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IN A NUTSHELL: NUTRITIONAL AND ENVIRONMENTAL FACTORS IMPACTING SMALL MAMMAL SEED SELECTION IN NORTHEASTERN FORESTS

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SMALL MAMMAL SEED SELECTION IN NORTHEASTERN FORESTS

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ABSTRACT

IN A NUTSHELL: NUTRITIONAL AND ENVIRONMENTAL FACTORS IMPACTING

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Rodents often play vital roles in their ecosystems as seed predators and dispersers and can significantly influence the succession and assembly of plant communities. We conducted seed tray experiments to assess the nutritional and environmental factors that influence selection and foraging time of three common rodent granivores: the white-footed mouse (*Peromyscus leucopus*), the deer mouse (*Peromyscus maniculatus*), and the southern red-backed vole (*Myodes gapperi*) for three common seeds: American beech (*Fagus grandifolia*), red maple (*Acer rubrum*), and eastern hemlock (*Tsuga canadensis*). This work was conducted at Bartlett Experimental Forest located within White Mountain National Forest in New Hampshire.

Using mixed-effects multinomial logistic models, we identified a strong preference in all three rodent species for American beech seeds, likely due to the combination of its high energetic value and low content of harmful secondary compounds when compared to the other seed types. When beech availability was low, the white footed mouse showed a secondary preference for hemlock, the red-backed vole for red maple, and the deer mouse equal preference for both. Red maple seeds individually contain more energy than eastern hemlock seeds but also contain significantly more harmful secondary compounds. An elongated cecum may allow voles to

process these compounds faster and more completely than mice, allowing them to safely forage on the red maple seeds. The resulting divergence in secondary preferences may lessen competition when beech availability is low and facilitate coexistence. Beech was not only the primary seed selected, but its availability was also the primary factor influencing foraging time. For all three rodent species, time on tray increased as beech availability decreased.

The impacts of environmental factors on selection and time on tray varied by species and were only significant when beech availability was low. Effects of precipitation and stem density on selection are consistent with predator avoidance behaviors, with larger seeds more likely to be chosen in the rain and under denser shrub cover. The effects of day of year appeared significant but may have been confounded by changing levels of naturally available seeds. Precipitation and luminosity also impacted foraging time. Animals spent less time on tray in the rain, consistent with thermoregulatory behaviors. Animals also spent less time on tray on more luminous nights, consistent with predator avoidance behaviors.

Our results illustrate the complexity of rodent foraging behaviors and decisions, with selections being driven by many factors. The most important of these factors is seed quality, though this can be influenced by other factors such as seed availability and environmental changes. These findings contribute to our understanding of rodent foraging patterns and underscore the importance of identifying factors influencing these patterns.

INTRODUCTION

Rodents play vital roles in ecosystems, often influencing the composition and structure of forests through foraging behaviors such as selective herbivory (Huntly 1991), fungivory (Stephens and Rowe 2020), and granivory (Sivy et al. 2011). Variation in occurrence and abundance of rodent species can impact the composition of local plant communities by affecting which seeds are selectively consumed as well as the extent of seed predation across the landscape as a whole. For example, granivory by rodents has been shown to shape forest structure, affecting oak and walnut regeneration through both dispersal and predation (Goheen and Swihart 2003), facilitating dispersal in masting pines (Vander Wall 2007), selectively inhibiting recruitment among conifer species (Lobo et al. 2009), and reducing exotic plant invasions following fire events (Clair et al. 2016). Likely as a result of these effects, reduction in rodent biodiversity has been found to directly correlate with reductions in plant biodiversity (Valone and Schutzenhofer 2007), influencing forest structure. Forest structure, in turn, determines resource availability (habitat and diet) for the rodent community, impacting the extent of interspecific competition and niche partitioning and thus influencing foraging behavior (Saitoh and Nakatsu 1997, Adler 1998). The feedback effects between forest structure and granivory within rodent communities can have far reaching consequences for the population and community dynamics of both plants and animals and underscores the importance for identifying the factors (abiotic and biotic) that shape rodent foraging behaviors, particularly seed predation.

Mast seeding events drive population fluctuations of rodents in Northeastern forests (Conrod and Reitsma 2015), significantly increasing rodent fecundity and reproductive success more so than habitat factors alone (Hoset et al. 2017). These studies suggest that pulses in resource availability, specifically food sources, may be the primary driver of small mammal

community dynamics. Rodents tend to show strong dietary niche partitioning (Reid et al. 2013, Stephens et al. 2019), suggesting that food sources are an important source of competition between rodent species, though the relationships are often complex (Gregory and MacDonald 2009). Pulses in food availability caused by masting events may therefore influence the intensity of competition within rodent communities and result in highly plastic dietary niches and shifting food preferences, especially for seeds.

Research on rodent seed preferences has identified relationships between seed selection and seed characteristics, principally size (including shell thickness), nutritional quality, secondary compounds, and quantity available. Seed size is positively correlated with both nutritional quality (Westoby et al. 1992) and handling time, or the time required for an animal to extract and consume a seed (Boone and Mortelliti 2019), and is often treated as a proxy for both (Sivy et al. 2011, Collins and Horn 2012, Richardson et al. 2013). Although increased handling time may lead to increased risk of predation, larger seeds may still be preferred due to their higher energetic content. However, when offered equal numbers of seeds of the same type but in different sizes, rodents tend to show variation in which seeds they remove, both among and within species, indicating factors other than seed size impact selection (Brehm et al. 2019). When offered different seed types, the variation in responses among rodents indicates that seed selection is influenced by rodent species, which may reflect local competition for resources (Sivy et al. 2011, Cramer 2014). Selection is also impacted by differences in both seed nutrition and availability (Boone and Mortelliti 2019), though nutrition has shown a stronger effect on selection than availability (Celis-Diez et al. 2004). Secondary compound contents, especially of tannins, may also influence rodent selections by lowering the perceived quality of a seed type (Ancillotto et al. 2015), though these effects may be weaker for some species of granivore

(Onodera et al. 2017) and mitigated by certain environmental conditions (Windley and Shimada 2020).

In addition to seed characteristics, environmental variables may also influence seed selection. Variables understood to relate to predator avoidance, such as moonlight and vegetation cover, have been examined for effects on seed selection with mixed results. Sivy et al. (2011) found no significant effects of shrub cover on seed selection. In contrast, Perea et al. (2011) found moonlight and shrub cover to impact both seed selection and handling time. In Northeastern forests, rain, temperature, and moonlight have been found to impact rodent seed selection, although which variable is most significant differed among rodent species (Boone and Mortelliti 2019).

Here, we use a seed selection experiment to quantify seed preferences of white-footed mice (*Peromyscus leucopus),* deer mice (*Peromyscus maniculatus),* and red backed voles (*Myodes gapperi*) in a forested system in the northeastern United States. These species frequently co-occur and are among the most abundant of rodent species in the region (DeGraaf and Yamasaki 2001). All consume seeds, though the proportion of seeds in the diet differs especially for voles, who are fungal specialists (Stephens and Rowe 2020). In addition, all three species are terrestrial, nocturnal, and similar in body size. We offered equal amounts of three seeds, which differ in size and nutritional content, and represent the most common tree species in the study area: American beech (*Fagus grandifolia*), red maple (*Acer rubrum*), and eastern hemlock (*Tsuga canadensis*). We used camera traps to record the seed type selected and time spent foraging on tray. Our objective was to identify nutritional and environmental factors that influence rodent seed selection. Specifically, we address the following three questions: 1) How do tradeoffs between seed quality and availability influence seed selection and time spent

foraging on tray? 2) Do environmental or habitat factors affect seed selection or perceived

foraging cost? 3) Do species differ in seed selection and time spent foraging on tray, and in

variables that influence these outcomes? By quantifying the relative impact of abiotic and biotic

factors on dietary partitioning among rodent granivores, we can better understand how rodent

population and community dynamics affect seed survival and dispersal and thus shape forest

composition (Schnurr et al. 2004, Larios et al. 2017, Guiden et al. 2019).

METHODS

Study System

We conducted our study at Bartlett Experimental Forest (44° 3' 7.2" N, 71° 7' 25.1" W), a sub-

administration of White Mountain National Forest in New Hampshire, at elevations ranging from

250m to 450m. The climate is humid continental, with warm summers (mean July temperature of

19°C) and cold winters (mean January temperature of -9°C) with an average annual

precipitation of 127cm (Richardson et al. 2007, King et al. 2011). Although the U.S. Forest

Service continues to manage the forest with commercial cuts, we targeted undisturbed stands

which we categorized by dominant tree species into three main types: hardwood, softwood, and

mixed. The forest is diverse with over 25 tree species, the three most dominant of which are

eastern hemlock (*Tsuga canadensis*), red maple (*Acer rubrum*), and American beech (*Fagus

grandifolia*). These three species combined make up 67.3% of the basal area within our stands.

Hardwood stands are dominated by American beech (34.3%) and red maple (24.2%) and

softwood stands by eastern hemlock (51.84%). Mixed stands are primarily composed of eastern

hemlock (33.2%) and red maple (26.9%), with a lesser beech component (5.8%) (Stephens et al.

2017). American beech in the region typically undergoes biennial masting events that occur in

the fall and result in large beech crops separated by a year of very low beech seed production. Hemlock germinates and releases seeds throughout the fall and into the winter each year. Red maple seeds are released in late May through June and also fluctuate in production year to year. Beech produces the largest seeds (175.3 ± 37.2g), followed by red maple (8.5 ± 1.9g), then hemlock (2.2 ± 0.5g), and all are important food sources for rodents (Stephens et al. 2019). Rodents often store beech in particular as an overwinter food source.

Small Mammal Surveys

We live-trapped small mammals across 12 mark-recapture grids, each consisting of 64 traps in an 8x8 array with 15m spacing between trap stations, for a total area of 11,025m^2 (ca. 1 ha). We stratified grids by forest type, with four each placed in hardwood, softwood, and mixed forest. We captured rodents using a combination of Sherman live traps (H. B. Sherman Co., Tallahassee, Florida) and pitfall traps (2.8 L). One live trap was set within 1.5 m of each trap station and one pitfall trap at every other station. All traps were checked twice daily for four consecutive days in June, July, and August of 2018. We baited the traps with birdseed and provided polyester fill for warmth. Captured animals were identified to species and marked with a uniquely numbered ear tag (model 1005-1; National Band and Tag Company, Newport, Kentucky). Passive integrated transponders (pit tag- model HPT9; Biomark, Boise, Idaho) were used to mark *Myodes gapperi* along with ear tags to combat high ear tag loss. To distinguish between deer mice (*Peromyscus maniculatus*) and white-footed mice (*Peromyscus leucopus*) on camera, we collected a hair sample (1-4mg) from the right haunch of *P. maniculatus* and the left haunch of *P. leucopus*. The trapping protocol was approved by the University of New Hampshire

Animal Care and Use Committee (protocol 180401) and followed guidelines outlined by the

American Society of Mammalogists for the use of wild mammals in research (Sikes 2016).

Seed Trays

Experimental seed trays and camera traps were placed at 8 permanently selected stations

on each of the twelve grids (Figure S1). Stations were staggered to provide the greatest possible

cover of each grid. We constructed the trays from boards of plywood (30x40x0.5cm) into which

96 12.7mm (0.5inch) seed wells were drilled spaced 12.7mm apart. We arranged the wells into

six blocks set in a 2x3 matrix, with each single block consisting of 16 wells (Figure 1a). Each

block was given a letter designation A, B, or C such that each letter is represented twice on the

tray without bordering another block of the same letter. We then assigned each letter one of three

seed types: American beech (*Fagus grandifolia*), red maple (*Acer rubrum*), or eastern hemlock

(*Tsuga canadensis*), with each well containing one seed of its assigned species. This labelling

system ensured all seed types occurred in two well defined patches of 16 seeds each on the tray,

resulting in six possible seed arrangements which were randomly assigned to each tray before

each experiment.

