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A checklist of the sap beetle (Coleoptera: Nitidulidae) fauna of Indiana, with notes on effective trapping methods

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Abstract. A total of 70 species of Nitidulidae are recorded from the state of Indiana. Nine of these species are recorded as **new state records**. The myrmecophile *Amphotis ulkei* LeConte, and the adventive *Carpophilus marginellus* Motschulsky, originally from Southeast Asia are added to the state fauna. The methods with which these new taxa were found are given, along with a brief discussion on trapping techniques used for the family as a whole. Targeted use of vinegar-based baits and yellow sticky cards were used in addition to the general implementation of fermenting brown sugar and malt beer bait filled jugs, UV lighting, and Lindgren funnels. An updated checklist of all sap beetle species known to occur in Indiana is presented within a modern taxonomic framework for the family.

Key Words. State record, Midwest, Cucujoidea, range extension, sampling, collecting, museum records.

Introduction

Nitidulidae is a cosmopolitan family of Cucujoidea. The family currently contains more than 4,000 species classified in ten subfamilies (Cline et al. 2014). There are families of Coleoptera containing more species, but few that are as ecologically diverse. Predation, frugivory, fungivory, detritivory, necrophagy and herbivory are all life history strategies employed in this group. Some specific ecological behaviors also include inquilinism, leaf-mining, and tunneling in bark beetle (Coleoptera: Curculionidae: Scolytine) galleries. A few species are considered pests (*Aethina tumida* Murray, *Stelidota geminata* (Say), *Colopterus truncatus* (Randell) and *Carpophilus sayi* Parsons; for example), and have occasionally been a target of surveys. Several regional assessments have also been undertaken in the past; however, no focused study has been undertaken in the state of Indiana prior to this work.

Blatchley (1910) compiled a list of all beetles occurring in Indiana and provided the foundation for future beetle checklists in the state. He reported 49 species of nitidulid for Indiana at that time (Blatchley 1910). Studies completed over the last century yielded several additions to the known Midwestern fauna (Cease and Juzwick 2001; Dodge 1937; Dowd and Nelson 1994; Dury 1902; Huang and Lin 2001; Neumann and Elzen 2004; Vogt 1950; Williams et al. 1997). Downie and Arnett (1996) summarized these published distributions and added others to yield a list for the state of Indiana totaling 52 species. Price and Young (2006) furthered the knowledge of the Nitidulidae and Kateretidae fauna of Wisconsin; including a literature review on the faunas of Illinois, Indiana, Michigan, Minnesota, Ohio, and Southcentral Canada. This list combined with other published records produced a total of 61 sap beetle species in 22 genera. Those numbers increase to 70 species in 23 genera in this work. Also there was one member of the recently elevated Cybocephalidae, *Cybocephalus nigritulus* LeConte, previously known from the state but was eliminated here due to recent classification changes within the group (Cline et al. 2014).

Materials and Methods

Specimens from the following collections were examined and the following codens are used throughout the paper:

BDBC – Brad D. Barnd Collection (Greenfield, IN)
FMNH – Field Museum of Natural History (Chicago, IL)
FSCA – Florida State Collection of Arthropods (Gainesville, FL)
GSPC – Gareth S. Powell Private Collection (Lafayette, IN)
INHS – Illinois Natural History Survey (Champaign-Urbana, IL)
KESC – Kyle E. Schnepp Private Collection (Gainesville, FL)
PERC – Purdue Entomological Research Collection (West Lafayette, IN)
RMBC – R. Mike Brattain Private Collection (Lafayette, IN)
TJSC – Tyler J. Stewart Private Collection (West Lafayette, IN)

