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THE LOST MICRO-DESERTS OF THE PATUXENT RIVER: USING LANDSCAPE HISTORY, INSECT AND PLANT SPECIMENS, AND FIELD WORK TO DETECT AND DEFINE A UNIQUE COMMUNITY

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Abstract.—Historical and recent records of both plants and insects are synthesized for uplands along the eastern edge of Maryland's Patuxent River from the edge of the Piedmont south to Jug Bay. This strip is characterized by deep sandy soils found in the Evesboro and Galestown sandy loams soil series. Within this narrow strip there exists a unique flora and fauna adapted to open dry sandy soils and occurring in small remnant patches associated with old sand mining operations and scattered protected areas. We illustrate the uniqueness of these sites using four groups, vascular plants, tenebrionid beetles (Coleoptera: Tenebrionidae), tiger beetles (Coleoptera: Cicindelidae), and bees (Hymenoptera: Apoidea: Anthophila). Within each of these groups, rare species were detected whose populations were locally restricted to this soil type and whose nearest known populations were often hundreds of kilometers away. In addition to documenting the direct conservation importance of these small sandy openings along the Patuxent, we contrast the lack of any indication from vertebrate inventories that this region is unique. The combination of plant and insect inventories appears to be a better means of clarifying a site's importance than does any survey of a single taxonomic group.

Key Words: Apoidea, Tenebrionidae, Cicindelidae, tiger beetles, bees, sand specialists, floristics, Maryland, Anne Arundel County, inventory, sand barrens, Jug Bay, sand pits

The Patuxent River flows southeast approximately 114 km from its start in Central Maryland to its mouth along the Chesapeake Bay's western shore draining a 2414 square kilometer watershed within seven Maryland counties. The watershed is in proximity to and partially drains the urban centers of Washington D.C., Annapolis, Maryland, and Baltimore, Maryland. As a consequence of the region's early settlement and proximity to large cities, this area has been visited, explored, and documented by numerous naturalists.

Recently, we independently concluded that the conservation value of land along the Patuxent River is not restricted to its highly visible bottomland forests and

tidal marshes. Each of us had discovered a scattering of uncommon plants and insects along the riverside terraces, particularly on the northeastern side. The flora and fauna of these sites exhibit affiliations with open-country and prairielike habitats rather than with the forests and cultivated lands that make up the weight of the region's landscape. A number of the uncommon insect species discovered are regionally disjunct, many with nearest known populations across the Chesapeake Bay or in other states. Plants exhibit less dramatic patterns, shifting communities toward dry site and sand specialists.

Within these small residual "micro-deserts," regionally rare invertebrates co-occur with uncommon plant communities; taken together such co-occurrences of rare species from different taxa imply that these largely ignored sites are of possible conservation concern. We present here a review of the historical context of these communities, as well as summarize the patterns of occurrence for four taxonomic groups, namely vascular plants, tenebrionid beetles, tiger beetles, and bees. These four taxa represent the areas of each of our natural history expertise and illustrate the value of a multitaxon approach to identifying areas of high biodiversity and rarity.

Historical Context

Currently these unusual plant and animal communities exist within small pockets of open sandy land along the Patuxent River. These micro-deserts occur in what would appear to be largely neglected lands associated with power lines, roadsides, and old sand and gravel operations, but a few occur on protected conservation lands. We are most familiar with sites occurring from Jug Bay Wetlands Sanctuary in Anne Arundel County upstream to Laurel, Maryland (Fig. 1), at which point the river meets the Piedmont and the sandy soils largely