We stapled sheets of white 10 mesh plastic canvas (Darice, Strongsville, Ohio) to the

bottom of the trays to hold seeds in place while also allowing precipitation to drain. Additionally,

the white color provided sufficient contrast to the dark hemlock seeds to facilitate their counting

on video. Pine slats were added to the back to prevent warping and secure the plastic mesh.

Because of the small mesh size (2 mm), we stapled a towel to the bottom of the trays to the break

water tension during rain events and facilitate draining. The resulting wells were deep enough to

contain the large beech nuts but shallow enough that small mammals were able to retrieve all

three seed types without difficulty. All seeds were collected at Bartlett Experimental Forest with beech nuts collected by hand during the fall of 2017, red maple collected the first week of June, 2018 using tarps, and hemlock seeds collected during the fall and winter of 2017 - 2018 in baskets installed to measure seed fall on the mark-recapture grids. Only red maple seeds with wings were used to stock seed trays but many of the seed wings for hemlock were disconnected because of their fragile nature.

To record foraging behavior, a camera was associated with each seed tray station (n = 96). We installed a steel conduit tube (diameter 1.8cm) securely into the ground within two meters of the station flag. We then placed the seed tray at the base of the tube before adding seeds to the wells based on the assigned arrangement. To ensure that trays did not shift at steep locations, we secured trays to the ground using metal garden staples (15 cm) placed through pre-drilled holes at the edges of the trays. We secured a Bushnell NatureView camera with a 600mm focal lens (Bushnell Corporation, Overland Park, Kansas) in a protective steel case (Camlockbox, Green Bay, Wisconsin) and fastened the case to the steel conduit tube using ring clamps. Prior to encasing the camera, we inserted a 16 GB SD card which provided 129 minutes of recording time. With another ring clamp, we secured the camera apparatus to the conduit between 32 - 36 cm above the ground (depending on how slope of the ground affected the frame of view) with the camera facing straight down. We used a steel flatbar running from the top of the camera apparatus to the top of the conduit tube to stabilize the camera (Figure 1b). Using a viewer included with each camera, we made final adjustments to center the entire seed tray in the camera's field of view, then set the camera to record 60 second videos with a one second interval between successive recordings upon being motion activated. We applied anti-fogging spray to the camera lens and sensors at the outset of each seed tray session.

Trays were only set out for the duration of the experiments. We conducted the seed tray experiment once per grid in each summer month (June, July, and August), during which the seed trays were deployed over two consecutive nights. Experiments were conducted 2-10 days after the monthly mark-recapture trapping session on each grid. As a result, the third experiments for two grids were conducted in early September. After the first night, we restocked the trays with seeds, replaced batteries when necessary, and checked the camera's field of view to ensure the tray remained completely visible. At the conclusion of each recording session, we disassembled the camera apparatus before removing the SD cards, uploading the videos onto a hard drive, and deleted the videos off the SD cards for reuse.

Environmental Variables

To determine the effects of environmental cues on foraging behavior, we assessed vegetation at each seed tray station. Specifically, we recorded the species, distance to and diameter at breast height of the nearest tree ≥3 cm , leaf litter depth, percent ground cover by class (grass, forbes, shrubs, leaf litter, coarse woody debris, and bare ground), and percent canopy cover as taken from the forest floor using a convex densiometer. We also compiled data on the basal area of each tree species and total number of stems within five meters of the station (for additional details, see Stephens et al. 2017). In addition, we compiled data on precipitation and moon luminosity. Precipitation data came from archives maintained by the National Ecological Observation Network and were recorded every 15 minutes by a 0.5mm tilting bucket rain gauge located in the center of the forest. We acquired moon luminosity data (as a percentage of moon face visible) for each night from the United States Naval Observatory.

Seed Nutritional Analysis

To assess the nutritional quality of the seeds, we compiled the percent content of lipids, carbohydrates, and proteins in each seed type. Data for hemlock and red maple were acquired from Boone and Mortelliti (2019) and data for beech was measured from 150 beech seeds analyzed by Dairy One (Ithaca, New York). Energy content per gram was found using standard constants for each class of macronutrient: 4 kcal/g of proteins, 4 kcal/g of carbohydrates, and 9 kcal/g of lipids. We then multiplied the per gram values by seed mass to calculate total energy per seed for each seed type. In addition to determining the macronutrient content, a pyrolytic analysis was conducted in the Soil Biogeochemistry and Fertility Lab at the University of New Hampshire to determine the chemical breakdown of each seed type and percent content of different classes of compounds, especially phenolic compounds such as tannins.

Video Processing

Video recordings were processed using Windows Media Player (Microsoft Corporation, Redmond, Washington). For each video containing a target small mammal species, we recorded location, date, time, species, whether the animal was marked, and sex (if previously captured), number and types of seeds available on the tray, the time spent on tray, and the number and type of each seed consumed on site or carried away. Videos were often slowed down to facilitate observations. Analysis of *Peromyscus* was restricted to individuals that were ear-tagged and thus for which species identity was known.

Data Analysis

To determine each rodent species' seed preference, we used multinomial, mixed effects models in which seed choice (the first seed chosen in a foraging event) was the categorical response variable. Such models are commonly used in seed selection studies (e.g. Richardson et al. 2013, Boone and Mortelliti 2019, Brehm et al. 2019). Seed availability was included as a fixed effect in all models and was calculated as the proportion of each type available at selection from the initial total of 32. We also examined, as fixed effects, Julian date, precipitation (presence/absence), luminosity, tree basal area, and stem density. By including station and grid as a nested random effect, we accounted for any potential autocorrelation in selections and trials that might occur from repeated visits by single individuals or different environmental conditions at a given station (Richardson et al. 2013). We used basal area as a proxy for canopy cover, as these are highly correlated. Leaf litter depth was excluded due to low levels of variation (0.5-5.5mm). We used stem density as a measure of shrub and understory complexity since herbaceous vegetation is lacking. Precipitation was recorded on 51% of nights during which seed trays were deployed by a tilting bucket rain gauge calibrated to record 0.5mm of rainfall. However, most rainfall events were light enough that given the nature of a tilting bucket gauge, which can only record cumulative rainfall in multiples of a predetermined volume, little variation in precipitation level was captured. Thus, we instead included occurrence of precipitation as a two-level categorical variable. All other variables were z-standardized to have a mean of 0 and a standard deviation of 1. When an animal made multiple selections in one video, we only used the first selection for analysis. Following Brehm et al. (2019), we fit multinomial, mixed effects models in the R packages "rethinking" (McElreath 2020, version 2.00) and "Rstan" (Koster and McElreath 2017, version 2.19.3) using weakly informative priors for the fixed effects and variance-covariance matrices (Koster and McElreath 2017). We ran models with three chains for

3000 iterations, discarding the first 1000 iterations as burn-in. We assessed convergence of models with traceplots and by checking the n-eff (*n* of effective samples) and Rhat.

For each rodent, seed availabilities were included as fixed effects in the base model. The remaining five environmental effects were then added to the models in all possible combinations for a total of 32 models per rodent species, including the base model. We used the Widely Applicable Information Criterion (WAIC) to rank the models and considered the "best" model as the one with the lowest ΔWAIC score while recognizing that all models with a ΔWAIC of <2 have substantial support (McElreath 2020). To evaluate the relative contributions of the different predictor variables, we calculated impact factors by summing the weights of each model containing the particular variable. Impact factors are a form of cross-model validation, and as such we interpret cumulative weights ≥0.8 as strong evidence for support (Burnham and Anderson 2002).

Interpreting coefficients of multinomial models is difficult because they do not simply indicate the effect a predictor (fixed effect) has on the probability of an outcome (in this case a seed selection) and are often misleading (Koster and McElreath 2017). Instead of relying on model coefficients, we used the "best" model to predict the probability of selection for each seed type and rodent species using the *link.mn* function (analogous to the *link* function in the "rethinking" package) developed by Koster and McElreath (2017). This function is specific to multinomial models and allows custom values to be applied for both fixed and random effects. The values are multiplied by the coefficients of each posterior sample from a model, resulting in a predicted distribution from which means and confidence intervals can be calculated. By necessity, these predicted probabilities sum to a value of 1. Using the *link.mn* function, we held environmental variables in the "best" model constant (at their mean) and assessed seed selection

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when all seeds were equally available (i.e. 100% availability). We did not supply custom values

for random effects.

Preferences for beech were so strong for all three rodent species that secondary

preferences, or second most preferred seed types, were obscured. To identify secondary

preferences, we also predicted selection probability when only a single beech seed was available

(1 of 32 or 3% availability). A similar approach was used by Boone and Mortelliti (2019) to look

at seed selection when availability was low. For each rodent species, we only examined the

influence of environmental variables with an impact factor ≥0.8 and used the model that

contained only these variables. For each continuous variable, we used the z-standardized

distribution to create a sequence of 100 values bounded by the minimum and maximum values.

We then used the *link.mn* function to hold all other environmental variables at mean level (i.e.

zero) and predicted outcomes along the distributional sequence for the variable of interest.

Where rain, a categorical variable, was found to be a strong factor, we again held all other

environmental factors constant and used the *link.mn* function to run an iteration both with and

without rain. We made predictions for each important environmental variable with all seeds fully

available and again with low beech availability. For all distributions we summarized predicted

selections as means and 89 percentile intervals (McElreath 2020).

We used time on tray as a measure of the perceived cost-benefit ratio for foraging, and

similar to seed selection, assessed the influence of seed availability and environmental variables.

Specifically, we fit linear mixed effects models to examine the impact of seed availability, Julian

date, precipitation, luminosity, basal tree area, and stem density on the amount of time (in

seconds) each animal spends foraging on tray in the R package "nlme." We then used backward

selection function in the R package "MASS" to determine the model with the best combination

of variables for each species. Because the "MASS" package is not compatible with random intercepts models, we first fit the models using a maximum likelihood method and then refit the best model using a random intercepts method to determine variable coefficients. Time on tray models included foraging events in which no selection was made.

RESULTS

We recorded 13,775 videos in total, of which 3,833 (27.8%) contained our target species (for full breakdown of videos by species, see Appendix A). From these target videos, we documented 4,645 discrete foraging events, with seeds being consumed or removed from tray in 2,758 (59.4%). The number of foraging and selection events differed among the three target species. *Peromyscus leucopus* accounted for 2,236 foraging events and made 1,371 selections, *P. maniculatus* accounted for 1,669 foraging events with 996 selections, and *M. gapperi* accounted for 740 foraging events with 391 selections. Seed selection models were built only from those foraging events in which a selection was made. Time on tray models were built from all foraging events, regardless of whether a seed was selected.

Seed Nutritional Analysis

The mass, composition for proteins, carbohydrates, and lipids, kilocalorie per gram, and kilocalorie per seed for each seed type are summarized in Table 1. Using the standard 4-4-9 rule for calculating kilocalories per gram for these macronutrient categories (Donato and Hegsted 1985, Boone and Mortelliti 2019), the energy value for beech is 6.20 kcal/g (1.09 kcal/seed), the energy value for hemlock is 6.47 kcal/g (0.01 kcal/seed), and the energy value for red maple is 4.21 kcal/g (0.04 kcal/seed). Beech and hemlock seeds contained far more lipids (per gram) than

proteins and carbohydrates, whereas red maple seeds are low in lipid content. The results of the

pyrolysis can be found in Appendix B. Of note is the relatively high percentage of phenols found

within red maple (11.8%) when compared to beech (3.3%) or hemlock (5.0%).

