determine that flower visitation does not equal pollination. Kyra found that in *Oenothera*, there are many species of insects that may visit a flower but only a few species are actually carrying the pollen.

Oenothera species appear to have a much more specialized pollination system than once believed. For example, hawk moths (Sphingidae) have been found to be the primary pollinator of yellow evening primrose, *Oenothera flava*. This plant blooms at night when the pollinator is active. However, a closely related species, little evening primrose, *O. perennis*, is pollinated during the day by flower flies (Syrphidae) and small bees. Skipper butterflies, bumblebees and honeybees were found to pollinate other species of *Oenothera*. One observation Kyra made was that if a flower was not pollinated at night by its primary pollinator, the flower stayed open and was pollinated the next morning by a day-flying insect.

***Manduca quinquemaculata* (five-spotted hawkmoth) (at flower) and *Sphinx eremitus* (hermit sphinx) (above) at flowers of *Oenothera macrocarpa*. Photo by Kyra Krakos.**

Kyra's research is nearing completion. At this point she believes she has collected enough data to make some very compelling ecological stories about *Oenothera* and their pollinators. With the data, Kyra hopes to be able to add insight into pollination systems in general. One point of note! Future pollination studies by other researchers are likely going to need additional data besides simple identification of insects visiting the flower. Actual pollen loads and ultimately pollen transfer data will be necessary to determine which species are the true pollinators of any plant. In the final year, she will be compiling all the data for a final dissertation. We in the WGNSS Entomology Group wish her success in this endeavor!

Sanctuary for the Betulaceae[1]

Ted C. MacRae

Nestled on the eastern side of the St. Francois Mountains, where the craggy exposures of the Ozarks most ancient rocks begin to subside underneath the Cambrian sandstones laid down over them, lies Hawn State Park—considered by many to be the loveliest of Missouri's state parks. I have written previously about Hawn—in fact, it was the subject of my very first post on this blog. I have long treasured Hawn for its excellent insect collecting, diversity of plants and habitats, and unbridled beauty. I have hiked the incomparable Pickle Creek and Whispering Pine Trails many times—far more than any other trail in the state, and each time I fall more deeply in love with what, to me, represents the essence of the Missouri Ozarks in their most pristine state.

The charm of Hawn results from a unique combination of geological features. The Lamotte sandstone outcrops that dominate Hawn's landscape are the oldest sedimentary rocks in the state, formed from coarse sand deposits that were laid down over the Precambrian rhyolites and granites that form the core of the St. Francois

Lamotte sandstone exposure along Pickle Creek Trail.

Mountains. These sand deposits were themselves buried under limestone and dolomite layers

[1] Reprinted from an article posted February 25, 2009 on the author's website: http://beetlesinthebush.wordpress.com. All photos by the author.

formed at the bottom of vast seas that later covered much of the interior of the continent. Subsequent periods of uplift and erosion once again exposed these sandstones, whose unique ability to hold groundwater has resulted in the formation of spring-fed streams that have cut deep into their soft layers to create canyon-rimmed valleys with tall vertical cliffs.

Igneous rhyolite "shut-ins" along Pickle Creek Trail.

One of these streams is Pickle Creek, which is fed throughout the year by Pickle Spring and has in some places cut all the way down to the underlying igneous rock to form "shut-ins." In contrast to the slow, sandy-bottomed stretches where Pickle Creek is still cutting through sandstones, the water in these igneous shut-ins rushes through narrow openings in the highly resistant rock. The igneous and sandstone exposures found in Hawn are spectacularly beautiful and support a unique flora due to the acid soils they produce. One group of plants that has taken sanctuary in these moist, acid soils is the Betulaceae, or birch family. Missouri is home to five native species of Betulaceae[1], and while none of them are extraordinarily uncommon they are limited in their occurrence to natural communities with sufficient moisture and exhibit a clear preference for acidic soils. This confluence of conditions occurs perfectly along Pickle Creek, allowing all five native species to grow here side-by-side—a betulaceous "hot spot" that represents not only the full diversity of the family in Missouri, but also the total generic diversity of the family in North America. In fact, only one other genus (*Ostryopsis*, shrubs related to *Corylus* and restricted to China) is assigned to the family on a global basis (Furlow 2004).

The Betulaceae are deciduous trees and shrubs that occur primarily in the boreal and cool temperate zones of the Northern Hemisphere, although outposts are also known from high elevations in the Neotropics and, as mentioned above, China. Fossils of this ancient lineage of flowering plants are traceable to the late Mesozoic (upper Cretaceous), and the family appears to form a clade with hamamelidaceous plants. As would be expected from a group with boreal affinities, most species exhibit adaptations for survival in cold climates, such as small stature, shrubby growth habits, and small leaves. Several of Missouri's species have performed well and gained acceptance as ornamental trees and shrubs, while others are important as sources of hazelnuts (genus *Corylus*) or ecologically for their ability to fix nitrogen (genus *Alnus*).

