

INSECTA MUNDI

A Journal of World Insect Systematics

0261

Comparison of three collection techniques for capture of Coleoptera,
with an emphasis on saproxylic species, in Great Smoky Mountains
National Park, USA

Michael L. Ferro

Louisiana State Arthropod Museum, Department of Entomology
Louisiana State University Agricultural Center
402 Life Sciences Building
Baton Rouge, LA, 70803, U.S.A.
spongymesophyll@gmail.com

Matthew L. Gimmel

Division of Entomology
Department of Ecology & Evolutionary Biology
University of Kansas
1501 Crestline Drive, Suite 140
Lawrence, KS, 66045, U.S.A.
phalacrid@gmail.com

Kyle E. Harms

Department of Biological Sciences
Louisiana State University
202 Life Sciences Building
Baton Rouge, LA, 70803, U.S.A.
kharms@lsu.edu

Christopher E. Carlton

Louisiana State Arthropod Museum, Department of Entomology
Louisiana State University Agricultural Center
402 Life Sciences Building
Baton Rouge, LA, 70803, U.S.A.
ccarlton@agcenter.lsu.edu

Date of Issue: November 30, 2012

M. L. Ferro, M. L. Gimmel, K. E. Harms and C. E. Carlton
Comparison of three collection techniques for capture of Coleoptera, with an emphasis on
saproxylic species, in Great Smoky Mountains National Park, USA
Insecta Mundi 0261: 1–31

Published in 2012 by

Center for Systematic Entomology, Inc.
P. O. Box 141874
Gainesville, FL 32614-1874 USA
<http://www.centerforsystematicentomology.org/>

Insecta Mundi is a journal primarily devoted to insect systematics, but articles can be published on any non-marine arthropod. Topics considered for publication include systematics, taxonomy, nomenclature, checklists, faunal works, and natural history. **Insecta Mundi** will not consider works in the applied sciences (i.e. medical entomology, pest control research, etc.), and no longer publishes book reviews or editorials. **Insecta Mundi** publishes original research or discoveries in an inexpensive and timely manner, distributing them free via open access on the internet on the date of publication.

Insecta Mundi is referenced or abstracted by several sources including the Zoological Record, CAB Abstracts, etc. **Insecta Mundi** is published irregularly throughout the year, with completed manuscripts assigned an individual number. Manuscripts must be peer reviewed prior to submission, after which they are reviewed by the editorial board to ensure quality. One author of each submitted manuscript must be a current member of the Center for Systematic Entomology.

Managing editor: Paul E. Skelley, e-mail: insectamundi@gmail.com

Production editors: Michael C. Thomas, Brian Armitage, Ian Stocks

Editorial board: J. H. Frank, M. J. Paulsen

Subject editors: G.B. Edwards, J. Eger, A. Rasmussen, F. Shockley, G. Steck, Ian Stocks, A. Van Pelt, J. Zaspel

Spanish editors: Julieta Brambila, Angélico Asenjo

Printed copies (ISSN 0749-6737) deposited in libraries of:

CSIRO, Canberra, ACT, Australia
Museu de Zoologia, São Paulo, Brazil
Agriculture and Agrifood Canada, Ottawa, ON, Canada
The Natural History Museum, London, Great Britain
Muzeum i Instytut Zoologiczny PAN, Warsaw, Poland
National Taiwan University, Taipei, Taiwan
California Academy of Sciences, San Francisco, CA, USA
Florida Department of Agriculture and Consumer Services, Gainesville, FL, USA
Field Museum of Natural History, Chicago, IL, USA
National Museum of Natural History, Smithsonian Institution, Washington, DC, USA
Zoological Institute of Russian Academy of Sciences, Saint-Petersburg, Russia

Electronic copies (On-Line ISSN 1942-1354, CDROM ISSN 1942-1362) in PDF format:

Printed CD mailed to all members at end of year.

Florida Center for Library Automation: <http://purl.fcla.edu/fcla/insectamundi>

University of Nebraska-Lincoln, Digital Commons: <http://digitalcommons.unl.edu/insectamundi/>

Goethe-Universität, Frankfurt am Main: <http://nbn-resolving.de/urn/resolver.pl?urn:nbn:de:hebis:30:3-135240>

Author instructions available on the *Insecta Mundi* page at:

<http://www.centerforsystematicentomology.org/insectamundi/>

Copyright held by the author(s). This is an open access article distributed under the terms of the Creative Commons, Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original author(s) and source are credited. <http://creativecommons.org/licenses/by-nc/3.0/>

Comparison of three collection techniques for capture of Coleoptera,
with an emphasis on saproxylic species, in Great Smoky Mountains
National Park, USA

Michael L. Ferro

Louisiana State Arthropod Museum, Department of Entomology
Louisiana State University Agricultural Center
402 Life Sciences Building
Baton Rouge, LA, 70803, U.S.A.
spongymesophyll@gmail.com

Matthew L. Gimmel

Division of Entomology
Department of Ecology & Evolutionary Biology
University of Kansas
1501 Crestline Drive, Suite 140
Lawrence, KS, 66045, U.S.A.
phalacrid@gmail.com

Kyle E. Harms

Department of Biological Sciences
Louisiana State University
202 Life Sciences Building
Baton Rouge, LA, 70803, U.S.A.
kharms@lsu.edu

Christopher E. Carlton

Louisiana State Arthropod Museum, Department of Entomology
Louisiana State University Agricultural Center
402 Life Sciences Building
Baton Rouge, LA, 70803, U.S.A.
ccarlton@agcenter.lsu.edu

Abstract. Collection methods and/or habitats sampled influence how many and which species are captured during entomological surveys. Here we compare Coleoptera catches among three survey activities, each using a single collection method, at the same study sites in Great Smoky Mountains National Park, USA. Activities included: short-term flight intercept trapping (FITs); sifting/Berlese funneling of leaf litter and extremely decayed downed coarse woody debris; and using emergence chambers containing coarse woody debris of various decay classes. In total, 2472 adult beetle specimens, representing 217 lowest identifiable taxa within 164 genera and 42 families, were collected during the FIT survey. Each survey activity yielded more than 2000 specimens, and a combined total of 413 species was collected. A combination of all surveys yielded the highest species richness when normalized for number of specimens indicating that variation of habitat and/or collection method significantly increases species richness. Of single surveys the FIT survey had the highest absolute species richness (217) and the highest richness when normalized for number of specimens. Species overlap among survey activities was low (Sorensen's quotient of similarity was 0.20–0.27), which showed that each was about equally dissimilar from all others. Overlap of catch between FITs and emergence chambers was too low to justify substitution of emergence surveys with the FIT survey protocol used when attempting to collect saproxylic Coleoptera.

Introduction

Concerning conservation of biodiversity, Aldo Leopold (1949) once admonished, “To keep every cog and wheel is the first precaution of intelligent tinkering.” However, from a practical standpoint, an inventory of the “cogs” and “wheels” (species) at a location, in a community, or within a habitat can be quite daunting, especially for entomologists. The large number and similarity of many species, difficulty of identification of immature forms, relatively short adult life spans, wide variety of micro-niches, and apparent scarcity of some species all contrive to make full inventories difficult.

Habitat and collection method have a major influence over which species and how many specimens are collected. Hammond (1990), in his overview of early results from Project Wallace, where more than 1,000,000 tropical beetle specimens were collected using a wide variety of techniques, reported that 60% of species were collected from only one type of sample. Siitonen (1994) found that window traps collected more saproxylic beetle species associated with a wider variety of habitats than subcortical hand sampling in a northern Finland forest. Hammond (1997) found that window traps and emergence collections showed taxon bias when used to collect arthropods in a Canadian forest. Window traps collected 204 beetle species whereas emergence collected 161 and a 42% overlap of species between the two surveys was documented. Ranius and Jansson (2002) surveyed beetles in hollow oaks using pitfall traps, window traps, and hand searching through wood mold. They found significant differences in catch among the three collection methods despite limiting themselves to a very specific habitat that occupies a relatively small volume. Window traps collected a greater number and wider variety (based on micro-habitat group) of species, but under-sampled eight species compared to the other methods. Touroult et al. (2010) compared seven methods used to collect longhorn beetles (Cerambycidae) in French Guiana. They found that time was an important factor in determining the efficiency of methods; emergence and flight intercept trapping (FIT) was most efficient during long studies, whereas direct collection (beating, hand collection) was most efficient during very short studies.

Species inventories and other comparative research are generally conducted by obtaining specimens (physical or observational) through “collecting” or “sampling” and here we differentiate the two activities. Collecting is a broad term for procuring specimens in any fashion or variety of fashions. It may be systematic, standardized, haphazard, eclectic, or serendipitous. Often specimens or groups of specimens obtained through collecting cannot be compared in any statistical sense to other groups, but this does not reduce the value of non-standardized collecting, which is vitally important for inventories, exploration of microhabitats, and obtaining specimens for taxonomic use.

