MARSHALL, MATTHEW M., M.S. The Influence of Managing a Loblolly Pine (*Pinus taeda*) Forest for Biofuels Production via Switchgrass (*Panicum virgatum* L.) Intercropping and Woody Debris Removal On Rodents. (2011)
Directed by Dr. Matina Kalcounis-Rüppell. 97 pp.

The abundance and distribution of wildlife communities can be influenced by many factors including resources, competitors, predators and parasites, and climate. Changes to managed forest understory composition and structure may affect ecologically important rodent communities. Furthermore, diversity of rodent communities can correlate with vertebrate biodiversity across a diverse range of ecosystem variables. To help meet demands for renewable sources of energy, biofuel feedstock production options include intercropping switchgrass (*Panicum virgatum* L.) within intensively managed loblolly pine (*Pinus taeda*) stands, and removal of residual woody debris. The objective of my study was to experimentally examine rodent responses to these options. I surveyed rodent populations using mark-recapture techniques to determine their responses to pine and switchgrass intercropping, and residual woody debris removal. For 6 months in 2009, and 5 months in 2010, we captured rodents on experimental plots within newly established pine plantations that were subjected to five different treatments that incorporate switchgrass and residual woody debris as biomass removal options. Habitat measurements conducted in 2010 on percent cover and height of habitat variables reflected differences among the 5 treatments as indicated by a significant interaction of habitat variable (i.e. grass, pine, etc.) among treatments and across sampling dates from April to October. This interaction indicates the preparation of the study plots created habitats that differed in structure. Rodent community diversity metrics including species

richness, Shannon Diversity index, and Fisher's α index were not influenced by biomass removal options in either 2009 or 2010. In 2009, treatment did not influence the abundance of any species. However, there was a trend for house mice (*Mus musculus*) and hispid cotton rats (*Sigmodon hispidus*) adults to be more abundant in habitats with switchgrass. In 2010, treatment significantly influenced the abundance of the number of unique individuals and total captures of white-footed mice (*Peromyscus leucopus*), *M. musculus,* and *S. hispidus* of. During the second year of study, *P. leucopus* adults showed highest abundance in non-switchgrass habitats, intermediate abundance in pine and switchgrass intercropped habitats, and lowest abundance in switchgrass only habitats. Additionally, *P. leucopus* juveniles showed a trend to be more abundant in habitats without switchgrass, suggesting differences were a result of *P. leucopus* reproduction in these habitats. *M. musculus* abundance was highest in switchgrass only habitats, intermediate in pine and switchgrass intercropped habitats, and lowest in habitats without switchgrass. *Mus musculus* juveniles showed a trend for higher abundance in habitats with switchgrass suggesting differences were a result of *M. musculus* reproduction. Abundance of *S. hispidus* tended to be higher in habitats with pine and switchgrass intercropped than habitats without switchgrass and habitats with only switchgrass. Juvenile abundance of *S. hispidus* did not differ among biomass removal options, suggesting all habitats in this study provided similar resources for *S. hispidus* reproduction. My results suggest residual woody debris removal has no influence on rodent population abundance, incorporation of switchgrass intercropping has an intermediate influence on rodent population abundance, and planting only switchgrass has a significant influence rodent population abundance. Switchgrass habitats supported higher abundance of the invasive *M. musculus,* and lower abundance of the native *P. leucopus* than habitats without switchgrass. Thus, forest managers may want to consider introducing switchgrass exclusively to interior forest stands that may be far from potential *M. musculus* source populations (e.g., agricultural fields and residential buildings. This strategy could also benefit native species that avoid switchgrass, such as *P. leucopus,* by providing refuge areas devoid of switchgrass in exterior stands. A better understanding of rodent responses to forest management will be beneficial in maintaining biodiversity and the sustained use of the services provided by forest habitats.

THE INFLUENCE OF MANAGING A LOBLOLLY PINE (*PINUS TAEDA*) FOREST FOR BIOFUELS PRODUCTION VIA SWITCHGRASS (*PANICUM VIRGATUM* L.) INTERCROPPING AND WOODY DEBRIS REMOVAL ON RODENTS

by

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A Thesis Submitted to
the Faculty of The Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Master of Science

Greensboro
2011

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ACKNOWLEDGMENTS

I am thankful to Dr. Matina Kalcounis-Rüppell for advising me on this manuscript.

I am very appreciative of the continuous hard work and helpful suggestions of Rada Petric, Megan Walrichs, Kim Briones, Jessica Homyack, Darren Miller, Zakiya Leggett, James Bland, Eric Sucre, and Jessica Briggs throughout the time I’ve worked on this project.

I thank Catchlight Energy LLC, the Chevron / Weyerhaeuser joint venture that supported the design and provided funding for this study, as well as the future prospect of creating a sustainable fuel resource foundation with special concern for our impacts on the environment. I thank Kim Briones for additional funding throughout the study.

My committee members: Dr. Matina Kalcounis-Rüppell, Dr. Jessica Homyack, Dr. Gideon Wasserberg, and Dr. Stanley Faeth provided helpful insight in this thesis, field work, and analysis.

I give ultimate gratitude to my family who continue providing funds, housing, meals, ears, support, stories, suggestions, and prayers through my scientific endeavors and idiosyncrasies.

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CHAPTER I

INTRODUCTION

Animal Abundance and Distribution

The abundance and distribution of terrestrial animals can be influenced by many biotic factors such as competition for resources (e.g., food and space), predation, parasites, and abiotic factors such as climate and availability of fresh water (Grant 1972a, Schoener 1974, Hansson 1987, Hawkins et al. 2003, Prasad and Snyder 2006). The abundance and distribution of terrestrial animals vary as a result of spatial and temporal changes in biotic and abiotic factors (Grant 1972a, Morris and Knight 1996, Culver et al. 2000, Hawkins et al. 2003, Prasad and Snyder 2006). For example, different habitats may provide varying resources such as food and nesting sites and these resources changes as habitats age (Atkeson and Johnson 1979; Morris and Knight 1996; White 2008).

When available resources within a given habitat, including space (e.g., nesting sites, mating grounds, protective cover) and food (e.g., abundance, food types) are limited, competition for resources may constrain population size and presence of a species (MacArthur 1960, Fox 1982, Connell 1983, Yunger et al. 2002). For example, experimental addition of food increases rodent abundance, survival, and reproduction (Taitt 1981, Brown and Munger 1985, Vessey 1987). As a resource is consumed or modified by an individual, it is made unavailable to both conspecifics and heterospecifics (MacArthur 1960, MacArthur and Levins 1964). Inter- and intra-specific competition for resources are important ecological interactions that limit population size (MacArthur and Levins 1964, Connell 1983). This type of control of population size is termed "bottom-up" or "resource based" (Yunger et al. 2002; MacArthur 1960; Connel 1983). The competitive exclusion principle states if more than one species is limited by a common resource (e.g., seeds), then the species which competes for that resource more efficiently will ultimately survive causing the less efficient species to become extirpated (Gause and Witt 1935, Park and Lloyd 1955, Hardin 1960).

In addition to bottom-up control when resources limit a population, top-down control occurs when a population is limited by interactions with predators or parasites (Connell 1983, Hunter and Price 1992, Chapin et al. 1997, Stiling and Rossi 1997). Predator and parasite populations can limit the distribution and abundance of prey organisms by reducing the ability of individuals to survive and reproduce (i.e., reducing fitness) and by eliminating individuals from the population (Nelson et al. 1960, Stiling and Rossi 1997, Barko 2003, Prasad and Snyder 2006). The magnitude of top-down interactions can vary with the number of prey and predator or parasite species, population abundance of predator, parasite, and prey species, and species-specific traits (Stiling and Rossi 1997, Prasad and Snyder 2006).

The intensity of interspecific competition is subject to individual and population characteristics of the species involved, and changes over time with the population size of each species (Grant 1972a, Chapin et al. 1997, Yunger et al. 2002). The intensity of competition varies with population size because large populations contain more individuals that require and consume resources than small populations (Grant 1972a, Connell 1983, Hansson 1987). The size of natural populations change over time as a result of bottom-up and top-down controls occurring simultaneously, and seasonal changes in the magnitude of these controls (e.g. food and water availability can change seasonally)(Naiman 1988, Hunter and Price 1992, Chapin et al. 1997, White 2008).

In addition to biotic controls of resource availability that can limit population growth and abundance, disturbances can also alter resource availability in a habitat including space (nesting sites, mating grounds, protective cover) and food (abundance, food types) (Atkeson and Johnson 1979, Wright 1990, White and Jentsch 2001). The intensity and frequency of disturbances are important factors that influence bottom-up and top-down factors and thus the relative abundances of species (White and Jentsch 2001).

The intermediate disturbance hypothesis suggests that disturbances that occur at intermediate frequencies support the most diverse biological communities (Roxburgh et al. 2004). At low frequency of disturbance, species diversity is low because competitivly superior species out-compete other species for resources and these other species go locally extinct (Roxburgh et al. 2004). At high frequency of disturbance, the species with lower reproduction rates are not able to enter and colonize an area (Roxburgh et al. 2004). At intermediate disturbance frequency, community diversity and biodiversity peaks as early colonizing species are still present, and are not excluded by superior competitors (Roxburgh et al. 2004). As a result, intermediate disturbance frequency can support communities with the highest diversity (Roxburgh et al. 2004; White and Jentsch 2001; Yunger et al. 2002).

Biodiversity Conservation

To maximize conservation efforts and develop management strategy, a basic understanding of how habitats contribute to biodiversity is needed (Barrows et al. 2005; Miller et al. 2009). An understanding of the interactions between resources and population abundances, how they are influenced by interspecific competiton, disturbances, and top-down forces are necessary for the development and implementation of multiple-species habitat conservation plans (Barrows et al. 2005; Lindenmayer et al. 2008). Furthermore, the interactions among species and resources are needed to understand individual and population responses of species, changes in the biotic community, and how these responses vary with time and space (Barrows et al. 2005; Lindenmayer et al. 2008; Miller et al. 2009).

Forest and Grassland Habitats

Forests and grasslands provide important habitats for a wide variety of biota (Atkeson and Johnson 1979, Tilman 1997, Caliman et al. 2010, Vance et al. 2010). Biodiversity conservation in forest and grassland ecosystems is important because these ecosystems provide services that are important both vitally (clean air, fresh water, food) and economically (food, raw materials) (Conner et al. 2001, Corvalan et al. 2005, National Commission on Science for Sustainable Forestry 2005, U. S. Forest Service 2010). Together, forest and grasslands cover approximately 70 percent of the United States and contribute economically important goods including timber products from forests and forage for livestock (Conner et al. 2001, U. S. Forest Service 2010). Forest and grassland habitats are crucial to a wide variety of fauna in diverse climates (Conner et al. 2001, U. S. Forest Service 2010). A better understanding of the resources forest and grassland ecosystems provide, and how wildlife uses these resources and responds to changes in resource availability is imperative to receiving ecosystems services (Corvalan et al. 2005).

Extracting forest products can dramatically change habitat structure and resource availability, such as in pine plantations in the southeastern United States. Loblolly pine (*Pinus taeda*) plantations may include site preparation and planting of pine seedlings in rows, pesticide and herbicide treatment, vegetation control, and thinning, followed by clear-cut harvest (Morris et al. 2010). Residual woody debris unsuitable for lumber production may be left to decay on site, piled, moved off site, or burned (Riffell, et al. 2011). In the years following establishment of plantations, timberlands undergo secondary succession. During this time habitat structure changes as plants and animals invade and make use of available space and resources. As planted pine trees grow, the area of shade they create increases until years 7-15 when the canopy closes, and limited light penetrates to the forest floor (Atkeson and Johnson 1979, Morris et al. 2010). Management practices can influence the ability of a forest to support biodiversity by altering conditions within (i.e., snags, stem density, species composition) or around forest stands (i.e., vegetation types, road density, hard edges) (Carey and Johnson 1995, Bowman et al. 2001, Loehle et al. 2005, Morris et al. 2010). Understanding resource requirements of animal species, population and community responses to habitat changes, and mechanisms that determine animal responses, can provide greater insight on animal communities and responses to varying resources in forest ecosystems (Miller and Conner 2007). Furthermore, identifying these relationships will be imperative to the development and implementation of effective plans to conserve biodiversity (Barrows et al. 2005; Lindenmayer et al. 2008; Miller et al. 2009).

The way in which grasslands are used can influence vegetation and wildlife that grasslands support (Conner et al. 2001). For example, removal of aboveground vegetation by harvesting or grazing livestock changes the habitat structure and influences the abundance of rodents, arthropods, vegetation height, and soil properties (Johnson and Horn 2008, Davidson et al. 2010). An understanding of the interactions between resources and biota in grassland ecosystems will be essential for the continued use of the services provided by these systems (Davidson et al. 2010).

Rodent Dynamics

Rodents are excellent model organisms for the examination of the relationships species abundance and resource availability within a habitat because rodents occur in a wide variety of terrestrial habitats and population densities of rodent species have strong and rapid numerical responses to habitat changes (Stenseth and Lidicker 1992). Individual fitness may change with availability of required resources resulting in subsequent changes in population growth rate and abundance (Gaines and McClenaghan 1980; Ostfeld 1985; Vessey 1987). Therefore, examination of the relative abundance of species in a community may reflect the abundance and distribution of available resources in the habitat, if populations are controlled by bottom-up factors (MacArthur and Levins 1964, Andersen 1994).

Rodents contribute to species and functional diversity of the animal community (Carey and Johnson 1995). Rodents can act as ecosystem engineers by creation, modification, and maintenance of habitat structures (such as burrows) that can influence nutrient cycling, soil aeration, and use by other animal species (Jones et al. 1994). Rodents directly influence the distribution and abundance of many species through their use of a variety of food sources (e.g. plants, lichen, fungi, and invertebrates) and as prey for a variety of vertebrate predators rely on rodent prey (Carey and Johnson 1995).

Habitat use by rodents has been well studied in forests (Stenseth and Lidicker 1992, Tews et al. 2004). For rodents to successfully colonize an area, habitat conditions must allow for the establishment of home ranges of reproductive adults (Clarke and White 2008). Furthermore, the presence of juveniles suggests successful recruitment. Measurement of overall abundance and juvenile abundance over time can estimate how a rodent population changes (Andersen 1994).

Rodent responses to various disturbances in southeastern forests ecosystems have been explained by changes in understory vegetation and coarse woody debris (Masters et al. 1998, Loeb 1999, Constantine et al. 2004). In managed pine (*Pinus* spp.) plantations on the Coastal Plain of South Carolina, capture rates of cotton mice (*Peromyscus gossypinus*), eastern harvest mice (*R. humulis*), and hispid cotton rats (*S. hispidus*) were greater in young forest stands with thick understory cover than old forest stands that typically lacked understory foliage (Constantine et al. 2004). In the Ouachita National Forest of Arkansas, increased rodent species richness and diversity was strongly related to mid-story removal and fire, which promoted herbaceous growth in the understory (Masters et al. 1998). The presence of large amounts of snags and downed logs following tornadoes in a managed pine forest in South Carolina increased overall rodent abundance and improved quality of forest stands as habitat for cotton mice (*P. gossypinus*) (Loeb 1999).

The rodent communities of grassland habitats are usually related to the type and height of foliage (French et al. 1976, Grant and Birney 1979). Tall- and mid-grass habitats often support rodent communities dominated by herbivorous species, whereas short-grass rodent fauna is commonly dependent on invertebrates (French et al. 1976). Moreover, rodent community composition changes along a gradient from short to tall grass cover (Grant and Birney 1979).

Rodent responses to various disturbances in grassland ecosystems have been explained by decreases in foliage height, aboveground plant biomass, and cover, as well as altered soil properties (Collins and Wallace 1990). Following a fire disturbance, species that use open habitats and feed on seeds and/or insects (e.g., *Peromyscus sp., Chaetodipus sp.*) typically increase in abundance. Conversely, species that consume foliage directly (e.g., *Sigmodon sp., Microtus sp.*), forage for invertebrates in the litter layer (e.g., *Soricidae sp.*), or use aboveground nests of plant debris (e.g., *Microtus sp., Reithrodontomys sp.*) often decrease in abundance in response to fire (Collins and Wallace 1990). In a northwestern Chihuahua Mexican grassland, limiting the disturbance of caused by grazing domestic cattle (*Bos taurus*) increased vegetation height and abundance of black-tailed prairie dogs (*Cynomys ludovicianus*) and banner-tailed kangaroo rats (*Dipodomys spectabilis*) (Davidson et al. 2010).

Managing Forests for Biomass Removal: Woody Debris and Switchgrass

Harvesting plant biomass from managed loblolly pine (*P. taeda*) forests of the southeastern U.S. is now a potential energy source. Two ways of increasing biomass for fuels are: 1) intercropping fast growing grasses for annual harvest and 2) removing residual woody debris produced during clear-cut harvest of timber. Plant biomass from residual woody debris and above ground biofuel crops can be converted to liquid fuels such as ethanol or biodiesel via cellulosic biofuel processing, and remains can be used directly as solid fuels (e.g., dried and compressed into blocks or logs for stoves) (Weng et al. 2008, Oak Ridge National Laboratory 2009).

Residual woody debris is characterized as any portion of harvested timber products that are unsuitable for lumber production, and includes tree branches and treetops produced during harvest. Silvicultural practices in managed pine forests typically include leaving residual woody debris in place between rows of newly planted pines to decay on site. Removal of residual woody debris changes habitat structure and thus, resources (e.g. nest site density, fungal distribution) available to rodents (Bowman et al. 2000; Loeb 1999). Woody debris can provide important nesting and foraging habitat, refuge sites from predators, and habitat heterogeneity. The presence of woody debris improves quality of pine stands as habitat for cotton mice (*P. gossypinus*) (Loeb 1999). Furthermore, woody was related to rodent abundances in similarly aged forest stands (Carey and Johnson 1995).