Seed Selection

For each rodent species, we accepted the model with the lowest WAIC score as the "best"

and used it to predict seed selection. The "best" model for *P. leucopus* included seed availability

and the occurrence of rain (w_i=0.1497). The second "best" model included basal tree area as well

(w_i=0.1202), with four additional models receiving ΔWAIC < 2, all of which included rain (see

Appendix C for full list of models). For *P. maniculatus*, the "best" model for seed selection

incorporated seed availability, Julian date, stem count, and rain (w_i = 0.1734). Six additional

models received ΔWAIC values < 2 including the global model containing all six variables

(Appendix C). The top seed selection model for *M. gapperi* included Julian date, stem count,

basal tree area, and rain (w_i = 0.3228). Two additional models, including the global model, also

received a ΔWAIC<2 (Appendix C).

All three rodent species strongly preferred beech seeds, taking beech nearly 100% of the

time when all three seed types were fully available (Figure 2). At low beech availability, each

rodent still selected beech most often, however secondary preferences were also apparent (Figure

2). *Peromyscus leucopus* showed a slight but notable secondary preference for hemlock (0.25

[0.17-0.33]) over red maple (0.13 [0.09-0.17]) seeds, whereas *M. gapperi* showed a strong

preference for red maple (0.37 [0.16-0.59]) over hemlock (0.09 [0.03-0.17]). *Peromyscus*

maniculatus showed no preference for either hemlock (0.18 [0.12-0.25]) or red maple seeds

(0.19 [0.13-0.25]), showing similar probabilities of selection.

To ascertain the relative impact of each environmental variable, we summed the weights of all models containing a particular variable and considered those with an impact factor ≥0.80 to have a strong influence on selection (Table 2). Of the five environmental variables tested, basal area and luminosity did not impact selection for any species. The remaining variables of precipitation, Julian date, and stem density were found to each influence seed selection of two of the target species. Precipitation influenced seed selection for both *P. leucopus* and *M. gapperi*, but only when beech availability was low. Both species had a higher probability of selection for beech during rainy conditions (Fig. 3). Similarly, Julian date and stem density only influenced seed selection of *P. maniculatus* and *M. gapperi* when beech availability was low (Figure 4). For both species, Julian date was inversely correlated with likelihood of selection of beech and positively correlated with selection of red maple, with animals less likely to choose beech and more likely to choose red maple as the season progressed (Figure 4b). This relationship was particularly strong for *M. gapperi*. For both species, stem density displayed a negative correlation with hemlock selection and a positive correlation with red maple selection. For beech selection, stem density showed a weak negative correlation for *P. maniculatus* and no relationship for *M. gapperi* (Figure 4).

Time on Tray

The linear mixed effects models indicated that three variables (beech availability, rain, and luminosity) influenced the time an animal spent on the tray (Table 3). Only beech availability influenced time on tray for all three target species. The top model for *P. leucopus* included beech availability and rain. *Peromyscus leucopus* spent less time on tray when beech availability was high and under rainy conditions. Likewise, *P. maniculatus* also spent less time

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on tray with high beech availability and under rainy conditions, but was also affected by moonlight, spending less time on tray under brighter conditions. *Myodes gapperi* was similarly impacted by beech availability and moonlight, spending less time on tray as these two factors increased. *Myodes gapperi* was the only species not influenced by rain.

DISCUSSION

Our objective was to identify nutritional and environmental factors that influence granivore seed selection. We examined three rodent species, *P. leucopus, P. maniculatus,* and *M. gapperi,* in northeastern forests and quantified their preferences for three seed types: American beech, red maple, and hemlock. All three species of rodent strongly preferred beech seeds over both hemlock and red maple. This preference was so strong that it obscured secondary selection and any effects of the environmental variables when beech was fully available. Beech availability was also the strongest determinant of how much time animals spent foraging on tray for all three rodent species.

Seed Selection

All three species strongly preferred beech seeds even when availability was low and under all environmental conditions. This strong preference for beech likely stems from the large seed size and high caloric content (Jensen 1985). Although beech and hemlock seeds have similar caloric content by gram (Table 1), beech seeds are nearly 76 times larger than hemlock (Stephens et al. 2019), thus despite their similar energy values per gram, a single beech seed provides far more energy than a single hemlock seed. The bulk of beech calories are in the form of lipids, whose main biological function is energy storage (Rosen and Spiegelman 2006). A

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surplus of lipids, both in cached seeds and in the adipose tissue of the animal itself from consumption of lipid rich foods, increases over winter survival of small rodents (Sealander 1951, Lynch 1973) and increases reproductive success in the following year (Judd et al. 1978). While hemlock seeds contain a similar percentage of lipids to beech, the effort required to consume or cache so many more seeds may offset the energetic benefit. Red maple seeds are both 21 times smaller than beech seeds and contain a lower lipid content than either beech or hemlock seeds. In addition, pyrolysis revealed that red maple contains a higher percentage of phenols, compounds known to inhibit protein digestion (Cirkovic Velickovic and Stanic-Vucinic 2018). The high absolute energy content of beech seeds, and in particular the high lipid content, is likely the primary driver of rodent preferences for beech.

Although all three rodents preferred beech seeds, secondary selection of hemlock or red maple seeds at low beech availability differed by species. *Peromyscus leucopus* showed a significant preference for hemlock seeds over red maple. Its congener *P. maniculatus*, however, did not show a secondary preference for either seed type, taking each in proportion to their relative availabilities. Red maple seeds are 4 times larger than hemlock seeds (Stephens et al. 2019) and despite the lower lipid content per gram contain the same the absolute lipid content per seed. However, the resulting increase in handling time (Boone and Mortelliti 2019) and higher content of phenols may result in red maple being perceived as lower quality than hemlock by foraging rodents and may explain the secondary preference for hemlock seen in *P. leucopus*. Past research has suggested *P. maniculatus* to be more of a seed specialist than *P. leucopus,* with seeds forming the majority of the species diet in both high and low mast years. In contrast, *P. leucopus* broadens its diet to include more non-seed food sources during low mast years (Stephens et al. 2019). These results can provide context to our selection outcomes, as *P.*

maniculatus may forage on hemlock and red maple equally despite differences in quality because seeds make up a larger component of its diet.

In contrast to either *Peromyscus* species*, M. gapperi* shows a secondary preference for red maple seeds. Vole gut anatomy may play a role in shaping these preferences. Compared to murine rodents such as *Peromyscus*, arvicoline rodents such as *M. gapperi* have an elongated cecum, possibly as an adaptation to a primarily herbivorous diet as the emergence of this group coincided with expanding grasslands (Butet and Delettre 2011). Cecal activity has been shown to affect bioavailability and breakdown of phenols in mice (Ye and Hendrich 2009). Although this effect remains unclear in other rodent and lagomorph species (Atsatt and Ingram 1983, Iason and Palo 1991), a larger cecum may allow voles to digest adequate protein from red maple seeds despite the high phenol content, and possibly even assist in breaking down the phenols at a faster rate.

The divergence in secondary preference among rodent species may facilitate co-occurrence during low beech years. Our results indicate that seed preferences are driven by both seed quality and availability, with all three species showing overlap in preference for the highest quality seed type (beech) when it is available but divergence in preference when beech availability was low. *Myodes gapperi*, showing particularly strong divergence from *Peromyscus*, possess anatomical and physiological advantages for the consumption of red maple. This, combined with the high percent of fungi in its diet (Stephens and Rowe 2020) would facilitate coexistence with both species of *Peromyscus* in low beech years.

The strength of the primary and secondary seed selections varied with environmental conditions, the effects of which were not consistent across rodent species. We chose this particular suite of environmental variables because they are thought to play a role in predator

avoidance behaviors which may impact seed selection or foraging time. Of the five variables, two (tree basal area and luminosity) did not have a strong effect on selection. While tree basal area has been found to impact rodent activity in general (M'Closkey and Fieldwick 1975), it does not appear to impact seed removal (Frock and Turner 2018) or selection in forested systems. However, basal area may impact seed selection as it decreases across a gradient from forested areas to fields (Myster and Pickett 1993). Increased moon luminosity is often thought to increase predation risk and decrease rodent activity levels as brighter conditions may facilitate hunting. However, recent evidence suggests the effects vary by system and species, with significantly less prominent effects in closed habitat (such as forests) and on rodents with good visual acuity (Prugh and Golden 2014). Additionally, where moonlight has been found to reduce overall activity levels, its impact on seed selection is contingent upon microhabitat (Perea et al. 2011).

The remaining three environmental factors (rain, stem density, and Julian date) showed strong effects on secondary seed selection, but only when beech availability was low. Under rainy conditions, both *P. leucopus* and *M. gapperi* were more likely to choose beech than under dry conditions. Daily rodent activity has been shown to increase under rainy conditions in some systems, and has been attributed to a decrease in avian predator activity and the need to escape flooded burrows (Maestri and Marinho 2014). Our results suggest rodents may be taking advantage of rain cover, when avian predator activity is low, to remove the larger, higher quality beech seeds which may require more time and energy to move. In contrast, under drier conditions with increased predator activity, both *M. gapperi* and *P. leucopus* may be more inclined to remove the smaller hemlock and red maple seeds due to lesser time and energy costs to handle.

Increased stem density may also provide greater cover from predators (Perea et al. 2011, Sivy et al. 2011). As stem density increased, both *P. maniculatus* and *M. gapperi* displayed a slightly increased likelihood of choosing red maple and decreased likelihood of choosing hemlock when beech availability was low. While red maple contains less energy per gram than hemlock, at four times the size of hemlock seeds they contain more overall available energy. As size correlates to handling time (Boone and Mortelliti 2019) and shrub cover generally provides protection from predators (Perea et al. 2011, Sivy et al. 2011), these results suggest that both species view red maple seeds as individually of higher quality than hemlock seeds, given that they are more likely to forage on the smaller and more easily handled hemlock only when at greater risk of predation. Neither species displays this trend for beech selection however, despite beech being the largest seed and presumably requiring the most handling time. Although largest in size, beech seeds required the shortest foraging time (i.e. time spent on tray foraging for seeds) of the three seed types for all three rodent species (Table 1) because rodents were not removing the seed from the shell on tray but instead taking them whole, likely caching them for removal at a later time in a safer place.

Later in the season, and when beech availability was low, both *P. maniculatus* and *M. gapperi* were less likely to choose beech and more likely to choose red maple. This trend was particularly strong for *M. gapperi*. By the end of the season, *M. gapperi* showed a preference for red maple over beech, the only time any species preferred any seed type other than beech. This pattern may be a result of the natural availability of seed on the forest floor. Red maple started to fruit just prior to initiating our experiment and continued through mid-June, resulting in an abundance of naturally available red maple seeds independent of what was offered on tray. With such an abundance, *P. maniculatus* and *M. gapperi* would likely prefer to take the scarcer beech.

As the naturally available red maple seeds were consumed or cached through June and July, they were reduced in number as the season progressed which may have increased the apparent preference for this seed type on tray.

Foraging Time

Beech was not only the primary seed selected by rodents in our study, but its availability was the primary factor influencing foraging time. For each rodent species, time on tray increased as beech availability decreased. This provides further evidence that beech is perceived as a high-quality food source. Animals are likely spending more time searching for beech, rather than removing one of the other more abundant seed types, despite the increase in predation risk.

In addition to beech availability, rain and luminosity impacted time spent foraging on tray. Both *Peromyscus* species spent less time foraging in the rain. This may simply be thermoregulatory behavior, spending less time exposed on tray in the rain to stay warmer and drier. For *P. leucopus*, this behavior may also be a product of selection and foraging time patterns, as beech is more likely to be chosen in the rain and has the shortest foraging time of the three seed types, thus incidentally reducing time spent on tray in the rain for this species. Foraging times for *P. maniculatus* and *M. gapperi* are affected by luminosity with both species spending less time on tray under more luminous conditions. These results agree with many other studies which indicate small mammals tend to curtail activity during brighter nights (Wolfe and Tan Summerlin 1989, Fanson 2010, Prugh and Golden 2014) and spend more time foraging under a new moon (Orrock et al. 2004), likely as a method of predator avoidance.

