Title: Improving management strategies linked to certification of sustainable forest practices for priority songbirds in West Virginia

Award: F20AC00018

Principle Investigators:
Christopher M. Lituma, *West Virginia University, Division of Forestry and Natural Resources, 1145 Evansdale Drive, Morgantown, West Virginia 26506, USA; cml0017@mail.wvu.edu*
Robert M. Ryan, *West Virginia University, Division of Forestry and Natural Resources, 1145 Evansdale Drive, Morgantown, West Virginia 26506, USA; rmr00023@mixl.wvu.edu*

Co-principle Investigator:
Petra B. Wood, *US Geological Survey, West Virginia Cooperative Fish and Wildlife Research Unit, West Virginia University, P.O. Box 6125, Morgantown, West Virginia 26506, USA; pbwood@wvu.edu*

Proposed Objectives:
The primary objective is to develop, and test means and efficacy of institutional landowner engagement in both implementation and monitoring of practices to improve conditions for declining bird species, in concert with adjacent ownerships, specifically those enrolled in National Council for Air and Stream Improvement (NCASI) forestry programs and National Alliance of Forest Owners (NAFO). The intent is to better understand multi-species approaches and practicalities of implementation with a focus on Sustainable Forestry Initiative (SFI) certified forests and surrounding family forestlands to optimize outcomes at a landscape scale. Focal species are Golden-winged warbler (*Vermivora chrysoptera*; GWWA), Cerulean warbler (*Setophaga cerulea*; CERW), Wood thrush (*Hylocichla mustellina*; WOTH), although the overall avian community (including game birds and night birds) is monitored.

Methods and Study Area:
The overall study includes 3 forest research blocks, each 2,000 ha in size.

1. Operational: A landscape entirely embedded within the operational forest context of Weyerhaeuser property. It will represent a heterogeneous forested landscape inclusive of forests of various age classes, certified to the SFI Forest Management Standard.
2. Operational with NRCS/NCASI/NAFO: We will work with NRCS, NCASI, and NAFO project partners to identify family-owned forest properties in proximity (or interspersed) to a block predominately owned/managed by Weyerhaeuser. This landscape is the focus of assessment and planning to enroll private landowners as part of NRCS, CERW Appalachian Forestland Enhancement Project (AFEP) and GWWA Working Lands for Wildlife (WLFW) project. The goal is to build landowner capacity, and test approaches to maximize outcomes across multiple ownership boundaries and objectives. Long-term monitoring will be essential to understand species responses across both ownership types.
3. Operational with Opportunity: The third landscape will seek opportunity for intersection of Weyerhaeuser forest management and other private lands, and potentially the engagement of additional ownership types and management strategies (e.g., State lands or federal lands). The same monitoring methodology will be applied, but this block will explore opportunities for creative engagement and learnings, including additional engagement of family forest landowners, and potentially building understanding of contributory value of surrounding state or federal lands.

Actual Accomplishments:

Beginning in 2021, we partnered with Weyerhaeuser to survey their privately held land in southern West Virginia. We randomly selected stratified survey points within the study site based on stand age post clear-cut (1-5 years, 6-10 year, 11-15 years, 16-20 years, 21-25 years, and >25 years) and proximity to any road <7 m in width. Each survey point was placed at least 250 m from a road and any other point. In 2022, each off-road point was given an associated roadside point for comparison. From May-July, we conducted multi-species, 100-m radius, 10-minute avian point counts conducted during the breeding season (May 15 – Jun 30) on Weyerhaeuser property (2021 n = 181; 2022 n = 206; 2023 n = 249; Figure 1). Approximately 12% of points were on sites 1-5 years post clear-cut, 30% on 6-11 years, 9% on 11-15 year, 16% on 16-20 year, 4% on 21-25 year, and 29% on >25 years post clear-cut. In 2023 we added 48 survey point locations in the Monongahela National Forest to act as a reference. Approximately 41% of points sampled were roadside points and assigned the same stand age as their paired off-road point.

We used Point counts began half an hour before sunrise each day and ended by 11am, or when a precipitous drop in singing individuals occurred. All points were visited twice throughout each field season. Every other week between 20 and 50 ARUs were deployed at a subset of off-road points and were recovered the following week to supplement bird detections from in-person surveys. This ARU deployment schedule was observed throughout both field seasons for the duration of the point counts. We collected habitat data through vegetation surveys assessing ground cover, canopy density, tree species prevalence, tree size, and tree species density at all sampling points.