Switchgrass (*Panicum virgatum* L.), a perennial C_4 grass native to the Great Plains region of North America, can thrive in a variety of environmental conditions and climates and is a biofuel feedstock with great potential (Oak Ridge National Laboratory 2009). Switchgrass can grow >2 meters tall in bunches, resulting in thick ground cover (Oak Ridge National Laboratory 2009). The root system is extensive, contains the majority of the plant's biomass, and can sequester nutrients and limit erosion (Oak Ridge National Laboratory 2009). Use of switchgrass as a biofuel crop requires low energy input for production, common farm equipment for planting and harvest, and cultivar plots can average up to 11,500 gallons of ethanol/acre/year for 10 consecutive years of harvest without yield decline (Fike et al. 2006, Oak Ridge National Laboratory 2009).

Switchgrass can be grown as monoculture or in combination with other crops via intercropping. Intercropping with existing pine has been suggested in managed pine stands where the space between rows of pine is typically unused. Introducing switchgrass into forests changes the availability and distribution of plants available to animals. Rodents use plants to meet daily (e.g., protection, cover, food) and reproductive needs (e.g., nest sites) (Carey and Johnson 1995). Planting switchgrass in pine forests is likely to increase understory plant cover, decrease plant community diversity, and decrease open space. Organisms that depend on understory plants for food, nest sites will be directly influenced if switchgrass replaces these understory plants. These organisms may continue inhabiting these areas if switchgrass provides the resources they need, and if not, emigrate or experience a decline in fitness.

To examine the influence of biomass removal options on ecological sustainability in a managed loblolly pine (*P. taeda*) forest, a long-term study was established in 2008-2009 immediately following clear-cut harvest and replanting of new forest stands in coastal North Carolina. Treatments established to examine biomass removal options in this study include: 1) pine with residual woody debris in place, 2) pine with residual woody debris removed, 3) pine and switchgrass intercropped with residual woody debris in place, 4) pine and switchgrass intercropped with residual woody debris removed, and 5) switchgrass only.

Objectives, hypotheses, and predictions

The objective of this study is to examine rodent responses to experimental biomass removal options by 1) characterizing features of habitat structure and their change in percent cover and height over among biomass removal options and over time, and 2) examining responses of rodents at population- and community-levels.

To characterize the habitat structure, I tested the assumption that biomass removal options will result in plots that differ in habitat structure. I predicted height and percent cover of residual woody debris will be greater in plots with residual woody debris in place, height and percent cover of grasses would be greater in plots where switchgrass was planted, and height and percent cover of residual woody debris and grasses would change over time as residual woody debris settles and decays, and switchgrass becomes established and grows over time.

Within these objectives, I test the following hypotheses.

Community-Level Hypothesis

Hypothesis 1) Rodent diversity will be influenced by biomass removal options.

Predictions H_1

Rodent diversity will increase in biomass removal options with residual woody debris because it will provide habitat heterogeneity such as nest and refuge sites. Rodent diversity will increase in biomass removal options with intercropped switchgrass because these plots will have greater habitat heterogeneity. Rodent diversity will be lower in monoculture biomass removal options (pine only, switchgrass only) because these plots provide a more homogenous distribution of food, nesting, or other resources.

Population-level hypotheses

Hypothesis 2) Population abundance (number of unique individuals and number of total captures) of rodent species will vary among biomass removal options and over time.

Predictions H_2

All rodent species will increase in abundance where woody debris was not removed because it will provide habitat heterogeneity such as nest and refuge sites. Rodent responses to the presence of switchgrass will be species specific. Abundance of granivores (*R. humulis*, house mouse, *Mus musculus*) and herbivores (*S. hispidus*) will increase in the presence of switchgrass due to increased food resources. Abundance of species that prefer open spaces (white-footed mouse, *Peromyscus leucopus*) will decrease in the presence of switchgrass due to high cover of grass. Seasonal and annual differences in available food resources, and rodent population cycles will result in abundance that changes over time for all rodent species.

Hypothesis 3) Abundance of juveniles in rodent populations will be influenced by biomass removal options.

Predictions H_3

Abundance of juveniles of all species will increase in the presence of woody debris because it will provide nest and refuge sites for adults. Species-specific variations in juvenile abundance will occur in presence of switchgrass. Juvenile abundance of granivores (*R. humulis, M. musculus*) and herbivores (*S. hispidus*) will increase in the presence of switchgrass due to increased food resources. Juvenile abundance of species that prefer open spaces (*P. leucopus*) will decrease in the presence of switchgrass due to high cover of grass.

CHAPTER II

METHODS

Study Area

This study was conducted on Weyerhaeuser Company's Lenoir 1 Sustainability Study Site, a research area in Lenoir County on the eastern coastal plain, near Dover, North Carolina, USA. The region is sandy bottomland forest dominated by agriculture and intensively managed loblolly pine forests. The 109 ha study site was a loblolly pine plantation established in 1974 with a site index of 70 for loblolly pine at 25 years (by 25 years of growth, mean loblolly pine trees can be expected to reach 70-feet (21.3m) in height due to site potential. Maintenance of water levels is via human-made linear ditches that run along forest edges and parallel each other through interiors of study site blocks (Figure 1). Within the Lenoir Tract, an approximate 72-ha research area was designated for study.

Weyerhaeuser Company's silviculture practices of managed loblolly pine forests include mechanical and chemical site preparation and planting of pine seedlings spaced 1-2 m apart on raised beds. Raised beds are in rows spaced 6.1 m apart. Residual woody debris generally is between rows of pine beds and decays on site. Pesticide and herbicide treatment, mechanical or chemical vegetation control, and commercial thinning occur as necessary. After 27-35 years pine forests are clear-cut harvested.

Experimental Design

The research area was composed of a 38.4 ha reference stand planted in 1974 and a 33.6 ha section divided into 30 experimental plots that were clear-cut harvested, and planted in 2008 – 2009 (Figure 1). The purpose of the reference stand was to qualitatively compare rodents in a 35 year old pine forest with experimental plots. Study plot sizes ranged from 0.76 ha to 1.39 ha ($\bar{x}$ = 1.11 ha). Plots were divided into four blocks consisting 5 plots each: Block 1 (Plots 2, 3, 13, 14, 22), Block 2 (Plots 5, 7, 9, 10, 11), Block 3 (Plots 16, 17, 18, 19, 20), and Block 4 (Plots 23, 25, 27, 29, 30; Figure 1). Within each block, experimental plots were randomly assigned a biomass removal option. The following five biomass removal options were examined in this study (Figure 1).

Biomass Removal Option Treatments

1. <u>Pine with residual woody debris in place, “Pine biomass +”</u>; (Plot 2, 9, 17, 30): Site preparation included V-shearing and construction of 1.5 m wide raised beds in rows with 6.1 m spacing between rows. Loblolly pines planted in December 2008 were centered on raised beds and spaced 1-2 m apart. Residual woody debris was placed between pine rows. This biomass removal option represented the control because this represents typical forest management (Figure 1).

2. <u>Pine with residual woody debris removed, “Pine biomass –”</u>; (Plot 5, 13, 20, 29): Site preparation included V-shearing and construction of 1.5 m wide raised beds in rows with

6.1 m spacing between rows. Loblolly pines planted in December 2008 were centered on raised beds and spaced 1-2 m apart. Residual woody debris was removed off the plot with an excavator to simulate a biomass harvest.

3. Pine and switchgrass intercropped with residual woody debris in place, "Pine × switchgrass, biomass +"; (Plot 7, 14, 16, 23): Site preparation included V-shearing and construction of 1.5 m wide raised beds in rows with 6.1 m spacing between rows. Loblolly pines planted in December 2008 were centered on raised beds and spaced 1-2 m apart. Residual woody debris was placed near the rows of pine. Switchgrass was machine-planted in May - July 2009 between pine rows.

4. Pine and switchgrass intercropped with residual woody debris removed, "Pine × switchgrass, biomass –"; (Plot 10, 19, 22, 27): Site preparation included V-shearing and construction of 1.5 m wide raised beds in rows with 6.1 m spacing between rows. Loblolly pines planted in December 2008 were centered on raised beds and spaced 1-2 m apart. Residual woody debris was removed off the plot with an excavator to simulate a biomass harvest. Switchgrass was machine-planted in May - July 2009 between pine rows.

5. Switchgrass Only (Plot 3, 11, 18, 25): Site preparation included excavation to remove residual woody debris, V-shearing, and root raking. Switchgrass was machine-planted in May - July 2009 on the entire plot.

Habitat Measurements

To assess habitat structure associated with the biomass removal options I used two, 30 m transect lines in each study plot during April, June, August, and October 2010. Transect lines were placed 20 m on either side of plot center and aligned perpendicular to rows of pines. I stretched a 30 m measuring tape across the plot from trap line A to trap line D, and attached it to steel spikes. I used a wooden meter-stick to achieve a vertical projection of the tape. I measured habitat features that crossed transect lines and covered a minimum area of 10 cm along the line using point interception methods (Floyd and Anderson 1987, Braun 2005). I categorized habitat features into one of the following variables: ferns, forbs, fungus, grasses, moss, vines, woody pines, hardwoods, exposed soil, other debris, woody debris (all), logs > 10 cm in diameter, logs < 10 cm in diameter, and stumps. I measured all habitat variables from one side to the other ignoring any breaks in their canopy. I recorded the distance (cm) that each habitat variable intersected a transect line as distance along the line to the nearest 10 cm. I estimated mean height (cm) above ground of each habitat variable to the nearest 10 cm using a wooden meter stick.

I estimated habitat structure as ‘percent cover’ and ‘height’ of each habitat variable. I calculated percent cover as the total linear distance each habitat variable covered divided by the total transect line distance, averaged across the two transect lines per plot. I estimated percent cover for time interval. I calculated height as the mean height of each habitat variable on a transect line, averaged for the two transect lines on each study plot, and calculated separately during each time interval (month).

Rodent Live Trapping

I conducted live trapping July 15- December 9, 2009, and July 19- November 14, 2010 on all plots and the reference stand (Figure 1). I established live trapping grids (30 m × 60m) approximately 20 m from the edge of each study plot and approximately 40m from the exterior edge of the reference stand (Figure 1). Each trapping grid consisted of 4 parallel trap lines with 10 m spacing between traps. Each trap line had 6 Sherman (H.B. Sherman Traps Inc., Tallahassee, FL) and 1 Longworth (Rogers Manufacturing Co., Peachland, BC) live traps assigned randomly. Trap lines were parallel to rows of pine.

I trapped each round for three consecutive nights, and all study plots in one block simultaneously. I set traps at sunset (1700-2030pm) and checked at sunrise (0600-0830am). I baited traps with a mixture of sunflower seeds and rolled oats. I conducted 8 trapping rounds between July 15- December 9, 2009, and 6 trapping rounds between July 19- November 14, 2010. Upon first capture, I marked all rodents with a unique numbered ear-tag (Monel Numeric size 1005-1). Upon capture of each rodent, I recorded ear-tag number, species, sex, age-class, reproductive condition, and mass. I considered *P. leucopus* to be adults if they had completed their post-juvenile molt (Layne, 1968) and *S. hispidus* to be adults if they weighed >80g (Chipman, 1965). I based age classes of other species on a combination of body mass and pelage characteristics. I determined pregnancy by palpitation. I determined lactation for captured females by bare and enlarged nipples. I determined males to be reproductive (scrotal) if testis were descended from the abdomen.

I estimated community diversity as species richness, Shannon Diversity Index, and Fisher's α Diversity Index. Species richness was the number of species captured in each plot in a year. I calculated Shannon Diversity Index as H' for each study plot using the total number of unique individuals (identified using ear tags) of all species captured in a year as $H' = -\sum_{i=1}^{S}(pi(\boldsymbol{ln}pi))$ where S = species richness, and *pi* = the proportion of individuals of a given species to the total number of individuals in the community (Shannon 1948). The Shannon Diversity Index includes a measure of evenness, a measure of the relative abundance, or proportion of individuals of a given species. Shannon Diversity Index was calculated using EcoSim7 software (Gotelli and Entsminger 2009). I calculated Fisher's α Diversity Index for each study plot using the total number of unique individuals of all species captured throughout a year as $S = a + \ln\left(I + \frac{n}{a}\right)$ where S = species richness, *n* = the number of unique individuals, and *a* = the Fisher's α, to obtain a non-bias measure of species diversity (Fisher et al. 1943). I calculated Fisher's α Diversity Index using Estimate S 8.2 software (Colwell 2009) with 1000 runs, strong hash encryption, and randomized samples without replacement. I calculated population abundance for each rodent population as the number of unique individuals captured and the number of total captures. I calculated both the number of unique individuals captured and the number of total captures during each trapping round, and habitat variable by biomass removal option for rodent species captured during ≥3 trapping rounds a year. Population abundance of *P. leucopus* captured in the reference stand during 2010 is presented as mean number of unique individuals per trapping round per 1800 m^2 for ease of comparison with abundance measures from study plots. Other population abundances from the reference stand are not presented as means because of small sample sizes, but instead as total number of individuals captured. I calculated juvenile abundance for each rodent population on each plot as the number of unique juveniles captured per year and. Juvenile abundance is presented as mean number of unique individuals per trapping round per 1800 m^2.

Rodents in the Study Area

The white-footed mouse (*P. leucopus*) is a native cricetid rodent that commonly resides in a variety of habitats including deciduous and coniferous forests, croplands, grasslands, and semi-desert throughout the central and eastern United States (Anthony et al. 1981, Merriam et al. 1989, Merriam and Lanoue 1990, Krohne and Hoch 1999, Barko et al. 2003). White-footed mice are often the most abundant rodent in deciduous forests and areas bordering agricultural lands, and following a disturbance (Lackey et al. 1985, Merriam et al. 1989, Merriam and Lanoue 1990, Barko et al. 2003). White-footed mice are omnivorous, feeding on a variety of plants, fruits, seeds, and arthropods (Myton 1974, Lackey et al. 1985, Derting and Hornung 2003).

The eastern harvest mouse (*R. humulis*) is a native cricetid rodent that can be found nesting in grassy habitats (Stalling 1997). The diet of eastern harvest mice is composed of grass and weed seeds, green vegetation, and orthopterous insects (Stalling

1997). Eastern harvest mice have been observed in association with *P. leucopus*, *S. hispidus*, and *M. musculus*, and are not locally abundant (Stalling 1997).

The hispid cotton rat (*S. hispidus*) is a native cricetid rodent that is often abundant in habitats of thick grasses and brush (French et al. 1976, Cameron and Spencer 1981, Foster and Gaines 1991, Loeb 1999). Hispid cotton rats are generalist herbivores that feed on a variety of plant species (Cameron and Spencer 1981, Randolph et al. 1991).

The marsh rice rat (*Oryzomys palustris*) is a native cricetid rodent that inhabits wetlands and coastal marshes of the southeastern U.S. (Wolfe 1982). Marsh rice rats are omnivorous and feed on vegetation, seeds, arthropods, and can be carnivorous (Wolfe 1982). Marsh rice rats are primarily nocturnal and often coexists with *S. hispidus* in southern habitats (Wolfe 1982).

The southern flying squirrel (*Glaucomys volans*) is a native sciurid rodent found in pine and hardwood forests east of the Mississippi river and isolated populations exist in central America (Dolan and Carter 1977). Southern flying squirrels are omnivorous, and feeds on invertebrates, eggs, nestlings, carrion, and a variety of nuts, fruits, and plant matter (Dolan and Carter 1977). Southern flying squirrels are arboreal and nest 4.5 to 6 m above ground (Dolan and Carter 1977).

The house mouse (*M. musculus*) is a murid rodent introduced from Europe that is now common throughout most of North America (Baker 1971, French et al. 1976, Webster et al. 1981, Mills and Childs 1998, Ballenger 2009). House mice are often found in a variety of grasslands as well as in close association with humans (Baker 1971, French et al. 1976, Ballenger 2009). House mice have a broad diet and can rapidly increase in abundance in the presence of required resources. Consequently, *M. musculus* is a pest species (Ballenger 2009).

Statistical Analyses

This study included measures and analyses of 1) habitat structure, 2) rodent community diversity, and 3) rodent species abundances. To quantify habitat structure, the dependent variables: percent cover and height were measured for the habitat variables (ferns, forbs, fungus, grass, moss, vines, pine, hardwood, exposed soil, other debris, woody debris) found in the study area. The independent variables used to analyze habitat structure were habitat variable, biomass removal option, and sampling date (month). To quantify rodent community diversity, the dependent variables species richness, Shannon Diversity Index, and Fisher's α Diversity Index were calculated. The independent variables used to analyze rodent community diversity were the treatments. To quantify rodent species abundances, the dependent variables were abundance (number of unique individuals and number of total captures), and number of unique juveniles. The independent variables used to analyze rodent abundance interactions were treatments, rodent species, and trapping round. The independent variable biomass removal option was used to analyze the dependent variable number of unique juveniles.

Community metrics and juvenile abundance are presented as mean ± 2 standard deviations. All other data are presented as mean ± 2 standard errors. All variables were standardized to the area of the trapping grid (1 800m^2). Variables were tested for normality using a Kolmogorov-Smirnov test and homogeneity of variance using a Levene's test. All variables that violated tests for normality or homogeneity of variance were transformed using log(+1), rank, squareroot, or squareroot-arcsin when appropriate. When transformations resulted in a more normal distribution or homogeneous variances as indicated by a higher p-value from a Kolmogorov-Smirnov test or Levene's test, transformed data were used for ANOVA tests. When transformations did not result in a more normal distribution or homogeneity of variances was not achieved, rank transformed variables were analyzed using parametric approaches because rank transformations have properties of robustness and power in analysis of variance (Conover and Inman 1982).

In the analysis of habitat structure, I examined the relationship of the dependent variables (percent cover and height) among the habitat variables within the different biomass removal options, and across sampling date (month). I used an ANOVA to test for interactions which address my main hypotheses even when parametric assumptions were violated. Generally, ANOVA tests are robust against heteroscedasticity of variance (Glass et al. 1972). To confirm statistical differences identified using ANOVAs, non-parametric Kruskal-Wallis tests were used to test the dependent variables percent cover and height for each habitat variable, and within each month, using the independent variable biomass removal option. When both ANOVA and Kruskal-Wallis tests identified significant differences, post-hoc analyses were conducted using multiple pairwise comparisons among biomass removal options with Mann-Whitney U tests and a Bonferroni correction (Bonferroni 1936).

