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Emporia State University's Natural Areas: A general overview of the areas and research pertaining to hydrogeology and climate change

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Emporia State University (ESU) manages eight sites (5 – 81 ha) that serve as outdoor laboratories for our students, faculty, and visiting scientists. The sites provide regional representation of major ecological communities, including tallgrass prairie, forest, streams, ponds, and wetlands. The sites have been used for decades, with the oldest site, the Ross Natural History Reservation, having been acquired in 1958. Common uses of our Natural Areas include field courses in ecology, botany, zoology, geospatial analysis, soil science, geology, and hydrology. Recent research has included investigations of hydrogeology of the Neosho and Cottonwood River basins and the effects of shrub encroachment on carbon dynamics in tallgrass prairie. The former has included long-term monitoring of rivers and groundwater at ESU's on-campus Hydrogeology Teaching and Research Station. Hydrologic conditions at a newly acquired, riverine wetland site in the Flint Hills are also currently under investigation.

Introduction

The mission for Emporia State University's (ESU) Natural Areas (http://www.emporia.edu/naturalareas/) is to provide sites for teaching, research, and preservation of natural ecological communities. The ESU Natural Areas system spans four contiguous counties in east-central Kansas – the main campus in Emporia being centrally located to the sites – in a region that lies at the ecological transition between eastern deciduous forests and western prairies of the Great Plains. Mean annual temperature and precipitation at Emporia, Kansas (central to the sites) are 19.3 °C and 92.5 cm, respectively (1981-2010, Emporia, Kansas) (NOAA 2014). The areas range in size from the 5-ha Campus Woods to the 81-ha Ross Natural History Reservation. Three sites are composites of grassland and woodland, three sites are primarily forested, and two sites are designated as wetlands. Most areas remain undeveloped, lacking any sort of unnatural infrastructure; the exception being the headquarters facilities at the Ross Natural History Reservation.

Recent research on hydrogeology and ecosystem function pertaining to climate change at ESU's Natural Areas could provide insight into environmental changes that might occur with global climate change. Our sites and facilities also provide platforms in the geographical array of academic field stations across Kansas for use in cross-site studies pertinent to climate variability.

The following is a profile of each of the eight Natural Areas, including biological and physical descriptions of the sites. The profiles are listed in chronological order of the date of acquisition by ESU. Within the theme of the symposium on Ecohydrology and Climate Change, held at the 2014 annual meeting of the Kansas Academy of Science at Emporia State University, we have highlighted pertinent research activities that have occurred at ESU's Natural Areas.

Campus Woods

The only designated Natural Area on the ESU campus proper is Campus Woods, a 5-ha tract of predominately riparian forest along the

Neosho River. It is located on a floodplain at the far north end of the university campus, north of Interstate I-35, and adjacent to the university's Trussler Sports Complex. The terrestrial environment is completely forested except for a 0.1-ha marsh at the southern edge of the site. Dominant tree species on the site include bur oak (*Quercus macroarpa*), hackberry (*Celtis occidentalis*), elms (*Ulmus* spp.), and cottonwood (*Populus deltoides*). The site is bound within a bend of the Neosho River that includes a few riffles at normal flow levels, but mostly pools through the length of the stream bordering the site. The site is publicly accessible and includes a hiking trail, interpretive signs, and a picnic area.

Stream flow in the Neosho River at ESU is regulated by flood-control and water-supply impoundments located approximately 32 km upstream and 42 km downstream of Campus Woods. The floodplain is underlain by an alluvial aquifer, which terminates 500 m to the south along a bedrock margin in the heart of the ESU campus. Characterization of the alluvial sediments and the associated Quaternary depositional history has been the subject of multiple ESU student research projects (e.g. Barnett, Musgrove and Schulmeister et al. 2006; Milner and Schulmeister 2007; Barker, Schulmeister and Dulaney et al. 2010; Jeannotte, Schulmeister and Dulaney 2010). The sediments are composed of 9 to 10 m of clay, overlying 1 to 3 m of sand and gravel. These units grade laterally to a single, 30-m, silty-clay unit with thin, interbedded sand lenses near the river (Hess, Schulmeister and Love 2005; Barker, Schulmeister and Dulaney et al. 2010). In 2004 and 2007, 12 on-campus, groundwater monitoring wells and 6 multilevel samplers were installed in the sand and gravel for environmental and hydrogeologic research and teaching purposes as part of ESU's Hydrogeology Teaching and Research Station (Schulmeister 2005). In 2009 and 2013, additional wells and multi-level samplers were installed immediately adjacent to the south bank of the river, approximately 500 m upstream of the Campus Woods trail. Continuous, automated groundwater monitoring of these wells has allowed for detailed examination of groundwater-surface water interaction in response to climate change. Groundwater levels, temperature, and near-stream water chemistry respond to three orders-of-magnitude variations in stream flow volume caused by drought, floods, and regulated stream flow (Flory, Schulmeister and Larsen 2007; Petty and Schulmeister 2011; Barlow and Schulmeister 2013). The impact of the 2009-2012 drought on the near-stream aquifer environment at ESU is described in greater detail elsewhere in this special volume (see Schulmeister and Barlow in this volume).