Conclusions

Overall, our results suggest that seed selection is driven by several factors, the most important of which are seed quality and availability. Beech seeds are of overwhelmingly higher quality in terms of energy and lipid content per seed than either red maple or hemlock seeds and are the preferred choice for all three rodent species even when at low availability. Secondary seed selections varied by rodent species, which would alleviate interspecific competition in years of low beech availability and facilitate co-occurrence. In fact, dietary niche plasticity has been described in this system for *Peromyscus* species, with species' diets overlapping and narrowly focused on beech after mast years and expanding and differentiating after non-mast years (Stephens et al. 2019). Beech availability was also the primary driver of foraging time, with animals risking predation to spend more time on tray searching for beech when availability was low. When environmental variables impacted selection and time on tray, animals showed behaviors consistent with predator avoidance. Our results indicate plasticity in rodent granivore seed preferences that allows animals to adjust their dietary niche to accommodate food availability and avoid competitive exclusion. Seed availability is not uniform over time and space, resulting in shifting rodent granivore foraging habits and an increase in heterogeneity in the rodent community. These shifting habits can impact forest succession, regeneration, and tree dispersal (Goheen and Swihart 2003, Vander Wall 2007, Lobo and Millar 2011). Thus, understanding these relationships and their consequences is vital to describing and predicting plant community succession and assembly on a rapidly changing planet.

Table 1: Mass, nutritional content, energy content, and mean foraging time by species for each seed type. Seed mass was acquired from Stephens et al. (2019). Nutritional and energy content for red maple and hemlock was acquired from Boone and Mortelliti (2019). Nutritional and energy content for beech was acquired from analysis performed by Dairy One (Ithaca, NY). Foraging times calculated from the mean of 100 randomly selected foraging events in each category.

Seed Type	Mass (g)	Nutritional content (%)			Calories		Foraging time (seconds)		
		Protein	Carbohydrates	Lipids	Kcal/g	Kcal/seed	*P. leucopus*	*P. maniculatus*	*M. gapperi*
Beech	175.3 ± 37.2	22.2	21.4	49.5	6.20	1.09	9.6	7.7	9.8
Red Maple	8.5 ± 1.9	36.6	36.7	14.5	4.21	0.04	35.2	35.1	50.9
Hemlock	2.2 ± 0.5	27.1	10.4	55.3	6.48	0.01	37.9	38.6	34.0

Table 2: Impact factors by variable for all three rodent species. Impact factors are the sum of the weights for each model containing the particular variable in the model set. Values in bold (> 0.80) are considered strong support.

Species	Julian date	Luminosity	Stem density	Basal area	Rain
P. leucopus	0.36	0.27	0.34	0.47	**0.89**
P. maniculatus	**1.00**	0.43	**0.99**	0.49	0.61
M. gapperi	**1.00**	0.23	**0.82**	0.56	**0.97**

Table 3: Coefficients from the "best" mixed effects models for predicting time spent on tray. Standard errors are provided in parentheses. Predictor variables that did not appear in any best model are not shown (tree basal area, stem density, Julian date, hemlock availability, red maple availability). Best models were found using a backward stepwise regression.

Species	Intercept	Beech availability	Luminosity	Rain
P. leucopus	18.034 (1.137)	-4.702 (0.372)		-3.077 (1.731)
P. maniculatus	18.915 (1.039)	-4.866 (0.511)	-3.454 (0.702)	-5.430 (2.392)
M. gapperi	13.937 (1.440)	-4.412 (0.745)	-3.269 (1.745)	
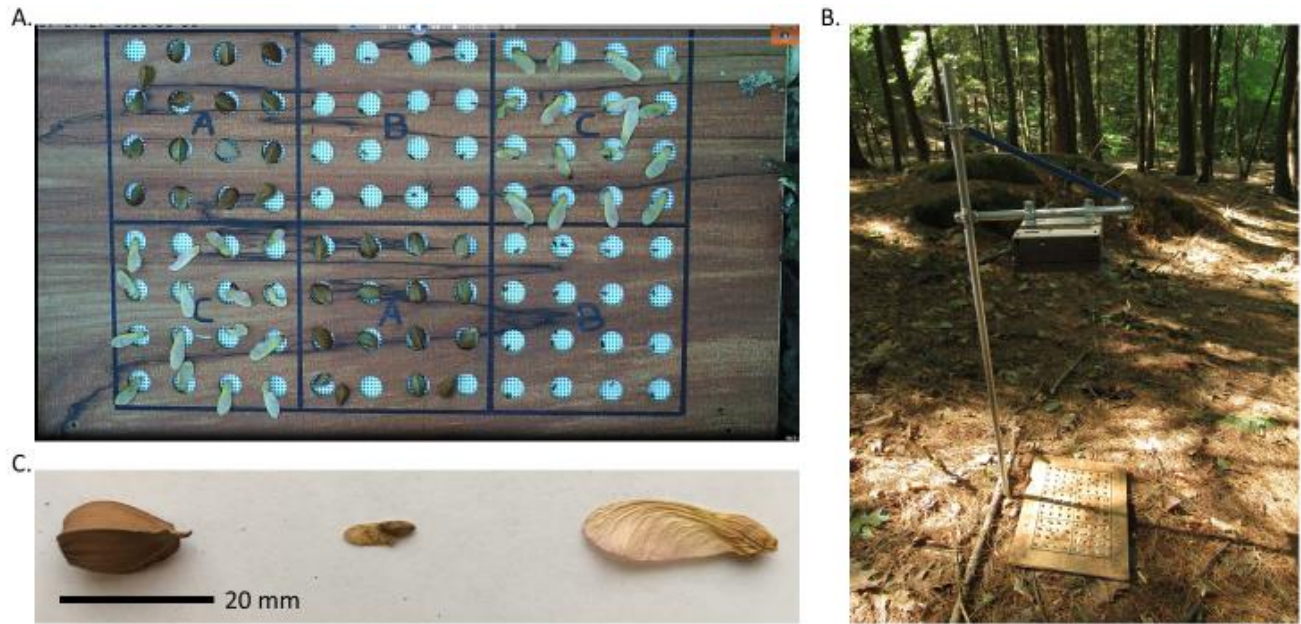
Figure 1: A) Seed tray with all seeds available. Trays were constructed from 30x40x0.5cm plywood boards and backed with mesh plastic canvas. 96 wells were drilled and arranged into a 2x3 matrix of 6 blocks of 16 wells each. Blocks were labelled with an A, B, or C and each letter randomly assigned a seed type. B) A camera was placed directly over the tray angled straight down, held by a steel conduit pole and support brace, and set to record 60 second videos upon being triggered by movement. C) Only beech seeds with unbroken shells and red maple seeds with intact wings were used. Hemlock wings were delicate and often detached.
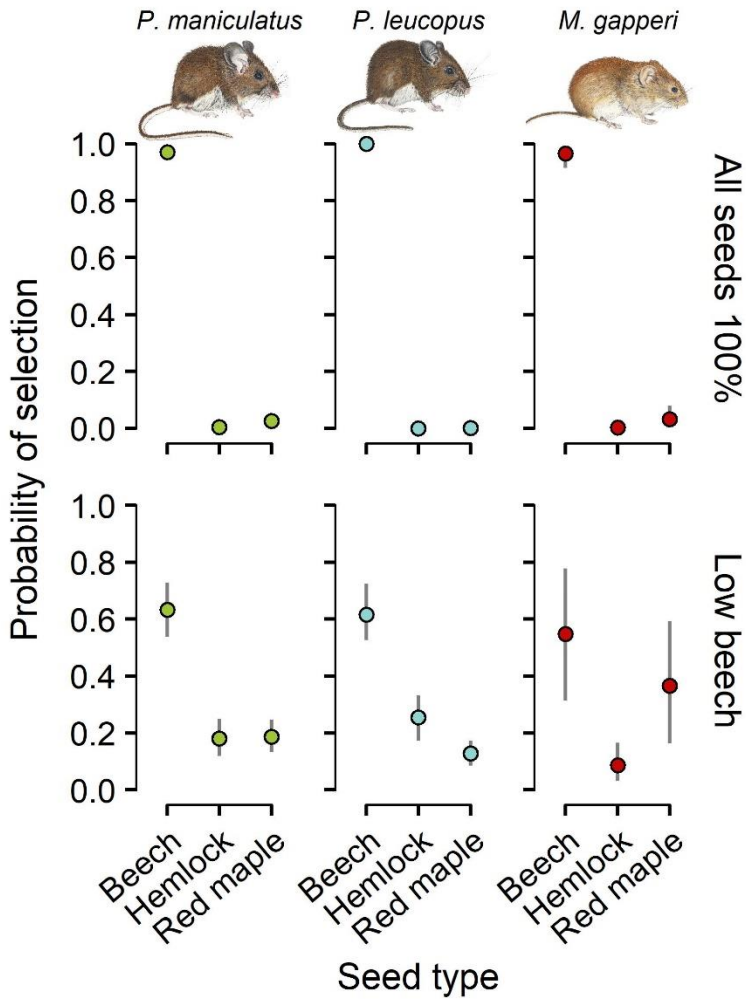
Figure 2: Probabilities of selection of each seed type when all seeds are fully available (top) and with only a single beech seed available (bottom). Selection for each species was assessed by comparing WAIC scores of 32 mixed effects multinomial logistic models containing seed availabilities and five environmental variables (Julian date, precipitation (presence/absence), luminosity, tree basal area, and stem density). The model with the lowest WAIC score was used to determine selection probabilities with 89% confidence intervals.
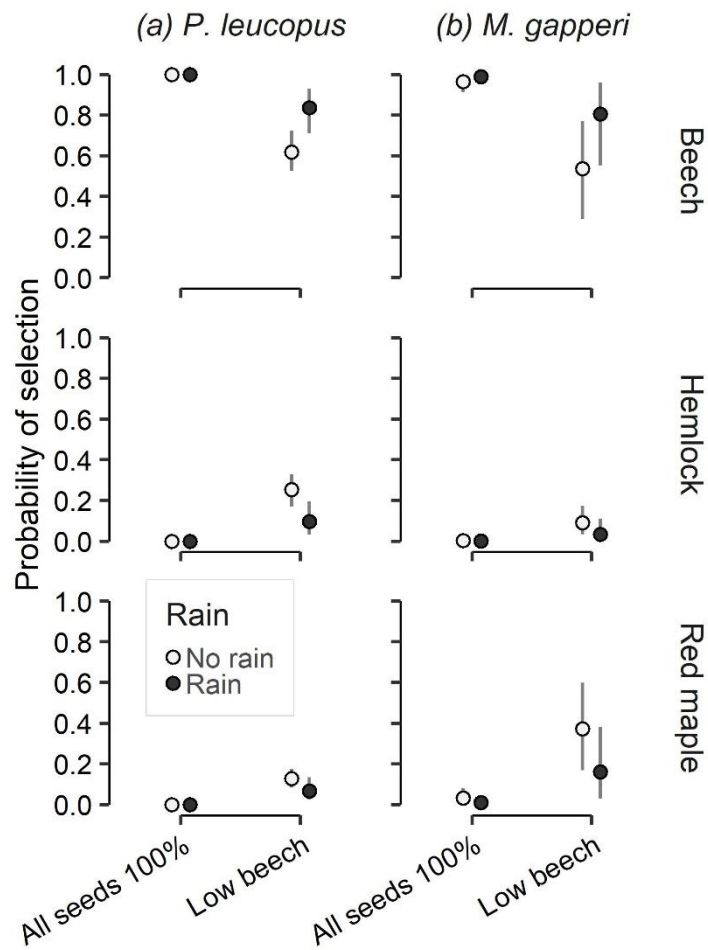
Figure 3: Effects of rain on selection probabilities when all seeds are fully available and with only a single beech seed available for (a) *P. leucopus* and (b) *M. gapperi*. Influence of environmental variables on selection probabilities for each species was determined using a mixed effects multinomial logistic model containing only those variables with a strong impact factor using 89% confidence intervals.
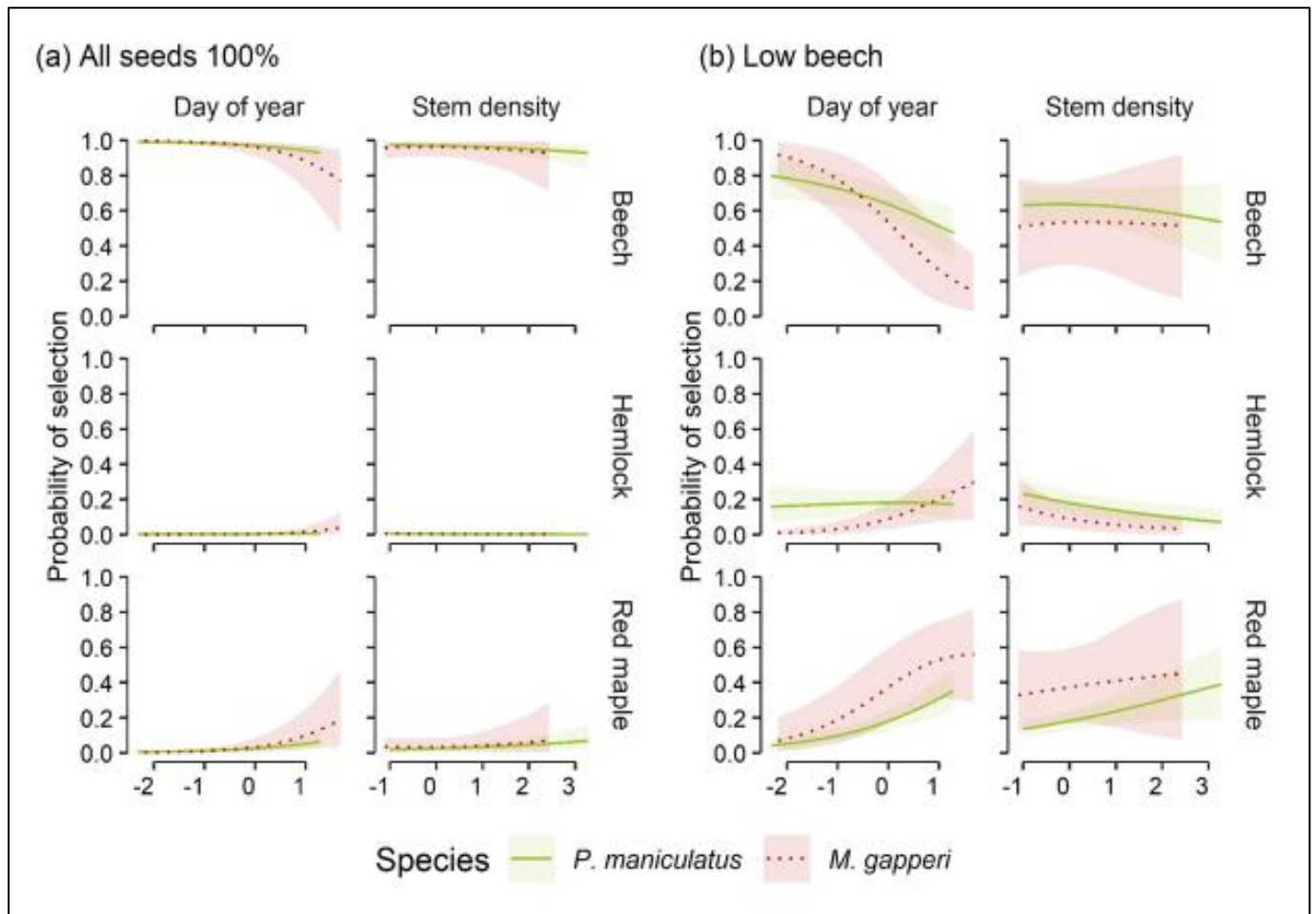
Figure 4: Effects of day of year (Julian date) and stem density on selection probabilities when all seeds are fully available (A) and with only a single beech seed available (B) for *M. gapperi* and *P. maniculatus*. Variable ranges have been standardized. Solid and dotted lines represent means for each species and the shaded areas represent 89% confidence intervals. Influence of environmental variables on selection probabilities for each species was determined using a mixed effects multinomial logistic model containing only those variables with a strong impact factor.