During the 2023 field season, data we prioritized repeat surveys of points with Golden-winged warbler or Blue-winged warbler detections, or points that had harvests occur between survey years. Currently, final data entry and proofing is being completed. Included are some preliminary data summaries and analyses which will be refined and completed in 2024. We chose to include some State Wildlife Action (SWAP) plan species identified as either young forest disturbance-dependent or forest interior associates. Those young forest disturbance-dependent species are (Figure 2): GWWA, Blue-winged warbler (*Vermivora cynaoptera*; BWWA), Field sparrow (*Spizella pusilla*l; FISP), and Canada warbler (*Cardellina canadensis*; CAWA). The forest interior species are (Figure 3): CERW, WOTH, Veery (*Catharus fuscescens*; VEER), and Black-throated blue warbler (*Setophaga caerulescens*; BTBW). We conducted multi-species occupancy modeling to evaluate occupancy relationships among species within groups and with explanatory environmental variables. Modeling is ongoing but marginal BWWA occupancy was negatively related to elevation, though the opposite was true of CAWA occupancy (Figure 4).

In addition to point counts and vegetation surveys being conducted a master's student, Alexander Clark, was recruited in 2021 to asses Eastern Whip-poor-will occupancy and explore questions related to habitat use as it relates to biotic and abiotic factors. In May 2023, he successfully defended and completed his thesis: *Assessing Landscape Features and Nocturnal Flying Insect Diversity as Predictors of Eastern Whip-poor-will Occupancy*. Included is a summary of that research.

Objectives:

1) Analyze Eastern whip-poor-will recordings from Autonomous Recording Units (ARUs) to determine the influence of landscape and forest stand variables (0 to 20 years post clear-cut, 0 years denoting a clear-cut created during the year of surveys) on occupancy
2) Evaluate occupancy probability of Eastern whip-poor-will in relation to proximity to riparian zones
3) Determine if available nocturnal moth (Lepidoptera) and beetle (Coleoptera) prey morphospecies richness, evenness, abundance, or biomass at specific points are positively correlated with Eastern whip-poor-will occupancy within varying-aged stands due to harvest

4) Assess effects of stand age and site-specific vegetative cover on nocturnal moth (Lepidoptera) and beetle (Coleoptera) morphospecies richness, evenness, and capture rate.

North American caprimulgids are disturbance-dependent and are in decline, requiring ephemeral early successional habitat for foraging activitie. Caprimulgids throughout Europe and North America have a higher probability of occupancy in mature forests interspersed with disturbed areas creating heterogeneous landscapes rather than homogeneous contiguous forests. Species like the Eastern whip-poor-will (*Antrostomus vociferus*) have experienced declines of 2.76% annually since the 1970s. Industrial forest landscapes provide frequent forest structure disturbance from timber harvesting activities which may suit the ephemeral foraging habitat needs of Eastern whip-poor-will. We used autonomous recording units (ARUs) deployed across 119 sampling points in 2021 and 2022 to collect occupancy data on Weyerhaeuser property located in Fayette, Nicholas, and Greenbrier Counties, WV (Figure 4). To determine insect prey availability affects on Eastern whip-poor-will occupancy, we collected nocturnal Lepidoptera and Coleoptera from 30 stands during 9 June – 1 July, 2022, beginning 30 minutes after sunset and continuing for 1 hour past sunset (~2130 – 2230). Each point was paired with an ARU sampling point and had only one trapping night. We sampled during the full and new moon phases to capture a representative sample of Lepidoptera and Coleoptera coinciding with variable Eastern whip-poor-will activity levels. Standard use black-light traps were used for all insect data collection (Figure 5). Eastern whip-poor-will occupancy probability was positively associated with lower elevations (Figure 6) and early successional forest features such as low basal area (i.e., density of trees), young stand age, and the presence of ground cover associated with diminished canopy cover like grasses, and solidago. Eastern whip-poor-will occupancy was not associated with prey availability. In contrast, available adult volant prey items for Eastern whip-poor-will were found to be more associated with later successional forest features such as higher basal area, diminished bare ground, and an increase in overall stand age (Figures 7 and 8). However, it should be noted that the volant adult morphs of captured species of Lepidoptera and Coleoptera are associated with these forest and vegetative cover features, not necessarily the younger larval stages. Examining the vegetative cover and forest feature requirements of the developing stages of these species elucidates a more complex relationship between Eastern whip-poor-will and their prey.

