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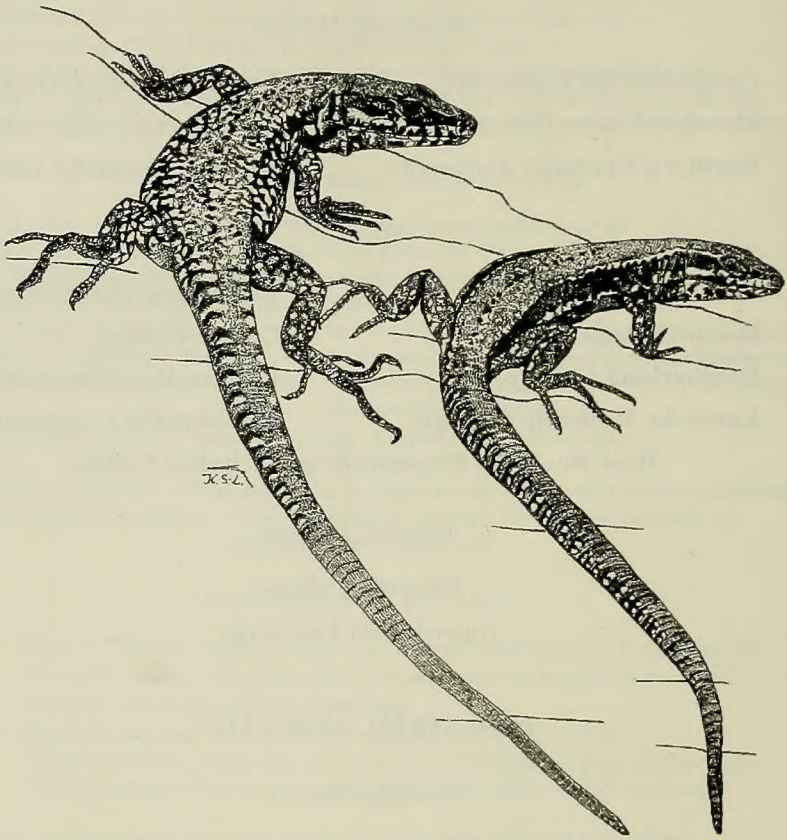

Figure 1. European wall lizards (*Podarcis muralis*). The larger female on the left has a regenerated tail as compared to the male on the right. Artwork by Katharina Schmidt-Loske.

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The Introduction of European and Italian Wall Lizards (*Podarcis muralis* and *P. sicula*; Reptilia, Lacertidae) into the United States

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ABSTRACT

Several populations of lacertid lizards were introduced to the United States during the last century. Of these, the European wall lizard (*Podarcis muralis*) in Cincinnati, Ohio, and northern Kentucky and the Italian wall lizard (*Podarcis sicula*) on Long Island, New York, and in Topeka, Kansas, have become well established. These urban populations are successful in that they have little competition from native species and are pre-adapted for the climate at these latitudes. Local scientists are taking advantage of the opportunity to study the natural history and population ecology of these populations.

INTRODUCTION

One of the most successful invasive groups of Old World reptiles found in the United States is from the family Lacertidae. Conant and Collins (1998) reported five possible extant populations of two lacertid lizard species in the eastern U.S. The first introduction of wall lizards was an accidental escape of several individuals of *Podarcis sicula* from an animal dealer in Philadelphia in 1927 (Kauffeld 1931); this population may now be extinct (Smith and Kohler 1977). A small population of *P. sicula* was established in Topeka, Kansas, from a similar loss of specimens by a pet dealer about 50 years ago (Collins 1982). A third population of this species was introduced to Long Island, New York, in 1966 (Gossweiler 1975).

A record of *Podarcis muralis* from Van Wert, Ohio, reported by Conant and Collins (1998) has recently been determined to be *Darevskia valentini* by Bischoff and Deichsel (2002) and was likely only a single specimen included in a shipment to an equipment company. No known population of *D. valentini* exists in the U.S. However, a successful introduction of *P. muralis* has occurred in Cincinnati, Ohio (Vigel 1977). A review of the systematics and natural history of the species can be found in Gruschwitz and Bohme (1986). When I first moved to the Cincinnati area in 1977, it was the local naturalist and nature cinematographer Karl Maslowski who told me the interesting story of the amazing "Lazarus Lizards" of Cincinnati (Maslowski and Maslowski 1979).

THE *PODARCIS MURALIS* INTRODUCTION

The confusion about the original introduction of *Podarcis muralis* in Cincinnati was clarified in a recent paper by Deichsel and Gist (2001). Based on this report, it now appears that 10 individuals were released, rather than the previously thought number of two (Vigle 1977). George Rau, a member of the locally well-known Lazarus family, released the lizards on Torrence Court in eastern Cincinnati when he was a child in 1951 or 1952 (Deichsel and Gist 2001). The source of these lizards of the subspecies *P. muralis muralis* was near Lake Garda, about 120 km away from Milan, Italy (Deichsel and Gist 2001).

In 1958, Rau claims to have also introduced 10 additional lacertid lizards at the same location from the island of Vedra off Ibiza, Spain, which were likely *Podarcis pityusensis vedrae* (Deichsel and Gist 2001). Deichsel and Gist (2001) pointed out that there is no evidence that this introduction was successful, which is likely due to its coming from a warm maritime climate where it does not need to enter dormancy in winter. On the other hand, Hedeen (1984) pointed out that the annual precipitation and temperature curve for Milan, Italy, and Cincinnati, Ohio, are almost identical, indicating that *P. muralis* was pre-adapted to its new home. Both Lake Como (the site of origin reported by Vigle 1977) and Lake Garda (the site of origin reported by Deichsel and Gist 2001) are near Milan in Lombardy Province in northern Italy (Hopkins 1997).

SUBSEQUENT DISPERSAL

In the original report in the literature of *Podarcis muralis* in Cincinnati, Vigle (1977) mentioned that the populations had spread to an oval-shaped distribution of about 1 × 3 km surrounding the reported site of release. He reported that they had dispersed over roads that were heavily traveled. Hedeen (1988) found that a second population was established at the Cincinnati Zoo and Botanical Garden by individuals that had escaped from an exhibit at the Children's Zoo. This extended the population about 4 km to the northwest of the original one. About that same time I confirmed reports from S.F. Platek (pers. comm.) that *P. muralis* spread up the floodplain and across the Little Miami River to the northeast from the original introduction. As Kauffeld (1931) speculated for *P. sicula* in Philadelphia, Hedeen and Hedeen (1999) reported that railroad rights-of-way have been a major avenue for the east-west dispersal of the original population.

The first anecdotal report of *Podarcis muralis* having crossed the Ohio River into northern Kentucky came from a high school teacher in Covington in 1988. Extensive searching of the area near Scott Boulevard and Twentieth Street by the author and Matthew Draud yielded no sightings. Other stories of young fishermen crossing the bridges and bringing wall lizards back to use as bait circulated in the herpetological community. It was not until September 1993, however, that the first documented state record of the species was made in Fort Thomas, Campbell County, Kentucky (Draud and Ferner 1994). Soon after that, G. Pille (pers. comm.) reported the release of several *P. muralis* captured from the Cincinnati population into gardens in Park Hills, Kenton County, Kentucky, which were immediately confirmed as an established, reproducing population (Ferner and Ferner 2002). Both these Kentucky populations have spread in a radius of about 0.5 km around the residential neighborhoods in which they were introduced.

RESEARCH ON THE INTRODUCED POPULATIONS

Introduced species provide research opportunities relative to both their basic biology as well as their process of colonization. *Podarcis muralis* from the Cincinnati population has had aspects of its natural history such as home range (Brown et al. 1995), reproductive cycle (Kwiat and Gist 1987), and freezing tolerance (Claussen et al. 1989) studied in detail. The food habits of the Long Island population of *P. sicula* have been found to be very similar to some European populations (Burke and Mercurio 2002). Burke and Ner (2004) reported the seasonal and diel activity of this species in New York to be impacted by the lower minimum temperatures than found in Italy. They found the wall lizards are inactive for 5 months over the winter in the U.S., as compared to at least some activity throughout the year in the Italian populations.

An additional area of inquiry of great interest with introduced populations is their genetic make up relative to such questions as genetic drift and selective pressures. Loss of variability is expected with introduced species because of their initial small gene pool (Gorman et al. 1978). Deichsel and Gist (2001) reported on unpublished data by R.M. Brown that indicates an absence of allozyme variation at 14 allozyme loci in the Cincinnati population of *Podarcis muralis*, which is now thought to have been established by the introduction of just 10 individuals. Further genetic studies of these spreading populations will be of interest.

THE FUTURE OF THE INTRODUCED POPULATIONS

While many intentional or accidental introductions of invasive species may not be suc-

cessful, those that become established warrant our concern. Three populations of *Podarcis* seem to be so well established that their long-term survival is likely. While there were some reports that the Philadelphia *P. sicula* had died out in the 1940s, Conant (1959) found them to be doing well in the original location as they may be to this day (Conant and Collins 1998). Brown et al. (1995) reported a decline of *P. muralis* in some neighborhoods in Cincinnati due to real estate development and restoration of retaining walls. However, my observations confirm that these are only very localized setbacks and overall the lizard populations remain vigorous and are continuing to disperse.

Another concern with introduced species is what impact they will have on other native or introduced species in the region (Frankenberg 1984; Salzburg 1984). Hedeen (pers. comm.) and I have not yet found sympatry between *Podarcis muralis* and the three native species in the Cincinnati and northern Kentucky region. These three species are *Sceloporus undulatus, Eumeces* fasciatus, and *E. laticeps,* with *S. undulatus* near the northern limit of its range and *E. fasciatus* having no confirmed records in northern Kentucky (Conant and Collins 1998). While old museum records of these species can be found in the vicinity where the wall lizards now roam, recent sightings of the native species in urbanized areas are lacking. *Podarcis muralis* is known to be an aggressive competitor and well adapted for urban environments (Deichsel and Gist 2001); it appears that the wall lizards have no competition from native species.

What would happen if *Podarcis muralis* moves from urban areas into more natural habitats such as those in California Woods City Park in Cincinnati or Devou Park in Covington, Kentucky? Wall lizards have dispersed to the edges of many such habitats where some native species may still remain. Based on a foraging mode using olfactory cues, these lacertids (Cooper 1995) seem more similar to the skinks than to the iguanid lizards. While relying heavily on olfaction, wall lizards also respond well to visual cues and therefore may be a very broad-based competitor (Amo et al. 2004). Mesocosm experiments similar to those done by Tiebout and Anderson (2001) are currently being done by students at Thomas More College to determine the potential for niche overlap should the alien wall lizards move into the range of the native lizards in the Cincinnati region.

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Search for the Parity-violating Energy Difference between a *d*- and *l*-iron Complex

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ABSTRACT

Mössbauer spectra for *l*- and *d*- enantiomers of the $Fe(phen)_3Sb_2(C_4H_2O_6)_2{\cdot}8H_2O$ complex are reported. The data show a small but reproducible energy shift of the Fe-Mössbauer spectra for the two enantiomers of 0.004 ± 0.002 mm/sec. This shift corresponds to an energy difference of 1.9×10^{-10} eV ($\Delta E/E\sim10^{-15}$). This energy difference is of the order of the parity violation energy difference (PVED); however, early theoretical calculations suggest that this shift may not be due to PVED. Other possible effects for this energy shift are discussed.

INTRODUCTION

The word chirality or handedness was first introduced into science by Lord Kelvin (William Thomson) who said "I call any geometrical figure, or groups of points, chiral, and say that it has chirality, if its image in plane mirror, ideally realized, cannot be brought to coincide with itself" (Lord Kelvin 1904). Two objects, which are mirror images of each other, are called enantiomers. Chiral molecules lead to macroscopically chiral phases of matter with different properties.

Limonene ($C_{10}H_{16}$) exists in two chiral forms that are mirror images of each other. The *d*-limonene has the pleasant scent of orange; the *l*-limonene, of lemon. The *l*-enantiomer of carvone ($C_{10}H_{14}O$) smells like spearmint; its *d*-enantiomer, of caraway. The *l*-form of cocaine ($C_{17}H_{21}NO_4$) is psychoactive but its *d*-enantiomer is not. The *l*-enantiomer of the artificial sweetener aspartame ($C_{14}H_{18}N_2O_5$) is 200 times sweeter than sugar, but the *d*-enantiomer is actually rather bitter tasting. The *l*-thalidomide cures the symptoms of morning sickness, but its *d*-enantiomer is a tragic teratogen, and although it is racemised in the body, it could never be safe for women of childbearing age.

On a biological level, most living things use *l*-amino acids in protein and *d*-sugars in the backbone of DNA, which generally spirals in one direction. It turns out that the natural *l*-amino acids are slightly more stable than their *d* mirror images. Many plants like honeysuckle twine in one direction and not the other. This asymmetry in biology is a feature of fundamental physics. The reason the *l*-amino acids are slightly more stable than their *d* mirror images is because the *l*-amino acids are lower in energy than their enantiomers. It has been suggested that this shift in energy may be due to the nuclear weak force (Letokhov 1975).

In physics, when radioactive atoms β-decay (via the weak force), the electrons they shoot off tend to have a left-handed spin. Wu (1957) discovered that when the ^{60}Co nucleus was placed in a magnetic field, electrons from the beta decay were preferentially emitted in the direction opposite that of the aligned angular momentum of the nucleus.

Out of the four fundamental forces in nature, the parity-violating weak force is the only one known to be chiral. The presence of weak neutral currents within the nucleus gives rise to an anapole moment for all atoms and, as a result, all atoms are chiral. The small optical activity for a number of atoms has been mea-

sured and has provided a test of the standard model of low energy nuclear physics (Wood et al. 1997). Chirality at the atomic level requires that non-superimposable mirror-image molecules (enantiomers) differ in total energy by the minute parity violating energy difference (PVED). Letokhov (1975) suggested that the electroweak interaction would lift the degeneracy between the enantiomers predicted by normal quantum electrodynamics. A number of calculations of the PVED for small molecules have been published (Bakasov et al. 1998; Hegstrom et al. 1980; Lazzeretti and Zanasi 1997; Khriplovich 1991; MacDermott and Tranter 1992; Mason and Tranter 1984; Masterson and Wieman 1995; Zanasi et al. 1999).

In our experiment, the *l*- and *d*- forms of the highly optically active $Fe(phen)_3Sb_2(C_4H_2O_6)_2{\cdot}8H_2O$ molecule were prepared. The crystals have been characterized with X-ray diffraction. Preliminary measurements of the Mössbauer spectra of the *l*- and *d*- forms of these molecular crystals show a small difference in the energy of the two enantiomers of 0.004 ± 0.002 mm/sec (1.9×10^{-10} eV, $\Delta E/E\sim10^{-15}$). This energy is of the right order of magnitude to be ascribed to the PVED if one scales the values predicted theoretically for smaller amino acids by the atomic number to the 6.2 power; however, these are closed shell molecules and the PVED is expected to be small ($\Delta E/E\sim10^{-18}$) (Daussy et al. 1999; Laerdahl et al. 2000; Laerdahl and Schwerdtfeger 1999).

MATERIALS AND METHODS

The *l*- and *d*- enantiomers of the $Fe(phen)_3Sb_2(C_4H_2O_6)_2{\cdot}8H_2O$ complex were obtained by initially reacting $FeCl_2{\cdot}H_2O$ with a solution of phenanthroline monohydrate ($C_{12}H_8N_2{\cdot}H_2O$) to produce the $Fe(phen)_3^{2+}$ cation. To resolve the *l*-enantiomer, commercially available potassium antimonyl-(+)-tartrate was added to the above solution to produce *l*-$Fe(phen)_3Sb_2(C_4H_2O_6)_2{\cdot}8H_2O$. The *d*-enantiomer was synthesized using potassium antimonyl-(−)-tartrate (obtained by some slight modifications of the procedure of Schlessinger (1962) for preparing sodium arsenyl-(+)-tartrate in which unnatural tartaric acid was used instead of the natural (+) tartaric acid) as the resolving agent. An early x-ray diffraction study of this molecule has shown that the *l*-$Fe(phen)_3^{2+}$ is in the form of the left handed propeller (Zalkin et al. 1973). Figure 1 shows the molecular structure of the two enantiomers of the $Fe(phen)_3^{2+}$ cation, which consists of a central iron atom with three planar phenanthroline ligands arranged to form a propeller shape.

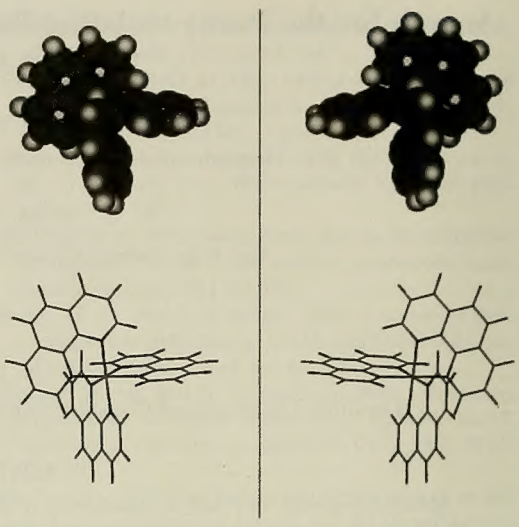


Figure 1. Structures of the *l* and *d* forms of $Fe(phen)_3^{2+}$ cations showing the propeller shapes of the ligands bonded to the central iron atom.

It is important to be clear on what is meant by *l*- and *d*- enantiomers since this molecule has an unusual optical rotatory dispersion (ORD) curve as seen in Figure 2. The *l*- designation refers to the counterclockwise rotation of plane polarized light (as one looks at the light source) at a wavelength of 589 nm, commonly known as the sodium D line. Thus, it is common to describe it as $(-)_{589}Fe(phen)_3$. Similarly, the *d*-enantiomer rotates plane polarized light in the clockwise direction at the sodium D line and is described as $(+)_{589}Fe(phen)_3$. Figure 2 also shows the circular dichroism for this compound. Thus, $Fe(phen)_3$ is seen to be a highly optically active molecule.

Despite the large specific rotation exhibited by the $Fe(phen)_3$ molecule at some wavelengths, $[\alpha]_D = \pm710°$, the two enantiomers are quite unstable with respect to racemization in solution. Many racemization studies have been performed on this particular mol-

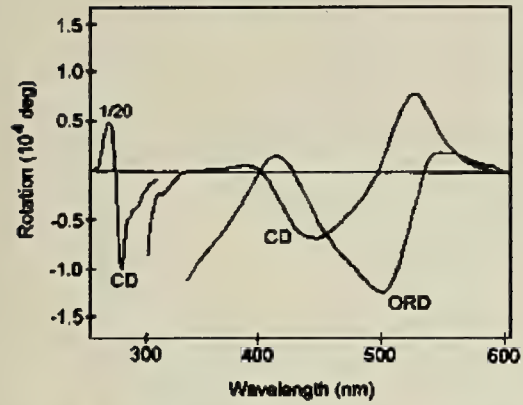


Figure 2. Plot of the circular dichroism (CD) and the optical rotatory dispersion (ORD) for the *d*-$Fe(phen)_3Sb_2(C_4H_2O_6)_2$. The mirror enantiomer shows the expected opposite CD and ORD.

ecule by a variety of investigators (Baslo et al. 1954). These studies revealed that the iron complex racemizes by an intramolecular mechanism in which the bonds between the phenanthroline ligands and the central iron atom distort and twist. This intramolecular mechanism reduces the activation energy for racemization, thus providing a possible explanation for the ease with which the enantiomers racemize. We measured the half-life of the racemization rate at room temperature for the $Fe(phen)_3$ to be ~2 minutes in acetonitrile. The half-life increases to 23 min when dissolved in water. These short racemization half-lives present difficulties in performing experiments on the enantiomers in solution unless the experiments are done at low temperatures where the complexes are more stable. The rapid racemization would indicate that the phenanthroline ligands are not strongly bonded.

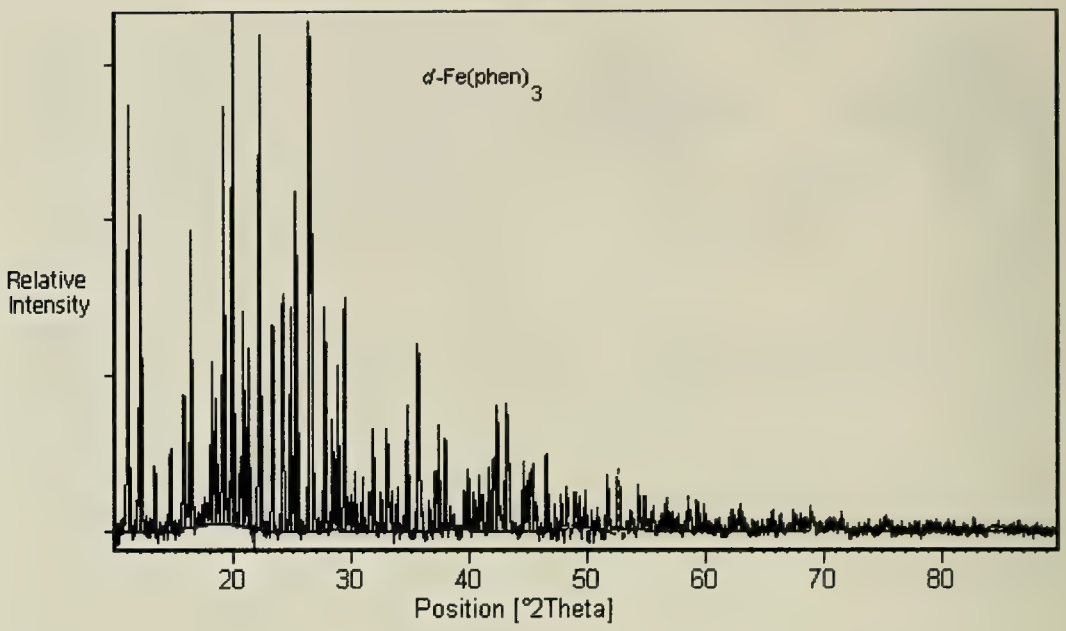
Physically, the material comes in the form of a deep red powder, which dissolves quite easily in water, or any polar solvent. To ensure that we had actually synthesized the molecule of interest and to determine if the two enantiomers had the same crystal structure, an x-ray diffraction pattern (Figure 3) was measured for the *d*- and *l*-$Fe(phen)_3Sb_2$(tartrate). From the x-ray diffraction patterns, there seem to be a minor variation in only peak-amplitudes between the two species.

RESULTS AND DISSCUSION

Mössbauer spectroscopy is a powerful technique to probe the iron site to discern the interactions between electrons and the iron nucleus. In Mössbauer spectroscopy, the ^{57}Fe nucleus is excited from the ground state with $I = ½$ to the first excited state with $I = ⅜$, where I is the nuclear spin of the iron nucleus. The photon energy, 14.4 keV, required for achieving this ^{57}Fe nuclear resonance is obtained from a radioactive source ^{57}Co which undergoes an electron capture process. Application of Doppler velocity of few mm/sec will not only compensate the recoilless loss but also modulate the 14.4 keV energy for the resonance to be observed. A plot of the transmitted gamma-radiation versus the applied velocity (Doppler) to the source constitutes a Mössbauer spectrum. From the Mössbauer spectrum one can determine the chemical shift (due to the net s-electrons density at the nucleus), the quadrupole interaction (due to the interaction between the electric field gradient tensor and the quadrupole moment of the iron nucleus), and the magnetic hyperfine interactions of the iron site (due to electron and nuclear spin interactions). These three parameters are known as isomer shift (δ), quadrupole splitting (Δ), and hyperfine magnetic field (hmf), respectively.

As stated earlier, under normal quantum electrodynamics, the total energies of enantiomers are degenerate. The PVED splits this degeneracy for each electronic level, one increasing and the other decreasing in energy. Any obvious difference in the observed Mössbauer transition energies between enantiomers might be attributed to a difference in the PVED.

Mössbauer absorbers were prepared from the *l*- and *d*- enantiomers of the $Fe(phen)_3Sb_2(C_4H_2O_6)_2{\cdot}8H_2O$ complexes with densities of order to 0.1482 and 0.1812 mg/cm^2 respectively. Room temperature ^{57}Fe Mössbauer effect spectra were obtained using ^{57}Co in rhodium matrix source and a Wissel system II constant acceleration spectrometer. The spectrometer had an intrinsic ^{57}Fe linewidth of 0.12 mm/sec. Each spectrum was accumulated over 2 million counts per channel. Two separate measurements were made on one sample (both *l*- and *d*- enantiomers). A



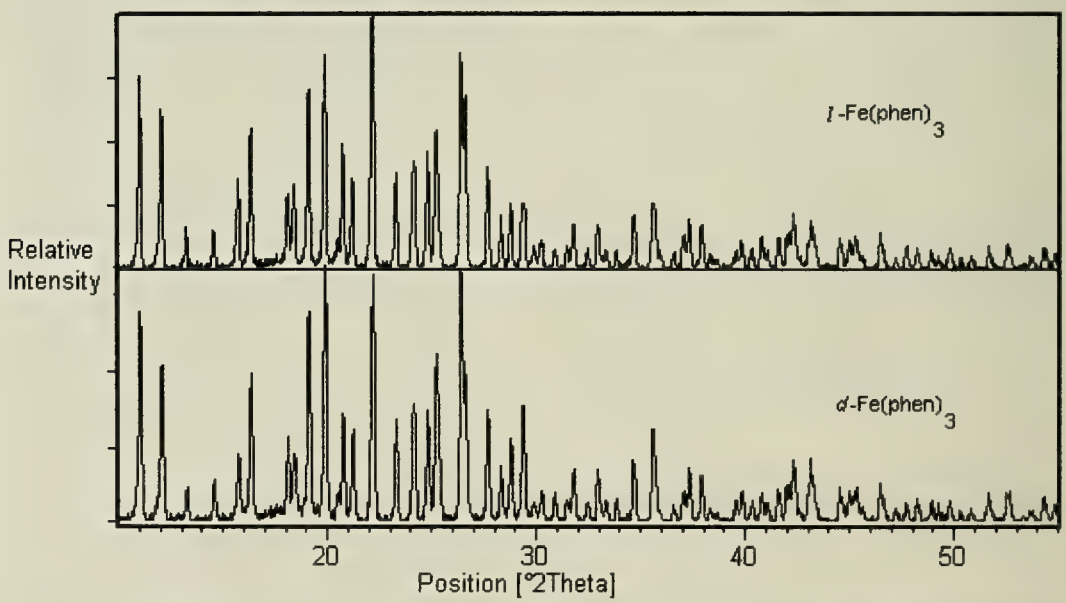


Figure 3. Upper: The x-ray diffraction patterns for the *d*-enantiomer of $Fe(phen)_3Sb_2(tartrate)$. The same graph was obtained for the *l*-enantiomer. Lower: The x-ray diffraction patterns for both *l*- and *d*-$Fe(phen)_3Sb_2(tartrate)$ at smaller angles.

