

Expanding the Ark:
The Emerging Science and Practice of Invertebrate Conservation

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POSTER SESSION

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*The Emerging Science and Practice
of Invertebrate Conservation*

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PREFERENCE FOR LIGHT SOURCES IN TWO TIGER BEETLE SPECIES, *CICINDELA* *NEVADICA LINCOLNIANA* AND *CICINDELA* *TOGATA GLOBICOLLIS*

Attraction to light is known to disrupt behavior and impact the life histories of insects, particularly Lepidoptera. However, the potential role of light pollution as a contributing factor to insect extinction has been largely overlooked. We consider this issue by examining the attraction of the endangered Salt Creek tiger beetle, *Cicindela nevadica lincolniانا*, and the white-cloaked tiger beetle, *C. togata globicollis*, to common urban light sources. We hypothesized that tiger beetles would be more attracted to lamps emitting ultraviolet (UV) wavelengths than to non-UV emitting lamps. In six, five, four and two-way choice tests tiger beetles were attracted to all lights tested, and significantly higher counts of tiger beetles were attracted to UV emitting lamps than to non-UV emitters. Responses to light in both species showed similar trends. Moreover, in behavioral threshold tests, beetles were significantly attracted to two lamps at the lowest measurable light intensities we could obtain. Unfortunately, in the beetles' main habitat light pollution from car dealerships and gas stations approximately one and a half kilometers away already exceeds light intensity levels used in our behavioral threshold tests in the lab. Construction of additional urban development projects, which will further increase light pollution, has already begun within one kilometer of the beetles' main populations. Potential impacts from attraction to light by tiger beetles could include disruption of nocturnal oviposition behavior and increased mortality. For species with critical nocturnal behaviors and limited populations, our results indicate light pollution could significantly contribute to population decline.

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BIODIVERSITY OF FRESHWATER MACROINVERTEBRATES ON SMALL CARIBBEAN ISLANDS

Very little is known about the freshwater macroinvertebrates of the Lesser Antilles and other small Caribbean islands. An ongoing survey of macroinvertebrates inhabiting freshwater habitats on several small Caribbean islands was initiated in 1991. Islands studied in this investigation include Barbados, Tobago, Grenada, St. Lucia, Dominica, Montserrat, Nevis, St.

Kitts, Saba, Antigua, Cayman Brac, Little Cayman, Grand Cayman, and Guanaja. Qualitative collections were made by sweeping a dip net through the water column and by hand examination of the rocks, plants, and debris submerged in both flowing and standing bodies of freshwater on each island, noting microhabitat preferences for each species. Collection data published by previous investigators were also included. My collections have yielded almost 200 species thus far, many of which were previously unknown from these islands. When this species list was combined with those of other researchers, at least 327 taxa were totaled. Dominant taxa present included several species of gastropods, decapods crustaceans, ephemeropterans, odonates, hemipterans, and coleopterans. Many of these taxa had fairly widespread distributions across the islands. Observations indicated that most stream species were associated with leaf packs and most pond species were associated with aquatic macrophytes. Generally the macroinvertebrate fauna of these islands was sparse, most likely due to their oceanic origins, small sizes, and frequent disturbances to their freshwater environments. As the species present on these islands is determined and additional ecological studies are conducted, scientists may begin to focus efforts toward conserving freshwater macroinvertebrates and their habitats.

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ARE WIDESPREAD AMAZONIAN INSECT SPECIES ACTUALLY SPECIES COMPLEXES?

Assumptions about the host and stratum specificity of tropical insects are routinely incorporated into estimates of global species richness and used to generate estimates of extinction rates, but empirical studies seldom reliably assess tropical insect specificity. Cerambycid beetles in the genus *Palame* reproduce exclusively in trees belonging to the Brazil nut family (*Lecythidaceae*). Their host, stratum, and seasonal specificity has been investigated during a year-long rearing project in French Guiana, and the study is continuing with a project currently in progress in Peru. The three species of *Palame* reared include a remarkable amount of diversity in DNA sequence. *Palame crassimana* currently includes at least four groups that can be distinguished by both mitochondrial (COI) and nuclear (elongation factor) DNA, different patterns in host use, and subtle morphological differences. In French Guiana, *Palame mimetica* includes three groups that can be distinguished by both mitochondrial and nuclear DNA, but no discrete morphological characters have yet been found, and the two common haplotype groups can be reared from the same host branch. The third, rare *P. mimetica* haplotype

is most closely related to haplotypes from Peru. *Palame anceps*, represented by a single mitochondrial haplotype group in French Guiana, has yielded two distinctly different (7% divergent) mitochondrial haplotypes groups in Peru. There are few changes in nuclear DNA, but preliminary data suggests that individuals from the two Peruvian haplotype groups are able to interbreed. The study has important implications for conservation because, should tropical species frequently prove to be complexes of cryptic species, the presence of specialized ecological requirements will be masked by the generalized habits of the “composite” species. The interbreeding hypothesized for individuals of *Palame anceps* with divergent mitochondrial haplotypes will also have implications for the first of Cracraft’s (2002) “Seven Great Questions...”—What IS a species?

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STRESSES ON EASTERN PENNSYLVANIA SURFACE WATERS OVER 20 YEARS: CHANGES IN LOTIC AND LENTIC BENTHIC MACROINVERTEBRATE ASSEMBLAGES

Evaluations of eastern Pennsylvania lotic and lentic benthic macroinvertebrate (BMI) assemblages over 20 to 30 years were conducted to detect any significant trends. In a limestone stream sampled at the same site over 30 years, land use changes are occurring within the drainage basin. BMI changes recorded include decreases ($p < 0.05$) in BMI total numbers, wet weight (mg), taxa richness and Trichoptera numbers (especially *Psychomyia*). No significant changes in water chemistry were discernible. Over 10 years in 8 acidifying Pocono Mountain lakes, acid sensitive groups such as Ephemeroptera, Amphipoda and Mollusca decreased as total alkalinity, specific conductance and calcium also decreased. Acid sensitive groups such as Chironomidae, Isopoda and certain Trichoptera increased as lakes became more acid. However, in one acidic lake (total alkalinity = -2 to 3 mg/L CaCO_3), studies over 20 years indicated no significant changes in numbers of numerically dominant Chironomidae, wet weight or total numbers. In a lake where motorboat numbers and horsepower are rapidly increasing over 20 years, Insecta numbers and total numbers decreased while Mollusca numbers and wet weight did not change. Taxa richness decreased only at the lake outlet, not at the inlet. The only significant change in water chemistry recorded in this lake was an increase in summer specific conductance ($p < 0.01$). Such long-term changes in lotic and lentic macroinvertebrate assemblage composition suggest that various stresses (e.g. acidification, development in drainage basin, land use changes, etc.) are causing measurable changes not only in assemblage composition but also

in taxa richness and biomass. Such changes in communities/assemblages may foreshadow functional changes in these ecosystems and suggest immediate action to conserve and improve the remaining assemblages.

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THE ROLE OF TERMITES IN ENHANCING INVERTEBRATE BIODIVERSITY OF EAST AFRICAN SAVANNAS

In semi-arid landscapes within Africa, termites (order Isoptera) are one of the most conspicuous and ubiquitous modifiers of habitats. Through their foraging and mound-building activities, termites directly modify the basal components of the ecosystems they inhabit (e.g. soil structure, nutrients, vegetation), thereby exerting strong indirect effects on entire communities. Perhaps because their presence across landscapes is so conspicuous, the importance of termites to the structure and function of African savanna communities is almost cliché. In spite of this, few hard data exist on the magnitude of and mechanisms for the community-wide effects of termites in these unique and threatened ecosystems. We assessed the importance of *Odontotermes* sp., a lenticular mound-building termite, to the diversity of the invertebrate community in the black cotton soils of the Laikipia district of central Kenya. Using sweep sampling and pitfall trapping, we found significantly higher densities of invertebrates on mounds versus off mounds. Because vertebrate herbivores preferentially feed on plants growing on *Odontotermes* mounds and they, in turn, enrich the soil, we tested the relative importance of vertebrate-induced soil enrichment versus termite-induced soil enrichment on invertebrate diversity. Removal of vertebrate herbivores did not significantly decrease the abundance or diversity of invertebrates on mounds. In addition to their impacts on ground-dwelling invertebrates, termites have significant impacts on acacia-inhabiting ants. Thus, termites are a key component of semi-arid grasslands and their activities promote and support invertebrate biodiversity of these communities. The impacts of management practices, such as rangeland stocking densities of cattle and invertebrate pest control, on the health and long-term persistence of termite colonies needs to be addressed.

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**CONSERVING BACKYARD BIODIVERSITY:
EFFECTS OF HABITAT STRUCTURE, PATCHINESS
AND HETEROGENEITY ON ARTHROPODS IN
LAWNS AND GARDENS**

The effects of urbanization on biodiversity are poorly understood, especially for terrestrial arthropods. Lawns and gardens represent habitats common in all urban ecosystems and provide a focal point for exploring the conservation of arthropods in urban landscapes. The objective of our research is to understand the effects of urban landscape design and management on arthropod communities. We are testing the hypotheses that arthropod communities differ 1) among various habitats based on differences in physical structure and 2) within landscapes that differ in levels of habitat patchiness and heterogeneity. In a field experiment, we created four urban habitats (mown and unmown vegetation, shredded bark and gravel mulches) in homogeneous or heterogeneous plots and sampled ground-dwelling and soil arthropods from them in 2003. Environmental conditions (i.e. temperature, moisture, resource availability) differed significantly among the habitats and likely influenced arthropod abundances. Arthropod abundances differed among the habitats, with spiders and collembolans more abundant in bark mulch and unmowed habitats. Habitat patchiness and heterogeneity also affected arthropod communities. Collembolan, spider, hemipteran and ant numbers generally, but not always, increased as the diversity of habitat structures increased within a lawn-dominated landscape. Therefore, non-lawn habitats provide potential refugia for arthropods that are negatively affected by lawn mowing. We conclude that increasing the amount of unmowed and other non-lawn habitats within urban landscapes will contribute to the conservation of beneficial arthropods, including predators that consume turfgrass pests. This information is useful to landscape designers and managers who seek to conserve urban biodiversity as part of integrated pest management practices. These results also have policy implications because local governments often have lawn management laws that impact urban biodiversity. As urbanization continues, more research will be needed on the effects of landscape management on biodiversity for the successful conservation of arthropods in urban ecosystems.

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**BACTERIAL INFECTION AND A-BIOTIC STRESS
AS LINKS TO A SPONGE DISEASE AFFECTING
IANTHELLA BASTA IN NEW BRITAIN, PAPUA
NEW GUINEA**

Ianthella basta marine sponges in Kimbe Bay, located in West New Britain, Papua New Guinea, showed signs of being affected by a disease-like syndrome and exhibited progressively worse mortality in studies performed in 1996, 1998 and 2000. These fan-shaped sponges were mottled with brown lesions, rotted tissue, and large holes. The holes and rotted tissue were surrounded by brown mucus that was smothering the ostia openings, as evidenced by light microscopy analysis. *I. basta* showed high mortality at three sites nearest to shore of West New Britain (within 16-20 km), but no mortality was observed at three other sites located further from shore (within 27 to 41 km), nor at 10 sites located more than 41 km from shore. These data suggest a terrestrial source of stress. The study sites located closest to shore were closest to a river that empties into Kimbe Bay (PNG) after running through land that is being increasingly deforested and developed for oil palm plantations. The river transports sediments and fertilizer to the inshore reef area. Comparison of the carbon source utilization patterns of bacteria inhabiting healthy and diseased individuals revealed the presence of three groups of bacteria specific to diseased *I. basta*. These bacteria were not present in healthy sponge samples. Bacteria isolated from affected sponges and inoculated onto healthy sponges caused disease signs similar to field specimens. The 16S rRNA genes from these bacteria were sequenced and found to correspond with the genus *Bacillus* and *Pseudomonas*. Field observations suggest that a-biotic stresses are involved in the virulence of this sponge pathology.

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DIET FOR AN ENDANGERED INSECT: WHAT DOES THE ZAYANTE BAND-WINGED GRASSHOPPER EAT?

One of the greatest challenges to protecting and restoring habitat for endangered invertebrates is insufficient basic life history and ecological information. Collecting such data for rare species is especially challenging because most host plant identification protocols involve destructive sampling, such as gut content analysis, that are inappropriate for endangered species. This study used a combination of frass analysis, field observations, and habitat use correlations to infer host plant use and preference for adult Zayante band-winged grasshopper (*ZBWG*) *Trimerotropis infantilis* (Orthoptera: Acrididae) in Santa Cruz County, California. Of 128 frass samples collected, host plant identity could be clearly determined through microscopic analysis in 103 samples. The majority of host plants found in the frass were *Lupinus albifrons* (Fabaceae) and *Heterotheca sessiliflora* (Asteraceae), with occasional evidence of the use of species in Poaceae. Results from frass analysis corresponded with data obtained through 33 hours of field observation. Habitat choice by *T. infantilis* did not correlate well with host plant choice, however. This result suggests that factors other than food source in the plant community, such as cover from predation or support of courtship and mating, may be important to *ZBWG* life history and fitness.