Understanding the life cycles of available prey items considering the results presented in this research, further support the importance of mosaic forest conditions. The various life cycles of the top three most abundant Lepidoptera and Coleoptera all require the presence of various covariates that were included in this research (e.g., presence of grass, varying levels of canopy cover, riparian areas). This knowledge, together with the known differences in the breeding and foraging habitat of Eastern whip-poor-will (later and early successional forest conditions respectively) strongly support the continued creation of mosaic forests. These conditions can be created through management practices that maintain patches of early successional forest via clear-cutting timber practices among older, later successional growth.

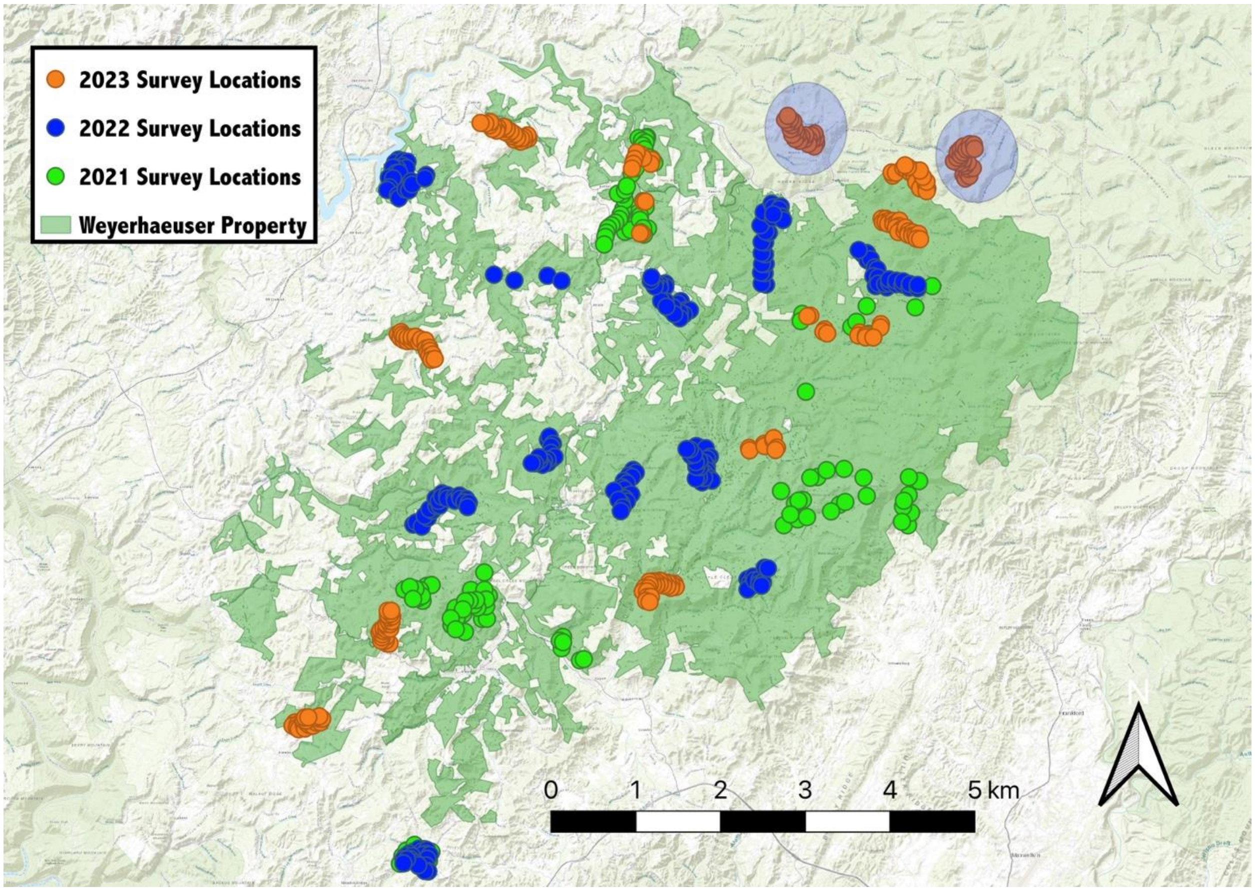

Figure 1. Map detailing the study area, ~250,900 hectares of Weyerhaeuser property managed for timber harvest. Points represent survey locations and are colored by year. Those points within the blue shaded circles represent control points surveyed within the Monongahela National Forest.

