Prairie National Preserve) said, “Geology is the reason we have prairie left.” The rocky landscape saved the Flint Hills from widespread plowing and helped preserve tallgrass species and soils. The soils, rich in calcium from limestone, also made the Flint Hills “nutritious” for cattle grazing. Ranching remains the dominant agricultural activity in the Flint Hills, with a legacy extending back for more than 100 years. Before this, bison grazed the prairies in the midcontinent. According to preserve staff, cattle fill this niche today. Grazing is a management tool (i.e., allotments with annual leases) to maintain the cultural and natural landscape.

### **Caves and Karst**

Limestone underlies Tallgrass Prairie National Preserve. Although groundwater dissolution enlarges fractures in the limestone, the bedrock layers are generally not thick enough to support large-scale caves. However, small alcoves form in outcrops, for instance in the Threemile Limestone. Scoping participants saw some of these alcoves during the field trip. Though not in the preserve, other areas of the Flint Hills are known for extensive systems of small caves (e.g., Jack Spring Cave in Chase County).

### **Disturbed Lands**

Disturbed lands are those parklands where the natural conditions and processes have been directly impacted by mining, oil and gas production, development (e.g., facilities, roads, dams, abandoned campgrounds, and user trails), agricultural practices (e.g., farming, grazing, timber harvest, and abandoned irrigation ditches), overuse, or inappropriate use. The NPS Disturbed Lands Restoration Program, administered by the Geologic Resources Division, usually does not consider lands disturbed by natural phenomena (e.g., landslides, earthquakes, floods, hurricanes, tornadoes, and fires) for restoration unless the areas are influenced by human activities.

At Tallgrass Prairie National Preserve, the largest areas of disturbed land are the bottomland fields along Fox Creek, which were farmed and are now used for hay production. Nonnative smooth brome (*Bromus inermis*) has replaced native grasses in these areas (Kristen Hase, Tallgrass Prairie National Preserve, written communication, September 5, 2008).

Scoping participants identified some other disturbances at Tallgrass Prairie National Preserve, namely enhanced erosion as a result of human activities. Erosion occurs on the two-track, dirt roads throughout the preserve. Some of these roads are open to the public (foot use); the preserve’s bus tours also use them. During the field trip, participants saw erosion along many of the small drainages, which may be part of natural landscape evolution. These drainages are avenues and conduits for seeps. Erosion also occurs near anything that cattle can rub against such as along fences and at mineral sites (salt licks). Cattle also cause erosion along stream banks and create trails to sources of water.

### **Oil and Gas Development**

The preserve and surrounding area have a history of oil and gas activity starting in 1929. Spring Hill Ranch, called Benninghoven Ranch during this time period, utilized this resource. The Nemaha uplift, which extends through the preserve, dominates the petroleum geology of Chase County. According to Carr (1998), this is the most important feature for both structural and stratigraphic trapping of oil and gas in Chase County. Gas production in the preserve is from very shallow reservoirs (60–120 m [200–400 ft]) that are part of the Davis Gas Field. Scoping participants noted that most of the production in Chase County is west of the preserve; moreover, production of coalbed methane currently does not occur as far west as the preserve. According to Carr (1998), reservoirs within the preserve may have additional potential, but the characteristics of the gas produced probably make development of the resource uneconomical. Furthermore, production from deeper

formations within the preserve would be from poorly defined strata and would be highly unlikely or speculative at best (Carr 1998; O'Dell 2000). Nevertheless, current gas prices may encourage renewed interest in developing gas in the preserve, and the National Park Service is keeping alert. In 1999 Pat O'Dell conducted an inventory of the oil and gas resources within the preserve. He documented 25 oil and gas wells, some of which had denuded sites, including soil contamination, vegetation loss, and eroding creek banks. He also noted a lack of adequate signage for visitor safety.

The mineral interests within the preserve are held by a third party (i.e., the Bank of America and Trust). Because of safety concerns (e.g., small releases of gas from the unplugged wells), preserve staff would like to plug the existing wells. In addition, prescribed fires burn near the wells and could become hazardous, although no problems have occurred to date. Preserve staff would likely request assistance from the Geologic Resources Division during well plugging.