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APPLICATION OF THE NATURESERVE EXPLORER (NSE) DATA SET TO NORTH AMERICAN INVERTEBRATE CONSERVATION

NatureServe (<http://www.natureserve.org/>), a non-profit conservation organization, and its network of Natural Heritage programs work to provide the scientific information and tools needed to help guide effective conservation action. NatureServe Explorer (<http://www.natureserve.org/explorer>) is an acclaimed website providing authoritative conservation information in a searchable database for more than 50,000 plants, animals, and ecological communities in every state and province of the United States and Canada. The NatureServe database currently houses data for some 14,400 invertebrate taxa, including 649 arachnids, 86 large branchiopods, 372 crayfish, 239 tiger beetles, 608 mayflies, 1438 butterflies and skippers, 1966 moths, 499 dragonflies and dam-

selfies, 668 grasshoppers, 630 stoneflies, 1094 caddisflies, 392 freshwater bivalves, 808 freshwater gastropods, and 2024 terrestrial gastropods. Information is maintained on classification, NatureServe conservation status (from critically imperiled "G1" to demonstrably secure "G5", as well as extinct "GX" or possibly extinct "GH"), IUCN Red List status, national status (U.S. Endangered Species Act, COSEWIC, NatureServe national ranks), and distribution (searchable down to sub-national level). All records are searchable on the NatureServe Explorer (NSE) website at the subnational, national, and global distribution levels. NSE represents a "snapshot" of dynamic data that is continually being refined through the input of hundreds of Natural Heritage scientists and collaborators. NSE is updated from central databases three times each year to reflect new data from field surveys, the latest taxonomic treatments, and updated conservation status assessments. Working enhancements to NSE include the addition of more detailed information on habitat requirements and ecology, guidelines for assessing relative viability of populations, interactive maps, and images (freely downloadable for noncommercial use).

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OVERVIEW OF THE FRESHWATER MUSSEL (BIVALVIA: UNIONOIDA) FAUNA OF NEW ENGLAND

Freshwater mussels (families Margaritiferidae and Unionidae) have attained their greatest diversity in North America with more than 300 of 1000 taxa worldwide. New England states are not particularly rich in freshwater mussel diversity, with 20 total species for all six states combined. No up-to-date comprehensive regional field guide exists for Rhode Island and New Hampshire, although guides to neighboring states have recently been produced or are in preparation. There currently exists a global crisis of freshwater mussel decline with 68% of North American species at risk of extinction. Threats include predation (limited), pollution, habitat degradation (channelization and impoundment), and introduced aquatic species. New England states incorporate mussel assemblages from the Atlantic slope (the area between Nova Scotia and Georgia) and the eastern Great Lakes via Lake Champlain in Vermont. Of the New England states, Rhode Island and Maine have the fewest species at ten, compared to 12 each in Connecticut, Massachusetts, and New Hampshire, and 17 in Vermont. Nearly all species are in some state of decline and local extirpations have occurred for some species in some states. Only *Alasmidonta heterodon*, the dwarf wedgemussel, is listed as federally endangered, although several species are listed as state endangered or threatened. Global and state rarity ranks (Natural Heritage Program methodology) will be presented for each species by state and state conservation efforts briefly outlined.

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PRESERVING INSECT DIVERSITY AT THE AMBROSE MONELL CRYO COLLECTION (AMCC) AT THE AMERICAN MUSEUM OF NATURAL HISTORY (AMNH)

In a time of massive species loss, natural history museums should lead the way in providing digital access to biodiversity information, especially for biomaterial collections used in modern genetic, genomic and taxonomic studies. The American Museum of Natural History (AMNH) established the Ambrose Monell Cryo Collection (AMCC) to help meet the demand for properly documented frozen tissue specimens required for scientific research. The rapidly growing AMCC collection houses over 18,000 specimens. Arthropods comprise more than 10% of the collection. Over 1000 specimens of Drosophilidae make this one of the largest repositories of fruit flies in the world. The AMCC continues to acquire and bank biomaterials, while actively developing and improving protocols for long-term storage of biomolecules. The collection maintains an online database (see: www.research.amnh.org/amcc/) that runs on the MySQL relational database management system. The database is integrated with the National Center for Biotechnology Information. This allows for AMCC records with nucleotide sequence accession numbers to link out to corresponding pages on the NCBI Genbank and Taxonomy sites. Conversely, records of genetic sequences on the GenBank website that are housed at the AMCC are linked to that specimen's details on the AMCC website. The AMCC database also links specimen records to digital images (e-vouchers), making for a complete connection between sequence data and the visual identity of the specimen examined. Consequently, specimen records in the collection may be located by barcode number, NCBI taxonomy number, GenBank sequence number, or taxon name, or browsed by taxonomic hierarchy. Tissue specimen collection records will ultimately be linked to bibliographic citations, alternate taxonomic determinations, and geospatial referencing information. The AMCC represents a unique effort in biodiversity preservation that can serve as a model facility for centralized biomaterial banking.

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INVASIVE EARTHWORM CONTROL METHODS TO PROMOTE THE RESTORATION OF A FOREST ECOSYSTEM

As part of extensive native forest restoration efforts at the Schuylkill Center for Environmental Education, Philadelphia, PA, a range of organic treatments to control exotic, invasive earthworms were tested. Amynthes spp. pose a threat to the forest ecosystem by increasing the soil pH and by removing the leaf litter layer. This results in erosion and compaction, thereby preventing native seedlings from establishing root systems and promoting the spread of invasive plant species. A pilot study of 26 treatments was established in 2002 to test a variety of control methods. In 2003, the most effective of these treatments were selected for a larger randomized complete block experiment with five blocks of six treatments. The treatments included a control, 180g pelletized sulfur/m², oak leaves and white pine needles at a depth of 10-15 cm, 18 whole black walnuts/m², and whole tobacco leaves and ground tobacco stems. The effects of Amynthes spp. were apparent upon the collection of baseline data. Average soil pH was 6.4, compaction was high, infiltration low, and average soil moisture was 60%. Chemical soil properties, worm population, plant biodiversity, leaf litter biomass, and Plethodon cinereus populations were also measured before and after the treatments were applied. Preliminary data of treatment effects will be discussed. It is important to find a management method for the control of invasive, exotic earthworms to aid in the restoration of forest ecosystems.

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THE EFFECT OF INVASIVE ARGENTINE ANTS ON THE HERBIVOROUS ARTHROPOD COMMUNITY OF DUBAUTIA MENZIESII IN HALEAKALA NATIONAL PARK, MAUI

Biological invasions pose threats to native flora and fauna in ecosystems worldwide, and can be particularly devastating to the specialized ecosystems of oceanic islands. The Argentine ant

(*Linepithema humile*) has been established in the high-elevation shrubland of Haleakala National Park, Maui HI, since at least 1967, and has been proven to significantly impact the endemic arthropod community. An ant-exclusion experiment, surveys of herbivorous insects on the endemic tarweed shrub *Dubautia menziesii*, surveys of local ant density, and behavioral experiments involving *L. humile* and representative herbivorous insects were conducted to determine effects of *L. humile* on the makeup of the local herbivorous insect community. Results indicate that ants determine the species composition of the herbivore community on *D. menziesii*, according to the level of aggression shown by the ants towards the insects during the behavioral experiments. The normally abundant native herbivorous species *Orthotylus iolani* (Heteroptera: Miridae) was completely absent within the ants' range, and was vigorously attacked by the ants during the behavioral experiment. Additionally, large populations of at least two species of possibly invasive and plant-damaging scale insects that are tended by the ants as trophobionts were found almost exclusively within the ants' range and not outside their range, and were shown no aggression during the behavior experiment. The exclusion experiment was only partially successful, with no significant changes evident in the insect communities as a result of short-term ant exclusion from *D. menziesii*. These results indicate that *L. humile* seems to contribute to significant changes in the Haleakala arthropod fauna and may pose a threat to endemic plants such as *D. menziesii* and the closely related and endangered Hawaiian silversword (*Argyroxiphium sandwicense* subsp. *macrocephalum*) by facilitating substantial populations of invasive herbivorous insects.

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FREEZING INSECTS: THE EFFECTS OF CRYOPRESERVATION PROTOCOLS ON NUCLEIC ACID DEGRADATION

Cryopreservation is a practical strategy for conserving and managing invertebrate diversity. Degraded nucleic acids present the single greatest obstacle to successful molecular research programs. Since storage at cryogenic temperatures essentially stops biological degradation, it is likely that long-term cryopreservation will be a suitable method for storing tissues for current scientific applications and for future genomic studies. Although some damage may occur, for most genetic techniques cryopreservation is a valid option for long-term tissue storage. Other commonly used tissue preservation methods, such as storage in ethanol, are increasingly revealed to be inadequate, even for present applications. A study undertaken by the Ambrose Monell Collection for Molecular and

Microbial Research compared the quality of DNA isolates from *Drosophila melanogaster* frozen under various conditions. Samples were frozen with 6 cryoprotectants in combination with 4 freeze/thaw strategies. The Comet Assay was used to visualize the extent of DNA fragmentation, in which spot applications of insect DNA are subjected to gel electrophoresis and a comet-like pattern of fragment migration is observed. The longer the tail, the greater the DNA damage. Results showed that DMSO, glycerol, and ethylene glycol were better than ethanol in protecting DNA from freeze/thaw damage. The slow freeze/slow thaw method caused the least amount of DNA damage with all cryoprotectants. Slow freezing with no cryoprotectant was found to be the best method for preserving DNA. The study was expanded to include a comparison of the effects of various combinations of temperatures and storage media on the preservation of DNA in beetles, which resist permeation by cryoprotectants. Samples were stored in buffer or ethanol, dry, or pretreated with a commercial preservative, RNAlater (Qiagen, Inc.), and frozen at -20°C and -160°C . DNA extractions were subjected to gel electrophoresis, and DNA was qualified and quantified. This study demonstrates the critical nature of specimen storage for biomolecule preservation.

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AN ENDEMIC MUTUALISM BETWEEN SENITA CACTI AND SENITA MOTHS IN THE SONORAN DESERT

Although often less appreciated than other fauna in national parks, insects play fundamental roles in the ecological and evolutionary processes occurring in nature. One key influence of insects is in the pollination and reproductive biology of many species of plants. Here, we describe the basic ecology of a recently discovered obligate pollination seed-consumption mutualism between senita cacti (*Lophocereus schottii*) and senita moths (*Upiga virescens*), both of which are geographically restricted to the Sonoran Desert of North America. Within the United States, these species are found only in Arizona within Organ Pipe Cactus National Monument. We compare the roles of senita moths and co-pollinating bees in the reproduction of senita cacti. Although co-pollinating bees can occasionally make small contributions to the pollination and reproduction of senita cacti, they are largely functionally redundant with senita moths. The unique behavioral and morphological adaptations of actively pollinating senita moths makes them highly effective pollinators on which senita cacti rely. If senita moths were removed from the system, then senita cactus populations would likely decline, possibly to extinction.

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SPECIMEN DATA FROM TAXONOMIC REVISIONS CONFIRM THE AFRICAN HOTSPOTS FOR ROBBER FLIES

Biodiversity research is an important area of inquiry in the modern biological sciences, because we still do not know how many species exist on our planet and where they primarily occur. Twenty-five biodiversity hotspots were defined, based on endemism of vascular plants and the degree of threat to the original vegetation, to conserve highly diverse habitats. However, it remains unclear whether these areas are also rich in endemics for other taxa. In order to test the biodiversity hotspots for invertebrates, we explored the use of specimen data from taxonomic revisions. The Afrotropical robber-fly (Insecta: Diptera: Asilidae) fauna was analysed because there are many modern taxonomic revisions of the African genera, the treatments include detailed specimen data (i.e. locality and/or collecting date), and there are a number of biodiversity hotspots found in continental Africa and adjacent islands. Species endemism of Asilidae in two biodiversity hotspots lying in western South Africa, i.e. the Cape Floristic Province and Succulent Karoo, were evaluated. It is shown that there are more species and endemics of robber flies in the two biodiversity hotspots in western South Africa than in two imaginary hotspots in eastern South Africa that are equal in size to the combined area of the two biodiversity hotspots. This finding is not the result of a sampling bias towards the arid regions in western South Africa because extensive collecting of Diptera, including robber flies, also took place in eastern South Africa (collections by researchers of the Natal Museum, Pietermaritzburg). Using this example of a non-phytophagous insect taxon that is relatively well-studied in southern Africa, we can test the biodiversity hotspots and have to conclude that the extremely diverse plant-based biodiversity hotspots do indeed also accommodate a richer and more diverse robber-fly fauna than similar areas in eastern South Africa.

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MANAGEMENT PLAN FOR CONSERVATION OF MALONE'S JUMPING-SLUG, (*HEMPHILLIA MALONEI*) ON FEDERAL LANDS IN WASHINGTON STATE

Under the Northwest Forest Plan, conservation plans were developed for several species of mollusks within the Survey and Manage program. Management recommendations for Malone's jumping-slug, a rare endemic species of Arionid slug, are intended to provide a reasonable assurance of species persistence on federal lands. Persistence is achieved by providing habitat of sufficient quality, distribution, and abundance to allow the species populations to stabilize on federal lands. Small gaps in distribution may continue to limit population interaction somewhat, but without causing isolation or extinction of local populations, loss of genetic or ecological diversity, or loss of ecological function. This plan builds on the protection afforded by the existing reserve system established by the Northwest Forest Plan, and uses additional acreage around selected high priority sites to augment that protection where needed at a sixth-field watershed scale to provide a reasonable assurance of persistence. This plan allows for up to 30% of the currently suitable habitat in each watershed to be harvested at any given time, while maintaining the necessary distribution of habitat for persistence of the species in reserves and in high-priority sites across its range. High-priority sites are selected from the available known sites based on habitat quality, location, and site stability. These management recommendations evaluate the need for high priority sites in each sixth-field watershed. High-priority sites are areas of at least 25 acres and are designed to provide habitat to support a functional population of the species. Although 40% of each high-priority site will be maintained undisturbed around site locations, management activities which result in some habitat alteration are allowed in the remainder of the high priority site area to provide foraging and dispersal habitat for the species.