Figure 2. Detections of young forest disturbance-dependent focal species on Weyerhaeuser property in West Virginia from point counts conducted May through July 2021-2023.

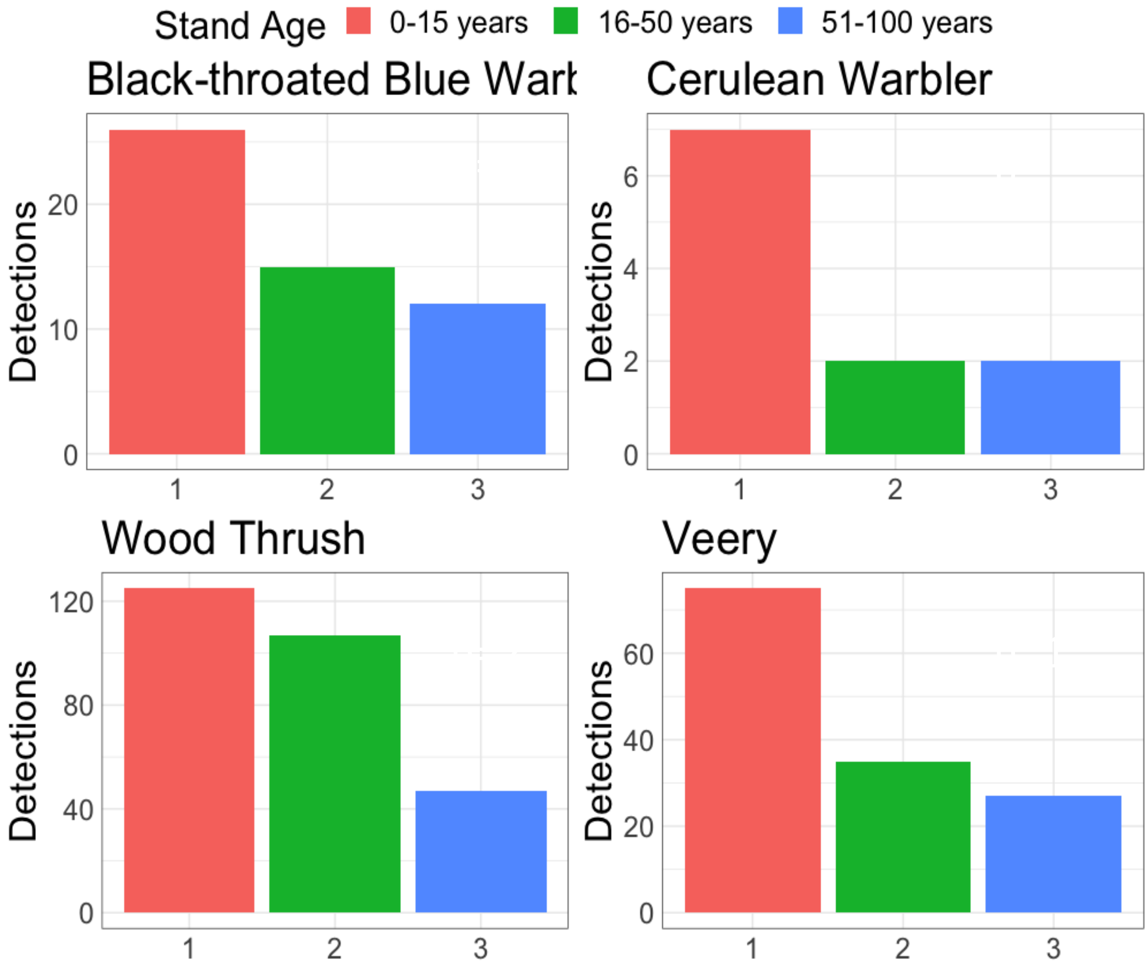

Figure 3. Detections of forest interior focal species on Weyerhaeuser property in West Virginia from point counts conducted May through July 2021-2023.

