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Altered understory characteristics affect rodent spatial and foraging behaviors and reproduction patterns

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ABSTRACT

Understanding how changes to habitat characteristics affect behaviors is necessary to integrate biodiversity goals with land management. Managed forests are a significant landscape component in the southern United States and provide opportunities for conservation alongside production of wood products. We investigated behavioral responses of rodents to differences in understory habitat characteristics from intercropping switchgrass (*Panicum virgatum*), a native biofuel feedstock, in intensively managed loblolly pine (*Pinus taeda*) stands. Previous research indicated that planting switchgrass increased rodent population abundance but reduced recruitment and community diversity. To understand potential mechanisms underlying our previous results, we measured behaviors of individual cotton rats (*Sigmodon hispidus*), a grassland specialist, to planted switchgrass. We hypothesized that female territory size, foraging activity, overlap with other adult females, and reproduction indices would differ among treatments (switchgrass monocrop, intercropped switchgrass, and control plots) due to variation in grass abundance and vertical vegetation cover. We conducted live-trapping, radio telemetry, and foraging activity surveys on cotton rats during summers of 2013–2015. We found no treatment effect on territory size, but foraging activity was 2 times higher in monocrop than control plots. We also found a positive relationship between female spatial overlap and percentage of grass in control plots and evidence for higher reproductive indices in control than monocrop plots. Our results suggest that cotton rats in monocrop plots exhibited unexpected behaviors, and monocrop plots may serve as population sinks with low rodent diversity. Overall, results from this replicated experiment suggested that intercropping provides adequate food and cover to maintain rodent populations and produce forest products.

1. Introduction

Conservation behavior, a relatively new interdisciplinary field, includes three domains that influence fitness and therefore can inform management decisions to conserve biodiversity: (1) movement and space use, (2) foraging and vigilance, and (3) social behavior and reproductive output (Berger-Tal et al., 2011). Individuals base behavioral decisions on several factors related to habitat, such as food availability and predator avoidance (Wasko and Sasa, 2012) and respond to changes in habitat by altering behaviors to increase fitness. However, anthropogenic habitat alterations may create ecological traps where individuals make faulty behavioral decisions due to altered resource availability and environmental cues (Schlaepfer et al., 2002). Faulty decisions are a result of individuals not recognizing a change in resources because they are responding to an unchanged cue (Schlaepfer et al., 2002). Thus, studying population abundance alone can produce misleading results and lead to poor management decisions (Van Horne, 1983), especially if there is a time lag between behavioral decisions and population level changes. Behaviors provide a direct and immediate assessment as to whether or not individuals are responding to their environment to maximize fitness and can indicate future population dynamics.

Individual decisions about movement and space use differ with vegetation structure. As juveniles, individuals may disperse and then make decisions that determine location and size of their home ranges (areas used, but not defended by individuals) or territories (Grant, 1993; Mabry et al., 2008; Mabry and Stamps, 2008). For example, individual brush mice (*Peromyscus boylii*) prefer to disperse to areas that

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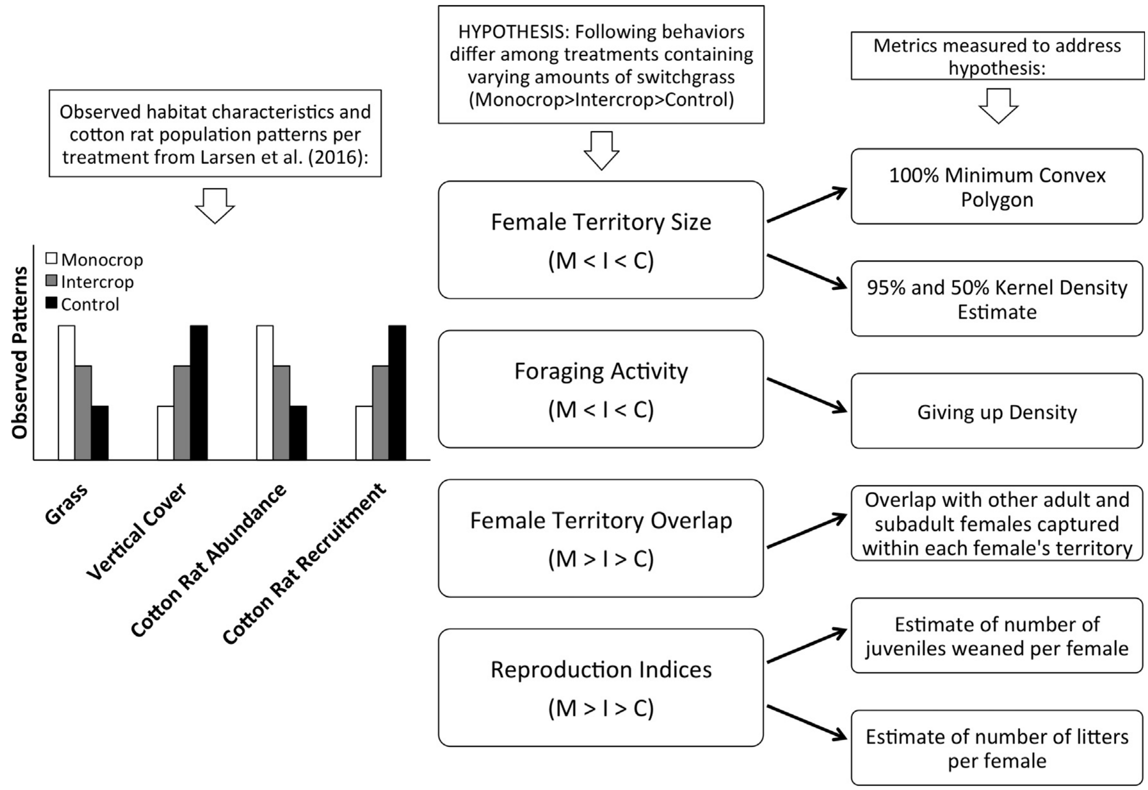