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**THE IMPACT OF LANDSCAPE USE CHANGE IN
NAPA AND SONOMA COUNTY OAK WOODLAND
ON BUMBLEBEES (HYMENOPTERA: APIDAE)**

Oak woodlands in northern California are becoming increasingly fragmented due to heightened urban and agricultural development. Much of the change in land use in Napa and Sonoma Counties has been from oak woodland to vineyards. Since bees do not utilize grape flowers, a change in land use to vineyards could potentially impact the local bee fauna. We look at, in this study, how *Bombus* (Apidae) abundance, species richness and host plant use are affected by the change in oak woodland landscape to vineyards. Adaptations such as larger body size, the ability to thermoregulate, and generalist foraging behavior may reduce the impact of this landscape change on bumblebees. This experiment is a paired design in which oak woodland sites with a high percentage (> 50%) of surrounding area converted to vineyard (the treatment) are paired with sites having a low percentage (< 10%) of vineyardization (the control). Three pairs of sites were chosen each in Napa and Sonoma Counties. Collections were made at each site twice per month between March and September in 2002 and between April and September 2003. Bumblebees were collected using nets and pan traps. To determine type of host plant used (native or exotic), after each bumblebee was netted, identified and released, the flower it was captured on was also identified and recorded. To determine if there is a significant difference in bumblebee abundance and bumblebee species richness between paired sites, I performed t-tests. To determine if there is any difference in host plant use- if bumblebees use native and non-native plants equally- I performed a univariate ANOVA, with host plant and %vineyard as fixed effects. I found no significant difference ($p > 0.05$) between pairs of sites for bumblebee abundance and species richness. There was also no significance for host plant use effect, vineyardization effect or interactive (host plant x vineyardization) effect.

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**PRELIMINARY PROPOSAL OF HYMENOPTERA
(INSECTA) AS A NEW GROUP FOR CONSERVA-
TION BIOLOGY IN CUBA**

Insects are major components of biodiversity, but still are underestimated and overlooked in Conservation Biology. Hymenoptera (wasps, ants and bees) is the second largest insect order, with a lot of useful services to mankind (e.g. pollination, pest control, natural products) as well as in ecosystem functioning. This paper reviews present knowledge about Cuban hymenopterans, analyzing updated nationwide data, as well as gaps in the current status of taxonomic, biological and ecological information. All these sources were matched and some groups/species with potential in conservation programs (as rare, endangered, charismatic, and/or key species) were chosen as a new way to deal with conservation efforts in the island. The following taxa are proposed: Formicidae, Ichneumonidae, Scoliidae, Vespidae, Pompilidae, Mutillidae, Spheciformes and Apiformes. Within these groups some genera/species are presented and ranked according to four different criterions. Brief details about each alternative are presented, and topics to be addressed in future researches are also discussed. This could be a pioneer approach in Cuba because only flowering plants, vertebrates, mollusks and butterflies have previously been used as indicator species.

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**POPULATION MONITORING OF THE EASTERN
REGAL FRITILLARY (*SPEYERIA IDALIA IDALIA*
DRURY) AND RESTORATION EFFORTS AT FORT
INDIANTOWN GAP, ANNVILLE, PENNSYLVANIA**

The eastern regal fritillary butterfly (*Speyeria idalia idalia*) historically ranged from Nova Scotia south to Northern Georgia and west to the Dakotas. Over the past two decades, local extirpation of eastern populations has left only two known populations east of Indiana. One of these populations, in south-central Pennsylvania, is located at the Fort Indiantown Gap

National Guard Training Center (FTIG), Annville, PA. Recent genetic work suggests that these remnant eastern populations represent a subspecies, *S. idalia idalia*, distinct from remaining western populations. Since 1994, The Nature Conservancy, in partnership with the military, has conducted ongoing population studies of the FTIG *S. i. idalia* population. In addition, restoration efforts have focused on defining and maintaining grassland habitats necessary to the survival of this butterfly, as well as identifying critical life history characteristics that might aid in conservation and future reintroduction efforts. Five sites are currently monitored for butterflies, four of which are protected. Of the three sites monitored over six years, none have shown significant changes in population size. Through this partnership, research and restoration efforts are attempting to define and maintain a complex mosaic grassland habitat that includes patches of recent disturbance necessary for larval food plant (*Viola* sp.) establishment, grasslands with nectar plants and mature warm season grasses within which larvae may hide and where pupation likely occurs, as well as scattered shrubby plants within which adults rest. Our monitoring results indicate that restoration efforts help maintain populations of butterflies in sites where they are established, perhaps at the carrying capacity of habitat patches. Detailed examination of data indicates that unused habitat patches within our sites can be returned to usable habitat. Future efforts will more accurately define suitable habitat and thus increase our abilities to expand the range of this butterfly within its former geographic range.

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INSECT DIVERSITY IN SONORA, MEXICO

This study explores the relationship between summer rains and insect, especially beetle, biodiversity in five different habitats in northern Sonora, Mexico. Unprecedented rates of land use change and development in this region are converting rich plant communities into monocrops or heavily grazed expanses. These changes undoubtedly affect the unique subtropical desert ecosystem of the Sonoran Desert, whose flora and fauna are largely undocumented. Through increased understanding of the biodiversity and conditions affecting it in this area, we can better

succeed in wise ecosystem management and preservation of important biological processes. Insects are essential to ecosystem functioning, and their richness and diversity make them excellent gauges of biodiversity in general. With this in mind, the Center for Insect Science at the University of Arizona has established a four-credit college course for both Mexican and U.S. students who wish to participate in a long-term insect biodiversity research project in Guaymas, Mexico, a region typical of newly developed areas in the Sonoran Desert. The research, now in its third year, employs five quantitative techniques for collecting insects in five habitat types (including undisturbed native habitats and habitats disturbed by cattle grazing and human habitation) in both pre-monsoon and post-monsoon seasons. Conventional wisdom among Sonoran Desert entomologists suggests that diversity increases after the onset of summer monsoon rains. Some, but not all, of the data are in line with these expectations. With added years of research we hope to develop a thorough understanding of how land use affects seasonal patterns of insect biodiversity in the Sonoran Desert. Ideally, this research will be applied to the conservation of this unique ecosystem.

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MONITORING RECOVERY FOR THE ENDANGERED KARNER BLUE BUTTERFLY (*LYCAEIDES MELISSA SAMUELIS*) IN NEW YORK STATE

The federal recovery plan (FRP) for the endangered Karner blue butterfly (Kbb) identifies minimum viability criteria for the recovery of viable metapopulations of the species in 14 recovery units within the species' historical range. The New York State recovery unit currently represents the best chance for the species on the eastern edge of its range. A system for measuring the current status of remnant metapopulations and evaluating recovery effort success in this recovery unit is lacking. We used The Nature Conservancy's Measures of Success Framework (Parrish et al. 2003) and anchored it to the FRP minimum viability criteria to establish multiple, definable indicators of the species and its habitat. A monitoring protocol has been developed for testing in the summer of 2004. Since successful recovery will depend on the restoration of hundreds of acres of suitable habitat, such metrics are critical to gauging recovery success. The incorporation of this new framework into New York State Kbb Recovery planning has advanced the adoptability of this concept throughout New York State, and is likely applicable across the entire global range of the species. We propose that the Measures of Success framework may provide a valuable tool for enhancing other Federally listed species recovery planning goals in order to more effectively track short-term progress and the long-term success of recovery efforts.

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CONSERVATION AND RESTORATION OF QUEEN CONCH (*STROMBUS GIGAS L.*) IN THE FLORIDA KEYS: INTEGRATING SCIENCE, MANAGEMENT, AND COMMUNITY

The queen conch population in the Florida Keys has been slow to recover from overexploitation despite a ban on harvest implemented in 1985. The moratorium was enacted at the behest of the public, concerned about the declining numbers of conch. In 1990, we began assessing proactive restoration strategies with the ultimate goal of reopening a limited recreational fishery. After evaluating releases of hatchery juveniles, we have adopted a community-based strategy combining translocations, metapopulation theory, and marine fishery reserves (MFRs). This approach is based upon research that demonstrated that non-reproductive conch inhabiting nearshore areas began reproducing when translocated offshore into spawning aggregations; conch found nearshore cannot migrate to breeding aggregations offshore. In addition, static and dynamic interaction studies have shown that translocated conch do not displace native offshore conch. To maximize the contribution these conch make to the recovery of the population, it is critical to translocate them to areas where the larvae have a high probability of being retained within the Keys. Therefore, we will examine the fate of larvae within the Keys by conducting a drift vial study and combine these results with plankton tows, satellite imagery, and hydrological data. If a fishery should reopen, effective MFRs will be essential to the sustainability of the population. Therefore, we used acoustic telemetry to elucidate important life-history parameters, including home range and habitat preferences, in order to design appropriately placed and sized MFRs. All past and current research uses an extensive base of community volunteers. Taken together, an approach that combines translocations with metapopulation theory and is implemented with the assistance of local volunteers appears to be an effective strategy for restoring Florida's queen conch population.

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NATURAL VS. MAN-MADE EPHEMERAL POOLS: PRELIMINARY ANALYSIS OF USE BY TWO CONGENERIC PAIRS OF FAIRY SHRIMP ON THE COLORADO PLATEAU (AND A LITTLE BEYOND)

Ephemeral pool habitat on the Colorado Plateau consists of two types: natural and man-made. Natural pools may be pools in exposed sandstone (potholes) or pools in closed basins (swale pools). Man-made habitat may consist of floodwater catch basins constructed by damming small drainages, small ruts along roads, or meander bends cut-off by road alignment. On the Colorado Plateau, these ephemeral aquatic habitats contain a number of branchiopod crustaceans, including at least five species (three genera) of fairy shrimp. Haphazard surveys across southern Utah indicated similar patterns of habitat segregation in two genera. *Streptocephalus dorotheae* was found only in constructed stock ponds and catch basins; *S. texanus* has been found only in potholes. *Branchinecta packardi* has also been found only in potholes in southeastern Utah, while *B. lindahli* occurs primarily in constructed pools in southeastern Utah, but has been found in both man-made and natural habitats in southwestern Utah. Stochastic events, or differences in dispersal abilities, life history characteristics, susceptibility to predation, or water chemistry affinities may explain the distribution patterns. Conservation implications of these patterns are not clear; *B. lindahli* and *S. dorotheae* may be excluding *B. packardi* and *S. texanus*, thereby limiting range expansion, but all these species have ranges extending beyond the Colorado Plateau. Man-made pools, especially catchments, are usually much larger than most rock pools, and last longer, allowing predaceous aquatic insects with longer life histories to occupy these pools and build up large populations. These insects can completely eliminate all branchiopods present during a wet cycle in these basins, affecting contribution to future generations in the pool. Insect populations in large pools can disperse to smaller pools that are too far from permanent water to be colonized directly by aquatic insects. Branchiopods in relatively isolated natural pools would then be eliminated as well.

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**SPATIAL AND TEMPORAL VARIATION OF
RIPARIAN INVERTEBRATE COMMUNITIES OF
SALT CREEK CAÑON, CANYONLANDS
NATIONAL PARK: INFLUENCE OF DROUGHT
AND VEHICLES**

Invertebrates represent all trophic levels above primary producers, performing many ecosystem functions, and thus provide a large pool from which to draw potential indicator taxa to monitor ecosystem condition. However, before they can be used as indicators, we must know which taxa are present, how they function in particular ecosystems, and how they respond to natural and anthropogenic disturbances. In July 1998, part of the road in Salt Creek cañon was closed, providing an opportunity to document riparian ecosystem response to elimination of vehicle perturbations. Since the closure, southeastern Utah has received significantly less precipitation than normal, overlaying the natural stress of drought on potential recovery from anthropogenic disturbance. Over 30,000 invertebrates have been collected to date; about 6000 samples have been sorted to order, with ants and beetles identified to genus or family/subfamily, respectively. Differences in the invertebrate communities are evident at the order level between cañon segments (open road, closed road and no road), and between months and years. Open road and closed road communities are more similar, and show similar fluctuation patterns, while the no road site communities had different proportions of each order, and fluctuations in abundance differed from open road and closed road patterns. Spatial and temporal dynamics are discussed in relation to road closure, drought and the value of invertebrates in assessing and monitoring ecosystem condition.

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**BEE FORAGING RANGES AND THEIR
RELATIONSHIP TO BODY SIZE**

Bees are the world's most important pollinators; however, little is known about how far foraging bees can and do move. This information is critical for understanding the scale at which bee populations respond to the landscape, for understanding the role of bee pollinators in affecting plant population structure, for planning conservation strategies for rare plants, and for designing

refugia that help to maintain pollination function for both natural communities and agricultural crops. Here, we review what is known about bee foraging distances, critique the measurement methods used, and summarize movement data for 48 bee species. Our analysis reveals a strong positive relationship between maximum movement distance and body size. Documenting this relationship provides a powerful tool for predicting bee foraging range, using a simple measure of intertegular span. We review and discuss environmental factors that may cause typical foraging distances to deviate from this maximum potential movement distance and compare scaling relationships in this insect group with that of vertebrates.