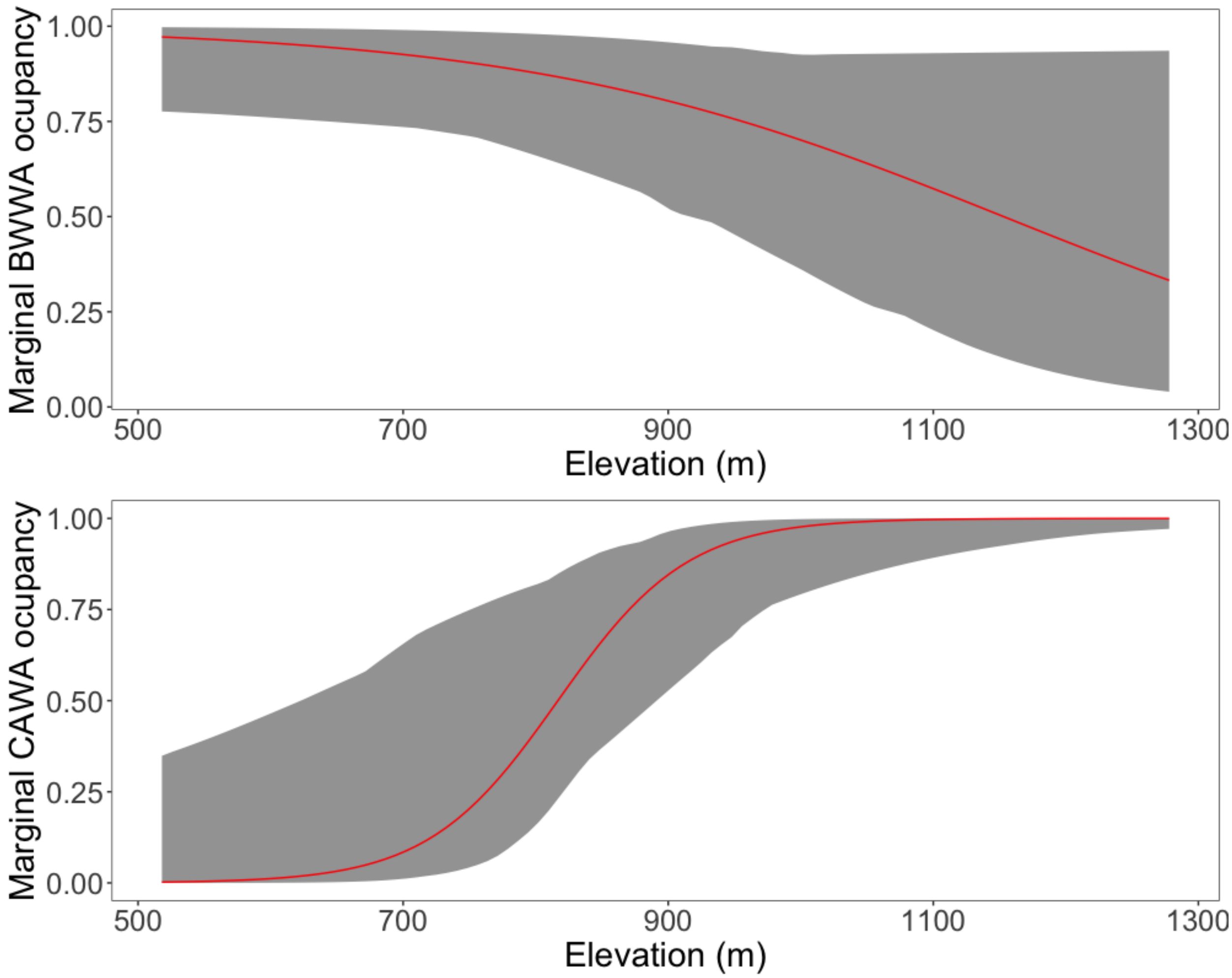

Figure 4. Marginal occupancy for Blue-winged warbler (BWAA) and Canada warbler (CAWA) on Weyerhaeuser property in West Virginia from point counts conducted May through July 2021-2023.