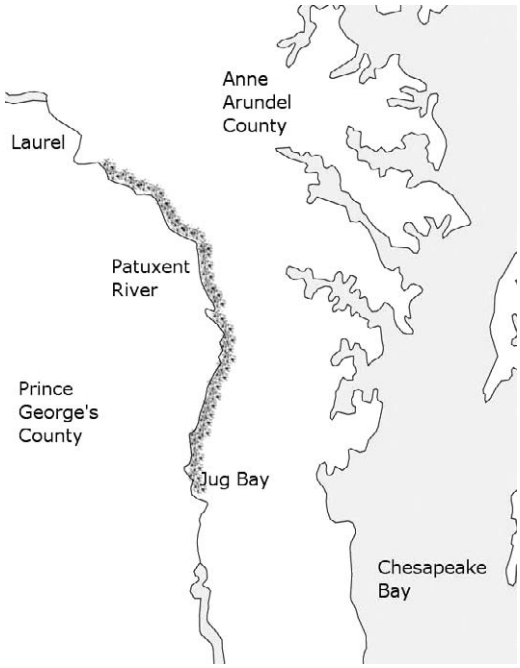

Fig. 1. Map of the micro-desert region (cross-hatched) of the Patuxent River in Maryland, U.S.A.

disappear. Sites may exist to the south of Jug Bay, but geological and soils maps indicate a lack of the deep sand formations found to the north.

Micro-deserts are located on deep sandy soils primarily on the northeastern side of the river where the prevailing winds have deposited the sand from marine and alluvial deposits exposed and reworked by the river (Glaser 1971). Evidence from Native American archaeological sites buried by blowing sands indicate that these sites were open and exposed during the Hypsithermal period approximately 4,000–6,000 years before present (Curry 1992). During the Hypsithermal period the region's temperatures averaged about 5°C higher than present, and the climate was much drier (Pielou 1991). At this time prairie plants, and undoubtedly their animal counterparts, migrated eastward from the Midwest. The abundance and patterns of geologically recent wind blown sand lenses throughout the Coastal Plain

of Maryland (Glaser 1971), as well as data from pollen cores, provide further evidence that during this period there were extensive non-forested areas, frequent fires, and a greatly increased abundance of pine (Brush 1994, Willard et al. 2003).

As climate subsequent to the Hypsithermal became wetter and cooler, these non-forested openings must either have persisted in place, or landscape gaps and openings were always plentiful enough to retain these populations. Initial European records from the region during exploration and settlement documented that areas of grasslands and low brush covered many square miles in the Great Valley and across a large swath of Howard, Carroll, and Baltimore counties of Maryland (Marye 1955a, b, c). Land records and early colonial newspaper accounts also documented similar barrens and open land in the sandy terraces along the Patuxent River on the present site of the Patuxent Wildlife Research Center (formerly the training grounds of the U.S. Army's Fort Meade) and surrounding area. These colonial open lands covered an area within and to the northeast of the region where the Big and Little Patuxent rivers join (Earle 1975). Additional unrecorded sites also were likely to have existed throughout the region given the historic and archeological evidence of dense Native American villages along the river (Browne 1985) and the general scarcity of written accounts during the period between initial contact and Native American depopulation.

Native Americans were known to have made extensive use of fire to create and maintain grasslands attractive to game, drive game during hunting, and expedite foraging (Whitney 1994). These fires were frequent enough to have affected the forest composition and structure, at least locally. Several accounts from the 17th century in the mid-Atlantic area noted the open nature of forests, lack of underbrush, and presence of good stands of grass within these forests (Force 1846, Hall 1910). Colonial records of boundary trees marking the original grants from the 17th and early 18th centuries in Anne Arundel County indicate a land whose large trees were dominated by oak and hickory, with few references to the less fire tolerant tulip-poplar (*Liriodendron tulpifera* L.) (Earle 1975).

Pollen profiles from Chesapeake Bay sediments dating back 2300 years ago indicate that early successional tree species such as pine and sweetgum (*Liquidambar styraciflua*) were continuously present but in perhaps varying ratios from that found today (Schneider 1996, Willard et al. 2003). Pine, in particular, requires bare soil and full sun to germinate, an indication that disturbance by fire, wind-throw, or cultivation of lands by Native Americans resulted in large acreages of exposed soil.

Following European colonization, open land and its associated flora and fauna persisted via a number of processes. Early cultivation practice (common until the late 1700's) was hoe-based, utilizing planting mounds rather than the plow. On most sites tobacco was grown following land clearance, and as fertility declined, the land was planted to corn (Smith 1986). Once the land could no longer support corn it was allowed to lie fallow for 20 or more years before the cycle was repeated. In such a way, the land was kept in a patchwork of early successional stages, with much of its native open-country flora and fauna likely retained. We believe that the lands along the river were too sandy and poor in nutrients to support heavy plantings of nutrient hungry tobacco and corn and were more likely kept open through grazing, fire, and wind-throw, along with naturally steep riverbanks.