Over the last six years (2009–2015), trapping and active collecting for nitidulids was undertaken at several sites covering over a dozen counties spanning the full length of the state (Fig. 1). A variety of habitats were included and sampling continued across multiple seasons. Traps were primarily placed in several areas of mixed hardwood forest in both the northern and southern areas of the state to include both the flat glaciated northern terrain and also the ridges and valleys common in the southern part of state, which were past the furthest reach of the most recent glacier. Stands of primarily conifers were also found and included in the sampling, however these were typically fewer and on average smaller than the hardwood stands. Sites included areas with good accessibility and places for which current permits had been issued. Each site presented something unique in terms of habitat and was incorporated in an attempt to cover the majority of environment types present in the state. The site in Harrison County was unique in that all the traps were placed in stands of Hemlock. Newton County was included as part of a larger "BioBlitz" that took place in 2012. This area represents a restored prairie environment that serves as an example of what much of that part of the state once was. The heavily sandy soil and oak barren landscape was not sampled anywhere else in the state except here. Muscatatuck National Wildlife Refuge in Jackson and Jennings County was surveyed in 2009 and again from 2013–2015; this area contains a managed lowland wetland that has become uncommon in Indiana. The Indiana Dunes State Park in Porter County provided several interesting habitats including lakefront sand dunes, Scotch pines, and high numbers of cottonwoods.

Active collecting methods primarily included the inspection of flowers, fungi, and mammal carcasses and were mainly opportunistic. Flowers were checked commonly in April or May, fungi and carcasses were searched upon discovery. More focused searches were performed within ant nests in Southern Indiana from April 2013 until September 2014. Nitidulids were also actively collected under bark and sifting leaf litter. Passive trapping included: fermenting beer and brown sugar baits, vinegar baits, rotting fruit, Lindgren funnels baited with EtOH, yellow sticky cards and UV lights.

Beer baits were generally active anywhere from March to September with May being the month with the most traps actively monitored. The fermenting mixture used here is one part dark brown sugar, one

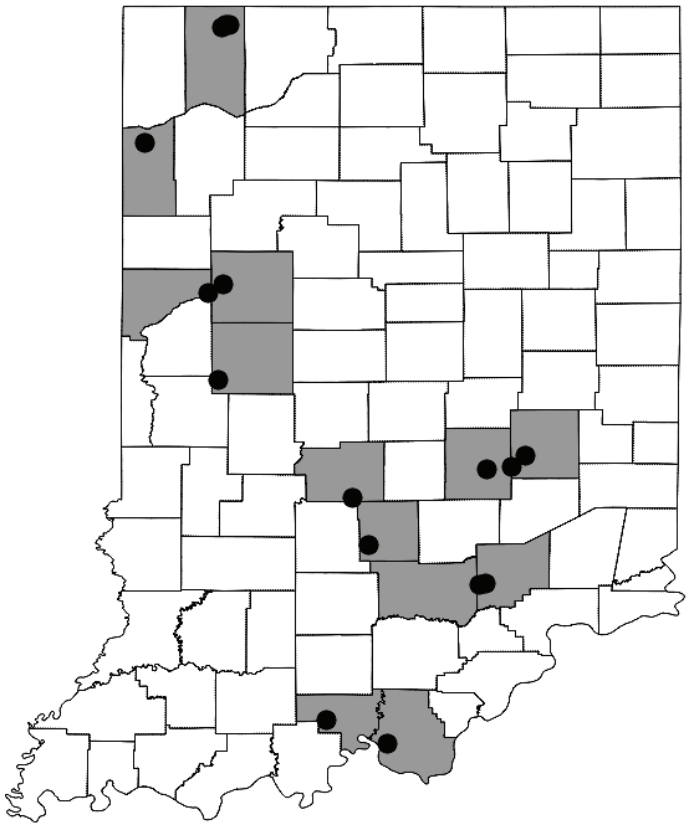

Figure 1. Map of Indiana with specific collecting sites used at various times from 2009–2015 denoted by circles. Counties shaded in grey indicate areas covered by this sampling regime.

Figures 2–3. Examples of trap designs. **2)** Plastic "jug" trap baited with fermenting mixture hung from tree branch in an open wooded area. **3)** Plastic "boat" trap baited with apple cider vinegar placed in the crotch of a large tree. The lid is propped open to allow attractant to spread but still shield the container from rain.

part beer, and two parts water. A small amount of active dry yeast was added to the solution to initiate fermentation. The mixture was then added to plastic one gallon jugs that had two square "windows" approximately four inches tall by six inches wide cut into the sides and were suspended six feet from the ground in a variety of habitats (Fig. 2). Rope was looped over a tree limb at least two inches in diameter and which ran close to perpendicular to the ground. The strength of the branch and the orientation allowed for the trap to be positioned away from the trunk of the tree to both discourage mammal foraging and increase the degree of visibility.