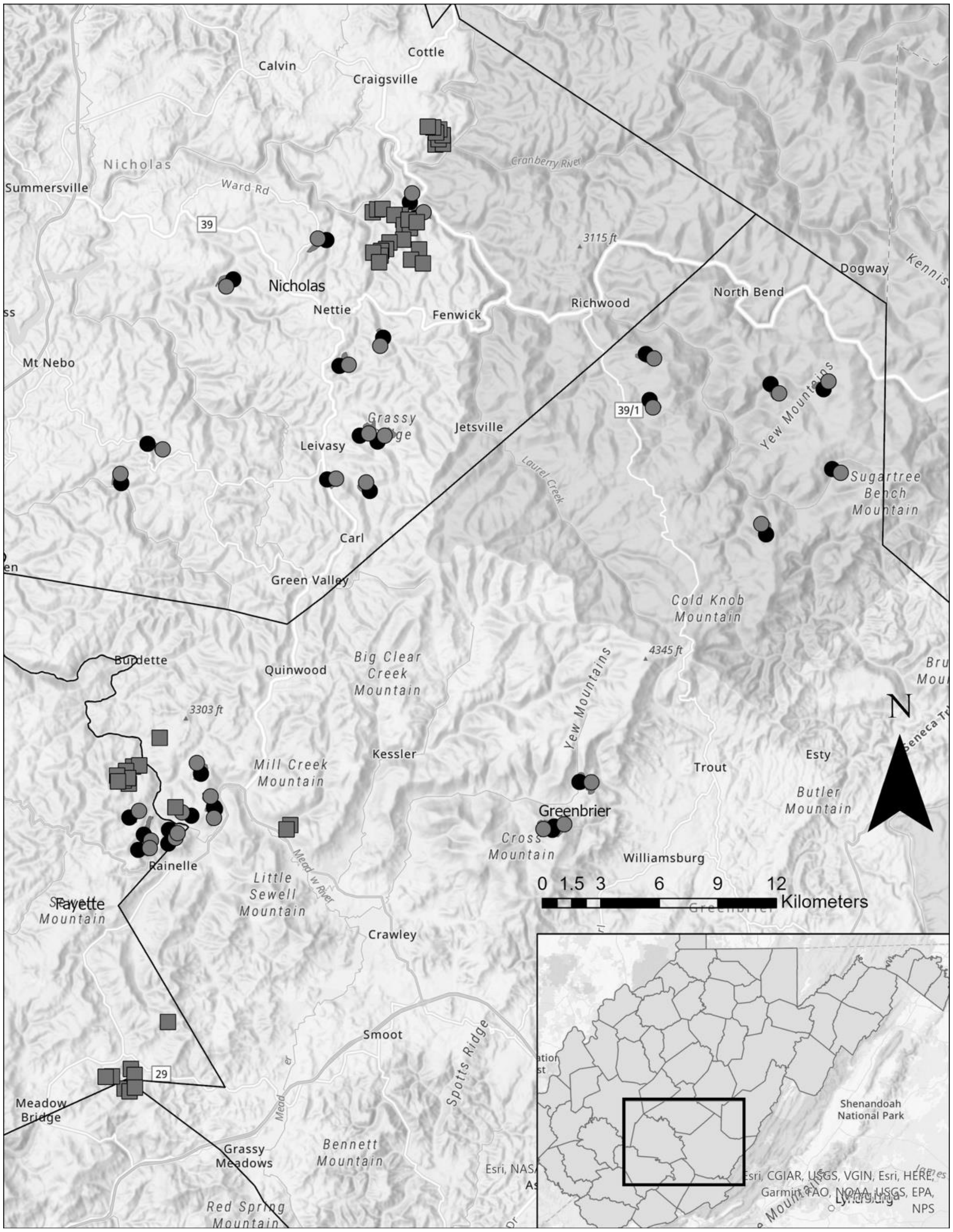

Figure 4. Central and southern portion of Weyerhaeuser property, located within Fayette, Nicholas, and Greenbrier counties, West Virginia. All locations had a recording ARU. Dates ranged from June 18 – June 29 in 2021 and 2022. Squares represent points from 2021. Circles represent points from 2022. Light circles were considered far from riparian zones (>450 m) from 2022. Dark circles represent points considered near riparian zones (<100 m) from 2022.

Figure 5. In-field example of black-light traps that were used to collect specimens. Traps were comprised of a 5-gallon bucket, altered funnel, 12 W black light, three acrylic panes, small battery and electronics. At the bottom of the funnel, a 1-gallon bag was attached to both collect specimens and to discourage escape.