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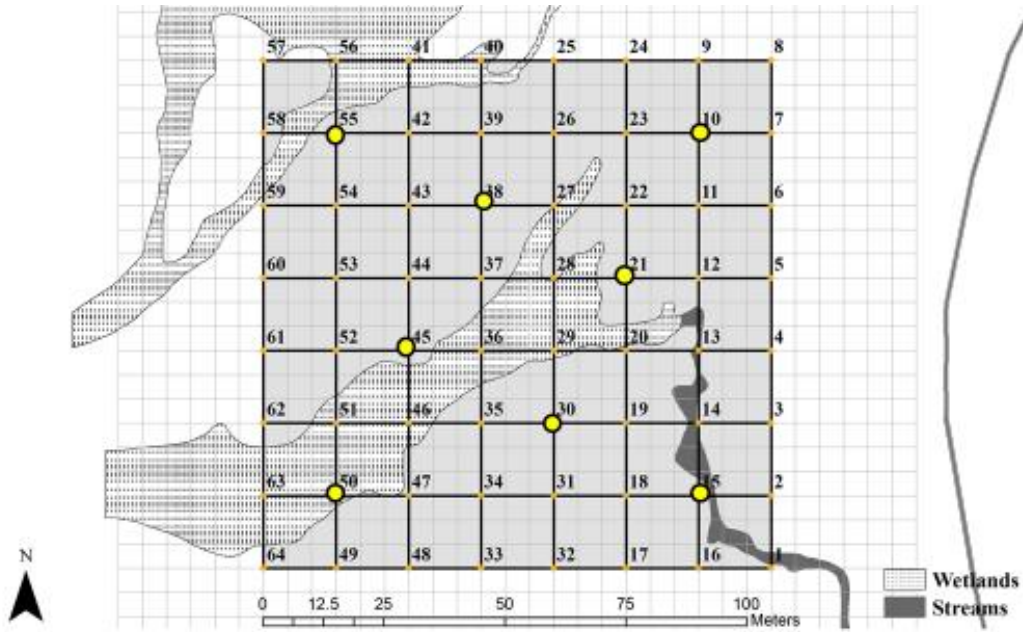
Figure S1: Map of a typical trapping grid. Trapping stations (n=64) are shown as small yellow dots and arranged in an 8x8 grid spaced 15m apart. Camera stations (n=8) are shown as large yellow circles and were placed at trapping stations chosen to provide for maximum coverage of the grid.

Number of videos by species. Large mammals and non-mammals are grouped by higher taxonomic order.
Added total is higher than listed total number of videos due to appearances of multiple species in single videos.

Video subject	# Videos
Blarina brevicauda	117
Erethizon dorsatum	1
Glaucomys volans	1458
Microtus pennsylvanicus	15
Myodes gapperi	740
Napaeozapus insignis	65
Peromyscus spp	2767
Peromyscus leucopus	2236
Peromyscus maniculatus	1669
Sorex cinereus	1
Sorex spp	1
Tamias striatus	506
Tamiasciurus hudsonicus	697
Aves	4
Carnivora	104
Invertebrates	15
Unknown	240
Camera/tray set up	1303
No animal detected	2688
Total videos	13775

APPENDIX B

Results of pyrolysis of seed samples consisting of compound name, type, source, and percentage composition of each sample. Letters of sample names correspond to seed types (B: beech, H: hemlock, R: red maple) and numbers of sample names correspond to grid from which seeds were collected for that sample.

Compound	Type	Source	B10	B11	B3	H12	H3	H6	R4	R5	R6
Benzene, butyl-	Aromatic	Aromatic	1.60%	1.13%	1.17%	1.91%	1.55%	1.71%	0.43%	0.60%	0.60%
Benzene, hexyl-	Aromatic	Aromatic	1.22%	1.30%	0.97%	1.48%	1.98%	1.27%	0.27%	0.39%	0.34%
Benzene, propyl-	Aromatic	Aromatic	0.55%	0.71%	0.42%	1.17%	1.50%	1.19%	0.42%	0.50%	0.50%
Benzene, 1,2,3-trimethyl-	Aromatic	Aromatic	0.49%	0.23%	0.39%	0.57%	0.48%	0.14%	0.12%	0.14%	0.06%
Benzene, (1,3-dimethylbutyl)-	Aromatic	Aromatic	0.36%	0.35%	0.32%	0.27%	0.40%	0.27%	0.06%	0.00%	0.05%
Phenol, 3,4-dimethyl-	Aromatic	Aromatic	0.21%	0.47%	0.52%	0.00%	0.82%	0.00%	0.69%	0.63%	0.65%
Benzene, 1,2,3,4-tetramethyl-	Aromatic	Aromatic	0.15%	0.86%	0.13%	0.52%	0.33%	0.27%	0.00%	0.00%	0.00%
Naphthalene	Aromatic	Aromatic	0.07%	0.12%	0.10%	0.16%	0.22%	0.15%	0.07%	0.09%	0.00%
Benzene, 1,2-diethyl-	Aromatic	Aromatic	0.07%	0.00%	0.04%	0.17%	0.07%	0.06%	0.11%	0.12%	0.00%
m-xylene	Aromatic	Aromatic	0.07%	0.43%	0.34%	0.63%	0.31%	0.80%	0.45%	0.30%	0.23%
Naphthalene, 1,2-dihydro-4-methyl-	Aromatic	Aromatic	0.06%	0.06%	0.09%	0.10%	0.12%	0.08%	0.00%	0.00%	0.04%
Benzene, (1-methylethyl)-	Aromatic	Aromatic	0.02%	0.04%	0.02%	0.04%	0.00%	0.08%	0.05%	0.06%	0.08%
Oxirane, ethenyl-	Aromatic	Aromatic	0.01%	0.00%	0.00%	0.06%	0.00%	0.15%	0.07%	0.13%	0.00%
Acetophenone	Aromatic	Aromatic	0.01%	0.00%	0.00%	0.01%	0.00%	0.04%	0.00%	0.00%	0.00%
Benzene, 2-propenyl-	Aromatic	Aromatic	0.00%	0.52%	0.31%	0.65%	0.35%	0.60%	0.13%	0.15%	0.21%
Benzaldehyde	Aromatic	Aromatic	0.00%	0.25%	0.00%	0.00%	0.33%	0.20%	0.00%	0.00%	0.00%
Phenol, 2,4-bis(1,1-dimethylethyl)-	Aromatic	Aromatic	0.00%	0.04%	0.00%	0.00%	0.00%	0.20%	0.66%	0.11%	0.19%
Benzene, 1-ethenyl-3-methyl-	Aromatic	Aromatic	0.00%	0.03%	0.04%	0.06%	0.00%	0.09%	0.12%	0.12%	0.11%
Biphenyl	Aromatic	Aromatic	0.00%	0.03%	0.00%	0.02%	0.00%	0.04%	0.04%	0.07%	0.06%
2H-1-Benzopyran-2-one	Aromatic	Aromatic	0.00%	0.00%	0.00%	0.02%	0.00%	0.00%	0.00%	0.01%	0.00%
Benzofuran	Aromatic	Aromatic	0.00%	0.00%	0.00%	0.00%	0.43%	0.00%	0.07%	0.00%	0.00%
Benzene	Aromatic	Aromatic	0.00%	0.00%	0.00%	0.00%	0.21%	0.00%	0.00%	0.00%	0.00%
Fluorene	Aromatic	Aromatic	0.00%	0.00%	0.00%	0.00%	0.06%	0.00%	0.04%	0.00%	0.00%
Ethylphenol	Aromatic	Lignin	0.17%	0.18%	0.00%	0.14%	0.20%	0.21%	0.11%	0.43%	0.09%
Phenol, 2-methoxy-(Guaiacol)	Aromatic	Lignin	0.11%	0.24%	0.12%	1.07%	0.54%	0.80%	0.34%	0.27%	0.26%
Phenol, 2,6-dimethoxy-(Syringol)	Aromatic	Lignin	0.06%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Phenol, 2-methoxy-4-methyl- (4-Methylguaiacol)	Aromatic	Lignin	0.00%	0.01%	0.00%	0.05%	0.04%	0.11%	0.08%	0.04%	0.08%
Phenol, 4-ethyl-2-methoxy-(Ethylguaiacol)	Aromatic	Lignin	0.00%	0.00%	0.00%	0.29%	0.00%	0.34%	0.12%	0.00%	0.08%
Phenol, 2-methoxy-4-(1-propenyl)- (4-Isoeugenol)	Aromatic	Lignin	0.00%	0.00%	0.00%	0.07%	0.00%	0.70%	0.00%	0.00%	0.00%
Ethanone, 1-(4-hydroxy-3-methoxyphenyl)-(Acetovanillone)	Aromatic	Lignin	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%	0.00%	0.00%	0.00%