In addition to direct forest loss due to agricultural practices, early records in

Anne Arundel County indicate that most forests were quickly cleared, with large amounts of wood products extracted from non-tillable lands. This resulted in wood shortages by the 1700's as demand for fencing, building, and energy needs exceeded supply (Earle 1975).

A further force in keeping colonial forest cover low was the establishment in the 1730's of the Patuxent Iron Works which opened up a set of foundries and forges along the Big and Little Patuxent rivers downstream of Laurel designed to exploit the iron containing nodular siderite-limonite deposits located nearby (Bernstein 1980). Those operations required great amounts of charcoal for the smelting and working of iron. For each ton of pig iron produced, 100–400 bushels of charcoal were required. An average colonial furnace was thus estimated to clear 100 acres of woods a year through charcoal production (Whitney 1994). The owners of the Patuxent Iron Works owned 32 square miles of the region's land (Cook 1976), much of that likely used to produce charcoal. Despite their extensive landholdings, the Iron Works had to close its operations in the 1850's due to lack of charcoal (Benson 1992).

Forest cover in Anne Arundel County was at its minimum in the late 1800's (Schneider 1996), subsequently climbed from 49% in 1907–1914 to 65% in 1950, and thereafter declined with increased human population density to 43% in 2000 (MD DNR 2000). Other than the continuing agricultural activities and the small amount of forestry in the region, the only other significant disturbance along the sandy terraces has been that of the gravel and sand extraction operations that began in the early 1900's.

Additional indirect evidence for the past presence of open, grass covered lands includes historic records of open country grazing animals such as bison and elk plus endemic eastern subspecies of obligate grassland or scrub birds such as Heath Hen (*Tympanuchus cupido cupido* L), Henslow's Sparrow (*Ammodramus henslowii susurrans* Brewster), Bewick's Wren (*Thryomanes bewickii altus* Audubon), and Northern Bobwhite (*Colinus virginianus marilandicus* L.) (Askins 1999), all of which have declined greatly or become extinct. Archaeological evidence also indicates the long-term presence of Northern Bobwhite as a Native American food item within the region (Bolgiano 2000). In order to persist and evolve into subspecies, this group of species would have depended on the continuous presence of extensive acreages of open grasslands and scrub in the East.

As mentioned previously, past climatic and cultural conditions likely resulted in the consistent presence of open land throughout the region. Past patterns of chronic disturbance contrast with the current absence of fire and only small-scale disturbances such as agriculture, grazing, and settlement. The small-scale disturbances have resulted in slow afforestation of this region along with growing permanent housing.

In the following sections we document a set of plants and insects from four taxonomic groups that are either restricted to or unusually abundant in the residual micro-deserts along the Patuxent River. In all cases it should be noted that this information comes from observer chosen collecting activities at specific accessible sites along the river. Consequently, while the issue of regional rarity remains clear, the complete pattern of occurrence and co-occurrence will not be made until more systematic surveys take place.

Micro-Desert Community Assessment

Floristics.—The plant communities of micro-deserts are associated with the sandy soils found in the Evesboro and Galestown sandy loams soil series. Sur-

face sand features in the Evesboro soil series occur as patches and low-profile dunes. Often these features occur on outcrops of the Aquia and Nanjemoy formations, which surround the upper tidal reaches and Coastal Plain drainages of the Patuxent River (for a map of the outcrops of these formations see Hansen (1996: figs. 4, 5)). No one has studied these low dunes to determine if they resulted from one prolonged event or accumulated through multiple periodic depositions. Nor has anyone examined the particular dynamics that resulted in their specific depositional location within the landscape.

