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Notes on Three Palustrine Natural Community Types in the Arkansas Ozarks

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The activity of phosphodiesterase in the starting medium and in a partially purified ammonium sulfate pellet is shown in Table 1. The same table also shows that this enzyme is heat stable, retaining up to 84% of the unheated activity after exposure to a boiling water bath for 5 min. Extracellular cyclic AMP phosphodiesterase from the same organism was previously shown to also be heat stable (Lynch and Farrell, 1985). Table 1 shows heat resistance at 5 min but gives no indication of how long the enzyme can withstand exposure to 100°C. Figure 1 shows cyclic GMP phosphodiesterase activity remaining after heating for up to twenty minutes in a boiling water bath. Both the starting medium and the ammonium sulfate pellet retained almost full phosphodiesterase activity even after twenty minutes of exposure to heat.

The effect of various compounds on partially purified cyclic GMP phosphodiesterase activity is shown in Table 2. MIX, theophylline and caffeine are all competitive inhibitors of phosphodiesterase. All three compounds inhibited enzyme activity with MIX being the most potent. Chlorpromazine (a phenothiazine) and Compound 48/80 (a condensation product of N-methyl-p-methoxy-phenethylamine with formaldehyde) are thought to inhibit calmodulin dependent phosphodiesterase by binding to calmodulin (Levin and Weiss, 1976; Gietzen et al., 1983). Both of these compounds stimulated plasmodial cyclic GMP phosphodiesterase. The mode of action of these two compounds on this enzyme is unknown.

Table 3 shows cyclic GMP phosphodiesterase activity at various pH values. a pH of 7.0 showed maximum enzyme activity with markedly reduced activity at pH 4.0 and 5.0. This is similar to cyclic AMP phosphodiesterase from the same organism in that the optimum pH for enzyme activity does not coincide with the optimum pH for growth. Uninoculated growth medium had a pH of 4.3 and after inoculation and growth, the pH of the medium rose to between 5 and 6. Under the growth conditions, cyclic GMP phosphodiesterase should be relatively inactive during the early stages of growth (the first few days after inoculation). Then, as the pH increases and approaches 5.0, the enzyme should become increasingly active.

All the previous enzyme assays were done using the resin assay which measures ^{3}H-guanosine as the end product. To insure the validity of our heat stability data, an alternate procedure for measuring phosphodiesterase activity was utilized. This procedure involved separating the product of phosphodiesterase (^{3}H-5′-GMP) by paper chromatography. Figure 2 shows a continuous assay of cyclic GMP phosphodiesterase for both heated and unheated samples as measured by paper chromatography. As can be seen, the heated sample retained enzymatic activity and product accumulation was linear with time.

As mentioned previously, extracellular cyclic AMP phosphodiesterase from the same organism is also heat stable. Work is presently underway in our laboratory to determine if the cyclic AMP enzyme is a di tinct protein from the cyclic GMP phosphodiesterase reported here and whether the two enzymes are indeed one and the same protein.

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NOTES ON THREE PALUSTRINE NATURAL COMMUNITY TYPES IN THE ARKANSAS OZARKS

Within the last five years three distinct palustrine (*sensu* Cowardin et al., 1979) community types not previously described in the literature as occurring in Arkansas have been recognized by the authors. The two fen community types have been reported previously in the Ozark Plateaus of southeastern Missouri (Orzell, 1983). Each of the recognized community types occur within the Ozark Natural Division (Pell, 1983) and is largely restricted to that part of the state. This paper represents an attempt to describe and classify these little-known natural communities.

The basis for our classification is the repeated occurrence on the landscape of particular combinations of vegetation structure and physiognomy, soil moisture regime, soil reaction, geologic substrate, topographic position, and species composition. Species composition, though obviously important, is not an overriding concern; in fact, examples of a given "natural community type" may vary considerably in this respect. A natural community classification emphasizes consistent ecological differences, not those due to the vagaries of dispersal or disturbance history. In many cases, more traditionally defined "plant community types" may be recognized within each natural community type.

The natural community descriptions presented here include information on distribution, topography, soils, community size and structure, natural processes, status and threats, and dominant and characteristic plant species. Dominant plants are species consistently occurring as major vegetation components (relative cover > 25 percent, based on visual estimates) of the type, though they need not dominant every example of that type. Characteristic plants are those typical or representative species that provide a reliable indicator of a given type. Dominant and characteristic species are not necessarily restricted to the types but, when considered together with other natural features, are diagnostic. Characteristic species were identified by constructing synthesis tables from species checklists compiled during field surveys (Mueller-Dombois and Ellenberg 1974). Fourteen streamside seep-fens, one sedge-shrub fen (only known example in Arkansas), and ten upland hydric forests served as the study sites. Specific locations and voucher specimen data for these sites are available from the Arkansas Natural Heritage Commission. Plant nomenclature follows Kartesz and Kartesz (1980).