However, often due to the nature of the question being asked, collecting *sensu lato* may not be appropriate and sampling, a type of collecting, must be employed. A sample is the subset representative of a larger set of entities (known as the “target statistical population”) (Dauffy-Richard et al. 2009). A sample is more than the specimens obtained; it also contains information important for standardization (e.g., concerning scale, technique, effort, etc.) so that samples can be compared with one another, and meaningful statements, such as extrapolations, can be made about a total. Samples also help to overcome collector bias. Conducting appropriate ecological studies without “sampling” may be impossible, and for the remainder of this study the term “sample” is used in this strict sense.

These designations are meant to emphasize that general collecting and sampling are both important tools but are generally appropriate for answering different questions. Nageleisen and Bouget (2009, and chapters therein) provided an excellent overview of general considerations and techniques used for conducting inventories of insects in forests. They emphasized the need to develop *a priori* a sampling protocol designed to answer the specific question being asked. Additionally they stressed that observations should be, above all, biologically meaningful, and that any sampling design and statistics should be based on the question being asked, not vice versa.

Concurrent research conducted at six sites in Great Smoky Mountains National Park (GSMNP), Tennessee, provided a unique opportunity to compare surveys used to inventory Coleoptera. Ferro et al. (2012a) surveyed Coleoptera in two habitats (or sub/meso-habitats within the greater “forest habitat”), leaf litter and hardwood coarse woody debris decay class V, using a sifting/Berlese funneling (sifting/Berlese) collection method. Three samples of each substrate were taken at each location during fall of 2006 and again spring 2007 (total of 12 samples at each site). They collected a total of 2069 specimens

and 128 species from both habitats combined at the two sites (Porters Creek and Greenbrier) surveyed during this study.

Ferro et al. (2012b) used emergence chambers to survey saproxylic Coleoptera emergent from the general woody debris habitat. Three samples of each of the following were taken at each study site during April 2006: fine woody debris decay class I and decay class II; coarse woody debris decay class I; decay class II; and decay classes III and IV combined (total of 15 samples at each site). Each sample consisted of enough substrate to fill a 68-L emergence chamber three-fourths of its capacity. Chambers were sealed and specimens emergent from dead wood were collected over a two year period. They collected a total of 2630 specimens and 190 species at the two sites (Porters Creek and Greenbrier) surveyed during this study.

The purpose of this research was to compare Coleoptera obtained from a survey using short-term FITs with those from sifting/Berlese and emergence surveys. A secondary goal was to determine whether short-term FITs could be substituted for emergence when attempting to collect saproxylic Coleoptera.

Material and Methods

Study Area. Great Smoky Mountains National Park was established in 1934, named as an International Biosphere Reserve in 1976, and a World Heritage Site in 1983. It encompasses 211,000 ha (521,490 acres) in Tennessee and North Carolina, USA. Five major forest communities are recognized in the park, though 80% may be broadly classified as eastern deciduous forest (Houk and Collier 1993). The eastern half of the park contains the largest remaining tract of old growth forest in the eastern U.S. (Davis 1996). See Ferro et al. (2012b) for more details.

Study Sites. Overstory vegetation data were obtained from Madden (Geospatial Dataset-1047498), and understory vegetation data were obtained from Madden (Geospatial Dataset-1047499); see Welch et al. (2002) and Madden et al. (2004) for a description of how data were collected. Geology data were obtained from National Park Service (2006). Vegetation disturbance history data were obtained from National Park Service (2007). Data on forest type in 1938 were obtained from National Park Service (2009). Three locations within each study site were surveyed using a point relascope sampling technique (Brissette et al. 2003; Gove et al. 1999). Findings were averaged to obtain volume of CWD per hectare at each study site.

Collections took place at two locations in GSMNP:

1) Porters Creek (TN: Sevier Co.: N35°40.790' W83°23.855'). The site was on Thunderhead Sandstone, has an acid cove forest overstory, and a medium rhododendron understory. Vegetation disturbance was light cut and during a 1938 survey this location was designated as cove hardwood. Coarse woody debris volume was 290 m³/ha. Because of the history of minimal disturbance this site is referred to as "primary forest."

2) Greenbrier (TN: Sevier Co.: N35°43.147' W83°23.349'). The site was on Roaring Fork Sandstone, has a successional hardwood overstory, and an herbaceous/deciduous understory. Vegetation disturbance was settlement class and during a 1938 survey this location was designated as grassland. Coarse woody debris volume was 143 m³/ha. Because of the history of disturbance (heavily logged) this site is referred to as "secondary forest."

Sampling. Three ground-level FITs (see Schauuff 2001 for basic design) were erected at each site on 1 July 2007 and removed on 8 July 2007. Each trap consisted of a vertical mesh pane 1 m high and 3 m long, a plastic horizontal rain fly 1 m wide and 3 m long, and eight collection containers with a combined collection surface of 1830 cm². Propylene glycol antifreeze (Prestone® Low Tox™ brand) was used as a killing and preserving agent. Position of traps was based on convenience, not based on proximity to snags or logs. Timing of sampling was based on anecdotal observations that FIT trapping is better in summer than spring or fall.

Adult Coleoptera were pinned or pointed as needed and labeled. Identification to the finest level possible (typically species) was performed with the appropriate taxonomic literature (primarily Arnett

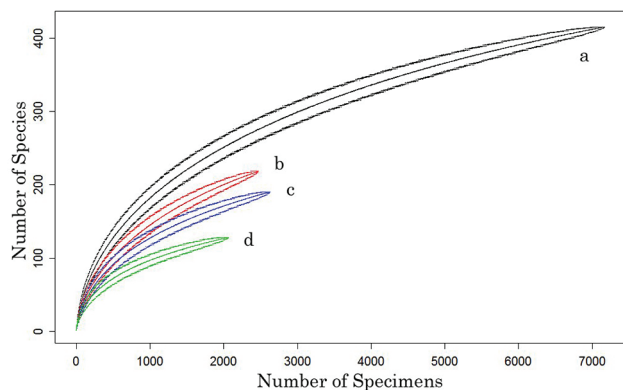


Figure 1. Species accumulation curves for a: all survey activities combined; b: FIT activity; c: emergence activity; d: sift/Berlese activity.

average curve and its 95% confidence limits were derived from the simulations, and a significant deviation from the simulated average occurred when an observed value fell outside the confidence interval. Each rarefaction curve is shown with a combination of these three lines and an average curve that lies outside the confidence interval of another curve can be considered different at least at the $\alpha = 0.05$ level.

Capture similarity was assessed using Sorensen's quotient of similarity (Southwood 1978).

Results

In total, 2472 adult beetle specimens, representing 217 lowest identifiable taxa within 164 genera and 42 families, were collected during the FIT survey. Of the 217 lowest identifiable taxa, 8 were identifiable only to family or tribe, 48 were identifiable only to genus, and 162 were identified to species (Appendix 1). Groups only identified to family, tribe, or genus may contain multiple species. For the remainder of the results and discussion all lowest identifiable taxa will be referred to as "species" in an attempt to reduce jargon and increase readability.

Staphylinidae were, by a wide margin, the most species rich family collected from the FIT survey with 66 species, followed by Leiodidae (25 spp.), Elateridae (11 spp.), and Curculionidae (10 spp.). Sixteen families were represented by a single species. Five species were represented by more than 100 specimens, and 87 species (40%) were singletons.

At the Porters Creek site 1393 adult beetle specimens, representing 131 species within 107 genera and 34 families, were collected. At the Greenbrier site 1079 adult beetle specimens, representing 160 species within 126 genera and 34 families, were collected.

Species richness based on species accumulation curve comparisons (Fig. 1) was highest for all surveys combined, followed by FIT, emergence, and lastly sifting/Berlese. All were significantly different from one another.

Sorensen's quotient of similarity for collection methods showed least similarity between sifting/Berlese and FIT (0.20), intermediate similarity between sifting/Berlese and emergence (0.22), and highest similarity between emergence and FIT (0.27).

Discussion

All surveys combined yielded 413 beetle species. The FIT survey collected 2472 specimens and 217 beetle species, compared to 2630 specimens and 190 species from the previous emergence survey (Ferro et al. 2012b), and 2069 specimens and 128 species from the previous sifting/Berlese survey (Ferro et al. 2012a) (Appendix 1). Emergence and FIT surveys shared the most species (55, 16%) while sifting and FIT surveys shared the fewest species (34, 11%) (Fig. 2). Only 15 species (4%) were collected in all three surveys. In total 80% of species were collected in only a single survey activity. Hammond (1990) reported 60% of beetle species collected from a single collection type, but collected many more specimens (1,000,000+) and used a wider variety of survey activities.

and Thomas (2001) and Arnett et al. (2002) and references therein, plus additional literature as needed), and/or comparison with authoritatively identified reference specimens. Specimens are deposited in the Louisiana State Arthropod Museum (LSAM), LSU AgCenter, Baton Rouge, Louisiana, and Great Smoky Mountains Natural History Museum (GSMNP), Gatlinburg, Tennessee.