Many sources of disturbance—in the past and present—continue to keep these dry sandy habitats open and thereby supporting a variety of herbaceous species. These disturbances include fire (Frost 1998), drought (Willard et al. 2003), wind-throw of trees, clearing, agriculture, grazing, succession, loss of predators, harvest of chestnut (Zon 1904), chestnut blight, military training, roadside maintenance, utility corridors (Sipple 2001), and sand and gravel mining. At various cycles and frequencies of the disturbance-recovery continuum, these dry sites could support early successional cryptobionic crusts of algae, lichens and mosses, old field herbaceous and graminoid communities, and woody forests.

Alga, lichens (particularly *Cladonia* spp.), and some mosses (for instance, *Dicranum condensatum*) can persist in these apparently dry conditions and dominate the initial stages of stabilization of exposed sandy soils. The resulting ''cryptobionic crusts'' (see Ladyman and Muldavin 1996) reduce wind erosion, influence seed germination, and increase nitrogen availability. One can observe this initial sequence at dry, sandy sites today following abandonment of sand and gravel mines, where succession is set back to earliest stages.

The physiological constraints of droughty, hot conditions at the surface of the soils of these micro-deserts limit the establishment of some arriving plant propagules. The limited extent of these micro-desert sites and their relatively small sizes means that seed and spore from nearby sources within Coastal Plain communities could readily immigrate to them. However, active sand disposition, lower depth to water table, low nutrient content, and extreme soil surface temperature fluctuations would favor the establishment of only tolerant plants.

We do not know which species of vascular plants formed the historic communities associated with the current micro-desert habitat patches. Archeological evidence indicates that deposition at one site occurred between 4,000–6,000 years before present (Curry 1992). This is more recent than the eolian deposition of Parsonburg Sand on the Eastern Shore of Maryland (Sirkin et al. 1977) between 30,000 and 13,000 years before present when birch (*Betula* sp.), spruce (*Picea* sp.), and dogwood (*Cornus* sp.) dominated. More recent studies (Willard et al. 2003) document the gross regional changes in vegetation types, but none provide evidence about the specific plants associated with the micro-desert habitats of interest.

We can, however, reasonably speculate on the species that historically occupied these sites. By assuming similar physiological tolerances of present day species, the possible pre-colonial flora of these sites may be inferred from the earliest collections from this vicinity. Brown et al. (1987), while studying early-Maryland plant collections at the British Natural History Museum and the University of Oxford, discovered that all collections occurred after about 1688 and were gathered primarily in Anne Arundel, Prince George's, Calvert, and St. Mary's counties on the Western

Shore and Talbot and Dorchester Counties on the Eastern Shore. Herbaceous species were not as comprehensively represented as woody species. Brown et al. (1987) characterized the colonial vegetation by summarizing notations found on historic herbarium sheets. These characterizations are currently our earliest glimpse of Coastal Plain dry sites of our modern flora.

In Table 1, we list some native plant species that are likely to be found in micro-desert habitats. This list is based on habitat descriptions in floras and personal experience. We have not observed all species listed, and undoubtedly additional species could be added to the list. This list has many species in common with those listed by Shreve (1910) for the Sandy Loam Upland Forests occurring on the Talbot Terrace on the Eastern Shore and the Pine-Oak Association of Chrysler (1910) for the Western Shore. Note in Table 1 that herbaceous species that are adapted to dry sites occur in a wide range of habitat types, from open beaches to shaded forests.

Several species of plants, now rare in Maryland (MWHD 2001), were collected during those historic, post-colonial efforts, particularly *Asclepias verticillata* L., *Desmodium ochroleucum* M.A. Curtis ex Canby, *Heilanthemum bicknellii* Fern., *Lespedeza stuevei* Nutt., *Matelea carolinensis* (Jacq.) Woods., *Rhynchosia tomentosa* L, *Polygala polygama* Walt., and *Schwalbea americana* L. Other rare plant species are known to occur on dry sites on the vicinity of the upper Patuxent Coastal Plain (see Table 2). Elsewhere in their ranges, a significant complement of the species listed in Table 2 have been found along roadside habitats believed to be relicts of fire-maintained grassy pine-oak barrens (Campbell et al. 1991). As a long-term dry feature of the Coastal Plain that is subject to periodic disturbances, the micro-desert sites are principal candidate sites for potential rare species discoveries.