Both fermenting brown sugar mixtures and vinegar-based baits have been shown to strongly attract sap beetles in the past (Williams et al. 1994). Vinegar baits were primarily used in the months of April and May. Small plastic containers were filled halfway, or approximately 3 cm with either; white, apple cider, or red wine vinegar (Fig. 3). The container was placed where the trunk of a tree splits between two and six feet above ground level. This vinegar bait mimics the rotting plant debris that builds up in these areas. The three different types of vinegar were used to provide a preliminary test of preference for sap beetles.

Bananas and strawberries were left to rot on bare ground on the edge of wooded areas and checked periodically for visiting Coleoptera. The fruit was crushed to increase surface area and release attractant volatiles. Bananas were always brown and soft, almost liquefied in some cases. The bare ground provided an efficient method of simply removing the body of the fruit and having a uniform surface to check residue for movement. Specimens found were taken with forceps and placed directly into 70% EtOH.

Sap beetles were common by-catch in Lindgren funnel traps that were being used for woodborer collecting. These funnels were baited with 95% EtOH and suspended in forested areas. The Lindgren Funnels were placed approximately seven feet above the ground, which is consistent with the most effective heights found in past studies (Peng and Williams 1991). This height also places the collecting container at eye level, and makes for effective servicing of the traps.

Yellow sticky cards were placed on foliage of trees and shrubs with an effort to maximize sunlight exposure. Several cards were placed on the outskirts of an oak-hickory woodlot, others were placed on apple trees, with the remaining cards placed near a mixed beech-maple forest; edge habitat adjoining an area with wild flowers in bloom was always targeted. These traps are designed to mimic flowers.

The nomenclature and classification used here was taken from Parsons (1943); general additions to this include: Connell (1984), whereas specific changes were made in Cline (2008) for *Pocadius* Erichson, in Howden (1961) for *Thalycra* Erichson, and in Leschen (1988) for *Pallodes* Erichson. Changes to the

higher-level classification were taken from Leschen (1999) and Cline et al. (2014). A modern generic-level summary of the North American Nitidulidae fauna is given in Habeck (2002).

Vouchers for each new state record collected from the recent fieldwork are deposited in either PERC or GSPC. Specimens representing species recorded in the literature remain in the collections from which they were recorded. For species such as *Carpophilus dimidiatus* (Fabricius); several museum records were discovered, the oldest is presented here. The oldest record from each source was included for species that were present in multiple collections. The specimens are labeled as follows with "/" denoting a line break and "//" denoting a new label. The source collection is given after each species name.

Results

The following is a complete checklist of the Nitidulidae known from Indiana compiled from recent fieldwork, museum records, and published data. New records for the state are denoted in bold. Species collected during the fieldwork discussed here are marked with "*".

Checklist of Nitidulidae

Epuraeinae Kirejtshuk, 1986
- *Epuraea aestiva* (Linnaeus)
- *Epuraea alternata* Parsons
- *Epuraea avara* (Randall)
- *Epuraea corticina* Erichson
- *Epuraea duryi* Blatchley
- *Epuraea erichsoni* Reitter
- *Epuraea helvola* Erichson
- *Epuraea horni* Crotch
- *Epuraea labilis* Erichson
- *Epuraea obtusicollis* Reitter
- *Epuraea ovata* Horn
- *Epuraea peltoides* Horn*
- *Epuraea rufa* (Say)*
- *Epuraea rufida* (Melsheimer)
- *Epuraea truncatella* Mannerheim

Carpophilinae Erichson, 1842
- *Carpophilus antiquus* Melsheimer*
- *Carpophilus brachypterus* (Say)*
- *Carpophilus corticinus* Erichson*
- ***Carpophilus dimidiatus* (Fabricius) new state record**
- ***Carpophilus discoideus* (LeConte)* new state record**
- *Carpophilus freemani* Dobson
- *Carpophilus fumatus* Boheman
- *Carpophilus hemipterus* (Linnaeus)
- *Carpophilus lugubris* Murray*
- ***Carpophilus marginatus* Erichson* new state record**
- ***Carpophilus marginellus* Motschulsky new state record**
- *Carpophilus melanopterus* Erichson*
- *Carpophilus mutilatus* Erichson
- *Carpophilus pallipennis* (Say)
- *Carpophilus sayi* Parsons*