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**BEE COMMUNITY COMPOSITION CHANGE
OVER A 35-YEAR PERIOD**

*In 1968/69, an extensive bee survey was conducted in an old-field habitat at the Forks of the Credit River, Ontario. Bees were re-sampled at the exact site after 35 years, following the same methods employed in the original study, to examine bee community composition changes. Bee species diversity was significantly greater in 2002 ($H' = 3.2$), when compared to 1968/69 ($H' = 2.0$) ($p < 0.001$). A total of 33 species and 6 genera, from '68/'69, were absent in the '02 study. This was accompanied by the presence of 26 species and 2 genera found in '02 but not in the original study. One species, *D. imitatus* (Smith), which constituted over 50% of abundance ($N = 5673$) in the '68/'69 dataset, was rarely collected from the site in 2002, thus increasing the evenness of species distribution in '02 and making diversity higher. These changes brought about significant differences in community composition over the 35-year period, evident from differences in similarity indices (5 % similarity), and de-trended correspondence analysis (DCA) between the two time periods.*

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**UNITE AND CONSERVE: BFCI MEMBERS AND
PARTNERS TEAM UP FOR KARNER BLUE BUT-
TERFLY RECOVERY**

In 2002, the Butterfly Conservation Initiative (BFCI) hosted the Karner Blue Butterfly (KBB) Recovery Implementation Workshop, bringing together key players in KBB recovery to discuss implementing priority actions identified in the species' fed-

eral recovery plan. Since then, KBB partnerships have flourished and connections made have led to the establishment of networks supporting other butterflies as well. The Toledo Zoo continues its active KBB habitat restoration, population monitoring, scientific research, and captive rearing programs, but has also teamed up with BFCI, the Wilds, and four other zoos in Ohio to create large-scale butterfly habitat, promote population monitoring, and increase butterfly education programming at zoos. A Michigan KBB working group, comprised of representatives from zoos, the MI Department of Natural Resources and the US Forest Service, formed to develop an education strategy for Michigan, a step missing from past KBB efforts in MI. Host plant propagation efforts brought together the Roger Williams Park Zoo (RWPZ) in Rhode Island, the New Hampshire Fish and Game Department, the National Wildlife Federation and schools in both NH and RI. Kids raise KBB host plants in Rhode Island and transplant them, with the Fish and Game Department's help, to New Hampshire. The Karner Kids program at the Seneca Park Zoo in New York connects the zoo to state agencies and the Nature Conservancy, and includes habitat creation and outreach at the airport in Rochester. BFCI members' efforts have not stopped with the Karner blue. BFCI members in the Pacific Northwest, excited by the outcomes of the KBB meeting, hosted their own Northwest Butterfly Conservation and Recovery Workshop in December 2003 and a meeting in March 2004 will establish a butterfly recovery and conservation network in California. All of these efforts stemmed from a single event, demonstrating the power of partnerships as a tool for protecting imperiled invertebrates.

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MASS REARING OF ENDANGERED TIGER BEETLES (COLEOPTERA: CARABIDAE)

Our research focuses on mass rearing of tiger beetles for reintroduction. Cicindelids occur worldwide and many species are of conservation concern. Here in the U.S. two species are already listed as federally threatened and many are considered state endangered. Given the similar life histories and reproductive biology of this taxon we are developing protocols and a configuration of rearing chambers suitable for producing large numbers of individuals (1,000+). Such a system may likely accommodate all species of tiger beetles and our primary focus is to apply it to those species already endangered. These protocols can be readily followed by non-specialists, with minimal amount of equipment and floor space and are well suited as a stand alone target project

for NGOs or as an element in a more comprehensive restoration plan for a given habitat. Captive rearing efforts that focus on vertebrates are inherently limited by the low birth rates and extensive husbandry requirements typical of such organisms. Reintroducing large numbers of an invertebrate species or taxon is a pioneering approach for conservation biologists to approach restoration of population structure and evolutionary potential on a landscape scale.

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IMPLICATIONS OF FIRELANE EXPANSION FOR HEMILEUCA MAIA ON MANUEL F. CORRELLUS STATE FOREST, MARTHA'S VINEYARD, MASSACHUSETTS

To mitigate the threat of fire moving from the Manuel F. Correllus State Forest onto adjacent private properties on Martha's Vineyard, the Massachusetts Department of Recreation and Conservation has proposed widening existing firebreaks from an average of 30 m to 60 m or more. However, the State Forest is dominated by the globally rare sandplain ecosystem, and is home to 22 insect species considered to be rare in the state. Many of these species are dependent upon the plant communities found here and could be negatively impacted by traditional firebreak expansion techniques that cause a shift away from shrub-dominated systems toward grassland habitats. To examine the effects of alternative firebreak expansion techniques on the habitats of one of these rare insect species, *Hemileuca maia* (Lepidoptera: Saturniidae), experimental plots were established to examine three fuel reduction techniques in three different habitat types. Fuels were reduced in the Pitch Pine, Oak Woodland, and Scrub Oak habitat types using combinations of thinning, grinding with a brush-hog, and grazing with sheep. Habitat characteristics were measured at locations of larvae of *H. maia* for comparison with those of the treatment plots. Based on logistic regression, the preferred habitat of *H. maia* had reduced canopy closures, high scrub oak stem counts, and a dominance of *Quercus ilicifolia* in the shrub layers. None of the treatment plots fit this habitat description prior to treatment, but Scrub Oak plots that were ground with a brush-hog and then grazed had characteristics similar to those found in the preferred *H. maia* habitats. Prescribed fire will be used this spring to assess the abilities of these fuel reduction techniques to reduce fire intensity. If it is determined that grinding and grazing significantly reduce the ability of a fire to grow and move, these techniques could be used to widen existing firebreaks while maintaining and possibly creating habitat for *Hemileuca maia*.

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STATUS OF THREE PREVIOUSLY COMMON, NATIVE LADY BEETLES IN EASTERN SOUTH DAKOTA

The lady beetle fauna of the northern Great Plains has changed substantially over recent years. Populations of three previously common, native species (Coccinella novemnotata, C. transversoguttata, and Adalia bipunctata) have decreased in some habitats, while two exotic species (C. septempunctata and Harmonia axyridis) have become relatively abundant after establishing in the region in the late 1980s and late 1990s, respectively. The objective of our study was to sample a wide array of habitats for Coccinella novemnotata, C. transversoguttata, and Adalia bipunctata in order to identify viable populations and refuge habitats for these species. From 1990 to 1995 and 2000 to 2003, we sampled for lady beetles among herbaceous and ligneous plants in a variety of habitats predominantly in eastern South Dakota using visual searches, sweep nets, sticky traps, and other methods. Habitats sampled included agricultural fields, horticultural areas, relict prairie, and woods. Over 6000 coccinellids were collected. However, only 4 Coccinella transversoguttata were found, and C. novemnotata and Adalia bipunctata were absent in samples. A search of specimens in two local, insect museum collections yielded only one specimen of A. bipunctata and no C. novemnotata or C. transversoguttata that had been collected since 1990. These findings indicate that C. novemnotata, C. transversoguttata, and A. bipunctata are extremely rare or even that populations are locally extinct in eastern South Dakota. As populations of C. novemnotata, C. transversoguttata, and perhaps A. bipunctata have also declined markedly in other areas of North America, efforts should be directed at finding and monitoring extant populations, identifying ecological characteristics that influence their abundance, and devising strategies to conserve these beneficial insect predators.

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HORSESHOE CRABS, CONSERVATION, AND A METHOD FOR DETERMINING REPRODUCTIVE CONDITION

Over the past few years, the harvesting of horseshoe crabs (Limulus polyphemus) along the Atlantic coast of the United States has created controversy. This species has been harvested in Delaware since the 1870's. Horseshoe crabs were used for fertilizer until the 1960's when harvest estimates dropped from 4 million to 100,000. The current status of the resource is in question, although some researchers believe that the population is in decline. Today, horseshoe crabs are important for a variety of uses including bait for conch and eel fishermen, and Limulus Amebocyte Lysate (LAL), which is used to test for contamination of pharmaceuticals. Their eggs are also an important part of migratory shore birds' diet on the Delaware Bay. Horseshoe crabs spawn once a year during the months of May and June; the crabs come to shore, deposit their eggs in the sand and return to the water. This critical time is when the majority of shorebirds are passing through, relying on the superabundance of eggs to complete their migration to nesting grounds in the Arctic. Currently there is no method to determine whether or not a female is carrying eggs without witnessing spawning or inflicting possible injury on the female. Through weighing and measuring females, and determining the presence of eggs, we are examining a method to determine the reproductive condition. The development of this technique will facilitate identification of mature females and provide better results for stock assessment, which in turn will yield management recommendations.

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WEST VIRGINIA CRAYFISH DATABASE: A TOOL TO MONITOR THREATENED SPECIES AND PLAN SUCCESSFUL REINTRODUCTION OF THREATENED AND EXTIRPATED SPECIES

*Extraction industry pollution has reduced numerous West Virginia crayfish species, while nonindigenous crayfishes threaten these freshwater ecosystems through predation and hybridization. The West Virginia Nongame Wildlife and Natural Heritage Program has determined that seven of 21 crayfish species are rare. Two of these species are unique to West Virginia: Elk River crayfish and Greenbrier Cave crayfish. Although some crayfish species thrive in variety of water conditions, most are sensitive to poor water quality and habitat destruction. Crayfish populations in West Virginia and around the world are threatened by bait bucket introductions. Fishermen bring non-native crayfish from one watershed and release them into another. These crayfish are replacing native species by out-competing them for food and shelter. We have built the West Virginia Crayfish Database using Microsoft Access and ArcView, linking species to their historic collection locations. We are systematically collecting and identifying crayfish from locations previously surveyed by Jezerinac, Stocker and Tarter (reported in Crayfish of West Virginia in 1995, Ohio Biological Survey Bulletin NS 10(1)) in order to document changes in species abundance and distribution. We are also conducting DNA analysis of invading and native crayfish populations to determine interspecies hybridization, the origin of invading species and diversity of rare species. New crayfish surveys of WV streams are being conducted in several watersheds (including New River Gorge, Four Pole Creek, and Upper Guyandotte). GIS and Spatial Analysis have been used to identify suitable habitat for *Cambarus veteranus*, a rare crayfish in the Upper Guyandotte basin. We propose reintroduction of this extirpated species to targeted locations after aquaculture cultivation of specimens obtained from neighboring states. The West Virginia Crayfish Database is a powerful tool to assess impact of invading species on native crayfish and characterize appropriate habitat for reintroduction programs.*

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TOOLS FOR INVERTEBRATE CONSERVATION IN THE NEW YORK METROPOLITAN REGION

Except for a few well-studied taxa (e.g. butterflies, dragonflies and damselflies, freshwater mussels), invertebrate biodiversity in the New York Metropolitan region is rarely included in conservation planning. Regional park managers and others have an interest in doing more to include invertebrates in their work but face several basic challenges: 1) lack of a mandate to work on species other than those listed as endangered or threatened; 2) a lack of regionally focused tools to assist with identification, surveys, and monitoring, and; 3) a need for guidance about how to use their findings effectively. Providing regionally targeted identification tools and technical support for surveys and monitoring is therefore critical to encourage agency biologists, managers, consultants, and amateur naturalists to focus on invertebrates. Better tools and training will enable these front-line conservation workers to strengthen our knowledge of invertebrate distribution, leading to more accurate status determinations of rarity or endangerment. To address some of these challenges in the New York area, the Metropolitan Biodiversity Program of the Center for Biodiversity and Conservation at the American Museum of Natural History has developed a variety of tools for invertebrate study, including web-based identification keys, regional annotated species lists, distribution maps, status summaries, and museum-based identification workshops and internships. We also focus on field surveys in local parks and natural areas, providing information for restoration and management. These efforts are intended to strengthen the mandate of local, state, and federal biologists to focus on the the critical role of invertebrates. Future work will focus on the development and distribution of tools for a broader range of taxa and on additional resource materials about invertebrates and conservation.

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PROPAGATION AND CULTURE OF ENDANGERED
JUVENILE MUSSELS (UNIONIDAE) AT THE
FRESHWATER MOLLUSK CONSERVATION
CENTER, VIRGINIA TECH

*North America contains the greatest diversity of freshwater mussels in the world, roughly 300 species; however, this family of mollusks is the most imperiled taxon in the United States. Already, 35 species are presumed extinct and 70 species are listed as endangered or threatened. Without immediate efforts to recover federally protected species in watersheds throughout the country, the extinction of additional species is likely. Biologists at the Freshwater Mollusk Conservation Center at Virginia Tech have developed methods to produce and culture endangered juvenile mussels. The Tennessee Wildlife Resources Agency, U.S. Fish and Wildlife Service, Virginia Department of Game and Inland Fisheries, and Virginia Tech have entered into a cooperative program to fund the production, culture, and release of large numbers of endangered juvenile mussels into rivers in Tennessee and Virginia. The goal of this project is to augment natural reproduction at sites with these species and to release juvenile mussels at historic sites within rivers to expand population ranges. Between 1998 and 2003, nearly 400,000 juvenile mussels of 9 endangered mussel species were released into the Big South Fork Cumberland, Clinch, Powell and Hiwassee rivers. These rivers contain sufficient brood-stock and suitable habitat to augment and re-establish populations of rare mussels. Juvenile mussels are typically between 700-1200 mm long and 60 days old at the time of their release into the rivers. Monitoring efforts at release sites have documented variable survival of juveniles. For example, survival of released juveniles of *E. capsaeformis* in the Clinch River has been documented, and augmentation efforts in the river appear successful. In contrast, released juveniles of the same species in the Powell River have shown no signs of survival. Propagation is now a viable tool to implement recovery of federally listed mussel species.*

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ESTABLISHMENT OF THE SOUTHEASTERN
REGIONAL TAXONOMIC CENTER (SERTC) IN
CHARLESTON, SC

Despite the global imperative to prevent loss of biodiversity, a 40-year decline has occurred in the number of taxonomists, and a shortage of taxonomic resources now impairs efforts to conserve biodiversity. This shortage also impedes efforts to determine effects of human population growth in the southeastern US, since accurate identification is a critical tool for distinguishing natural distributions from those altered by anthropogenic processes. The dwindling number of scientists who can reliably identify the biota of the region also severely diminishes our capacity to recognize the presence of invasive species. In response to this taxonomic crisis, the SCDNR established the Southeastern Regional Taxonomic Center at the Marine Resources Research Institute and the Grice Marine Laboratory in Charleston, South Carolina. SERTC provides a regional focus on developing taxonomic expertise and the infrastructure to support the region's resource management and scientific communities. The SERTC staff has begun accumulating a specimen collection that will be managed using SPECIFY software, a library of taxonomic literature, and a tissue repository for use in genetic differentiation of species. Future efforts will include preparation of taxonomic descriptions, keys, and illustrations of new species from the region, along with website construction to provide access to that material, and to profiles of selected species and links to the literature and specimen databases. Workshops at SERTC will support regional taxonomic training and research. SERTC encourages donation of whole specimens, research vouchers and taxonomic literature from other regional institutions, and is pursuing collaborative efforts with facilities that have holdings of taxonomic value.