In the analysis of the dependent variables for community structure and juvenile abundance, I examined the relationship between the dependent variables (i.e., richness, Shannon Diversity index, Fisher's α index, and juvenile abundance) and treatments. I used an ANOVA to analyze dependent variables among treatments when parametric assumptions were met, or a Kruskal-Wallis test otherwise. In addition, I used Morisita's index of similarity to evaluate the similarity among rodent communities in the biomass removal options because this index is independent of sample size and diversity (Morisita 1959; Wolda 1981).

For comparisons of rodent population abundance, I examined interactions among the dependent variables (i.e., the number of unique individuals, and the number of total captures) of each species among biomass removal options and trapping round. Rank transformations were performed because parametric tests were used and neither dependent variable met parametric assumptions (Conover and Inman 1982). Many individuals were captured repeatedly across rounds in both 2009 and 2010, so trapping rounds could not be considered as independent events. Therefore, I used a repeated measures ANOVA with 2 grouping (between-subject) factors and one within-subject factor (time), to test for all interactions. The repeated measures ANOVA tests did not meet assumptions of sphericity. Therefore, a Greenhouse-Geisser correction factor was used (Greenhouse and Geisser, 1959) because this correction factor has been shown to provide an equally powerful alternative in repeated measures analysis of variance (Grieve, 1984). To confirm statistical differences identified using repeated measures ANOVA tests, Kruskal-Wallis tests were used to test for biomass removal options for either number of unique individuals or number of total captures of each species. When both repeated measures ANOVA and Kruskal-Wallis tests identified significant differences, post-hoc analyses were conducted using multiple Mann-Whitney U tests with a Bonferroni correction (Bonferroni 1936).

Animals captured in the reference stand were not included in analyses and are presented for a qualitative comparison between the rodent communities that can be found in the interior of loblolly pine stands ~35 years of age.

A rejection criterion of $p<0.05$ was used for 1-factor ANOVA, 2-factor ANOVA, and Kruskal-Wallis tests. Mann-Whitney U tests with a Bonferroni correction were used for pairwise comparisons. All statistical analyses were conducted in SPSS 16.0 (SPSS 2007, Chicago, Il, USA).

CHAPTER III

RESULTS

Habitat Structure

Transect line measurements were conducted on all study plots during April 17-19, June 24-27, August 27-30, and October 8-11 2010. The variables percent cover and height differed among sampling dates, biomass removal options, and habitat variables. There was a significant interaction of biomass removal option × habitat variable × sampling date (month) for both percent cover ($F_{76,1120}$=2.011; p<0.001, Table 1) and height ($F_{64,980}$=1.667; p=0.001, Table 2). Below I describe percent cover and height of habitat for the first (April) and last (October) vegetation sampling dates. Results from June and August are intermediate to the first and last sampling dates.

In April, grasses, exposed soil, and woody debris composed the predominant cover on all biomass removal options (Figure 2a). Biomass removal options differed with respect to percent cover of forbs, grasses, pines, woody debris, and exposed soil (Figure 2a, Table C 1). Percent cover of forbs was higher in the biomass removal option pine biomass + than switchgrass only (Figure 2a, Table C 2a). Percent cover of grasses was higher in the biomass removal options pine × switchgrass biomass +, and pine × switchgrass biomass - than both pine biomass - and pine biomass + (Figure 2a, Table C 2b). Percent cover of pines was higher in the biomass removal options pine biomass -, pine biomass +, and pine × switchgrass biomass + than switchgrass only (Figure 2a, Table C 3a). Percent cover of woody debris was higher in the biomass removal option pine biomass + than pine biomass -, pine × switchgrass biomass -, and switchgrass only (Table C 3b). Pairwise analysis failed to reveal a difference for percent cover of exposed soil between any two biomass removal options (Figure 2a, Table C 4). Moreover, in April biomass removal options differed with respect to height of forbs, pines, and woody debris (Figure 3, Table C 5). Height of forbs was higher in the biomass removal the option pine biomass + than switchgrass only (Figure 3, Table C 6a). Height of pines was higher in the biomass removal options pine biomass -, pine biomass +, and pine × switchgrass biomass + than switchgrass only (Figure 3, Table C 6b). Height of woody debris was higher in the biomass removal options pine biomass + and pine × switchgrass biomass + than switchgrass only (Figure 3, Table C 7).

In October percent cover of forbs, grasses, pines, and woody debris differed among biomass removal options (Figure 2b, Table C 1b). In October, there was no difference in percent cover of exposed soil among biomass removal options (Figure 2b, Table C 1b). Percent cover of forbs was lowest in the biomass removal option switchgrass only (Figure 2b, Table C 8a). Percent cover of grasses was highest in the biomass removal option switchgrass only (Figure 2b, Table C 8b). Additionally, percent cover of grasses was higher in the biomass removal option pine × switchgrass biomass - than pine biomass + (Figure 2b, Table C 8b). Percent cover of pine was lowest in the biomass removal option switchgrass only (Figure 2b, Table C 9a). Percent cover of woody debris was higher in the biomass removal option pine biomass + than pine biomass -, pine × switchgrass biomass -, and switchgrass only (Figure 2b, Table C 9b). Additionally, percent cover of woody debris was higher in the biomass removal options pine biomass - and pine × switchgrass biomass + than switchgrass only (Figure 2b, Table C9b). In October 2010 biomass removal options differed with respect to height of forbs, grasses, pines, and woody debris (Figure 3, Table C 5b). Pairwise analysis failed to reveal a difference for height of forbs between any two biomass removal options (Figure 3, Table C 10a). Height of grasses was higher in the biomass removal option switchgrass only than pine biomass - and pine biomass + (Figure 3, Table C 10b). Height of pines was lowest in the biomass removal option switchgrass only (Figure 3, Table C 11a). Height of woody debris was higher in the biomass removal options pine biomass -, pine biomass +, and pine × switchgrass biomass + than switchgrass only (Figure 3, Table 11b).

Rodent Results

Trapping occurred between July 15 and December 9 in 2009. I captured 648 unique individual rodents (267 *P. leucopus*, 248 *M. musculus*, 122 *S. hispidus*, 11 *R. humulis*) 1806 times on the study plots. Captures in 2009 occurred over 77 nights resulting in 15,366 trap nights. In 2010 trapping occurred between July 19 and November 14. I captured 1,634 unique individual rodents (1,030 *S. hispidus*, 310 *M. musculus*, 297 *P. leucopus*, 15 *R. humulis*, 6 *O. palustris*) 3,594 times on the study plots. Captures in 2010 occurred over 54 nights resulting in 11,044 trap nights.

Reference Stand

In 2009, the reference stand was trapped for 73 nights resulting in 2040 trap nights. Two individuals (1 *S. hispidus* and 1 *R. humulis*) were captured. In 2010, the reference stand was trapped for 33 nights resulting in 921 trap nights. Forty unique individuals (37 *P. leucopus*, 1 *G. volans*, 1 *M. musculus*, and 1 *S. hispidus*) were captured. I captured 6.2 ± 3.4 *P. leucopus* individuals /1800m^2 per round.

Rodent Community Diversity

In 2009, biomass removal option did not affect the rodent community (species richness, χ^2=3.167, *df*=3, p=0.530, Shannon Diversity Index, F=0.670, *df*=4,19, p=0.623, Fisher's α Diversity Index, F=0.109, *df*=4,19, p=0.977) (Table 3). In 2010, there was no biomass removal option effect on the rodent community (species richness, χ^2=3.167, *df*=3, p=0.530, Shannon Diversity Index, F=0.292, *df*=4,19, p=0.879, or Fisher's α Diversity Index, F=0.412, *df*=4,19, p=0.797) (Table 4). In 2009 and 2010, the rodent community found in the biomass removal options pine biomass – and pine biomass + were most similar as indicated by the highest value of similarity (Table 5 & 6). In 2009, the rodent community found in pine × switchgrass biomass – was the least similar to options without switchgrass (Table 5). In 2010, the rodent community found in switchgrass only was least similar to options without switchgrass (Table 6).

Rodent Population Abundance

I report results of analyses on the dependent variable unique number of individuals below because there was a general concordance between results of unique number of individuals and total number of captures. Unless otherwise specified, the results of analyses on the number of total captures agree. Tables and figures presented in this section show both unique number of individuals and total number of captures. I included *R. humulis* in repeated measures 2-factor ANOVA tests, but excluded them post-hoc analyses due to small sample sizes in both 2009 and 2010. Significant differences are identified from repeated measures 2-factor ANOVA tests at $p \leq 0.05$, and biologically important trends are identified at $0.05 \leq p \leq 0.10$ (Ramsey and Schafer 2002).

In 2009, there was a significant species effect on the number of unique individuals, indicating that some species were more abundant than others (F=59.876, *df*=3, p<0.001, Table 7a). There were more *P. leucopus* unique individuals captured than *M. musculus*, and *S. hispidus* (Table 8a). The number of total unique individuals did not differ among biomass removal options (F=1.241, *df*= 4, p=0.303, Table 7a). There was a trend for the relative number of unique individuals of each species to differ among biomass removal options (species × biomass removal option: F=1.736, *df*=12, p=0.081, Table 7a). This trend is illustrated in the number of unique *M. musculus* and *S. hispidus* individuals appearing higher in the biomass removal options with switchgrass and *P. leucopus* appearing lower in the biomass removal option pine × switchgrass biomass - (Figure 4a). However, the species by biomass removal option was not significant for total captures (species × biomass removal option: F=1.448, *df*=12, p=0.170, Table 7b). There was a significant trapping round effect on the number of unique individuals, indicating that the number of all rodents changed over time (F=9.202, *df*=4.860, p<0.001, Table 7a).

The interaction of trapping round × biomass removal option on the number of unique individuals was not significant suggesting temporal changes in the number of unique individuals did not differ among biomass removal options (F=0.792, *df*=19.441, p=0.719, Table 7a). The significant interaction of trapping round × species on the number of unique individuals indicates that temporal changes in the number of unique individuals differed among species (F=5.230, *df*=14.581, p<0.001, Table 7a, Figure 5a). The number of unique *M. musculus* individuals differed among trapping rounds in 2009 (Table 9a), beginning low in July, increasing until mid-September, followed by a decline until late-October and early November, after which abundance again increased in late November – mid December (Figure 5a). The number of unique *S. hispidus* individuals differed among trapping rounds (Table 9a), beginning low in July, increasing until mid-September, followed by a decline until late-October after which abundance again increased in late November- mid December (Figure 5a). The number of unique *P. leucopus* individuals displayed a trend to differ among trapping rounds (Table 9a), and total *P. leucopus* captures differed among rounds (Figure 5b; Table 9b). Total *P. leucopus* captures initially rose between July and late-August, decreased in mid-October, then increased in late October and remained high through December (Figure 5b). There was a trend suggesting an interaction of trapping round × biomass removal option × species for the number of unique individuals captured (F=1.361, *df*=58.324, p=0.053, Table 7a), but not for total captures (F=1.151, *df*=54.974, p=0.234, Table 7a). This suggests the number of individual rodents of each species differed with the biomass removal options (Figure 4a) and across rounds (Figure 5a).

During 2010, there was a significant species effect on the number of unique individuals, indicating that some species were more abundant than others (F=74.915, *df*=4, p<0.001, Table 10a). More *S. hispidus* individuals were captured than *P. leucopus* or *M. musculus* individuals (Table 11a). The number of unique individual rodents did not differ among biomass removal options (F=0.613, *df*=4, p=0.655, Table 10a). However, the number of unique individuals of the different species differed among biomass removal options (F=3.329, *df*=16, p<0.001, Table 10a). The number of unique *P. leucopus, M. musculus,* and *S. hispidus* individuals differed among biomass removal options (Table 12a). More individual *P. leucopus* were captured in the biomass removal options without switchgrass (Figure 6a, Table C 12a). In addition, more *P. leucopus* individuals were captured in the biomass options pine × switchgrass biomass - than switchgrass only (Figure 6a, Table C12a). More *M. musculus* individuals were captured in the biomass removal option switchgrass only (Figure 6a, Table C 13a). In addition, more *M. musculus* individuals were captured in the biomass removal options pine × switchgrass biomass - than pine biomass + (Figure 6a, Table C 13a). More individual *S. hispidus* were captured in the biomass removal option pine × switchgrass biomass - than switchgrass only (Figure 6a, Table C 14a). There was a significant trapping round effect on the number of unique individual rodents, indicating that the number of unique rodents captured changed over time (F=27.124, df=4.077, p<0.001, Table 10a). The interaction of trapping round × biomass removal option on the number of unique individuals was not significant, suggesting the number of unique individuals did not differ among biomass removal options with time (F=0.842, df=16.307, p=0.640, Table 10a). The interaction of trapping round × species on the number of unique individuals was significant indicating temporal changes in the number of unique individuals differed among species (F=26.817, df=16.307, p<0.001, Table 10a, Figure 7a). The number of unique *S. hispidus* captured differed among trapping rounds (Table 13a). The number of unique *S. hispidus* individuals increased from mid-July until late-September, decreased in late-October, and again increased in mid-November (Figure 7a). There was a trend for the number of unique *M. musculus* individuals to differ among trapping rounds (Table 13a). The number of total *M. musculus* captures differed among trapping rounds (Table 13b). The number of total *M. musculus* captures increased between July and August, and steadily declined through mid-November (Figure 7b). The number of unique *P. leucopus* individuals did not differ among trapping rounds in 2010 (Figure 7a; Table 13a). The interaction of trapping round × biomass removal option × species on the number of unique individuals captured was not significant (F=0.919, *df*=65.228, p=0.652, Table 10a). This suggests that temporal differences in the number of individual rodents of each species did not differ among biomass removal options.

Rodent Juvenile Abundance

In 2009, the number of unique juveniles did not differ among biomass removal options for the three most abundant species, *P. leucopus* (χ^2=2.392, df=4, p=0.664), *M. musculus* (χ^2=6.561, df=4, p=0.161), or *S. hispidus* (χ^2=6.088, df=4, p=0.193) (Table 14). During year 2, the number of unique juveniles differed among biomass removal options for the species, *P. leucopus* (χ^2=11.103, df=4, p=0.025), *M. musculus* (χ^2=11.257, df=4, p=0.024), but did not differ for *S. hispidus* (χ^2=3.886, df=4, p=0.422) (Table 15). Multiple pairwise comparisons of the unique number of juveniles captured failed to reveal a difference between any two biomass removal options after a Bonferroni correction for the species *P. leucopus* or *M. musculus* (Table C 15). However, examination of the post-hoc analyses reveals a trend for lower abundance of *P. leucopus* juveniles to be captured in biomass removal options with increasing cover of switchgrass. Moreover, *M. musculus* juveniles show a trend to have higher abundance in habitats with switchgrass than pine biomass - plots.

Additional demographic information on adult sex ratio is included for information purposes only and presented as mean ± standard deviation (Table C 16 & C 17).

CHAPTER IV

DISCUSSION

Summary of Results

Habitat structure changed over time and differed among biomass removal options verifying that the biomass removal options affected structural characteristics important to southeastern rodents. Despite differences in habitat structure associated with biomass removal options, there were no differences in species richness, Shannon Diversity index, or Fisher's α index among biomass removal options during either year. Moreover, overall rodent abundance did not differ among biomass removal options in either year. In the first year of study, more *P. leucopus* individuals were captured than any other species, and in the second year of study, more *S. hispidus* individuals were captured than any other species. Overall rodent abundance and species specific abundance changed over time in both years. In the first year of study, abundance of each rodent species showed a trend to differ among biomass removal options. This trend suggests abundance of *M. musculus* and *S. hispidus* individuals was greater in habitats with switchgrass. In the second year of study, abundance of *P. leucopus*, *M. musculus,* and *S. hispidus* differed among biomass removal options. Abundance of *P. leucopus* was higher in habitats without switchgrass, intermediate in habitats with pine and switchgrass intercropped and lowest in switchgrass only habitats. The opposite pattern was observed in the abundance of *M. musculus,* which was highest in switchgrass only habitats, intermediate in habitats with pine and switchgrass intercropped and lowest in habitats without switchgrass. The abundance of *S. hispidus* individuals appeared to increase with coverage of grasses for each habitat that contained pine, but this pattern did not continue in switchgrass only habitats. In the first year of study, juvenile abundance of each species did not differ among biomass removal options. In the second year of study, the number of unique *P. leucopus* and *M. musculus* juveniles differed among biomass removal options and paralleled patterns of adult abundance.

Influence of Biomass Removal Options on Habitat Structure

Differences occurred in habitat structure over time within the biomass removal options during this study. Grass coverage and height increased on the entire study site, but remained highest in plots with switchgrass. Furthermore, pine and switchgrass became established and increased in height during the second year of study, and woody debris remained high in plots with residual woody debris left in place. This confirms the preparation of the study plots was successful because the habitat structure of the study area differed among biomass removal options and changed as plants colonized exposed soil over time.

Influence of Biomass Removal Options on Rodents

Rodent Community

All rodent species captured in this study were expected to be found inhabiting pine forests in the southeast and have previously been observed in these habitats

(Atkeson and Johnson 1979, Loeb 1999, Mengak and Guynn 2003). *Peromyscus leucopus, S. hispidus, R. humulis, and M. musculus* were the only species captured in study plots in the first year of study, and >99% of the unique individuals captured in the second year of study (6 *O. palustris* were captured during November 2010). These same species (excluding *O. palustris*) were captured in young pine plantations (1-3 years post-planting) in the Georgia Piedmont (Atkeson and Johnson 1979).