STREAMSIDE SEEP-FENS

Topography, Hydrology, and Soils

Streamside seep-fens are located along second and third order Ozark streams, usually within deeply dissected, relatively small drainage basins. These streams have a permanent flow of clear, cold, minerotrophic water, sustained by diffuse seepage or discrete seep-springs. They are usually medium- to high-gradient streams of shallow depth, with a bedrock floor of Ordovician dolomite. Potholes, shallow pools alternating with shallow runs, rock terraces with small cascading waterfalls, and small sand-gravel alluvial deposits are common features.

Seep-fens are generally along the upper reaches of these streams, either on adjacent sideslopes, along narrow streamside corridors, or on exposed bedrock in the stream bed. Soil moisture is dependent upon seasonal fluctuations; in dry weather free surface water may be absent but soil remains damp, with pockets of permanent seepage. Shallow organic muck or mineral soil or a mixture of muck, sand, and cherty residuum derived from weathered dolomitic parent material forms the substrate. Bedrock strata—primarily Powell, Cotter, or Jefferson City dolomite (Lower Ordovician), but sometimes St. Peter Sandstone (Middle Ordovician)—are occasionally exposed.

Natural Processes

The rooting zone is occasionally to constantly saturated by cold, minerotrophic groundwater. Chemical and physical weathering of the bedrock produces a calcareous substrate. The microclimate is strongly moderated by cold water springs, late spring frosts, and early autumn frosts. Fluctuations in stream discharge periodically scour the streamside, creating areas almost "permanently" in a pioneer stage of succession.

Community Structure

Microassociations of fen calcicoles occur along narrow streamside corridors or on exposed bedrock in the streambed. The prevailing cover consists of sedges or mixed graminoids. The sedges are usually less than 30 cm tall and often form tussocks. Grasses and heliophytic forbs are medium to tall in height and often are most conspicuous in autumnal aspect. Shrubs may be present as well.

Dominant Plants

Gravelly seepage areas - *Fuirena simplex* Vahl, *Parnassia grandifolia* DC., *Rudbeckia fulgida* Ait. var. *umbrosa* (C.L. Boynt. & Beadle) Cronq., *Senecio aureus* L., and *Calamintha arkansana* (Nutt.) Shinners. Seep springs - *Justicia americana* (L.) Vahl, *Nasturtium officinale* R. Br., and *Carex torta* Boott.

Characteristic Plants

Carex hystricina Muhl. ex Willd., *C. lurida* Wahlenb., *Equisetum hyemale* L., *Oxypolis rigidior* (L.) Raf., *Scirpus americanus* Pers., *S. lineatus* Michx., *S. atrovirens* Willd., *Selaginella apoda* (L.) Fern., *Cornus amomum* P. Mill. ssp. *obliqua* (Raf.) J.S. Wilson, *Helenium autumnale* L., *Lobelia siphilitica* L., *Lysimachia quadriflora* Sims. and sometimes *Rhynchospora capillacea* Torr.

It appears that streamside seep-fens provide migrational routes for fen calcicoles in the Ozark region and refugia for extraneous taxa having north-central, northeastern, and southeastern geographic affinities. Plant taxa generally found in the Arkansas Ozarks only in streamside seep-fens include *R. capillacea* (Marion, Baxter, Stone, and Sharp counties), *Scleria verticillata* Muhl. ex Willd. (Sharp Co. and, historically, Benton Co.), *Mimulus ringens* L. (Baxter, Fulton, and Sharp counties), *Solidago riddellii* Frank (Sharp Co.), *Plantago cordata* Lam. (Baxter and Randolph counties), *Spiranthes lucida* (H.H. Eat.) Ames (Baxter, Stone, Marion, and Izard counties), and *Pycnanthemum virginianum* (L.) Durand & Jackson (Sharp and Fulton counties). If *Salix sericea* Marsh. (Fulton Co., historically) is relocated in the state, it probably will be associated with seep-fens.

Distribution and Size

Streamside seep-fens are found principally in the Salem Plateau subdivision and less frequently in the Springfield Plateau subdivision of the Ozark National Division. Seep-fens presently are known to occur in Marion, Baxter, Fulton, Izard, Sharp, Stone, and Randolph counties. They are to be expected in surrounding counties, especially Independence, Lawrence, and Searcy. Seep-fens are well developed along second- or third-order streams in the North Sylamore Creek watershed (Stone Co.) and the Spring River watershed (Fulton and Randolph counties). Seep-fens in the Salem Plateau of adjacent southeastern Missouri were recently described by Orzell (1983). Individual streamside seep-fens are generally small in extent, ranging from 0.1 ha to 2.0 ha in size, but may occur intermittently along several miles of stream.

Status and Threats

The type is uncommon, and undisturbed high-quality examples are becoming increasingly rare. Threats include clear-cutting, siltation, water pollution, grazing, and reservoir construction. Some seep-fens in the Sylamore District of the Ozark National Forest are fairly well protected as part of a special interest area but these may eventually become subject to recreational pressures.