Data analysis. Individual-based rarefaction curves were used to compare species richness among surveys (Gotelli and Colwell 2001). Curves were constructed using code developed by MLF and KEH and run in the R programming environment (R Development Core Team 2010). For each subset, 1000 rarefaction curves were created, an

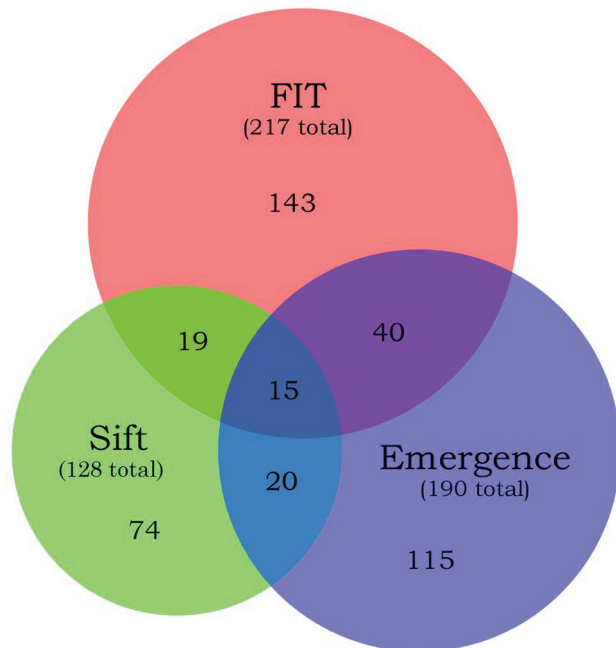


Figure 2. Species overlap among survey activities. Size of circle is proportional to species richness.

multiple collection techniques showed that *L. pertenuis* may be found in a various places, but that it is most abundant in CWD. In contrast *Cercyon occallatus* (Say) (Hydrophilidae) is represented by four specimens collected by sifting, one emergent from CWD, and 385 collected with FITs. The large number of specimens collected with FITs shows that *C. occallatus*, while also collected in a variety of places, is not a general leaf litter dweller or associated with CWD, but must be spending its time elsewhere.

Myrmedonota n. sp. (Staphylinidae) offers an interesting mystery. In total, 282 specimens were collected from both sites with FITs, but no specimens were collected from leaf litter or dead wood. A short adult life span or specificity of microhabitat (e.g. particular fungi, etc.) may explain this interesting observation, but until specimens are collected from a particular substrate, explanations will remain speculative. Without FIT collections this apparently abundant undescribed species would have remained overlooked.

Saproxylic Coleoptera. Other researchers (Siitonen 1994; Hammond 1997) reported a wide overlap of saproxylic beetle species between flight intercept traps and other collection methods. However, their intercept traps were generally much smaller and placed immediately against target habitat such as snags. Additionally they trapped over a much longer period time, up to eight months over a two year period.

Within this research, most families with a high proportion of saproxylic species were poorly represented in the FIT survey compared to the emergence survey. However, Leiodidae, Mordellidae, and Nitidulidae, families with some saproxylic species, were better represented in the FIT survey than either emergence or sifting/Berlese surveys (Appendix 1). Overlap of catch between the FIT and emergence surveys was too low to justify substitution. Therefore, a survey composed of the FIT collection protocol used in this research is not an effective alternative to emergence surveys when attempting to collect saproxylic Coleoptera.

Related Research. This publication represents a portion of a larger body of research, specifically the Coleoptera component of the All Taxa Biodiversity Inventory at GSMNP (Carlton and Bayless 2007). See Ferro et al. (2012b) for a list of publications resultant from this research.

The species accumulation curve for all surveys combined was significantly higher than any single survey. The individual influences of either habitat or collection method cannot be assessed based on this study, but it is clear that variation of those factors significantly increases species richness.

Of individual surveys, the FIT survey collected significantly higher species richness than any other survey (Fig. 1). However, surveys had low similarity, ranging from 0.20 to 0.27, which showed that each was about equally dissimilar from all others. Therefore, substitution of one survey for another would be ineffective at recovering similar species.

Application of Survey Comparisons. Use of multiple collection techniques and collection from multiple habitats at a single site offers an opportunity to compare techniques, and provides rudimentary natural history and ecological information about the taxa collected. *Leptoplectus pertenuis* (Casey) (Staphylinidae) is represented by three specimens collected by sifting, 39 emergent from CWD, and two collected in FITs. Mul-

Conclusion

An accurate survey of the Coleoptera in a given area is difficult owing to the wide variety of species and their habits. The three separate surveys using different collection methods and targeting different habitats resulted in the total collection of 7171 specimens and 413 beetle species at two sites in GSMNP. However, there was very little overlap in catch among surveys, indicating that various survey types would increase catch richness, and that substitution of one survey type for another will not yield similar species.

Acknowledgments

We thank Victoria Bayless and Stephanie Gil for help in the Louisiana State Arthropod Museum. We thank Robert Anderson (Canadian Museum of Nature) for Curculionidae identifications, Stephanie Gil (Louisiana State University) for Corylophidae identifications, W. Eugene Hall (University of Colorado) for Ptiliidae identifications, Jong-Seok Park (Louisiana State University), Alfred Newton and Margaret Thayer (Field Museum of Natural History), and Lee Herman (American Museum of Natural History) for Staphylinidae identifications, Robert Rabaglia (Maryland Department of Agriculture) for Scolytinae identification, Igor Sokolov for Carabidae identifications, and Alexey Tishechkin (Santa Barbara Museum of Natural History) for Histeridae identifications. We thank Michael and Marilynn Ferro for help with servicing and recovery of the FITs. We thank Heather Bird Jackson (Carleton University) for her help with R code. We thank Chuck Cooper, Jeanie Hilten, Michael Kunze, Keith Langdon, Adriean Mayor, Becky Nichols, and Chuck Parker for assistance in GSMNP. We thank Katherine Parys (Louisiana State University) and Marguerite Madden (University of Georgia) for help with GIS applications and characterizations of the study sites. Janice Bossart and Arnold Van Pelt reviewed this manuscript and provided valuable comments. This publication was approved by the Director, Louisiana Agricultural Experiment Station as manuscript number 2012-234-7273. This project was funded in part by National Science Foundation NSF DEB-0516311 to Christopher Carlton and Victoria Bayless and the Discover Life in America minigrants program.

Literature Cited

- Arnett, R. H., Jr., and M. C. Thomas (eds.). 2001.** American beetles. Volume 1. CRC Press; Boca Raton, FL. ix + 443 p.
- Arnett, R. H., Jr., M. C. Thomas, P. E. Skelley, and J. H. Frank (eds.). 2002.** American beetles. Volume 2. Polyphaga: Scarabaeoidea through Curculionoidea. CRC Press; Boca Raton, FL. xiv + 861 p.
- Brissette, J. C., M. J. Ducey, and J. H. Gove. 2003.** A field test of point relascope sampling of down coarse woody material in managed stands in the Acadian Forest. *Journal of the Torrey Botanical Society* 130: 79–88.
- Carlton, C. E., and V. Bayless. 2007.** Documenting beetle (Arthropoda: Insecta: Coleoptera) diversity in Great Smoky Mountains National Park: beyond the halfway point. *Southeastern Naturalist Special Issue 1*: 183–192.
- Bouchard, P., Y. Bousquet, A. E. Davies, M. A. Alonso-Zarazaga, J. F. Lawrence, C. H. C. Lyal, A. F. Newton, C. A. M. Reid, M. Schmitt, S. A. Ślipiński, and A. B. T. Smith. 2011.** Family-group names in Coleoptera (Insecta). *Zookeys* 88: 1–972.
- Dauffy-Richard, E., P. Bonneli, and C. Bouget. 2009.** Designing an inventory: how should a sampling plan be defined? p. 15–32. *In*: L. M. Nageleisen, and C. Bouget (eds.). *Forest insect studies: methods and techniques. Key considerations for standardization. An overview of the reflections of the “Environmental Forest Inventories” working group (Inv. Ent. For.)*. Office National des Forêts, Les Dossiers Forestiers 19: 1–144.
- Davis, M. B. (ed.). 1996.** Eastern old-growth forests: prospects for rediscovery and recovery. Island Press; Washington, D. C. 383 p.