F.B. and Rena G. Ross Natural History Reservation

The F.B. and Rena G. Ross Natural History Reservation (Hartman 1960; Breukelman, Eddy and Hartman 1961; Spencer 1980; Harrell, Aber and Sleezer 2007) was the first Natural Area off the main campus to be acquired by ESU. The site is 81 ha of native and restored tallgrass prairie, shrubland, and woodland, including a stream, springs, ponds, and other habitats located approximately 24 km northwest of the University's main campus. The area was donated to the University in 1958. Approximately 40% of the original tallgrass prairie was plowed in the early 1900s, but cultivation on the site ceased in the mid-1900s. Several ha of unplowed tallgrass prairie remain on the site. Facilities include a climate-controlled building with a classroom, a wet lab and restrooms, as well as outdoor picnic facilities. The building was renovated in 2015 to enhance its capacity to host on-site coursework as well as special events, such as meetings of professional societies.

The Ross Natural History Reservation has been used to evaluate ecosystem-level impacts of vegetative change from an ecosystem dominated

by warm-season grasses to one increasingly encroched upon by shrubs. This shift in vegetative structure has numerous potential causes, one of which is climate change (Archer, Boutton and Hibbard et al. 2001; Briggs, Knapp and Blair et al. 2005). The expansion of shrubs throughout grasslands of the Midwest is expected to continue, if not accelerate, under future climate change scenarios (Archer 1995). Lyon (2011) studied how the shift from a grass-dominated to a shrub-dominated system would impact soil carbon storage by investigating the quality and rate of carbon inputs and losses under both vegetative environments. Decomposition rates of shrub leaf litter were much higher than grass leaf litter. In addition, both vegetation types decomposed at a faster rate within a shrub dominated environment. Subsequent analysis of stable carbon isotope ratios of leaf litter types and soil carbon under both vegetation types revealed that shrubs have not significantly contributed to the soil carbon pool.

Reading Woods Natural Area

Reading Woods is a 15-ha tract of upland and lowland deciduous forest, located near the town of Reading, Kansas, about 24 km northeast of Emporia. The plant community on the site is characteristic of forests throughout much of eastern Kansas and Missouri. Because of its unique flora, fauna, and geological features, Reading Woods is maintained as a preserve in a relatively undisturbed state. The university acquired the land in 1971.

Sarah Howe Natural Area

"Howe Woods" is a 5-ha tract of forest in eastern Lyon County that contains several large bur oak trees, however, fire suppression (the site is surrounded on the east, west, and north by two homesteads and a road, respectively) has allowed understory succession by elms and other fire-intolerant trees. The area is maintained as a preserve at the request of Sarah Howe who deeded the land to the University in 1982.

Charles Coughlen Natural Area

Acquired in 1985, the Coughlen Natural Area is an 18-ha tract of tallgrass prairie located 14.5 km southwest of Emporia along Interstate I-35. It consists of mostly native and restored tallgrass prairie, with a riparian woodland, an upland spring, and a stream with a small impoundment. The demarcation of unplowed and previously-plowed prairie is not distinct, but terraces are vaguely evident on the site. The stream is relatively pristine upstream and downstream of the small (0.5 ha) impoundment. The title to the land is held by the ESU Foundation, but the site is managed by ESU.

Hamilton Fossil Quarry

Hamilton Fossil Quarry is a 21-ha tract approximately 5 km east of Hamilton in Greenwood County that was acquired by ESU in 1996. Formerly the location of a commercial rock quarry, the property includes numerous fossil sites that have yielded a large, world-famous collection of late Pennsylvanian-age fossilized vertebrates, invertebrates, and plants, as well as microfossils. Many of the area's fossils are exhibited in ESU's Johnston Geology Museum in Cram Science Hall.

Dunlap Bottoms

One of two new wetland Natural Areas, this 50-ha tract in southeastern Morris County was restored from cropland to a wet meadow of native, warm-season grasses under the U. S. Department of Agriculture's Wetlands Reserve Program (WRP) (as a permanent easement) by a previous landowner in 2005. The Dunlap Bottoms and Neva Marsh sites were donated to ESU in 2008. The titles to both sites are held by the ESU Foundation, but the areas are managed by ESU.

