The impact of tornado and salvage-logging on ground beetle (Coleoptera: Carabidae) taxonomic and functional diversity

**Methods**

Study site and tornado event

Research was conducted at Powdermill Nature Preserve in Rector, Westmoreland County, Pennsylvania. This is an area of temperate deciduous forest which serves as the field research station for the Carnegie Museum of Natural History. In June 2012, a tornado touched down, uprooting canopy trees in two areas, each about 120 × 480 m. The areas are located approximately at (40.14266, -79.27889) and (40.1447, -79.27491). These two areas are on the north- or northwest-facing slopes, which were dominated by maples (*Acer* spp.), tuliptree (*Liriodendron tulipifera*), black cherry (*Prunus serotina*), and other deciduous trees (Murphy et al. 2015), with an understory of predominately spicebush (*Lindera benzoin*) (Calinger et al. 2015). Before the tornado, this area had been forested since at least 1939 (Murphy et al. 2015).

Salvage logging

In summer through winter of 2013, half of each wind-disturbed area was salvage-logged using heavy machinery to remove the fallen and residual standing trees. In the southwest tornado-impacted area, the northwestern (lower elevation) side was logged, while in the northeast tornado-impacted area, the southeastern (higher elevation) side was logged. The operation of salvage logging on only half of the tornado-impacted area allowed us to compare arthropod communities between salvaged and un-salvaged areas.

Invertebrate sampling

In 2015 and 2022 (three and ten years post-tornado), ground-dwelling invertebrates were sampled as part of a larger research effort to understand the impacts of salvage-logging. Six transects were established across the disturbances, each with a site in wind-disturbed (n=6), salvage-logged (n=6), and surrounding undisturbed forest (n=12). To capture invertebrates, one barrier pitfall trap was installed in each site and monitored every two weeks during the summer months. In 2015, traps were set up on May 27-28 and taken down on August 17 for a total of 6 collection intervals. In 2022, traps were set up on June 1-2 and taken down on September 6 for a total of 8 collection intervals. A pitfall trap consisted of two pairs of plastic cups (each pair having an inner 500 mL cup and an outer 1 L cup) which were placed into the ground so that the lip of the cup was flush with the ground surface. The two pairs of cups were placed 1 m from each other, and garden edging (Suncast® eco edge) was placed between them to create a barrier to lead ground-dwelling invertebrates into the cups. Cups were filled 4 cm high with propylene glycol (recreational vehicle and marine antifreeze, Peak Company Old World Industries, Clear Lake, Texas) with a few drops of detergent added to prevent escapes. Masonite board (100 cm2) was placed at 3 cm above each cup to prevent overfilling due to rain. Steel landscaping cloth was secured over cups using 30 cm stakes in order to limit mammal disturbance. Traps were collected every 2 weeks by pouring sample through a fine mesh strainer and placing the contents into 70% ethanol, before refilling the sample cups with propylene glycol for the following interval.

Annual temperature and rainfall

Environmental variables of the forest floor

Ground beetle identification

Beetles were counted and removed from the samples, and all ground beetles (Carabidae) were pinned or pointed. Ground beetles were identified to species using keys in (Lindroth 1961; Bousquet 2010; Freitag 1969; Bousquet and Messer 2010; Harden and Guarnieri 2017) and the nomenclature was verified using (Bousquet 2012).