- Ferro, M. L., M. L. Gimmel, K. E. Harms, and C. E. Carlton. 2012a.** Comparison of the Coleoptera communities in leaf litter and rotten wood in Great Smoky Mountains National Park, USA. *Insecta Mundi* 259: 1–58.
- Ferro, M. L., M. L. Gimmel, K. E. Harms, and C. E. Carlton. 2012b.** Comparison of Coleoptera emergent from various decay classes of downed coarse woody debris in Great Smoky Mountains National Park, USA. *Insecta Mundi* 260: 1–80.
- Gotelli, N. J., and R. K. Colwell. 2001.** Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. *Ecology Letters* 4: 379–391.
- Gove, J. H., A. Ringvall, G. Stahl, and M. J. Ducey. 1999.** Point relascope sampling of downed coarse woody debris. *Canadian Journal of Forest Research* 29: 1718–1726.
- Hammond, H. E. J. 1997.** Arthropod biodiversity from *Populus* coarse woody material in north-central Alberta: a review of taxa and collection methods. *The Canadian Entomologist* 129: 1009–1033.
- Hammond, P. M. 1990.** Insect diversity and abundance in the Dumoga-Bone National Park, N. Sulawesi, with special reference to the beetle fauna of lowland rainforest of Toraut region. p. 197–254. *In*: W. J. Knight, and J. D. Holloway (eds.). *Insects and the rain forests of South East Asia* (Wallacea). The Royal Entomological Society; London. 343 p.
- Houk, R., and M. Collier. 1993.** Great Smoky Mountains National Park—a natural history guide. Houghton Mifflin Co.; New York. 227 p.
- Leopold, A. 1949.** A Sand County almanac, and sketches here and there. Oxford University Press; New York. 226 p.
- Madden, D. [No Date]. Geospatial Dataset-1047498.** Overstory vegetation at Great Smoky Mountains National Park, Tennessee and North Carolina. The Center for Remote Sensing and Mapping Science, University of Georgia. <http://nrinfo.nps.gov/Reference.mvc/Profile?Code=1047498> [accessed online 25 August 2011]
- Madden, D. [No Date]. Geospatial Dataset-1047499.** Understory vegetation at Great Smoky Mountains National Park, Tennessee and North Carolina. The Center for Remote Sensing and Mapping Science, University of Georgia. <http://nrinfo.nps.gov/Reference.mvc/Profile?Code=1047499> [accessed online 25 August 2011]
- Madden, M., R. Welch, T. Jordan, P. Jackson, R. Seavey, and J. Seavey (CMRS, Department of Geography, University of Georgia, Athens, GA). 2004.** Digital vegetation maps for the Great Smoky Mountains National Park. Final report 15 Jul 2004. Gatlinburg, TN: U.S. Department of Interior, National Park Service, Great Smoky Mountains National Park. Cooperative Agreement No. 1443-CA-5460-98-019: 1–44.
- Nageleisen, L. M., and C. Bouget (eds.). 2009.** Forest insect studies: methods and techniques. Key considerations for standardization. An overview of the reflections of the “Environmental Forest Inventories” working group (Inv.Ent.For.). Office National des Forests. *Les Dossiers Forestiers* no. 19: 1–144.
- National Park Service, Geologic Resources Inventory Program. 2006.** Digital geologic map of Great Smoky Mountains National Park and vicinity, Tennessee and North Carolina (NPS, GRD, GRE, GRSM). NPS Geologic Resources Inventory Program. Lakewood, CO. Geospatial Dataset-1041729. <http://nrinfo.nps.gov/Reference.mvc/Profile?Code=1041729> [accessed online 25 August 2011]
- National Park Service, Great Smoky Mountains National Park. 2007.** Vegetation disturbance history at Great Smoky Mountains National Park, Tennessee and North Carolina. National Park Service, Great Smoky Mountains National Park, Resource Management and Science. Geospatial Dataset-1045868. <http://nrinfo.nps.gov/Reference.mvc/Profile?Code=1045868> [accessed online 25 August 2011]
- National Park Service, Great Smoky Mountains National Park. 2009.** Polygon feature class of Frank Miller’s detailed 1938 forest types map at Great Smoky Mountains National Park, Tennessee and North Carolina. National Park Service, Great Smoky Mountains National Park, Resource Management and Science. Geospatial Dataset-1048239. <https://nrinfo.nps.gov/Reference.mvc/Profile?Code=1048239> [accessed online 25 August 2011]

- R Development Core Team. 2010.** R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. <http://cran.r-project.org/doc/manuals/full-refman.pdf> (accessed online 18 July 2010).
- Ranius, T., and N. Jansson. 2002.** A comparison of three methods to survey saproxylic beetles in hollow oaks. *Biodiversity and Conservation* 11: 1759–1771.
- Schauff, M. E. (ed.). 2001.** Collecting and preserving insects and mites: techniques and tools. Updated and modified WWW version of: G. C. Steyskal, W. L. Murphy, and E. H. Hoover (eds.). 1986. *Insects and mites: techniques for collection and preservation*. Agricultural Research Service, USDA, Miscellaneous Publication 1443: 1–103. Available from www.ars.usda.gov/Main/site_main.htm?docid=10141 (accessed online 18 July 2011).
- Siitonen, J. 1994.** Decaying wood and saproxylic Coleoptera in two old spruce forests: a comparison based on two sampling methods. *Annales Zoologici Fennici* 31: 89–95.
- Southwood, T. R. E. 1978.** *Ecological methods with particular reference to the study of insect populations*. Second Edition. Chapman and Hall; New York. 524 p.
- Touroult, J., P-H. Dalens, S. Brule, and E. Poirier. 2010.** Inventaire des longicornes: analyse de l'efficacite des techniques de collecte en Guyane. Supplement au Bulletin de liaison d'ACOREP-France "Le Coleopteriste" 1: 15–33.
- Welch, R., M. Madden, and T. Jordan. 2002.** Photogrammetric and GIS techniques for the development of vegetation databases of mountainous areas: Great Smoky Mountains National Park. *ISPRS Journal of Photogrammetry and Remote Sensing* 57: 53–68.

Received April 16, 2012; Accepted May 22, 2012.

Subject Edited by A. VanPelt.

Appendix 1. List of taxa and number of specimens collected at Greenbrier and Porters Creek sites. Sifting/Berlese data are from Ferro et al. (2012a), and emergence data are from Ferro et al. (2012b). Family names follow Bouchard et al. (2011).

SPECIES	GREENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
ADERIDAE						
1 <i>Vanonus huronicus</i> Casey	—	1	1	—	—	—
AGYRTIDAE						
2 <i>Necrophilus petiti</i> Horn	—	—	—	1	—	—
ANTHICIDAE						
3 <i>Ischalia costata</i> (LeConte)	—	—	1	—	—	1
ANTHRIBIDAE						
4 <i>Eurymycter tricarinatus</i> Pierce	—	—	1	—	—	—
ARTEMATOPODIDAE						
5 <i>Eurypogon niger</i> (Melsheimer)	—	—	—	—	—	1
BUPRESTIDAE						
6 <i>Dicerca divaricata</i> (Say)	—	1	1	—	3	—
CANTHARIDAE						
7 Cantharidae gen. sp.	—	—	—	—	—	1

	SPECIES	GREENBRIER			PORTERS CREEK		
		SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
CARABIDAE							
8	<i>Agonum ferreum</i> Haldeman	—	—	—	—	1	—
9	<i>Anilinus langdoni</i> Sokolov and Carlton	88	—	—	107	—	—
10	<i>Apenes lucidulus</i> (Dejean)	1	—	—	—	—	—
11	Carabidae gen. sp. (teneral specimen)	—	1	—	—	—	—
12	<i>Carabus goryi</i> Dejean	—	—	—	—	—	1
13	<i>Clinidium baldufi</i> Bell	—	2	—	—	2	—
14	<i>Clinidium rosenbergi</i> Bell	—	—	—	—	1	—
15	<i>Clinidium valentinei</i> Bell	3	—	—	—	—	—
16	<i>Cyclotrachelus freitagi</i> Bousquet	2	—	—	—	—	—
17	<i>Dicaelus (Paradicaelus) dilatatus</i> Say	1	—	—	—	—	—
18	<i>Gastrellarius blanchardi</i> (Horn)	—	—	—	1	—	—
19	<i>Gastrellarius honestus</i> (Say)	1	3	—	—	6	—
20	<i>Mioptachys flavicauda</i> (Say)	—	7	—	—	1	—
21	<i>Platynus parmarginatus</i> Hamilton	—	—	—	—	—	3
22	<i>Polyderis laevis</i> (Say)	—	1	—	—	—	—
23	<i>Pterostichus (Steropus) moestus</i> (Say)	—	—	—	1	—	—
24	<i>Scaphinotus (Maronetus) spp.</i>	—	—	—	3	—	—
25	<i>Serranillus</i> sp.	1	—	—	—	—	—
26	<i>Sphaeroderus stenostomus lecontei</i> Dejean	1	—	—	—	—	—
27	<i>Trechus (Microtrechus) pisgahensis</i> Barr	—	—	—	2	—	—
28	<i>Trichotichnus autumnalis</i> (Say)	1	—	—	—	—	—