Tenebrionid beetles.—Tenebrionid beetles are a diverse group of insects that includes many sand ''specialists'' that serve as indicators of micro-desert type habitats. Some species are among the rarest insects in Maryland, known only from one or two localities. Development and survival of larvae depends on the presence of friable sandy substrates (Steiner 1995) in open gaps and edges of otherwise unsuitable habitat, such as dense plant cover or low wet areas. These beetle species occur in maritime dune scrub and grass zones on barrier islands, on estuarine sand beaches, on sand bars along rivers, and in ''fossil dune'' sites or inland sandhill formations. All of these habitats occur in Maryland but do not all share the same assemblages of geophilous beetles, as some species appear to be restricted to pure coastal sands, while others occur only at inland sites. Maintenance of microsite openness may be more important than the type of soil for species such as *Polypleurus perforatus* (Germar), which lives in dry rotten fallen wood. This beetle and several others, *Alaetrinus minimus* (Palisot de Beauvois), *Blapstinus metallicus* (F.), *Bl. moestus* Melsheimer., *Bothrotes canaliculatus* (Say), *Hymenorus sobrinus* Casey, and *Paratenetus fuscus* LeConte, have been found in association with the dry sand deposits along the Patuxent River; a few additional psammophile species, known elsewhere in the state, could also be found to occur here through additional searches. At least 128 species of Tenebrionidae have been recorded as occurring in Maryland (Steiner 2008), including non-native introductions.

Five of the seven species listed here are flightless; Steiner (1999) reviewed their known distributions and habitats. The winged *Bo. canaliculatus* inhabits a wide

Table 1. Some native Coastal Plain plants of Maryland adapted for dry sites and their habitat relationships classified by Brown et al. (1987) from historic collections. Question marks indicate historic collection exists but not classified to habitat by Brown et al. (1987). Superscript 1 = As *Aster linariifolius*. Superscript 2 = As *Cyperus filiculmis*.

Species	Family	Brown et al. (1987) historic habitat			
		"Beaches and Dunes"	"Forest Types—Pine	"Forest Types—Oak"	"Open areas and borders of woods"
Rhus copallina	Anacardiaceae	X	x		
Asclepias amplexicaulis	Asclepidaceae	?	?	?	?
Asclepias tuberosa	Asclepidaceae				x
Asclepias verticillata	Asclepidaceae				x
Matelaea carolinensis	Asclepidaceae	?	?	?	?
Chrysopsis mariana	Asteraceae				x
Coreopsis verticillata	Asteraceae	?	?	?	?
Eupatorium aromaticum	Asteraceae				
Eupatorium hyssopifolium	Asteraceae		x		x
Eupatorium rotundifolium	Asteraceae	X			
Hieracium gronovii	Asteraceae				
Ionactis linariifolius[1]	Asteraceae	?	?	?	?
Krigia virginica	Asteraceae	?	?	?	?
Liatris graminiifolia	Asteraceae				x
Sericocarpus asteroides	Asteraceae	?	?	?	?
Sericocarpus linifolius	Asteraceae	?	?	?	?
Solidago odora	Asteraceae	?	?	?	?
Virgulis concolor	Asteraceae				x
Polypremum procumbens	Buddlejaceae				
Opuntia humifusa	Cactaceae	?	?	?	?
Helianthemum bicknellii	Cistaceae		x		
Helianthemum canadense	Cistaceae				
Lechea racemulosa	Cistaceae				
Hypericum gentianoides	Clusiaceae	X	x		
Carex tonsa	Cyperaceae				
Carex umbellata	Cyperaceae				
Cyperus lupulinus[2]	Cyperaceae	?	?	?	?
Euphorbia corollata	Euphorbiaceae				x
Euphorbia ipecachuanae	Euphorbiaceae			x	x
Baptisia tinctoria	Fabaceae	?	?	?	?
Crotalaria sagittalis	Fabaceae				
Desmodium marilandicum	Fabaceae	?	?	?	?
Desmodium ochroleucum	Fabaceae	?	?	?	?
Galactia regularis	Fabaceae				
Lespedeza capitata	Fabaceae				
Lespedeza procumbens	Fabaceae			x	
Lespedeza repens	Fabaceae	?	?	?	?
Lespedeza stuevei	Fabaceae	?	?	?	?
Lupinus perennis	Fabaceae				
Rhynchosia tomentosa	Fabaceae	?	?	?	?
Strophostyles umbellata	Fabaceae	?	?	?	?
Stylosanthes biflora	Fabaceae	?	?	?	?
Tephrosia virginiana	Fabaceae				x
Castanea dentata	Fagaceae	?	?	?	?
Castanea pumila	Fagaceae	?	?	?	?
Quercus falcata	Fagaceae	X		x	
Quercus marilandica	Fagaceae			x	
Quercus stellata	Fagaceae				
Geranium carolinianum	Geraniaceae				
Carya pallida	Juglandaceae				