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Name	Type	Category									
2-Propanone, 1-(4-hydroxy-3-methoxyphenyl)-(Guaiacylacetone)	Aromatic	Lignin	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
Ethanone, 1-(3,4-dimethoxyphenyl)-	Aromatic	Lignin+T MAH	0.56%	0.47%	0.51%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Benzene, 1-methoxy-4-methyl-	Aromatic	Lignin+T MAH	0.00%	0.00%	0.09%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Benzene, 1-ethenyl-4-methoxy-	Aromatic	Lignin+T MAH	0.00%	0.00%	0.00%	0.09%	0.00%	0.06%	0.00%	0.00%	0.00%
Benzene, 4-ethenyl-1,2-dimethoxy-	Aromatic	Lignin+T MAH	0.00%	0.00%	0.00%	0.06%	0.00%	0.00%	0.00%	0.00%	0.00%
n-Heptane	Aliphatic	Lipid	6.35%	1.19%	2.11%	0.69%	1.84%	0.55%	0.00%	0.10%	0.04%
n-Pentadecane	Aliphatic	Lipid	4.44%	3.20%	3.87%	1.32%	2.08%	0.76%	0.29%	0.37%	0.30%
n-Heptadecane	Aliphatic	Lipid	3.88%	2.01%	3.06%	0.00%	1.59%	0.58%	0.42%	0.00%	0.00%
Dodecene	Aliphatic	Lipid	3.58%	2.12%	1.55%	0.00%	0.00%	1.44%	0.00%	0.00%	0.00%
9,12-Octadecadienoic acid (Z,Z)-, ME ? (C18:2n6c Linoleic acid ME))	FAME	Lipid	3.22%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1,3-Octadiene	Aliphatic	Lipid	2.90%	2.74%	2.64%	6.13%	3.58%	5.14%	0.58%	1.53%	0.94%
7-Tetradecene	Aliphatic	Lipid	2.89%	2.74%	3.52%	1.44%	1.94%	1.51%	0.49%	0.94%	1.35%
Hex-2-yn-4-one, 2-methyl-	Aliphatic	Lipid	2.67%	4.67%	2.64%	1.69%	0.39%	2.42%	1.35%	2.01%	2.13%
3-Decene	Aliphatic	Lipid	2.26%	2.03%	2.10%	0.77%	1.65%	1.21%	0.84%	1.06%	1.63%
n-Octane	Aliphatic	Lipid	2.23%	1.69%	2.27%	0.66%	2.98%	0.69%	0.16%	0.29%	0.00%
n-Nonane	Aliphatic	Lipid	1.33%	1.09%	1.36%	0.60%	0.85%	0.48%	0.11%	0.15%	0.14%
1-Hexene, 3-methyl-	Aliphatic	Lipid	1.28%	1.06%	1.24%	1.33%	0.67%	1.06%	0.10%	0.16%	5.62%
Octadecanoic acid, 2-propenyl ester	FAME	Lipid	0.87%	0.51%	0.87%	1.72%	0.44%	0.00%	0.00%	0.98%	1.21%
n-Undecane	Aliphatic	Lipid	0.87%	0.42%	0.55%	0.10%	0.40%	0.00%	0.00%	0.00%	0.00%
n-Tetradecane	Aliphatic	Lipid	0.86%	0.67%	1.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1-Hexadecene	Aliphatic	Lipid	0.86%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.42%	0.00%
n-Hexadecane	Aliphatic	Lipid	0.74%	0.23%	0.49%	0.00%	0.05%	0.00%	0.00%	0.00%	0.00%
n-Decane	Aliphatic	Lipid	0.62%	0.46%	0.70%	0.20%	0.22%	0.19%	0.11%	0.11%	0.07%
n-Dodecane	Aliphatic	Lipid	0.61%	0.69%	0.62%	0.00%	0.61%	0.00%	0.00%	0.00%	0.00%
1-Heptene	Aliphatic	Lipid	0.30%	5.96%	5.31%	4.76%	4.96%	2.81%	1.58%	2.20%	2.06%
n-Octadecane	Aliphatic	Lipid	0.17%	0.00%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
n-Tricosane (C23)	Aliphatic	Lipid	0.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Hexadecanoic acid, methyl ester (Palmitic acid-C16)	FAME	Lipid	0.02%	0.00%	0.04%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%
1-Pentene, 3-ethyl-2-methyl-	Aliphatic	Lipid	0.00%	3.02%	3.59%	2.97%	5.10%	2.71%	0.73%	1.14%	1.16%
C14_alkene_#3	other	Lipid	0.00%	1.40%	0.90%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
n-Tridecane	Aliphatic	Lipid	0.00%	0.83%	0.95%	0.27%	0.00%	0.00%	0.00%	0.00%	0.00%
1,3-Butadiene	Aliphatic	Lipid	0.00%	0.00%	0.00%	0.09%	0.00%	0.00%	0.06%	0.10%	0.21%
1-Butyne, 3,3-dimethyl-	Aliphatic	Lipid	0.00%	0.00%	0.00%	0.00%	0.66%	0.61%	0.08%	0.10%	0.12%
9-Octadecenoic acid, methyl ester, (E)-	FAME	Lipid	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	27.20%	25.96%	24.40%
1H-Pyrrole, 3-methyl-	Aromatic	N-Bearing	0.64%	0.72%	0.66%	0.28%	0.00%	0.82%	1.71%	1.76%	1.52%
Acetamide, N-hydroxy	Aliphatic	N-	0.42%	0.00%	0.19%	0.00%	0.00%	0.88%	1.12%	0.00%	1.13%

Compound	Type	Category									
Aniline	Aromatic	Bearing N-	0.37%	0.45%	0.08%	0.03%	0.53%	0.00%	0.00%	0.00%	0.00%
Propane, 2-nitro-	Aliphatic	Bearing N-	0.33%	0.44%	0.41%	0.12%	0.30%	0.18%	0.63%	0.51%	0.59%
Hexanedinitrile	Aliphatic	Bearing N-	0.25%	0.39%	0.33%	0.00%	0.26%	0.00%	0.15%	0.13%	0.11%
1H-Pyrrole-2-carboxaldehyde, 1-methyl-	Aromatic	Bearing N-	0.05%	0.01%	0.00%	0.00%	0.07%	0.00%	0.11%	0.09%	0.14%
1H-Pyrrole-2-carboxaldehyde	Aromatic	Bearing N-	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.27%	0.00%
2-Pyridinecarbonitrile	Aromatic	Bearing N-	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
5-Dimethylaminopyrimidine	Aromatic	Bearing N-	0.02%	0.00%	0.09%	0.00%	0.00%	0.05%	0.00%	0.00%	0.00%
3-Pyridinol	Aromatic	Bearing N-	0.00%	0.62%	0.88%	0.16%	0.00%	0.00%	1.35%	1.04%	0.44%
Pyrazolo[5,1-c][1,2,4]benzotriazin-8-ol	Aromatic	Bearing N-	0.00%	0.44%	0.00%	0.12%	0.00%	0.18%	0.75%	0.56%	0.69%
2-Amino-4-methylpyrimidine	Aromatic	Bearing N-	0.00%	0.29%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2,5-Furandione, 3-methyl-	Aromatic	Bearing N-	0.00%	0.19%	0.00%	0.25%	0.23%	0.35%	0.00%	0.00%	0.00%
Pyridine 3-methyl	Aromatic	Bearing N-	0.00%	0.13%	0.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
3-Phenylpyridine	Aromatic	Bearing N-	0.00%	0.06%	0.12%	0.00%	0.00%	0.00%	0.16%	0.00%	0.12%
5H-1-Pyrindine	Aromatic	Bearing N-	0.00%	0.05%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%
4-Pyridinecarboxaldehyde	Aromatic	Bearing N-	0.00%	0.03%	0.14%	0.00%	0.07%	0.00%	0.20%	0.19%	0.17%
1H-Tetrazole, 1-methyl-	Aromatic	Bearing N-	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.04%	0.05%	0.05%
Alpha-amino-gamma-butyrolactone	Aromatic	Bearing N-	0.00%	0.02%	0.02%	0.00%	0.00%	0.00%	0.00%	0.05%	0.06%
Ethanone, 1-(1-methyl-1H-pyrrol-2-yl)-	Aromatic	Bearing N-	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%
Piperidine-2,5-dione	Aromatic	Bearing N-	0.00%	0.00%	0.09%	0.00%	0.00%	0.00%	0.06%	0.06%	0.09%
4-Amino-2(1H)-pyridinone	Aromatic	Bearing N-	0.00%	0.00%	0.07%	0.00%	0.00%	0.00%	0.45%	0.00%	0.00%
2-Pyrimidinamine	Aromatic	Bearing N-	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Diethyltoluamide (DEET)	Aromatic	Bearing N-	0.00%	0.00%	0.00%	0.08%	0.00%	0.18%	0.07%	0.20%	0.26%
N-Butyl-tert-butylamine	Aliphatic	Bearing N-	0.00%	0.00%	0.00%	0.02%	0.00%	0.00%	0.25%	0.00%	0.00%
Pyridine, 2-ethyl	Aliphatic	Bearing N-	0.00%	0.00%	0.00%	0.00%	0.16%	0.14%	0.07%	0.08%	0.16%
p-Aminotoluene	Aromatic	N-	0.00%	0.00%	0.00%	0.00%	0.03%	0.00%	0.03%	0.02%	0.02%