Amphicrossinae Kirejtshuk, 1986
- *Amphicrossus ciliatus* (Olivier)*

Nitidulinae Latreille, 1802
Aethina tumida Murray*
***Amphotis ulkei* LeConte* new state record (Fig. 4)**
Cychramus adustus Erichson
Cyllodes biplagiatus LeConte*
Lobiopa setosa Harold*
Lobiopa undulata (Say)*
Nitidula bipunctata Linnaeus
Nitidula carnaria (Schaller)
Nitidula rufipes (Linnaeus)
Nitidula ziczac Say
Omosita neartica (Kirejtshuk)*
***Omosita discoidea* (Fabricius)* new state record**
Pallodes austrinus Leschen
Pallodes pallidus (Beauvois)*
Phenolia grossa (Fabricius)*
Pocadius helvolus Erichson
Prometopia sexmaculata Say*
Psilopyga histrina LeConte
Psilopyga nigripennis LeConte
Stelidota geminata (Say)*
Stelidota octomaculata (Say)*
Thalycra orientalis Howden
Meligethinae Thomas, 1859
Brassicogethes simplipes (Easton)
***Brassicogethes viridiscens* (Fabricius)* new state record**
Fabogethes nigrescens (Stephens)*
Cillaeinae Kirejtshuk and Audisio, 1986
***Colopterus maculatus* (Erichson)* new state record**
Colopterus niger (Say)*
Colopterus semitectus (Say)*
Colopterus truncatus (Randall)*
***Colopterus unicolor* (Say) new state record**
Conotelus obscurus (Erichson)*
Cryptarchinae Thomas, 1859
Cryptarcha ampla Erichson*
Cryptarcha concinna Melsheimer*
Cryptarcha strigatula Parsons
Glischrochilus confluentus (Say)* (Fig. 5)
Glischrochilus fasciatus (Olivier)*
Glischrochilus obtusus (Say)*
Glischrochilus quadrisignatus (Say)*
Glischrochilus sanguinolentus (Olivier)*

Label data for new Nitidulidae state records

Carpophilus dimidiatus, (PERC)
Vigo Co. / Ind. W.S.B. / 9-23-1894

Carpophilus discoideus, (GSPC)
IN: Tippecanoe Co. / Ross Hills Park / May 14 – June 7 2013 / Col. Gareth S. Powell / Fermenting Bait Trap / WGS84 40.4077 / -87.0601 Elv. 155m

Carpophilus marginellus, (BDBC)
US IN Hancock Co / Barnd Residence / 39.766N 85.823W / coll B Barnd 9 IX 2010/ collected on and underneath watermelon scraps on edge of corn field

Carpophilus marginatus, (BDBC) (GSPC)
US IN Tippecanoe Co / Horticulture Park / 40.427N 86.935W / coll B Barnd 6 V 2007 // IN: Tippecanoe Co. / Ross Hills Park / May 12 2013 / Col. Gareth S. Powell / Apple Cider Vinegar Bait / WGS84 40.4077 / -87.0601 Elv. 155m

Amphotis ulkei, (GSPC) (KESC) (RMBC)
USA: IN: Brown Co. / Dewar Ridge Rd. / May 5 2014 / Col. Gareth S. Powell / with *Lasius* ants / WGS84 39.1322 / -86.3365 Elv. 205m // Indiana: Brown Co. / May 6, 2013 / in *Lasius alienus* ant nest / Kyle E. Schnepp // IN: Brown Co. / WGS84 N39.123 / W86.339 / 2.5km SSE Belmont / August 19 2013 / R.M. Brattain

Omosita discoidea, (GSPC)
USA: IN: Warren Co. / edge of pasture / April 12 2014 / Col Julie Speelman / On Opossum carcass / 6:30pm, sunny / WGS84 40.2107 / -87.4521

Brassicogethes viridiscens, (GSPC)
USA: IN: Montgomery Co. / Shades State Park / May 24 2013 / Col. Gareth S. Powell / WGS84 39.9445 / -87.0769 Elv. 220m

Colopterus maculatus, (GSPC) (KESC)
USA: IN: Jackson Co. / Muscatatuck NWR / May 10 – June 7 2013 / Col. Gareth S. Powell / Lindgren funnel Trap / WGS84 38.9406 / -85.8045 Elv. 165m // Indiana: Morgan Co. / May 12-22, 2011 / clear bottle trap with / fermenting fruit bait / Kyle E. Schnepp