SEDGE-SHRUB FEN

Topography, Hydrology, and Soils

Sedge-shrub fens are located on toeslopes near upper to middle reaches of gaining streams of moderately to deeply dissected valleys. The groundwater arises from a shallow, unconsolidated aquifer in the weathered porous residuum of the surrounding uplands and is minerotrophic and circumneutral. Soils are saturated, bog-like, and produce a quaking sensation when traversed by foot. Poor internal drainage may result in shallow pooling of water. Depth of the saturated muck or mucky peat may exceed 2 m. Underlying material is gravelly alluvium and colluvium.

Natural Processes

The soil is constantly saturated by minerotrophic water. Fens are rarely inundated and would be destroyed by prolonged flooding. In presettlement time fires retarded invasion by woody plants; windthrow and anaerobic soil conditions continue to afford this community some resistance to woody invasion.

Community Structure

Sedge-shrub fens consist of a sedge mat with rushes, cattails, and forbs intermixed, mats of dense "brown mosses," and patches of medium to tall shrubs. The sedges are short to medium in height and either caespitose or tussock-forming. Shrubs, mostly *Salix* spp., form thickets or are scattered throughout. Species diversity in undisturbed sedge-shrub fens is relatively high.

Dominant Plants (based on one known example in Arkansas)

Rhynchospora capillacea, Carex stricta Lam. var *strictior* (Dewey) Carey, *Rudbeckia fulgida* var. *umbrosa, Typha latifolia* L., *Boehmeria cylindrica* (L.) Sw., *Impatiens capensis* Meerb., and *Salix* spp. (the last three occur primarily in thickets). Other plants found at this site, but not dominant in the community, include *Oxypolis rigidior, Senecio aureus, Lobelia siphilitica, Lysimachia quadrifolia, Carex hystricina, C. lurida, Scirpus atrovirens, S. lineatus, Castilleja coccinea* (L.) Streng., and *Helenium autumnale.*

Status and Threats

High quality, undisturbed fens are extremely rare. Threats include grazing pressure, ditching, clearing for cultivation, road-, pond-, and reservoir-construction, excessive well drilling, pumping, dewatering of shallow aquifers, and damage by off-road vehicles. The single Arkansas example is protected, insofar as possible, by the U.S. Army Corps of Engineers (Little Rock District).

UPLAND HYDRIC FORESTS

Topography, hydrology, and soils

Upland hydric forests occur in shallow depressions isolated on broad saddles or benches at elevations of 335 to 580 m (ca. 1100-1900 ft). They are underlain by the basal sandstone member of the Atoka Formation (Pennsylvanian). Soils are deep, poorly drained, slowly permeable, and nearly level. They usually form in silty or clayey deposits and are underlain by a fragipan. The source of water for these communities is precipitation, which pools generally 0.3 to 0.9 m during the winter for several months. Water levels are considerably lower during the summer, except after periods of heavy rainfall, and the depressions often lack standing water during the summer.

Natural Processes

The degree of wetness is variable, largely dependent on precipitation and evapo-transpiration.

Community Structure

Upland hydric forests in the Boston Mountains have a semi-open canopy of medium height (19-27 m) and generally lack an understory. Vines often form a tangled thicket near the edge of the saturated soil zone, especially if heavily disturbed historically by timber practices. Ground cover sometimes consists of vines, bryophytes, and mixed sedges or spikerushes, but is generally species-poor.

Dominant Plants

Quercus lyrata Walt. and/or *Quercus palustris* Muenchh. in the overstory.

Characteristic Plants

Liquidambar styraciflua L., *Nyssa sylvatica* Marsh., *Acer rubrum* L., *Fraxinus pennsylvanica* Marsh., and species of *Sphagnum* and *Polytrichum* moss. Other plants found in association include *Cephalanthus occidentalis* L., *Lyonia ligustrina* (L.) DC., *Eleocharis obtusa* (Willd.) Schultes, *Cyperus strigosus* L., *Carex lurida* Wahlenb., *Bidens aristosa* (Michx.) Britt., and *Helenium autumnale* L.

Distribution and Size

This community type is known from Johnson, Pope, Madison, and Newton counties and has been reported from Searcy, Van Buren, and Cleburne counties, all in the Boston Mountain subdivision of the Ozark Natural Division. It has also been reported from Magazine Mountain (Logan County) in the Arkansas Valley Natural Division. Representative stands are 0.4 ha to 1.8 has in size. Similar upland communities dominated by *Quercus phellos* L. have been observed in the Arkansas Valley (Cleburne Co.)., the Boston Mountains (Searcy and Van Buren counties), and the Ouachita Mountains (Saline and Perry counties). Because additional research is needed to document the species composition, hydrologic relations, and distribution of these upland willow oak forests, they are not discussed further in this paper.

Status and Threats

Unaltered examples are rare. Threats include timber cutting, artificial drainage, and damming to create year-round wildlife ponds. Two quality occurrences of this type in Pope County are protected as part of the recently-designated East Fork Wilderness Area.

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