SPECIES	GREENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
CERAMBYCIDAE						
29 <i>Aegomorphus modestus</i> (Gyllenhal)	—	1	—	—	—	—
30 <i>Aegomorphus quadrigibbus</i> (Say)	—	—	—	—	2	—
31 <i>Analeptura lineola</i> Say	—	4	—	—	—	—
32 <i>Astylopsis maculata</i> (Say)	—	3	—	—	—	—
33 <i>Clytus ruficola</i> (Olivier)	—	—	—	—	1	—
34 <i>Cyrtophorus verrucosus</i> (Olivier)	—	—	—	—	1	—
35 <i>Grammoptera exigua</i> (Newman)	—	1	—	—	—	—
36 <i>Graphisurus fasciatus</i> (DeGeer)	—	—	—	—	13	—
37 <i>Leptorhabdium pictum</i> (Haldeman)	—	—	—	—	2	—
38 <i>Leptostylus transversus</i> (Gyllenhal)	—	1	—	—	—	—
39 <i>Metacmaeops vittata</i> (Swederus)	—	—	—	—	—	2
40 <i>Microgoes oculatus</i> (LeConte)	—	4	1	—	10	—
41 <i>Molorchus b. bimaculatus</i> Say	—	3	—	—	—	—
42 <i>Neandra brunnea</i> (Fabricius)	—	1	—	—	1	—
43 <i>Oplosia nubila</i> (LeConte)	—	5	—	—	—	—
44 <i>Saperda vestita</i> Say	—	1	—	—	—	—
45 <i>Strangalepta abbreviata</i> (Germar)	—	1	1	—	—	—
46 <i>Trachysida mutabilis</i> (Newman)	—	1	—	—	12	—
47 <i>Tragosoma depsarium</i> (Linnaeus)	—	—	—	—	—	1
48 <i>Urgleptes querci</i> (Fitch)	—	1	—	—	—	—

SPECIES	GREENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
CERYLONIDAE						
49 <i>Cerylon castaneum</i> Say	—	—	—	—	3	—
50 <i>Cerylon unicolor</i> Ziegler	—	1	—	—	—	—
51 <i>Hypodacne punctata</i> LeConte	—	1	—	—	—	—
52 <i>Mychocerus striatus</i> (Sen Gupta and Crowson)	100	9	—	31	—	—
53 <i>Philothermus glabriculus</i> (LeConte)	—	8	—	—	16	—
54 <i>Philothermus stephani</i> Gimmel and Slipinski	—	—	—	2	—	—
CHRYSOMELIDAE						
55 <i>Altica</i> sp.	—	—	—	—	—	1
56 <i>Disonycha leptolineata</i> Blatchley	—	—	—	1	—	—
57 <i>Disonycha xanthomelas</i> (Dalman)	—	—	—	1	—	1
58 <i>Odonotota dorsalis</i> (Thunberg)	—	—	—	2	—	—
59 <i>Psylliodes appalachianus</i> Konstantinov and Tishechkin	—	—	—	6	—	21
60 <i>Rhabdopterus</i> spp. (female)	—	—	—	—	—	4
61 <i>Sumitrosis inaequalis</i> (Weber)	—	—	—	—	—	19
62 <i>Sumitrosis rosea</i> (Weber)	—	—	—	—	—	3
63 <i>Tymnes</i> sp.	—	—	1	—	—	—
CIIDAE						
64 <i>Ceracis sallei</i> (Mellie)	—	3	—	—	—	—
65 <i>Ceracis singularis</i> (Dury)	—	—	1	—	1	—
66 <i>Ceracis</i> spp.	—	4	1	—	—	—
67 <i>Ceracis thoracicornis</i> (Ziegler)	—	3	—	—	—	—

SPECIES	GRENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
68 Ciidae gen. spp.	—	—	1	—	2	—
69 <i>Cis fuscipes</i> Mellie	—	—	—	—	2	—
70 <i>Octotemnus laevis</i> Casey	—	—	—	—	42	—
71 <i>Rhopalodontus</i> sp.	—	—	—	—	1	—
CLAMBIDAE						
72 <i>Clambus</i> sp.	—	—	—	1	—	—
CORYLOPHIDAE						
73 <i>Holopsis</i> spp.	2	—	—	—	—	—
74 <i>Sericoderus</i> sp.	—	—	—	—	1	—
CRYPTOPHAGIDAE						
75 <i>Atomaria</i> spp.	—	13	—	—	7	—
76 <i>Cryptophagus</i> spp.	—	14	—	1	28	—
CUCUJIDAE						
77 <i>Cucujus clavipes</i> Fabricius	—	1	—	—	—	—
CUPEIDAE						
78 <i>Cupes capitatus</i> Fabricius	—	1	—	—	1	—

SPECIES	GRENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
CURCULIONIDAE						
79 <i>Acalles carinatus</i> LeConte	—	1	—	—	2	—
80 <i>Acalles</i> spp.	—	—	—	3	—	—
81 <i>Caulophilus dubius</i> (Horn)	6	17	—	21	3	—
82 <i>Cophes obtentus</i> (Herbst)	—	—	—	—	1	—
83 <i>Cossonus impressifrons</i> Boheman	—	3	—	—	—	—
84 Curculionidae gen. spp.	1	1	3	3	—	—
85 <i>Cyrtopistomus castaneus</i> (Roelofs)	1	—	—	—	1	—
86 <i>Dryophthorus americanus</i> Bedel	7	57	52	—	134	23
87 <i>Eurhoptus</i> n. sp.	25	—	—	—	—	—
88 <i>Eurhoptus pyriformis</i> LeConte	1	—	—	5	—	—
89 <i>Hylesinus pruniosus</i> Eichhoff	—	—	—	—	3	—
90 <i>Hylesinus</i> sp.	—	—	—	—	1	—
91 <i>Hypothenenus</i> spp.	—	3	—	—	—	1
92 <i>Lechriops oculus</i> (Say)	—	—	2	—	—	—
93 <i>Microhyus setiger</i> LeConte	—	—	—	2	—	1
94 <i>Microminus corticalis</i> Boheman	—	2	—	—	—	—
95 <i>Myosides seriehispidus</i> Roelofs	9	2	—	—	—	—
96 <i>Panscopus impressus</i> Pierce	—	—	—	1	—	—
97 <i>Stenoscelis brevis</i> (Boheman)	—	9	—	—	18	—
98 <i>Xyleborinus saxeseni</i> (Ratzeburg)	—	—	1	—	—	—
99 <i>Xyleborus affinis</i> Eichhoff	—	—	—	—	1	—
100 <i>Xyleborus atratus</i> Eichhoff	—	—	3	—	6	—

SPECIES	GREENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
101 <i>Xyleborus californicus</i> Wood	—	—	—	—	1	—
102 <i>Xyleborus ferrugineus</i> (Fabricius)	—	—	2	—	1	—
103 <i>Xylosandrus germanus</i> (Blandford)	—	—	1	—	14	6
104 <i>Xyloterinus politus</i> (Say)	—	1	17	—	2	—
DERMESTIDAE						
105 <i>Anthrenus</i> spp.	—	—	1	—	—	3
ELATERIDAE						
106 <i>Ampedus areolatus</i> (Say)	—	10	—	—	13	—
107 <i>Ampedus luteolus</i> (LeConte)	—	5	—	—	1	—
108 <i>Ampedus rubricus</i> (Say)	—	—	—	1	—	—
109 <i>Ampedus semicinctus</i> (Randall)	—	1	—	—	1	—
110 <i>Athous acanthus</i> (Say)	—	—	—	—	—	1
111 <i>Athous brightwelli</i> (Kirby)	—	—	2	—	—	1
112 <i>Athous cucullatus</i> (Say)	—	2	—	—	—	—
113 <i>Athous rufifrons</i> (Randall)	—	—	—	—	1	—
114 <i>Athous scapularis</i> (Say)	—	1	—	—	3	—
115 <i>Cardiophorus</i> sp.	—	—	1	—	—	—
116 <i>Ctenicera mimica</i> Becker	—	—	1	—	—	3
117 <i>Dalopius</i> sp.	—	—	—	1	—	—
118 Elateridae gen. spp.	—	—	1	—	—	1
119 <i>Hemicrepidius memnonius</i> (Herbst)	—	—	—	—	—	2
120 <i>Limonium aurifer</i> LeConte	—	—	1	—	—	—