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**ASSESSMENT AND MANAGEMENT OF THE
MAINE SEA CUCUMBER (CUCUMARIA FRON-
DOSA) FISHERY — A MULTIDISCIPLINARY
APPROACH**

The sea cucumber (Cucumaria frondosa) fishery in the state of Maine is relatively new and still developing. Population dynamics for this species are not well understood and information on the fishery and resource is limited. Therefore, the current status of the Maine sea cucumber fishery and impacts of exploitation to the resource are undefined. Slow growth and aggregate distribution are, however, likely to make this a boom-bust fishery like other similar fisheries in the area (such as the Maine sea urchin fishery) if not managed appropriately. In cooperation with the fishing industry, we are conducting research to estimate key life history parameters and quantify spatial and temporal distributions of the sea cucumber in Maine. Focus group meetings will be held to collect the information on fishermen's insights and experience about the fishery and their fishing behaviors and possible responses towards different management strategies. Using the information collected, we will evaluate possible impacts of exploitation and identify main habitats and key ecological variables that influence population dynamics of the sea cucumber. The results of the study will be used to explore possible management strategies, including temporal and spatial closures of different scales, establishment of marine protected areas, and input and output control management systems. A risk analysis will be conducted to evaluate the effectiveness of various management strategies and identify an optimal management plan for the Maine sea cucumber fishery.

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**ARTHROPOD COMMUNITY CHANGES
ASSOCIATED WITH INTRODUCED PLANT SPECIES**

Soil and terrestrial arthropods are highly susceptible to changes in microhabitats and plant communities. We are addressing several aspects of the biology of an alien plant invasion and its impact on a terrestrial arthropod community using plant surveys, pitfall traps and soil-core extractions in a low forest. The forest borders Dyke Marsh, a 7000-yr-old freshwater tidal marsh

along the Potomac River, across from the District of Columbia, in the George Washington Memorial Parkway National Park. This low forest has, on average, 45% alien plant coverage. We have found an associated increase in some arthropod species, including several alien arthropod species, and a decrease in other arthropod species with increasing levels of invasion. This poster will specifically examine the impact of the alien plant invasion on the forest's total ant community, one ant species (Aphaenogaster rudis), and the native plant community. We have found that ant abundance increases with increased invasion of alien plants, and that A. rudis may be a good indicator of ecological change associated with alien plant invasion. Native plant richness dramatically decreased with increased invasive plant coverage. Alien invasive plants should be of major concern to arthropod conservationists for the preservation of arthropod communities.

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**A STANDARDIZED METHOD FOR MONITORING
SOLITARY BEE COMMUNITIES**

Bees are the principal pollinators of flowering plants in most terrestrial ecosystems of the world and arguably no taxonomic group has been more important for the evolution and function of these ecosystems. Bee activity translates broadly and directly to human well-being. In North America alone, estimates of the value of bees (natives and the introduced honey bee) as pollinators of crops ranged between \$4.6 and \$18.8 billion. Despite their well-recognized economic and ecological value, we lack basic information on the global, regional, and local patterns of diversity and population trends of this species-rich (approximately 20,000 species) and ecologically important group.

To begin to fill this gap, we have developed and tested a simple sampling protocol (<http://online.sfsu.edu/~beeplot>) that requires low-cost equipment available worldwide. Our protocol is usable by scientists of many interests, as well as amateurs and school groups. Data generated using this protocol will be useful for 1)

conservation planning and strategy development; 2) local, regional and national assessments of species richness; and 3) evaluations of population trends in different habitat types (i.e. agricultural versus wilderness sites). This collaborative effort will allow us to begin to detect differences in species richness and population trends among biomes, ecoregions, habitats, communities, and plots.

We are certain use of the protocol will expand rapidly because of widespread interest in the fate of pollinators. This simple sampling protocol is designed to contribute to a database that will be available for comparisons across any geographic scale (local, within-ecosystem or worldwide). The end results will be a rapid expansion of identified bees in collections and basic information on bee biodiversity and patterns of species richness from throughout the world; information necessary to conserve these important pollinators.

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PATTERNS OF ENDANGERMENT OR PATHWAYS TO ENLIGHTENMENT? RECONSTRUCTING THE FAUNA HAWAIIENSIS

The associated collecting lots of specimens culminating in the Fauna Hawaiiensis were used to reconstruct the assemblages of carabid beetle species (Coleoptera: Carabidae) recorded from Hawaii in the late 19th Century. Ecological associations among a total of 193 species on an island-by-island basis permit concise hypotheses concerning habitat preferences for many of the 32 carabid species collected during the early period of European scientific exploration (1872-1902), but not observed since. Taxonomic disparity of the carabid beetle fauna across the archipelago prevents generalization concerning the likelihood of endangerment within various habitats on the various islands. Nevertheless, viewed island-by-island, hypotheses of habitat preference can be used to guide present-day field-inventory activities. In several instances, past species associations may implicate instances of extinction, such as the loss in recent times of a suite of four Maui species associated with Koa (*Acacia koa* A. Gray: Fabaceae), and the probable extinction of the previously abundant *Blackburnia tantalus* (Blackburn) on Oahu. The candidate list of threatened and endangered species of the U.S. Fish and Wildlife Service established prior to 1994 comprised one species missing since 1902, plus eight species observed at various times over the past century, illustrating vast improvements in our knowledge of carabid beetle species' spatial distribution and temporal persistence based on recent taxonomic research and field surveys. Future consideration of official conservation status for any Hawaiian

carabid beetle species must account for the limited likelihood that individuals of long-missing species can be observed in nature, based on their natural relative rarity, or their secretive habits within restricted geographic and ecological distributions.

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THE ECONOMIC VALUE OF ECOLOGICAL SERVICES PROVIDED BY INVERTEBRATES

The economic value of ecological services provided by insects including pollination, decomposition, biological control, and recreation was calculated using values from published sources. The overall value was calculated to be at least 70 billion dollars annually in the United States. The single largest component of this total was the value of insects to the "recreation" industry. The value of insects to the recreation industry was calculated to be 48 billion dollars annually in the United States based on data from the U.S. Census. Value to this industry was calculated based on expenditures for observation or collection of insects and expenditures for observation, hunting, or fishing of organisms that depend on insects for food. The values of dung decomposition, pollination, and biological control (totaling 22 billion dollars) were calculated based on value added or losses avoided in agriculture. There have been several reviews of the value of ecological services, but none focused specifically on invertebrates. Building a sense of the economic worth of insects can work in tandem with sensitivity for their aesthetic value ("biophilia"). Dozens of threatened and endangered insects are protected by state, national and international laws, but the only legislation designed to protect insects providing services are pesticide label restrictions against harming domesticated bees. A greater sense of the economic value of services provided by insects will allow legislators, growers, developers, and others to make informed decisions, including the allocation of resources towards insect conservation.

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THE GLOBAL DECLINE OF NONMARINE MOLLUSKS

Given the limited resources for species-by-species conservation approaches, it has been suggested that conservation biologists identify 'biodiversity hotspots' where exceptional concentrations of endemic species are found and are undergoing rapid extinction or decline from loss or degradation of habitat, invasive species, and other human-caused mechanisms. Recently, numerous hotspots for conservation priorities have been identified and arguments made to focus our limited resources and conservation planning on these regions. An assumption of the biodiversity hotspot identification approach is that all organisms track the pattern of diversity exhibited by the usual surrogate species chosen for analyses (i.e., birds, mammals, and vascular plants). Although invertebrate species represent greater than 95% of animal diversity, they rarely serve as indicator species. Justification for the failure to use invertebrate indicator species has been our lack of basic biological knowledge about most invertebrate faunas around the world. Although certainly many invertebrate species would be protected by default using vertebrate and vascular plant-based hotspots, we believe it is critical to include other taxonomic groups to further assess hotspot delineations. Arguably, one of the most imperiled groups of animals is the non-marine mollusks. Non-marine mol-

lusks include a number of phylogenetically disparate lineages and species-rich assemblages that represent two molluscan classes—Bivalvia (clams and mussels) and Gastropoda. Here, we provide several specific case studies documenting the diversity and global decline of non-marine mollusks, demonstrate the need for biotic surveys and inventories including modern taxonomic monography, and make a case for computerization of the wealth of data that resides in museum collections. Finally, we discuss what role mollusks and malacologists should play in conservation.

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THE PHYLOGENY AND BIOGEOGRAPHY OF THREATENED SPIDERS IN ENDANGERED HABITATS

Phylogenetic studies can inform conservation decisions by indicating regions of particular interest based on the distribution of evolutionarily significant taxa. We studied the evolutionary diversification of the Geolycosa wolf spiders of the eastern US, with a focus on the Floridian species. Our study of the distribution of Geolycosa species supported the general model of the historical biography of Florida: A clear dichotomy between the more ancient, interior scrubs and the more recently formed scrubs found near current coastlines. We also examined the patterns of evolutionary diversification based on gene sequence data. We used mtDNA and nDNA (CO1, Cyt b, ND1, ITS 1&2) to generate the phylogenetic hypothesis for species and population relationships. We found support for all but one of the currently described species, as well as some surprising species groupings. We were particularly surprised to find that the Gulf Coast species *G. escambiensis* was a more basal taxon that grouped with the two Geolycosa species (*G. pikei* and *G. turricola*) of the Atlantic coast (ranging from Georgia up to New England). *Geolycosa escambiensis* has been recognized as a species of special concern in Florida and our phylogenetic studies confirm its status as a biologically significant species. We also discovered that the Panhandle population of a second species, *G. patellonigra*, may represent an undescribed taxon. This morphologically distinct species population is not a sister taxon to conspecific populations in the Peninsula. Our studies also found evidence that barren-sand specialists such as *G. escambiensis* and *G. patellonigra* are dependant on fire to maintain suitable habitat. We uncovered evidence that this specialized microhabitat association evolved 5 times from litter-dependant ancestors. Taken together, our findings indicate that the scrubs of Florida's Panhandle may contain biologically significant scrub taxa, as are found in the scrubs of the Lake Wales Ridge.

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**THE FEDERAL INTERAGENCY COMMITTEE
ON INVASIVE TERRESTRIAL ANIMALS AND
PATHOGENS (ITAP): ORGANIZING TO
CONTROL INVERTEBRATE INVASIVE SPECIES
AND PROTECT BIODIVERSITY**

Invasive species have been identified as second only to habitat loss as a threat to imperiled species and communities. The Federal government has the responsibility to protect our national borders from the importation of harmful and invasive organisms, manage hundreds of millions of acres for multiple uses, including the protection of biodiversity, monitor native and non-native species, and conduct basic and applied conservation research including the impacts of invasive species on native species and communities. These responsibilities are shared among many federal agencies. ITAP was formed to provide a forum to support technical coordination and cooperation among member agencies on problems associated with terrestrial invasive invertebrates, vertebrates and plant and animal pathogens. The purpose of this poster is to familiarize the conservation community with ITAP, encourage a dialogue with scientists, policy-makers and resource managers concerned with invertebrate conservation, and provide specific examples addressed by member agencies of the known and potential impacts of invasive species on native invertebrates.

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**DEVELOPING A SOUND ENHANCEMENT STRAT-
EGY FOR THE FIRST ENDANGERED MARINE
INVERTEBRATE, WHITE ABALONE (HALIOTIS
SORENSENII)**

White abalone (Haliotis sorenseni) occurs in deeper-water kelp forest habitats of the southern California, USA and central Baja California, Mexico coasts. After a short period of intensive commercial fishing, the California population declined to an estimated < 0.1% of its pre-exploited size, resulting in wild densities that were too low for successful spawning. White abalone became the first marine invertebrate to be added to the Endangered Species List in May 2001. Critical to developing an effective recovery plan for white abalone is a better understanding of the factors that led to the decline of the species, improving current estimates of abundance, and refining the focus of future conservation efforts. The effect of increasing sea surface temperature on the decline of white abalone is likely minimal compared to the impact of fishery exploitation (290 metric tons landed), especially given experimental evidence that recruitment success in white abalone may be linked to relatively warm water temperatures (~ 15°C). Recent surveys conducted at two banks off the southern California coast revealed that the total white abalone population size may be higher than previously estimated (40,000 individuals versus 2,540). This discrepancy is due largely to the use of revised available habitat estimates. Densities remain at least an order of magnitude lower (3-50 per ha) than pre-exploitation densities (479-2,300 per ha). Surviving individuals on offshore banks are relatively large (> 100mm), primarily solitary (> 1m from its nearest neighbor), and occur between 30-60m depth at water temperatures of ~ 10-12°C. Given the scarcity of small (< 100mm) survivors and possible temperature limitations for developing larva, the viability of offshore bank populations remains unknown. These data highlight the fact that continued monitoring of trends in wild populations is crucial. Future recovery activities should focus on determining the critical densities required for successful spawning.

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INVERTEBRATE CONSERVATION AND COWS: THE INFLUENCE OF LIVESTOCK GRAZING ON ANT COMMUNITY STRUCTURE IN A SHRUB- STEPPE ECOSYSTEM

Globally, and specifically in the western United States, livestock grazing has become one of the most pervasive land use practices and an important agent of habitat degradation. While the long-term consequences of grazing are relatively well known for taxa such as plants, less well understood are its effects on invertebrates, especially the initial impact of grazing upon relatively undisturbed communities. This study examined the initial response of a shrub-steppe ant community to cattle introduction at a previously ungrazed site. Eight paired plots (control and grazed) were sampled for ants, vegetation characteristics, and soil properties before cattle introduction, and again in two post-introduction years. Twenty ant species occurred across the study site. Local richness varied from 4 to 12 species per plot. Half of the grazed plots decreased in richness in the first season after grazing compared to control plots, while 2 plots remained unaffected and 2 plots increased in richness. In the second post-introduction season, the opposite trend was observed; 4 of 8 plots increased in richness. Individual species showed mixed responses to grazing, but changes in abundance seemed to be related to the diet breadth of individual species. Ant species with narrow diets were more likely to decrease in abundance in the first season than species with broad diets. During the first season, shrub and grass cover were reduced on grazed versus control plots while soil penetrability remained unchanged. These preliminary results suggest that grazing may affect ants indirectly via changes in food availability (vegetation factors) rather than nest site suitability (soil factors). Moreover, grazing may be more detrimental for specialist feeders such as seed-harvesting ants. These findings suggest the need for future experimental manipulations to help elucidate potential mechanisms by which livestock grazing affects invertebrate communities.