Table 1. Continued.

Species	Family	Brown et al. (1987) historic habitat			
		"Beaches and Dunes"	"Forest Types—Pine	"Forest Types—Oak"	"Open areas and borders of woods"
Carya tomentosa	Juglandaceae			x	
Cunila origanoides	Lamiaceae	?	?	?	?
Monarda punctata	Lamiaceae			x	
Trichostema dichotomum	Lamiaceae				
Linum medium	Linaceae				
Comptonia peregrina	Myricaceae			x	
Pinus virginiana	Pinaceae		x		
Andropogon ternarius	Poaceae				
Andropogon virginicus	Poaceae				x
Aristida dichotoma	Poaceae	?	?	?	?
Aristida dichotoma var. curtissii	Poaceae				
Cenchrus tribuloides	Poaceae	?	?	?	?
Danthonia spicata	Poaceae				
Dichanthelium meridionale	Poaceae				
Dichanthelium sphaerocarpon	Poaceae				
Digitaria cognata	Poaceae				
Eragrostis spectabilis	Poaceae				
Gymnopogon ambiguus	Poaceae	?	?	?	?
Panicum capillare	Poaceae				x
Schizachyrium scoprium	Poaceae	?	?	?	?
Sorghastrum nutans	Poaceae				x
Sporobolus vaginiflorus	Poaceae				
Polygala mariana	Polygalaceae	?	?	?	?
Polygala polygama	Polygalaceae	?	?	?	?
Polygonum tenue	Polygonaceae	?	?	?	?
Rubus cuneifolius	Rosaceae				
Diodia teres	Rubiaceae				
Galium pilosum	Rubiaceae				
Agalinis purpurea	Scrophulariaceae	?	?	?	?
Linaria canadensis	Scrophulariaceae	x			
Melampyrum lineare	Scrophulariaceae	?	?	?	?
Schwalbea americana	Scrophulariaceae	?	?	?	?

variety of sandy sites throughout the Maryland Coastal Plain (Steiner in press), but a population at the Patuxent Wildlife Research Refuge North Tract, near Tipton Airport, is the most inland and disjunct from those along Chesapeake coastal sands. Prior to the report of *H. sobrinus* from oak savanna and other sandy localities in Wisconsin (Dunford and Young 2004), the species was presumed to be endemic to Florida (Peck and Thomas 1998). Recently, specimens have been identified from a number of states, and all collection sites are sandhill or "blowout" habitats.

Tiger beetles.—Tiger beetles are one of the most popular groups with insect collectors, and unlike many other insect groups, extensive information on past tiger beetle populations is available through museum specimens and literature records (Mawdsley 2005). Specimen records from the Smithsonian Institution National Museum of Natural History (NMNH) indicate that tiger beetles were collected in Anne Arundel County as early as 1894, with the first collections from Patuxent micro-desert habitat in 1906. Subsequent collections at these sites were made in 1912–1918, 1942,

Table 2. Rare plants reported from dry, sandy habitats within the Bowie, Bristol Odenton USGS quadrangles. Source: Maryland Natural Heritage Program (2005). % = Occurs on very dry soil at Jug Bay. # = "Moist to dry pinelands, oak-woods or clearings" (Fernald 1950); "Dry sandy soil on knobs and sandstone plateau margins" (Braun 1937).