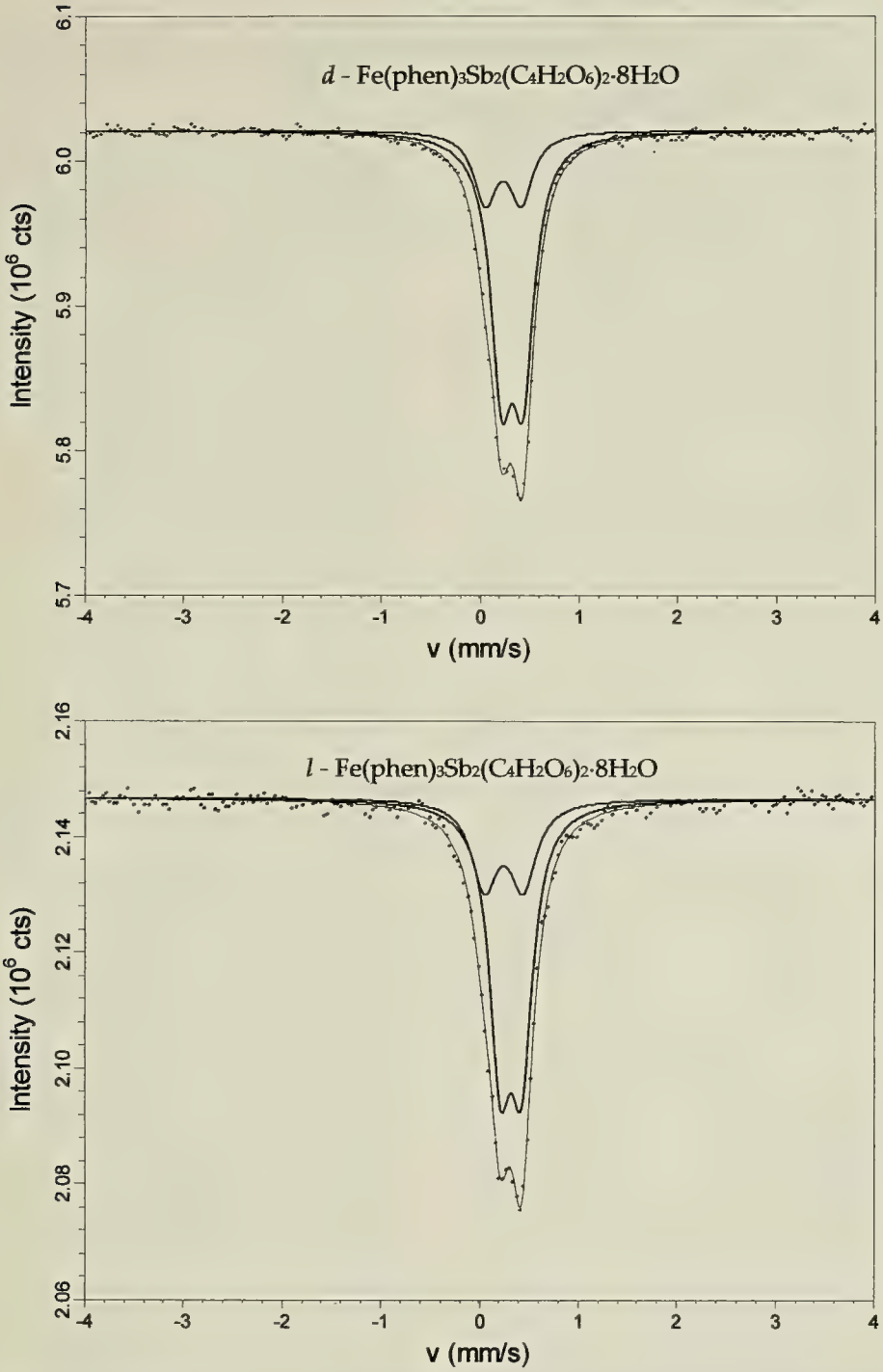


Figure 4. The Mössbauer data for the two enantiomers. The plots show the data along with two doublets which were used to obtain the fitted curves.

Table 1. Summary of the results of the Lorenzian line fitting routine of both enantiomers. δ is the isomer shift, Δ is the quadrupole splitting. The uncertainties expressed in the parentheses refer to the quality of the fit for each experimental data set.

Run number	Enantiomer	δ (mm/sec)	Δ (mm/sec)	$\delta_l - \delta_d$ (mm/sec)
1	*l*	0.3241 (83)	0.219 (17)	0.007
	d	0.317 (23)	0.216 (58)	
2	*l*	0.3191 (53)	0.2164 (97)	0.002
	d	0.3174 (29)	0.223 (58)	
3	*l*	0.316 (15)	0.223 (25)	0.005
	d	0.311 (76)	0.23 (15)	
4	*l*	0.3177 (99)	0.214 (22)	0.002
	d	0.316 (17)	0.222 (28)	

second experiment was performed on a second sample in which the *l*- and *d*- were not known to the Mössbauer experimentalist in advance (blind experiment). The data from all of the three experiments were consistent. Room temperature ^{57}Fe Mössbauer effect spectra observed for the two enantiomers studied here are shown in Figure 4. The spectra were analyzed (fitted) using two sets of quadrupole doublets. The results of the fit are shown in Table 1.

CONCLUSIONS

In summary, the first experimental evidence for an energy difference between enantiomers of chiral molecules in a crystal has been reported. Analysis of all of the data on isomer shift of the major doublet (doublet 2) yields a difference in their isomer shift of 0.004 mm/sec, which corresponds to an energy difference of 1.9×10^{-10} eV. All four sets of data show that the *d*-enantiomer lies below that of the *l*-enantiomer by $\sim1.9\times10^{-10}$ eV. Although this energy difference is on the order of magnitude of that predicted by a $Z^{6.2}$ scaling law of the lower Z parity violation energy difference, it could be due to some, as yet undetermined, properties of the crystals or an effect of the chiral antimony tartrate on $[Fe(phen_3)]^{+2}$ (Hegstrom et al. 1980; Laerdahl and Schwerdtfeger 1999). However, x-ray diffraction data indicate that the enantiomers are structurally identical. Clearly more detailed calculations and further experiments are needed. Plans for ^{119}Sn probe to measure the energy differences for $Sn(phen)_3Sb_2(C_4H_2O_6)_2\cdot 8H_2O$ enantiomers using ^{119}Sn Mössbauer spectroscopy are underway. The larger Z (50) of Sn would predict an increase over the present results by ~70.

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The 1974–1975 Archaeological Excavations at Owl Cave (15Ed43), Mammoth Cave National Park, Kentucky

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ABSTRACT

Archaeological excavations in the vestibule of Owl Cave (15Ed43) during winter 1974–1975 revealed the presence of Early, Middle, and Late Archaic/Early Woodland occupations. Analysis of the archaeological record from Owl Cave indicates that Early Archaic environmental exploitation was focused toward deer hunting and was without evidence of horticulture. Middle Archaic cultures using the Owl Cave vestibule exploited a wider range of resources, following a more diffuse economic subsistence pattern. The incipient horticultural evidence from the "large caves" in the Mammoth Cave area (e.g., Mammoth, Salts, and Lee), and from evidence within the archaeological record at Middle and Late Archaic shell mounds in the Big Bend region of Green River, probably arose from a diffuse economic subsistence pattern as evidenced by the number of environmental zones exploited by Middle Archaic Owl Cave residents and as exemplified by the Horizon II archaeological record at Owl Cave. Late Archaic/Early Woodland levels at Owl Cave contain meager evidence of plant domestication (a single *Cucurbita* seed hull).

INTRODUCTION

Archaeological excavations at Owl Cave in Mammoth Cave National Park (MCNP), Kentucky, began outside the cave entrance in fall 1974 but, due to excessively bad weather, were moved into the gridded south portion (four, 1 × 1 m test units: C, D, E, and F) of Owl Cave vestibule. Excavations continued from December through January 1975. Additional excavations were carried out by Dr. Darlene Applegate from Western Kentucky University in 1999 prior to installation of a cave gate at Owl Cave (Applegate 1999). The content of this paper, however, addresses only the materials recovered during the 1974–1975 Owl Cave excavations supervised by Carstens.

The Owl Cave excavations were a part of a larger project directed by Dr. Patty Jo Watson of Washington University, St. Louis, Missouri, that addressed the origins of plant domestication in the Eastern Woodlands (Crothers 2001; Crothers et al. 2002; Marquardt and Watson n.d.; Watson 1969, 1974; Watson and Kennedy 1991).

The general excavating format used at Owl Cave included removing deposits by 10 cm arbitrary levels and taking four flotation samples when possible per level. (Flotation samples are 10 liter bags of soil removed from each excavation level, then separated for microscopic and macroscopic evidence of seeds, artifacts [ceramic, lithic, bone, ground stone], and animal bones.) Excavation was accomplished by troweling and occasionally by shovel-skimming. Whenever prehistoric artifacts were found in situ, they were plotted using a cartesian coordinate system for spatial (horizontal) and temporal (vertical) control. Excavations were halted when limestone bedrock was encountered.

CAVE STRATIGRAPHY

Variations in depositional processes at Owl Cave may be related to both cultural and natural processes. Cultural occupation in the grid-south area of Owl Cave vestibule began ca. 8000 years ago and occurred before the deposition of loamy sands. Numerous artifacts were found lying on limestone bedrock within the cave excavations. Occupation was not intensive at any one time but occurred sporadically as revealed by the excavation of four 1 × 1 meter excavation units. Several lenses of ash, and/or ash and charcoal, indicate that fire building occurred inside the vestibule area, but no hearths were encountered within any of the excavations. Although charcoal flecks were present, not enough were collected for a radiocarbon date. It appears that prehistoric use of the cave ceased by 2000 years ago.

Limestone breakdown (ceiling collapse) was deposited concurrently with the deposition of cultural deposits; however, this natural deposition was probably not a major consideration for transitory vestibule inhabitants. Soil and

Table 1. Stratigraphical sequence and date ranges at Owl Cave, Mammoth Cave National Park, Kentucky.

Excavation unit and level					
C	D	E	F	Horizon	Date range
1	1–2	1	1	H III	4000–2500 years ago
2–3	3–5	2	2–3	H II	5000–2400 years ago
4	6–8	3	4–7	H I	8000–4000 years ago

pollen samples were collected from the combined deposits, but the analysis of these samples by specialists was never completed. These samples are now curated in the cultural resources lab at Washington University, St. Louis, Missouri, and at Mammoth Cave National Park, Edmondson County, Kentucky.

Based on the cultural and natural deposits at this site, three cultural periods were distinguished in the Owl Cave excavations: a basal Horizon I, which probably dates between 8000 and 4000 years ago; a middle Horizon II, which probably dates between 5000 and 2400 years ago; and a Horizon III, which overlaps with Horzion II and dates between 4000 and 2500 years ago (Table 1). This dating sequence is based on the presence of temporally diagnostic bifacial projectile point styles (e.g., arrowheads) that have been dated by conventional radiocarbon dating methods.

ARTIFACT DESCRIPTIONS

The artifacts recovered from Owl Cave vestibule may be grouped into the following categories: utilized and non-utilized chipped stone, vertebrate faunal remains, non-vertebrate faunal remains (not discussed in this paper), and botanical remains. The following is a brief description of these categories presented by cultural horizon.

A total of 462 pieces of chipped stone was recovered from the four test units. Two different methods of analysis were used for the chipped stone materials recovered in situ and from the screening box: (1) hand tabulations for units C, E, and F; and (2) computer tabulations of morphological traits for unit D. The former analysis concentrated on the fluctuation of blade, non-blade, and waste flake production through time. It also emphasized the specific area of the core from which the flake was detached. All chert was examined for possible special methods of treatment, such as heat-treating. The computer-tabulated study was accomplished to provide a single stratigraphic control sample that might demonstrate developments in lithic technology through time. Similar controls and studies have been used at other archaeological sites in MCNP.

Only 8% of the excavated chipped stone sample evinces utilization. This very small percentage supports the idea that the site was used sporadically and that cultural activities at the site were not intensive. The utilized materials can be subdivided into bifacial (projectile and non-projectile) and unifacial categories. A biface is a chipped stone tool that is worked on two opposing faces. A unifacial tool has workmanship (chipping) along only one edge. The bifacial category represents about 5% of the total chipped stone category and 64% of the total utilized stone inventory.

Horizon I, representing the lowest stratigraphic levels of the site, contained three projectile points/knives; Horizon II had four, and Horizon III contained one projectile fragment (Figure 1). The three projectiles from Horizon I varied in shape, yet the three styles are common Early to Middle Archaic forms, ca. 8000–5000 years ago. One point is a small, triangular, untyped side-notched version. It resembles a Lamoka projectile (ca. 3000–5000 years ago) but occurs in a context with other points that pre-date Lamoka style projectiles (Ritchie 1932). This projectile point form is not common in the central Kentucky karst area, but another similar side-notched point was found on the surface at Owl Cave. This Lamoka-like point is very similar in size and appearance to Tremble and Merom side-notched points of the Wabash Valley's Riverton culture that dates between 4000 and 3000 years ago (Winters 1969:151–154).

A second point was found in test unit C, level 4. This projectile point, similar to the MacCorkle style, is characterized by a large, corner-notched, triangular blade with a bifurcated base. This point was used ca. 8000 years ago.

The third projectile form is similar to the Cypress Creek I point type (Lewis and Lewis 1961:13). Cypress Creek I projectiles were found in the Stratum IV horizon at the Eva site and have been dated to 7200 B.P. ± 1500 (M-357). On the basis of projectile point ty-

Figure 1. Excavated and surface collected projectile points from Owl Cave, Mammoth Cave National Park, Kentucky. **A.** Adena projectile form, Horizon II. **B–D.** Surface collected early and middle projectile point forms. **E–F.** Buck Creek projectile forms, Horizon II. **G.** MacCorkle projectile form, Horizon II. **H.** Turkey-tail projectile form, Horizon III. **I–K.** Horizon I projectile forms (I, MacCorkle; J, Cypress Creek; and K, Lamoka-like).

pology, Owl Cave Horizon I should date between 8000 and 5000 years ago.

The four projectiles points recovered from Horizon II include three recognizable projectile forms: two Buck Creek, a MacCorkle, and an Adena. The Early Archaic MacCorkle form was found above the Buck Creek type in Test Unit E, out of temporal context. It likely represents either artifact mixing in the shallow Horizon II deposit of Test Unit E or the continued use, reuse, or curation of an earlier projectile variety found on site by Native Americans. The Buck Creek projectile style was described by Seeman (1975:106–108). It is a small (ca. 2–4 cm) triangular point that has straight to incurvate lateral margins and usually a straight to slightly expanding stem. The stem cuts deeply into the blade, producing a barbed projectile. Seeman places this projectile type in the Late Archaic to Early Woodland periods for southern Ohio (ca. 4000 to 2400 years ago). This projectile type has been found in Late Archaic deposits (ca. 5000 to 3500 years ago) (Hay 1957:9–15) in Montgomery County, Tennessee. The Adena point may be found in contexts ranging from Early Woodland to Late Woodland but usually dates between 2800 and 2400 years ago. Thus, projectile point typology indicates Owl Cave Horizon II probably dates to the Late Archaic/Early Woodland transitional period, ca. 5000–2400 years ago.

A fragment of one projectile point resembling the Turkey-tail was recovered from Horizon III. According to Bell (1960), this form is transitional Late Archaic–Early Woodland and has been found in contexts dating between 4000 and 2500 years ago. This time

range overlaps with Horizon I. Numerous turkey-tail points have been found in Mammoth Cave National Park, especially on the surface at Salts Sink (Watson 1974:14).

The metrical descriptions of the non-projectile, bifacial and unifacial, utilized chipped stone materials, described by horizon, illustrate that the total number of utilized non-projectile materials is small, and that the data reveal insight about chipped stone tool production at Owl Cave.

The frequency of utilized non-projectile artifacts increases slightly from Horizon I to Horizon II. This increase is followed by a decrease in Horizon III. The mean length/width and mean thickness/weight ratios also exhibit some variability and similarity between bifacial non-projectile forms and unifacial tools. There is a tendency for bifacial tools to be larger and heavier than unifacial tools at Owl Cave through time. A possible explanation for this is that bifacial tools may perform more "heavy-duty" tasks than do unifacial tools, such as butchering, as opposed to skinning or scraping. Unifacial tool length also appears to decrease through time, yet the average width per tool increases. Such a size change may represent a functional difference of tool use through time. Unifacial tools at Owl Cave demonstrate a change from multi-purpose cutting-scraping tools (e.g., jackknife-like function) to a more specific (specialized) function (e.g., end scrapers). There also appears to be a cultural selectivity for either flake size or flake task, as length-width and thickness-weight categories do not overlap as would be expected if there were no cultural selection for flake size.

Flake type characteristics of the non-utilized chipped stone materials indicate that there is an infrequency of decortication flakes (chipped flakes with an exterior cortex) in the entire chipped stone industry at Owl Cave. Fifteen percent of the hand-tabulated material was comprised of decortication flakes, but only 5% had primary coverage (i.e., more than 90% of the surface covered with cortex). This may indicate that chert and semi-finished chipped stone tools were "roughed-out" elsewhere and brought back to Owl Cave for completion and use. This pattern remains somewhat constant throughout the cultural horizons with percentages of 6.6 for HI, 5.3 for HII, and 4.0 for HIII, respectively. Additional evidence is found in the extremely high and diachronically consistent percentages of non-identifiable waste flakes, which consistently constitute about 50% of the non-utilized chipped stone materials (Horizon I, 53%; HII, 49%; HIII, 45%). The total weight of waste flake averages less than 0.9 g per flake. I would suggest that similar chipped stone tool manufacturing activities (tool manufacture and completion, and tool maintenance) occurred throughout the sporadic occupations at Owl Cave.

FAUNAL REMAINS

A total of 272 non-human vertebrate faunal remains was recovered from the four test excavations in Owl Cave vestibule. Seventy-five percent of these vertebrate remains (N = 204) were identified to genus. Of this total, the remains of white-tailed deer were the most abundant, constituting 81% of the identifiable remains.

The predominance of deer bone to non-deer bone demonstrates that a focal hunting pattern was emphasized at Owl Cave. Emphasis on deer hunting occurs diachronically and is very similar in frequency to the focal hunting evidenced at other Early Archaic through Late Archaic sites (e.g., the Eva site, the Carlston Annis site, and the Riverton site) (Crothers n.d.; Glore n.d.; Lewis 1996; Lewis and Lewis 1961; Phillips and Brown 1983; Marquardt and Watson n.d.; Webb 1950; Winters 1969). A gradual decrease in the hunting of smaller animals (e.g., squirrels, rabbits, and raccoons) also occurs through time. A complete absence of turkey in Horizon III may be significant and may further substantiate the subsistence commitment to a hunting pattern focused on deer. Conversely, however, the number of exploited floral ecological zones increases through time. The changes in faunal frequencies, especially between Horizons II and III (Late Archaic to Early Woodland) may be related to changes in the economic subsistence system or social structure of the site's inhabitants. That is, emphasis in subsistence pursuits may have changed from focal hunting-focal niche exploitation to focal hunting and limited multi-niche exploitation. A shift such as this could explain the continued dominance of deer hunting and the decrease in the exploitation of lesser animals *if* diffuse niche

exploitation was shifting toward gathering and processing of plant foods. There is some indication, such as charred hickory nut-shell fragments and several carbonized seeds, that plant fruits were being collected (Wagner 1976, 1978).

The cultural selectivity for a particular anatomical area of the deer is also indicated by the data. Skeletal remains from the excavated sample consistently reflect selection for four areas of the deer: cranial (usually represented by antler fragments), axial (vertebral column), pectoral (forelimbs), and pelvic (hind limbs). A fifth category, general appendicular, includes those bone fragments probably representing long bones (e.g., femur, tibia, metapodial, and humerus); these were too small for exact identification. There appears to be a definite selection for the pelvic and rear anatomical areas, especially that area from the innominates through the tibia that contains the maximum amount of meat and fat on a deer. Axial and cranial fragments are relatively low in frequency. The element most frequently identified for the cranial area was antler, especially in Horizon II. However, many of these antler remains belonged to the same fragmented antler tool that was not reassembled until after the identification process and therefore skewed the frequency tabulations. Nonetheless, the preponderance of antler tools at the site indicates that deer antler was of techno-economic importance to the prehistoric inhabitants of Owl Cave and that selectivity for certain anatomical areas of the deer was practiced by the occupants of Owl Cave throughout each occupation.

SEASONALITY

Three independent lines of evidence indicate that the vestibule of Owl Cave was used in the late fall to early winter: species of animals present in the archaeological record, age of identified animals, and type of identified botanical materials.

Kentucky winters are usually mild, and animals that might be less available (e.g., box turtle and squirrels) in areas north of the Ohio River are occasionally accessible in the Green River area year round. Secondly, tooth eruption rates of white-tailed deer indicate that the dental remains of deer found within Horizons I through III range between 1.5 and 1.75 years of age. Hence, because deer are usually born in late May to early June, the dental remains represent deer killed between October and January of the following year. The presence of charred hickory nut-shell in association with these deer remains gives additional support to this seasonality of site occupation, unless the nut remains were stored (there is at present no evidence of storage pits or containers from Owl Cave).

BONE TOOLS

Ten bone tools and tool fragments were recovered from the excavations in Owl Cave vestibule. All of these tools were made from deer bone, especially deer antler (60%). Only four bone tools were found in Horizon I. Two of these tools made from deer antler are fragments from the distal antler tine and were probably used as an antler pressure flaker. Another bone tool probably functioned as a side scraper or as some other hide-working implement. The last specimen is a small fragment of a deer long-bone shaft. It is pointed and exhibits some degree of use. It may have functioned as a small bone punch or awl.

Horizon II also contained four bone tools and/or tool fragments. Three of these tools, made from deer antler, demonstrate distal "edge wear" of the kind expected had they been used to knap chert by means of pressure flaking or indirect percussion flaking. The fourth specimen probably functioned as an awl or bone punch for leather working.

Only two bone tools were found in Horizon III. One specimen may be either a punch or fragment of an antler projectile point. However, the lack of wear (polish) on the distal end and the absence of a socket for hafting on the proximal end indicate that neither suggestion is completely satisfactory. The other specimen is a long bone shaft fragment with a small semi-circular depression along the lateral edge. The depression is highly polished over an area ca. 8 mm in length. This tool may have been used as an abrader or spokeshave for such items as wood or cane.

The bone tool inventory is small in number, but the repetition of similar tool types indicates that the bone tool industry functioned similarly through time at Owl Cave and appears to have been rather limited in its variety.

BOTANICAL

An analysis of charred botanical remains recovered in the 63.5 mm^2 fine screen mesh sifting screens (Wagner 1976) and by flotation (Wagner 1978) offers insight into the botanical subsistence base at Owl Cave. Wagner's data, when presented by cultural horizon, indicate that both charred wood and hickory nut (*Carya*) remains were somewhat equally represented and utilized during Horizon I. The frequency of hickory nuts continue to increase into Horizon II, while the frequency of charred wood diminishes rapidly. Both types of charred botanical remains, especially hickory nut, become infrequent in Horizon III.

A charred walnut (*Juglans*) hull was found in Horizon II. A single squash (*Cucurbita*) seed hull was found in Horizon III, indicating the possible presence of horticultural activity or associated activity occurring at Owl Cave during Horizon III (ca. 4000–2500 years ago). This is the same time interval of incipient horticulture observed at the large caves in MCNP (Mammoth, Salts, and Lee), and within the Late Archaic shellmound deposits west of the Park in the Big Bend Region of Green River in Ohio and Butler counties (Prentice 1994).

INTERPRETATION OF THE OWL CAVE VESTIBULE CULTURAL REMAINS

The cultural deposits in Owl Cave range in age from ca. 8000 to 2500 years ago. This temporal span may be divided into three cultural horizons on the basis of projectile point typologies and stratigraphic similarities. Overall, the material cultural remains are similar throughout the cultural horizons except for fluctuations in frequency. It is the changing frequencies of certain artifacts and ecofacts that enable an interpretation of the cultural record.