### **Eolian Features and Processes**

During the Pleistocene Epoch, loess (deposits of windblown dust) was undoubtedly a significant part of the landscape. Since then, however, these deposits have eroded and been reworked as part of valley sediments. Winds consistently blow across the landscape and high winds occur, but not much dust is available for transport. Wind does erode the banks of ponds, which cattle traffic has loosened.

The wind poses a concern for preserve staff with respect to development of wind energy. Kansas already has wind farms to the south of the preserve. The concern is primarily for the preservation of the viewshed. From the rolling ridges, visitors to the preserve can enjoy expansive views of prairie, with very few human or natural obstructions. This is a highly regarded value that preserve staff wants to maintain.

The practice of burning dead grass each spring has both natural and cultural roots. The National Park Service continues this practice with annual controlled burns. After fires, windblown ash may inhibit air quality, but this is short lived.

### **Fluvial Features and Processes**

Intermittent and perennial streams dissect Tallgrass Prairie National Preserve; they are the primary driver of landscape evolution. Alluvial/colluvial fans, a widespread alluvial terrace, and a lower and higher floodplain attest to 20,000 years of change in the Fox Creek valley (Mandel 2006). The major streams in the preserve are Fox Creek—a major tributary of Cottonwood River, which bisects the preserve flowing north to south—and Palmer Creek—a tributary to Fox Creek, which is located in the northern portion of the preserve and flows west to east. Both creeks are known to flood, which affects the trails in the bottomlands and low-water crossings. In 2008 the NPS Water Resources Division analyzed the 100- and 500-year floodplains within the preserve for the effects on proposed development (see Martin 2008). Fluvial erosion is also a management concern for the protection of archaeological and paleontological sites along streams (see “Paleontological Resources” section). Fluvial erosion is exacerbated by cattle going to the streams.

Fluvial processes pose a natural resource concern with regards to sediment and nutrient inputs, stream stability, and aquatic life, including the federally endangered Topeka shiner (*Notropis topeka*). However, the issue is not significant enough at this time to warrant mitigation or restoration (Kristen Hase, Tallgrass Prairie National Preserve, written communication, September 5, 2008).

### **Hillslope Features and Processes**

The vast plain in which the preserve is situated yields minimal landslides and rockfall hazards. Gravity-driven processes are primarily associated with fluvial features, for example, slumping along the banks of creeks, many of which can be quite steep. During the field trip, participants also saw the potential for sheet flow along roads.

## Lacustrine Features and Processes

In 1998, contractors completed an inventory of the 26 dams in Tallgrass Prairie National Preserve (Cellier and Stonecheck 1998). These dams are associated with ponds that were constructed in the 1930s for stock use. Some of the ponds are associated with springs. Many of the dams were not properly engineered, which results in minor flooding and erosion. Cattle traffic along the shores of the ponds causes erosion, which is exacerbated by the wind.

## Paleontological Resources

The rocks at Tallgrass Prairie National Preserve are part of the North American Wolfcampian Series of the Permian Period. Globally the Wolfcampian Series is part of the Cisuralian Series (299–270 million years ago). The Permian Period is known for being the time when all the world’s landmasses were joined together into a single continent called Pangaea that spread from pole to pole. A large ocean called Panthalassa covered much of Earth’s surface during this time. Alternating layers of limestone containing siliceous rock (chert/flint) and shale form the Flint Hills and contain abundant remains of shelled marine organisms (Bennett 1984). During scoping, participants mentioned numerous fossiliferous rock units (table 2). They also mentioned stromatolites—dome-like masses of limestone built by marine algae and bacteria; however, participants did not know which formation contains these masses.