Scientific Name	Common Name	Habitat Description from Gleason & Cronquist (1991)
Agalinis fasciculata	Fascicled gerardia	"Dry sandy soil, often weedy"
Aristida curtissii	Curtiss' three-awn	"Dry, often sandy soil"
Aristida lanosa	Woolly three-awn	"Dry sandy soil on the coastal plain"
Desmodium humifusum	Trailing tick-trefoil	"Dry sandy woods"
Desmodium strictum	Stiff tick-trefoil	"Pine barrens on the coastal plain"
Galactia volubilis	Downy milk pea	"Dry upland woods and barrens"
Galium hispidulum	Coast bedstraw	"Sandy soil, especially pine-land on the coastal plain"
Helianthemum bicknellii	Hoary frostweed	"Dry, usually sandy soil."
Lespedeza stuevei	Downy bushclover	"Dry upland woods and barrens"
Matelea carolinensis	Anglepod	"Rich thickets"%
Monotropsis odorata	Sweet pinesap	"Dry woods"
Pyrola virens	Greenish-flowered pyrola	"Dry woods"
Rhynchosia tomentosa	Hairy snoutbean	"Dry sandy woods and barrens, chiefly on coastal plain"
Schwalbea americana	Chaffseed	"Moist sandy soil"#
Solidago speciosa	Showy goldenrod	"Open woods, fields, prairies, plains"
Vitis rupestris	Sand grape	"Dry hills and rocks"

1972–1973, 1993, and 2004–2007. These specimens document a rich tiger beetle fauna, with many species occurring in large numbers at multiple sites in both recent and past surveys.

Species which have been found recently at sites along the Patuxent River include *Megacephala virginica* (L.), *Cicindela punctulata* Olivier, *C. repanda* DeJean, *C. rufiventris* DeJean, *C. scutellaris rugifrons* DeJean (both color forms), *C. sexguttata* F., *C. splendida* Hentz, *C. tranquebarica* Herbst, and *C. unipunctata* F. (Mawdsley 2007a, 2007b, 2007c). Museum specimens indicate that many of these species were once found in open barrens areas across central Maryland (Glaser 1984; Mawdsley 2005, 2007a). Many of these other sites have been lost as suburban development and uncontrolled vegetative succession eliminated suitable open habitat for these beetles (Glaser 1984; Knisley and Schultz 1997; Mawdsley 2005, 2007a). Species restricted to sandy barrens habitats, particularly *C. scutellaris rugifrons* but also *C. tranquebarica*, have consequently disappeared from much of central Maryland (Mawdsley 2007a).

Two tiger beetle species associated with coastal pine barrens in the northeastern U.S. have apparently been completely extirpated from central Maryland: *C. patruela* Dejean, a sand barrens specialist, and *C. purpurea* Olivier, a species with somewhat broader habitat tolerances. Both of these species were collected during the first half of the 20th century at sandy barrens sites near Washington, D.C. which have since been lost to urban and suburban development (Mawdsley 2005, 2007a). There are literature and/or specimen records of both species from Anne Arundel County, suggesting that these species may have once occurred in the Patuxent microdeserts (Knisley and Schultz 1997, Mawdsley 2005). However, neither species has been found at sites along the Patuxent River during recent intensive searches (Mawdsley 2007a, 2007c). The closest known extant population of *C. patruela* is in the Bear Pond Mountains of western Maryland, while the closest

known extant population of *C. purpurea* is at Soldiers Delight Natural Environment Area in Baltimore County (Glaser 1995, Mawdsley 2007a).

Bees.—Some regional information on past patterns of abundance and distribution of bee species exists in the collections deposited at the NMNH. The majority of these specimens date from the early 20th century, and collection localities were concentrated along the Potomac River and in some of the conveniently accessible counties surrounding Washington D.C. We have not located any historic collections from along the Anne Arundel County side of the Patuxent River. However, recent surveys at several sites located from the USGS Patuxent Wildlife Research Center south to Jug Bay Wetlands Reserve have resulted in a number of new state records and an assemblage of species that appear to be at least regionally restricted to this strip of sandy open county. It is likely that exploration of similar and more extensive sandy barren land on the Eastern Shore of Maryland would uncover the presence of similar species. While life history information on these species is scant, what is known indicates that this group of regionally rare bees is found here because of the presence of the specific plant genera on which they specialize and the sandy soil substrates some require for nesting.