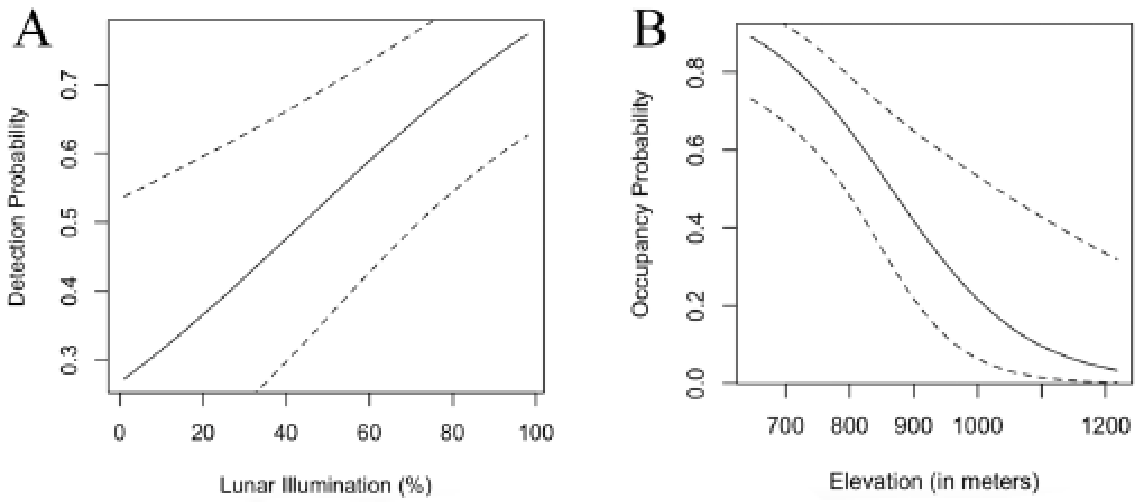

Figure 6. Top detection covariate (lunar illumination) (A) and occupancy covariate (elevation)(B) plotted using generalized linear models with 95% confidence interval curves.

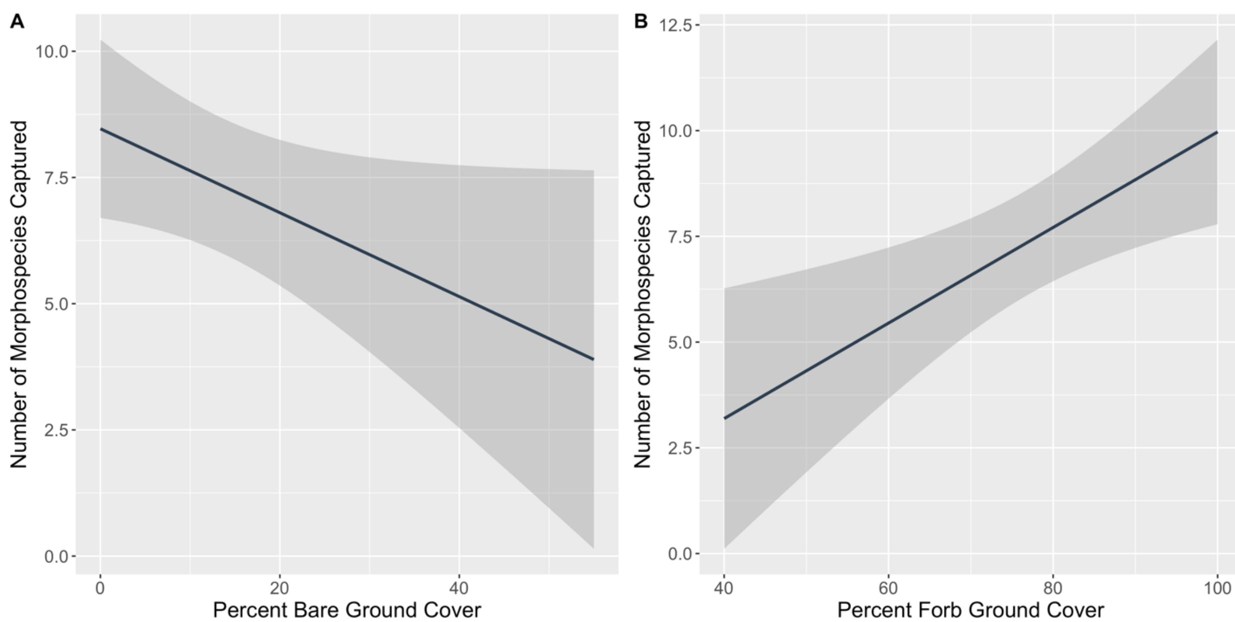

Figure 7. Significant ground cover covariates and their effect on available prey species richness. Bare ground (A) and forb (B) showed significant influences (Table 3.6). Covariates plotted using generalized linear models with 95% confidence interval curves.