Horizon I is the oldest of the three cultural horizons. Projectile point typology indicates that Horizon I dates between 8000 and 5000 years ago. The artifacts within this horizon demonstrate sporadic activity at a special purpose site. Both the techno-economic and related subsistence pursuits appear to be focused. The techno-economic cultural subsystem is inferred from the material remains, such as tool types and/or tool kits. There is a low degree of variation and frequency of tool types and/or tool kits. Tool types include several projectile point forms, bifacial knives, several unifacial scrapers, an antler tine flaker, and several bone splinter awls or punches. This limited tool kit is indicative of hunting, butchering, and hide-working activities. The predominance of deer remains indicates that deer hunting was the focal activity. Selection for certain anatomical areas of the deer and prior primary chipped stone biface reduction was possibly a function of distance from Owl Cave. That is, both primary butchering following the kill of the deer, and the initial cortext removal and initial chipping on bifacial tools, occurred at distances away from the Owl Cave site; selected portions of the deer carcass (primarily antlers and hind quarters) and partially completed chipped stone tools were brought back to the site for consumption and completion, respectively.

Based on the presence of charred botanical remains, it appears that hickory nuts were gathered to supplement the protein-rich diet. The frequency of this gathering process in Horizon I is not as great as in Horizon II. As is the case with Horizons II and III, there were no vegetal processing tool kits recovered in Horizon I.

The overall interpretation of Horizon I is that focal techno-economic subsistence strategies were employed sporadically between 8000 and 5000 years ago. These activities focused on the hunting of deer. The hunting and processing of deer may well have been accomplished by a small band of hunters, probably all male. The sporadic human occupancy of Owl Cave vestibule during Horizon I occurred between the late fall and early winter seasons.

Horizon II seemingly dates from about 5000 to 2400 years ago and is therefore equivalent with the Late Archaic to Early Woodland cultural periods. Projectile points changed in style from side-notched and bifurcated-types to stemmed varieties. Chert flakes appear to have been selected by size to make up a slightly more diversified chipped stone tool kit consisting of unifacial (smaller) and bifacial (larger) tools. There is also a greater range in the number of ecological habitats exploited as interpreted by the types of biological remains (ecofacts) preserved at the site (Figure 2). Larger frequencies and greater varieties of this material were interpreted as representing

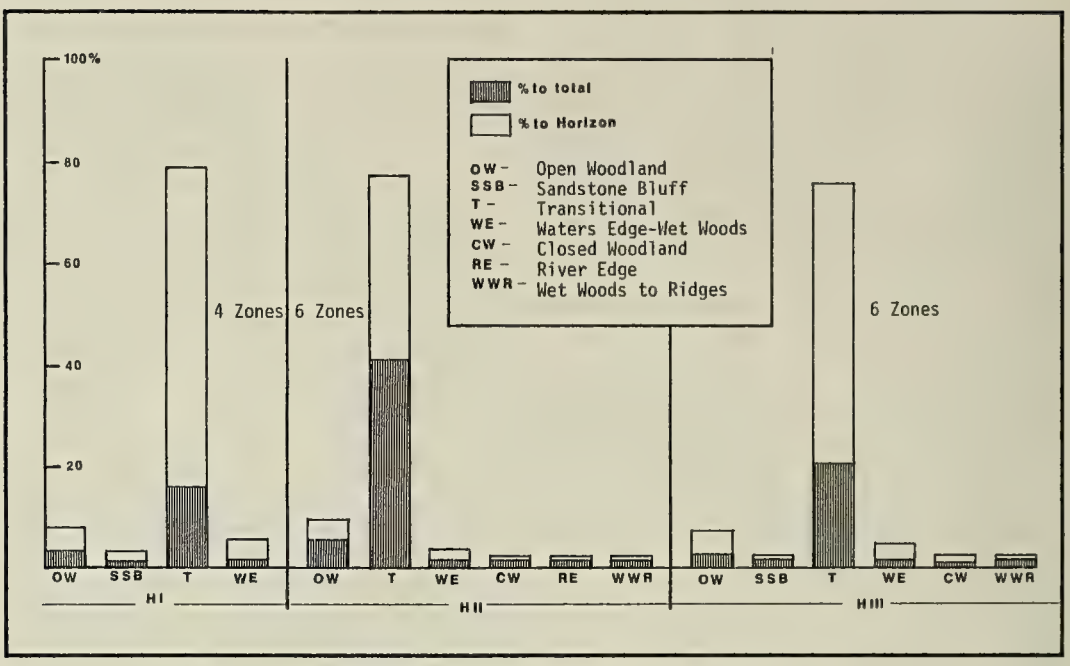

Figure 2. Animal habitats exploited by Owl Cave inhabitants, Mammoth Cave National Park, Kentucky.

a more diffuse techno-economic subsistence adaptation. The continued dominance of deer hunting, however, argues against defining the cultural adaptation as diffuse. Yet the greater variance of Horizon II subsistence practices argues for an increase in population size, or an increase in occupation intensity, or both. Although the array of eco-niche exploitation in Horizon II increases slightly, the intensity and importance of multi-niche exploitation is *not* indicated by the Owl Cave data. The data *do* indicate incipient diffuse exploitation practices. The importance of this non-intensive, multi-niche subsistence "dabbling" is that it hints of a greater cultural awareness and use of environmental resources than is evidenced in Horizon I. It is possible that changes were occurring in the overall social structure of the Owl Cave culture as a result of some unknown stress factors during the Horizon II period, e.g., increase in population pressure or environmental change or both (Boserup 1965; Cohen 1977). Or, as Cleland (1976) suggested, social change may have resulted from the observable successfulness of the Horizon I focal hunting pattern (Sauer 1950, 1952; Watson and Watson 1969). In theory, the result of a successful focal economy is that innovation is "born of luxury, not necessity" (Cleland 1976: 61). It is the implied sedentism and successfulness of the focal economy that provides economic security and experimentation with local environments, out of which cultural change gradually occurs. The evidence indicates that the initial multi-niche contact that is evinced in Horizon II of Owl Cave exhibits characteristics of a new mode of cultural adaptation in the central Kentucky karst. Although there is no definite evidence of horticultural activities in the upper portions of Owl Cave's Horizon II, as there is at Salts Cave between 2800 and 2400 years ago, there is evidence of a slight increase in the number of ecological niches exploited by the Owl Cave inhabitants. It is this expansion of environmental-zone exploitation that is interpreted as a period of early plant experimentation and economic (subsistence) change. However, persistence of more refined and developed horticultural pursuits depends on its own success.

Horizon III overlaps with the terminal range of Horizon II and probably dates be-

tween 4000 and 2500 years ago. The undisturbed portion of Horizon III is a continuation of the more open or "diffuse" economy of Horizon II. The general decrease in the frequency of similar chipped stone and bone tool types in Horizon II, and the continued but minor importance of multi-niche exploitation, are interpreted as a decrease in site use. The example of *Cucurbita* may represent possible horticultural pursuits. As in Horizons I and II, Horizon III probably was occupied during the late-fall (October) to early-winter seasons by a small band of hunters. The charred squash hull may indicate storage of *Cucurbita* as part of the Owl Cave occupant's subsistence base.

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Nesting Success of Forest Songbirds in Mixed Mesophytic Forests in Eastern Kentucky

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ABSTRACT

Despite numerous studies of predation and parasitism effects on nesting in forest songbirds, virtually no data exist on nesting success of songbirds in the heavily forested region of the Cumberland Plateau in eastern Kentucky. We surveyed the abundance of avian nest predators and brown-headed cowbirds (*Molothrus ater*) and examined nesting success of forest songbirds in older-growth (>70 yr old) stands located within a fragmented forest (91.7% intact) versus an unfragmented forest (99.7%) matrix in the Daniel Boone National Forest, Kentucky. Data indicated that cowbirds were more prevalent in roadside counts in the fragmented forest than in the unfragmented forest ($P < 0.01$). Furthermore, cowbirds were more commonly observed in older-growth stands in the fragmented forest than in the unfragmented forest ($P < 0.05$). Parasitism by cowbirds on songbird nests was evident in the fragmented forest (31.2%); no nest found in the unfragmented forest showed signs of parasitism. American crows (*Corvus brachyrhynchos*) were commonly observed in all older-growth stands, suggesting that this species is the predominant avian nest predator in forests of this region. Nest predation was evident in older-growth stands in both forests, with 43.8% of nests subject to predation in stands in the fragmented forest versus 25% in the unfragmented forest. Percent nest failure of hooded warblers (*Wilsonia citrina*) was higher ($P < 0.05$) in older-growth stands in the fragmented forest (86%) versus the unfragmented forest (14%). Our data reflect patterns largely consistent with studies completed in other heavily forested landscapes in eastern North America. We suggest that management of forests on public lands in eastern Kentucky consider minimizing fragmentation effects on forest songbirds, and we encourage the continuation of wilderness areas that provide source populations of forest songbirds and serve as benchmark habitats for evaluating fragmentation effects in this region.

INTRODUCTION

Monitoring trends in populations of North American passerines, especially neotropical migrant land birds, continues to be a focus of conservation efforts (Finch and Stangel 1993; Gale et al. 1997). Of special interest are the forest songbirds, species that are dependent upon large expanses of forestland to successfully recruit fledglings into the adult breeding population (Askins 1994). The status of forest songbirds continues to be a concern because of land-use practices that modify and fragment heavily forested landscapes (Rosenberg et al. 1999).

Increases in the extent of fragmentation of forest habitats have been shown to affect a number of changes in forest songbird behavior and ecology in the vicinity of edge habitats, including reduced density of birds (Burke and Nol 1998; Lent and Capen 1995), reduced pairing success of adults (Gibbs and Faaborg 1990; Villard et al. 1993), lowered availability of potential nest sites and food (Burke and Nol 1998), increased nest predation (Porneluzi et al. 1993; Robinson et al. 1995b), and increased brood parasitism by brown-headed cowbirds (*Molothrus ater*; Robinson et al. 1995a). The entire picture is muddled, however, by regional differences in the influence of fragmentation effects, by the considerable variation in species responses to fragmentation across their distributions, and by a dearth of knowledge on fragmentation effects for some geographic regions (Carrie 1999; Robinson et al. 1995b).

Evidence suggests that effects due to predation and parasitism on nesting songbirds in forest-dominated landscapes may be less severe than for forest songbirds in highly fragmented, agricultural landscapes (Rudnicky and Hunter 1993; Welsh and Healy 1993). The prevailing thought is that small cuts in heavily forested landscapes are temporal in time and space and are likely to be less attractive to encroachment by avian nest predators and brown-headed cowbirds (Askins 1994; Welsh and Healy 1993). More study is needed, however, to assess variation in fragmentation effects for individual species of forest songbirds across their entire range and to

evaluate regional differences in susceptibility of forest songbirds to fragmentation (Askins 1994; Rosenberg et al. 1999).

Studies of nest predation and parasitism in heavily forested landscapes remain insufficient to fully evaluate the response of forest songbirds to fragmentation effects (Andren 1992; Rudnicky and Hunter 1993). This is especially true for forested landscapes where gaps created by logging activities are infrequent and temporal in time and space. The Daniel Boone National Forest in eastern Kentucky constitutes a large expanse of forested land with a varied history of disturbance ranging from clearcut harvesting to no-harvest wilderness areas. Presently, no study of nesting success of forest songbirds exists for this heavily forested region (Baker and Lacki 1997; Lacki 2000). Moreover, limited data are available on the effects of avian nest predators and cowbird parasitism on forest songbirds in the Cumberland Plateau of Kentucky (Lacki and Baker 1998). This paper, a study of nesting success of forest songbirds on the Daniel Boone National Forest in eastern Kentucky, includes a comparison of the prevalence of avian nest predators and brown-headed cowbirds between a forested landscape with a recent history of timber harvesting, i.e., active harvesting within the last 15 years, and another landscape managed as a wilderness area with timber harvesting restrictions.

STUDY AREA

The Daniel Boone National Forest is a 271,000-ha parcel of predominantly forested land situated in eastern Kentucky on the Cumberland Plateau physiographic province (Fenneman 1938). Rough topography, a vast cliff system, and relatively mature ravine forests are characteristic of this region. Our study was conducted on two different ranger districts, Morehead and Stanton, of the Daniel Boone National Forest in Bath and Wolfe counties, Kentucky, respectively. All forest stands examined were situated between 37°45′ and 38°07′30″ north latitude and 83°30′ and 83°37′30″ west longitude, at elevations ranging from 276 to 346 m above mean sea level. Climate is temperate, with humid, warm summers. Thirty-year averages (1961–1990) for temperature and precipitation during May and June are 17.5°C and 22°C and 11.6 cm and 10.2 cm, respectively (Priddy 1993).

Four older-growth forest stands were chosen for study, two on the Morehead Ranger District and two on the Stanton Ranger District. Stands of timber were 70 to 100 years in age and 9 to 18 ha in size. Percent slope of stands ranged from 21% to 63%. Stands on the Morehead Ranger District were located within the Pioneer Weapons Hunting Area (fragmented forest, FF), an actively managed landscape containing stands of older-growth forest in a fragmented matrix that also included clearcuts and shelterwood cuts of various ages since timber harvest (Baker and Lacki 1997). We compared these with stands on the Stanton Ranger District in the Red River Gorge Geologic Area (unfragmented forest, UF), a largely intact, forested landscape managed primarily as a wilderness area. Recreation opportunities are emphasized such that an extensive road network persists, equal to that on the Pioneer Weapons Hunting Area. Intact forest, or stands of timber not logged since 1987, made up a lower percentage of the landscape surrounding study stands on the FF (91.7% within a 3.2-km radius) than on the UF (99.7%). Since 1987, 251.5 ha of forest were logged within a 3.2-km radius of study stands on the FF versus only 11.3 ha near stands in the UF. Stands on the FF were immediately adjacent to one or more recent timber harvests, i.e., clearcut or shelterwood cut, of less than 15 years in age and ≤16 ha in size; all stands sampled in the UF were at least 400 m from any edge.

Both study areas were situated at the western end of the mixed mesophytic forest and the eastern limits of the oak-hickory forest (Hinkle et al. 1993). Stands on the Pioneer Weapons Hunting Area were dominated in the overstory by white oak (*Quercus alba*), chestnut oak (*Q. prinus*), northern red oak (*Q. rubra*), scarlet oak (*Q. coccinea*), black oak (*Q. velutina*), yellow-poplar (*Liriodendron tulipifera*), and hickories (*Carya* spp.). Understories were made up of young red maple (*A. rubrum*), flowering dogwood (*Cornus florida*), young American beech (*Fagus grandifolia*), spicebush (*Lindera benzoin*), and pawpaw (*Asimina triloba*) (Baker and Lacki 1997). Stands on the Red River Gorge Geologic Area had black oak, chestnut oak, scarlet oak, white oak,

Virginia pine (*Pinus virginiana*), shortleaf pine (*P. echinata*), and hickories. Understories were dominated by rhododendron (*Rhododendron maximum*) and mountain-laurel (*Kalmia latifolia*).

METHODS

To assess the prevalence of brown-headed cowbirds in the landscape surrounding forest stands, we established a series of 30 roadside counts in the FF and UF at known stations along the road network. Each count station was visited once in either May or June 1998. All stations were <1.6 km from a forest stand chosen for study and all stations were at least 0.3 km from each other. Counts were taken from the center of the road to maximize detection of cowbirds. The typical width of the gap associated with roads in the road networks was ca. 7 m. Stations were randomly selected for survey among sampling days. At each station, cowbirds were searched by sight and sound for a period of 10 min within an area of 50-m radius. Surveys were conducted between sunrise and 0900, with all surveys completed by a single investigator (HFY). We analyzed mean detection of cowbirds, i.e., cowbirds/roadside count, between the FF and UF using a Student's *t*-test based on a pooled estimate of common variance (Sokal and Rohlf 1969). The null hypothesis was no difference in cowbird abundance in roadside counts between the FF and UF; the alternative hypothesis was that cowbirds should be more abundant in roadside counts in the FF than the UF.

Prevalence of avian nest predators, i.e., blue jay (*Cyanocitta cristata*) and American crow (*Corvus brachyrhynchos*), and brown-headed cowbirds in forest stands was determined using 10-min counts at three stations per stand. All stations in all stands were positioned >50 m from any stand boundary. Surveys were conducted using the same daytime and seasonal constraints as described for the roadside counts. Target species were recorded by both sight and sound within an area of 50-m radius. All stations were visited four times from 12 May to 28 Jun 1998. To avoid problems of pseudo-replication, we chose the maximum number observed across the four samples at each station for use in statistical analysis. We compared the mean maximum detection, i.e., maximum number/survey station, of blue jays, American crows, and brown-headed cowbirds, respectively, between forest stands of the FF and UF. Because of small sample size and the likelihood that data were not normally distributed, we used Wilcoxon Rank Sum tests to evaluate mean maximum detection values (Hollander and Wolfe 1973). The null hypotheses were that avian nest predators and brown-headed cowbirds were equally abundant between the FF and UF; the alternative hypotheses were that avian nest predators and brown-headed cowbirds should be more prevalent in forest stands in the FF versus the UF.

We conducted nest searches at the four older-growth forest stands from 11 May to 17 Jul 1998. For each nest located, we recorded the species of bird and the date of location. Afterwards, we revisited each nest every 3 to 5 days and recorded the number of eggs, the number of hatched young, and eggs or hatched young of non-host species, i.e., cowbirds. We monitored a nest until the young fledged or the nest was abandoned or destroyed. We calculated the proportion of nest failures of forest songbirds by species for stands in the FF and UF, respectively. In cases where data for a species were sufficient, we tested the proportion of nest failure between the FF and UF using a Z-test of the difference between two sample proportions (Daniel 1974). The null hypothesis was that nest failure of songbirds should be equal between the FF and UF; the alternative hypothesis was that nest failure should be greater for songbirds nesting in the FF versus those nesting in the UF.

RESULTS

Brown-headed cowbirds were more prevalent in roadside counts within the FF ($\bar{x} \pm$ SE; 0.53 ± 0.15 no./count) than in the UF (0.07 ± 0.05 no./count; $t = 2.99$, df = 58, $P < 0.01$). Only two cowbirds were observed in 24 counts (8.3%) in the UF, whereas cowbirds appeared in 8 of 24 counts (33.3%) in the FF. Furthermore, mean maximum detection of cowbirds was higher (W = 26, df = 11, $P < 0.05$) in forest stands in the FF (1.67 ± 0.42 max. no./survey station) than in the UF (0.33 ± 0.21).

There was no difference evident, in mean maximum detection of blue jays (W = 43, df = 11, $P > 0.05$), between stands in the FF (0.33 ± 0.21 max. no./survey station) and the

Table 1. Nests of songbirds found by species in forest stands of fragmented and unfragmented forests in eastern Kentucky, 1998. The number of nests, the total observation days, proportion of failed nests, and the cause of nest failures are indicated.

Forest	Species	No. nests	Total days	Proportion failed	Cause of failure		
					Depredation	Parasitism	Abandonment
Fragmented	*Wilsonia citrina*	6	95	0.83	2	1	2
	Empidonax virescens	2	60	1.0	2	—	—
	Mniotilta varia	2	30	0.5	1	—	—
	Setophaga ruticilla	3	30	0.33	—	—	1
	Dendroica discolor	2	29	1.0	1	—	1
	Vireo olivaceus	1	19	1.0	1	—	—
Unfragmented	*Wilsonia citrina*	7	127	0.14	1	—	—
	Seiurus aurocapillus	6	90	0.33	2	—	—
	Vireo solitarius	2	25	0.50	1	—	—
	Dendroica virens	1	14	1.0	—	—	1

UF (0.67 ± 0.33). Blue jays were uncommon in surveys in all forest stands. American crows were more abundant, however, being equally common (W = 40, df = 11, $P > 0.05$) in stands in both the FF (2.67 ± 0.71 max. no./survey station) and UF (2.33 ± 0.33).

Thirty-two nests of nine species of songbirds were found during search efforts in 1998 (Table 1). Of these, 16 nests were located in stands in the FF and 16 nests in stands in the UF. Nests of hooded warblers (*Wilsonia citrina*) were most common, with the proportion of nest failure in this species being greater for nests in stands in the FF than for those in the UF (Z = 3.75, df = 11, $P < 0.01$). Nests of ovenbirds (*Seiurus aurocapillus*, n = 6) were observed only at sites in the UF. Five nests (31.2%) in stands in the FF had ≥one brown-headed cowbird egg present, and included nests of hooded warblers (n = 4) and Acadian flycatchers (*Empidonax virescens*). Parasitism was responsible for failure of only one nest, however. No nest found in the UF showed evidence of parasitism by brown-headed cowbirds.

Predation of nests was evident in stands in both forests, with seven nests (43.8%) subjected to predation in the FF and four nests (25%) subjected to predation in the UF (Table 1). The only confirmed nest predator observed was a copperhead (*Agkistrodon contortrix mokasen*) consuming a clutch of five eggs in an ovenbird nest at a site in the UF.

DISCUSSION

It is largely agreed that the principal cause of nest failure in forest songbirds is nest predation, with nest predation perceived as a major factor regulating bird community assemblages (Martin 1996). Although our study included only a single season of nest searching, the data are consistent with the above premise as nest predation (64.7%) represented the majority of nest failures we observed. Predation has been shown to account for loss of 39% of nests of songbirds in bottomland hardwood forest (Twedt et al. 2001), and to cause 94% of all nest failures of forest songbirds in forests in Minnesota (Manolis et al. 2002).

The relative importance of avian, mammalian, and reptilian nest predators in the older-growth stands we sampled was unclear. Blue jays were scarce in count surveys, suggesting that this species might have limited impact on nesting success of forest songbirds in eastern Kentucky. This is in contrast to other forested regions where blue jays were found to be common throughout forests regardless of the type of forest management practiced (Annand and Thompson 1997; Robinson and Robinson 1999). American crows were much more prevalent than blue jays in stands in both fragmented and unfragmented forests and, thus, appear more likely to negatively affect nesting success of forest songbirds in this region. Using artificial nests, Luginbuhl et al. (2001) demonstrated a strong association between the abundance of corvids in point counts and the extent of predation on artificial nests of forest songbirds in Washington.

Nest parasitism accounted only for a single (3.1%) nest failure in this study, even though eggs of brown-headed cowbirds were present

in 15.6% of the nests observed. Rates of nest parasitism have been reported for other heavily forested landscapes and range from 9% in Louisiana (Twedt et al. 2001), 3.9% in east Texas (Carrie 1999), <2% in the Great Smoky Mountains National Park, Tennessee (Farnsworth and Simons 1999), and 1.8% in Minnesota (Manolis et al. 2002). Roadside counts and surveys in forest stands demonstrated that cowbirds were more prevalent in fragmented than unfragmented forest in eastern Kentucky, comparable to findings reported for forests in southeastern Missouri (Annand and Thompson 1997). Regardless, studies across different forested regions have produced varying results, with cowbird abundance not always related to the extent of local forest fragmentation (Robinson and Robinson 1999).

Our data reflect patterns largely consistent with studies completed in other heavily forested landscapes in eastern North America: that nest predation rates are high regardless of the extent of fragmentation, and that parasitism of nests by brown-headed cowbirds is reduced in landscapes with minimal habitat fragmentation. Coker and Capen (1995) suggested that small (ca. 4 ha) irregularly spaced gaps in an otherwise contiguous forest landscape will not lead to elevated levels of parasitism by cowbirds. Whether this level of fragmentation would be harmful to nesting success of songbirds in unfragmented forests of eastern Kentucky remains unclear. We observed few cowbirds in roadside counts and no evidence of parasitism by cowbirds in the unfragmented forest, despite the existence of an extensive road network to facilitate recreation activity of humans. These findings suggest that existing management strategies for wilderness areas in eastern Kentucky are adequate for minimizing nest parasitism, although nest predation remains a problem for songbirds nesting in these forests. Suarez et al. (1993) described a "paradox of predation" to address the fact that nest predation rates do not always decline with an increase in the size of forest fragment; thus, nest predation can be expected to continue in large tracts of forests in eastern Kentucky, no matter what extent of fragmentation is present. Regardless, based on our findings we suggest that management of forests on public lands in eastern Kentucky should be sensitive to minimizing fragmentation effects on forest songbirds (Baker and Lacki 1997; Lacki and Baker 1998). We encourage the continuation of wilderness areas, where logging is restricted and other disturbance effects are minimized, to provide for habitats that support source populations of songbirds and to serve as benchmark habitats for evaluating fragmentation effects on songbirds in this region (Lacki 2000).

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Effect of the Invasive Shrub *Lonicera maackii* (Caprifoliaceae; Amur Honeysuckle) on Autumn Herpetofauna Biodiversity

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ABSTRACT

Amur honeysuckle, *Lonicera maackii,* is an Asian woody shrub that has spread throughout the eastern United States within the past 100 years. Despite a documented life history of the plant, no studies have been performed to determine the effect of this exotic species on native herpetofauna. The Cincinnati Nature Center (CNC), Clermont County, Ohio, one of the largest landholdings of remnant old-growth forest remaining in that state, has recently been invaded by exotic plant species, predominantly *L. maackii.* We studied the effect of this exotic shrub on herpetofauna abundance, distribution, and body size at CNC in areas invaded and areas lacking *L. maackii* during the late summer and early autumn. The results suggest that the herpetofauna diversity was significantly greater in the non-invaded ($H' = 2.2$) than invaded habitat ($H' = 1.8$). Species evenness was also greater in non-invaded habitats, primarily due to some less abundant species (e.g., snakes) found in the *L. maackii* habitat. Amphibians (*Plethodon glutinosus, Rana clamitans*) had larger body mass in the non-invaded habitats, suggesting a loss in native food resources from areas encroached by *L. maackii.* A lack of ground resources may also explain the absence of turtles (*Terrapene carolina*) from invaded habitats, despite the use of these habitats by snakes. It appears that structural vegetation changes by *L. maackii* influence the distribution of amphibian and reptile species, being perhaps beneficial for some (e.g., snakes) but not for others (e.g., frogs and turtles).