My interest in these plants has nothing to do with their economic importance, but rather in their role as host plants for several rarely encountered species of woodboring beetles. Often, insects in this group may be collected on foliage of their hosts during the summer, making host identification fairly easy due to the presence of leaves. This is not always possible, however, due to limited periods of adult activity or low population densities. Rearing these insects from their hosts provides additional opportunity to document their occurrence, and winter is often the best time to collect the dead branches in which they breed, since by that time they have nearly completed their development and will be ready to emerge as soon as temperatures rise during spring. Identifying woody plants without foliage can be a challenge, but the ability to distinguish host plants by non-foliage characters such as bark, growth habit, bud shape, etc. greatly facilitates studies of wood boring beetles through rearing. In the past I have relied heavily on Cliburn and Klomps' (1980), *A Key to Missouri Trees in Winter*, which utilizes mostly details of the twigs and buds to discriminate among Missouri's 160+ species of trees. However, after a certain level of familiarity is gained, one eventually learns to recognize winter

[1] Dr. George Yatskievych, in his recently published *Steyermark's Flora of Missouri* (2006), regarded the presence of *Corylus cornuta* in Missouri as unlikely despite earlier reports of such. Dr. Yatskievych also recorded a single escape of the European species *Alnus glutinosa* from Springfield, Missouri.

trees and even downed logs or fallen branches simply by their "look".

Betula nigra

Betula nigra (river birch) is the only member of this largely boreal genus found in the middle and southern latitudes of the U.S. and, thus, cannot be confused with any of Missouri's other betulaceous species[1]. It is the largest of the five and, along with the following species, is the most demanding in terms of keeping its "feet" wet. Trees are usually encountered right at the water's edge, with tall, slender, often twisted or leaning trunks. Young trees and large branches on older trees exhibit gorgeous reddish brown bark peeling in thin, papery sheets, becoming thick and scaly on the main trunks of older trees. Small branches are dark, purplish brown in color with smooth bark and distinctly horizontal lenticels. I have reared a small jewel beetle from fallen, dead branches of this tree collected at several locations in Missouri—this beetle turned out to be new to science, which I described and named *Agrilus betulanigrae* in reference to its (then) only known host (MacRae 2003). I have also reared tremendous series of another jewel beetle, *Anthaxia cyanella*, which at the time was not known to utilize this host and was considered uncommon. As it turns out, *Betula nigra* is its preferred host, and the rearing of large series from many locations resulted in improved knowledge about color forms and variability in this species (MacRae & Nelson 2003).

Alnus serrulata

Alnus serrulata (common alder, hazel alder, smooth alder, tag alder…) also demands to be next to (or even in) the water. Unlike *B. nigra*, however, this species rarely reaches true tree status, instead usually forming shrubby thickets along the water's edge. Saplings can resemble those of *B. nigra* due to their smooth brownish bark, but the latter is usually more purplish, and the lenticels of *A. serrulata* are not distinctly horizontal as in *B. nigra*. The large purple-red buds also differ from the small brown buds of *B. nigra*, and during winter *A. serrulata* is adorned with numerous staminate catkins. The persistent woody cones also cannot be mistaken for those of any other species of

[1] The widely planted but dreadfully non-adapted *Betula pendula* (European white birch) and *B. papyrifera* (paper birch) can be recognized by their distinctly white bark. These species are limited to urban landscapes where they rarely achieve significant stature before declining and eventually succumbing to insect pests such as *Agrilus anxius* (bronze birch borer). River birch provides an equally attractive and much more durable choice!

Betulaceae in Missouri. Associated with this plant is the longhorned beetle, *Saperda obliqua*, which reaches its southwestern-most distributional limit in Missouri on the basis of a single specimen collected some 25 years ago right here along Pickle Creek and given to me by lepidopterist George Balogh. Numerous attempts to find this species here since then have not (yet!) been successful.

Carpinus caroliniana

Carpinus caroliniana (blue beech, hornbeam, musclewood) is one of my favorite betulaceous species. The beautifully fluted trunks and smooth, light gray bark are reminiscent of the limbs of a sinewy, muscular person—every time I see this tree I cannot resist the temptation to grab and stroke the hard limbs (should I be admitting this?). This character begins to show even in very young trees, making its identification during winter quite easy. These trees also like to be near water, but they are not so demanding to be right at the water's edge as are the previous two species. They usually form small trees, often in clumps with multiple trunks. There are some notable insect associations that I've found with this plant. One is a small jewel beetle, *Agrilus ohioensis*, which I reared from dead branches of this plant collected along Pickle Creek (Nelson & MacRae 1990), and which after more than 20 years still remain the only known Missouri specimens of this species. Another is the longhorned beetle, *Trachysida mutabilis*, a single adult of which I reared from a dead (almost rotting) branch of this plant collected not too far from Pickle Creek in Iron Co. This beetle also is the only representative of its species known from Missouri (MacRae & Rice 2007).