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DISCOVERING THE DIVERSITY OF LIFE IN GREAT SMOKY MOUNTAINS NATIONAL PARK

The floral and faunal communities in Great Smoky Mountains National Park are some of the richest and most diverse in the temperate world; however, fewer than 10,000 of the estimated 100,000 species in the Park are known. The Park

comprises more than 210,000 hectares of rugged, heavily forested mountains in the southern Appalachian range. Gaining a better understanding of natural communities, species distributions, and interactions will provide a critical knowledge base for responding to threats that these resources face. The need for this type of information has, in part, led to the inception of an All Taxa Biodiversity Inventory (ATBI). This effort, which is the first of its kind at this scale, involves inventorying every species of life found within the Park, estimating relative abundances, plotting distributions, and documenting species, community, and habitat associations. Products include web pages, interactive keys, reference specimens, and protocols applicable to other natural areas. The many benefits of this project include the improvement of Park resource management, tremendous educational opportunities, and hopefully a renewed interest in the field of taxonomy. In the Park, we currently know of approximately 1500 species of Lepidoptera, 1500 species of Coleoptera, 500 species of Diptera, 518 species of spiders, and 132 species of mollusks, to name just a few. Also, since the beginning of this project, we have discovered over 400 species that are undescribed and over 3,000 species that are new records for the Park, most of which are invertebrates. These amazing discoveries are providing the information necessary for better managing this very diverse Park.

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SHIFTS IN DUNG BEETLE (SCARABAEIDAE) COMMUNITY STRUCTURE ALONG AN URBAN-TO-RURAL GRADIENT: IMPLICATIONS FOR INVERTEBRATE CONSERVATION AND ECOLOGICAL SERVICES

Despite the rapid pace of urban expansion around the globe, relatively little is understood about the dynamics of biodiversity in the urban landscape, particularly those of invertebrates. Even in highly modified human-dominated habitats we are dependent upon many of the ecological services mediated by insects, including pollination and decomposition. This study used a gradient analysis approach to understand the impacts of urbanization on the community structure of dung beetles (Family Scarabaeidae) and their interspecific competition with dung flies (Family Muscoidea). A total of 3348 beetles in 11 species were captured in pitfall traps placed at the margins of 60 forest fragments surrounded by urban, suburban, agricultural and forested habitats in 11 counties of New York and New Jersey. Dung beetle diversity and abundance in urban forest fragments was significantly reduced relative to all other treatments; species level diversity was on average less than half and relative abundance less than two-thirds that of other treatments or contiguous forest.

Beetle community structure in urban sites differed significantly from all other treatments, though it was most similar to suburban sites. Deer dung specialists provided the majority of individuals in all treatments excluding urban sites, and was highest in sites located in Westchester County, where deer overpopulation is well documented. Muscoid fly diversity and abundance was highest in urban areas, where fly-larvae consuming beetles of the family Histeridae dominated. Availability and type of food resources may play the dominant role in structuring dung beetle community composition. Dung beetles have been shown to significantly reduce levels of *Cryptosporidium parvum* in the landscape, an infective protozoan present in the New York City water supply; future work will address the empirical linkages between ecological and human health through analyzing the role of dung beetles in reducing *C. parvum* levels in water reservoirs along an urban-to-rural gradient.

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THE CONSERVATION AND MANAGEMENT OF ENDANGERED O'AHU TREE SNAILS (GENUS: ACHATINELLA)

Nearly seventy-five percent of 750 recognized species of terrestrial Hawaiian snails (99% of which are endemic) have disappeared in the past 70 years. Snails in the genus *Achatinella* are some of the most threatened. Remaining populations of this remarkably diverse group are small, highly fragmented, and continue to be faced with annihilation by a myriad of threats including: habitat degradation and destruction, shell collection, and introduced predators (three rat species and the predatory snail *Euglandina rosea*). With low fecundity (~5 offspring per year), limited vagility, slow growth, and late age of maturity (five years), the colorful and charismatic O'ahu tree snails are particularly prone to extinction from these threats. All 41 species of the genus *Achatinella* were placed on the Endangered Species List in 1981; only 8-9 species are extant. Efforts to conserve and manage these remnant populations have been ongoing for nearly two decades. They include captive rearing, monitoring of populations in the field, predator control and exclusion, and the use of molecular genetic data to guide management and recovery plans. Methods of propagating snails in the laboratory have been developed and our facilities have expanded greatly over the past five years. Captive populations of most, but not all, species are growing. Experimental release of captive-born snails has proven that wild populations can be successfully re-established. Long-term

mark-recapture studies in the field are ongoing and have been essential to identifying population declines. Specially designed fences are being built to protect populations from predators in situ and serve as potential sites for reintroduction. Most recently, mitochondrial DNA sequences have identified high levels of population structure within one species, *Achatinella mustelina*, and are currently being used to prioritize the placement of predator exclusion fences, identify target populations for captive-rearing, and guide reintroduction and translocation efforts.

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THE USE OF ECLOSING TRAPS TO COMPARE REPRODUCTIVE OUTPUT OF THE AMERICAN BURYING BEETLE ON TWO NEW ENGLAND ISLANDS

The American burying beetle (*Nicrophorus americanus*) was once commonly found in the eastern and central United States and in the southern portions of three Canadian provinces. The only native population east of the Mississippi River now occurs on Block Island, off the southern coast of Rhode Island. Declared an endangered species in 1989, the U.S. Fish and Wildlife Service is attempting to reintroduce the species to historic habitat on Nantucket Island, MA. Roger Williams Park Zoo maintains a colony of *N. americanus* as a source of animals for this reintroduction effort. *N. americanus* raise their young underground, feeding them with a prepared vertebrate carcass. The standard method of assessing the reproductive output for this species has been to exhume brood chambers and count the third instar larvae. Although this technique does not seem to affect ultimate eclosion of young in the zoo, there was concern that, in the field, exhumation of burial carrion would result in brood failure. A method of constraining beetles after eclosion allowed me to test whether counting larvae was a valid method of measuring reproductive output on Block Island and Nantucket Island. Because constrained freshly-enclosed beetles were marked prior to release, we were able to estimate winter mortality for this species in two consecutive seasons on Block Island. These data will be helpful in refining reintroduction protocols for this species and will allow better evaluation of future reintroduction efforts.

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THREATS FACING SOUTHERN AFRICA'S UNIQUE SCORPION FAUNA

The southern African scorpion fauna is remarkably diverse. The region contains 8 % of the world's genera and at least 10 % of the world's species. Some 38 % of the genera and at least 86 % of the species of southern African scorpions are endemic. Three genera—Hadogenes (Liochelidae), Opisthophthalmus (Scorpionidae) and Parabuthus (Buthidae)—dominate the fauna, together comprising approximately 67 % of the described species. Each is characterised by numerous morphological novelties. Opisthophthalmus and Parabuthus possess uniquely different stridulation organs. Hadogenes exhibit the highest trichobothrial counts of any known scorpion, and some Opisthophthalmus species display the lowest pectinal tooth counts. All three genera are characterised by a preponderance of unusually large species. Hadogenes includes the world's longest scorpions, e.g. H. troglodytes, reaching a length of 210 mm and a mass of 32 g. Parabuthus includes the world's largest buthid scorpions: P. granulatus, P. schlechteri, P. transvaalicus and P. villosus can reach a length of 140 mm and a mass of 14 g. Several Opisthophthalmus species are also exceptionally large, e.g., O. gigas reaches 160 mm in length. Many species in these genera are characterised by exaggerated sexual dimorphism. Opisthophthalmus species often display dimorphism in pedipalp chela shape and pectinal tooth counts, whereas many species of Hadogenes are characterised by dimorphism in metasomal length. Unfortunately, this diversity is increasingly threatened as habitat destruction continues unabated and new threats (i.e. harvesting for the pet trade) arise, while existing legislation and protected area networks have little impact on their conservation. At least one Opisthophthalmus species may be extinct, and several others are critically endangered. The threats faced by many of these unique but extremely range-restricted scorpions makes the task of inventorying their diversity and distribution an urgent priority if steps towards their conservation are to be implemented without further delay.

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RED LIST FOR HABITATS AND GREEN LISTS FOR SPECIES: A TOP DOWN STRATEGY FOR CONSERVING INVERTEBRATES

Although the concept of biodiversity shot up to this popularity more than a decade back, our conservation policies are still pivoting around the concept of conserving the game mammals. While considering the conservation, we forget insects and other invertebrates, which comprise more than 94% of the species, and talk about the other 6% and do something for a few charismatic taxa.

Many species of insects and invertebrates are being discovered from extremely small areas of Tropics. So the potential insect diversity of tropics will be very high and most of these species are endemic to a very small area. So if a relatively small area is logged or disturbed, many species will disappear forever. Since the majority of species remain undescribed and data on the distribution and abundance of only a very few described species are available, assessing the threat status of each species according IUCN norms is not practical. So for conservation, rather than species, habitats should be prioritised. A 'critical habitat index' is suggested for evaluating the importance of habitats for conservation. A 'species status index' based on rarity of each species is suggested for assessing the status of a species. 'Critical habitat index' along with 'species status index' is expected to provide a viable alternative to the present day charismatic taxa-oriented conservation strategies.

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BIODIVERSITY HOT SPOTS, EXPLORING BELOW THE TIP OF THE ICEBERG: A CASE STUDY OF CADDISFLY (INSECTA: TRICHOPTERA) SPECIES DIVERSITY IN NORTHERN FLORIDA

In the past, geographic regions have been designated as biodiversity "hot spots" based largely on the concentrated occurrence of distinctive mega- fauna and flora. This biota represents only the tip of the iceberg in terms of taxonomic diversity when considering lesser-known, yet much more species-rich taxa, as is found within the invertebrate classes. Conducting freshwater invertebrate surveys that focus on unique aquatic habitats within biodiversity hot spots are a potentially productive approach for adding significantly to our understanding of hot spot species

diversity. This was demonstrated by investigating caddisfly species diversity in ravine ecosystems across northern Florida. Ravine ecosystems on the Southeastern Coastal Plain are known to support diverse biota, including Appalachian elements and indigenous species, but information concerning stream insects was very limited. This study documented caddisfly species diversity by sampling adults and immatures, during different times of year, along upper and lower reaches of ravine streams located within several different major drainage basins and biogeographic regions in northern Florida. The survey revealed a rich and distinctive fauna associated with ravine ecosystems, including many ravine crenobionts, narrow-range endemics, and species with disjunct distributions. At least 12 caddisfly species previously unknown to science were discovered, eleven of which were subsequently described and named. Steephead ravine streams in the western Florida panhandle contain a highly endemic fauna, and the ravine fauna associated with the Apalachicola River drainage has the strongest Appalachian affinities. Cluster analysis of the macrocaddisfly survey results placed study sites into groupings congruent with regional biogeography and stream type. This study demonstrates that focusing on a single, diverse group of freshwater invertebrates in unique habitats across a biogeographically heterogeneous region can reveal important intra-regional differences in biodiversity within a hot spot.

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PRELIMINARY STUDY OF ANT DIVERSITY IN URBAN AREAS: THE ROLE OF TRAMP SPECIES IN SHAPING THE ANT COMMUNITY IN BOGOR, WEST JAVA, INDONESIA

This research focuses on measuring ant diversity in urban areas in the tropics. We are particularly interested in studying the impact of tramp species (including invasive ones) on the structure and composition of urban ant communities and in biotic homogenization in general. Over 77 species of ants have been collected from 20 different sites in the Bogor area, ranging from downtown to the periphery of the city. At each site, different types of land use can be found, including houses/buildings, gardens,

*city parks, small patches of forest and their edges, and rice fields. Ant collections were done by hand collecting and with honey baiting. Analysis using Shinozaki species accumulation curves showed that the number of ant species continues increasing with increasing sampling sites, which means that the number of species collected so far has not reached the saturation level. Using multidimensional scaling (MDS) analysis, we found different similarity levels in ant diversity among the sites, with some sites having high similarity. This may have been caused by the different types of habitat that dominated each site. There was also similarity in the type of species among similar habitats. Most of the 77 species collected are tramp or wide-ranging species, with several that are well known as invasive species. Species such as *Odontoponera denticulata*, *Paratrechina longicornis*, *Dolichoderus thoracicus*, *Pheidole plagiaria*, *Tapinoma melanocephalum*, *Anoplolepis gracilipes*, *Tetramorium similimum*, and *Monomorium floricola* are very common and were found at almost all the sites surveyed. Our preliminary conclusion showed that habitats with high human disturbance have low ant diversity, higher tramp species ratios and a constant presence of invasive species. This suggests the possibility that tramp species, especially invasive ones, have dominated the urban habitat, with a huge impact on native ant communities. In other locations, like forest edges, small forest patches, and parks, the diversity is still relatively high, suggesting the possibility that some native elements still survive there.*

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INVERTEBRATE CONSERVATION EFFORTS OF THE VIRGINIA DEPARTMENT OF CONSERVATION AND RECREATION

The Virginia Department of Conservation and Recreation, Division of Natural Heritage, was established in 1986 to serve as the first comprehensive program for the conservation of the state's biological diversity. Its primary goals are to conserve the habitats of rare, threatened, and endangered plant and animal species, exemplary natural communities, habitats, and ecosystems, and other natural features. Activities of the program include an intensive statewide biological inventory, field surveys, electronic and manual database management, environmental review of proposed projects, karst inventory and protection efforts, and natural area protection and stewardship. Since its inception, the Division of Natural Heritage has developed a system of 40 natural area preserves totaling nearly 30,000 acres in Virginia. Invertebrates are an integral part of the program's inventory and protection efforts. Natural heritage inventories are making substantial contributions to knowledge of the distribution and con-

servation status of the (non-marine) invertebrate fauna of the state. Field sampling includes a wide variety of invertebrates, including mollusks, crustaceans, insects (numerous groups), cave organisms, and various other taxonomic groups. Numerous status surveys have been conducted for specific rare, threatened, and endangered species as well as general sampling of the state's invertebrate fauna, often in unique habitats that had never been sampled by zoologists. Hundreds of new state records have been documented, often representing significant expansions of the known ranges of those species. Field surveys have also resulted in the discovery of several dozen species (and one genus) of invertebrates new to science. Annual monitoring is conducted for selected rare species populations, including those of the federally Threatened northeastern beach tiger beetle (*Cicindela dorsalis dorsalis*), federally Endangered Mitchell's satyr butterfly (*Neonympha mitchellii*), and the rare and declining regal fritillary butterfly (*Speyeria idalia*). Metapopulation studies have also been conducted on each of these three species, yielding important results for their conservation.