INTRODUCTION

Invasive species often change the composition of biological communities by altering the diversity and abundance of species within those communities. Invasive species are able to rapidly populate an area and consume resources that might otherwise sustain native species. Plant species such as Eurasian milfoil (*Myriophyllum spicatum*), purple loosestrife (*Lythrum salicaria*), and kudzu (*Pueraria montana*) are prime examples of run-away species that were originally introduced as garden ornamentals or governmental solutions to erosion problems (Gutin 1999; Mack 1985). The Greater Cincinnati area and much of Ohio and Kentucky has experienced its own invasion with the Asian woody shrub Amur honeysuckle (*Lonicera maackii,* Caprifoliaceae) with its spread throughout the eastern U.S. (Luken and Thieret 1996). Despite the well-documented life history of this plant (Luken 1988; Luken and Goessling 1995; Luken and Mattimiro 1991), no studies have been conducted to determine the effect of this shrub on native herpetofauna.

The Cincinnati Nature Center (CNC), Clermont County, Ohio, founded in 1965, has a three-part mission to (1) provide the community with the opportunity to experience, study, and enjoy the natural world; (2) encourage understanding, appreciation, and responsible stewardship of the environment through education; and (3) preserve the heritage and integrity of the natural and agricultural lands owned by CNC. The Rowe Woods location of CNC is a 360-ha preserve. As a nature sanctuary for the people of southwestern Ohio, it contains some of the largest holdings of old-growth deciduous hardwoods in Ohio and supports several ponds, a stream, and some grasslands (www.cincynature.org).

Much of the wildlife within the preserve remains undocumented, especially reptiles and amphibians. Moreover, portions of CNC contain exotic plant species, including the invasive *L. maackii.* The goal of our study was to understand the effects of *L. maackii* on the reptile and amphibian biodiversity within Rowe Woods. We hypothesized that *L. maackii* affects the abundance, species diversity, and species evenness of reptiles and amphibians communities through changes to the habitat structure and potential resources. Our focus was on the abundance and diversity of herpetofauna species that inhabit the old-growth

forests areas that contain invaded plant growth.

Here we provide a tally of the amphibian and reptiles species abundances in the Rowe Woods habitat and the potential effects of *L. maackii* on autumn herpetofauna distribution patterns. No prior surveys of this type exist for CNC, and an understanding of herpetofauna biodiversity is important in explaining the herpetofauna's contribution to the community in this old-growth forest system. These animals provide a major link in the food web as predators of smaller vertebrates and invertebrates and as prey for other vertebrates. This research should be useful to wildlife managers and applied ecologists interested in the habitat specificity of reptiles and amphibians and in the range of tolerances exhibited by these animals under changing environmental conditions.

MATERIALS AND METHODS

This study took place at Rowe Woods, the main location of CNC, in Milford, Clermont County, Ohio (lat 39°07′35″N, long 84°14′46″W). Twelve locations for both invaded and non-invaded habitat were identified using vegetation abundance maps provided by the Environmental Resource Management Center of Northern Kentucky University. Areas with *L. maackii* were termed "highly invaded." Herpetofauna collection plots were organized within these areas throughout the CNC along with corresponding "non-invaded" plots of similar terrain and general surroundings.

We censused the herpetofauna with a variety of collection techniques to determine species presence or absence, their activity patterns, and habitat utilization (Heyer et al. 1994). Hide boards were deployed throughout the plots. These were simple structures to provide animals with cover from predators and the drying effects of the sun. Hide boards were constructed from 0.64 cm thick OSB (Oriental Strand Board) plywood and were placed flat on the ground with sufficient clearance for organism entrance and exit. The boards were deployed along transects within each habitat type. Each board covered an area of 0.37 m^2, and 4 boards were placed in each of the 24 survey plots. The boards remained in the plots for 7 days, when they were lifted in a search for herpetofauna. Haphazard walks (searches using hand- and rake-survey techniques) over 0.5-ha plots were conducted to manually search for animals in each habitat type. Collection intensity and duration were rated to equal 1 man-hour of searching in both plots termed "invaded" and "non-invaded." The haphazard manual searches were most productive in finding organisms of interest. We recorded the habitat ("invaded"/"non-invaded," date, weather notes, general observations on organism activity, position, microhabitat, and species identifications. In addition, morphological measurements were collected from each individual, including sex, snout-vent length (SVL), mass, and carapace length (in turtles). Surveys were conducted on afternoons of alternate days from mid-August through mid-October 2001.

Community composition and similarity between invaded and non-invaded areas were evaluated for Species Richness (S) and Sørensen's Index of similarity (SI) (Brower et al. 1997; Smith and Smith 2001). SI ranges from 0 to 1, where 0 = no similarity and 1 = complete similarity. Biodiversity was evaluated for each area community type using the Shannon Diversity Index (H′), and H′ was used in the calculation of species evenness (J′) within the two area types. Parametric *t*-tests were used to compare mean values of species numbers and numbers of individuals within distinct taxa between habitat types. Shannon diversity indices (H′) were also compared with a Student's *t*-test. For comparison of evenness values (J′), confidence intervals (CI) were evaluated using a bootstrap technique (Dixon 2001). These confidence intervals were generated with 2000 bootstrap iterations. All tests were considered significant at $\alpha = 0.05$.

RESULTS

Thirteen species of reptiles and amphibians were collected within the 12 pairs of plots (Table 1). The herpetofauna species richness in non-invaded areas (S = 10) was similar to areas containing *L. maackii* (S = 9).

On a per-site basis, there was also no significant difference in the richness or abundance of reptiles and amphibians as a group between habitat types (Figure 1). Sørensen's Index was 0.632, suggesting a moderate number of species shared between these two hab-

Table 1. Species of amphibians and reptiles found within the Cincinnati Nature Center, Clermont County, Ohio.

Amphibia
Caudata (salamanders)
Family Plethodontidae (lungless salamanders)
Desmognathus fuscus (dusky salamander)
Eurecea cirrigera (southern two-lined salamander)
Plethodon cinereus (redbacked salamander)
Plethodon glutinosus (slimy salamander)
Plethodon richmondi (ravine salamander)
Family Salamandridae (newts)
Notopthalamus viridescens (central newt)
Anura (frogs and toads)
Family Bufonidae (toads)
Bufo americanus (American toad)
Family Ranidae (true frogs)
Rana catesbeiana (bullfrog)
Rana clamitans (green frog)
Reptilia
Testudines (turtles)
Family Emydidae (box and water turtles)
Terrapene carolina (eastern box turtle)
Squamata, Serpentes (snakes)
Family Colubridae (colubrids)
Elaphe obsolete (black rat snake)
Storaria dekai (brown snake)
Thamnophis sirtalis (eastern garter snake)

itats. There was also no significant difference between the mean number of frog and salamander individuals in the invaded and non-invaded habitats (Figure 2). Snakes were observed or collected only from the invaded habitats, and turtles were found only in the non-invaded habitats. The box turtle (*Terrapene carolina*) was the only land turtle we observed.

The overall herpetofauna diversity in the non-invaded habitat ($H' = 2.2$) was significantly higher than the invaded *L. maackii* habitat ($H' = 1.8$; $t_{66} = 2.7$, $P < 0.01$). Evenness was also significantly higher in the non-invaded habitats ($J' = 0.93$; CI = 0.887–0.981) than the invaded habitats ($J' = 0.80$; CI = 0.715–0.836). The lower diversity and evenness values observed in the invaded habitat were in part due to having a large number of rare species (e.g., snakes) that were each represented by a single individual. Frogs and salamanders were found inhabiting both habitats, with the exception of the redbacked salamander (*P. cinereus*), the bullfrog (*R. catesbeiana*), and the toad (*Bufo americana*), which were found only in the non-invaded areas.

Snout–vent length did not vary between habitats for those amphibians and reptiles

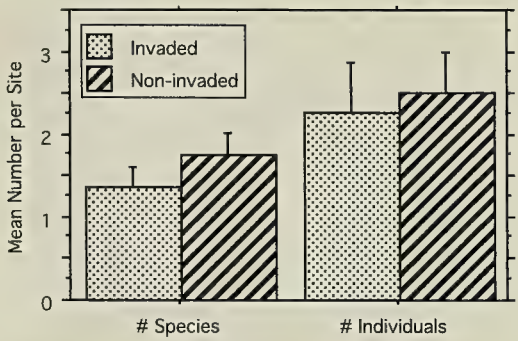

Figure 1. Mean site abundances of amphibians and reptiles in invaded and non-invaded habitats at the Cincinnati Nature Center, Clermont County, Ohio.

found in both habitat types (Figure 3). However, significantly higher body masses were found in some frogs (*Rana clamitans* $\bar{x}_{mass} = 20.36$ g; $t_6 = -3.63$, $P = 0.011$) and salamanders (*Plethodon glutinosus* $\bar{x}_{mass} = 3.85$ g; $t_6 = -3.02$, $P = 0.023$) in the non-invaded habitats (Figure 4).

DISCUSSION

As invasive species continue to spread, changes are expected in community structure. The invasive *L. maackii* has come to dominate the understory shrub layer in some locations of southwestern Ohio (Gayek and Quigley 2001; Hutchinson and Vankat 1997, 1998). It is one of the first plants to leaf out in spring and one of last to drop leaves in fall. Moreover, *L. maackii* is one of the last to have berries in fall (Luken and Thieret 1996). Berries are consumed by animals (primarily birds),

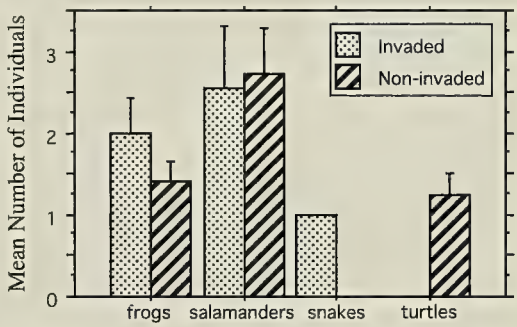

Figure 2. Mean number of individuals per sampling area for major groups of amphibians and reptiles found in invaded and non-invaded habitats at the Cincinnati Nature Center, Clermont County, Ohio.

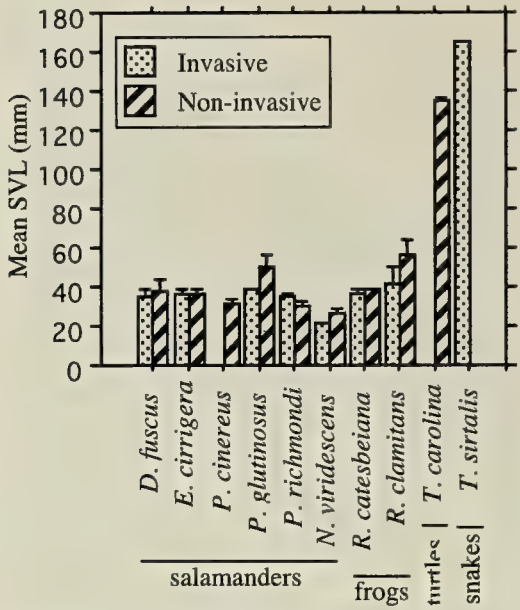

Figure 3. Mean body size as body length or snout-vent length (SVL) in mm for amphibian and reptile species found in invaded and non-invaded habitats at the Cincinnati Nature Center, Clermont County, Ohio.

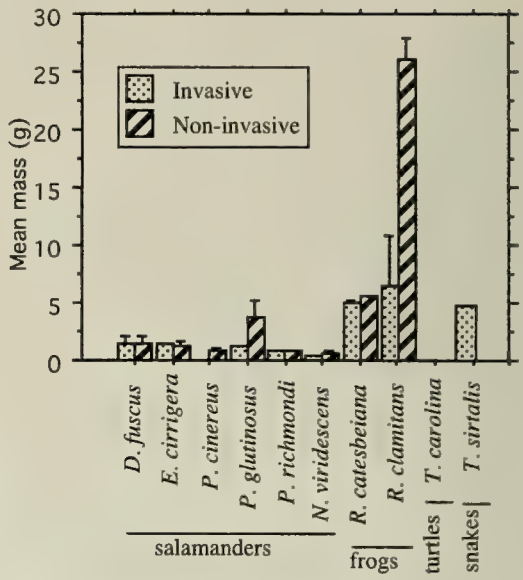

Figure 4. Mean body size as body mass (g) for amphibian and reptile species found in invaded and non-invaded habitats at the Cincinnati Nature Center, Clermont County, Ohio.

which distribute seeds to new habitats (Ingold and Craycraft 1983; Luken and Thieret 1996). When in leaf, *L. maackii* has a dense canopy extending close to the ground that heavily shades the forest floor, changing the vegetative structure of secondary forests and native plant populations (Collier et al. 2002). Not only are native understory plants (annuals) and tree seedlings excluded due to a lack of light and nutrients (Gould and Gorchov 2000; Gorchov and Trisel 2003), but associated insect guilds could also decline following the loss of these native plants. The presence of exotic invasive plants has been shown to decrease native invertebrate populations numbers, in some cases leading to the disappearance locally of certain invertebrate species (Sumways et al. 1996). How other animal groups, particularly ectothermic vertebrates, respond to *L. maackii* may depend largely on the changes in habitat structure and resource availability for these vertebrates.

The limitations of amphibian and reptile species abundance and diversity observed from all areas in this study may be a result of variations in temporal activities among herpetofauna. Activity of individuals in the autumn may be sporadic as populations begin winter hibernation. This activity can be greatly affected by seasonal timing cues and food availability for building winter energy reserves. Moreover, several species are inactive in fall. For example, at CNC, the Jefferson salamander (*Ambystoma jeffersonianum*) is active above ground only in early spring during the breeding season, and the broad-headed skink (*Eumeces laticeps*) is active mainly in late spring and summer months (R. D. Durtsche pers. obs.). Due to these limitations of sampling and the season, where not every species may have been documented, the potential exists that diversity indices are underestimates and the evenness values are overestimates of actual values for the entire herpetofauna community.

The non-invaded native habitat held a significantly greater ($P < 0.01$) diversity of amphibian and reptile species than did the *L. maackii* habitats based on Shannon diversity indices. While the site means suggest there were no significant differences in richness and abundance between habitats (Figure 1), this reflects the high degree of variation among the sites. There was, however, a moderate overlap

in the species that occupied both habitats (SI = 0.632). The evenness values suggest that individuals were not as evenly distributed among species in the invaded habitat as they were in the non-invaded habitat. The lower evenness value found in the *L. maackii* habitat can be attributed in part to the greater distribution of rare species, namely snakes. The snakes may prefer the invaded areas because these areas provide a lower canopy and a thicker shelter for them. This structural change in habitat may also provide ideal vantage points to ambush prey, for example birds. Songbirds such as the American robin (*Turdus migratorius*) and the wood thrush (*Hylocichlia mustelina*) that use *L. maackii* as nesting sites have been found to experience higher predation than those birds nesting in native vegetation (Schmidt and Whelan 1999). The turtles may prefer the non-invaded areas because those areas are less dense and easier for them to traverse. Also, as *L. maackii* does not allow many other plant species to grow under it, the turtles may not find their needed food source within these areas. Native animals such as desert tortoises are known to be affected by alien plants, because these plants have altered the habitat structure and the species composition of food plants (Brooks and Esque 2002). The differences in food availability between habitats for some species may be expressed in the larger body size observed in the frogs (*Rana clamitans*) and salamanders (*Plethodon glutinosus*) from the non-invaded areas (Figure 4).

In conclusion, significant differences in diversity were found between invaded and non-invaded habitats, with *L. maackii* habitats having a lower herpetofauna diversity. It appears that areas invaded with *L. maackii* limit the community of amphibians and reptiles that exist there. The evenness values suggest that there was a greater number of low population size species, like the guild of snakes, that were found in the *L. maackii* habitat. The species (e.g., snakes) that do live in *L. maackii* habitats may be able to exploit them because they can find shelter against predation and potentially can use a structural vantage point (within the branches of the shrub) for ambushing prey. Future studies should evaluate how these habitats, in particular those with *L. maackii*, are functionally used by amphibians and reptiles.

AKNOWLEDGMENTS

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Distribution and Habitat Use of the Allegheny Woodrat (*Neotoma magister*) in a Mixed-mesophytic Forest in Southeastern Kentucky

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ABSTRACT

The Cumberland Plateau (eastern coal fields) of eastern Kentucky constitutes the bulk of the range of the Allegheny woodrat (*Neotoma magister*) in the state. Previous studies of *N. magister* in Kentucky focused on populations in the extensive cliff lines of the Daniel Boone National Forest along the western edge of the Cumberland Plateau. The University of Kentucky's Robinson Forest is on the Cumberland Plateau ca. 45 km east of the Daniel Boone National Forest. Robinson Forest lacks extensive cliff lines but rather has an abundance of small, isolated rock formations. This represents a distinctly different, and less studied, habitat occupied by *N. magister*. From February 2000 to June 2001, we examined 153 rock formations in Robinson Forest to determine the distribution and habitat use of *N. magister*. Of these rock formations, 38% had evidence of such use, but only 10% yielded specimens. All formations with fresh sign yielded *N. magister*, but only 10% without such sign yielded specimens. Ninety-seven percent of formations with evidence of *N. magister* (mostly as midden piles) were found in high-elevation rock formations (rock outcrops and capstones) above 335 m. The total capture rate was 7.2 *N. magister* per 100 trap-nights, with 100% of all specimens trapped at high elevations. The majority of *N. magister* (79%) were trapped in the northwest section of the forest; only one specimen was trapped in the eastern half despite the large number of high-elevation rock formations and abundant evidence. This distribution may represent either a subpopulation exhibiting metapopulation dynamics or a declining population caused by forest fragmentation.

INTRODUCTION

The Allegheny woodrat (*Neotoma magister*) occurs in high-elevation spruce forests and eastern deciduous forest. This species is closely associated with rock formations such as capstones and cliff lines (Hayes 1999; Myers 1977; Newcombe 1930; Poole 1940; Wiley 1980). Rock formations occupied by *N. magister* have deep vertical and horizontal crevices that are dry and protected from snow, rain, and seeping water.

The current range of *N. magister* extends from New Jersey south to Alabama and west to Indiana (Hayes 1999). *Neotoma magister* is not a federally endangered species but is considered endangered, threatened, or of special concern in virtually every state within the northern part of its range (Bommarito 1999; McMurray 2001). Population declines and extinctions have occurred in Indiana, New Jersey, New York, Ohio, and Pennsylvania (Balcom and Yahner 1996; Beans 1992; Castleberry et al. 2002; Hicks 1989). *Neotoma magister* is not listed as endangered, threatened, or of special concern in Kentucky.

Multiple hypotheses have been generated to explain population declines of *N. magister* (Balcom and Yahner 1996; Hayes 1999; Meyer 1997; Page et al. 1998; Page et al. 1999). These include (1) human disturbance in the form of encroachment of agriculture and urbanization, (2) reduced acorn production due to oak defoliation by gypsy moths (*Lymantria dispar*), (3) hard mast reduction from the chestnut blight (*Cryphonectria parasitica*), (4) increased exposure to the lethal raccoon roundworm (*Baylisascaris procyonis*) due to increase in raccoon (*Procyon lotor*) populations, (5) forest fragmentation, (6) climatic changes, and (7) increased predation pressure associated with habitat fragmentation.

In Kentucky, *N. magister* is found primarily on the Cumberland Plateau, which covers the eastern third of the state. It is missing from the Bluegrass region of north-central Kentucky and from a portion of the southern Highland Rim that extends south to Tennessee. *Neotoma magister* occurs in a narrow band on the Highland Rim west of the Bluegrass region (Bommarito 1999; McMurray

2001). Currently, the highest density populations of *N. magister* in Kentucky are located in the Daniel Boone National Forest along the western edge of the Cumberland Plateau where 5400 km of clifflines provide prime habitat (Bommarito 1999; McMurray 2001). The University of Kentucky's Robinson Forest is located ca. 45 km east of Daniel Boone National Forest. The habitat favored by *N. magister* in Robinson Forest differs drastically from that in the Daniel Boone National Forest. Cliff lines are essentially lacking; instead, an abundance of small, isolated capstones and rock outcrops are scattered through the forest. Much of the habitat surrounding Robinson Forest has been destroyed by surface mining and mountain top removal for coal.

Robinson Forest has become increasingly isolated to the point of representing an island of mixed-mesophytic forest on the coalfields of southeastern Kentucky. Consequently, the forest is experiencing ecological changes (both natural and in response to human activities) that have caused new species of mammals to invade the forest (e.g., meadow vole, *Microtus pennsylvanicus*), while previously common species (e.g., southern bog lemming, *Synaptomys cooperi*) have become extremely rare (Krupa and Haskins 1996). Other species of mammals may be experiencing population changes as well (Krupa and Lacki 2002). Currently, little quantitative information is available documenting fluctuations by other mammal populations that may be sensitive to ecological changes in the forest. Baseline data are essential to determine future ecological shifts that may occur in the region. Thus, the purpose of this study was to determine distribution and habitat use of *N. magister* in Robinson Forest. From these results, comparative data will be available for future studies.

STUDY SITE

The University of Kentucky's Robinson Forest is a maze of deep, narrow valleys, steep slopes, and narrow, winding ridges with elevations from 210 to 460 m (Overstreet 1984; Figure 1). The forest represents one of the largest remaining contiguously forested areas on the Cumberland Plateau east of the Daniel Boone National Forest. Robinson Forest is a second-growth forest located in Breathitt, Knott, and Perry counties with the largest contiguous tract in Breathitt and Knott counties. This forest has become increasingly isolated due to surface mining and logging on sections of the forest and adjacent lands. See Krupa and Lacki (2002) for a more detailed description of the forest. The present study took place in the main 4085 ha tract located in Breathitt and Knott counties (Figure 1); this area represents the most protected and least disturbed section of the forest.

Four distinct categories of sandstone rock formations occur in Robinson Forest. First, capstones are irregularly distributed throughout the forest and are always on ridge tops. These formations, at elevations from 425 to 460 m, range in length from 5 to 150 m. Second, high-elevation rock outcrops protrude from slopes above 335 m. These formations are always below ridge tops. Third, low-elevation outcrops protrude from slopes along streams at elevations from 214 to 300 m. Fourth, low-elevation rock talus slopes form along streams from 214 to 300 m; they are comprised of many large colluvial blocks that have gradually slid down slopes. Only two such formations are known to exist in the forest. Typically, capstones and high-elevation outcrops have deep vertical and horizontal crevices, which are more extensive in capstones. Low-elevation outcrops typically lack crevices; rock piles that form talus slopes do have shallow horizontal and vertical crevices.

METHODS

Rock formations were located in early 2000 using geological maps, road surveys, a 2-day aerial survey, and information provided by Robinson Forest staff. Between 18 Feb 2000 and 21 Jun 2001, we examined each formation for evidence of *N. magister* to help determine trapping effort. Middens were large and distinct and the primary evidence of *N. magister*. These were comprised of sticks, woodrat scat, piles of shells of hickory nuts and acorns, scat of other mammals, pieces of freshly clipped leaves, human trash, bones, and feathers. Although other species of mammals are capable of depositing some of the above components (such as sticks, acorns, nuts, and scat) in rock formations, we are not aware of other species capable of constructing such large middens. Therefore the presence of middens was considered evidence of *N. magister*. Because mid-

Figure 1. Map of the 4085-ha study area in Robinson Forest, Breathitt and Knott counties, Kentucky. Open circles represent examined rock formations that lacked any evidence of *Neotoma magister*. Solid circles represent rock formations that had evidence of *N. magister*, but where trapping yielded no specimens. Triangles represent rock formations where trapping yielded specimens.

dens could be deposited by other mammal species, we trapped in all rock formations with evidence or suitable habitat (primarily crevices) for at least one night. Initially, we trapped in low-elevation rock formations that were wet, that lacked crevices, or that lacked evidence of *N. magister* during spring 2000. This was discontinued once it was clear *N. magister* were not present. We did not trap in six such sites. We trapped in all other rock formations. All trapping was with #102 Tomahawk livetraps (Tomahawk Trap Co., Tomahawk, WI) baited with a combination of apple slices, carrots, and whole grapes. A large piece of cotton was placed in each trap, and each trap was placed in a horizontal crevice or under a rock ledge protected from wind and rain. Traps were covered with rocks and leaves for additional shelter. They were set out from late morning until dusk and collected beginning at dawn the next morning. Depending on the size of the rock formation, the number of crevices, and the amount of evidence, two to eight traps were set. We trapped at three locations with large middens and old scat twice (first in March 2000 then May 2001). Generally we trapped at formations in close proximity on the same night. Rock formations were placed in one of the four categories, and elevation of each location was estimated based on topographic maps. Sex, body mass, and age (adult vs. juvenile) were recorded for each woodrat captured. All individuals were released, unmarked, at site of capture.

RESULTS

We spent 44 days locating and examining 153 rock formations in Robinson Forest (Figure 1). All total, 265 traps were set during 28 nights to catch 19 *N. magister*. The overall capture rate was 7.2% *N. magister* per 100 trap nights. In all, 58 (38%) of the 153 rock

Table 1. Summary of the number of sites per rock formation, evidence, and habitat use of *Neotoma magister*, and trap success for the study from February 2000 to June 2001 in Robinson Forest, Breathitt and Knott counties. Numbers in parentheses represent the number of sites. Numbers in brackets represent the number of *N. magister* trapped. Note that traps were not set in 6 of the 16 low-elevation outcrops that were wet and lacked crevices. Traps were set in all other rock formations.