SPECIES	GREENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
121 <i>Limonius griseus</i> (Beauvois)	—	—	1	—	—	—
122 <i>Limonius nimbatus</i> (Say)	1	—	—	—	—	—
123 <i>Melanotus decumanus</i> (Erichson)	—	—	—	—	1	—
124 <i>Melanotus parallelus</i> Blatchley	—	—	1	—	—	—
125 <i>Melanotus sagittarius</i> (LeConte)	—	—	1	—	—	—
126 <i>Pityobius anguinus</i> LeConte	—	—	1	—	—	—
ENDOMYCHIDAE						
127 <i>Bystus ulkei</i> (Crotch)	—	3	—	—	8	—
128 <i>Endomychus biguttatus</i> Say	—	—	1	—	2	1
129 <i>Micropsephodes lundgreni</i> Leschen and Carlton	—	1	—	—	—	—
130 <i>Mycetina perpulchra</i> (Newman)	—	—	3	—	—	—
EROTYLIDAE						
131 <i>Tritoma humeralis</i> Fabricius	—	—	—	—	—	1
132 <i>Tritoma mimetica</i> (Crotch)	—	—	2	—	—	—
133 <i>Tritoma unicolor</i> Say	1	—	1	—	—	—
EUCINETIDAE						
134 <i>Tohlezkus inexpectus</i> Vit	4	8	—	6	127	—
EUCNEMIDAE						
135 <i>Dirrhagofarsus lewisi</i> (Fleutiaux)	—	—	1	—	—	—
136 <i>Dromaeolus cylindricollis</i> (Say)	—	—	1	—	1	—
137 <i>Entomophthalmus rufolus</i> (LeConte)	—	3	—	—	—	—

SPECIES	GREENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
138 <i>Isorthis rufipes</i> (Melsheimer)	—	—	—	—	5	—
139 <i>Isorthis obliqua</i> (Say)	—	—	1	—	—	—
140 <i>Melasis pectinicornis</i> Melsheimer	—	24	—	—	—	—
141 <i>Microrhagus subsinuatus</i> LeConte	—	6	1	—	4	7
GEOTRUPIDAE						
142 <i>Geotrupes balyi</i> Jekel	—	—	2	—	—	—
143 <i>Geotrupes splendidus</i> (Fabricius)	—	—	1	—	—	—
144 <i>Odonteus liebecki</i> (Wallis)	—	—	1	—	—	—
HISTERIDAE						
145 <i>Aeletes floridae</i> (Marseul)	—	—	3	—	—	—
146 <i>Bacanius tantillus</i> LeConte	—	3	—	—	6	—
147 <i>Geomysaprinus</i> sp.	—	—	—	—	—	4
148 <i>Hololepta lucida</i> LeConte	—	—	2	—	—	—
149 <i>Margarinotus lecontei</i> Wenzel	—	—	29	—	—	84
150 <i>Onthophilus pluricostatus</i> LeConte	—	—	21	—	—	—
151 <i>Xestipyge geminatum</i> (LeConte)	—	—	2	—	—	—
HYDROPHILIDAE						
152 <i>Cercyon assecla</i> Smetana	—	1	1	—	—	8
153 <i>Cercyon occallatus</i> (Say)	—	—	88	4	1	297
154 <i>Cercyon pygmaeus</i> (Illiger)	—	—	2	—	—	1
155 <i>Cymbiodyta blanchardi</i> Horn	—	—	1	—	—	—
156 <i>Pemelus costatus</i> (LeConte)	—	—	5	—	—	—

SPECIES	GREENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
157 <i>Tectosternum naviculare</i> (Zimmermann)	—	—	1	—	—	—
LAMPYRIDAE						
158 Lampyridae gen. spp.	—	—	1	—	—	1
159 <i>Lucidota</i> spp.	—	—	—	—	4	—
160 <i>Photinus</i> spp.	—	—	—	—	—	11
LATRIDIIDAE						
161 <i>Corticarina fuscata</i> (Gyllenhal)	—	—	—	—	—	1
162 <i>Melanophthalma americana</i> (Mannerheim)	—	—	1	—	—	1
LEIODIDAE						
163 <i>Agathidium compressidens</i> Fall	—	—	—	1	—	—
164 <i>Agathidium kimberlae</i> Miller and Wheeler	1	—	—	—	—	—
165 <i>Agathidium</i> n. sp.	1	—	—	—	—	—
166 <i>Agathidium oniscoides</i> Beauvois	—	1	1	2	3	—
167 <i>Agathidium</i> spp. (female)	6	6	—	4	11	1
168 <i>Aglyptinus laevis</i> (LeConte)	1	—	—	—	—	—
169 <i>Anisotoma bifoveata</i> Wheeler	—	—	2	—	—	2
170 <i>Anisotoma blanchardi</i> (Horn)	—	—	2	—	—	—
171 <i>Anisotoma discolor</i> (Melsheimer)	—	—	1	—	—	—
172 <i>Anisotoma geminata</i> (Horn)	—	—	—	—	—	1
173 <i>Anisotoma</i> spp. (female)	—	—	3	—	—	2
174 <i>Anogdus puritanus</i> (Fall)	—	—	1	—	—	—
175 <i>Catopocerus appalachianus</i> Peck	2	—	—	2	—	—

SPECIES	GREENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
176 <i>Catopocerus</i> n. sp.	1	—	—	2	—	—
177 <i>Catopocerus</i> spp. (female)	5	1	—	8	1	—
178 <i>Catops basilaris</i> Say	—	—	—	—	—	1
179 <i>Colenis impunctata</i> LeConte	7	—	6	—	—	4
180 <i>Colon dentatum</i> LeConte	—	—	1	—	—	—
181 <i>Colon megasetosum</i> Stephan and Peck	—	—	1	—	—	1
182 <i>Colon oblongum</i> Blatchley	—	—	2	—	—	—
183 <i>Colon</i> spp. (female)	—	—	7	—	—	—
184 <i>Dissochaetus oblitus</i> Peck	—	—	1	—	—	—
185 <i>Gelae</i> spp. (female)	—	—	2	—	—	1
186 <i>Hydnobius substriatus</i> (LeConte)	1	—	—	—	—	—
187 <i>Leitodes appalachiana</i> Baranowski	—	—	1	—	—	—
188 <i>Leitodes impressa</i> Baranowski	—	—	1	—	—	1
189 <i>Liocyrtusa luggeri</i> (Hatch)	—	—	2	—	—	—
190 <i>Nemadus</i> spp. (female)	—	—	2	—	—	—
191 <i>Nemadus triangulum</i> Jeannel	—	2	—	—	—	—
192 <i>Ptomaphagus (Adelops) brevior</i> Jeannel	—	—	2	—	—	16
193 <i>Ptomaphagus (Adelops) ulkei</i> Horn	—	—	—	—	—	1
194 <i>Ptomaphagus (Appadelopsis) appalachianus</i> (Peck)	—	—	—	25	—	—
195 <i>Ptomaphagus (Appadelopsis) richlandensis</i> (Peck)	—	—	—	—	—	1
196 <i>Ptomaphagus</i> spp.	1	—	1	20	—	—
197 <i>Sciodreporoides latinotum</i> Peck and Cook	—	1	—	—	1	—
198 <i>Sciodreporoides</i> sp. (female)	—	—	—	—	—	1
199 <i>Sciodreporoides watsoni</i> (Spence)	—	—	—	1	—	—

SPECIES	GRENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
LUCANIDAE						
200 <i>Ceruchus piceus</i> (Weber)	—	—	—	—	—	3
201 <i>Platycerus virescens</i> (Fabricius)	—	—	—	1	—	—
LYCIDAE						
202 <i>Lycidae</i> gen. spp.	—	—	1	—	—	1
203 <i>Plateros</i> spp.	—	1	1	—	—	2
MELANDRYIDAE						
204 <i>Dircaea liturata</i> (LeConte)	—	—	1	—	—	—
205 <i>Emmesa connectens</i> (Newman)	—	—	—	—	2	—
206 <i>Hypulus simulator</i> Newman	—	8	—	—	2	—
207 <i>Microtonus sericans</i> LeConte	—	—	—	—	1	—
208 <i>Phloeotrya vaudoueri</i> Mulsant	—	—	—	—	2	—
MONOTOMIDAE						
209 <i>Europs pallipennis</i> (LeConte)	—	—	1	—	—	—
MORDELLIDAE						
210 <i>Falsomordellistena bihamata</i> (Melsheimer)	—	3	6	—	—	4
211 <i>Falsomordellistena pubescens</i> (Fabricius)	—	—	1	—	—	—
212 <i>Glipostenoda ambusta</i> (LeConte)	—	—	1	—	2	6
213 <i>Mordellistena frosti</i> Liljeblad	—	—	1	—	—	1
214 <i>Mordellistena trifasciata</i> Ray	—	—	1	—	—	—
215 <i>Paramordellaria triloba</i> (Say)	—	—	7	—	—	—