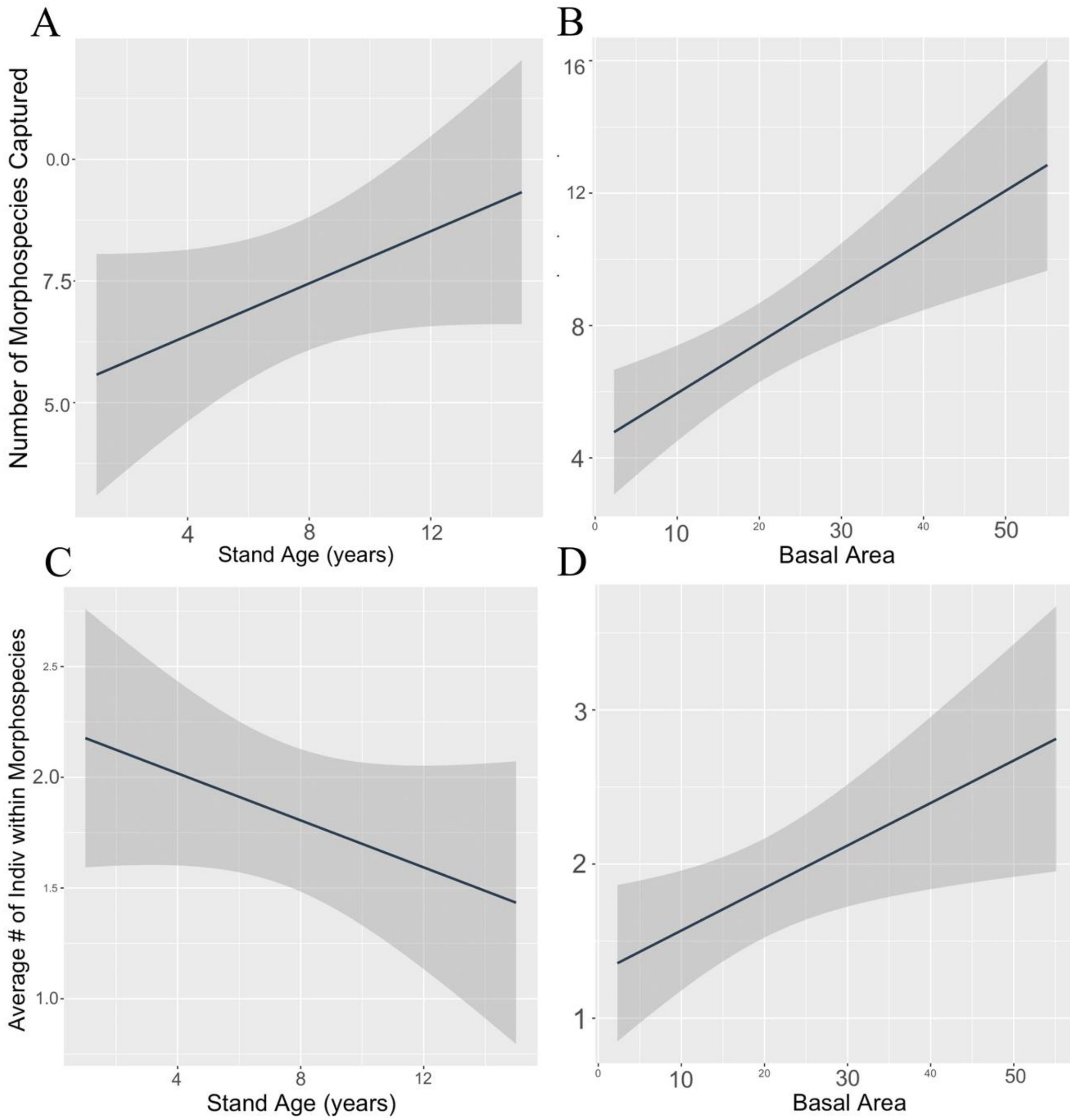

Figure 8. Influences of stand age (A, C) and basal area (B, D) on number of total morphospecies captured (richness) (A, B) and average number of individuals within each morphospecies (evenness) (C, D). Covariates plotted using generalized linear models with 95% confidence interval curves.

We will continue analyses to include refined stand-level variables, landscape-level variables, and variables focused on forest stand age-stage structure changes during the study. We will also analyze Autonomous Recording Unit data this winter. Anticipated completion is December 2024.