Rock formation	Number of sites	Evidence			Trap nights	Percent of sites with at least one type of evidence	Percent of sites with *N. magister*
		N. magister scat	Middens	Fresh sign*			
Capstones	40	11	21	2	119 [5]	55% (22)	13% (5)
High-elevation outcrops	95	14	30	8	115 [14]	34% (34)	11% (10)
Low-elevation outcrops	16	1	1	0	12	6% (1)	0%
Talus slopes	2	1	1	0	19	50% (1)	0%
All formations combined	153	27	53	10	265 [19]	38% (58)	10% (15)

* Fresh sign included soft and moist woodrat scat, green moss, and leaves that had not wilted. Leaves were from red maple, flowering dogwood, Christmas fern, and rattlesnake plantain.

formations had evidence (old or fresh) of *N. magister* (Table 1), but only 15 (10%) yielded *N. magister* (four rock formations yielded multiple *N. magister*). Of the 10 rock formations that had fresh sign, all yielded *N. magister*. Fresh sign was in the form of soft and moist *N. magister* scat, green moss, and recently gathered leaves of red maple (*Acer rubrum*), flowering dogwood (*Cornus florida*), Christmas fern (*Polystichum acrostichoides*), and rattlesnake plantain (*Goodyera pubescens*). *Neotoma magister* were caught at five rock formations that lacked fresh sign.

All rock formations with relatively dry, deep crevices had evidence of *N. magister*. Formations with more numerous, complex crevices generally exhibited more evidence and larger middens. Fifty-six (97%) of the 58 rock formations with evidence of *N. magister* were capstones or high-elevation outcrops (Table 1). Although there were more high-elevation outcrops than capstones (2.5 times more), a larger percentage of capstones (55%) had evidence of *N. magister* (versus 34% for high-elevation outcrops), and a larger percentage of capstones (13%) had *N. magister* captures than high-elevation outcrops (11%). Only one talus slope and one low-elevation outcrop had evidence of *N. magister*.

With respect to midden locations, Robinson Forest was divided into three sections. The first and smallest section was south of Buckhorn Creek (Figure 1). Seven rock formations with evidence were found mostly above Miller Branch, and two of these (29%) yielded three *N. magister*. One of the four largest middens located during this study was found in this section along Improvement Branch (Figure 1); it did not yield a specimen. In the second section west of Clemons Fork, 25 rock formations had evidence of *N. magister*. Of these, 12 (48%) yielded 15 *N. magister*. The third and largest section was north of Buckhorn Creek and east of the Knott County boundary line (Figure 1). Twenty-four rock formations had evidence of *N. magister* in this section, and only one (4%) yielded *N. magister*. Three of the four largest middens were found in this section (two near Bee Creek and the largest along Snag Ridge Fork; see Figure 1).

DISCUSSION

Fresh sign was the most reliable evidence that *N. magister* were present since all formations with fresh sign yielded at least one specimen. We found that virtually all evidence of *N. magister* was in rock formations that were both at high-elevations (outcrops and capstones) and a complex of dry crevices. Further, most *N. magister* were trapped in the northwest section; only one, in the eastern half of the forest. This was surprising considering the large number of high-elevation rock formations with dry crevices and abundant evidence of *N. magister* in the eastern region of the forest.

The habitat use of *N. magister* in Robinson Forest is probably the result of location of the most complex rock formations. *Neotoma magister* were not trapped at rock formations lack-

ing dry crevices. Specimens were generally found associated with the largest rock formations exhibiting the most extensive and complex crevices that were dry. Such crevices were characteristic of high-elevation rock formations and capstones tended to be larger with more extensive crevice systems. We do not know if a low-elevation rock formation with a complex system of dry crevices could attract *N. magister*; such habitat does not exist in the forest.

The lack of *N. magister* in the eastern half of the forest is puzzling. This region has an abundance of high-elevation rock formations with complex crevices, and evidence of *N. magister* was extensive. Although fresh sign was virtually lacking, the largest midden piles in the forest were in this region. Two possible explanations for this distribution exist. First the Robinson Forest population of *N. magister* may exhibit a meta-population phenomenon where local sub-populations go extinct (Harrison and Taylor 1997). *Neotoma magister* has been considered an example of meta-populations comprised of sub-populations (Castleberry et al. 2000) in other parts of its range. Similarly, the clustered rock formations and discontinuous distribution of *N. magister* in the forest suggest a meta-population. Local extinction, migration, and recolonization are characteristic of meta-populations and may be characteristic of the Robinson Forest population as well. Thus the current distribution may simply indicate that the sub-population in Knott County is nearly extinct and may become reestablished in the future.

The second, more plausible explanation for the distribution of *N. magister* in Robinson Forest may be that reduced recruitment in the eastern section is due to isolation from forest fragmentation. The northwestern section of the forest is connected to the only existing dispersal corridor for *N. magister*. This corridor follows Buckhorn Creek as it flows to the west and empties into Troublesome Creek. The corridor continues along Troublesome Creek. High-elevation ridge tops with numerous capstones and high elevation outcrops flank these creeks. *Neotoma magister* are abundant in these rock formations (Krupa unpubl. data). It is possible that recruitment into Robinson Forest results as animals immigrate from the west. This may explain why 79% of all *N. magister* were trapped in the northwestern section of the forest despite the suitable habitat to the east. In contrast, extensive clear cutting and mountain top removal to mine coal has occurred around the northern, southern, and eastern boundaries of the forest, resulting in forest fragmentation. Possibly, the eastern half of Robinson Forest may be more isolated with a lack of corridors for *N. magister*, despite the abundance of suitable rock formations. Thus flow of individuals into this section may be limited.

Currently, we cannot conclude if the distribution of *N. magister* in Robinson Forest is the result of meta-population dynamics or of isolation from forest fragmentation. Furthermore, we cannot determine if the population of *N. magister* in the forest is stable or in decline. Only a study that involves long-term trapping can determine what factors influence this population of *N. magister*. Such a study is currently underway.

ACKNOWLEDGMENTS

This study was part of a course to provide field research experience for undergraduates (Bio 395 Research in Biology). We thank the Robinson Forest staff and the University of Kentucky Department of Forestry for providing housing and vehicles during the study. The University of Kentucky Department of Biology also provided vehicles. We thank W. Marshall and A. Marshall Jr. for sharing their knowledge of location of rock formations in Robinson Forest; J. Larkin for providing additional information on location of rock formation as well as sighting and marking formations while flying over the forest; Mark Clemens for providing amazing expertise in piloting the plane and enthusiasm towards locating rock formations; K. Haskins, K. Hopper, and J. Wagner for helping with trapping; F. Ettensohn for his knowledge of the geology of Robinson Forest; K. Geluso for reading an earlier draft of this manuscript; and A. Fox for drawing the map of Robinson Forest.

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Comments on *Flora of North America*

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ABSTRACT

Study of the flora (plants) of the North American continent has a long and interesting history. Several attempts at compiling a Flora (publication describing the plants) of North America have been made in the last 2 centuries, each of which fell short of completion. These attempts are discussed and an overview of the current *Flora of North America north of Mexico* is presented, with comments on each volume published.

INTRODUCTION

In the last half of the 20th century, floristic treatments were written for many regions of the world, such as *Flora Europaea* (Tutin et al. 1964–1980), *Flora S.S.S.R.* (Komarov et al. 1934–1964), *Flora Reipublicae Popularis Sinicae* (Academia Sinica 1959–present [an English version is being published by the Missouri Botanical Garden]); and the ongoing *Flora of Australia* (ABSR 1981–present). Until the last decade of that century, no comprehensive Flora existed for North America. While there have been many state or regional Floras written for North America, this lack of a comprehensive treatise on the continent's plants resulted in a lack of understanding of the flora as a whole and has led to regionalizing of the application of plant names in groups for which no monographs have been completed. The need for such a floristic treatment for this continent has been voiced by many in the last 200 years (e.g., Asa Gray's [1880] remarks on the need for such a Flora), and the need has grown tremendously as the Information Age has advanced and the disparities in regional application of names have become more and more evident. Several treatises have been written on the history of botany and floristics in North America (Ewan 1969a; Reveal and Pringle 1993). In this paper, I present a history of the publications dealing with the flora as a whole and discuss the current project, of which eight volumes are published.

Throughout this commentary, I use the term "flora" when discussing plants in general, and the capitalized "Flora" when discussing a treatise written about those plants.

HISTORICAL PERSPECTIVE

As is the case with all taxonomic endeavors, the publication of a Flora of a region needs to be put in an historical perspective. In the case of the flora of North America, no comprehensive treatment of the flora has been completed to this day, in spite of the vast resources historically available in North America for floristic studies. There are many reasons why this is the case, perhaps chief among them the vast nature of the flora. There have been, however, several attempts at a Flora of the continent, and I will now outline some of the major ones.

Although there were pre-Linnean descriptions of plants from the North American continent, these names have no bearing on present nomenclature of our species; the current International Code of Botanical Nomenclature (Greuter 2000; available on-line at http://www.bgbm.fu-berlin.de/iapt/nomenclature/code/SaintLouis/0000St.Luistitle.htm) specifies Linnaeus *Species Plantarum,* (Linnaeus 1753) as the starting point for modern nomenclature. Linnaeus published the names of many new species of plants from North America but made no attempt at compiling a Flora of the continent. Among the earliest writings strictly on the flora of North America are those of Gronovius (1739–1743; *Flora Virginica*), Marshall (1785; *Arbustum Americanum*), and Walter (1788; *Flora Caroliniana*). In 1771, Johann Forster published a work with an extremely ambitious title, *Flora Americae Septentrionalis, or, A Catalogue of the Plants of North America* (Forster 1771). In spite of the promise of the name, this publication is actually a small booklet of 51 pages in which Forster arranged plants known to him from the continent.

An important figure in the history of North American botany is André Michaux, French botanist and friend of Thomas Jefferson. He was sent by the French government to the

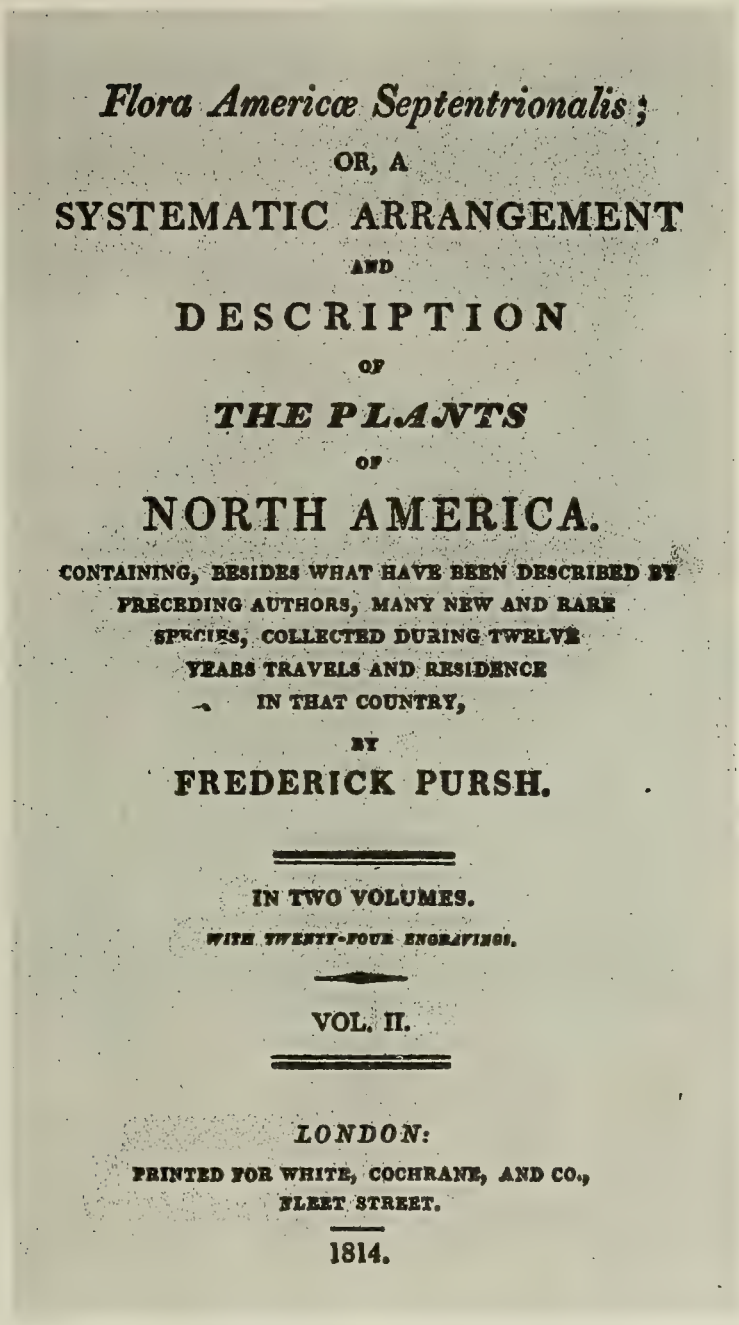
U.S. in 1785, along with his 15-year-old son François-André and several others, to search for timber trees, medicinal plants, and crop plants (Ewan 1969a; Ewan 1974; Savage and Savage 1986). The Michauxs traveled throughout the eastern U.S. from Florida north to Hudson Bay and west to the Mississippi River, collecting specimens and living plants. According to legend, Michaux was forced to leave the country under a cloud (espionage?; Anonymous 1997), though some authors (Savage and Savage 1986) stated that he left due to financial hardships. André Michaux died on a trip to Madagascar in 1802. The elder Michaux's book *Flora Boreali-Americana* was published posthumously (Michaux 1803). François-André (Michaux *fils*), who made several later trips to America, published a three-volume work on North American trees, *Histoire des arbres forestieres de l'Amerique Septentrionale* (Michaux 1810–1813).

Now I must mention Benjamin Smith Barton (1766–1815), apparently only the second professor of botany in the U.S. and author of the first botanical textbook published in the U.S., *Elements of Botany*. Barton, hired as professor of botany at the College of Philadelphia in 1789, planned to publish a Flora of the continent; he hired several European botanists as assistants to collect specimens for his Flora. The first, hired by Barton in 1807, was Frederick Pursh, a German gardener (Ewan 1979). Pursh left for London soon after being hired by Barton, and in 1814 he published on his own a two-volume work also titled *Flora Americae Septentrionalis* (Pursh 1814) (Figure 1), based partly on specimens in Barton's herbarium from the Lewis and Clark expedition. Thus, Barton was thwarted in his attempt at a Flora. In 1808, he hired an English naturalist, Thomas Nuttall, to collect specimens (Graustein 1967). Nuttall returned to England when hostilities arose between the U.S. and England in 1812; in 1818 he published his own book, *Genera of North American Plants* (Nuttall 1818), intended as a revision of Pursh's work. The unfortunate Barton died in 1815, but his nephew, William P.C. Barton, published three volumes of a *Flora of North America* from 1820 to 1823 (Figure 2), though the work was never completed (Barton 1820–1823).

The next player on the "North American Flora" field is Constantine Rafinesque-Schmaltz (1773–1840; Boewe 1982). Rafinesque came to North America in 1802, collected some 10,000 specimens in 2 years, and returned to Italy. He came back to the U.S. in 1815 and was professor of botany at Transylvania University in Lexington, Kentucky, from 1819 to 1826, after which he lived in Philadelphia until his death. Rafinesque, considered eccentric and unconventional, authored over 9500 new names of plants (Merrill 1949). In 1836 his *New Flora and Botany of North America* was published (Rafinesque 1836) (Figure 3). He also published one of the earliest treatments of medical uses of North American plants, his *Medical Flora*, in 1828 (Rafinesque 1828).

The British botanist Sir William Jackson Hooker (Allan 1967; Isely 1994) published a major work on the flora of North America, though it was restricted to British possessions on the continent. His *Flora Boreali-Americana* (Hooker 1840) added tremendously to the knowledge of the flora of the continent, but it was incomplete and limited in scope.

The next attempt at a truly continental Flora was made by John Torrey (1796–1873; Isely 1994), professor of botany at Columbia University, and his assistant, the young Asa Gray (1810–1888; Isely 1994), who would later become at Harvard University one of the preeminent scholars of North American botany and author of *Manual of botany* (Gray 1848). Torrey hired Gray to co-write the Flora with him, but Gray ended up doing a substantial portion of the writing himself (Dupree 1959). From 1838 to 1843 Torrey and Gray published *A Flora of North America* (Torrey and Gray 1838–1843) (Figure 4) in two volumes of seven parts, to high praise (Ewan 1969b; Rodgers 1942). Asa Gray himself began working toward a Flora of North America, published in parts from 1878 to 1897 as *A Synoptical Flora of North America* (Gray 1878–1897), but the work was not completed, though several editions exist (Figure 5). Gray (1880) continued to hope for publication of a complete Flora, and late in his life he wrote on the subject, wistfully stating that while he would be unable to complete such a project, those coming after him would be required to complete it (but that everyone should continue to send him specimens and notes on interesting discoveries).



Flora Americæ Septentrionalis;

OR, A

SYSTEMATIC ARRANGEMENT

AND

DESCRIPTION

OF

THE PLANTS

OF

NORTH AMERICA.

CONTAINING, BESIDES WHAT HAVE BEEN DESCRIBED BY PRECEDING AUTHORS, MANY NEW AND RARE SPECIES, COLLECTED DURING TWELVE YEARS TRAVELS AND RESIDENCE IN THAT COUNTRY,

BY

FREDERICK PURSH.

IN TWO VOLUMES.

WITH TWENTY-FOUR ENGRAVINGS.

VOL. II.

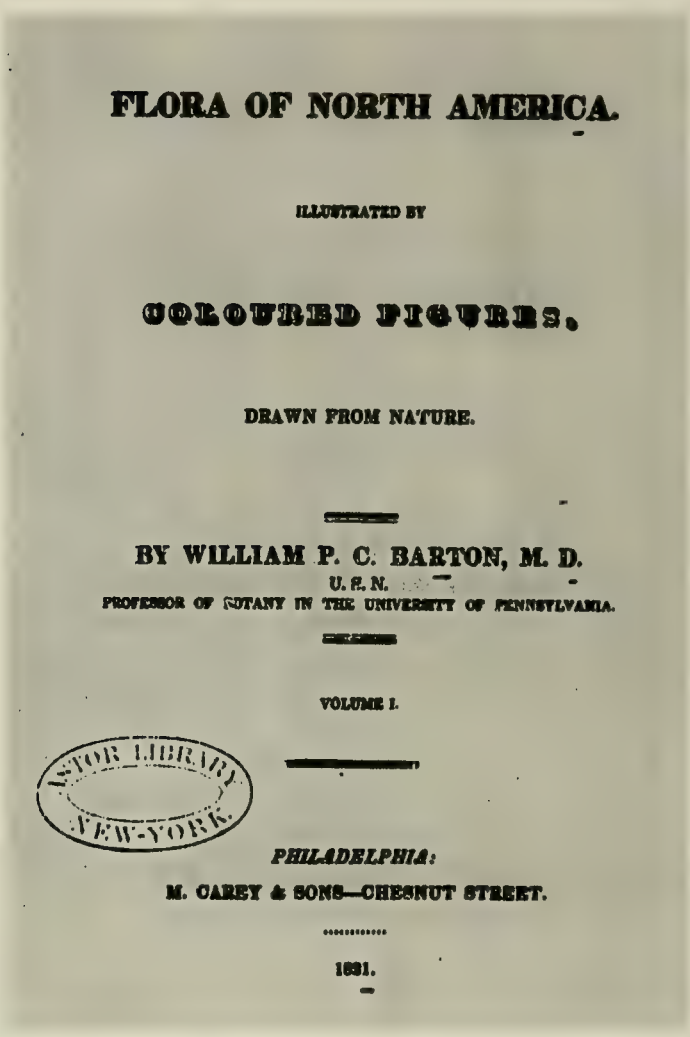
LONDON:

PRINTED FOR WHITE, COCHRANE, AND CO., FLEET STREET.

1814.

Figure 1. Title page from volume 2 of Pursh's *Flora Americae Septentrionalis,* published in 1814.

After the Torrey and Gray (1838–1843) and Gray (1878–1897) publications, focus in publication shifted to regional floras. Until the present-day *Flora of North America,* no other attempt at a continental Flora was made except by Nathanael Lord Britton, of the New York Botanical Garden, who began a serial publication titled *North American Flora.* This serial, which was published irregularly (New York Botanical Garden 1905–1990), focused



FLORA OF NORTH AMERICA.

ILLUSTRATED BY

COLOURED FIGURES,

DRAWN FROM NATURE.

BY WILLIAM P. C. BARTON, M. D.
U. S. N.
PROFESSOR OF BOTANY IN THE UNIVERSITY OF PENNSYLVANIA.

VOLUME I.

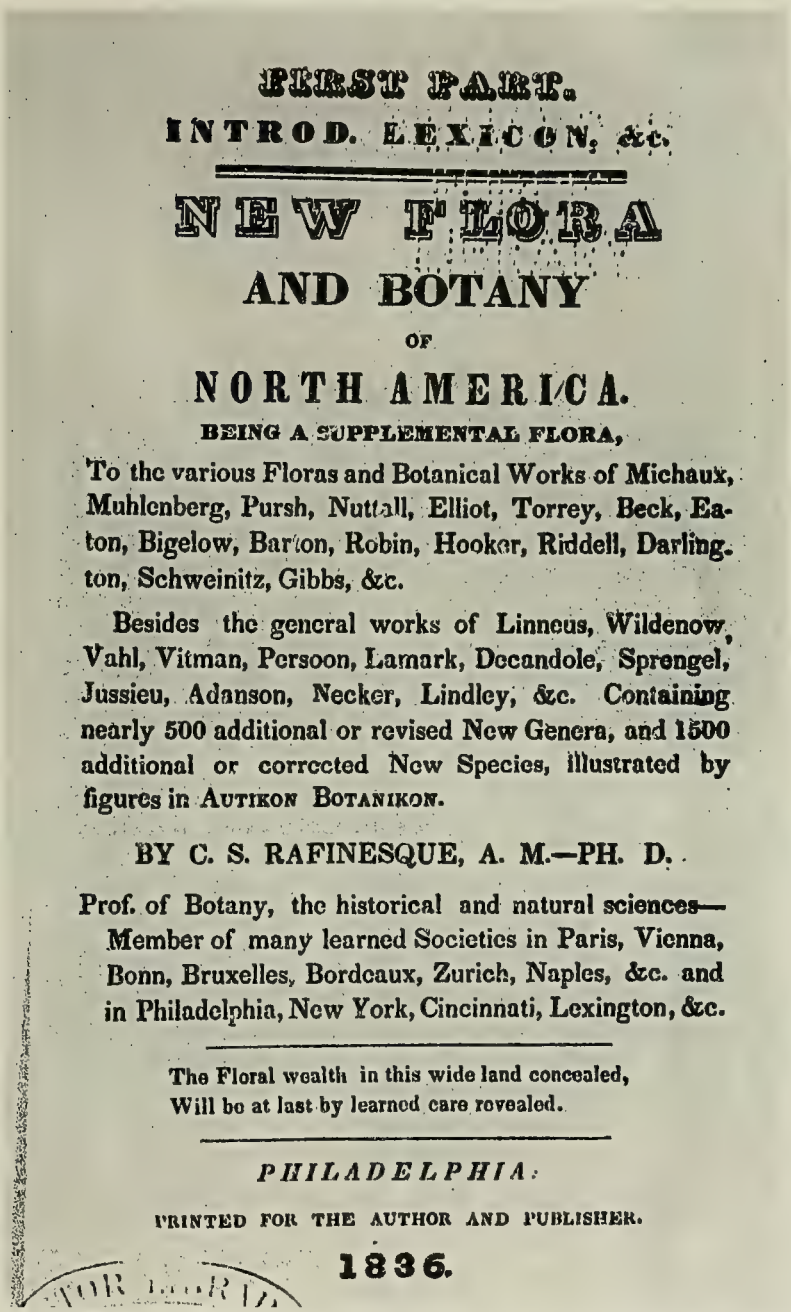
PHILADELPHIA:
M. CAREY & SONS—CHESNUT STREET.

1821.

Figure 2. Title page from Barton's *Flora of North America,* published in 1820–1823, but never completed.

on monographs of various groups of vascular plants, fungi, algae, mosses, and so on, and was not a comprehensive treatment of the entire flora of the continent. *North American Flora* was published in two series, the first from 1905 to 1949 (94 parts), and the second from 1954 to 1990 (13 parts), totaling 107 volumes.

A first try at a modern Flora was initiated in 1964, when the Council of the American Society of Plant Taxonomists established a committee to study the feasibility of such a project. This attempt, called *Flora North America,* was formally begun in 1966; several symposia were held to promote the concept (Gates 1971; Mickel 1969; Shetler 1971; Taylor 1971; Thorne 1971a, b). *Flora North America* was envisioned as an information system, using GIS and various other computer systems as a means of storing and accessing the data (Crovello 1977; Krauss 1973; Morse 1977; Shetler 1971, 1975). In 1973 the *Flora North America* initiative ultimately failed for lack of funding (Irwin 1973; Morin and Spellenberg 1993; Rohr et al. 1977; Walsh 1973). In March 1973 the American Institute of Biological Sciences passed a resolution condemning the suspension of funding for the project (BioScience 23:213) and sent copies to President Richard Nixon and the Office of



FIRST PART.

INTROD. LEXICON, &c.

NEW FLORA

AND BOTANY

OF

NORTH AMERICA.