SPECIES	GREENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
NITIDULIDAE						
216 <i>Brassicogethes simplipes</i> (Easton)	—	—	—	—	—	2
217 <i>Carpophilus</i> spp.	—	1	1	—	—	—
218 <i>Epuraea</i> spp.	1	1	—	—	—	2
219 <i>Glischrochilus confluentus</i> (Say)	—	1	—	—	—	—
220 <i>Glischrochilus sanguinolentus</i> (Olivier)	—	—	1	—	—	2
221 <i>Pallodes pallidus</i> (Beauvois)	—	—	22	2	—	25
222 <i>Phenolia grossa</i> (Fabricius)	—	—	—	—	—	1
223 <i>Stelidota geminata</i> (Say)	1	—	45	—	—	9
224 <i>Stelidota octomaculata</i> (Say)	19	—	—	4	—	—
OEDEMERIDAE						
225 <i>Asclera ruficollis</i> (Say)	—	—	—	—	2	—
PHALACRIDAE						
226 <i>Acylopus</i> n. sp.	1	—	—	—	—	—
PTILIDAE						
227 <i>Acrotrichis</i> spp.	—	1	27	461	—	73
228 <i>Micridium</i> sp.	—	—	—	—	1	—
229 <i>Nossidium</i> spp.	—	—	10	5	—	2
230 <i>Ptenidium</i> sp.	—	—	1	—	—	1
231 <i>Pteryx</i> spp.	2	84	—	2	56	—
232 <i>Ptiliidae</i> gen. spp.	—	22	42	1	9	39

SPECIES	GRENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
PTILODACTYLIDAE						
233 <i>Ptilodactyla angustata</i> Horn	—	—	5	—	—	1
234 <i>Ptilodactyla carinata</i> Johnson and Freytag	—	3	—	—	1	1
235 <i>Ptilodactyla</i> spp. (female)	—	—	2	—	2	2
PTINIDAE (formerly ANOBIIDAE)						
236 <i>Caenocara</i> spp.	—	—	1	—	—	4
237 <i>Priobium sericeum</i> (Say)	—	5	1	—	6	1
238 <i>Protheca hispida</i> LeConte	—	—	4	—	—	—
239 <i>Sculptotheca puberula</i> (LeConte)	—	1	3	—	—	—
240 <i>Trichodesma klagesi</i> Fall	—	—	—	—	3	—
241 <i>Vrilletta laurentina</i> Fall	—	1	—	—	—	—
PYROCHROIDAE						
242 <i>Dendroides canadensis</i> Latreille	—	7	—	—	22	—
243 <i>Dendroides concolor</i> (Newman)	—	—	—	—	5	—
244 <i>Neopyrochroa flabellata</i> (Fabricius)	—	—	2	—	5	1
SALPINGIDAE						
245 <i>Rhinosimus viridiaeneus</i> (Randall)	—	—	—	—	11	—

SPECIES	GREENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
SCARABAEIDAE						
246 <i>Canthon chalcites</i> (Haldeman)	—	—	1	—	—	1
247 <i>Canthon viridis</i> (Beauvois)	—	—	2	—	—	—
248 <i>Dialytellus tragicus</i> (Schmidt)	—	—	—	38	—	—
249 <i>Dialytes ulkei</i> Horn	—	—	1	—	—	—
250 <i>Gnorimella maculosa</i> (Knoch)	—	1	—	—	—	—
251 <i>Onthophagus hecate</i> (Panzer)	—	—	1	—	—	—
252 <i>Onthophagus orpheus</i> (Fabricius)	—	—	12	—	—	2
253 <i>Onthophagus striatulus</i> (Beauvois)	—	—	5	—	—	—
254 <i>Onthophagus taurus</i> (Schreber)	—	—	1	—	—	2
255 <i>Serica</i> spp. (female)	2	—	4	2	—	2
SCRAPTIIDAE						
256 <i>Anaspis rufa</i> Say	—	—	—	—	—	19
SILPHIDAE						
257 <i>Nicrophorus defodiens</i> Mannerheim	—	—	—	—	—	3
258 <i>Nicrophorus orbicollis</i> Say	—	—	18	—	—	3
SILVANIDAE						
259 <i>Uleiota dubia</i> (Fabricius)	—	1	—	—	—	—
SPHINDIDAE						
260 <i>Euryphindus comatulus</i> McHugh	—	—	—	—	—	2

SPECIES	GRENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
STAPHYLINIDAE						
Aleocharinae						
261 <i>Aleocharinae</i> gen. spp.	—	13	41	3	24	45
262 <i>Aleodorus bilobatus</i> (Say)	—	—	—	28	2	3
263 <i>Aitha</i> spp.	—	21	57	—	26	27
264 <i>Athetini</i> gen. spp.	4	1	15	5	1	29
265 <i>Borboropora quadriceps</i> (LeConte)	—	—	3	—	—	1
266 <i>Earota</i> spp.	—	—	—	—	1	—
267 <i>Euvira</i> sp.	3	—	—	2	—	—
268 <i>Gyrophaena</i> sp.	1	—	—	—	—	—
269 <i>Hoplandria klimaszewskii</i> Genier	—	—	7	—	—	16
270 <i>Leptusa cribratula</i> (Casey)	—	3	—	—	8	—
271 <i>Leptusa pseudomokyienis</i> Park and Carlton	—	—	—	1	—	—
272 <i>Leptusa pusio</i> (Casey)	—	1	—	13	11	—
273 <i>Leptusa</i> spp.	1	4	—	5	5	1
274 <i>Meronea venustula</i> (Erichson)	—	—	—	—	—	2
275 <i>Myllaena</i> spp.	—	—	—	4	—	—
276 <i>Myrmecocephalus cingulatus</i> (LeConte)	—	—	2	—	5	—
277 <i>Myrmedonota</i> n. sp.	—	—	5	—	—	277
278 <i>Oxypoda</i> sp.	—	—	—	1	—	—
279 <i>Placusa</i> spp.	—	—	—	—	—	2
Dasycterinae						
280 <i>Dasycerus</i> spp.	20	—	—	—	—	—

SPECIES	GREENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
Euaesthetinae						
281 <i>Edaphus americanus</i> Puthz	4	3	—	1	1	—
Megalopsidiinae						
282 <i>Megalopinus caelatus</i> (Gravenhorst)	—	—	1	—	—	—
Omalinae						
283 <i>Omalium fractum</i> Fauvel	—	1	—	—	1	—
Osoriinae						
284 <i>Thoracophorus costalis</i> (Erichson)	—	41	1	—	610	3
Oxyporinae						
285 <i>Oxyporus vittatus</i> Gravenhorst	—	—	1	—	—	—
Oxytelinae						
286 <i>Anotylus</i> spp.	—	—	16	83	1	27
287 <i>Carpelinus</i> sp. 1	—	—	—	11	—	—
288 <i>Oxytelus convergens</i> LeConte	—	—	—	1	—	2
289 <i>Oxytelus</i> spp. (female)	—	—	2	2	—	5
Paederinae						
290 <i>Achenomorphus corticinus</i> (Gravenhorst)	1	—	3	—	—	1
291 <i>Palaminus fraternus</i> Casey	1	—	—	—	—	—
292 <i>Palaminus</i> sp. (female)	1	—	—	—	—	—
293 <i>Rugilus</i> spp.	—	—	2	—	—	3
294 <i>Stilicopsis paradoxa</i> Sachse	2	—	—	—	—	—
295 <i>Sunius rufipes</i> (Casey)	154	—	—	93	—	—
296 <i>Sunius</i> spp.	—	—	1	—	1	—
Phloeocharinae						
297 <i>Charhyphus picipennis</i> (LeConte)	—	—	—	—	1	—

SPECIES	GREENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
Piestinae						
298 <i>Stagonium americanum</i> (Melsheimer)	—	—	—	—	—	1
Proteininae						
299 <i>Proteinus</i> spp.	—	—	5	—	—	1
Pselaphinae						
300 <i>Actiastes fundatum</i> Grigarick and Schuster	—	—	—	38	—	3
301 <i>Actiastes</i> spp. (female)	—	—	—	76	1	1
302 <i>Actiastes suteri</i> (Park)	—	—	—	—	1	—
303 <i>Adranes lecontei</i> Brendel	7	11	—	—	—	—
304 <i>Batrisodes auerbachii</i> Park	—	—	1	—	—	2
305 <i>Batrisodes beyeri</i> Schaeffer	—	—	—	9	1	—
306 <i>Batrisodes ionae</i> (LeConte)	—	—	1	—	—	—
307 <i>Batrisodes lineaticollis</i> Aube	1	—	1	3	5	—
308 <i>Batrisodes schauimi</i> (Aube)	—	—	—	—	1	2
309 <i>Batrisodes</i> sp. 2	2	—	—	8	—	1
310 <i>Batrisodes</i> spp. (female)	—	1	1	—	6	—
311 <i>Biblopectus</i> sp. (female)	—	1	—	—	—	—
312 <i>Cedius cruralis</i> Park	—	1	—	—	—	—
313 <i>Cedius spinosus</i> LeConte	—	—	—	—	3	—
314 <i>Conoplectus canaliculatus</i> (Brendel)	1	—	3	—	—	—
315 <i>Ctenisodes</i> spp.	19	—	—	—	—	—
316 <i>Custotychus spiculifer</i> (Casey)	2	—	—	—	—	—
317 <i>Custotychus</i> spp.	4	1	—	—	—	—
318 <i>Dalmosella tenuis</i> Casey	—	1	—	—	—	—
319 <i>Decarthron nigrocauum</i> Park	2	—	—	—	—	—