Rodent community diversity was not influenced by biomass removal options during either year as measured by species richness, Shannon Diversity index, or Fisher's α index, and did not support the hypothesis that rodent diversity was influenced by biomass removal options. Species richness would not be expected to change unless species were locally extirpated, and source populations of unique species were not present in the surrounding pine forests or agricultural fields to supply immigrants to the study area. Without changes in species richness, the species diversity indices used would not be expected to differ among biomass removal options unless there were differences in the abundance of the most common species. Based on the similarities in community diversity metrics among biomass removal options, my results suggest the presence of residual woody debris had a small influence on community similarity, and the presence of switchgrass had a significant influence on community similarity. In all cases, larger differences were observed between switchgrass only plots and all other biomass removal options during the second year of study suggesting switchgrass only habitats had much different structure, and offered different resources to rodents at this time.

However, relative species abundance varied by year on all plots. In 2009, *P. leucopus* was the most abundant species captured, whereas in 2010 *S. hispidus* was the most abundant species captured. This shift in the most abundant species of the rodent community over years has been seen in other studies of young pine plantations in the southeastern U.S., and in secondary succession of both forest and grassland habitats (Atkeson and Johnson 1979; Clarke and White 2008; Masters 1993). This shift in the most abundant species across years suggests the rodent community responded to changes that occurred in the habitat structure during this study.

Rodent Population Responses to Biomass Removal Options

Overall rodent abundance did not differ with respect to biomass removal options. However, abundance of each species showed a trend to differ among biomass removal options in the first year, and significant differences in second year of the experiment. My results support the hypothesis that population abundance of rodent species vary among biomass removal options. This result was expected because resource requirements and the ability to respond to changes in resource abundance differ among rodent species (Bownam, et al. 2001; Fox 1987; MacArthur and Levines 1964).

The presence of residual woody debris did not appear to influence rodents within the first two years post-planting in this system because treatments with removal of woody debris did not differ with respect to rodent abundance from those without removals. Although residual woody debris provides important habitat structure for rodents, it is likely that the influence of other factors such as food sources, foliage cover, or soil characteristics were the habitat components that exerted the greatest influence during early succession in this managed pine forest. In contrast, the presence of switchgrass changed the habitat structure and resources available to the rodent community in young managed pine stands during the first two years of growth. The differences in habitat structure among biomass removal options with and without switchgrass were reflected in rodent populations within the first year of study, and a stronger influence on rodents during the second year of the study. Based on my results biomass removal options appear to affect habitat quality of the rodents.

Peromyscus leucopus appears to be negatively affected by switchgrass in terms of abundance. During the second year of study, *P. leucopus* adults were found in high abundance in non-switchgrass habitats, intermediate abundance in pine and switchgrass intercropped habitats, and the lowest abundance in switchgrass only habitats. Furthermore, this is concordant with the observation that fewer *P. leucopus* juveniles were captured in habitats with switchgrass during the second year of study. The presence of juveniles in habitats without switchgrass provides evidence that differences in abundance were a result of *P. leucopus* reproduction in these habitats as opposed to only immigration. Juvenile abundance in switchgrass habitats was low, suggesting switchgrass provides limited resources for adult reproduction of *P. leucopus* and emigration or exclusion may have had a stronger influence on *P. leucopus* in these habitats. *Peromyscus leucopus* is typically an early successional species that is more abundant in open habitats than those with high understory foliage cover (Atkeson and Johnson 1979; Merriam and Lanoue 1990). Habitats with switchgrass contain dense cover, and therefore would be expected to support few *P. leucopus*. The result of fewer *P. leucopus* found in habitats with switchgrass suggests switchgrass habitats may fail to provide sufficient resources to support *P. leucopus,* and *P. leucopus* may be unable to successfully compete for resources in switchgrass habitats.

Mus musculus appeared to be positively affected by switchgrass in terms of abundance. During the first year of study, there was a trend for higher abundances of *M. musculus* adults in habitats with switchgrass. In the second year of study there were nearly twice as many adults captured in switchgrass only habitats than any other biomass removal option. *Mus musculus* abundance was intermediate in pine and switchgrass intercropped habitats, and lowest in habitats without switchgrass. An examination of the number of *M. musculus* juveniles on each biomass removal option suggests habitats with switchgrass provided the best habitat for *M. musculus* reproduction, and corresponds to the observed patterns in adult *M. musculus* abundance and provides evidence that abundance was a result of *M. musculus* reproduction in these habitats as opposed to only immigration. Juvenile abundance in habitats without switchgrass was low suggesting habitats without switchgrass provide limited resources for *M. musculus* reproduction, and immigration from other areas or competitive exclusion may have had a stronger influence on *M. musculus* in these habitats. *M. musculus* is a pest species due that can rapidly increase in abundance in the presence of required food resources (Stenseth, et al. 2003). These results suggest *M. musculus* may be able to out-compete other species for resources in switchgrass habitats.

Sigmodon hispidus appears to be positively influenced by switchgrass intercropping, but not switchgrass habitats without pine. In the first year of study, the abundance of *S. hispidus* showed a trend to be higher in habitats with switchgrass. In the second year, abundance of *S. hispidus* individuals appeared to increase with coverage of grasses in habitats containing pine. In switchgrass habitats without pine however, the abundance of *S. hispidus* was similar to in habitats without switchgrass. Juvenile abundance of *S. hispidus* did not differ among biomass removal options in either year, suggesting all habitats examined in this study provided similar resources for *S. hispidus* reproduction. Furthermore, the presence of juvenile *S. hispidus* in all biomass removal options suggests differences in abundance were not due to *S. hispidus* reproduction, but differential survival, immigration, or emigration among biomass options. *Sigmodon hispidus* has been found to out-compete other rodent species for resources in habitats with high understory foliage cover (Raun and Wilks 1964, Grant 1972b, Grime 1973). These results are consistent with findings that *S. hispidus* may be a better competitor in habitats with high foliage cover, but also suggest that some habitat structure feature provided by the presence of pine may be important for this pattern to occur. I speculate that the additional protection from avian predators provided by pine may have been one of these important features. Additionally, these results suggest *S. hispidus* individuals may be provided the best combination of available resources in habitats with pine and switchgrass intercropped, and may be able to out-compete other rodent species for resources in intercropped habitats.

The influence of biomass removal options on *R. humulis* could not be determined from this study. During both years of study, and other studies in southeastern pine forests, few *R. humulis* individuals were captured, suggesting this is a rare species in pine forest habitats (Atkeson and Johnson 1979). Moreover, *R. humulis* individuals were captured in all biomass removal options examined.

The three most abundant species of rodents *P. leucopus, M. musculus,* and *S. hispidus* all responded along a gradient of increasing degree of change from pine habitats with residual woody debris in place. Thus, as the habitat structure became more different from pine habitats with residual woody debris in place, the abundance of generally *P. leucopus, M. musculus,* and *S. hispidus* became increasingly different. Removal of residual woody biomass did not result in changes of rodent abundance. My results suggest residual woody debris removal in this pine forest system has no influence on rodent abundances. Intercropped pine and switchgrass habitats showed intermediate responses of rodent abundance, and no differences were identified between intercropped habitats with or without residual woody debris. My results suggest incorporation of switchgrass intercropping in this pine forest system would have an intermediate influence on rodents. Habitats that contained only switchgrass resulted in significant changes in abundance of the *P. leucopus* and *M. musculus* populations, however *S. hispidus* was found in similar abundance to habitats without switchgrass. My results suggest that planting only switchgrass in this pine forest system will have a significant influence on rodent populations.

Temporal Changes of Rodent Populations

In both years, overall rodent abundance increased between July and late-September, and remained high until trapping ended in mid-December (2009) or mid-November (2010). Rodent abundance in the southeast U.S. typically increases in the end of summer and fall as a result of increased vegetative cover, food resources, and individual reproduction during this time of year (Atkeson and Johnson 1979; Myton 1974).

Temporal changes that occurred in rodent abundance did not differ among biomass removal options. The changes that occurred in resources that determined temporal trends in rodent abundance may have been due to seasonal changes as opposed to differences among habitats provided by the biomass removal options. In addition, rodent populations grow over the breeding season (Myton 1974; Carey and Johnson 1995). Rodent abundances have been shown to fluctuate seasonally in a variety of habitats including forests and grasslands throughout North America (Odum 1955; Grant and Birney 1979; Seagle 1985; Briese and Smith 1974).

In the first year of study, *P. leucopus* abundance fluctuated over time and displayed an overall increasing trend in abundance. However, there was a decrease of *P. leucopus* captures in mid-October, likely due to rain events, before abundance increased in late October and remained high through December. In the second year of study, *P. leucopus* abundance did vary over time. This lack of increase may result from a high abundance of *S. hispidus*, and potential competition for resources in the study area may have limited *P. leucopus* abundance. The diets of *S. hispidus* and *P. leucopus* overlap substantially, and *S. hispidus* can out-compete other species in habitats with high understory cover (Raun and Wilks 1964, Grant 1972b, Grime 1973). In Georgia, *P. leucopus* populations were the most abundant in recently planted stands, and were reduced in abundance in stands 3 or more years post-planting, corresponding to an increase in *S. hispidus* abundance (Atkeson and Johnson 1979). Thus, *P. leucopus* individuals may out-compete other species for resources in open habitats, but are unable to do so in habitats with high ground cover (Atkeson and Johnson 1979; Merriam and Lanoue 1990).

In the first year of study, *M. musculus* abundance fluctuated with time and increased in abundance. The appearance of *M. musculus* in late August occurred simultaneously with the harvest of corn (*Zea mays*) fields located adjacent to the study area. Once captured initially, the abundance of *M. musculus* adults increased, suggesting immigration occurred to the study site from adjacent agricultural fields. Additionally, locations of the trap stations where *M. musculus* individuals were first captured support this possibility. *Mus musculus* is an invasive omnivore that can increase in abundance rapidly when required resources become available (Stenseth, et al. 2003). Increased *M. musculus* abundance suggests resources did not limit abundance in the first year of study. In the second year of study, *M. musculus* abundance showed a decreasing trend in number of unique individuals captured and a significant decrease in total captures between July and November. This decline in abundance may have occurred because of the greater abundance of *S. hispidus,* a potential competitor, and competition for resources in the study area may have limited changes in population abundance. *Mus* *musculus* has been found to decline in abundance as habitat structure changed over time, and the old-field mouse (*Peromyscus polionotus*) was able to competitively exclude *M. musculus* individuals in 1 acre field enclosures (Grant 1972b).

In both years of study, *S. hispidus* abundance increased throughout the trapping period and corresponded to increasing foliage ground cover. Managed pine stands 2-7 years of age have high densities of understory foliage, and have been found to support higher abundances of *S. hispidus* compared to younger or older stands (Atkeson and Johnson 1979). My results suggest *S. hispidus* individuals may be out-competing *P. leucopus* for resources such as food and nest sites in habitats with high foliage cover (Raun and Wilks 1964, Grant 1972b, Grime 1973).

During both years of study, *R. humulis* abundance remained low. This result was surprising because the *R. humulis* population was expected to increase in the presence of switchgrass due to increased availability of seeds during autumn. The lack of response of *R. humulis* abundance suggests this species does not respond to changes in resource abundance rapidly, *R. humulis* individuals are poor competitors for resources with *S. hispidus*, or they are rare pine forests (Constantine et al., 2005; Stalling 1997).

Reference Stand

During both years, I found smaller rodent populations in the 35-year old reference stand than in the 1-2 year old study plots with the exception of *P. leucopus* in the second year of study. Thus, low densities of *P. leucopus, M. musculus, S. hispidus,* and *R. humulis* can be found in 35-year old pine forests in this system. In the second year of study, the population of *P. leucopus* that was found in the reference stand had a mean of 6 ± 3.4 individuals/round/1800m^2, suggesting a 35-year old pine forest can to provide sufficient resources to support high densities of this native species. For comparison, during the first year of study *P. leucopus* was the most abundant species captured with a mean of 5 ± 2.4 individuals/round/1800m^2. Furthermore, in the second year of study a mean of 7 ± 1.1 individuals/round/1800m^2 were captured in treatments that supported the highest *P. leucopus* abundances. It was surprising to find this abundance of *P. leucopus* in the reference stand because previous studies have not found this species at densities this high in mature pine forests (Atkeson and Johnson 1979, Loeb 1999, Constantine et al. 2004, Miller et al. 2004). The differences observed in *P. leucopus* population abundance between years may be a result of the natural fluctuations in population size characteristic of rodents, or an effect of the adjacent experimental study plots. The reference stand was established ~100m from the study plots (Figure 1), and individuals displaced from study plots may have moved to the reference stand. This finding indirectly supports the hypothesis that *P. leucopus* individuals may have been competitively excluded from the study plots. In addition, the presence of single *S. hispidus, R. humulis* (the first year of study) and *M. musculus, S. hispidus* (the second year of study) that were captured only one time suggests these species can be expected to have small population abundances in 35-year old pine forest stands, as observed in other studies (Atkeson and Johnson 1979Atkeson and Johnson 1979, Loeb 1999, Constantine et al. 2004, Miller et al. 2004). A single *G. volans* was captured one time during the second year of study, providing further evidence that pine forest habitats >30 years in age support this species in the southeast (Loeb 1999).

Potential Mechanisms

The mechanisms underlying the observed patterns of rodent abundance would require further experimentation to be identified. It is likely that the observed patterns of rodent population abundances are the result of differences in available resources as well as interspecific competition for these resources and effects of habitat structure. Differences in habitat structure among biomass removal options may also influence predator and parasite populations. The degree to which rodent populations are influenced by resource availability, interspecific competition, or natural enemies cannot be inferred from the results of this experiment.

The influence of food resource availability on these rodent populations could be examined experimentally by manipulating food densities in habitat enclosures that contain different relative abundances of species. For example, to examine the influence of food resources on *P. leucopus* in switchgrass habitats, one set of switchgrass plots could be supplied with seeds and insects while in another set of switchgrass plots seeds and insects could be removed, and a third set of plots could serve as an unmanipulated control. Differences in population abundance and changes in abundance over time could be observed, and compared to unmanipulated control plots.

The influence of interspecific competition could be examined experimentally by manipulating rodent densities within enclosures containing combinations of 2 species.

For example, to examine the influence of interspecific competition between *P. leucopus* and *M. musculus*, removal experiments could be conducted. To identify the influence of *M. musculus* individuals on *P. leucopus* abundance in pine only, and switchgrass only habitats, the abundance of *P. leucopus* individuals could be kept constant, across several replicated plots. Increasing densities of *M. musculus* could then be added to some plots at low density, others at medium density, and others at high densities. The abundance of both populations could be examined over time to examine the changes in population abundances that occur over time and across a gradient of *M. musculus* densities. The results from my study suggest *P. leucopus* to be the more competitive species in pine only habitats, and *M. musculus* to be the more competitive species in switchgrass only habitats.

Management Implications

The objective of my study was to experimentally examine rodent responses to different biomass removal options. The three most abundant rodent species responded via changes in abundance along a gradient to increasing intensity of change from pine habitats with residual woody debris in place to switchgrass only. In this pine forest system my results suggest residual woody debris removal has no influence on rodent population abundances, incorporation of switchgrass intercropping has an intermediate influence on rodent population abundances, and planting switchgrass only has a significant influence rodent population abundances.

Switchgrass habitats supported higher abundances of the invasive *M. musculus*, and lower abundance of the native *P. leucopus* than habitats without switchgrass. Thus, forest managers may want to consider maintaining a mosaic of habitats with introduction of switchgrass exclusively at interior forest stands. This strategy could benefit native species that avoid switchgrass, such as *P. leucopus*, by providing refuge areas devoid of switchgrass in exterior stands. Moreover, if interior stands are further from source populations of *M. musculus* such as agricultural fields and buildings, the rapid increase in abundance of this invasive species may be delayed.

These conclusions arise from observations made on experimental plots during the first two years following planting of switchgrass. Pine trees in this habitat are likely to require at least 7 years of growth before the canopy closes and shades the understory. During this time switchgrass could spread to cover more area in intercropped biomass removal options than was observed in this study. Furthermore, the influence of switchgrass on the rodent community in subsequent years cannot be extrapolated from current data.

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APPENDIX A: FIGURES

Figure 1. Map of Weyerhaeuser Company’s Lenoir 1 Long-term Sustainability Study Site

Study site located in Lenoir County, NC. Plots in this study include the biomass removal options: Pine Biomass +; Pine Biomass -; Pine × Switchgrass Biomass +; Pine × Switchgrass Biomass -; Switchgrass only. Each biomass removal option is replicated four times, with one replicate in each Block 1, 2, 3, & 4.