BEING A SUPPLEMENTAL FLORA,

To the various Floras and Botanical Works of Michaux, Muhlenberg, Pursh, Nuttall, Elliot, Torrey, Beck, Eaton, Bigelow, Barton, Robin, Hooker, Riddell, Darlington, Schweinitz, Gibbs, &c.

Besides the general works of Linneus, Wildenow, Vahl, Vitman, Persoon, Lamark, Decandole, Sprengel, Jussieu, Adanson, Necker, Lindley, &c. Containing nearly 500 additional or revised New Genera, and 1500 additional or corrected New Species, illustrated by figures in AUTIKON BOTANIKON.

BY C. S. RAFINESQUE, A. M.—PH. D.

Prof. of Botany, the historical and natural sciences—Member of many learned Societies in Paris, Vienna, Bonn, Bruxelles, Bordeaux, Zurich, Naples, &c. and in Philadelphia, New York, Cincinnati, Lexington, &c.

The Floral wealth in this wide land concealed,
Will be at last by learned care revealed.

PHILADELPHIA:

PRINTED FOR THE AUTHOR AND PUBLISHER.

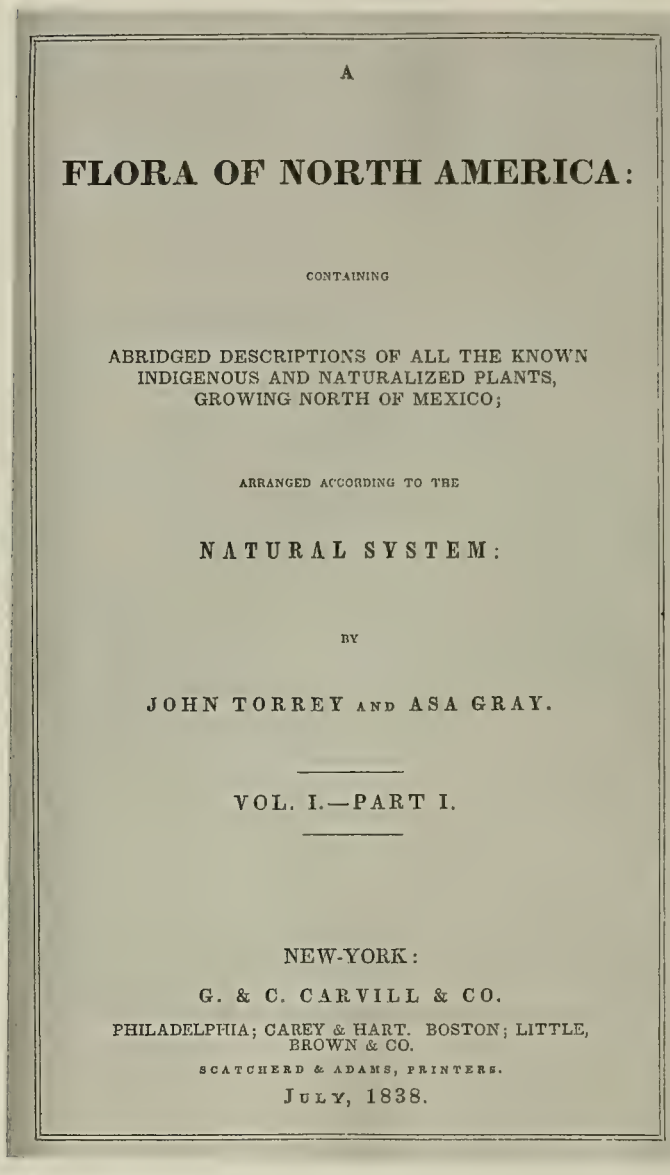
1836.

Figure 3. Title page from Rafineque's *New Flora and Botany of North America*, published in 1836.

Management and Budget. Subsequent tries at funding *Flora North America* through the Man in the Biosphere project and the National Park service were also unsuccessful (Morin and Spellenberg 1993; Ornduff 1994).

THE CURRENT ATTEMPT

Morin and Spellenberg (1993) presented a synopsis of the history of the current attempt at a Flora for continental North America, titled the *Flora of North America north of Mex-*



A

FLORA OF NORTH AMERICA:

CONTAINING

ABRIDGED DESCRIPTIONS OF ALL THE KNOWN INDIGENOUS AND NATURALIZED PLANTS, GROWING NORTH OF MEXICO;

ARRANGED ACCORDING TO THE

NATURAL SYSTEM:

BY

JOHN TORREY AND ASA GRAY.

VOL. I.—PART I.

NEW-YORK:

G. & C. CARVILL & CO.

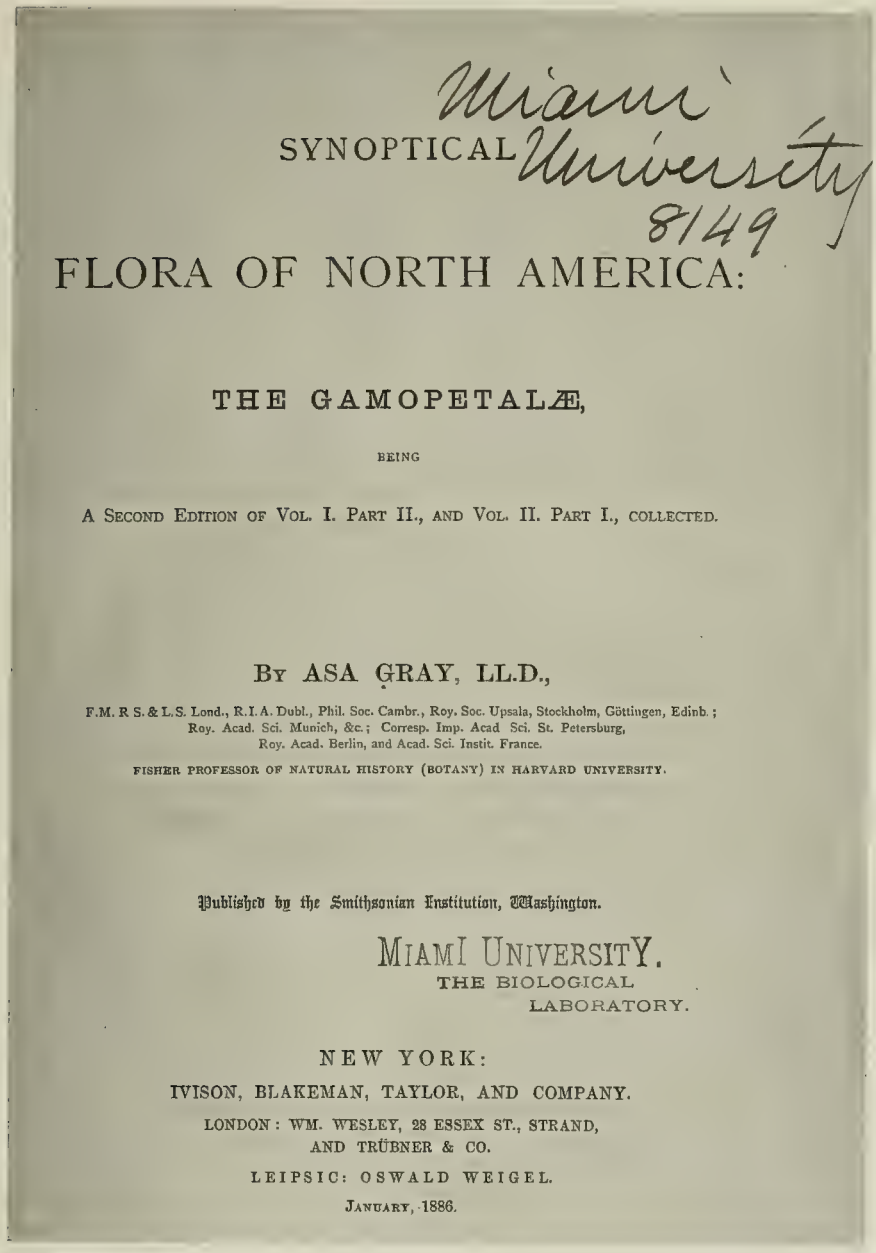
PHILADELPHIA; CAREY & HART. BOSTON; LITTLE, BROWN & CO.

SCATCHERD & ADAMS, PRINTERS.

JULY, 1838.

Figure 4. Title page from Torrey and Gray's *Flora of North America*, begun in 1838.

ico (FNA). After the failure of the *Flora North America* project in 1973, a renewed attempt at establishing the project came in 1982 at a meeting at the Missouri Botanical Garden, during a time when the need was seen for a comprehensive biological survey for the U.S. (Tangley 1985). At this meeting, a steering committee was set up, and planning began in earnest for preparation of the Flora. During the planning, it was decided that it would be specimen-based and that computerization of data for the Flora would be an important part of the project. Numerous papers and abstracts on the project that gave updates on the progress of FNA (Morin 1991, 1993; Morin and Barkley 1990; Morin, Eckenwalder, and Thieret 1991; Morin, Wagner, and Smith 1991; Morin, Whittemore, et al. 1988; Whetstone and Morin 1991) were presented between this first meeting and the publication of the first



Miami University 8149

SYNOPTICAL

FLORA OF NORTH AMERICA:

THE GAMOPETALÆ,

BEING

A SECOND EDITION OF VOL. I. PART II., AND VOL. II. PART I., COLLECTED.

BY ASA GRAY, LL.D.,

F.M. R S. & L.S. Lond., R.I.A. Dubl., Phil. Soc. Cambr., Roy. Soc. Upsala, Stockholm, Göttingen, Edinb.; Roy. Acad. Sci. Munich, &c.; Corresp. Imp. Acad Sci. St. Petersburg, Roy. Acad. Berlin, and Acad. Sci. Instit. France.

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Figure 5. Title page from the second edition of Asa Gray's *Synoptical Flora of North America,* published in 1886. Publication of the first edition was begun in 1878.

volume. A workshop on the future of floristics was held in 1988 in Alexandria, Virginia; recommendations were made about how floristic information could be used, ideas on production of an ideal Flora were discussed, and directions for research were compiled (Morin, Whetstone, et al. 1989). The first volume of FNA was published in 1993, and now eight volumes, to be discussed below, are in print. FNA is available on-line at http://hua.huh.harvard.edu/FNA/, with links to pages titled Introduction, History, Scope and Rationale, Content, How to Cite, Administration, Funding, and the FNA Newsletter. FNA was

originally envisioned as 12 volumes of vascular plants only, but volumes for bryophytes were eventually planned, and the entire Flora will now consist of 30 volumes. The contents for most published volumes (except Vol. 26, part 1 of the grasses, which can be accessed at http://herbarium.usu.edu/webmanual/) can be accessed on the FNA web site, and all descriptions, comments, keys, maps, and illustrations can be seen there. To date, eight volumes of FNA have been published. I will now outline the contents of each and comment on the volumes, their strengths and weaknesses, and attempt to compile the reviews of the project that have been written by others.

Volume 1, dated 1993, presents the introduction to the entire *Flora* and contains informational essays on the history of the project; the physical setting, past and present vegetation, and human interactions with the flora; and commentaries on the taxonomic and classification concepts used in FNA. The essays, an excellent introduction to the whole of the North American flora, can be used widely in any floristically or taxonomically oriented class. Reviews of the volume (Fiedler 1994; Harriman 1994; Ornduff 1994; Schmid 1994; Shetler 1994; Taylor 1993) have been very positive and even ecstatic.

Volume 2, dated 1993, contains treatments of the pteridophytes and gymnosperms, covering 26 families and 78 genera of pteridophytes and 6 families and 20 genera of gymnosperms, for a total of 555 species. Descriptions, keys, and detailed (though small) range maps are given for each species, and representative species are illustrated. Reviews of the volume (Harriman 1994; Judd 1994; Liston 1994; Ornduff 1994; Schmid 1994, 1997; Shetler 1994; Taylor 1993) are generally positive. Škoda (1997) presented an extremely detailed review of the volume and each taxon included in it and made new combinations for some of the species to bring them in line with current European thinking on pteridophyte nomenclature. When the second printing was issued, numerous corrections and rewrites were made without any indication of these changes; rather unfortunately, all printings show the same date. An example of such an unannounced change includes ranges given for some species of *Botrychium* in the Ophioglossaceae. This creates difficulties for people citing the volume in publications and could have been avoided by changing the date on the substantially rewritten printings.

Volume 3, dated 1997, contains Magnoliophyta: Magnoliidae and Hamamelidae. Included are treatments of 32 families containing 128 genera and 738 species. Content, in much the same format as for volume 2, covers such large families as Fagaceae (97 species), Papaveraceae (285 species), and Ranunculaceae (63 species). Reviews of the third volume (Porter 1999; Reveal 2000; Schenk 1998; Schmid 1998) are generally positive.

Volume 4, dated 2003, contains Magnoliophyta: Caryophyllidae, part 1, and includes 10 families encompassing 117 genera and 652 species. The two largest families included are Cactaceae (34 genera and 189 species) and Chenopodiaceae (27 genera and 168 species). Content is similar to that of volumes 2 and 3 but differs in that there is a color frontispiece and the maps for some taxa give distributions by means of a single dot on each state, rather than showing the detailed range. Overall quality of the volume is comparable to that of the first three volumes except for the unfortunate change in the maps. There are not yet any published reviews of this volume. Some surprising changes from traditional nomenclature, such as that in Gleason and Cronquist (1991), can be found in volume 4, such as the adoption of *Dysphania* R.Br. for some familiar *Chenopodium* species (e.g., *C. ambrosioides* and *C. botrys*). There are several cases when distributional information given in the text does not agree with the map for the taxon. For example, Ohio is listed in the range for *Dysphania anthelmitica* but there is no corresponding indication of the species for Ohio on the map, as is also the case for *Spinacia oleracea*. Some new species for a given state have shown up in this volume, such as the listing of *Atriplex littoralis* L. for Ohio, not previously known for the state (Cooperrider et al. 2001). Conversely, some species reported for Ohio by Cooperrider et al. (2001) are not attributed to Ohio in the volume (e.g., *Atriplex hortensis, Celosia argentea, Claytonia caroliniana, Monolepis nuttalliana, Salicornia europea* [=*S. depressa* in this volume], and *Salsola collina*). In some of these instances, it is interesting to see distributions on maps that snake around Ohio, but never cross into it, which causes this writer

to wonder about the thoroughness of literature and herbarium reviews by authors of treatments in the volume. Overall, nonetheless, this is a fine volume with an unbelievable wealth of information and quite usable keys. It is a huge leap from our former understandings of some of these very difficult genera in North America.

Volume 22, dated 2000, the first volume to treat monocot groups, contains treatments of Magnoliophyta: Alismatidae, Arecidae, Commelinidae (in part), and Zingiberidae. Covering 424 species in 89 genera and 30 families, this volume is the slimmest of all produced to date. Interestingly, I have been unable to locate any published reviews of this volume, even though it has been in print for 4 years. The largest families treated are the Alismataceae (4 genera and 34 species), Commelinaceae (6 genera and 51 species), Juncaceae (2 genera and 118 species), and Potamogetonaceae (2 genera and 37 species). Other families included are the palms (Arecaceae), bromeliads (Bromeliaceae), cat-tails (Typhaceae), and aroids (Araceae). Once more, the information presented follows essentially the same format as the earlier volumes, and the maps are presented in the more complete format found in volumes 2 and 3. A few changes from Gleason and Cronquist (1991) nomenclature are found in volume 22, such as the adoption of *Stuckenia* Börner for some plants formerly known as *Potamogeton* (e.g., *S. filiformis* and *S. pectinata* for *Potamogeton filiformis* and *P. pectinatus,* respectively). Once again, some taxa not reported for (or excluded from) Ohio by Cooperrider et al. (2001) are given for the state in this volume, such as *Lemna valdiviana.* As has been the case with each volume, reading this one has been a great educational experience; I learned, for example, that the commonly cultivated (though politically incorrectly named) "Wandering-Jew" is now to be called *Tradescantia zebrina* rather than *Zebrina pendula.* The treatments presented in this volume are for the most part well prepared, with usable keys (even the *Juncus* key, which I tested thoroughly), good descriptions, and fine illustrations.

Volume 23, dated 2002, contains the treatment of a single family, Cyperaceae. This is an enormous family, and the volume treats 27 genera and 843 species, 471 of which are endemic to North America, and 51 of which are introduced. *Carex,* with 480 species and by far the largest genus treated in the volume, is followed by *Cyperus* (96 species), *Rhynchospora* (68 species), and *Eleocharis* (67 species). Again, I have been unable to locate any published reviews of this volume. The format is essentially the same as for previously published volumes, though all of the taxa in this volume are mapped "one dot per state/province," which I find less than helpful, since the true extent of the species in a given state is impossible to ascertain from these maps. It is unfortunate that this change has been made in mapping the taxa. Be that as it may, this is a magnificent volume, crammed with knowledge and bursting at the seams with hard work. Some of the major changes from Gleason and Cronquist (1991) include the splitting off from *Scirpus* of *Schoenoplectus,* giving rise to such mouthfuls as *Schoenoplectus tabernaemontani* (instead of *Scirpus validus,* which I personally find much easier to pronounce). Here and there, one will find the odd error, such as disconnects between distributional statements and maps, but the keys are well constructed and the illustrations are useful (it appears that all taxa are illustrated, which is certainly a great boon to the novice in the vast morass of *Carex*).

Volume 25, dated 2003, covers the second half of the grass family (Poaceae), the remainder of which will be covered in volume 24. These two volumes represent work begun in 1986 to revise Hitchcock and Chase's (1950) *Manual of Grasses of the United States,* and brought into the FNA fold in 1999. The general format of the volume is the same as that of others already published, and most species are illustrated (in full page plates, a vast improvement over the plates in previous volumes). The format of the maps is different from those in other volumes in that the distributional ranges are given on a county-by-county basis, still in the small size, but the scale of each map changes as the shown range changes, so that a map for one species may show all of North America, while that for another may show only the southeastern quarter of the continent. This is a very helpful change. Although the maps provide a visual description of where each species is found, I was disappointed with the elimination of verbal rang-

es from the text. The taxa included in the volume encompass not only native and introduced, naturalized species but also cultivated species such as crop plants, ornamentals, and some species that are not yet known but may be found in the Flora range. This inclusiveness shows forethought and is a valuable addition. Reviews of this volume (Bloodworth 2003b; Smith 2004) have been positive, and I have found the volume extremely helpful in grass identification. There are errors, such as some incorrect figures and maps, and a few problems in textual discussions; these are published on a web site: http://herbarium.usu.edu/grassmanual/fna25/. I have printed the corrected plates and maps and tipped them into my copy of the volume. When the first grass volume, and later a field manual, become available, this treatment will become my most heavily used part of FNA.

Volume 26, dated 2002, covering the Liliidae, includes treatments of some of the most popular and widely cultivated ornamental plants: lilies and orchids. The volume covers 11 families of monocots, encompassing 177 genera and 908 species. The largest family is Liliaceae, with treatments of 70 genera and 478 species, followed by Orchidaceae, with treatments of 69 genera and 207 species. Content of this volume follows the same format as for earlier volumes, beginning with a color frontispiece and providing distributional range maps, rather than state dot maps as seen in volume 23; perhaps this is because some of the treatments were written longer ago. The volume opens, after the introductory, statistical treatment, with a very useful chapter updating the reader on current ideas on monocot phylogeny and classification. This article shows the vast changes in thought on the subject from the "Cronquistian" arrangement with which many of us are familiar; the text of this volume, however, does not adopt many of the rearrangements discussed but follows Cronquist in most cases, which is a shortcoming. Reviews of the volume (Bloodworth 2003a; Burkhart 2003) have been very positive. A few nomenclatural changes taken up in this volume may surprise some readers, such as application of *Maianthemum* in a broad sense to include *Smilacina*, or the use of *Manfreda* for some former *Agave* species, or the sinking of *Dioscorea quaternata* into *D. villosa*. There are the occasional misfits between textual and map distributional data, but these are minor problems. As is the case for all volumes of FNA released to date, the treatments are scholarly and detailed and are a tremendous storehouse of knowledge.

Any discussion of the current state of knowledge of the flora of North America must mention several other works that, while not a part of FNA, form an extremely important part of the overall knowledge of our flora. Among these is the recent CD publication of Kartesz and Meacham (1999), *Synthesis of the North American Flora*. This CD (which could be considered an expansion of the Kartesz and Kartesz [1980] checklist) includes valuable information on the distribution of plant taxa in North America, providing sources for many of the data, and gives descriptive and other types of information. Another is the U.S.D.A. Plants web site (http://plants.usda.gov/), which provides similar types of information and gives illustrations for some taxa and links to other web sites. Lastly, the Missouri Botanical Garden's W³TROPICOS web site (http://mobot.mobot.org/W3T/Search/vast.html) provides information on the nomenclature of plant taxa world-wide, including synonyms, publications citing a name, and photos of many species.

In conclusion, it appears that the hopes expressed by Asa Gray in 1880 are finally being realized, and that a comprehensive Flora of North America is becoming a reality. This is an exciting beginning to research on our flora and its relationships to the floras of other regions of the earth in a time when much of our world biotic diversity is under severe pressure.

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NOTE

Lobed leaves in *Salix exigua*, sandbar willow (Salicaceae), in Kentucky.—The genus *Salix* (Salicaceae), the willows, usually does not come to mind when lobed leaves are mentioned. The leaf blades of North American willows—usually described as ranging from linear to broadly obovate or elliptic—are typically entire to toothed. In the seedling stage, however, the sandbar willow, *Salix exigua* Nuttall (*S. interior* Rowlee), may have prominently lobed blades. In mid-summer (15 August 1982) we noted plants with such leaves in moist soil along the shore of the Ohio River in Campbell County, Kentucky (voucher: JWT 53869, KNK). The hundreds of young willows there ranged from rosette-like individuals to plants ca. 30 cm tall. At first glance we thought that they were one of the species of *Rorippa*, yellow cress, which occur infrequently in that habitat, and so we searched for flowering specimens. But, eventually noting that the distal leaves of taller individuals were not lobed and bore widely spaced, shallow teeth, we soon realized that here were seedlings of sandbar willow. Thickets of mature plants of that species were frequent along the river at the site.

The leaf blades were more or less lanceolate and up to 6 cm long. The lowest ones bore up to 6 major lobes, with small, toothlike lobes sometimes interspersed. Transition to the distal, unlobed leaves was rather rapid (Figure 1).

The seeds of willows are viable for only a short time, germinating usually in 12 to 24 hours after falling on damp soil (1). The shedding of seeds by sandbar willow in our area occurs in late June to mid-July. We assume that the seedlings we observed were plants of the year.

Plant collectors often do not pay much attention to seedlings. We wonder how many other kinds of woody plants have seedlings with leaves so different from the leaves of mature individuals. We have noted, for example, that the first leaves of seedlings of Kentucky coffeetree (*Gymnocladus dioicus*) are but 1-pinnate, in contrast to the mature leaves, which are 2-pinnate. The first leaves of *Fraxinus americana*, too, are quite different from mature leaves of that species, being simple instead of pinnately compound.

Figure 1. *Salix exigua*, sandbar willow. Seedlings with lobed leaves; collected in mid-summer along the Ohio River in Campbell County, Kentucky.

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Professor Willem Meijer (1923–2003)

Willem Meijer, Emeritus Professor of Biology, University of Kentucky, died of heart failure at the age of 80 on 22 October 2003 in Lexington, Kentucky. He was born in The Hague, The Netherlands, in 1923 and received his Ph.D. from the University of Amsterdam in 1951. From 1951 to 1968, Dr. Meijer worked as a botanist in Java, West Sumatra, and North Borneo. He joined the faculty of the then Botany Department at the University of Kentucky as an associate professor in 1968, became a full professor in 1983, and retired in 1993.

His interest in natural history began in the early 1930s, and in 1939 he published his first paper, which was an essay on some bryophytes from near Amsterdam. During his early explorations of the coastal dunes, moist meadows, fens, and wetlands of The Netherlands, he developed a strong interest in plant collecting and identification and in nature conservation. He was talking about these passions on the day of his death.

His work in Indonesia involved botanical exploration (part of which is chronicled in *Flora Malesiana,* Series I, Vol. 5, pp. 68–70), teaching, and development of herbaria. His research on bryophytes and other plants not only resulted in many publications but also thousands of specimens (over 14,000 from Indonesia) that he deposited in various herbaria, thus making the material available for study by future generations of botanists. He was a well-recognized authority on bryophytes, Dipterocarpaceae (a family in southeast Asian rain forests with many valuable timber trees), and *Rafflesia* (a parasitic plant with the world's largest flower).

At the University of Kentucky, Professor Meijer enjoyed studying the flora and vegetation of Kentucky and continuing his studies on tropical species. He was a challenging teacher for many unsuspecting, not-so-well-traveled undergraduates, who had no clue as to what they should do with a class handout written in German. He was avid about taking students on fieldtrips and made a lasting impression (for the better) on many of them. The students quickly learned, however, that it was best if one of them drove during fieldtrips, thereby allowing the Professor to devote full attention to expounding on the plants seen along the way. He organized a "protest" and saved the Mathews Garden in Lexington from becoming a grassy lawn. Then he worked to increase the number of native species in the garden, making it a valuable teaching resource. Dr. Meijer served as the major professor for eight M.S. and two Ph.D. students.

Professor Meijer's botanical travels took him not only to Indonesia but also to Ceylon; Pakistan; Celebes; West Papua, New Guinea; west Africa; Venezuela; and Panama. He was a research associate of the Missouri Botanical Garden in St. Louis and was involved in the garden's tropical research efforts in southeast Asia and Latin America.