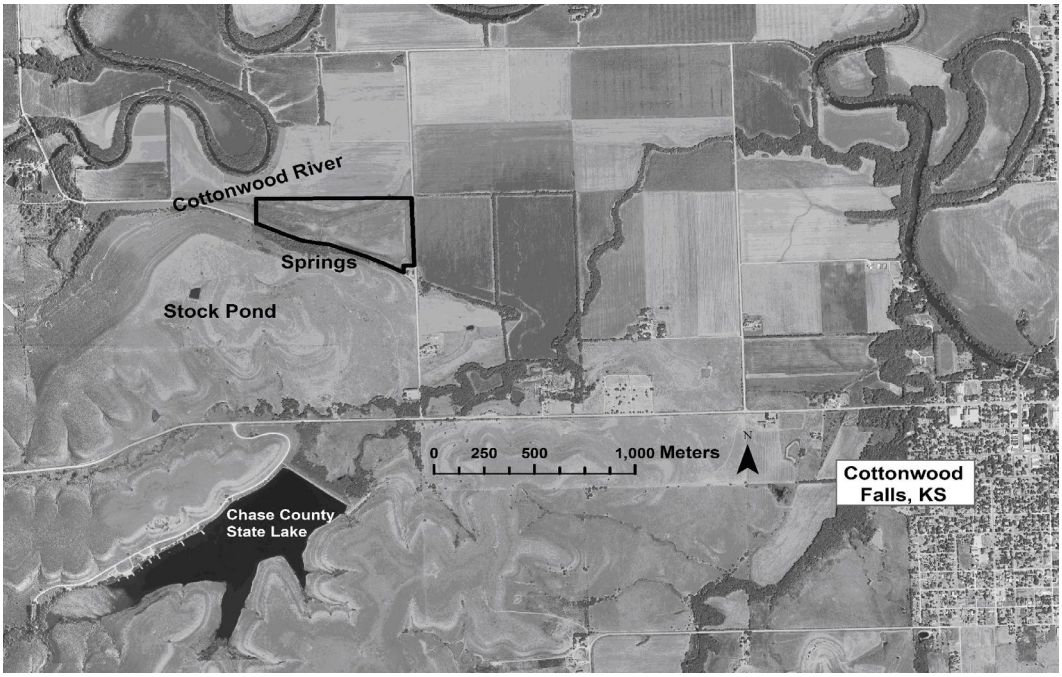

Figure 1. Geomorphic and hydrologic features of importance at Emporia State University's Neva Marsh (black border) near Cottonwood Falls, Kansas.

Neva Marsh

Another newly acquired wetland site, the 21-ha Neva Marsh, is located on the Cottonwood River floodplain in the Flint Hills of Chase County. Also enrolled in a WRP permanent easement, the site's broad, shallow impoundments support aquatic vegetation and wildlife. Native, warm-season grasses were also reseeded on the area. The site was restored to a wetland in 2005, though much of what, historically, had been the wetter, western portion of the area was not regularly farmed and thus had more fallow vegetation and less-intensively disturbed soils.

The site's floodplain margin location provides an opportunity to examine hydrogeologic response to climatic events during a wetland restoration process. The riverine depression wetland (Brinson 1993) receives partial recharge from upland spring water sources. Permian limestone and shale strata (Moore, Jewitt and O'Connor 2004) rise 150 m above the immediate southern boundary of the marsh. The site is underlain by the Osage silty clay loam (USDA 2009) and Quaternary alluvial sediments of the Cottonwood River (O'Conner 1951). Intermittent upland limestone springs provide an important seasonal source of recharge to the marsh (Figure 1). A bend in the Cottonwood River, approximately 100 m from the northwest corner of the site, supplies additional occasional flood water to the marsh. Low to moderately-low soil transmissivity (0 to 1.5 cm/hr; USDA 2009) retards vertical infiltration of rainfall, sustaining the marsh during normal to wet years. The timing and duration of each recharge source is influenced by meteorological and hydrological drought and flood conditions, and is important to the wetland's management. Current research (Drake 2009) is exploring the hydrologic controls on the fate of nutrients and agricultural chemicals in the marsh.

Conclusion

Emporia State University's Natural Areas provide several sites suitable for research on hydrology, climate change, and myriad other

scientific investigations. Though the sites are individually small (5-81 ha), they span a variety of natural ecological communities across four counties in east-central Kansas. Emporia State University welcomes visiting scientists to conduct their research or teaching activities on our Natural Areas. For access to ESU's Natural Areas or to arrange a tour, visit our website at http://www.emporia.edu/naturalareas/ or call 620-341-5311.

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