Bee species regionally restricted to Patuxent micro-deserts include: *Andrena fulvipennis* Smith, *An. rudbeckiae* Robertson, *Agapostemon splendens* (Lepeletier), *Colletes americanus* Cresson, *C. brevicornis* Robertson, *Lasioglossum sopinci* (Crawford), *L. vierecki* (Crawford), *Dieunomia heteropoda* (Say), *Epeolus howardi* Mitchell, *Megachile addenda* Cresson, *Nomada texana* Cresson, *Perdita boltoniae* (Robertson), *P. octomaculata* (Say), *P. bequaerti* Viereck, *Perdita bishoppi* Cockerell, 1906, *Pseudopanurgus rugosus* Robertson, *Sphecodes johnsonii* Lovell, and *Svastra compta* Cresson. None of these species were mentioned in Mitchell (1960, 1962) as having occurred in Maryland.

This list will grow given that many unexplored sites have incomplete seasonal coverage. Because of the close association between many of the uncommon plants and their specialist bee pollinators, plant and bee diversity would be expected to be strongly linked.

Community relationships.—That all four groups of species have affinities with, and in many cases are restricted to, the same small number of sites appears clear. While both recent and historical collecting activities involving these species in the Baltimore and Washington region have been uncoordinated and usually non-systematic, they have been extensive and focused on the uncommon habitats likely to harbor rare species. Consequently, it seems unlikely that more than small pockets of these species would be found anywhere outside of the terraces of the Patuxent River.

The life histories of the beetle species listed here appear to be largely tied to the architecture of the sandy soils, pattern and type of detritus present, amount of exposed soil, and structure of the plants present. Bees clearly have a relationship with the plants present through the use of both pollen and nectar as larval nest provisions. A known example of these close associations is the relationship between two uncommon species of *Perdita* (*P. boltoniae* and *P. octomaculata*), both of which specialize on *Chrysopsis mariana*, a locally common sandy soil plant found primarily in micro-desert habitats along the Patuxent. Soil structure likely plays a strong role with species such as *L. vierecki* and *L. sopinci*, which are in a genus with few plant specialists. Further study of the remaining species would likely reveal similar associations or, in the case of the three parasitic species (*Nomada texana*, *Sphe-*

codes johnsonii, and *Epeolus howardi*), indirect ones through their choice of hosts or perhaps simply chance due to their overall rarity.

Discussion

Surveying insect groups along with the more consistently and traditionally inventoried plant and vertebrate groups while investigating biodiversity, ecological communities, and sites for potential preservation increases the amount and completeness of information available for consideration (Kremen et al. 2008). Insects offer alternative and often more specific confirmation of the biodiversity of a site due to their overall greater species richness, the lower acreages of land needed for population viability, the breadth of their specialized niches, and their often greater abundance. In addition to the three groups mentioned in this paper, there are others that have representatives restricted to sandy open areas or to the plants that live in them. In some instances it may be these groups rather than the plants or vertebrates that will better define uniqueness and value of a site for conservation.

The benefit of surveying multiple insect groups is that it invites a multidisciplinary, collaborative approach among specialists who otherwise have few opportunities to interact. For instance, without sharing notes on our insect and plant collecting activities, we would not have realized the scope of the importance of these relict micro-deserts to regional biodiversity. Our plant and insect records separately were of interest, but through collaboration we each learned of additional sites and the co-occurrence of these uncommon species.

This process has already had positive local effects. Prior to our studies, the only management action these lands received was revegetation. Sites were fertilized, hydroseeded, and planted with mixes of exotic grasses, legumes, and trees to the immediate destruction of any rare native communities. Discussions with landowners and managers have been very positive and have lead to the implementation and exploration of alternatives and the possibility of restoration of some of these lands. A cataloging of current, past, and potential micro-desert sites, along with natural history surveys of the Patuxent and elsewhere, would be a valuable next step.

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