Fig. 1. Descriptive figure of habitat and cotton rat population patterns observed in Larsen et al. (2016) with the current study's hypothesis and measurements. Predictions of treatment pattern for each cotton rat behavior are listed in parentheses (M = Monocrop, I = Intercrop, C = Control). We based predictions on the amount of switchgrass in each treatment and whether switchgrass is providing adequate food and cover resources per behavior. We measured behavior to understand cotton rat responses.

are similar to their natal habitat (Mabry et al., 2008; Mabry and Stamps, 2008). Another study of female striped mice (*Rhabdomys pumilio*) documented that a combination of season (breeding versus non-breeding), percent cover, percent food plants, number of neighbors, and relative body mass influenced home range size (Schradin et al., 2010). Other factors, such as predation risk, interspecific competition, and individual variation in explorative behavior, also influenced home range size of striped mice (Bell, 2007; Schradin et al., 2010). Assuming resources are abundant and all other factors are equal, an individual should require a relatively small area to obtain all required resources. At high densities, there is also a higher probability that individuals will have a smaller territory, as there will be more conspecifics defending their territories. However, there could also be a density threshold where defending a territory no longer outweighs costs, and that point may vary among individuals (Grant, 1993). Individual rodents who have smaller territories, and likely move less to obtain necessary resources, would be predicted to have higher survival compared to individuals with larger territories due to less exposure to predators (Lima and Dill, 1990).

Individuals evaluate costs and benefits to determine when and where to forage. Altered habitat can affect how individuals perceive predation risk when foraging. An individual may cease foraging when perceived costs (e.g. predation risk) become greater than perceived benefits (e.g. energy intake) (Brown, 1988). Predation risk is influenced by the amount and structure of vegetative cover individuals can access to avoid predators, although ambush predators, such as snakes, have an opportunity to hide in dense cover (Abu Baker and Brown, 2010). Perceived benefits also depend on the quality of the individual's environment, including resources in areas of competition (Abu Baker and Brown, 2010). For example, in areas of low food availability and high competition, an individual will perceive a food patch as having higher benefits than if that same food patch was in an area with high food availability and low competition, given there are likely several food patches available (Abu Baker and Brown, 2010).

Lastly, social behavior and reproductive output can be behavioral indicators of individual responses to altered habitat. Female territoriality in small mammals is hypothesized to be driven by protecting resources (Ostfeld, 1985) or protecting offspring from infanticide (Wolff, 1993). Ostfeld (1985), based on the resource-defense hypothesis, predicted that female territoriality would exist in areas where food is limited, patchy, and slowly renewable and there is low to moderate population density. Further, territoriality increases during the breeding season because energetic demand of females is higher in an area with limited resources, but the cost of defense is lower in areas where there are few conspecifics (Ostfeld, 1985). Infanticide, which can occur in small mammal species (Wolff, 1993), has been found to increase with increasing density of conspecifics (Korpela et al., 2010) and vary with heterogeneous resources (Rémy et al., 2013). Thus, reproductive output depends on survival, availability of resources (especially food and nesting sites), and ability to locate a mate, all of which vary in heterogeneous environments (Wellington and Victor, 1988).

As habitat loss for some species continues with spreading human development, managed lands will be increasingly important to consider when planning for biodiversity conservation (Chapin et al., 1998; O'Bryan et al., 2016). In the southern US, 19% of forests are intensively managed for high productivity of wood products, but while also contributing to conservation of biodiversity (Wear and Greis, 2012). Yet effectiveness of some management techniques for biodiversity conservation in intensively managed forests are not fully understood (Greene et al., 2016). The drive for renewable fuels (Cheng and Timilsina, 2011) has caused some landowners to consider using intercropping, where two crops are planted in alternating rows (Garrett and Buck, 1997). In one form of intercropping, switchgrass (*Panicum virgatum*) is planted between loblolly pine (*Pinus taeda*) rows. This method allows managers to plant a biofuel feedstock crop, switchgrass, in planted pine stands where it is not competing with food crops and can