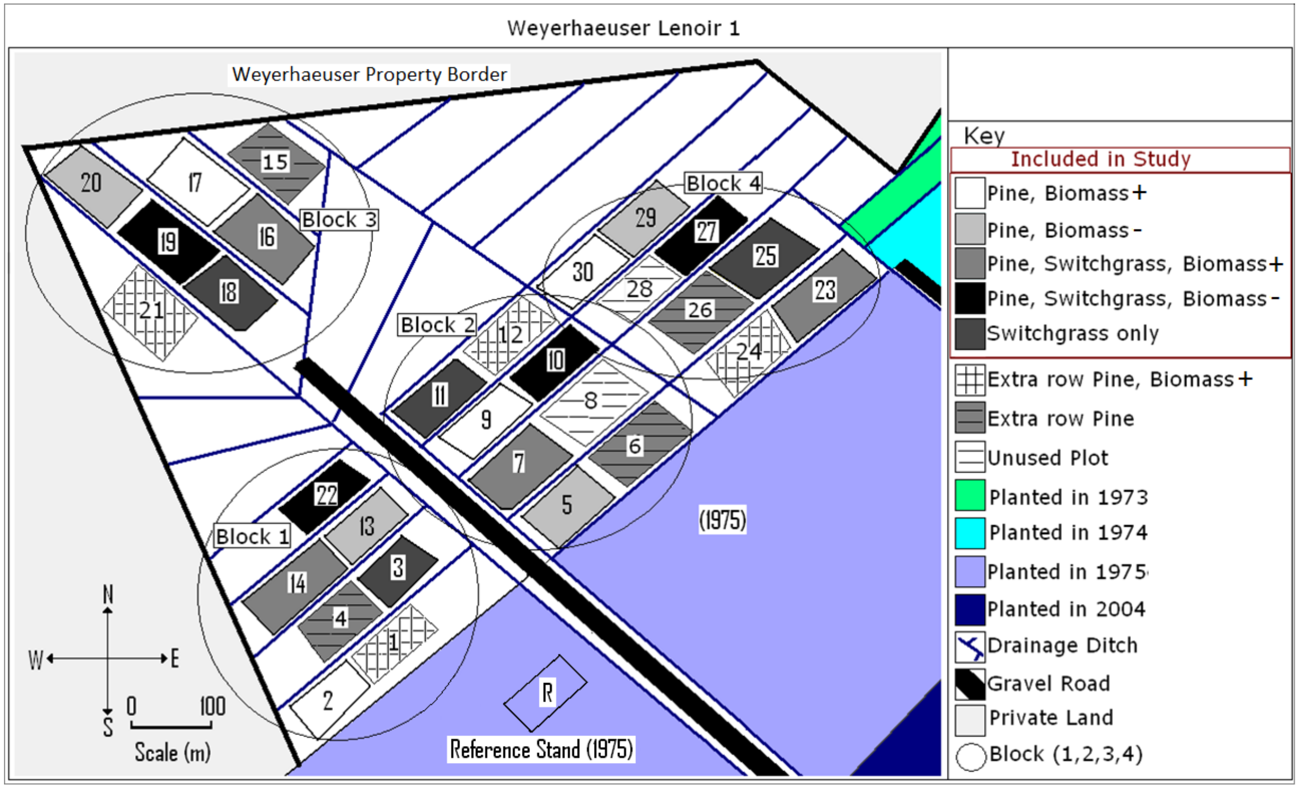


Figure 2. Mean Percent Cover of Habitat Variable by Biomass Removal Options from Transect Line Measurements during April and October 2010

Mean percent cover of habitat variables are shown by biomass removal option during a. April 17-19, and b. October 8-11, 2010. Multiple pairwise Mann-Whitney U tests with a Bonferroni correction were used to identify significant differences among biomass removal options as indicated above each bar. Different letters indicate that pairwise comparisons within habitat variable were significant at p≤0.005. Although only April and October are shown (to underscore differences from first to last vegetation sampling dates) samples were taken from June 24-27 and August 27-30, 2010 and results are intermediate. All measurements occurred at Weyerhaeuser Company’s Lenoir 1 long-term sustainability study site. Details of post hoc comparisons can be found in Tables C1-C4, C8, & C9.

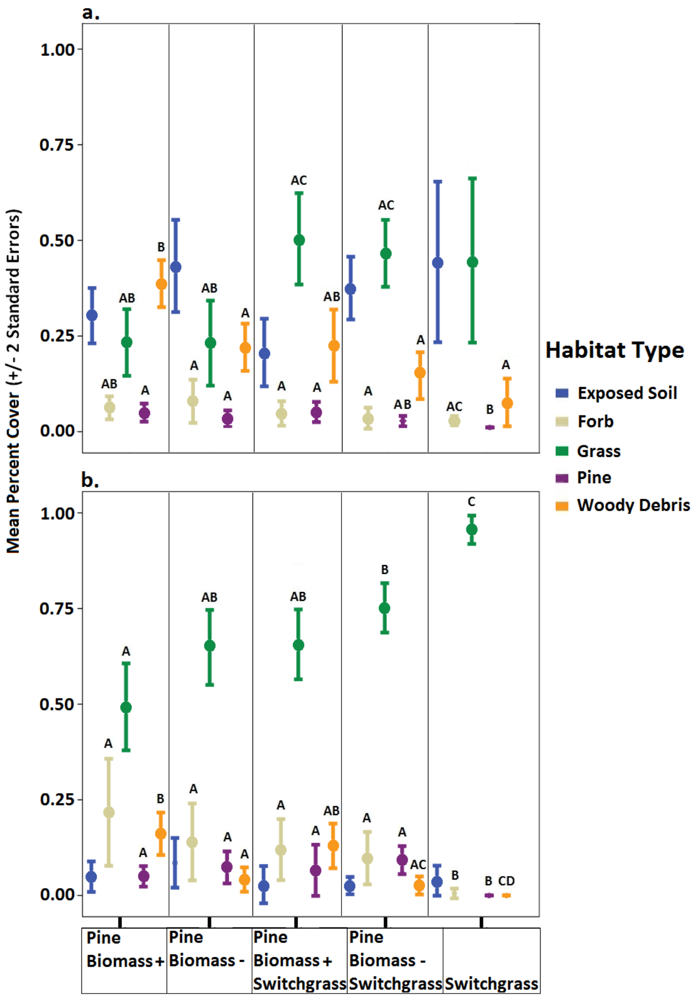


Figure 3. Mean Height of Habitat Variable by Biomass option from Transect Line Measurements during 2010

Mean height of habitat variables are shown by biomass removal options during 2010. All measurements occurred at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site. Error bars are off-set for ease of viewing. Details of post hoc comparisons can be found in Tables C5- C7, C10, & C11.

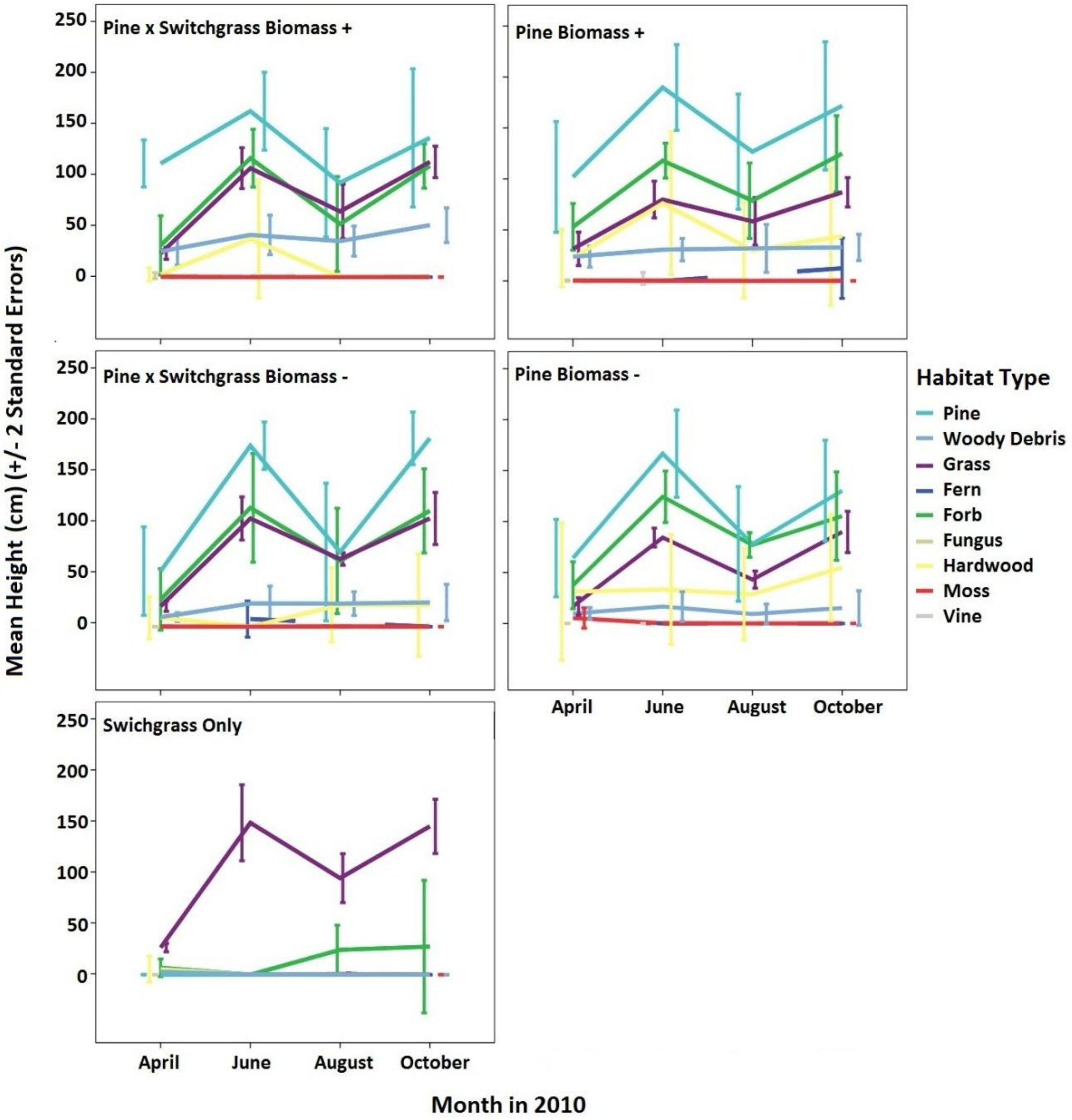


Figure 4. 2009 Mean Number of Unique Individuals and Total Captures for *M. musculus, P. leucopus, R. humulis*, and *S. hispidus* Captured by Biomass Removal Option

a. Mean number of unique individuals/round/1800m^2, and b. mean number of total captures/round/1800m^2, +/- 2 standard errors, displayed by biomass removal option. Rodents were captured and released at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 15- December 9, 2009. Post hoc analyses were not completed because species abundance did not differ among biomass removal options.

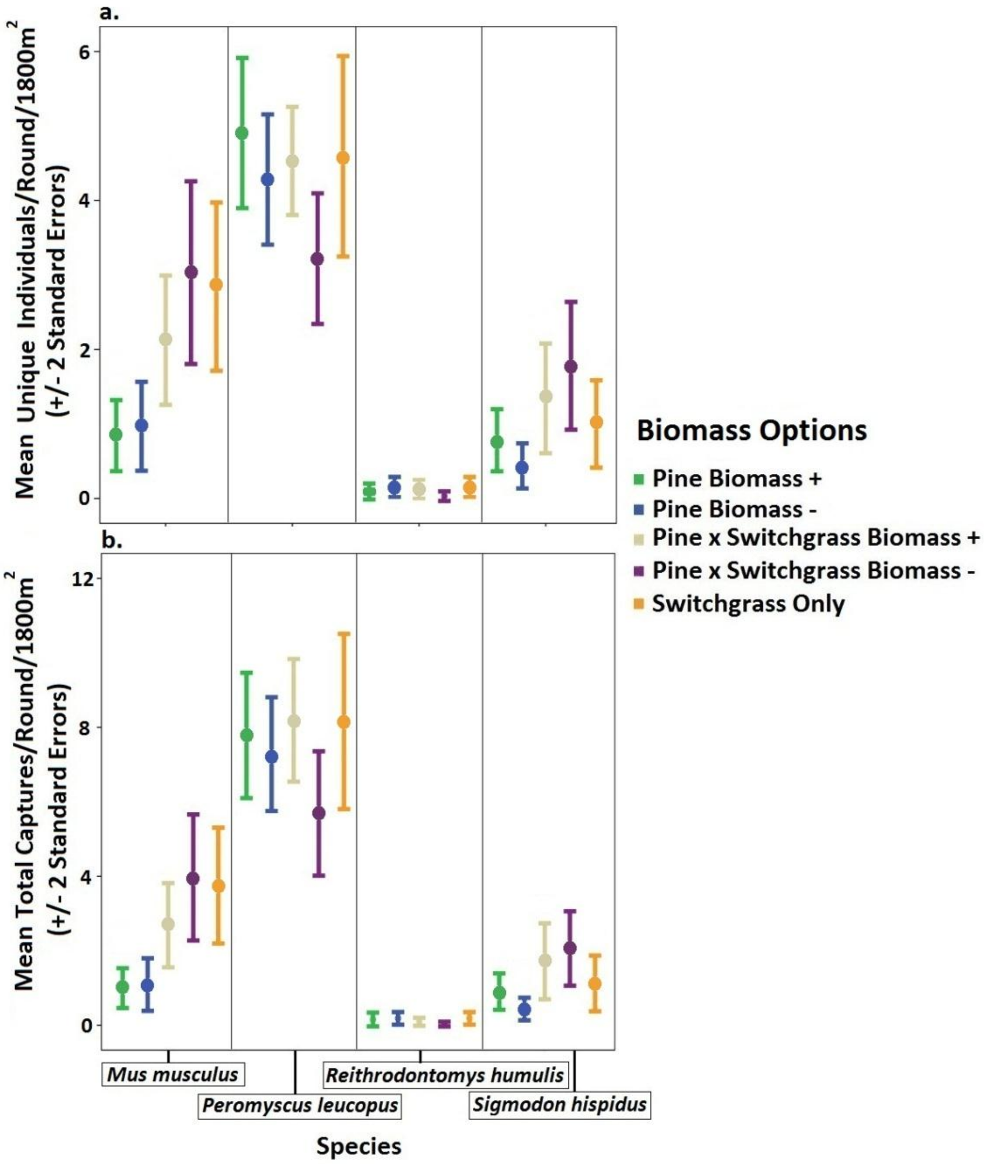


Figure 5. 2009 Mean Number of Unique Individuals and Total Captures by Trapping Round for *M. musculus, P. leucopus, R. humulis,* and *S. hispidus*

a. Mean number of unique individuals/round/1800m^2, and b. mean number of total captures/round/1800m^2, +/- 2 standard errors, displayed by trapping round. Each trapping round consisted of 3 consecutive nights on each plot (round 1= July 15-28; round 2= July 30-August 9; round 3= August 18-30; round 4= September 9-15; round 5= September 19-October 21; round 6= October 20-27; round 7= November 2-9; round 8= November 29-December 9). Rodents were captured and released at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 15- December 9, 2009. Details of post hoc comparisons can be found in Table 7.

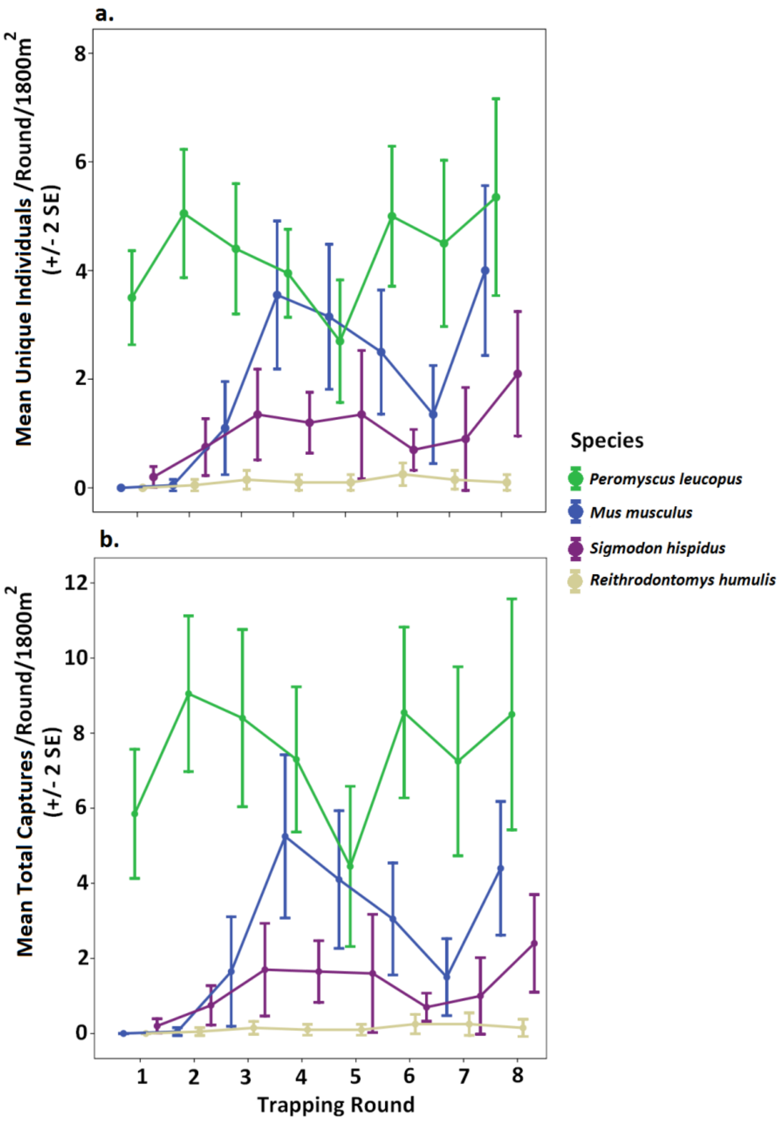


Figure 6. 2010 Mean Number of Unique Individuals and Total Captures for *M. musculus, P. leucopus, R. humulis*, and *S. hispidus* by Biomass Removal Option

a. Mean number of unique individuals/round/1800m^2, and b. mean total captures/round/1800m^2, +/- 2 standard errors, displayed by biomass removal option. Multiple pairwise Mann-Whitney U tests were used to identify significant differences between biomass removal options as indicated above each habitat variable. Different letters indicate tests were significant at $p \leq 0.005$. Rodents were captured and released at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 19 - November 14, 2010. Details of post hoc comparisons can be found in Tables C12-C14.