Compound	Type	Category									
		Bearing									
Pyrrolo[1,2-a]pyrazine-1,4-dione, hexahydro-3-(2-methylpropyl)-	Aromatic	Bearing N-	0.00%	0.00%	0.00%	0.00%	0.00%	0.95%	0.06%	0.00%	0.00%
4(1H)-Pyridinone, 2,3-dihydro-1-methyl-	Aromatic	Bearing N-	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.04%	0.00%
Pyrrolidine, 1-nitroso	Aromatic	Bearing N-	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.31%	0.09%	0.11%
Pentylenetetrazol	Aromatic	Bearing N-	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.22%	0.03%	0.00%
Pyrimidine	Aromatic	Bearing N-	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%	0.00%	0.00%
3-Methylpyridazine	Aromatic	Bearing N-	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%	0.00%	0.00%
Maleic hydrazide	Aromatic	Bearing N-	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%	0.00%	0.00%
1,4-Benzenediamine	Aromatic	Bearing N-	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.07%	0.09%
Cyanamide, dimethyl-	Aliphatic	Bearing N-	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Phenol, 4-methyl-	Aromatic	Phenol	2.06%	2.20%	2.59%	2.72%	4.03%	3.27%	6.74%	5.86%	5.55%
Phenol	Aromatic	Phenol	0.09%	3.28%	2.40%	1.24%	1.88%	1.73%	6.33%	5.29%	5.52%
Benzene, 1-ethyl-4-methoxy-	Aromatic	Phenol+T MAH	0.00%	0.00%	0.00%	0.00%	0.04%	0.00%	0.00%	0.00%	0.00%
Cyclopentanone	Aromatic	Polysaccharide	3.41%	0.03%	0.04%	0.00%	0.22%	0.15%	0.06%	0.06%	0.13%
2-Cyclopenten-1-one, 2-methyl-	Aromatic	Polysaccharide	1.02%	0.94%	0.99%	1.24%	1.56%	1.40%	0.16%	0.15%	0.29%
Furan, 2-ethyl-	Aromatic	Polysaccharide	0.67%	0.71%	0.63%	0.75%	0.00%	0.94%	0.03%	0.23%	0.28%
Benzofuran, 2,3-dihydro-	Aromatic	Polysaccharide	0.41%	0.84%	1.01%	1.59%	1.10%	0.76%	1.25%	1.35%	1.25%
2-Cyclopenten-1-one, 2-hydroxy-3-methyl-	Aromatic	Polysaccharide	0.32%	0.27%	0.00%	0.00%	0.44%	0.00%	0.64%	0.00%	0.00%
Furan, 2,5-dimethyl-	Aromatic	Polysaccharide	0.26%	0.37%	0.20%	0.15%	0.39%	0.29%	0.88%	0.83%	0.84%
2-Acetylfuran	Aromatic	Polysaccharide	0.24%	0.00%	0.00%	0.11%	0.12%	0.13%	0.22%	0.19%	0.26%
Furan, 2,4-dimethyl-	Aromatic	Polysaccharide	0.22%	1.00%	0.18%	0.95%	0.00%	0.76%	0.45%	0.57%	0.47%
2-Cyclopenten-1-one, 3-methyl-	Aromatic	Polysaccharide	0.16%	0.12%	0.00%	0.08%	0.00%	0.00%	0.18%	0.27%	0.00%
Furfural, 5-methyl-	Aromatic	Polysaccharide	0.09%	0.13%	0.09%	0.06%	0.19%	0.19%	0.38%	0.39%	0.39%
2(5H)-Furanone	Aromatic	Polysaccharide	0.09%	0.00%	0.00%	0.09%	0.09%	0.27%	0.30%	0.28%	0.27%
Furfural	Aromatic	Polysaccharide	0.07%	0.25%	0.14%	0.10%	0.18%	0.24%	0.30%	0.24%	0.66%
Furan, 2-ethyl-5-methyl-	Aromatic	Polysaccharide	0.05%	0.03%	0.00%	0.01%	0.05%	0.06%	0.07%	0.08%	0.09%

Compound	Type	Origin								
2(5H)-Furanone, 5-methyl-	Aromatic	Polysaccharide	0.04%	0.64%	0.05%	0.21%	0.60%	0.00%	0.09%	0.00%	0.06%
2-Cyclopenten-1-one, 2,3-dimethyl-	Aromatic	Polysaccharide	0.00%	0.14%	0.45%	0.77%	0.51%	0.62%	0.20%	0.19%	0.41%
2(3H)-Furanone, 5-methyl-	Aromatic	Polysaccharide	0.00%	0.13%	0.00%	0.00%	0.00%	0.00%	0.09%	0.00%	0.00%
3-Furaldehyde	Aromatic	Polysaccharide	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.11%	0.11%	0.12%
Acetic anhydride	Aliphatic	Polysaccharide	0.00%	0.00%	0.04%	0.00%	0.00%	0.12%	0.04%	0.00%	0.00%
Benzofuran, 2-methyl-	Aromatic	Polysaccharide	0.00%	0.00%	0.00%	0.05%	0.00%	0.00%	0.00%	0.08%	0.07%
Butanal, 2-methyl-	Aliphatic	Polysaccharide	0.00%	0.00%	0.00%	0.03%	0.00%	0.00%	0.50%	0.53%	0.00%
2H-Pyran-2-one	Aliphatic	Polysaccharide	0.00%	0.00%	0.00%	0.00%	0.07%	0.00%	0.02%	0.09%	0.10%
2-Furanmethanol	Aromatic	Polysaccharide	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.68%	0.65%	0.48%
Levoglucosan	Aromatic	Polysaccharide	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.64%	0.00%	1.07%
Cyclopropanecarboxaldehyde, methylene-	Aromatic	Polysaccharide	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.42%	0.00%	0.00%
4H-Pyran-4-one, 3-hydroxy-2-methyl-	Aromatic	Polysaccharide	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.08%	0.00%	0.24%
Furan, 2,3,5-trimethyl-	Aromatic	Polysaccharide	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%	0.00%	0.00%
Pyrrole	Aromatic	Protein	1.55%	1.40%	1.14%	0.92%	1.54%	1.32%	2.47%	2.22%	1.97%
Pyridine	Aromatic	Protein	1.01%	1.28%	1.03%	2.45%	1.88%	3.41%	0.28%	0.59%	0.56%
Ethylbenzene	Aromatic	Protein	0.98%	1.22%	1.14%	0.90%	1.45%	1.62%	1.31%	1.46%	1.28%
3-Methylindole	Aromatic	Protein	0.95%	1.07%	0.98%	1.73%	1.99%	2.11%	2.97%	2.79%	2.60%
Pyridine	Aromatic	Protein	0.65%	0.71%	0.39%	0.24%	0.32%	0.00%	0.59%	0.00%	0.00%
Benzyl nitrile	Aromatic	Protein	0.58%	0.83%	0.86%	0.29%	0.62%	0.41%	2.86%	1.87%	1.56%
4-Pyridinamine	Aromatic	Protein	0.32%	0.51%	0.39%	0.00%	0.29%	0.52%	0.29%	0.22%	0.16%
Pyridine, 3,5-dimethyl-	Aromatic	Protein	0.14%	0.00%	0.04%	0.00%	0.12%	0.07%	0.00%	0.00%	0.00%
1 H-Pyrrole, 2-ethyl-	Aromatic	Protein	0.13%	0.00%	0.08%	0.00%	0.11%	0.14%	0.00%	0.31%	0.30%
Benzenepropanenitrile	Aromatic	Protein	0.00%	0.42%	0.23%	0.48%	0.54%	0.30%	0.57%	0.65%	0.51%
Benzonitrile	Aromatic	Protein	0.00%	0.06%	0.10%	0.00%	0.00%	0.11%	0.00%	0.21%	0.08%
Styrene	Aromatic	Protein	0.00%	0.00%	2.05%	2.47%	0.20%	2.71%	2.17%	2.42%	2.24%
1H-Pyrrole, 1-methyl-	Aromatic	Protein	0.00%	0.00%	0.06%	0.00%	0.00%	0.00%	0.02%	0.25%	0.13%
1H-Pyrrole, 2-methyl-	Aromatic	Protein	0.00%	0.00%	0.00%	0.12%	0.00%	0.18%	1.26%	1.21%	1.19%
17à-Methyltestosterone	Aromatic	Unknown Origin	11.21%	7.61%	10.64%	3.04%	2.47%	3.67%	1.31%	2.60%	2.30%
Toluene	Aromatic	Unknown Origin	6.00%	7.61%	7.11%	6.56%	9.22%	7.85%	11.11%	11.19%	9.94%
Benzene, pentyl-	Aromatic	Unknown Origin	4.97%	4.23%	5.01%	23.39%	10.21%	19.95%	0.79%	1.39%	1.42%
5-Heptadecene, 1-bromo-	Aliphatic	Unknown Origin	3.15%	3.16%	3.50%	3.82%	1.07%	2.36%	0.32%	0.42%	0.42%
Squalane	Aliphatic	Unknown Origin	2.52%	2.16%	1.79%	1.22%	1.57%	0.60%	0.27%	0.43%	0.56%

1-Undecanol	Aliphatic	Unknown Origin	2.43%	3.14%	2.77%	1.63%	2.09%	1.74%	0.78%	1.01%	0.98%
1,3,5,7-Cyclooctatetraene	Aromatic	Unknown Origin	1.78%	2.09%	0.00%	0.00%	2.82%	0.00%	0.00%	0.00%	0.00%
Monobenzone	Aromatic	Unknown Origin	0.35%	0.00%	0.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
9-Octadecen-1-ol	Aliphatic	Unknown Origin	0.34%	0.00%	0.41%	0.22%	0.00%	0.00%	0.00%	0.00%	0.00%
D-Limonene	Aromatic	Unknown Origin	0.25%	0.00%	0.05%	0.39%	0.59%	0.58%	0.00%	0.62%	0.91%
Indane	Aromatic	Unknown Origin	0.22%	0.33%	0.46%	0.55%	0.43%	0.43%	0.26%	0.25%	0.24%
C9_H8	other	Unknown Origin	0.16%	0.25%	0.23%	0.31%	0.56%	0.51%	0.00%	0.00%	0.00%
2-Cyclohexen-1-one	Aromatic	Unknown Origin	0.06%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
(E)-1,3-Butadien-1-ol	Aliphatic	Unknown Origin	0.04%	0.00%	0.00%	0.00%	0.25%	0.00%	0.00%	0.00%	0.00%
C8_H16	other	Unknown Origin	0.02%	0.28%	0.00%	3.07%	4.72%	1.76%	0.00%	0.58%	0.00%
Pyruvaldehyde	Aliphatic	Unknown Origin	0.00%	0.23%	0.00%	0.25%	0.00%	0.00%	0.00%	0.00%	0.00%
Methanesulfonic acid, methyl ester	Aliphatic	Unknown Origin	0.00%	0.14%	0.00%	0.02%	0.00%	0.10%	0.17%	0.14%	0.00%
Trimethylphenol	Aromatic	Unknown Origin	0.00%	0.07%	0.00%	0.04%	0.13%	0.09%	0.10%	0.22%	0.09%
(ISTD) Ethyl vanillin	Aromatic	Unknown Origin	0.00%	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Propanoic acid, 2-hydroxy-, methyl ester, (Ò)-	FAME	Unknown Origin	0.00%	0.02%	0.00%	0.00%	0.00%	0.02%	0.04%	0.04%	0.03%
1,3,5-Cycloheptatriene	Aromatic	Unknown Origin	0.00%	0.01%	0.06%	0.00%	0.00%	0.00%	0.24%	0.42%	0.44%
Spiro[2.4]hepta-4,6-diene	Aromatic	Unknown Origin	0.00%	0.00%	0.09%	0.00%	0.11%	0.13%	0.00%	0.06%	0.00%
1,3,5-Cyclooctatriene	Aromatic	Unknown Origin	0.00%	0.00%	0.00%	0.13%	0.17%	0.18%	0.00%	0.00%	0.00%
Beta-Pinene	Aromatic	Unknown Origin	0.00%	0.00%	0.00%	0.11%	0.00%	0.00%	0.00%	0.00%	0.00%
C11_H12	other	Unknown Origin	0.00%	0.00%	0.00%	0.10%	0.07%	0.00%	0.00%	0.00%	0.00%
2-Propenoic acid, ethenyl ester	Aliphatic	Unknown Origin	0.00%	0.00%	0.00%	0.01%	0.04%	0.00%	0.00%	0.00%	0.00%
Hydroquinone	Aromatic	Unknown Origin	0.00%	0.00%	0.00%	0.00%	0.88%	0.10%	0.00%	0.00%	0.00%
Unknown 21.272	other	Unknown Origin	0.00%	0.00%	0.00%	0.00%	0.47%	0.00%	0.00%	0.00%	0.00%
Resorcinol (Dihydroxybenzene)	Aromatic	Unknown Origin	0.00%	0.00%	0.00%	0.00%	0.00%	0.42%	1.27%	0.36%	0.20%
2-Heptanone	Aliphatic	Unknown Origin	0.00%	0.00%	0.00%	0.00%	0.00%	0.24%	0.00%	0.00%	0.00%

1,2-Benzenediol, 3-methoxy-	Aromatic	Unknown Origin	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.70%	0.48%	0.46%
Dimethylbenzofuran	Aromatic	Unknown Origin	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.22%	0.07%	0.07%
Ethanone, 1-(3-hydroxy-4-methoxyphenyl)-	Aromatic	Unknown Origin	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.15%	0.13%	0.00%
Acenaphthylene	Aromatic	Unknown Origin	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.14%	0.66%	0.00%
3-Penten-2-one, (E)-	Aliphatic	Unknown Origin	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.12%	0.11%	0.00%
2-Butanone, 3,3-dimethyl-	Aliphatic	Unknown Origin	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.06%	0.00%
3-Methylthiophene-2-carbonitrile	Aromatic	Unknown Origin	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%	0.00%
Cyclopentane, bromo-	Aromatic	Unknown Origin	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Model list for each rodent species including model name, WAIC score, change in WAIC score from top model, and model weight.