Willem had a keen interest in people, places, and natural history. He was constantly trying to motivate people to do things for the sake of conservation, including arguing with government officials in Indonesia about logging the rain forests and urging a Kentucky citizen to grow thousands of oak seedlings for a restoration project.

Sometimes his demands really got on people's nerves; however, no one held a grudge against this innocent scholar. People greatly respected his wealth of knowledge and realized that he was a kind and caring person, who was deeply concerned about saving the world's biota, especially plants. He worried out loud on many occasions about the death of orangutans as a result of the destruction of rain forests in southeast Asia. He was a "friend" of all plants and hated the idea that anyone would spray herbicides—even to kill dandelions in a lawn—and was not shy about speaking against this practice. Dr. Meijer touched many lives, and his sense of humor and his passion for plants and nature conservation will not be forgotten.

Professor Meijer is survived by a daughter,

Frederica, in Amsterdam; a son, Johan, and two granddaughters in Portland, Oregon; and a son, George, and two grandsons in Copenhagen, Denmark.

This Memorial Resolution was presented to the University of Kentucky Senate at its 9 December 2003 meeting.

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BOOK REVIEW

Nicholas P. Money. 2002, Mr. Bloomfield's Orchard: The Mysterious World of Mushrooms, Molds, and Mycologists. Oxford University Press, New York, NY. 208 pages. ISBN 0-19-515457-6. $26.00.

Fungi are among the most economically and ecologically important organisms on the planet. They are major decomposers in both terrestrial and aquatic ecosystems. Yeasts are a key ingredient in the production of bread and of alcoholic beverages; molds are the culprits behind much food spoilage. Fungi are crucial symbionts of trees and other plants but also cause some genuinely nasty diseases of livestock, crops, and humans. Despite their importance, their often subterranean habits and slow-moving lifestyles keep them out of the public eye. Or, as so aptly stated by Dr. Money, a mycologist and professor at Miami University, Oxford, Ohio, "When making sense of life on earth, biologists (and filmmakers) usually rely on images of big cats and bleeding gazelles and ignore things like water molds that are hidden underwater in their parallel lilliputian universe."

Mr. Bloomfield's Orchard attempts to glamorize the natural history of fungi while simultaneously providing elegant insights into the nature of science and biological processes in general. That it manages to do all of these things with a pleasantly flowing and often humorous style is a testament to the mycological knowledge and enthusiasm of its author. The book covers some truly complex material in a light, straightforward manner that makes the technical details seem obvious. Though some background in the biological sciences will help readers appreciate the detail of the text, a degree in mycology, or even in biology, is not necessary for its interpretation and enjoyment.

The text covers a broad array of fungal topics, with an overall emphasis on the mechanisms behind the unique lifestyles of these organisms, and how scientists have used experimentation to unravel the mysteries of fungal growth and development. Though the chapter titles are entertainingly whimsical (e.g., "Offensive Phalli and Frigid Caps," "Ingold's Jewels," "Siren Songs"), an amazing amount of hard science is slipped in between fungal anecdotes. Convergent evolution, meiosis and mitosis, natural versus artificial groups, and the internal structures of cells are among the topics covered. Explanations of these subjects are concise and refreshingly clear, neither confusing to the novice nor too simplified for the scientist.

The book begins with spore dispersal mechanisms, focusing on the startling techniques of the stinkhorns or phallic fungi. Next up are gross but interesting fungal diseases, which help introduce the topic of fungal nutrition. Nutrition is further covered in a chapter on the mycelium, or vegetative body, of the fungus. Ascomycetes (such as yeast and morels), famous eccentric mycologists, the glorious and functional spores of aquatic fungi, and fungal pheromones and poisons also get their 15 minutes of fame. The book concludes with an informative look at the making of a mycologist and how Dr. Money first became fascinated by the fungi.

The one drawback of the text is the dearth of photographs. Although line drawings are provided, they fail to capture the weird beauty and wild variety of the macroscopic fungi. The drawings provide the reader with an idea of the structure of these organisms, but seem rather unreal to someone who hasn't seen them in the field.

A particular strength of the work is that each chapter can stand alone, and many of these would make good short reading assignments for AP or freshmen level biology students. All in all, *Mr. Bloomfield's Orchard* provides both entertaining and educational reading and is well-suited to both mycological enthusiasts and those who just enjoy natural history.

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Kentucky Academy of Science: Awards 2003

Outstanding College/University Science Teacher Award

The recipient of the 2003 Outstanding University/College Science Teacher Award is Dr. Brent C. White, Matton Professor of Psychology at Centre College. Dr. White received his bachelor's degree with honors from the University of Utah, and his Ph.D. in psychology from Princeton University. Dr. White joined the faculty of the Department of Psychology at Centre College in 1971. In addition to his faculty position, Dr. White has served in numerous leadership positions over the years including chairperson of the psychology program, chairperson of the psychobiology program, chairperson of the life sciences program, and chairperson of the Division of Science and Mathematics.

As a teacher, Dr. White sets high standards for his students as a whole, yet unselfishly works with individual students so they can reach their true academic potential. One supporter believes that Dr. White's greatest strength as a teacher is his undying love of science. Another suggests that Dr. White's greatest strength is his innovation. Over the past 32 years, he has been an agent of continuous course improvement not only within his discipline of psychobiology, but also in psychology and science as whole. For example, he was instrumental in integrating a seamless laboratory experience into the existing introductory psychology class. Similarly, he played a major role in developing a natural science course sequence for Centre's general education program. Not content to teach the same classes and laboratories year after year, Dr. White has developed and taught 13 different courses in biology and psychology since joining the Centre faculty. Not only has he devoted considerable time and energy to the development of innovative curricula, he has also sought and received considerable external grant funds to support these efforts. Indeed, over the years, Dr.White has received seven instructional, equipment, and infrastructure grants from the National Science Foundation.

Throughout his career, Dr. White has maintained an active research program. Early in his career, he conducted numerous laboratory studies concerning the role of catecholamine neurotransmitter systems in the regulation of behavior. This work resulted in numerous papers and publications in prominent journals, including the journal *Science*. In the late 1980s, Dr. White switched gears and began to intensively study the social behavior of primates. This research led to strong collaborations with colleagues both in the Columbian rainforest and the Louisville Zoo. In appreciation for his research and conservation efforts with primates, Dr. White received the "Good Egg" award from the Louisville Zoological Society in 1987. From the laboratory and the zoo to the rainforest, he has always involved students in his research programs. Many of these students have presented the results of their work with Dr. White at meetings of the the Kentucky Academy of Science.

Outside the classroom and laboratory, Dr. White has also been very active. He founded and is president of The Woolly Monkey Preservation Foundation. He is also a member of several organizations that seek to study, protect, and conserve primates in both natural and zoo settings. One of his supporters summed up the justification for the present awarded by stating, Dr. White "is a fine teacher, he is one of the most productive researchers in the science division at Centre, he maintains high standards in all his academic pursuits, he is respected among his peers and students in the community, and his positive attitude and tireless work ethic are an inspiration to all of us."

It is with great pleasure that the Kentucky Academy of Science recognizes this dedicated teacher and gifted researcher by bestowing upon him the Outstanding University/College Science Teacher Award for 2003.

Outstanding Secondary School Science Teacher Award

The 2003 recipient of the Outstanding Secondary School Science Teacher Award is Ms. Diane Johnson, science teacher and science department head at Lewis County High School. Ms. Johnson received her bachelor's

degree in biology and chemistry, her master's degree in biology, her rank 1 in leadership and principalship, and her supervision certification from Morehead State University. Currently, she is working on a doctoral degree in curriculum and instruction at the University of Kentucky.

Over the past 22 years as a teacher at Lewis County High School, Ms. Johnson has passed on her love of science and learning to her students. One supporter noted that "Ms. Johnson has the one thing every outstanding teacher must possess, a passion for teaching and instilling knowledge in her students." She never gives up on students and exhorts them to reach their full potential. She gives 110% effort to make science meaningful to her students and expects no less effort from them. A parent of one of Ms. Johnson's former students stated, "While I appreciate Ms. Johnson for her knowledge, dedication, and creative lessons, I most appreciate the opportunities she made sure were available for her science students." She has served as the sponsor of PULSAR, the school's science club for the past 20 years, regularly arranging educational trips to major cities to visit museums and other educational exhibits. Similarly, Ms. Johnson has served as the director of the local science fair for the last 15 years. Her students have been frequent poster presenters at regional and state science fairs and at the Junior Science and Humanities Symposium.

In addition to her efforts on behalf of her students, Ms. Johnson has also been active at the regional, state, and national levels in science education. She currently serves as a resource teacher in the ARSI master teacher program, sharing her knowledge and enthusiasm with science teachers in Lewis, Bath, and Rockcastle counties to help improve their science programs. Since presenting her first paper at the meetings of the Kentucky Academy of Science in 1982, Ms. Johnson has been a frequent presenter at meetings of the Kentucky Science Teachers Association (KSTA) and the National Science Teachers Association (NSTA). Moreover, she has conducted over 200 workshops for science teachers in the district, region, state, and nation. In 2002, Ms. Johnson served as president of the Kentucky Science Teachers Association and is currently chair of the NSTA High School Program Convention committee. In addition to her many presentations and workshops, Ms. Johnson has also published articles in the *Kentucky Teacher, Charmed Particles,* and the KSTA *Newsletter.*

Given her vast achievements, it is not surprising that Ms. Johnson has received numerous awards for her efforts. She received the Ashland Oil Teacher Achievement Award in 1990, the Outstanding Senior High School Teacher Award at the Northeast Kentucky Science Fair in 1992, the Mathematics Education Service and Achievement Award in 1995, and was accepted into the Toyota International Teacher Program in 1999. One of her colleagues noted that "As most of us teachers reach the latter years of our career, we discuss retirement or other employment. Diane discusses working on her doctorate and continuing to explore research based education. There are few teachers who share Diane Johnson's dedication, ambition, and drive." She is an outstanding role model for both her students and her peers.

The Kentucky Academy of Science is pleased to recognize Ms. Diane Johnson as its 2003 Outstanding Secondary School Science Teacher.

Outstanding Academy Service Award

The recipient of the 2003 Outstanding Academy Service Award is Dr. Donald T. Frazier, professor of physiology and biomedical engineering at the University of Kentucky Medical Center. A native of Martin, Kentucky, Dr. Frazier received his bachelor's, master's, and Ph.D. degrees from the University of Kentucky. He returned to the Department of Physiology and Biophysics at the University of Kentucky in 1968 after establishing a successful research program in the neurophysiology of respiratory neurons at the University of New Mexico School of Medicine. He served as chair of the Department from 1980 to 1992.

Dr. Frazier's scientific accomplishments over the past 35 years are too numerous to list. He has published over 200 articles and abstracts in highly respected journals, he has maintained almost continuous funding for his research through grants from the National Institutes of Health, he has served on numerous scientific boards and review groups, and he has mentored dozens of Ph.D. students and

post-doctoral fellows. His distinguished research career was recognized by the Kentucky Academy os Science in 1994 when he received the Distinguished College/University Scientist Award.

Since 1990, Dr. Frazier has devoted a considerable effort toward the improvement of science education at both the college and precollege levels. He has served as director of the Science Outreach Center at the University of Kentucky since 1993. Under his direction, the center has received considerable funding over the past 10 years to provide support services for secondary science teachers and meaningful scientific experiences for students throughout the state. He served as President of the Kentucky Science Teachers Association in 1993–1994 and is on the Executive Board of the East Kentucky Center for Science, Mathematics, and Technology based in Prestonsburg. A long-time member of the Kentucky Academy of Science, Dr. Frazier has served as executive secretary of the academy since 1997. In this volunteer position, he has directed the day-to-day operation of the academy and has had a major impact on the academy's programs. As a result of Dr. Frazier's support, the academy established its first permanent office with part-time administrative support in 1998. Working with multiple academy presidents and members of the Governing Board, his influence and insight has been instrumental in numerous improvements in the organization and coordination of academy outreach programs and in the annual meeting. He has strengthened ties between the academy and the University of Kentucky and has been involved in all major initiatives of the academy. Clearly, Dr. Frazier has contributed greatly to the image of the academy and its recognition throughout the Commonwealth.

In recognition of his unselfish contributions to the academy, the Kentucky Academy of Science is pleased to present the 2003 Academy Service Award to Dr. Donald T. Frazier.

Distinguished College/University Scientist Award

The recipient of the 2003 Distinguished College/University Scientist Award is Dr. Nigel G.F. Cooper, professor of anatomical sciences and neurobiology, ophthalmology and visual sciences, and director of Integrated Programs in Biomedical Sciences at the University of Louisville School of Medicine. Dr. Cooper received his bachelor's degree in biology from Open University in England and his Ph.D. in anatomy and neurobiology from the University of Tennessee. He was recruited to the University of Louisville in 1991 after establishing a very successful neuroscience research program at the University of Tennessee Center for the Health Sciences. What a coup for the Commonwealth of Kentucky! During his tenure at the University of Louisville, Dr. Cooper has established himself as a highly respected researcher and a leader in developing programs that have had a sustainable impact on biomedical education and research, not only at the University of Louisville but also at nearly every college and university in the state.

Funded by the National Institutes of Health and the National Science Foundation, Dr. Cooper has maintained an active neuroscience research program for over 20 years. His research on the developing retina has shown that synaptic receptor molecules in the retina can be altered by light deprivation in newborns but not in adult rodents and that stimulation of these same receptors can lead to enhanced transcription of apoptosis-associated genes in the inner layer of the retina. This finding has led to the development of a model for the study of certain neurodegenerative processes in the eye, and the search for the signal transduction pathway between the stimulus and cell death, which could be targeted for neurotherapeutic intervention. More important, Dr. Cooper's work may become the first model for understanding the pathogenesis of glaucoma, for which there is no known pathological cause for cell death by apoptosis in the inner retina during advanced intraocular pressure.

Although Dr. Cooper's distinguished scientific career alone would be sufficient to qualify him for this award, his contributions to the development of biomedical research capacity at the University of Louisville and throughout the state are even greater. Soon after his arrival at the University of Louisville, he submitted and received a large NSF-EPSCoR grant in developmental and neurobiology that provided funding for the recruitment of junior faculty using molecular genetic approaches to study the development and function of the

nervous system. As a direct result of Dr. Cooper's guidance and support, these recruited faculty now all have independent, federally funded research programs. This award also established training programs in molecular and gene-based technologies for graduate students and postdoctoral fellows in disciplines spanning several departments at the medical school and the main campus. More recently, Dr. Cooper played a significant role in bringing five diverse faculty disciplines at the University of Louisville together to develop an integrated program in biomedical sciences (IPIBS). Recognizing his considerable leadership skills, he was his colleagues' top choice to be the director of this program.

Dr. Cooper's impact on biomedical research across the state has been equally impressive. Several years ago, he brought together biomedical researchers from the state regional comprehensive universities and the private liberal arts colleges to discuss forming a research network. His efforts ultimately led to a six million dollar grant from the National Institutes of Health in 2001 to form the Kentucky Biomedical Research Infrastructure Network (KBRIN). The KBRIN consortium consisting of 13 institutions across the state can only be described as incredible success. As a direct result of Dr. Cooper's leadership, core facilities for genomics and bioinformatics research have been established at the University of Louisville and the University of Kentucky, providing access to researchers across the state to DNA sequencing, microarray technology, and supercomputer facilities. This project also created two scientific research cores that provided major funding to 12 faculty members at the comprehensive and private universities. In addition, funding was provided for significant research infrastructure development across the state, and for summer research experiences for undergraduate students and faculty collaborations. Although the network is now only beginning its third year of existence, it has already had a lasting impact on biomedical education and research throughout the state. As one supporter noted, "Dr. Cooper's has had the vision through the KBRIN program to encourage, nurture, and promote the potential that lies within the scientists and students of the Commonwealth of Kentucky. He has made a difference."

In recognition of his distinguished scientific career and his significant contributions to science and science education in the Commonwealth of Kentucky, the Kentucky Academy of Science is pleased to present the 2003 Distinguished College/University Scientist Award to Dr. Nigel G.F. Cooper.

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Abstracts of Some Papers Presented at the 2003 Annual Meeting of the Kentucky Academy of Science

Edited by Robert J. Barney

AGRICULTURAL SCIENCES

Residues and half-lives of pyrethrins on field-grown pepper and tomato fruits. GEORGE F. ANTONIOUS, Land-Grant Program, Department of Plant and Soil Science, Kentucky State University, Frankfort, KY 40601.

The dried flower heads of *Tanacetum cinerariifolium* (Asteraceae) contain insecticidal compounds collectively called Apyrethrins@. Pyrethrins are the subject of intense interest for use in crop protection because their toxicological properties permit control of certain insect species at application rates as low as 5–10 g/acre. Botanically-derived insecticides have gained favor in recent years, due in part to the perception that, because they originate from plant material, they are more safe or natural. A field study was conducted at Kentucky State University Research Farm (Franklin County, KY). Seedlings of sweet pepper (*Capsicum annuum* 'Bell Boy' Hybrid and tomato (*Lycopersicon esculentum* 'Mountain Spring' F1 Hybrid were planted. A multi-purpose insecticide formulation containing pyrethrins 0.2%, technical piperonyl butoxide (PBO) 1.0%, diatomaceous earth 88.0%, and inert ingredients 10.8% was sprayed on pepper and tomato foliage when tomato fruits became red ripe and pepper became mature green at the rate of 6 lbs of formulated product per acre (5.4 and 27.2 g a.i. of pyrethrin and PBO, respectively). Following spraying, pepper and tomato fruits were collected at different time intervals for residue analysis using high pressure liquid chromatography (HPLC). Dissipation rates and half-lives ($T_{1/}$) of pyrethrins and PBO residues on pepper and tomato leaves and fruits were determined. Initial deposits (1 hr following spraying) of pyrethrins were significantly higher on pepper than tomato fruits. Half-lives on pepper and tomato fruits did not exceed 2 hr. Where concern exists over pesticide residues on treated crops and in the environment, pyrethrins can be used to reduce the risk of exposure to synthetic pesticide residues.

Phytochemicals for pest control. DADDY N. BOATENG** and GEORGE F. ANTONIOUS, Land-Grant Program, Department of Plant and Soil Science, and TEJINDER S. KOCHHAR, Department of Math and Sciences, Kentucky State University, Frankfort, KY 40601.

Several wild tomato accessions of *Lycopersicon hirsutum* that are not consumed by humans were planted under greenhouse conditions for mass production of leaves. The foliage of the wild tomato *L. hirsutum* f. *glabratum*, *L. hirsutum* f. *hirsutum*, and *L. pennellii* (Solanaceae) is covered with glandular trichomes (plant hairs). Glandular trichomes on the leaves of *L.hirsutum* f. *hirsutum*, *L. hirsutum* f. *glabratum*, *L. pennellii*, and *L. pimpinellifolium* were counted monthly. Trichome contents were separated, purified, and quantified using a gas chromatograph equipped with mass selective detector (GC/MSD) for biochemical composition. Considerable variations in biochemical constituents among accessions were detected. Two sesquiterpene hydrocarbons, zingiberene and curcumene, were found in *L. hirsutum* f. *hirsutum*. An average 3-month-old plant of *L. hirsutum* f. *hirsutum* (PI-127827) has 1.30 kg fresh leaves averaging about 28,130 cm^2 exposed leaf surface area produced 17.2 g zingiberene and 1.8 g of curcumene. Four methyl ketones (2-tridecanone, 2-dodecanone, 2-undecanone, and 2-pentadecanone) were found in *L. hirsutum* f. *glabratum*. Two methyl ketones, 2-undecanone and 2-tridecanone, which have insecticidal activity against many herbivorous insects, predominated hair secretions in five of the *L. hirsutum* f. *glabratum* accessions tested. Concentrations of total methyl ketones ranged from 81.3 ìg/g fresh leaflets on *L. esculentum* cv. Fabulous (a commercial tomato cultivar) to 5.5 mg/g on *L. hirsutum f. glabratum*.

Impact of soil management on herbicide movement in soil water. CLARENCE JORDAN**, GEORGE F. ANTONIOUS, and MATTHEW A. PATTERSON, Land-Grant Program, Department of Plant and Soil Science, Kentucky State University, Frankfort, KY 40601.

Runoff from agricultural watersheds carries enormous amounts of pesticides. During plant production, pesticides may move from application site into runoff water and runoff sediment following irrigation systems or natural rainfall events. Organic amendments, commonly used to enrich soils of low organic matter content, can modify the soil surface and stimulate soil microbial activity which could potentially lead to pesticide degradation and amount of chemical available for leaching. Field studies were conducted at Kentucky State University Research Farm (Franklin County, KY) to assess the influence of composted sewage sludge mixed with native soil at the rate of 50 tons/acre (on a dry weight basis) on trifluralin (Treflan) and napropamide (Devrinol) movement. Following pesticide spraying, triplicate water samples were collected periodically for trifluralin and napropamide analysis using a gas chromatograph equipped with nitrogen-phosphorus detector (GC/NPD). Results have indicated that the use of sewage sludge can become a useful technique for trapping non-polar pesticides such as trifluralin and may reduce surface and groundwater contamination by non-polar pesticides.

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* Presenter

** Undergraduate student competition

Repellency of wild tomato leaf extracts to the two-spotted spider mite, *Tetranychus urticae*. LISA M. HAWKINS* and GEORGE F. ANTONIOUS, Land Grant Program, Department of Plant and Soil Science, Kentucky State University, Frankfort, KY 40601, and JOHN C. SNYDER, University of Kentucky, Department of Horticulture, Lexington, KY 40546.

The potential of using allelochemicals from the leaves of wild tomato accessions for controlling mites is a promising alternative to synthetic pesticides. In order to determine the effectiveness of wild tomato accessions against the two-spotted spider mite, *Tetranychus urticae*, three separate solvents, chloroform, ethanol, and hexane, were used to extract several compounds from the leaves of the wild tomato plants. These compounds were identified by GC/MSD and the crude extracts were utilized in bioassays. Crude extracts of three accessions of *Lycopersicon hirsutum* f. *hirsutum*, six accessions of *L. hirsutum* f. *glabratum*, one accession of *L. pennellii*, and one accession of *L. pimpinellifolium* were prepared. To determine the acaricidal performance of the wild tomato accessions, two bioassays were utilized. The first was used to test for mortality using a 6-hr no-choice test. The second utilized a ring bioassay to determine repellency. Both bioassay results showed a greater response of the spider mites to the chloroform extracts of *L. hirsutum* f. *glabratum* accessions (PI-251304, PI-134417, PI-134418, and PI-126449). This study provides a new avenue for controlling spider mites using botanical extracts from wild tomato leaves.

Reversed phase thin-layer chromatography for testing mobility of azadirachtin in soil. MATTHEW A. PATTERSON* and GEORGE F. ANTONIOUS, Land-Grant Program, Department of Plant and Soil Science, Kentucky State University, Frankfort, KY 40601.

Bioactivity, mobility and fate of pesticides in the environment depend mainly on their adsorption to soil particles. Adsorption may reduce the concentration of pesticides in the soil solution, decrease their bioavailability, increase their rates of chemical degradation by soil microorganisms, or decrease their mobility into runoff and infiltration water. The objectives of this investigation were (1) to study the impact of mixing soil with yard waste compost on the adsorption of azadirachtin residues and (2) to study the impact of humic and fulvic acids in yard waste compost on the mobility of azadirachtin. Mobility of azadirachtin was studied by a reverse-phase thin layer chromatographic (RPTLC) technique. Humic and fulvic acids were extracted from soil amended with yard waste compost. Results indicated that the R_f values of azadirachtin decreased as the amount of humic acid (a significant component of soil organic matter) and fulvic acid in soil increased. This information can be explored in soil management practices to reduce non-point source pollution by pesticides.

Application of sewage sludge in land farming: advantages and disadvantages. SAMUEL M. MUTISYA**, GEORGE F. ANTONIOUS, and MATTHEW A. PATTERSON, Land-Grant Program, Department of Plant and Soil Science, Kentucky State University, Frankfort, KY 40601.

The Environmental Protection Agency estimates that ca. 15 million tons of biosolids and 31 million tons of yard waste are discarded annually in the U.S. Recycling this material as soil amendments for reclamation sites, forestlands, and agricultural land would (1) reduce the need for landfill disposal and/or incineration and (2) reduce the impact of these disposal methods on environmental quality. The objective of this study was to assess the effect of class-A biosolid and yard waste compost on potato and bell pepper yields under field conditions. Field studies were conducted on a Lowell silt loam soil located at the Kentucky State University Research Farm, Franklin County, KY. Six replicates of each soil amendment were mixed with native soil at a rate of 50 tons/acre on a dry weight basis in standard USLE research plots (22 × 3.7 m, 10% slope). Total potato and pepper yields from yard waste compost amended soils (3330.9 lbs/acre and 9187.1 lbs/acre, respectively) were significantly higher ($P < 0.05$) than yields from either the soil amended with class-A biosolid (2835.2 lbs/acre and 6984.2 lbs/acre, respectively) or the unamended soils (2429.6 lbs/acre and 7161.7 lbs/acre, respectively).

GEOGRAPHY

Refining Kentucky's Level IV Ecoregions map by conflation to the state boundary. DEMETRIO P. ZOURARAKIS, Kentucky Division of Conservation, Department for Natural Resources, Frankfort, KY 40601.