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THE POTENTIAL CONSERVATION VALUE OF UNMOWED POWERLINE STRIPS FOR NATIVE BEES

The land area covered by powerline easements in the United States (over five million acres; Knight and Kawashima 1993) exceeds the area of most national parks, including Yellowstone. In parts of Europe and the U.S., electric companies have altered their land management practices from annual or periodic mowing to selective extraction of tall vegetation. To investigate whether this alternate management practice could produce higher quality habitat for native bees, we compared the bee fauna collected in un-mowed powerline rights-of-way and nearby mowed grassy fields at the Patuxent Wildlife Research Center (MD). Surveys were conducted in the spring of 2001 at a total of 16 sites using forty modified pan traps at each site. Powerline sites had more spatially rare species and a significantly richer bee community than the grassy fields, although the difference was less pronounced than we expected. Bee communities change progressively through the season, but differences between the site types were persistent. Further analyses suggest that the surrounding, non-grassland landscape has a strong influence on the bee species collected at the grassland sites as some bees are likely foraging in the grasslands, but nesting elsewhere. Improving habitat for native bees will help defray some of the pollination loss due to

the collapse of wild and managed honeybee populations. This study suggests that un-mowed powerline strips have the potential to provide five million acres of bee-friendly habitat in the U.S. if current management practices are altered, thereby promoting the health of native bee populations and the native and cultivated plants that depend on them for reproduction.

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INTRODUCING SPIDA-WEB: AN AUTOMATED IDENTIFICATION SYSTEM FOR BIOLOGICAL SPECIES

At present, the most severely limiting factor on our understanding of community structure, diversity, and how diversity relates to ecosystem function and services is the lack of experts capable of identifying biological specimens to species. For most groups of organisms, the number of trained systematists is low, and the success rate of non-specialists trying to achieve accurate identifications on their own, with currently available tools, is even lower. The situation is worst for relatively small and inconspicuous organisms (i.e., precisely those groups that comprise the bulk of our planet's biodiversity). One way to ameliorate this problem is to encapsulate the taxonomic expertise of a specialist into a computerized identification system. We are currently developing an Internet-accessible automated identification system that uses artificial neural networks to make identifications based on digital images. We call this system **SPIDA-web** (**S**pecies **I**dentification, **A**utomated and **w**eb accessible). Our test group for the prototype is one of the world's most diverse—spiders, Order Araneae. We are developing the system from two perspectives: taxonomic and geographic. We are still in the early stages of prototype development, but preliminary results indicate that SPIDA will be able to classify images to genus with 95—100% accuracy. Classification to species has proven more problematic due to the paucity of replicate specimens, but when sufficient numbers are available, accuracy is within 90—99%. A system that can identify any species in a particular family, or from a particular area, without requiring the user to have more than the most basic knowledge of the organism to be identified has the potential to drastically improve the efficiency and scope of biological inventories (AND subsequent monitoring efforts), thereby making the inclusion of arthropods in conservation planning a more realistic objective.

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EFFECTS OF RIPARIAN FOREST MANAGEMENT ON MICROCLIMATE AND THE DISTRIBUTION OF GROUND-DWELLING INVERTEBRATES IN THE CASCADE RANGE OF OREGON

Headwater streams and their riparian zones comprise the vast majority of the lotic network within Douglas-fir forests of the Pacific Northwest, yet they have received disproportionately little study or protection. In the region's heavily harvested landscapes, controversial new regulations on public lands mandate the preservation of riparian forest "buffers" on headwater streams, with the expectation that they will protect both aquatic and terrestrial riparian resources. As these practices may take a large amount of land out of timber production, it is critical to learn more about the ecological significance of headwater stream riparian zones as habitat for forest species, and how forest diversity and function may be affected by various management strategies. We evaluated the effectiveness of riparian buffers in preserving the biological integrity of riparian forest communities by comparing the forest-floor invertebrate fauna (beetles, spiders, millipedes, and gastropods) and microclimate among three treatments: (1) headwater stream riparian sites with 30m forested buffers; (2) unmanaged riparian forests; (3) riparian areas where harvesting had occurred up to the stream edge. We sampled invertebrates in pitfall traps along 70m transects perpendicular to the stream at 15 sites. Ordination analysis revealed elevation, treatment, and distance-from-stream to be important variables in ordering samples with similar invertebrates. Several forest species were strongly associated with the stream edge. Differences in species composition were most pronounced between forested and clearcut sites, riparian buffer sites were most similar to forested sites. Air/soil temperatures and relative humidity in riparian buffers were also more similar to forest than to clearcut conditions, but did show some edge effects. We conclude that canopy removal affects microclimatic variables, which are associated, in turn, with changes in the distribution of forest-floor invertebrates. Despite an influence of edge effects, buffers are likely serving an important role in maintaining biological integrity in headwater stream riparian zones.

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A PRELIMINARY STUDY OF THE EFFECTS OF LANDUSE AND FOREST DISTURBANCE ON BUTTERFLY DIVERSITY AT MOUNT SALAK, JAVA (INDONESIA)

*Effects of forest destruction and land-use change on butterfly diversity in Mount Salak and its surroundings are being studied between September 2003 and September 2004. Preliminary research was conducted at five different locations covering two different habitats, secondary forest and paddy fields (at the lower slopes of Mount Salak). Butterflies were surveyed by conducting transect walks. Specimens that could not be designated to species in the field were caught with a sweep net and identified subsequently in the laboratory. So far, we have found 33 butterfly species at Mount Salak. Ten species were found in several forest types as well as in paddy fields, such as *Lethe confusa*, *Melanitis leda*, *Eurema hecabe*, and *Faunis canens arcesilas*. Two butterfly species, a *Radena (Ideopsis) sp.* and a *Cethosia sp.*, were found only in forest and not in paddy fields. Our findings from different areas at Mount Salak showed that species composition of butterfly communities was significantly related to habitat type. Furthermore, species richness in areas where forest experienced only minor disturbance was higher than in areas with heavily modified habitats. Several species could be found in only one forest type. For example, the species *Prioneris autothisbe*, *Cepora aspasia*, *Graphium evemon*, and *Jamides caeruleus* were found only in production forest, while *Taenaris sp.*, *Papilio demolion*, *Cethosia sp.* and *Delias belisama* were found only in secondary forest with a low degree of forest disturbance. *Radena (Idiopsis) sp.* could be found only in very disturbed forest. Our preliminary data indicate that there is a site-specific species composition of butterfly communities and habitat isolation that may contribute significantly to the presence of single species. Implications of these findings towards butterfly conservation are discussed. Future research will also focus on effects of habitat fragmentation on species composition facilitated by local extinction and re-colonization processes.*

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POLLINATOR ASSEMBLAGE OF THE ENDANGERED PLANT *CORDYLANTHUS PALMATUS* (SCROPHULARIACEAE) AT SPRINGTOWN WETLANDS RESERVE, LIVERMORE, CALIFORNIA

In March 2002, we conducted a study of the primary flower visitors of the endangered plant Cordylanthus palmatus (Ferris) MacBr. at the Springtown Wetlands Reserves. The pollinator assemblage and nesting behavior data were recorded. This study resulted in important modification for conservation management planning in general and specifically for small remnant ecosystems. Lasioglossum spp. represented 96% of bees observed visiting C. palmatus during timed observations in 18-five minute trials conducted over a thirty-day period from Jun through Jul. Bombus vosnesenskii Rad. was the most common Bombus species at Springtown in 2002 and was the only Bombus species observed visiting C. palmatus during the entire flowering season. Bombus melanopygus, and B. crotchii were present at the Springtown site but did not visit C. palmatus. Other Hymenoptera present at the study site included semi-social and solitary bees (members of the family Andrenidae [Panurginus, Calliopsis], leafcutter bees in the family Megachilidae [Melissodes, Megachile, Osmia], and sweat bees in the family Halictidae [Halictus, Lasioglossum (Dialictus) and Lasioglossum (Evylaeus)]. Bombus vosnesenskii females visited a mean of 6.7 flowers per minute. Lasioglossum spp. visited approximately 3.4 flowers per minute and Halictus tripartitus Cockerell averaged 2.8 flowers per minute. The average time a B. vosnesenskii individual spent at an individual Cordylanthus flower was 1.43 - 19.0 (5.53 sec \pm 3.83). Three active B. vosnesenskii nests were located in rodent burrows in the mima mounds immediately adjacent to a large stand of C. palmatus. Lasioglossum (Dialictus) sp. and H. tripartitus Cockerell utilize the banks of Altamont Creek for nesting. A new, undescribed species of solitary bee in the genus Panurginus (Andrenidae) was observed nesting in the lowland areas of Springtown Wetlands Reserve.

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TEACHING CONSERVATION WITH INVERTEBRATE COLLECTIONS IN DUBLIN

Collections-based Biology in Dublin (CoBiD) is making specimen resources more available to conservation workers. This new partnership between the National University of Ireland (University College Dublin) and the National Museum of Ireland (Natural History) aims to develop teaching and research resources locally, as well as improve collections access to all researchers internationally. The NMINH collections contain some 3 - 4 million specimen objects in total from worldwide collections, but chronic understaffing has severely limited their availability for research use. Important holdings include strong entomological collections, Atlantic marine invertebrates and terrestrial mollusc collections, increasing material from ongoing regional studies, as well as important historical collections. For example, voucher specimens from the European Union "BioMar" (1996) survey of Irish nearshore invertebrate faunas comprises detailed biogeographical data for marine species and "biotopes" defined by the project. Together with colleagues from the Ulster Museum (Belfast), we are developing this material for continuous biodiversity assessment. Use and accessibility of voucher material is essential to biological conservation research—particularly in invertebrate collections, where depositing voucher specimens is often required by research permits but consultation of existing collections may or may not be obligatory. With this in mind, a pilot undergraduate course is currently underway (Spring 2004) to teach senior undergraduates about the applications of archival collections in conservation-oriented research, with work based in the collections of the National Museum of Ireland. This new teaching programme serves to bridge a gap between "ecology-style" conservation research (well represented in the UCD Zoology department) and systematic collections of the Museum. In the long term, training the next generation of biologists to use and conserve archival specimen collections will benefit invertebrate conservation through forming "baseline" pilot data and preventing unnecessary specimen collection.

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**CONSERVATION OF SUBTERRANEAN
INVERTEBRATE SPECIES FOUND IN THE CAVES
OF THE OZARK PLATEAU**

*Invertebrate biodiversity in the caves of the Ozark Plateau has received very little attention compared to biodiversity studies in other cave regions. Although over 10,000 caves are known from the Ozarks, less than 15% have been thoroughly inventoried for invertebrate species. Currently, 92 troglobitic (cave-limited) species have been recorded from Ozark caves. New species continue to be reported in the literature, and many undescribed species await formal description. Protecting these species involves a collaboration of dedicated agencies, organizations, and individuals. Two cave crayfish, *Cambarus aculabrum* and *C. zophonastes*, and one cavesnail, *Antrobia culveri*, receive federal protection under the Endangered Species Act. *C. aculabrum* occurs in two caves, while *C. zophonastes* and *A. culveri* are known from one cave each. Extensive biological inventories in the caves surrounding these populations have reinforced the rarity of these species. Population monitoring of the two cave crayfish species has determined that crayfish populations appear to be stable; the cavesnail population, however, continues to decline. In addition to efforts concerning federally listed species, conservation measures are being directed to other rare, endemic Ozark cave invertebrates. The Pink Planarian, *Macrocotyla glandulosa*, is a single site endemic whose population also appears to be in decline. A baseline population density has been determined, and permanent census plots have been established within the cave for monitoring purposes. A gate placed on the entrance of a Big-eared bat cave offers protection for a rare carabid beetle, *Rhadine ozarkensis*, found only at this location. Gated entrances also offer protection for three cave crayfish species: *C. setosus*, *C. subterraneus*, and *C. tartarus*. It is important that continued emphasis be placed on conserving Ozark subterranean species due to an increasing number of negative factors impacting these organisms.*

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**HORSESHOE CRAB (*LIMULUS POLYPHEMUS*)
FISHERIES AND CONSERVATION CHALLENGES**

*Populations of the horseshoe crab (*Limulus polyphemus*), a renowned living fossil, have been shaped by a history of boom and bust fisheries. We review horseshoe crab fisheries from the 'king crab' fertilizer industry (1870-1970) to the present harvest of horseshoe crabs for bait and biomedical uses. Past fisheries have been unmanaged because horseshoe crabs were thought to be plentiful or a nuisance due to their trophic position as a bivalve predator. Recent efforts to manage horseshoe crab harvest were propelled largely by concerns over indirect effects on shorebirds (vertebrates) rather than a direct concern for the conservation of horseshoe crab populations (the invertebrate). Horseshoe crab eggs, especially those in Delaware Bay, are a vital food source for transcontinental migratory shorebirds. Conserving horseshoe crabs and their ecosystem role challenges traditional fishery management because objectives focus not only on sustainable harvest of horseshoe crabs but also on conservation of species that depend on horseshoe crabs, such as migratory shorebirds. We end with an update of current management actions, suggest a multi-species adaptive management framework for conserving horseshoe crab's ecosystem role, and discuss future directions.*