**Table 2. Paleontological Resources at Tallgrass Prairie National Preserve**

| Formation           | Member                | Fossils                                             |
|---------------------|-----------------------|-----------------------------------------------------|
| Alluvium            |                       | Bison (see Mandel 2006)                             |
| Colluvium/Alluvium  |                       |                                                     |
| Barneston Limestone | Florence Limestone    | Fossiliferous                                       |
| Matfield Shale      | Blue Springs Shale    |                                                     |
|                     | Kinney Limestone      | Fossiliferous—ostracodes common, gastropod coquinas |
|                     | Wymore Shale          |                                                     |
| Wreford Limestone   | Schroyer Limestone    | Fossiliferous—echinoid spines, crinoids stems       |
|                     | Havensville Shale     | Fossiliferous—brachiopods in “life position”        |
|                     | Threemile Limestone   | Fossiliferous                                       |
| Speiser Shale       |                       | Fossiliferous                                       |
| Funston Limestone   |                       | Fossiliferous                                       |
| Blue Rapids Shale   |                       |                                                     |
| Crouse Limestone    |                       | Fossiliferous—bivalves and snails                   |
| Easily Creek Shale  |                       | Fossiliferous—algal-coated bivalves and brachiopods |
| Bader Limestone     | Middlesburg Limestone | Fossiliferous                                       |
|                     | Hooser Shale          |                                                     |
|                     | Eiss Limestone        |                                                     |
| Beattie Limestone   | Morrill Limestone     |                                                     |
|                     | Florena Shale         | Fossiliferous—brachiopods                           |
|                     | Cottonwood Limestone  | Fossiliferous—abundant wheat grain-shaped fusulinid |
| Eskridge Shale      |                       |                                                     |

Sources: Sawin (2008) and May 14, 2008, GRE scoping notes.

Managers are not too concerned about vandalism or theft of fossil resources in the preserve. As Rex Buchanan stated, “Anything you can get here, you can get somewhere else easier.” The National Park Service has contracted with ReBecca Hunt to conduct an inventory of paleontological resources for the Heartland Network. Information from this inventory will be used in preparing the final GRE report.

## Seismicity

The risk of a large earthquake in the vicinity of the preserve is low. However, historic records document at least 25 earthquakes between 1867 and 1976, and seismographs recorded more than 100 between 1977 and 1989 in Kansas (Steeple and Brosius 1996). Most of these were microearthquakes and too small to be felt. The largest recorded earthquake in Kansas hit the Manhattan area in 1867. It toppled chimneys and cracked foundations and was felt as far away as Dubuque, Iowa (Steeple and Brosius 1996). Closer to Tallgrass Prairie National Preserve, a magnitude IV earthquake on the modified Mercalli scale (magnitude 3 or 3.5 on

the Richter scale) occurred in Ford County, southwest of the preserve, in 1904. In 1929, a magnitude V earthquake on the modified Mercalli scale (magnitude 3.5 or 4 on the Richter scale) was felt in Geary County, north of the preserve. The Kansas Geological Survey has published earthquake intensities for Kansas (DuBois and Wilson 1978); a historic earthquake map is posted at [http://www.kgs.ku.edu/Publications/pic3/pic3\\_1.html](http://www.kgs.ku.edu/Publications/pic3/pic3_1.html).

The Kansas Geological Survey did not map any faults within Tallgrass Prairie National Preserve. Any seismic activity felt within the preserve would probably originate from the 300-million-year-old Nemaha uplift, which extends from Omaha, Nebraska, to Oklahoma City, Oklahoma. The faults that bound the Nemaha uplift are still slightly active today, especially the Humboldt fault zone that passes through east central Kansas. At nearby Fort Riley, dams are built and retrofitted to withstand magnitude 6 (on the Richter scale) earthquakes. Also, Tuttle Creek dam, near Manhattan, is being retrofitted to withstand high magnitude earthquakes.

## **Springs**

Interest in groundwater resources at Tallgrass Prairie National Preserve led to the Kansas Geological Survey to producing a geologic map of the preserve. Rex Buchanan and Bob Sawin conducted a spring survey and identified 236 springs within the preserve and potential aquifers in the Eiss, Funston, Threemile, and Crouse limestones. The final GRE map product includes locations of these springs from Sawin and Buchanan (2008).

Eiss Limestone contains gypsum in the subsurface, but tests have not detected elevated sulfates that would impact the quality of the groundwater in the preserve.

Of management concern is an intermittent spring that runs through the crawl space under the main ranch house, which can be heard during flood events and may be damaging the building's foundation. In order to protect the structure, preserve staff is considering installing a drain system.

## **Interpretive Opportunities**

Interpretive opportunities abound at Tallgrass Prairie National Preserve. The preserve had 23,000 visitors in 2007. This number includes many school groups, particularly in May when one or two groups are scheduled daily. During this time, additional seasonal interpreters are hired. Preserve staff has already incorporated geology into the interpretive program as part of the bus tours, Jr. Ranger Program, and a brochure describing the geology of the Flint Hills. Geologists from the Kansas Geological Survey, for instance Rex Buchanan and Bob Sawin, have conducted geologic training for seasonal staff.