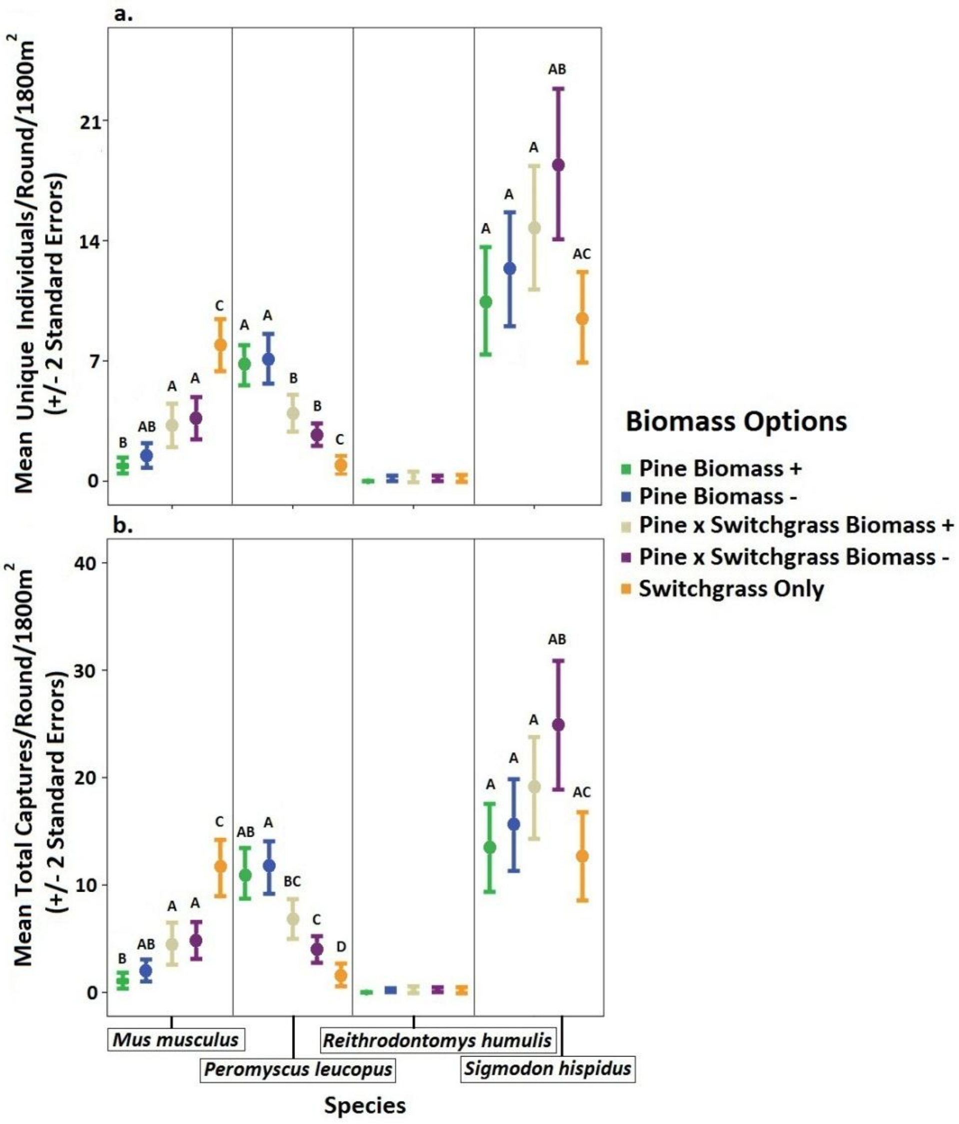
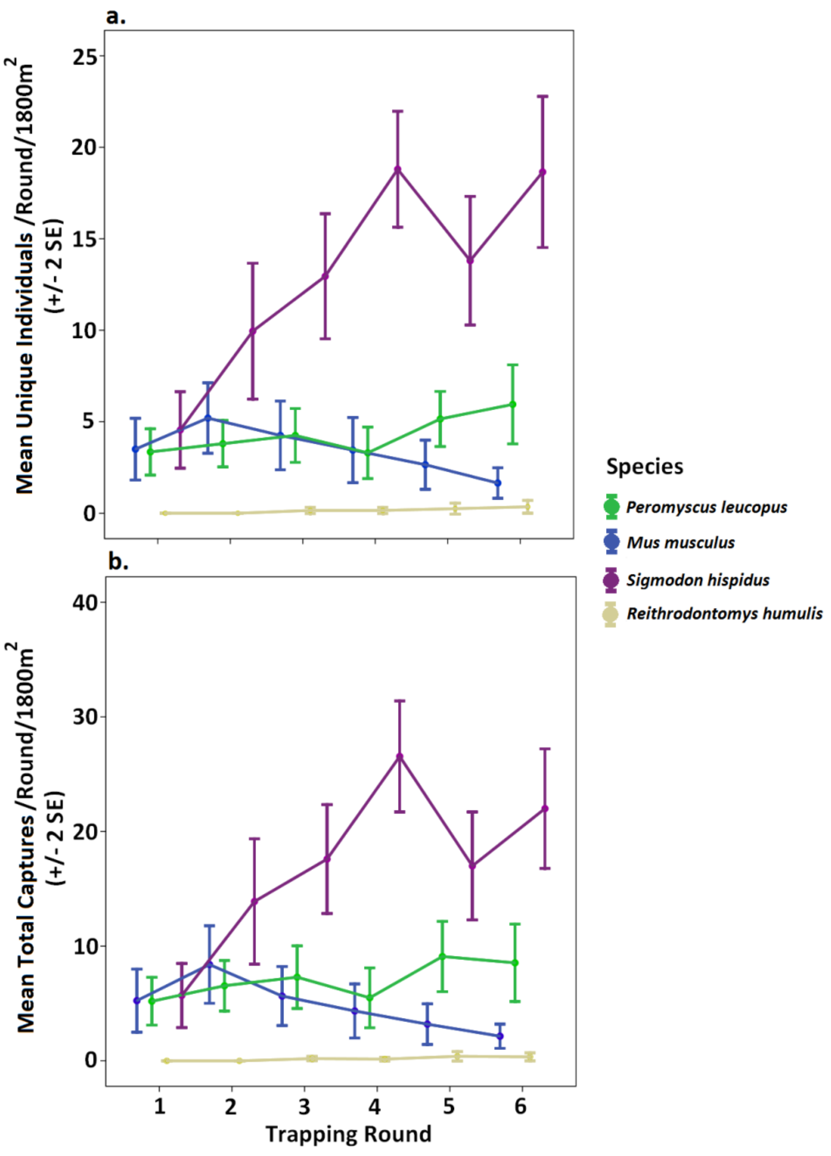


Figure 7. 2010 Mean Number of Unique Individuals and Total Captures by Trapping Round for *M. musculus, P. leucopus, R. humulis,* and *S. hispidus*

a. Mean number of unique individuals/round/1800m^2, and b. mean total captures/round/1800m^2, +/- 2 standard errors, displayed by trapping round. Each trapping round consisted of 3 consecutive nights on each plot (round 1= July 19-30; round 2= July 31-August 11; round 3= September 3-12; round 4= September 16-25; round 5= October 8-17; round 6= November 5-14). Rodents were captured and released at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 19 - November 14, 2010. Details of post hoc comparisons can be found in Table 10.



APPENDIX B: TABLES

Table 1. ANOVA Results of Percent Cover by Biomass Removal Option × Habitat Variable × Sampling Date

3-factor ANOVA results of the dependent variable square-root transformed percent cover by biomass removal option × habitat variable × sampling date (month) are displayed. Measurements occurred during April (17-19), June (24-27), August (27-30), and October (8-11), 2010. Habitat variables identified with transect measurements include ferns, forbs, fungi, grasses, hardwoods, mosses, pines, vines, woody debris, and exposed soil. ANOVA tests are significant (*) at p≤0.050. All measurements occurred at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site.

Source	Type III Sum of Squares	*df*	Mean Square	*F*	*P*
Corrected Model	82.682	159	0.520	51.627	<0.001 *
Intercept	46.903	1	46.903	4656.529	<0.001 *
Removal Option	0.878	4	0.220	21.794	<0.001 *
Habitat Variable	62.844	9	6.983	693.245	<0.001 *
Date	0.211	3	0.070	6.977	<0.001 *
Removal Option × Habitat Variable	8.074	36	0.224	22.267	<0.001 *
Removal Option × Date	0.140	12	0.012	1.160	0.307
Habitat Variable × Date	7.949	19	0.418	41.538	<0.001 *
Removal option × Habitat Variable × Date	1.540	76	0.020	2.011	<0.001 *
Error	11.281	1120	0.010		
Total	160.662	1280			
Overall Model Sum of Squares	93.963	1279			

Table 2. ANOVA Results of Habitat Height by Biomass Removal Option × Habitat Variable × Sampling Date

3-factor ANOVA results of the dependent variable height by biomass removal option × habitat variable × sampling date (month) are displayed. Measurements occurred during April (17-19), June (24-27), August (27-30), and October (8-11), 2010. Height (cm) was measured of each habitat variable: ferns, forbs, fungi, grasses, hardwoods, mosses, pines, vines, and woody debris to the nearest 10 cm. ANOVA tests are significant (*) at $p \leq 0.050$. All measurements occurred at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site.

Source	Type III Sum of Squares	*df*	Mean Square	*F*	*P*
Corrected Model	2845764.123	139	20473.123	18.835	<0.001 *
Intercept	1222917.978	1	122917.978	1125.087	<0.001 *
Removal Option	112632.454	4	28158.114	25.906	<0.001 *
Habitat Variable	1649428.522	8	206178.565	189.685	<0.001 *
Date	268491.106	3	89497.035	82.337	<0.001 *
Removal Option × Habitat Variable	501481.721	32	15671.304	14.418	<0.001 *
Removal Option × Date	27881.291	12	2323.441	2.138	0.013 *
Habitat Variable × Date	204930.566	16	12808.160	11.784	<0.001 *
Removal option × Habitat Variable × Date	115993.702	64	1812.402	1.667	<0.001 *
Error	1065215.259	980	0.010		
Total	5832568.294	1120			
Overall Model Sum of Squares	3910979.382	1119			

Table 3. 2009 Mean Rodent Community Species Richness, Shannon Diversity Index, and Fisher's α Diversity Index

Means ± standard deviation of rodent species richness, Shannon Diversity, and Fisher's α Diversity values listed by biomass removal option variable for total number of rodents in 2009 (n = 729 individuals). All rodents were captured and released on site at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 15 -December 9, 2009.

Biomass option	Species Richness	Shannon Diversity Index	Fisher's α Index
Pine Biomass +	3.25 ± 0.50	0.88 ± 0.12	0.90 ± 0.18
Pine Biomass -	3.25 ± 0.50	0.78 ± 0.44	0.86 ± 0.34
Pine Switchgrass Biomass +	3.25 ± 0.50	1.04 ± 0.04	0.81 ± 0.28
Pine Switchgrass Biomass -	3.50 ± 0.58	1.02 ± 0.23	0.82 ± 0.27
Switchgrass only	3.75 ± 0.50	0.92 ± 0.26	0.90 ± 0.26

Table 4. 2010 Mean Rodent Community Species Richness, Shannon Diversity Index, and Fisher's α Diversity Index

Means ± standard deviation of rodent species richness, Shannon Diversity, and Fisher's α Diversity values listed by biomass removal option variable for total number of rodents in 2010 (n = 1,634 individuals). All rodents were captured and released on site at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 19 - November 14, 2010.

Biomass option	Species Richness	Shannon Diversity Index	Fisher's α Index
Pine Biomass +	3.00 ± 0.00	0.79 ± 0.17	0.57 ± 0.03
Pine Biomass -	3.50 ± 0.58	0.89 ± 0.13	0.68 ± 0.18
Pine Switchgrass Biomass +	3.5 ± 0.58	0.86 ± 0.28	0.67 ± 0.16
Pine Switchgrass Biomass -	3.5 ± 0.58	0.76 ± 0.31	0.65 ± 0.17
Switchgrass only	3.5 ± 0.58	0.88 ± 0.16	0.69 ± 0.15

Table 5. 2009 Morisita's Index of Similarity of Rodent Community Among Biomass Options

2009 Morisita's Index of Similarity results of rodent community among biomass options calculated using unique number of individuals of each species captured. Index values represent degree of similarity among rodent communities (1.0 = identical; 0.0 = completely different). (PB+=Pine Biomass+, PB-=Pine Biomass -, PSB+=Pine × Switchgrass Biomass +, PSB-=Pine × Switchgrass Biomass-, S=Switchgrass only). All rodents were captured and released on site at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 15- December 9, 2009.

	PB+	PB-	PSB+	PSB-	S
PB+	0	0.500	0.470	0.395	0.454
PB-	-	0	0.477	0.408	0.466
PSB+	-	-	0	0.478	0.497
PSB-	-	-	-	0	0.484
S	-	-	-	-	0

Table 6. 2010 Morisita’s Index of Similarity of Rodent Community Among Biomass Options

2010 Morisita’s Index of Similarity results of rodent community among biomass options calculated using unique number of individuals of each species captured. Index values represent degree of similarity among rodent communities (1.0 = identical; 0.0 = completely different). (PB+=Pine Biomass+, PB-=Pine Biomass -, PSB+=Pine × Switchgrass Biomass +, PSB-=Pine × Switchgrass Biomass-, S=Switchgrass only). All rodents were captured and released on site at Weyerhaeuser Company’s Lenoir 1 long-term sustainability study site July 19 - November 14, 2010.

	PB+	PB-	PSB+	PSB-	S
PB+	0	0.500	0.473	0.451	0.367
PB-	-	0	0.481	0.461	0.384
PSB+	-	-	0	0.496	0.439
PSB-	-	-	-	0	0.436
S	-	-	-	-	0

Table 7. **2009 Repeated Measures ANOVA Results of Rank-tranformed Rodent Abundance by Trapping Round × Biomass Removal Option × Species**

2-factor repeated measures ANOVA results of dependent variables a. rank-transformed unique individuals, and b. rank-transformed total number of captures by date × biomass removal option × species after Greenhouse-Geisser adjustment. [Adjusted *d.f.* are not whole numbers] Tests are significant (*) at p≤0.050. All rodents were captured and released on site at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 15- December 9, 2009. Results from 3-factor repeated measures ANOVA of non-transformed data can be found in Table C 18.

a.

	Source	*df*	Mean Square	*F*	*P*
Between Trapping Rounds	Biomass option	4	1.332	1.241	.303
	Species	3	64.293	59.876	<.001 *
	Biomass option × Species	12	1.864	1.736	.081
	Error	60	1.074		
Within Trapping Rounds	Round	4.860	37.736	9.202	<.001 *
	Round × Biomass option	19.441	3.248	.792	.719
	Round × Species	14.581	21.448	5.230	<.001 *
	Round × Biomass option × Species	58.324	5.581	1.361	.053
	Error	291.622	4.101		

b.

	Source	*df*	Mean Square	*F*	*P*
Between Trapping Rounds	Biomass option	4	3.217	1.317	.274
	Species	3	205.154	83.980	<.001*
	Biomass option × Species	12	3.536	1.448	.170
	Error	60	2.443		
Within Trapping Rounds	Round	4.581	65.235	5.588	<.001*
	Round × Biomass option	18.325	8.444	.723	.789
	Round × Species	13.743	49.256	4.219	<.001*
	Round × Biomass option × Species	54.974	13.433	1.151	.234
	Error	274.868	11.673		

Table 8. 2009 Mann-Whitney U Test Results of Pairwise Comparisons on Unique Individuals and Total Captures Between Rodent Species

Mann-Whitney U test results of pairwise comparisons on the dependent variables a. unique number of individuals, and b. total captures between rodent species. Tests are significant (*) at Bonferroni corrected values of $p \leq 0.017$. All rodents were captured and released on site at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 15- December 9, 2009.

a.

Species Comparisons	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
P. leucopus vs. M. musculus	6120.500	19000.500	-8.175	<0.001*
P. leucopus vs. S. hispidus	3465.500	16345.500	-11.493	<0.001*
M. musculus vs. S. hispidus	10733.000	23613.000	-2.698	0.007*

b.

Species Comparisons	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
P. leucopus vs. M. musculus	4848.000	17728.000	-9.708	<0.001*
P. leucopus vs. S. hispidus	2623.500	15503.500	-12.503	<0.001*
M. musculus vs. S. hispidus	10606.500	23486.500	-2.864	0.004*

Table 9. 2009 Kruskal-Wallis Test Results of Rodent Abundance by Trapping Round

Kruskal-Wallis test results of number of a. unique individuals/round/1800m^2 in 2009 (n = 648), b. total captures/round/1800m^2 in 2009 (n=1,806) by trapping round. Kruskal-Wallis tests are significant (*) at $p \leq 0.050$. All rodents were captured and released on site at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 15-December 9, 2009.

a.

Species	χ^2	*df*	p (2-sided)
P. leucopus	14.017	7	0.051
M. musculus	65.629	7	<0.001*
S. hispidus	16.998	7	0.017*

b.

Species	χ^2	*df*	p (2-sided)
P. leucopus	16.148	7	0.024*
M. musculus	65.961	7	<0.001*
S. hispidus	19.649	7	0.006*

Table 10. 2010 Repeated Measures ANOVA Results of Rank-tranformed Rodent Abundance by Trapping Round × Biomass Removal Option × Species

2-factor repeated measures ANOVA results of a. rank-transformed unique individuals, and b. rank-transformed total captures by date × biomass removal option × species after Greenhouse-Geisser adjustment. [Adjusted *d.f.* are not whole numbers] Tests are significant (*) at p≤0.050. All rodents were captured and released on site at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 19 - November 14, 2010. Results from 3-factor repeated measures ANOVA of non-transformed data can be found in Table C 19.

a.

	Source	*df*	Mean Square	*F*	*P*
Between Trapping Rounds	Biomass option	4	4.694	0.613	0.655
	Species	4	573.831	74.915	<.001*
	Biomass option × Species	16	25.500	3.329	<.001*
	Error	75	7.660		
Within Trapping Rounds	Round	4.077	161.531	27.124	<.001*
	Round × Biomass option	16.307	5.012	0.842	0.640
	Round × Species	16.307	159.705	26.817	<.001*
	Round × Biomass option × Species	65.228	5.474	0.919	0.652
	Error	305.758	5.955		

b.

	Source	*df*	Mean Square	*F*	*P*
Between Trapping Rounds	Biomass option	4	5.304	0.366	0.832
	Species	4	919.502	63.468	<.001*
	Biomass option × Species	16	53.980	3.726	<.001*
	Error	75	14.488		
Within Trapping Rounds	Round	4.007	207.020	16.700	<.001*
	Round × Biomass option	16.027	14.290	1.153	0.306
	Round × Species	16.027	276.453	22.302	<.001*
	Round × Biomass option × Species	64.108	10.801	.871	0.744
	Error	300.504	12.396		

Table 11. 2010 Mann-Whitney U Test Results of Pairwise Comparisons on Unique Individuals and Total Captures Between Rodent Species

Mann-Whitney U test results of pairwise comparisons on the dependent variables a. unique number of individuals, and b. total captures between rodent species. Tests are significant (*) at Bonferroni corrected values of $p \leq 0.017$. All rodents were captured and released on site at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 19 - November 14, 2010.

a.