Ostrya virginiana

Ostrya virginiana (hop hornbean, American hornbeam) has a form and growth habit very similar to *C. caroliniana*, but its leaves that persist through the winter make it instantly recognizable from afar. In Missouri, this habit is most often seen with the oaks (*Quercus* spp.). This species can be found even further away from the water than the previous species, and its small stature combines with the orangish, persistent leaves to form a distinctive understory layer during winter. Also, in contrast to the smooth gray bark of *Carpinus*, this species exhibits scaly, light reddish brown to brownish gray bark. I have succeeded in rearing one of the two known Missouri specimens of another jewel beetle, *Agrilus champlaini*, from *O. virginiana* collected along Pickle Creek (the other specimen was reared from wood collected at Graham Cave State Park, another site where sandstone bedrocks favor an *O. virginiana* understory). Unlike most other jewel beetles, *A. champlaini* forms galls in small living branches of its host. I have collected the distinctive swellings during winter on many occasions but managed to rear only these two individuals (plus one ichneumonid parasitoid). I have also noted similar swellings on *Carpinus* but have not yet managed to definitely associated them with this beetle.

Corylus americana

Corylus americana (hazelnut, American hazelnut) is the smallest of Missouri's five betulaceous species, always forming shrubs, sometimes in thickets, and never assuming the form of a tree. Its staminate catkins present during winter immediately identify plants of this species as Betulaceae, but the small, globe-shaped buds are unlike the more pointed buds of *Ostrya* and the elongated, reddish buds of *Alnus*. This species is the least demanding in terms of being near water and can be found even in upland prairies and glades. I haven't yet associated any woodboring beetles with this plant in Missouri, but there are several jewel beetles known from the eastern U.S. that utilize *Corylus* (*Agrilus corylicola*, *A. fulgens*, and *A. pseudocoryli*) and could occur in Missouri.

Upland habitats

The upland habitats at Hawn are of interest as well. Lamotte sandstones are the dominant

***Rhododendron prinophyllum* (wild azalea) in fruit along Whispering Pines Trail.**

Controlled burns are being used to restore pine savanna at Hawn State Park (Whispering Pines Trail).

bedrock, creating acid soils that support a canopy dominated by Missouri's only native species of pine, *Pinus echinata* (shortleaf pine), several species of oak, and a diversity of acid-loving shrubs primarily in the family Ericaceae (including the stunningly beautiful *Rhododendron prinophyllum*, or wild azalea).

Historically, so-called "pine savanna" was prevalent in this area, a natural community in which periodic fires maintained an open structure amongst the fire-adapted pines and allowed a diverse herbaceous layer beneath the open canopy. Much of Hawn has closed up after decades of fire suppression; however, the Department of Natural Resources has implemented a rotational burn management regime to recreate pine savanna habitat within Hawn's Whispering Pines Wild

Pine savanna needs fire to create open canopies under which warm-season grasses and other herbaceous plants can thrive.

Area. Evidence of what appeared to be very recent burns could be seen at several places as I hiked along the Whispering Pines Trail, and while many visitors might have been alarmed at the apparent "damage" they were observing, my heart sang with the prospect of seeing mature pine savanna communities taking hold throughout my beloved Hawn. As I stood atop this ridge and looked back down from where I had come, I could almost see Henry Schoolcraft and Levi Pettibone in the distance on horseback, perhaps pausing to gaze at an elk.

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A New Parasitic Plant in Missouri

For many years, botanists have recognized two ecological "races" of *Orobanche ludoviciana* (Louisiana broomrape), a parasitic plant in the family Orobanchaceae. One of these races is found primarily in the Great Plains region, where it is associated with upland habitats and utilizes perennial species of *Grindelia* (gumweed), *Artemisia* (sagebrush), and *Heterotheca* (false goldenaster). The other race is more confined to bottomlands associated with major river systems in central and eastern U.S., where it parasitizes annual species of *Ambrosia* (ragweed), *Xanthium* (cocklebur), and *Dicoria* (twinbugs). The latter race is now recognized as a distinct species—*O. riparia*—as a result of additional investigations by George Yatskievych and colleagues and presented in a recent issue of the *Journal of the Botanical Research Institute of Texas*. In addition to their ecological isolation, the two forms show numerous differences in floral characters and flowering periods that seem to support their recognition as distinct species.

Orobanche riparia **("riparian" broomrape). Photo provided by George Yastkievych.**