Plans for a new visitor center provide perhaps the greatest opportunity for visitor education of the geologic resources at Tallgrass Prairie National Preserve. The future site is just south of the main ranch area. Preserve staff wants to include an interactive exhibit about geology. Kansas Geological Survey staff will be involved in the planning and have suggested the possibility of using sediment cores, rocks, or fossils as part of the display. Furthermore, the formation of the present topography is an important concept to interpret for visitors. Scoping participants suggested that staff at the Denver Museum of Nature and Science might be a good resource, particularly in light of the diorama at the museum that shows Permian landscapes in the West.

## **References**

- Bennett, D. K. 1984. Fossils. In *Kansas geology: An Introduction to Landscapes, Rocks, Minerals, and Fossils*, ed. R. Buchanan, 96–162. Lawrence, KS: University Press of Kansas (published for the Kansas Geological Survey).
- Bruff, G., P. Budde, K. Butler, S. Cinnamon, M. J. Evans, A. S. Fisher, M. M. Hardt, B. A. Jones, D. Licht, M. Mandell, J. McMillen, S. Miller, J. Neal, G. Oviatt, and D. Sanford. 2000. *Tallgrass Prairie National*

- Preserve, Kansas, general management plan/environmental impact statement, September 2000.*  
Cottonwood Falls, KS: National Park Service, Tallgrass Prairie National Preserve.
- Carr, T. R. 1998. *Report to United States Department of Interior, National Park Service: Petroleum geology and oil and gas operations in Chase County with emphasis on the Tallgrass Prairie National Preserve.* Open-File Report 98-46. Lawrence, KS: Kansas Geological Survey.
- Cellier, B. F., and S. A. Stonecheck. 1998. Dam inventory, Tallgrass Prairie National Preserve, National Park Service, Strong City, Kansas. Project 98-1823, November 20, 1998. Monroeville, PA: Paul C. Rizzo Associates.
- Conard, R., and S. Hess. 1998. *Tallgrass Prairie National Preserve legislative history, 1920–1996.* Iowa City, IA: Tallgrass Historians L.C.
- DuBois, S. M., and F. W. Wilson. 1978. *List of earthquake intensities for Kansas, 1867–1967.* Environmental Geology 2. Lawrence, KS: Kansas Geological Survey.
- Hoy, J. 2006. *America's Tallgrass Prairie National Preserve.* Salina, KS: Kansas Park Trust.
- Mandel, R. D. 2006. *Geomorphology, Quaternary stratigraphy, and geoarcheology of Fox Creek valley, Tallgrass Prairie National Preserve, northeast Kansas.* Open-File Report 2006-29. Lawrence, KS: Kansas Geological Survey.
- Martin, M. 2008. Memorandum to superintendent, Tallgrass Prairie National Preserve (TAPR). L54 (2380), TAPR/General. August 6, 2008. Fort Collins, CO: National Park Service, Water Resources Division.
- O'Dell, P. 2000. Tallgrass Prairie National Preserve, May 25, 1999, trip report. Lakewood, CO: National Park Service, Geologic Resources Division.
- Steeple, D. W., and L. Brosius. 1996. *Kansas earthquakes.* Public Information Circular 3. Lawrence, KS: Kansas Geological Survey. [http://www.kgs.ku.edu/Publications/pic3/pic3\\_1.html](http://www.kgs.ku.edu/Publications/pic3/pic3_1.html).
- Sawin, R. S. 2008. *Surficial geology of the Tallgrass Prairie National Preserve, Chase County, Kansas.* M-119A. Scale 1:12,000. Lawrence, KS: Kansas Geological Survey.
- Sawin, R. S., and Buchanan, R. C. 2008. *Water-bearing units of the Tallgrass Prairie National Preserve, Chase County, Kansas.* M-119B. Scale 1:12,000. Lawrence, KS: Kansas Geological Survey.
- Wilson, F. 1984. Landscapes: A geologic diary. In *Kansas Geology: An Introduction to Landscapes, Rocks, Minerals, and Fossils*, ed. R. Buchanan, 9–39. Lawrence, KS: University Press of Kansas (published for the Kansas Geological Survey).
- Young, C., P. Adams, M. DeBacker, and M. Williams. 2004. Heartland Network vital signs monitoring plan: Phase II report. Fort Collins, CO: United States Department of the Interior, National Park Service, Inventory and Monitoring Program.