Species Comparisons	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
P. leucopus vs. M. musculus	5934.500	13194.500	-2.368	0.018
P. leucopus vs. S. hispidus	2597.500	9857.500	-8.574	<0.001*
M. musculus vs. S. hispidus	2131.500	9391.500	-9.450	<0.001*

b.

Species Comparisons	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
P. leucopus vs. M. musculus	5436.500	12696.500	-3.293	0.001*
P. leucopus vs. S. hispidus	3355.500	10615.500	-7.156	<0.001*
M. musculus vs. S. hispidus	2393.000	9653.000	-8.956	<0.001*

Table 12. 2010 Kruskal-Wallis Test Results of the Unique Number of Individuals, and Total Captures by Biomass Removal Option

a. 2010 Kruskal-Wallis test results of unique number of individuals by biomass removal option, and b. 2010 Kruskal-Wallis test results of total captures by biomass removal option for *P. leucopus*, *M. musculus, S. hispidus*, and *R. humulis*. Kruskal-Wallis tests are significant (*) at $p \leq 0.050$. All rodents were captured and released on site at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 15- December 9, 2009.

a.

Species	χ^2	*df*	p (2-sided)
P. leucopus	65.757	4	<0.001*
M. musculus	51.070	4	<0.001*
S. hispidus	12.719	4	0.013*

b.

Species	χ^2	*df*	p (2-sided)
P. leucopus	59.311	4	<0.001*
M. musculus	48.773	4	<0.001*
S. hispidus	13.047	4	0.011*

Table 13. 2010 Kruskal-Wallis Test Results of Rodent Abundance by Trapping Round

Kruskal-Wallis test results of number of a. unique individuals/round/1800m^2 in 2010 (n = 1,634), and b. total captures/round/1800m^2 in 2010 (n=3,594) by trapping round. Kruskal-Wallis tests are significant (*) at p≤0.050. All rodents were captured and released on site at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 19 - November 14, 2010.

a.

Species	χ^2	*df*	p (2-sided)
P. leucopus	7.581	5	0.181
M. musculus	10.252	5	0.068
S. hispidus	42.569	5	<0.001*

b.

Species	χ^2	*df*	p (2-sided)
P. leucopus	6.324	5	0.276
M. musculus	11.874	5	0.037*
S. hispidus	41.366	5	<0.001*

Table 14. 2009 *P. leucopus, M. musculus,* and *S. hispidus* Mean Number of Unique Juveniles

Mean values/round/1800m^2 plus and minus standard deviation for 2009 number of unique juveniles of *P. leucopus, M. musculus, and S. hispidus* listed by biomass removal option. All rodents were captured and released on site at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 15- December 9, 2009.

Species	Biomass option	Unique Juveniles
P. leucopus	Pine Biomass +	0.34 ± 0.31
	Pine Biomass -	0.25 ± 0.18
	Pine Switchgrass Biomass +	0.34 ± 0.12
	Pine Switchgrass Biomass -	0.38 ± 0.44
	Switchgrass only	0.16 ± 0.16
M. musculus	Pine Biomass +	0.09 ± 0.12
	Pine Biomass -	0.16 ± 0.12
	Pine Switchgrass Biomass +	0.09 ± 0.06
	Pine Switchgrass Biomass -	0.50 ± 0.40
	Switchgrass only	0.31 ± 0.16
S. hispidus	Pine Biomass +	0.09 ± 0.12
	Pine Biomass -	0.03 ± 0.06
	Pine Switchgrass Biomass +	0.25 ± 0.23
	Pine Switchgrass Biomass -	0.00 ± 0.00
	Switchgrass only	0.09 ± 0.12

Table 15. 2010 *P. leucopus, M. musculus,* and *S. hispidus* Mean Number of Unique Juveniles

Mean values/round/1800m^2 plus and minus standard deviation for 2010 number of unique juveniles of *P. leucopus, M. musculus, and S. hispidus* listed by biomass removal option. No significant differences were identified among biomass removal options. All rodents were captured and released on site at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 19 - November 14, 2010.

Species	Biomass option	Unique Juveniles
P. leucopus	Pine Biomass +	1.25 ± 1.90
	Pine Biomass -	4.75 ± 3.50
	Pine Switchgrass Biomass +	0.25 ± 0.50
	Pine Switchgrass Biomass -	0.00 ± 0.00
	Switchgrass only	0.25 ± 0.50
M. musculus	Pine Biomass +	0.00 ± 0.00
	Pine Biomass -	1.00 ± 0.82
	Pine Switchgrass Biomass +	2.25 ± 3.30
	Pine Switchgrass Biomass -	1.25 ± 0.50
	Switchgrass only	4.25 ± 1.26
S. hispidus	Pine Biomass +	9.75 ± 7.89
	Pine Biomass -	13.75 ± 8.42
	Pine Switchgrass Biomass +	9.25 ± 3.69
	Pine Switchgrass Biomass -	16.75 ± 8.26
	Switchgrass only	8.00 ± 3.16

APPENDIX C: SUPPLEMENTARY STATISTICAL TABLES

Table C 1. April 2010, and October 2010 Kruskal-Wallis Test Results of Habitat Variable Percent Cover by Biomass Removal Option

a. April 2010, and b. October 2010 Kruskal-Wallis statistics of percent cover of habitat variables (forbs, grasses, pines, woody debris, and exposed soil) by biomass removal option. Kruskal-Wallis tests are significant (*) at p≤0.050.

a.

Habitat variable	χ^2	d.f.	p (2-sided)
Forbs	12.375	4.000	0.015*
Grasses	16.508	4.000	0.002*
Pines	17.254	4.000	0.002*
Woody Debris	4.000	4.000	<0.001*
Exposed Soil	11.810	4.000	0.019*

b.

Habitat variable	χ^2	d.f.	p (2-sided)
Forbs	17.044	4.000	0.002*
Grasses	26.792	4.000	<0.001*
Pines	10.058	4.000	0.001*
Woody Debris	28.462	4.000	<0.001*
Exposed Soil	5.265	4.000	0.261

Table C 2. April 2010 Pairwise Mann-Whitney U Test Results of Forbs and Grasses Percent Cover by Biomass Removal Option

a. Forbs and b. Grasses percent cover Mann-Whitney U pairwise comparison test results. (PB+=Pine Biomass+, PB-=Pine Biomass -, PSB+=Pine × Switchgrass Biomass +, PSB-=Pine × Switchgrass Biomass-, S=Switchgrass only). Mann-Whitney U tests are significant (*) at p≤0.005. Measurements were taken at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site April 17-19, 2010.

a.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	26.500	62.500	-0.579	0.563
PB- vs. PSB+	24.500	60.500	-0.795	0.427
PB- vs. PSB-	16.500	52.500	-1.646	0.100
PB- vs. S	8.000	44.000	-2.558	0.011
PB+ vs. PSB+	22.000	58.000	-1.057	0.290
PB+ vs. PSB-	7.000	43.000	-2.641	0.008
PB+ vs. S	4.000	40.001	-2.967	0.003*
PSB+ vs. PSB-	26.000	62.000	-0.642	0.574
PSB+ vs. S	20.001	56.000	-1.316	0.188
PSB- vs. S	17.000	53.000	-1.624	0.104

b.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	26.500	62.500	-0.579	0.563
PB- vs. PSB+	5.000	41.000	-2.838	0.005*
PB- vs. PSB-	4.000	40.001	-2.943	0.003*
PB- vs. S	18.000	54.000	-1.471	0.141
PB+ vs. PSB+	4.000	40.001	-2.943	0.003*
PB+ vs. PSB-	5.000	41.000	-2.838	0.005*
PB+ vs. S	14.000	50.001	-1.892	0.059
PSB+ vs. PSB-	26.000	62.000	-0.630	0.529
PSB+ vs. S	26.000	62.000	-0.631	0.528
PSB- vs. S	27.000	63.000	-0.525	0.600

Table C 3. April 2010 Pairwise Mann-Whitney U Test Results of Pines and Woody Debris Percent Cover by Biomass Removal Option

a. Pines and b. Woody Debris percent cover Mann-Whitney U pairwise comparison test results. (PB+=Pine Biomass+, PB-=Pine Biomass -, PSB+=Pine × Switchgrass Biomass +, PSB-=Pine × Switchgrass Biomass-, S=Switchgrass only). Mann-Whitney U tests are significant (*) at p≤0.005. Measurements were taken at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site April 17-19, 2010.

a.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	20.500	56.500	-1.213	0.225
PB- vs. PSB+	22.500	58.500	-1.004	0.316
PB- vs. PSB-	25.500	61.500	-0.696	0.487
PB- vs. S	8.000	44.000	-2.899	0.004*
PB+ vs. PSB+	31.000	67.000	-0.105	0.916
PB+ vs. PSB-	15.000	51.000	-1.800	0.072
PB+ vs. S	4.000	40.001	-3.240	0.001*
PSB+ vs. PSB-	14.500	50.500	-1.852	0.064
PSB+ vs. S	0.001	36.000	-3.596	<0.001*
PSB- vs. S	12.000	48.000	-2.554	0.011

b.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	3.500	39.500	-3.000	0.003*
PB- vs. PSB+	25.500	61.500	-0.684	0.494
PB- vs. PSB-	14.000	50.001	-1.892	0.059
PB- vs. S	6.500	42.500	-2.684	0.007
PB+ vs. PSB+	8.000	44.000	-2.522	0.012
PB+ vs. PSB-	1.000	37.000	-3.258	0.001*
PB+ vs. S	0.500	36.500	-3.315	0.001*
PSB+ vs. PSB-	17.500	53.500	-1.524	0.128
PSB+ vs. S	8.000	44.000	-2.522	0.012
PSB- vs. S	13.500	49.500	-1.946	0.050

Table C 4. April 2010 Pairwise Mann-Whitney U Test Results of Exposed Soil Percent Cover by Biomass Removal Option

Exposed soil percent cover Mann-Whitney U pairwise comparison test results. (PB+=Pine Biomass+, PB-=Pine Biomass -, PSB+=Pine × Switchgrass Biomass +, PSB-=Pine × Switchgrass Biomass-, S=Switchgrass only). Mann-Whitney U tests are significant (*) at $p \leq 0.005$. Measurements were taken at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site April 17-19, 2010.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	14.000	50.001	-1.893	0.058
PB- vs. PSB+	6.000	42.000	-2.731	0.006
PB- vs. PSB-	25.500	61.500	-0.683	0.495
PB- vs. S	31.000	67.000	-0.105	0.916
PB+ vs. PSB+	11.000	47.000	-2.209	0.027
PB+ vs. PSB-	16.500	52.500	-1.631	0.103
PB+ vs. S	20.001	56.000	-1.263	0.207
PSB+ vs. PSB-	7.000	43.000	-2.626	0.009
PSB+ vs. S	15.500	51.500	-1.735	0.083
PSB- vs. S	28.000	64.000	-0.420	0.674

Table C 5. April 2010, and October 2010 Kruskal-Wallis Test Results of Habitat Variable Height by Biomass Removal Option

a. April 2010, and b. October 2010 Kruskal-Wallis statistics of height of habitat variables (forbs, grasses, pines, and woody debris) by biomass removal option. Kruskal-Wallis tests are significant (*) at $p \leq 0.050$.

a.

Habitat variable	χ^2	d.f.	p (2-sided)
Forbs	11.753	4.000	0.019*
Grasses	7.688	4.000	0.104
Pines	18.803	4.000	0.001*
Woody Debris	24.062	4.000	<0.001*

b.

Habitat variable	χ^2	d.f.	p (2-sided)
Forbs	9.800	4.000	0.044*
Grasses	18.528	4.000	0.001*
Pines	20.207	4.000	<0.001*
Woody Debris	21.330	4.000	<0.001*

Table C 6. April 2010 Pairwise Mann-Whitney U Test Results of Forbs and Pines Height by Biomass Removal Option

a. Forbs and b. Pines height Mann-Whitney U pairwise comparison test results. (PB+=Pine Biomass+, PB-=Pine Biomass -, PSB+=Pine × Switchgrass Biomass +, PSB-=Pine × Switchgrass Biomass-, S=Switchgrass only). Mann-Whitney U tests are significant (*) at p≤0.005. Measurements were taken at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site April 17-19, 2010.

a.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	22.000	58.000	-1.052	0.293
PB- vs. PSB+	26.500	62.500	-0.582	0.561
PB- vs. PSB-	22.500	58.500	-1.001	0.317
PB- vs. S	9.000	45.000	-2.452	0.014
PB+ vs. PSB+	16.000	52.000	-1.685	0.092
PB+ vs. PSB-	14.000	50.001	-1.892	0.059
PB+ vs. S	2.000	38.000	-3.174	0.002*
PSB+ vs. PSB-	32.000	68.000	0.001	1.000
PSB+ vs. S	20.001	56.000	-1.316	0.188
PSB- vs. S	19.000	55.000	-1.404	0.160

b.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	18.500	54.500	-1.423	0.155
PB- vs. PSB+	11.000	47.000	-2.207	0.027
PB- vs. PSB-	30.001	66.000	-0.213	0.831
PB- vs. S	8.000	44.000	-2.896	0.004*
PB+ vs. PSB+	27.000	63.000	-0.525	0.600
PB+ vs. PSB-	19.500	55.500	-1.323	0.186
PB+ vs. S	4.000	40.001	-3.140	0.001*
PSB+ vs. PSB-	11.500	47.500	-2.161	0.031
PSB+ vs. S	0.001	36.000	-3.590	<0.001*
PSB- vs. S	12.000	48.000	-2.554	0.011

Table C 7. April 2010 Pairwise Mann-Whitney U Test Results of Woody Debris Height by Biomass Removal Option

Woody debris height Mann-Whitney U pairwise comparison test results. (PB+=Pine Biomass+, PB-=Pine Biomass -, PSB+=Pine × Switchgrass Biomass +, PSB-=Pine × Switchgrass Biomass-, S=Switchgrass only). Mann-Whitney U tests are significant (*) at $p \leq 0.005$. Measurements were taken at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site April 17-19, 2010.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	8.000	44.000	-2.521	0.012
PB- vs. PSB+	9.000	45.000	-2.415	0.016
PB- vs. PS	31.000	67.000	-0.105	0.916
PB- vs. S	7.000	43.000	-2.633	0.008
PB+ vs. PSB+	31.000	67.000	-0.105	0.916
PB+ vs. PS	9.000	45.000	-2.417	0.016
PB+ vs. S	0.001	36.000	-3.363	0.001*
PSB+ vs. PS	9.000	45.000	-2.417	0.016
PSB+ vs. S	0.001	36.000	-3.363	0.001*
PSB- vs. S	7.000	43.000	-2.645	0.008

Table C 8. October 2010 Pairwise Mann-Whitney U Test Results of Forbs and Grass Percent Cover by Biomass Removal Option

a. Forbs and b. Grass percent cover Mann-Whitney U pairwise comparison test results. (PB+=Pine Biomass+, PB-=Pine Biomass -, PSB+=Pine × Switchgrass Biomass +, PSB-=Pine × Switchgrass Biomass-, S=Switchgrass only). Mann-Whitney U tests are significant (*) at p≤0.005. Measurements were taken at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site October 8-11, 2010.

a.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	22.000	58.000	1.050	0.294
PB- vs. PSB+	29.000	65.000	-0.316	0.752
PB- vs. PSB-	25.500	61.500	-0.684	0.494
PB- vs. S	5.500	41.500	-2.973	0.003*
PB+ vs. PSB+	21.000	57.000	-1.156	0.248
PB+ vs. PSB-	16.500	52.500	-1.629	0.103
PB+ vs. S	1.000	37.000	-3.399	0.001*
PSB+ vs. PSB-	27.500	63.500	-0.473	0.636
PSB+ vs. S	2.000	38.000	-3.292	0.001*
PSB- vs. S	6.500	42.500	-2.861	0.004*

b.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	12.500	48.500	-2.049	0.040
PB- vs. PSB+	31.500	67.500	-0.053	0.958
PB- vs. PSB-	17.000	53.000	-1.575	0.115
PB- vs. S	0.001	36.000	-3.371	0.001*
PB+ vs. PSB+	11.000	47.000	-2.205	0.027
PB+ vs. PSB-	0.001	36.000	-3.361	0.001*
PB+ vs. S	0.001	36.000	-3.371	0.001*
PSB+ vs. PSB-	18.500	54.500	-1.419	0.156
PSB+ vs. S	0.001	36.000	-3.371	0.001*
PSB- vs. S	1.000	37.000	-3.265	0.001*

Table C 9. October 2010 Pairwise Mann-Whitney U Test Results of Pines and Woody Debris Percent Cover by Biomass Removal Option

a. Pines and b. Woody Debris percent cover Mann-Whitney U pairwise comparison test results. (PB+=Pine Biomass+, PB-=Pine Biomass -, PSB+=Pine × Switchgrass Biomass +, PSB-=Pine × Switchgrass Biomass-, S=Switchgrass only). Mann-Whitney U tests are significant (*) at p≤0.005. Measurements were taken at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site October 8-11, 2010.

a.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	21.500	57.500	-1.105	0.269
PB- vs. PSB+	23.000	59.000	-0.947	0.344
PB- vs. PSB-	25.500	61.500	-0.684	0.494
PB- vs. S	4.000	40.001	-3.240	0.001*
PB+ vs. PSB+	31.500	67.500	-0.053	0.958
PB+ vs. PSB-	15.000	51.000	-1.789	0.074
PB+ vs. S	4.000	40.001	-3.246	0.001*
PSB+ vs. PSB-	15.000	51.000	-1.787	0.074
PSB+ vs. S	4.000	40.001	-3.240	0.001*
PSB- vs. S	0.001	36.000	-3.593	<0.001*

b.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	2.500	38.500	-3.103	0.002*
PB- vs. PSB+	8.000	44.000	-2.522	0.012
PB- vs. PSB-	23.000	59.000	-0.961	0.337
PB- vs. S	8.000	44.000	-2.896	0.004*
PB+ vs. PSB+	24.500	60.500	-0.788	0.431
PB+ vs. PSB-	0.001	36.000	-3.371	0.001*
PB+ vs. S	0.001	36.000	-3.590	<0.001*
PSB+ vs. PSB-	6.000	42.000	-2.739	0.006
PSB+ vs. S	0.001	36.000	-3.590	<0.001*
PSB- vs. S	12.000	48.000	-2.554	0.011