Colopterus unicolor, (RMBC)
IN: Monroe Co. / IN-PSB / IV-2001 / S. Galford

Notes on Trap Efficacy

The sampling scheme discussed here collected a confirmed 37 species, or about 50% of the total known fauna. No empirical analysis of the efficiency of each trap was performed but notes on specific experiences can be presented. The fermenting beer bait overall produced the most nitidulid specimens per trap, and was found to be the most effective method used here to collect members of Carpophilinae and Cryptarchinae. The Lindgren funnels consistently yielded nitidulid beetles, most commonly members of the genera *Glischrochilus* Reitter and *Colopterus* Erichson. Unfortunately the Lindgren funnels did not yield the diversity other methods produced. The fruit baits were most effective at collecting *Stelidota* Erichson and some *Carpophilus* Stephens. Certain genera of Nitidulinae, i.e. *Prometopia* Erichson, *Lobiopa* Erichson, and *Amphicrossus* Erichson, were common at UV lights in several areas across Indiana. Vinegar baits most notably yielded specimens of both Carpophilinae and Epuraeinae. An initial indication is that red wine vinegar was more than twice as effective as either apple cider or plain white vinegar in attracting nitidulids. However, more empirical based tests will be needed to further define this phenomenon (Powell, unpublished data). The yellow sticky cards were found to be very inefficient in the collecting conditions herein, many more specimens of Meligethinae were collected by hand than with this method. Several nitidulid species were only collected via active targeted collecting: *Carpophilus melanopterus* on *Yuccae* sp. blooms (Asparagaceae), *Amphotis ulkei* in *Lasius* sp. ant colonies (Formicidae), *Cyllodes biplagiatus* on fungi, *Omosita* spp. on mammal carcasses, and *Conotelus obscurus* on *Ipomoea* sp. (Convolvulaeae).