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**A CASE STUDY IN OVERCOMING THE
TAXONOMIC IMPEDIMENT: THE MANTIDS OF
SOUTHERN AFRICA**

The lack of scientific names, difficulty identifying species, inaccessibility of taxonomic literature and collections, and the dwindling number of systematists are the various problems cumulatively known as the taxonomic impediment. The taxono-

onomic impediment is a clear threat to conservation and has been repeatedly cited by ecologists and conservation biologists as among the greatest difficulties to studying and protecting insects. Many insects are lost with their habitat before their existence is documented. Historically, mantids have not been subjected to intensive ecological or systematic research, in part because no mantid species are pests. There remains a considerable impediment to identifying mantids because species descriptions are scattered among technical taxonomic literature. Otte and Spearman (in press) have recently completed a World Mantid Species Catalogue, which provides the backbone to Mantid Species File online (MSF). Grounded in the natural history museums of the world, MSF will consolidate research collection data and taxonomic literature and make it available on the Internet as a searchable database. This database will include identification tools such as specimen photos, diagnostic keys and distribution maps. The process of constructing MSF will begin with the implementation of Mantid Species File Southern Africa. The growth of MSF radiates from Africa because it has the richest mantid fauna (1081 species out of 2405) of all the world's zoogeographical regions. Within Africa, the southern African mantid fauna is highly diverse, comprising 7 of the 9 families worldwide, 60 genera and possibly over 250 species (Otte & Spearman, in press). South Africa additionally has two biomes that are declared biodiversity hotspots; centers of diversity under immediate threat of destruction, needing extensive invertebrate documentation. Overcoming the taxonomic impediment for mantids in southern Africa will be a case study for other understudied terrestrial invertebrate conservation efforts.

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THE EFFECT OF OFF-ROAD VEHICLES (ORVS) ON BEACH INVERTEBRATES IN THE NORTH- EASTERN UNITED STATES

We investigated the effects of off-road vehicles (ORVs) on invertebrates inhabiting sandy Atlantic beaches in the northeastern United States. Cores, wrack quadrats, and pitfall traps were used to sample four beaches, which all had vehicle-free sections in close proximity to ORV corridors. This allowed for paired traffic/no-traffic samples at these sites. A manipulative experiment was also performed on a remote beach, where nylon-mesh bags filled with eelgrass (*Zostera marina*) wrack were allowed to colonize and were then subjected to treatments of high-, low-, and no-traffic. Pitfall trap samples had consistently higher overall abundances in vehicle-free zones on all four beaches.

In contrast, both the wrack quadrats and the cores taken directly beneath them did not show consistent differences in overall invertebrate abundances in areas open and closed to vehicles. The Talitrid amphipod *Talorchestia longicornis* and the Lycosid spider *Arctosa littoralis*, both of which burrow in supratidal bare sands as adults, were always less abundant in beach sections open to vehicle traffic, regardless of the sampling method used. Other invertebrates, such as oligochaetes (family Enchytraeidae) and Tethinid flies (*Tethina parvula*), both of which spend most of their lives within/beneath wrack detritus, showed either no response or a positive response to traffic disturbance. Therefore, ORVs appear to adversely affect certain species, especially those that tend to burrow between the dune and the last spring-tide wrack, where motorists on these beaches are instructed to drive. In the manipulative experiment, species also differed in response to traffic. The tenebrionid beetle *Phaleria testacea* was significantly lower in disturbed wrack bags than in controls, while *Tethina parvula* showed a reverse trend, possibly due to the lower volumes and higher burial rates for bags subjected to traffic.

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THREATENED OR ENDANGERED STATUS FOR A FORMERLY COMMON LADYBEETLE: THE CASE STUDY OF COCCINELLA NOVEMNOTATA, THE NINE SPOT LADY BEETLE

Coccinella novemnotata (or C-9) was formerly very common and ranged across North America from Northern Mexico to Southern Canada. C-9 was so common and ate such a range of agricultural pests that it was named New York's State insect in 1989. Not only is C-9 no longer collected, but several other native species have not been collected or are collected only rarely, including *Adalia bipunctata*, *Coccinella trifasciata*, *Coccinella tredecimpunctata* and *Hippodamia convergens*. The latest collection records for C-9 will be presented along with data on current and past coccinellid community composition. Conserving C-9 could allow for the conservation of a suite of native coccinellids. In light of the establishment of introduced species and changing land-use patterns, it is increasingly important to not only sample rare and endemic species, but also to sample species believed to be common.

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PACIFIC NORTHWEST NATIVE FRESHWATER MUSSEL WORKGROUP

The status of the seven species of freshwater mussels native to the Pacific Northwest has received very little attention, despite the fact that freshwater mussels are considered to be the most endangered group of animals in North America. On February 19, 2003, a workshop on freshwater mussels was held in Vancouver, Washington that consisted of presented papers and a panel discussion. The purpose of the workshop was to initiate discussion on the regional population status of freshwater mussels. The workshop was attended by 91 participants of very diverse backgrounds. From this meeting, the Pacific Northwest Native Freshwater Mussel Workgroup was founded. The goal of the Workgroup is to "ensure that freshwater mussel research, management, and educational activities are coordinated, prioritized, and are consistent with identified information needs." The Workgroup will meet at least four times annually. Recent accomplishments are the establishment of a website (<http://columbiariver.fws.gov/musselwlg.htm>), the planning of two mussel educational courses scheduled for next year in Portland, OR and Ellensburg, WA, and the planning of the second annual mussel workshop. This workshop will be held in western Washington with the purpose of continuing discussion on the status of freshwater mussel research, management, and education. The annual workshop will rotate throughout the Pacific Northwest to ensure maximum participation and information distribution. The Workgroup intends to raise the awareness of the status of freshwater mussels and assure that the mollusk knowledge base continues to build.

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THE EFFECTS OF FOREST HARVEST GAPS ON CLICK BEETLE (COLEOPTERA: ELATERIDAE) COMMUNITIES INHABITING COARSE WOODY DEBRIS IN MAINE, USA

Although insects are an important component of forest ecosystems, little is known about the effects of forest management practices on insect communities. We therefore examined how click beetle communities in a mixed hardwood-softwood forest in Maine, USA, are affected by small and large gap harvesting in

the Forest Ecosystem Research Project (FERP). The FERP harvest regime creates gaps in the canopy based on natural disturbance patterns in the Acadian forest. It therefore produces differences in micro-environmental conditions to which insects might respond. Specifically, we compared the differences in community composition of click beetles (Elateridae: Coleoptera) between harvested gaps and the unharvested portions of the stand. We used emergence traps during the summers of 2001 and 2002 to capture adult click beetles as they emerged from down coarse woody debris (CWD). We collected over thirty species and found that community composition between sites was significantly affected by microhabitat variables such as CWD type (softwood vs. hardwood), decay class, and placement relative to harvest gap exposure. While there was a significant overall response to some of the variables, the significant species by habitat variable interactions suggested that not all species responded similarly. The most abundant species were then analyzed separately to clarify the differences between species in response to the habitat variables and their interactions. In addition to the results obtained for overall responses across taxa, size of CWD was significant for certain species. Forest management that incorporates sustainability and conservation objectives requires knowledge of the effects of harvesting on forest species. This study therefore contributes to successful conservation of forest insects and the vertebrates that depend on them.

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INDIRECT EFFECTS OF MARINE RESERVES ON SEVERAL SPECIES OF SNAILS, SMALL CRABS AND SCALLOPS IN SAN JUAN CHANNEL, WASHINGTON

In 1990, two marine reserves were established in San Juan Channel, Washington, with the goal of protecting bottomfish from harvest. The goal of this study was to explore the indirect effects that these reserves are having on small, non-target invertebrates. I studied several snail, crab and scallop species by comparing population densities and individual sizes between paired reserve and non-reserve locations. At one location, one of the snail species (*Trichotropis* spp.) and scallops (*Chalmys* spp.) existed in higher densities in the reserve than in its paired non-reserve. These responses may be due to interactions with small fishes, which are eaten by large fishes and are predators on and competitors with the snails and scallops. At the same location, the size-frequency distribution of all small crabs pooled was found to be skewed to smaller sizes in the reserve area than in the non-reserve area, probably due to an increase in large fishes in the reserve. These results support the hypothesis that marine reserves designed to protect large fishes can have indirect effects on some facets of the invertebrate community, although the effects may not be seen universally among all species or at all sites.

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TROPICAL DUNG BEETLES, SEED DISPERSAL, AND THE CONSERVATION OF ECOSYSTEM PROCESSES

Seed dispersal is regarded as one of the most important processes in maintaining tropical forests. Seeds from tropical fruiting trees ingested and defecated on the soil surface by primary dispersers, such as primates, are vulnerable to destruction from rodents, insects, and fungi. Burial by dung beetles as an incidental result of their feeding and nesting activities often contributes to germination success. Habitat disturbance has a profound effect on the dung beetle communities involved in this process. In this paper, I present data from a long-term study of dung beetle communities across the Amazon Basin. With increasing levels of disturbance, species richness, abundance, and biomass of dung beetles declines, with the greatest impact seen in clear-cut areas. Furthermore, different Amazonian habitats contained vastly different beetle guild structures, a finding that has profound implications for seed fate. Beetles that bury seeds deeply and in a clumped distribution were more dominant in the fauna of terra firma forests and beetles that bury seeds in a scattered, shallow pattern were a greater part of the biomass in inundated várzea areas. Because disturbed areas have fewer beetles, and a guild structure that is dominated by large nocturnal buriers, small seeds deposited in these areas will be at risk of being buried too deeply for germination. In addition to habitat destruction in the Amazon, overhunting of large vertebrates will contribute to the decline of the dung beetle fauna.

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INSECT DOMINATED SAND COMMUNITIES OF THE CONNECTICUT RIVER VALLEY

Open sand communities, because they lack appreciable plant cover and are largely devoid of birds and other taxa that are commonly the focus of conservation efforts, have been neglected in conservation planning in the Northeast. Inland dunes, sandplains, blowouts, erosional banks, and other sandy communities are home to hundreds of invertebrate species in the Northeast, some of which (such as the Dune Ghost Tiger Beetle, Cicindela lepida) sit at the brink of extirpation in the region. We record 323 species of mostly holometabolous insects from 14 examples of these communities in the Connecticut River Valley of Connecticut and Massachusetts, many of which are open sand specialists. The five most species rich families encountered in our surveys were the Carabidae or ground beetles (S=62), Sphecidae or digger wasps (S=49), Formicidae or ants (S=41), Halictidae or sweat bees (S=26), and Pompilidae or spider wasps (S=25). More than a dozen state records were added as a result of our surveys; several taxa, especially among the hymenopteran families Sphecidae, Pompilidae, and Andrenidae, are believed to represent regional records, i.e., major range extensions; one scythridid, one coleophorid (both Lepidoptera) and one bombyliid (Diptera) represent undescribed species. The scythridid is presently known only from Turner Falls Airport, Montague, MA. The results of our three-year survey provide only a glimpse of the species diversity and importance of these communities. More biotic inventory is urgently needed to adequately assess their uniqueness and develop an understanding of which taxa are likely to be most imperiled. Because sand is an important construction material and there are but modest geological deposits in the inland areas of New England, many of the sites sampled in this survey are in imminent danger of mining and development. Moreover, many of the region's sand communities in public ownership are threatened by succession, invasive species, and excessive ATV traffic. In sum, these are rich, unique, trophically complex, insect-dominated communities worthy of considerably more study and attention from land managers, town planners, and others concerned with preserving the region's biodiversity.

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**HYMENOPTERAN CONSERVATION GENETICS:
BEES AS INDICATORS FOR MONITORING
ECOSYSTEM HEALTH**

*B*ees are keystone taxa in almost all terrestrial ecosystems and their conservation is of prime importance. Pollination deficits in natural and agricultural systems suggest negative trends in many bee populations, increasing the urgency to develop conservation theory and actions specifically for them, as haplodiploidy renders most conservation genetic theory unsuitable. Here we show that small bee populations are particularly susceptible to endangerment for genetic reasons. We show that specialist bees, ones that collect pollen and nectar from one or a few closely-related plant species, tend to persist in smaller, more isolated populations than generalist bees, resulting in significantly lower levels of genetic variation. Following expectations from neutral theory, we show that the reduction in the effective population size (N_e) of specialist bees, when compared to generalist bees, can reach an order of magnitude. As a consequence of the sex determination system in the Hymenoptera, reductions in N_e in small and/or isolated bee populations will lead to the production of sterile diploid males. We present data on high levels of diploid male production, and low N_e , in two apparently common bees (*Euglossa imperialis*, and *Halictus poeyi*). We propose that bees, and other Hymenoptera, are particularly susceptible to endangerment due to genetic, in addition to demographic, causes, and show that diploid male production is a useful parameter to indicate small bee populations in need of conservation. We argue that levels of diploid males in hymenopteran populations are a good indicator of “ecosystem health.”

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Wolfe, Amy	WEST VIRGINIA CRAYFISH DATABASE: A TOOL TO MONITOR THREATENED SPECIES AND PLAN SUCCESSFUL REINTRODUCTION OF THREATENED AND EXTIRPATED SPECIES	F3	Jeong, Jooha
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Wu, Ting	THE PHYLOGENY AND BIOGEOGRAPHY OF THREATENED SPIDERS IN ENDANGERED HABITATS	TES10	Marshall, Samuel D.
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