Table C 10. October 2010 Pairwise Mann-Whitney U Test Results of Forbs and Grasses Height by Biomass Removal Option

a. Forbs and b. Grasses height Mann-Whitney U pairwise comparison test results. (PB+=Pine Biomass+, PB-=Pine Biomass -, PSB+=Pine × Switchgrass Biomass +, PSB-=Pine × Switchgrass Biomass-, S=Switchgrass only). Mann-Whitney U tests are significant (*) at p≤0.005. Measurements were taken at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site October 8-11, 2010.

a.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	25.000	61.000	-0.738	0.461
PB- vs. PSB+	29.000	65.000	-0.317	0.751
PB- vs. PSB-	30.500	66.500	-0.159	0.873
PB- vs. S	11.500	47.500	-2.304	0.021
PB+ vs. PSB+	29.500	65.500	-0.263	0.793
PB+ vs. PSB-	25.500	61.500	-0.684	0.494
PB+ vs. S	7.000	43.000	-2.741	0.006
PSB+ vs. PSB-	24.500	60.500	-0.791	0.429
PSB+ vs. S	8.000	44.000	-2.631	0.009
PSB- vs. S	11.500	47.500	-2.302	0.021

b.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	29.000	65.000	-0.315	0.753
PB- vs. PSB+	11.000	47.000	-2.205	0.027
PB- vs. PSB-	26.000	62.000	-0.630	0.529
PB- vs. S	4.000	40.001	-2.945	0.003*
PB+ vs. PSB+	11.000	47.000	-2.205	0.027
PB+ vs. PSB-	16.000	52.000	-1.680	0.093
PB+ vs. S	0.001	36.000	-3.361	0.001*
PSB+ vs. PSB-	23.000	59.000	-0.945	0.345
PSB+ vs. S	12.000	48.000	-2.100	0.036
PSB- vs. S	6.000	42.000	-2.731	0.006

Table C 11. October 2010 Pairwise Mann-Whitney U Test Results of Pines and Woody Debris Height by Biomass Removal Option

a. Pines and b. Woody Debris height Mann-Whitney U pairwise comparison test results. (PB+=Pine Biomass+, PB-=Pine Biomass -, PSB+=Pine × Switchgrass Biomass +, PSB-=Pine × Switchgrass Biomass-, S=Switchgrass only) Mann-Whitney U tests are significant (*) at p≤0.005. Measurements were taken at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site October 8-11, 2010.

a.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	12.500	48.500	-2.051	0.040
PB- vs. PSB+	27.500	63.500	-0.474	0.635
PB- vs. PSB-	8.500	44.500	-2.479	0.013
PB- vs. S	4.000	40.001	-3.243	0.001*
PB+ vs. PSB+	23.000	59.000	-0.947	0.344
PB+ vs. PSB-	27.500	63.500	-0.473	0.636
PB+ vs. S	4.000	40.001	-3.240	0.001*
PSB+ vs. PSB-	20.500	56.500	-1.210	0.226
PSB+ vs. S	4.000	40.001	-3.240	0.001*
PSB- vs. S	0.001	36.000	-3.593	<0.001*

b.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	15.500	51.500	-1.735	0.083
PB- vs. PSB+	8.000	44.000	-2.530	0.011
PB- vs. PSB-	29.000	65.000	-0.322	0.747
PB- vs. S	8.000	44.000	-2.896	0.004*
PB+ vs. PSB+	14.000	50.001	-1.892	0.059
PB+ vs. PSB-	25.500	61.500	-0.690	0.490
PB+ vs. S	0.001	36.000	-3.590	<0.001*
PSB+ vs. PSB-	11.000	47.000	-2.225	0.026
PSB+ vs. S	0.001	36.000	-3.590	<0.001*
PSB- vs. S	12.000	48.000	-2.565	0.010

Table C 12. 2010 Pairwise Mann-Whitney U Test Results of *P. leucopus* Unique Individuals and Total Captures by Biomass Removal Option

Mann-Whitney U test results of pairwise comparisons for *P. leucopus* a. unique individuals, and b. total captures during 2010. Mann-Whitney U tests are significant (*) at $p \leq 0.005$. (PB+=Pine Biomass+, PB-=Pine Biomass -, PSB+=Pine × Switchgrass Biomass +, PSB-=Pine × Switchgrass Biomass-, S=Switchgrass only) All rodents were captured and released on site at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 19- November 14, 2010.

a.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	286.0	586.0	-0.042	0.967
PB- vs. PSB+	122.0	422.0	-3.444	0.001*
PB- vs. PSB-	57.0	357.0	-4.794	<0.001*
PB- vs. S	11.5	311.5	-5.762	<0.001*
PB+ vs. PSB+	129.5	429.5	-3.286	0.001*
PB+ vs. PSB-	68.5	368.5	-4.554	<0.001*
PB+ vs. S	20.5	320.5	-5.577	<0.001*
PSB+ vs. PSB-	202.5	502.5	-1.789	0.074
PSB+ vs. S	60.0	369.0	-4.589	<0.001*
PSB- vs. S	105.5	405.5	-3.845	<0.001*

b.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	278.5	578.5	-0.196	0.844
PB- vs. PSB+	139.5	439.5	-3.071	0.002*
PB- vs. PSB-	65.0	365.0	-4.612	<0.001*
PB- vs. S	25.0	325.0	-5.472	<0.001*
PB+ vs. PSB+	159.0	459.0	-2.669	0.008
PB+ vs. PSB-	86.5	386.5	-4.168	<0.001*
PB+ vs. S	32.5	332.5	-5.313	<0.001*
PSB+ vs. PSB-	167.5	467.5	-2.496	0.013
PSB+ vs. S	66.5	366.5	-4.616	<0.001*
PSB- vs. S	124.5	424.5	-3.422	0.001*

Table C 13. 2010 Pairwise Mann-Whitney U Test Results of *M. musculus* Unique Individuals and Total Captures by Biomass Removal Option

Mann-Whitney U test results of pairwise comparisons for *M. musculus* a. unique individuals, and b. total captures during 2010. Mann-Whitney U tests are significant (*) at p≤0.005. (PB+=Pine Biomass+, PB-=Pine Biomass -, PSB+=Pine × Switchgrass Biomass +, PSB-=Pine × Switchgrass Biomass-, S=Switchgrass only) All rodents were captured and released on site at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 19- November 14, 2010.

a.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	238.0	538.0	-1.086	0.277
PB- vs. PSB+	179.5	479.5	-2.28	0.023
PB- vs. PSB-	160.5	460.5	-2.674	0.007
PB- vs. S	32.0	332.0	-5.315	<0.001*
PB+ vs. PSB+	131.5	431.5	-3.316	0.001*
PB+ vs. PSB-	123.5	423.5	-3.474	0.001*
PB+ vs. S	15.0	315.0	-5.696	<0.001*
PSB+ vs. PSB-	260.0	560.0	-0.582	0.561
PSB+ vs. S	94.0	394.0	-4.019	<0.001*
PSB- vs. S	106.0	406.0	-3.769	<0.001*

b.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	222.5	522.5	-1.401	0.161
PB- vs. PSB+	188.5	488.5	-2.088	0.037
PB- vs. PSB-	176.0	476.0	-2.337	0.019
PB- vs. S	32.5	332.5	-5.296	<0.001*
PB+ vs. PSB+	139.0	439.0	-3.138	0.002*
PB+ vs. PSB-	133.0	433.0	-3.260	0.001*
PB+ vs. S	14.5	314.5	-5.682	<0.001*
PSB+ vs. PSB-	268.5	568.5	-0.405	0.686
PSB+ vs. S	96.0	396.0	-3.972	<0.001*
PSB- vs. S	112.5	412.5	-3.628	< 0.001*

Table C 14. 2010 Pairwise Mann-Whitney U Test Results of *S. hispidus* Unique Individuals and Total Captures by Biomass Removal Option

Mann-Whitney U test results of pairwise comparisons for *S. hispidus* a. unique individuals, and b. total captures during 2010. Mann-Whitney U tests are significant (*) at p≤0.005. (PB+=Pine Biomass+, PB-=Pine Biomass -, PSB+=Pine × Switchgrass Biomass +, PSB-=Pine × Switchgrass Biomass-, S=Switchgrass only). All rodents were captured and released on site at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 19- November 14, 2010.

a.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	245.5	556.5	-0.650	0.515
PB- vs. PSB+	237.5	537.5	-1.043	0.297
PB- vs. PSB-	191.5	481.5	-1.992	0.046
PB- vs. S	234.5	534.5	-1.105	0.269
PB+ vs. PSB+	201.5	501.5	-1.786	0.074
PB+ vs. PSB-	165.0	465.0	-2.539	0.011
PB+ vs. S	275.5	575.5	-0.258	0.796
PSB+ vs. PSB-	229.0	529.0	-1.218	0.223
PSB+ vs. S	186.0	486.0	-2.106	0.035
PSB- vs. S	141.0	441.0	-3.035	0.002*

b.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	256.5	556.5	-0.650	0.515
PB- vs. PSB+	234.5	534.5	-1.105	0.269
PB- vs. PSB-	180.5	480.5	-2.219	0.026
PB- vs. S	238.0	538.0	-1.032	0.302
PB+ vs. PSB+	205.0	505.0	-1.713	0.087
PB+ vs. PSB-	160.5	460.5	-2.631	0.009
PB+ vs. S	274.5	574.5	-0.279	0.780
PSB+ vs. PSB-	215.5	515.5	-1.497	0.134
PSB+ vs. S	189.0	489.0	-2.044	0.041
PSB- vs. S	147.0	447.0	-2.911	0.004*

Table C 15. 2010 Pairwise Mann-Whitney U tests results of *P. leucopus* and *M. musculus* Number of Unique Juveniles by Treatment

Mann-Whitney U test results of pairwise comparisons of number of unique individuals for a. *P. leucopus* b. *M. musculus* during 2010. Mann-Whitney U tests are significant (*) at p≤0.005. (PB+=Pine Biomass+, PB-=Pine Biomass -, PSB+=Pine × Switchgrass Biomass +, PSB-=Pine × Switchgrass Biomass-, S=Switchgrass only). All rodents were captured and released on site at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 19- November 14, 2010.

a.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	2.0	12.0	-2.000	0.046
PB- vs. PSB+	7.5	17.5	-0.150	0.881
PB- vs. PSB-	6.5	16.5	-0.500	0.617
PB- vs. S	0.0	10.0	-2.337	0.019
PB+ vs. PSB+	4.0	14.0	-1.512	0.131
PB+ vs. PSB-	0.0	10.0	-2.530	0.011
PB+ vs. S	0.0	10.0	-2.477	0.013
PSB+ vs. PSB-	7.5	17.5	-0.150	0.881
PSB+ vs. S	4.0	14.0	-1.169	0.243
PSB- vs. S	0.0	10.0	-2.381	0.017

b.

Comparison	Mann-Whitney U	Wilcoxon W	Z	p (2-tailed)
PB- vs. PB+	2.5	12.5	-1.607	0.108
PB- vs. PSB+	0.5	10.5	-2.233	0.026
PB- vs. PSB-	0.0	10.0	-2.460	0.014
PB- vs. S	0.5	10.5	-2.233	0.026
PB+ vs. PSB+	5.5	15.5	-0.833	0.405
PB+ vs. PSB-	4.0	14.0	-1.512	0.131
PB+ vs. S	5.5	15.5	-0.833	0.405
PSB+ vs. PSB-	6.0	16.0	-1.000	0.317
PSB+ vs. S	8.0	18.0	0.000	1.000
PSB- vs. S	6.0	16.0	-1.000	0.317

Table C 16. 2009 *P. leucopus, M. musculus,* and *S. hispidus* Mean Adult Sex Ratio

Mean values/round/1800m^2 ± standard deviation for 2009 adult sex ratio of *P. leucopus, M. musculus, and S. hispidus* listed by biomass removal option. All rodents were captured and released on site at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 15- December 9, 2009.

Species	Biomass option	Adult Sex Ratio
P. leucopus	Pine Biomass +	0.62 ± 0.16
	Pine Biomass -	0.76 ± 0.08
	Pine Switchgrass Biomass +	0.61 ± 0.08
	Pine Switchgrass Biomass -	0.70 ± 0.09
	Switchgrass only	0.66 ± 0.03
M. musculus	Pine Biomass +	0.70 ± 0.14
	Pine Biomass -	0.68 ± 0.16
	Pine Switchgrass Biomass +	0.56 ± 0.08
	Pine Switchgrass Biomass -	0.53 ± 0.12
	Switchgrass only	0.65 ± 0.14
S. hispidus	Pine Biomass +	0.49 ± 0.28
	Pine Biomass -	0.68 ± 0.32
	Pine Switchgrass Biomass +	0.47 ± 0.03
	Pine Switchgrass Biomass -	0.70 ± 0.32
	Switchgrass only	0.72 ± 0.24

Table C 17. 2010 *P. leucopus, M. musculus,* and *S. hispidus* Mean Adult Sex Ratio

Mean values/round/1800m^2 ± standard deviation for 2010 adult sex ratio of *P. leucopus, M. musculus, and S. hispidus* listed by biomass removal option. All rodents were captured and released on site at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 19 - November 14, 2010.

Species	Biomass option	Adult Sex Ratio
P. leucopus	Pine Biomass +	0.62 ± 0.08
	Pine Biomass -	0.57 ± 0.12
	Pine Switchgrass Biomass +	0.72 ± 0.12
	Pine Switchgrass Biomass -	0.65 ± 0.26
	Switchgrass only	0.68 ± 0.28
M. musculus	Pine Biomass +	0.52 ± 0.04
	Pine Biomass -	0.78 ± 0.10
	Pine Switchgrass Biomass +	0.74 ± 0.18
	Pine Switchgrass Biomass -	0.68 ± 0.15
	Switchgrass only	0.66 ± 0.10
S. hispidus	Pine Biomass +	0.61 ± 0.10
	Pine Biomass -	0.53 ± 0.08
	Pine Switchgrass Biomass +	0.49 ± 0.08
	Pine Switchgrass Biomass -	0.45 ± 0.07
	Switchgrass only	0.61 ± 0.09

Table C 18. 2009 Repeated Measures ANOVA Results of Non-transformed Rodent Abundance by Trapping Round × Biomass Removal Option × Species

2-factor repeated measures ANOVA results of dependent variables a. non-transformed unique individuals, and b. non-transformed total number of captures by date × biomass removal option × species after Greenhouse-Geisser adjustment. [Adjusted *d.f.* are not whole numbers] Tests are significant (*) at p≤0.050. All rodents were captured and released on site at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 15- December 9, 2009.

a.

	Source	*df*	Mean Square	*F*	*P*
Between Trapping Rounds	Biomass option	4	1.350	1.243	0.303
	Species	3	64.496	59.378	<.001*
	Biomass option × Species	12	1.864	1.716	0.086
	Error	60	1.086		
Within Trapping Rounds	Round	4.860	37.679	9.110	<.001*
	Round × Biomass option	19.441	3.264	0.789	0.723
	Round × Species	14.581	21.492	5.196	<.001*
	Round × Biomass option × Species	58.322	5.597	1.353	0.057
	Error	291.611	4.136		

b.

	Source	*df*	Mean Square	*F*	*P*
Between Trapping Rounds	Biomass option	4	3.305	1.325	0.271
	Species	3	206.301	82.723	<.001*
	Biomass option × Species	12	3.551	1.424	0.181
	Error	60	2.494		
Within Trapping Rounds	Round	4.504	67.112	5.565	<.001*
	Round × Biomass option	18.018	8.587	0.712	0.798
	Round × Species	13.513	50.120	4.156	<.001*
	Round × Biomass option × Species	54.053	13.797	1.144	0.244
	Error	270.264	12.060		

Table C 19. 2010 ANOVA Results of Non-transformed Rodent Abundance by Trapping Round × Biomass Removal Option × Species

2-factor repeated measures ANOVA results of a. non-transformed unique individuals, and b. non-transformed total captures by date × biomass removal option × species after Greenhouse-Geisser adjustment. [Adjusted *d.f.* are not whole numbers] Tests are significant (*) at p≤0.050. All rodents were captured and released on site at Weyerhaeuser Company's Lenoir 1 long-term sustainability study site July 19 - November 14, 2010.

a.

	Source	*df*	Mean Square	*F*	*P*
Between Trapping Rounds	Biomass option	4	5.598	0.675	0.612
	Species	4	589.529	71.055	<.001*
	Biomass option × Species	16	26.858	3.237	<.001*
	Error	75	8.297		
Within Trapping Rounds	Round	3.993	174.540	27.197	<.001*
	Round × Biomass option	15.972	5.629	0.877	0.596
	Round × Species	15.972	172.762	26.920	<.001*
	Round × Biomass option × Species	63.888	6.056	0.944	0.600
	Error	299.474	6.418		

b.

	Source	*df*	Mean Square	*F*	*P*
Between Trapping Rounds	Biomass option	4	7.856	0.469	0.758
	Species	4	979.518	58.483	<.001*
	Biomass option × Species	16	58.900	3.517	<.001*
	Error	75	16.749		
Within Trapping Rounds	Round	4.043	230.945	17.025	<.001*
	Round × Biomass option	16.172	15.633	1.152	.306
	Round × Species	16.172	305.047	22.488	<.001*
	Round × Biomass option × Species	64.688	12.555	0.926	0.638
	Error	303.225	13.565		