**Table 3. GRE Scoping Participants for Tallgrass Prairie National Preserve**

| <b>Name</b>       | <b>Affiliation</b>                                                 | <b>Title</b>                                | <b>Phone</b> | <b>E-Mail</b>                                                              |
|-------------------|--------------------------------------------------------------------|---------------------------------------------|--------------|----------------------------------------------------------------------------|
| Heather Brown     | Tallgrass Prairie National Preserve                                | Chief of Interpretation                     | 620-273-8494 | <a href="mailto:heather_brown@nps.gov">heather_brown@nps.gov</a>           |
| Rex Buchanan      | Kansas Geological Survey                                           | Deputy Director                             | 785-864-2106 | <a href="mailto:rex@kgs.ku.edu">rex@kgs.ku.edu</a>                         |
| *Lynne Burns      | Tallgrass Prairie National Preserve                                | Interpreter                                 | 316-284-1045 | <a href="mailto:lynnellenburns@nps.gov">lynnellenburns@nps.gov</a>         |
| Nick Callaghan    | Kansas Geological Survey and Data Access and Support Center (DASC) | GIS Analyst                                 | 785-864-2132 | <a href="mailto:nick@kgs.ku.edu">nick@kgs.ku.edu</a>                       |
| Tim Connors       | Geologic Resources Division                                        | Geologist                                   | 303-969-2093 | <a href="mailto:tim_connors@nps.gov">tim_connors@nps.gov</a>               |
| Kristen Hase      | Tallgrass Prairie National Preserve                                | Chief of National Resources                 | 620-273-6034 | <a href="mailto:kristen_hase@nps.gov">kristen_hase@nps.gov</a>             |
| ReBecca Hunt      | Geologic Resources Division and Augustana College                  | Paleontologist<br>Research Associate        | 309-798-6016 | <a href="mailto:rkhynt.nps.pale.@gmail.com">rkhynt.nps.pale.@gmail.com</a> |
| Katie KellerLynn  | Colorado State University                                          | Geologist/Research Associate                | 801-608-7114 | <a href="mailto:katiekellerlynn@msn.com">katiekellerlynn@msn.com</a>       |
| *Rolfe Mandel     | University of Kansas and Kansas Geological Survey                  | Associate Professor & Associate Scientist   | 785-864-2171 | <a href="mailto:mandel@kgs.ku.edu">mandel@kgs.ku.edu</a>                   |
| *Dianna McKeage   | Tallgrass Prairie National Preserve                                | Interpreter                                 | 208-358-3859 | <a href="mailto:dianna_mckeage@nps.gov">dianna_mckeage@nps.gov</a>         |
| Stephen Miller    | Tallgrass Prairie National Preserve                                | Superintendent                              | 620-273-6034 | <a href="mailto:stephen_t_miller@nps.gov">stephen_t_miller@nps.gov</a>     |
| MaryBeth Murawski | Tallgrass Prairie National Preserve                                | Administrative Technician                   | 620-273-6034 | <a href="mailto:mary_murawski@nps.gov">mary_murawski@nps.gov</a>           |
| Lisa Norby        | Geologic Resources Division                                        | Geologist                                   | 303-969-2318 | <a href="mailto:lisa_norby@nps.gov">lisa_norby@nps.gov</a>                 |
| Billy Robb        | Tallgrass Prairie National Preserve                                | Biological Technician                       | 620-273-8494 | <a href="mailto:billy_robb@nps.gov">billy_robb@nps.gov</a>                 |
| Tobin Roop        | Tallgrass Prairie National Preserve                                | Chief of Maintenance and Cultural Resources | 620-273-6034 | <a href="mailto:tobin_roop@nps.gov">tobin_roop@nps.gov</a>                 |
| Bob Sawin         | Kansas Geological Survey                                           | Geologist                                   | 785-864-2099 | <a href="mailto:bsawin@kgs.ku.edu">bsawin@kgs.ku.edu</a>                   |

\*Field trip only.