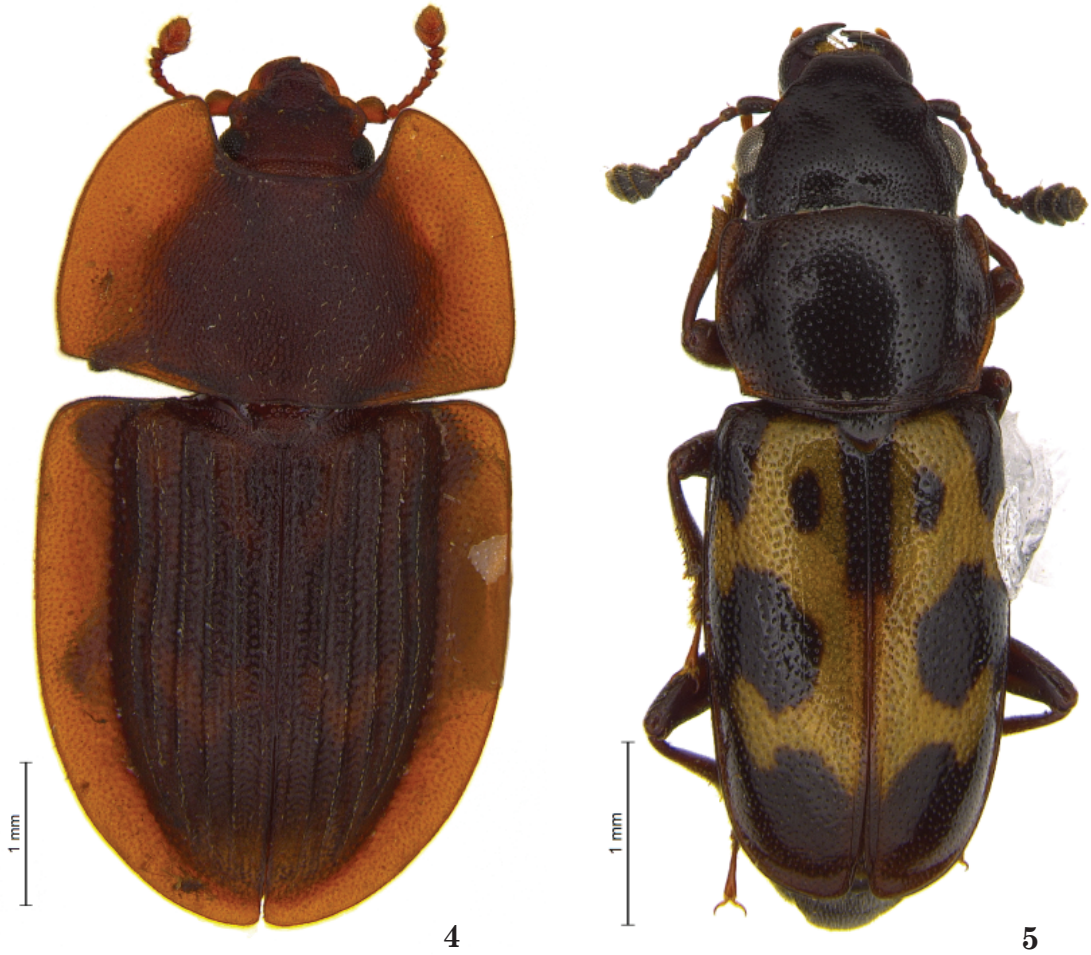

Figure 4–5. Dorsal habitus of two species of Nitidulidae. **4)** *Amphotis ulkei* LeConte. **5)** *Glischrochilus confluentus* (Say).

Discussion

The discovery of the above new state records were the result of several circumstances. For example, in the case of *Omosita discoidea,* this can be attributed to the continued spread of invasive species. Originally the species was described from England but was known from across Europe and Northern Asia. This beetle had been subsequently found across the western United States; specifically, California, New Mexico and Colorado, and then separately in New Jersey and Maryland prior to 1943 (Parsons 1943). The species is not considered an economically important pest so it has not officially been tracked since then. The new record published here is a testament to the truly Holarctic distribution the species has subsequently attained. In the case of *Amphotis ulkei*, this beetle is found as an inquiline in ant colonies (*Lasius* sp.). However, without focused searching in this environment, the species would have to be an accidental capture in a flight intercept trap or light trap during a presumed rare dispersion event. This type of event was how the first specimen of this genus was collected in Canada (Glasier 2013).

Other new records, for example, *Carpophilus dimidiatus,* were found searching through existing museum holdings in groups that commonly lack species-level determinations. Thus, a lack of specialist expertise in the group was responsible for the lack of records for this species in the state. This may be the case for other Nitidulidae genera as well, specifically the difficult to identify members of *Epuraea*. As more material from additional museums and private collections is examined, the true identity of the local fauna will have the potential to increase.

The small hive beetle, *Aethina tumida,* is an invasive species native to Africa but is a beetle that has been causing significant damage to honey bee colonies in the United States (Neumann and Elzan 2004). The species was first detected in Indiana in 2000, and it has since spread across much of North America. This study yielded many recently collected specimens of *Aethina tumida*, confirming the statewide distribution it has achieved.

Several species are likely to be present in Indiana as they are confirmed to be found in adjacent states. A short list of these include: *Epuraea flavomaculata* Mäklin, *Epuraea fulvescens* Horn, *Epuraea obliquus* Hatch, *Epuraea populi* Dodge, *Epurara terminalis* Mannerheim, *Epuraea umbrosa* Horn, *Thalycra concolor* LeConte, *Afrogethes saevus* (LeConte), *Pityophagus cephalotes* LeConte, and *Glischrochilus siepmanni* Brown (Price and Young 2006).

Both active and passive sampling efforts performed for this study will continue. The addition of whole wheat bread dough to baited pitfalls will be one new method employed. Some species, particularly members of the genus *Nitidula* Fabricius, have been shown to be fall or even winter active so active searching will progress in a more year-round attempt to find species whose activity falls outside the norm for Coleoptera collectors in the Midwest. Several species of Nitidulidae are known to be specialists on various fungi; in an effort to add more records, examination of fungi will become more targeted. Geographically, some areas will be dropped from future study due to accessibility; however, new sites are being identified in the extreme southwestern corner of the state and the northeastern quadrant as well. Both of these areas fill gaps in previous collecting and may yield further additions to the fauna due to the unique nature of the flora present. A particular site along the Ohio River is unique in the area due to the presence of *Quercus bicolor*, *Taxodium distichum*, and *Quercus lyrata*.

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