The recently released Level IV Ecoregions Map for Kentucky represents a new and essential data layer. A part of the level IV Ecoregions map for the conterminous U.S., the data product was digitized at the 1:250,000 scale from yet smaller scale maps. The original electronic data set did not follow the official state boundary, digitized at a much larger scale, resulting in the creation of sliver polygons, particularly along the Ohio River. A refined digital layer, conflated to the official state boundary working at a larger scale is proposed. Commonplace GIS editing techniques were utilized for the removal of 190 outside slivers (91,776 acres or 0.35% of state area), followed by the subsequent merging of 175 inside slivers (140,342 acres or 0.54% of state area). Level III or IV regions were neither deleted nor added. Three level IV ecoregions lost 6 polygon features, bringing their total to 30. Reshaping of features was done near the state boundary to prolong undershoots. The new data layer was later reviewed and approved by the original authors, constituting the official Kentucky data set.

HEALTH SCIENCES

Competitive foods negatively impact nutritional benefit of school lunch. SUSAN B. TEMPLETON* and MAR-

THA A. MARLETTE, Human Nutrition Research, Kentucky State University, Frankfort, KY 40601.

We photographed trays of 743 sixth-graders before and after they ate lunch, then collected and weighed their leftovers. The before photos were compared to weighed portions from sample trays to estimate initial portion size; plate waste was subtracted to calculate students' actual consumption. Nutrient content was analyzed using Nutritionist V; statistical analysis was performed using SPSS 10 for Windows. One-third of participating students purchased competitive food (CF) items along with lunch—non-carbonated drinks, chips, snack cakes, etc. Students purchasing CF items selected fewer items and/or smaller portions from the school lunch (SL) menu. The mean number of SL items selected was 4.9 for the SL group and 4.0 for the SL+CF group, while the mean total weight of SL items selected was 559 grams for the SL group and 423 grams for the SL+CF group (both significant at $P < 0.001$). Students in the SL group consumed 81% of the SL calories they selected; students in the SL+CF group only consumed 74% of the SL calories they selected. The SL+CF students received only three-fourths the energy that SL students did from the SL items. While energy provided by CF items increased their total energy intake to 120% of the SL group's intake, 36% of CF calories came from sugar, and 37% came from fat. CF items contributed little to students' protein, vitamin, and mineral intakes. Students' lunchtime nutritional benefits can be increased by improving the palatability of SL items and restricting CF choices to more nutrient dense items.

Menu offerings, preparation methods, and competitive food purchases impact school lunch plate waste. ESUGHANI OKONNY**, SUSAN B. TEMPLETON, and MARTHA A. MARLETTE, Human Nutrition Research, Kentucky State University, Frankfort, KY 40601.

Being overweight is increasingly prevalent among America's children. Many choose high fat/high sugar snacks over nutrient dense fruits and vegetables. We photographed lunch trays of 743 sixth-grade students in three local middle school cafeterias before the students ate, and then collected the leftovers. Plate waste was weighed for each food item. Intact portions on five sample trays were also photographed and weighed. Nutrient content of the plate waste was calculated using Nutritionist V and aggregated by student; SPSS 10 was used for statistical analysis. The most wasted foods were fruits (40% of initial portion weight was left) and vegetables (30%). Mixed dishes (pizza, sandwiches, casseroles, etc.) had 22% wastage, meats had 21%, and grains had 16%. Students left 15% of their milk and 12% of cheese (used as a topping). The competitive food items purchased separately in the cafeteria were wasted least: salty snacks (5%), non-carbonated drinks (12%), and snack cakes/cookies (3%). Preparation method influenced waste for fruits (canned wasted less than fresh, $P < 0.001$) and potatoes (mashed wasted less than boiled or fries, $P < 0.001$). An average of 156 kcal of dietary energy was wasted by students who had purchased a la carte items with their school lunch, while 129 kcal was wasted by those who had school lunch items only ($P < 0.05$). Females wasted 167 kcal; males wasted 112 kcal ($P < 0.001$). Consequently, lunchtime energy intake averaged only 24% of the Recommended Daily Allowance for girls and 25% for boys. Student comments indicated taste was a major factor in the wastage of food.

Influences on food choices of sixth-grade students indicated by focus groups. MARTHA A. MARLETTE* and SUSAN B. TEMPLETON, Human Nutrition Research Program, Kentucky State University, Frankfort, KY 40601.

Focus groups were conducted in three local schools to explore factors that influence food choices of sixth-graders. A 24-hour food recall was included; participants used colored sponges to classify items by food source: home-prepared or comparable items, convenience items (frozen, ready to eat, etc.), items from fast-food restaurants, and snack items. At the end of each session, participants completed a questionnaire about food choices and household eating patterns. Each session was recorded, transcribed into text documents, and analyzed using TextSmart. The survey data was analyzed using SPSS v 10.0. Forty sixth-grade students (29 female, 11 male) participated. Over half of the students reported taste was "very important," appearance and health benefits were "somewhat important," and incentives and cultural differences were "not important" influences on their food choices. The majority reported that mothers did menu planning, food shopping, and food preparation for the household. Although foods reported in the 24-hour recall showed that most participants had milk for breakfast (52%), colas were the most consumed beverage (29%) for the evening meal. Seventy-five percent "usually" ate lunch in the school cafeteria. Over 20% reported eating only a salad and 13% reported skipping lunch "sometimes." Over 15% brought lunch from home when they did not like the cafeteria offerings or could not eat the food for religious reasons. Nutrition education is needed to enable students to make better food choices. Menu ingredients and nutrient content information should be furnished so students may take full advantage of the school lunch program.

Changes in calcium (Ca), zinc (Zn), and copper (Cu) concentrations in plasma of rats fed varying levels of Ca, Zn, and Cu in the diet and exposed to a mixture of pesticides. HERMINE NGWANG**, ROBERT C. RIVERS, FRED N. BEBE, and MYNA PANEMANGALORE, Nutrition and Health Program, Kentucky State University, Frankfort, KY 40601.

The interaction between minerals Ca, Zn, and Cu and a mixture of pesticides was determined on plasma mineral concentrations in rats. Male, Sprague Dawley rats, weighing 175–200 g, 6/grp were fed AIN 93M or the same modified to contain 500 mg Ca (low Ca), 7 mg Zn (low Zn), 2 mg Cu (low Cu), 60 mg Zn (high Zn), or 12 mg Cu (high Cu) in combination: Control (CON), LCa+LZn, LCa+LZn+LCu, or HZn+HCu with or without pesti-

cides. A mixture of Endosulfan, Thiram, and Acephate at 25% of LD50 was added to the diet of pesticide exposed groups. The rats were fed for 4 wk. Plasma Ca concentrations (mg/L) declined by about 17% in groups fed low Ca diets and by a similar amount in the HZn+HCu group; exposure to pesticides in the diet decreased plasma Ca in the CON and LCa+LZn groups by 14% but not in the LCa+LZn+LCu and HZn+HCu groups (P æ 0.05). Plasma Zn declined by more than 50% in the LCa+LZn and LCa+LZn+LCu groups, and the HZn+HCu diet also reduced plasma Zn by 56%, but pesticide exposure did not further modify plasma Zn ($P \leq 0.05$). Plasma Cu decreased by 82% in the LCa+LZn+LCu group and was similar to the control in all other groups; there was a 2.5-fold increase in plasma Cu in the pesticide exposed LCa+LZn+LCu group with no change in all the other groups ($P \leq 0.05$). This suggests interaction between pesticides, Ca, and Cu at the level of absorption.

Arsenic in tap water primarily from private wells in central Appalachia. JOHN G. SHIBER, Division of Math & Science, Big Sandy Community & Technical College District, Prestonsburg, KY 41653.

Over 200 tap water samples from homes in 92 towns/cities in eastern Kentucky, West Virginia, and Ohio were collected and analyzed for arsenic. 83% of the homes are serviced by private wells, 4% by private springs, and 13% by public water systems. Almost all samples collected from homes with public water supplies had no detectable arsenic in their tap water. In contrast, arsenic was detected in half of the samples coming from homes with private wells. Of these, 43% had 0.5 to 1.0 ppb, 34% 1.1 to 3.0 ppb, 5% 3.1 to 5.0 ppb, 11% 5.1 to 10.0 ppb, and 7% had arsenic levels far exceeding its maximum contamination level (MCL) of 10 ppb. The MCL for arsenic was recently lowered from 50 ppb to 10 ppb amidst great controversy. Many scientists believe that even 1.0 ppb arsenic is too high for people who are chronically exposed because of its implication in cardiovascular diseases, diabetes, and certain cancers, i.e., the same diseases very prevalent in central Appalachia, especially eastern Kentucky. Thousands of homes in this region still use wells as their primary water source, and the Federal 2006 compliance law for public systems does not extend to private well users. These and other factors, together with the results of this pilot study, build a good case for a regional effort to alert private well owners to this potential toxic contaminant, facilitate getting their water analyzed for arsenic on the most sensitive equipment available, and inform them as to what can be done to remove arsenic from their water, if present.

PHYSICS AND ASTRONOMY

Gravitational lensing of black holes with a cosmological constant. SIDDHARTH MUNSIF** and SHAMANTHI FERNANDO, Department of Physics and Geology, Northern Kentucky University, Highland Heights, KY 41099.

According to Einstein's theory of gravity, the gravitational field of massive objects such as stars, galaxies, and black holes bends light in the direction of the object. This phenomenon is called gravitational lensing. Gravitational lensing is one possible way to detect black holes. We are currently studying black holes with a cosmological constant.

PHYSIOLOGY AND BIOCHEMISTRY

The health of white-footed mice (*Peromyscus leucopus*) in close proximity to human activities. RICHARD BLALOCK**, CALEB MATHIS, MANINDER VIRK, STEPHEN COMPTON, STEVE COE, and TERRY DERTING, Department of Biological Sciences, Murray State University, Murray, KY 42071.

Habitat loss of small mammals is becoming an increasing problem due to the development of rural and agricultural areas. When habitats become fragmented, population densities of small mammal species within fragments increase. With increased densities, the competition for mates and food increases as well. Increases in competition along with environmental pollutants can lead to increased stress, resulting in harmful physiological effects. To determine the physiological effects of habitat fragmentation on white-footed mice, traps were placed in 1–3 ha forested areas surrounded by either agriculture fields or housing. Control groups were trapped in areas with minimal disturbance. Subjects were immunochallenged by injections of phytohemmaglutinin (PHA) and sheep red blood cells. The immune system was then assessed using white blood cell counts, hemagglutination assays, and the reaction to PHA. Subjects in residential and agricultural areas had a stronger reaction to PHA, a lower hematocrit, and a lower antibody titre than the controls. Dissections of test subjects showed that mice from residential areas had a smaller stomach and caecum mass than mice from control and agricultural habitats. The reproductive system and corticosterone level were not affected by habitat type. These results suggest that mice found in agricultural and residential areas have a reduced humoral immune response and a lower hematocrit, but a stronger cell-mediated immune system, than controls. The dissection data suggest that mice in residential areas had a lower quality diet than controls. Collectively, our results indicated that habitat fragmentation was associated with specific, rather than general, impacts on the health of white-footed mice.

The effects of anthropogenic disturbance on the health of white-footed mice (*Peromyscus leucopus*). CALEB MATHIS**, RICHARD BLALOCK, MANINDER VIRK, STEPHEN COMPTON, STEVE COE, and TERRY DERTING, Department of Biological Sciences, Murray State University, Murray, KY 42071.

Habitat fragmentation of white-footed mice due to urbanization is believed to have an effect on the health of the animals in these areas. We tested the null hypothesis that habitat fragmentation has no effect on immunocompetence, stress levels, masses of gastrointestinal organs, or

masses of reproductive organs. Adult male specimens were trapped live from the field and brought immediately into the laboratory for blood samples. Subjects were then injected with sheep red blood cells (SRBC) the following morning. Phytohemalutinin (PHA) injections were given 7 d post SRBC injections. Final blood samples were taken the eighth day after the SRBC injections. Subjects were then dissected and organs weighed. Change in WBC count in response to SRBC injection was less in mice found in disturbed patches; however the cell mediated immune response to the PHA injection was significantly greater than those of undisturbed patches. Humeral immune response showed no significant differences. To evaluate stress, blood levels of corticosterone were measured as well as the mass of the adrenal glands. Mass of adrenal glands was found to be greater in mice caught in undisturbed areas. Mass of the gut was found to be significantly greater in mice found in undisturbed patches, primarily due to a larger stomach and caecum. No significant differences were found in the masses of reproductive organs. We concluded that both positive and negative impacts on animal health were associated with human disturbance.

SCIENCE EDUCATION

Enhancing science instruction in middle schools: A collaboration between Eastern Kentucky University and Madison Middle School. MATTHEW THOMPSON* and TOM OTIENO, Department of Chemistry, Eastern Kentucky University, Richmond, KY 40475, and MARGARET M. SOTO, Madison Middle School, Richmond, KY 40475.

Through a grant from the National Science Foundation, Eastern Kentucky University is collaborating with several Appalachian middle schools on a project whose goal is to improve inquiry-based instruction of science, technology, and mathematics in Appalachian middle schools. The program provides fellowships for graduate and advanced undergraduate students to work with science and mathematics middle school teachers. It is being implemented by 12 teams, each composed of a fellow, a science or math middle school teacher, and an Eastern Kentucky University faculty mentor. This presentation discusses the activities of one of the two science teams at Madison Middle School.

Action research implemented to improve zoology laboratory activities in a freshman biology majors course. DIANNE RAUBENHEIMER, Department of Education, and JENNIFER LEIGH MYKA, Department of Biology, Brescia University, Owensboro, KY 42301.

Action research was used to explore student impressions of both learning and enjoyment associated with specific laboratory exercises in two semesters of a zoology laboratory. Previous laboratories had primarily included observations of slides, preserved specimens, and group dissections of preserved animals. Four laboratory activities (annelids, molluscs, echinoderms, and arthropods) were altered to include higher levels of intellectual challenge. Animal behavior experiments, a dichotomous key activity, tables of structures and function, classification exercises, and a model building activity were added to the traditional laboratory observation and dissections. A survey was given at the end of the semester to assay student reactions to the new activities, with Kendall's coefficient of concordance showing an overall similarity between each student's ranking of preferred learning activities and of activities rated for enjoyment for the 2 yr studied. The survey also compared both student learning and student enjoyment for each type of activity done in the laboratory throughout the semester. Student enjoyment and student learning were significantly correlated by Spearman's rank order correlation. In addition, the results of the survey were compared with results of a lab practical exam for one semester to determine if student impressions of learning correlated with performance. Preliminary analysis showed that students performed better on redesigned activity questions. The results of this study will be used to further adjust zoology laboratory activities to maximize both student enjoyment and student learning. In addition, a closer look at dissections as a learning tool will be implemented in the following semester.

Implementation of an integrated, plant-based laboratory project involving botany, genetics, and biochemistry students. JENNIFER LEIGH MYKA, Department of Biology, Brescia University, Owensboro, KY 42301.

To provide opportunities for interaction between freshmen and upperclassmen in the biology program and to give students a personal experience with the interdisciplinary nature of scientific research in their laboratory courses, an integrated, plant-based laboratory project was implemented during the fall semester 2003 at Brescia University. The objectives of the project were (a) collection of plant material from the field by botany students, (b) preparation and analysis of plant genomic DNA by genetics students, (c) preparation of an enzyme extract by biochemistry students, and (d) presentation of results of the genetic and biochemical analyses by upperclassmen to the freshmen enrolled in botany. Botany students collected specimens of two different plant species from three different sites as a part of an ecology lab activity. A portion of the leaf material was then turned over to the genetics students for genomic DNA extraction from each sample, followed by agarose gel electrophoresis analysis. The remaining plant material was turned over to the biochemistry students for root peroxidase extract preparation. Enzyme assays were performed and the enzyme specific activity was determined for each plant species. Both the genetics and biochemistry students then prepared scientific posters and presented their results to their peers during a scheduled botany lecture. Future goals include an expansion of the project to comprise a larger portion of the laboratory course curriculum.

Guidelines for Contributors to the Journal

1. GENERAL

A. Original research/review papers in science will be considered for publication in JKAS; at least the first author must be a member of the Academy. Announcements, news, and notes will be included as received.

B. Acceptance of papers for publication in JKAS depends on merit as evaluated by each of two or more reviewers.

C. Papers (in triplicate) may be submitted at any time to the editor.

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List in the cover letter your telephone/FAX numbers, your E-mail address, and the names, addresses, and telephone numbers of two persons who are potential reviewers.

D. Format/style of papers must conform to these guidelines and also to practices in recent issues of JKAS, which are, in effect, a style manual.

E. Papers should be submitted in hard copy. Do not staple pages together.

F. Indent the first line of each paragraph (but not the first line of entries in the Literature Cited).

2. FORMAT

A. Papers should be in 12-point type on white paper 8.5 × 11 inches, with margins at least 1 inch all around. Double-space throughout the paper (i.e., one full line of space between each two lines of text, literature cited, or tabular data). Do not justify right margins.

B. Except for scientific names of genera and of infrageneric taxa, which should be typed in italics, the same type (roman) should be used throughout (i.e., one type size only; bold only for paper title).

C. Sequence of sections in papers should, where appropriate, be as follows: title of paper, name/address of author(s), abstract, body of paper, footnotes, table captions, figure captions (all the preceding on consecutively numbered pages), tables, and figures.

D. The running head (top right) should give name(s) of author(s), a short version of paper title, and page number of total.

E. The first page should include the running head and, centered near the top of the sheet, the paper's title and the name and address of author(s). These should be followed immediately by the abstract. (The first page should look as much as possible like the first page of articles in JKAS.)

F. The abstract, not to exceed 200 words, should be concise, descriptive, and complete in itself without reference to the paper.

G. The body of the paper should, where appropriate, include the following sections: Introduction, Materials and Methods, Results, Discussion, Summary, Acknowledgments, and Literature Cited.

H. No more than three levels of headings should be used: level 1, in capitals, centered; level 2, in capitals/lowercase, flush left; level 3, in italics, a paragraph indent, with initial capital only (except proper nouns and adjectives), and followed by a period, the text then starting after one blank space.

I. Personal communications (avoid if possible) should be indicated in the text as follows: (name, affiliation, pers. comm., date), e.g., (O.T. Mark, Wainwright College, pers. comm., 5 Jun 1995).

3. STYLE

A. In text, spell out one-digit numbers unless they are used with units of measure (four oranges, 4 cm) and use numerals for larger numbers; do not begin any sentence with a numeral.

B. Use no footnotes except those for title page and tables. Footnotes, identified by consecutive superscript numbers, should be entered on a separate sheet.

C. Measurements should be in metric and Celsius units. Define lesser-known symbols and give the meaning of acronyms at first use. Express time of day in the 24-hour system. Dates should be written day, month (abbreviated to three letters), year without internal punctuation. Units with multiple components should have individual components separated by a virgule (e.g., g/m^2 or $g/m^2/yr$).

D. Names of authors of binomials may be included but only at the first mention of the binomial. Cultivar names are not italicized but are enclosed in single quotes.

E. Useful guides for contributors to JKAS are the following: *Scientific style and format: the CBE manual for authors, editors, and publishers*, 6th ed., Cambridge University Press, 1994; *The Chicago manual of style*, 14th ed., University of Chicago Press, 1993; *The ACS style guide*, American Chemical Society, Washington, DC, 1986; and *AIP style manual*, American Institute of Physics, New York, 1990.

4. IN-TEXT CITATION OF LITERATURE

A. Cite publications in the text by author(s) and date—e.g., (Readley 1994); multiple citations should be in alphabetical order and separated by semi-colons—e.g., (Ashley 1987; Brown 1994; Foster 1975); multiple citations of works by one author(s) should be in chronological order—e.g., (Jones 1978, 1983); publications by one author(s) in the same year should be distinguished by a, b, c, etc.—e.g., (Smith 1994a, 1994b). For in-text references to works with one or two authors use names of both authors—e.g., (Jones and Williams 1991); for works with three or more authors use name

of the first author followed by et al.—e.g., (Lee et al. 1985).

B. Do not include any reference unless it has been published or accepted for publication ("in press"; see below).

5. LITERATURE CITED

A. List all authors of each entry. Do not abbreviate journal titles; abbreviations for these will be supplied by the editor.

B. The first line of each reference should be typed flush left; the remaining lines should be indented.

C. Examples of common types of references are given below.

JOURNAL ARTICLE

Lacki, M.J. 1994. Metal concentrations in guano from a gray bat summer roost. Transactions of the Kentucky Academy of Science 55:124–126.

BOOK

Ware, M., and R.W. Tare. 1991. Plains life and love. Pioneer Press, Crete, WY.

PART OF A BOOK

Kohn, J.R. 1993. Pinaceae. Pages 32–50 in J.F. Nadel (ed). Flora of the Black Mountains. University of Northwestern South Dakota Press, Utopia, SD.

WORK IN PRESS

Groves, S.J., I.V. Woodland, and G.H. Tobosa. n.d. Deserts of Trans-Pecos Texas. 2nd ed. Ocotillo Press, Yucca City, TX.

6. ILLUSTRATIONS

FIGURES (LINE DRAWINGS, MAPS, GRAPHS, PHOTOGRAPHS)

Figures must be camera-ready, glossy, black-and-white prints of high quality or laser prints of presentation quality. These should be designed to use available space effectively: a full page or part of one, or a full column or part of one. They should be mounted on heavy white board and covered with a protective sheet of paper; photographs to be grouped as a plate should have no space between them. Dimensions of plates must observe page proportions of the journal. Each illustration in a plate may be numbered as a separate figure or the entire plate may be treated as one figure. Include scale bars where appropriate. Lettering should be large enough to be legible after reduction; use lowercase letters for sections of a figure. Figure captions should be self-explanatory without reference to the text and should be entered on a page separate from the text. Number figures in Arabic numerals. Statistics presented in figures should be explained in the caption (e.g., means are presented ± SE, n = 7).

TABLES

Each table and its caption must be double-spaced, numbered in Arabic numerals, and set on a sheet separate from the text. The caption should begin with a title relating the table to the paper of which it is a part; it should be informative of the table's contents. Statistics presented in the table should be explained in the caption (e.g., means are presented ± SE, n = 7). Table should be submitted in hard copy only; they need not be included on a disk.

7. ETHICAL TREATMENT OF ANIMALS AS RESEARCH SUBJECTS

If vertebrate or invertebrate animals are involved in a research project, the author(s) should follow those guidelines for ethical treatment of animals appropriate for the subjects, e.g., for mammals or for amphibians and reptiles. Papers submitted to JKAS will be rejected if their content violates either the letter or the spirit of the guidelines.

8. PROOFS

Authors are responsible for correcting proofs. Alterations on proofs are expensive; costs will be assessed to authors. Proofs must be returned to the editor within 3 days after the author receives them; delay in return may result in delay of publication.

9. REPRINTS

Forms for ordering reprints will be sent to the author when the proofs are sent. They are to be returned directly to Allen Press, not to the editor.

10. PAGE CHARGES

Pages charges are assessed to authors of papers published in *Journal of the Kentucky Academy of Science.*

11. ABSTRACTS FOR ANNUAL MEETINGS

Instructions on style of abstract preparation for papers presented at annual meetings may be obtained from the editor. Copies will be available also at each annual meeting of the Academy.

NEWS

2004 Meeting of the Kentucky Academy of Science

The Kentucky Academy of Science will hold its 2004 meeting at Murray State University on Thursday, Friday, and Saturday, November 4 through 6. (See details on our web site, http://kas.wku.edu/kas/meetinginfo.asp.) The academy encourages faculty and professional presentations in all sections to augment the increasingly strong showing by student members of K.A.S. in recent years.

A new section in ecology and environmental science will be chaired this year by Albert Meier of Western Kentucky University. Our intent in creating this section is to provide expanded opportunities for professional interactions in these disciplines, particularly for population, community/systems ecologists, and environmental scientists who have not presented in the botany or zoology sections in the past.

We have renewed the computer and information sciences section, to be chaired by Charles Frank of Northern Kentucky University. This section is open to the emerging informatics fields as well as to the more established areas of computer science. Engineering is also experiencing a revitalization this year under the direction of Dr. Ted Thiede, Murray State and University of Kentucky.

The zoology section plans a sectional symposium with invited speakers in addition to contributed papers. Details will be available in future newsletters and on the web site this summer.

Kentucky Heritage Land Conservation Fund

The mission of the Kentucky Heritage Land Conservation Fund (KHLCF) is to award funding to purchase and preserve selected natural areas in the Commonwealth; to protect rare and endangered species and migratory birds; to save threatened areas of natural importance; and to provide natural areas for public use, outdoor recreation, and education.

Established by the 1994 Kentucky Legislature, KHLCF is administered by a 12-member board appointed by the governor. The board can award grants to acquire and protect areas of natural significance to local governments, state colleges/universities, and specified state agencies. Special consideration will be given to the funding of agencies working together to meet the listed goals. All acquisition applications, along with comprehensive management plans, must be submitted to and approved by the board.

The year 2003 was another eventful year for the KHLCF board. During 2003 it received and reviewed a large number of applications and approved 14 projects in 13 counties. In 2003 local government projects were approved in Calloway, Clark, Green, Harrison, Livingston, Logan, and Oldham counties; state agency projects were approved in Franklin, Garrard, Hardin, Harlan, Larue, and Letcher counties. The board also approved the Pine Mountain Trail State Park and provided initial acquisition funds. The trail will traverse Bell, Harlan, Letcher, and Pike counties.

Since the first awards were made in October 1995 the board has approved 116 projects in 56 Kentucky counties. Almost 20,000 acres have been purchased.

The fund is supported by the state portion of the unmined minerals tax, environmental fines, the $10 additional fee to purchase a Kentucky nature license plate, and interest on the fund's assets.

For more information, contact the Department of Natural Resources, Commissioner's Office, 663 Teton Trail, Frankfort, KY 40601. The phone number is (502) 564-2184; the e-mail address is www.heritageland.ky.gov.

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