SPECIES	GRENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
320 <i>Euboarhexius perscitus</i> (Fletcher)	—	—	—	55	—	—
321 <i>Euboarhexius trogasteroides</i> Brendel	1	—	—	3	—	—
322 <i>Euplectus confluens</i> LeConte	—	—	—	—	1	—
323 <i>Euplectus longicollis</i> Casey	—	1	—	—	—	—
324 <i>Euplectus</i> spp. (female)	—	—	3	—	—	2
325 <i>Eutyphlus dybasi</i> Park	—	—	—	3	—	—
326 <i>Eutyphlus similis</i> LeConte	—	—	—	—	1	—
327 <i>Eutyphlus</i> sp. (female)	17	—	—	56	—	—
328 <i>Leptoplectus pertinuis</i> (Casey)	3	17	2	—	22	—
329 <i>Prespelea quirsfeldi</i> Park	—	—	—	3	—	—
330 <i>Pseudactium arcuatum</i> (LeConte)	15	—	—	—	—	—
331 <i>Pycnoplectus difficilis</i> (LeConte)	—	—	—	—	—	1
332 <i>Pycnoplectus infossus</i> (Raffray)	1	3	—	—	—	—
333 <i>Pycnoplectus interruptus</i> (LeConte)	—	—	—	1	—	—
334 <i>Pycnoplectus</i> spp. (female)	1	9	—	1	3	—
335 <i>Rhexius schmitti</i> Brendel	1	1	—	—	—	—
336 <i>Rhexius</i> spp. (female)	1	1	—	—	—	—
337 <i>Sonoma chouljenkoi</i> Ferro and Carlton	—	1	—	1	4	—
338 <i>Sonoma gilae</i> Ferro and Carlton	—	1	—	—	—	—
339 <i>Sonoma gimmelii</i> Ferro and Carlton	3	6	—	—	—	—
340 <i>Sonoma</i> spp. (female)	7	14	—	7	6	—
341 <i>Thesium cavifrons</i> (LeConte)	—	—	—	—	2	—
342 <i>Thesium</i> spp. (female)	—	—	—	—	2	—
343 <i>Trimiomelba dubia</i> (LeConte)	—	2	3	—	1	—
344 <i>Trimioplectus obsoletus</i> Brendel	—	5	—	—	3	—

SPECIES	GRENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
Scaphidiinae						
345 <i>Baeocera pallida</i> Casey	—	—	—	—	—	1
346 <i>Baeocera</i> spp.	—	—	2	—	—	—
347 <i>Cyparium concolor</i> (Fabricius)	—	—	5	—	—	2
348 <i>Scaphisoma carolinae</i> Casey	—	—	1	—	—	—
349 <i>Scaphisoma convexum</i> Say	—	1	2	—	1	—
350 <i>Scaphisoma suturale</i> LeConte	2	—	—	—	—	1
351 <i>Toxidium gammaroides</i> LeConte	2	—	1	—	—	—
Scydmaeninae						
352 <i>Brachycephis</i> sp.	1	—	—	—	—	—
353 <i>Euconus (Napochus)</i> spp.	81	5	11	20	3	3
354 <i>Euconus (Napocornus)</i> spp.	—	—	—	—	2	—
355 <i>Euconus (Scopophus)</i> n. sp.	—	3	—	—	4	1
356 <i>Euconus (Scopophus)</i> spp.	12	5	3	18	7	8
357 <i>Euconus</i> spp.	6	—	—	1	—	—
358 <i>Euthiconus</i> sp.	1	—	1	—	—	—
359 <i>Microscydmus (Deliis)</i> sp.	—	1	—	—	—	—
360 <i>Microscydmus (Neladius)</i> sp.	—	—	1	—	—	—
361 <i>Parascydmus</i> spp.	—	2	7	—	1	2
362 <i>Scydmaenus</i> spp.	—	—	1	6	1	—
363 <i>Stenichnus</i> spp.	—	—	2	—	—	—
Staphylininae						
364 <i>Atracus americanus</i> (Casey)	—	—	—	—	—	1
365 <i>Belonuchus rufipennis</i> (Fabricius)	—	1	—	—	2	—
366 <i>Bisnius blandus</i> (Gravenhorst)	—	1	50	—	—	39

SPECIES	GREENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
367 <i>Gabrius fallaciosus</i> (Horn)	—	—	—	—	5	3
368 <i>Hesperus apicalis</i> (Say)	—	51	—	—	36	—
369 <i>Hesperus ballimorensis</i> (Gravenhorst)	—	1	—	—	1	—
370 <i>Ontholestes cingulatus</i> (Gravenhorst)	—	—	30	—	—	25
371 <i>Philonithus asper</i> Horn	—	—	—	—	—	5
372 <i>Philonithus caeruleipennis</i> Mannerheim	—	—	163	—	—	29
373 <i>Philonithus</i> spp.	—	—	4	1	—	2
374 <i>Platyracus violaceus</i> (Gravenhorst)	—	—	7	—	—	3
375 <i>Platyracus viridanus</i> (Horn)	—	1	—	—	—	—
376 <i>Tympanophorus puncticollis</i> Erichson	—	—	1	—	—	—
Steninae						
377 <i>Stenus</i> spp.	—	—	—	2	—	—
Tachyporinae						
378 <i>Bryoporus rufescens</i> LeConte	5	—	21	—	—	2
379 <i>Bryoporus testaceus</i> LeConte	—	—	1	—	—	1
380 <i>Ischnosoma lecontei</i> Campbell	5	—	—	3	—	—
381 <i>Lordithon cinctus</i> (Gravenhorst)	—	—	1	—	—	—
382 <i>Lordithon facilis</i> (Casey)	—	—	—	—	—	1
383 <i>Lordithon notabilis</i> Campbell	—	—	2	—	—	5
384 <i>Mycetoporus americanus</i> Erichson	—	—	—	1	—	—
385 <i>Mycetoporus consors</i> LeConte	—	—	—	—	—	1
386 <i>Sepedophilus brachypterus</i> Campbell	—	—	—	2	4	—
387 <i>Sepedophilus cinctulus</i> (Erichson)	—	13	7	—	6	—
388 <i>Sepedophilus crassus</i> (Gravenhorst)	—	—	2	—	—	3

SPECIES	GREENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
389 <i>Sepedophilus occultus</i> (Casey)	—	10	2	—	1	—
390 <i>Sepedophilus opicus</i> (Say)	—	—	1	—	—	—
391 <i>Sepedophilus</i> sp.	—	—	—	—	1	—
392 <i>Tachinus canadensis</i> Horn	—	—	—	—	—	1
393 <i>Tachinus fimbriatus</i> Gravenhorst	—	—	24	—	—	10
394 <i>Tachinus fumipennis</i> (Say)	—	—	—	—	—	3
395 <i>Tachinus luridus</i> Erichson	—	—	1	—	—	11
STENOTRACHELIDAE						
396 <i>Cephaloon lepturides</i> Newman	—	—	—	—	1	—
TENEBRIONIDAE						
397 <i>Anacetus brunneus</i> (Ziegler)	1	1	—	—	—	—
398 <i>Arthromacra aenea lengi</i> Parsons	—	1	—	—	—	—
399 <i>Centronopus calcaratus</i> (Fabricius)	—	—	—	—	8	—
400 <i>Dioedus punctatus</i> LeConte	—	—	—	—	—	1
401 <i>Hymenorus</i> spp. (female)	—	5	—	—	7	—
402 <i>Meracantha contracta</i> (Beauvois)	—	3	—	—	—	—
403 <i>Paratenetus</i> sp. 1	4	—	—	1	—	—
404 <i>Tenebrionidae</i> gen. spp.	—	4	—	—	1	—
TETRATOMIDAE						
405 <i>Eustrophopsis bicolor</i> (Fabricius)	—	—	1	—	—	—
406 <i>Holostrophus bifasciatus</i> (Say)	—	—	—	—	1	—
407 <i>Synstrophus repandus</i> (Horn)	—	—	—	—	—	1

SPECIES	GREENBRIER			PORTERS CREEK		
	SIFT (77)	EMERGENCE (123)	FIT (159)	SIFT (81)	EMERGENCE (130)	FIT (131)
THROSCIDAE						
408 <i>Autonothroscus distans</i> Blanchard	—	248	1	—	158	—
409 <i>Autonothroscus</i> spp.	—	—	—	—	1	—
TROGIDAE						
410 <i>Trox variolatus</i> Melsheimer	—	—	—	—	—	2
TROGOSSITIDAE						
411 <i>Thymalus marginicollis</i> Chevrolat	—	1	—	—	—	—
ZOPHERIDAE						
412 <i>Paha laticollis</i> (LeConte)	—	1	—	—	—	—
413 <i>Synchita fuliginosa</i> Melsheimer	—	—	—	—	2	—
Total (specimens/species)	709/77	941/123	1079/159	1360/81	1689/130	1393/131