Species	Model	WAIC	SE	dWAIC	dSE	pWAIC	weight
P. leucopus	mfit_idgrid_AVAIL_Rain	1240.35	57.09	0.00	NA	42.72	0.15
P. leucopus	mfit_idgrid_AVAIL_BA_Rain	1240.79	57.42	0.44	4.03	42.74	0.12
P. leucopus	mfit_idgrid_AVAIL_Stems_BA_Rain	1241.20	57.50	0.85	4.03	44.86	0.10
P. leucopus	mfit_idgrid_AVAIL_DOY_Rain	1241.51	57.40	1.16	2.37	45.56	0.08
P. leucopus	mfit_idgrid_AVAIL_DOY_BA_Rain	1241.65	57.79	1.30	5.05	42.64	0.08
P. leucopus	mfit_idgrid_AVAIL_Stems_Rain	1241.66	57.16	1.31	1.21	46.99	0.08
P. leucopus	mfit_idgrid_AVAIL_DOY_Moon_BA_Rain	1242.77	57.94	2.43	5.41	43.09	0.04
P. leucopus	mfit_idgrid_AVAIL_Moon_Rain	1242.83	57.23	2.48	0.78	45.92	0.04
P. leucopus	mfit_idgrid_AVAIL_DOY_Moon_Rain	1242.92	57.64	2.57	2.78	46.79	0.04
P. leucopus	mfit_idgrid_AVAIL_Moon_BA_Rain	1243.44	57.51	3.10	4.07	44.51	0.03
P. leucopus	mfit_idgrid_AVAIL_DOY_Stems_Rain	1243.60	57.52	3.25	2.44	47.30	0.03
P. leucopus	mfit_idgrid_AVAIL_Moon_Stems_Rain	1243.73	57.36	3.39	1.23	48.09	0.03
P. leucopus	mfit_idgrid_AVAIL_DOY_Stems_BA_Rain	1243.79	57.91	3.44	5.08	45.20	0.03
P. leucopus	mfit_idgrid_AVAIL_DOY_Moon_Stems_Rain	1244.73	57.70	4.38	3.03	48.71	0.02
P. leucopus	mfit_idgrid_AVAIL	1244.82	56.89	4.48	4.98	43.90	0.02
P. leucopus	mfit_idgrid_AVAIL_Moon_Stems_BA_Rain	1244.91	57.68	4.56	4.04	46.74	0.02
P. leucopus	mfit_idgrid_AVAIL_DOY	1245.28	57.24	4.93	5.46	44.95	0.01
P. leucopus	mfit_idgrid_AVAIL_BA	1245.31	57.14	4.97	6.34	42.45	0.01
P. leucopus	mfit_idgrid_AVAIL_Stems	1245.52	57.00	5.17	5.05	46.05	0.01
P. leucopus	mfit_idgrid_AVAIL_Moon_BA	1245.74	57.36	5.39	6.21	45.09	0.01
P. leucopus	mfit_idgrid_AVAIL_DOY_Moon_Stems_BA_Rain	1245.78	58.07	5.43	5.32	46.97	0.01
P. leucopus	mfit_idgrid_AVAIL_Stems_BA	1246.58	57.25	6.24	6.33	44.45	0.01
P. leucopus	mfit_idgrid_AVAIL_DOY_BA	1246.69	57.60	6.34	7.03	43.36	0.01
P. leucopus	mfit_idgrid_AVAIL_Moon	1246.76	57.19	6.41	4.76	44.86	0.01
P. leucopus	mfit_idgrid_AVAIL_Moon_Stems	1247.01	57.13	6.67	4.82	46.93	0.01
P. leucopus	mfit_idgrid_AVAIL_Moon_Stems_BA	1247.79	57.47	7.45	6.20	46.88	0.00
P. leucopus	mfit_idgrid_AVAIL_DOY_Moon_BA	1247.90	57.88	7.55	7.32	44.02	0.00
P. leucopus	mfit_idgrid_AVAIL_DOY_Moon	1248.19	57.53	7.84	5.69	45.86	0.00
P. leucopus	mfit_idgrid_AVAIL_DOY_Stems	1248.26	57.45	7.91	5.48	46.68	0.00
P. leucopus	mfit_idgrid_AVAIL_DOY_Moon_Stems_BA	1248.53	57.87	8.18	7.29	46.10	0.00
P. leucopus	mfit_idgrid_AVAIL_DOY_Moon_Stems	1249.32	57.67	8.97	5.82	48.59	0.00
P. leucopus	mfit_idgrid_AVAIL_DOY_Stems_BA	1249.60	57.76	9.25	7.08	46.11	0.00
P. maniculatus	mfit_idgrid_AVAIL_DOY_Stems_Rain	1271.68	49.11	0.00	NA	37.79	0.17
P. maniculatus	mfit_idgrid_AVAIL_DOY_Moon_Stems_Rain	1271.82	48.94	0.14	3.34	39.66	0.16
P. maniculatus	mfit_idgrid_AVAIL_DOY_Stems_BA_Rain	1271.91	49.33	0.23	1.75	40.60	0.15
P. maniculatus	mfit_idgrid_AVAIL_DOY_Stems_BA	1272.15	49.40	0.47	3.05	40.00	0.14
P. maniculatus	mfit_idgrid_AVAIL_DOY_Moon_Stems_BA_Rain	1272.58	49.10	0.90	3.75	42.45	0.11
P. maniculatus	mfit_idgrid_AVAIL_DOY_Stems	1272.69	49.22	1.01	2.41	37.55	0.10
P. maniculatus	mfit_idgrid_AVAIL_DOY_Moon_Stems_BA	1273.16	49.17	1.48	4.17	41.69	0.08
P. maniculatus	mfit_idgrid_AVAIL_DOY_Moon_Stems	1273.69	49.01	2.02	3.79	38.62	0.06
P. maniculatus	mfit_idgrid_AVAIL_DOY_Moon_Rain	1279.04	48.73	7.37	7.25	42.33	0.00
P. maniculatus	mfit_idgrid_AVAIL_DOY_Moon_BA_Rain	1279.79	48.91	8.11	7.46	45.50	0.00
P. maniculatus	mfit_idgrid_AVAIL_DOY_Moon	1281.13	48.79	9.45	7.49	41.47	0.00

P. maniculatus	mfit_idgrid_AVAIL_DOY_Moon_BA	1281.73	48.94	10.05	7.68	44.23	0.00
P. maniculatus	mfit_idgrid_AVAIL_DOY_BA_Rain	1282.59	49.04	10.91	6.30	43.58	0.00
P. maniculatus	mfit_idgrid_AVAIL_DOY_Rain	1282.59	48.90	10.92	6.15	41.25	0.00
P. maniculatus	mfit_idgrid_AVAIL_DOY	1283.08	48.96	11.40	6.64	40.31	0.00
P. maniculatus	mfit_idgrid_AVAIL_DOY_BA	1283.26	49.24	11.58	6.78	43.95	0.00
P. maniculatus	mfit_idgrid_AVAIL_Moon_Stems_Rain	1285.56	49.66	13.88	6.67	38.44	0.00
P. maniculatus	mfit_idgrid_AVAIL_Stems_Rain	1286.81	49.91	15.13	6.53	36.82	0.00
P. maniculatus	mfit_idgrid_AVAIL_Moon_Stems_BA_Rain	1287.54	49.83	15.86	6.73	41.31	0.00
P. maniculatus	mfit_idgrid_AVAIL_Stems_BA_Rain	1288.10	50.17	16.43	6.67	40.20	0.00
P. maniculatus	mfit_idgrid_AVAIL_Moon_Stems	1289.09	49.70	17.41	6.96	37.64	0.00
P. maniculatus	mfit_idgrid_AVAIL_Stems	1289.56	50.13	17.88	7.15	36.37	0.00
P. maniculatus	mfit_idgrid_AVAIL_Moon_Stems_BA	1289.80	49.89	18.12	6.98	40.41	0.00
P. maniculatus	mfit_idgrid_AVAIL_Moon_Rain	1290.22	49.34	18.55	8.25	39.19	0.00
P. maniculatus	mfit_idgrid_AVAIL_Stems_BA	1291.33	50.31	19.66	7.27	38.88	0.00
P. maniculatus	mfit_idgrid_AVAIL_Moon_BA_Rain	1291.49	49.43	19.81	8.32	41.92	0.00
P. maniculatus	mfit_idgrid_AVAIL_Moon	1292.15	49.26	20.48	8.54	37.71	0.00
P. maniculatus	mfit_idgrid_AVAIL_Rain	1292.58	49.64	20.91	7.93	37.26	0.00
P. maniculatus	mfit_idgrid_AVAIL_BA_Rain	1292.80	49.71	21.12	7.92	40.02	0.00
P. maniculatus	mfit_idgrid_AVAIL_Moon_BA	1292.97	49.47	21.29	8.49	40.74	0.00
P. maniculatus	mfit_idgrid_AVAIL	1294.96	49.75	23.29	8.47	36.30	0.00
P. maniculatus	mfit_idgrid_AVAIL_BA	1295.79	49.82	24.11	8.37	39.20	0.00
Myodes gapperi	mfit_idgrid_AVAIL_DOY_Stems_BA_Rain	386.75	32.07	0.00	NA	31.67	0.32
Myodes gapperi	mfit_idgrid_AVAIL_DOY_Stems_Rain	386.94	32.08	0.20	0.80	30.87	0.29
Myodes gapperi	mfit_idgrid_AVAIL_DOY_Moon_Stems_BA_Rain	388.66	32.43	1.92	1.58	33.60	0.12
Myodes gapperi	mfit_idgrid_AVAIL_DOY_BA_Rain	389.60	31.84	2.85	2.59	31.72	0.08
Myodes gapperi	mfit_idgrid_AVAIL_DOY_Moon_Stems_Rain	389.99	32.51	3.25	1.77	33.04	0.06
Myodes gapperi	mfit_idgrid_AVAIL_DOY_Rain	390.19	31.95	3.45	2.73	31.08	0.06
Myodes gapperi	mfit_idgrid_AVAIL_DOY_Moon_BA_Rain	392.17	32.10	5.43	2.83	33.41	0.02
Myodes gapperi	mfit_idgrid_AVAIL_DOY_Moon_Rain	392.93	32.02	6.19	3.07	32.73	0.01
Myodes gapperi	mfit_idgrid_AVAIL_DOY_Stems_BA	394.08	32.32	7.34	2.51	31.89	0.01
Myodes gapperi	mfit_idgrid_AVAIL_DOY_Stems	394.71	32.44	7.96	2.60	31.20	0.01
Myodes gapperi	mfit_idgrid_AVAIL_DOY_Moon_Stems	395.83	32.77	9.09	2.75	33.01	0.00
Myodes gapperi	mfit_idgrid_AVAIL_DOY_Moon_Stems_BA	395.99	32.76	9.24	2.77	34.04	0.00
Myodes gapperi	mfit_idgrid_AVAIL_DOY_Moon_BA	397.48	32.30	10.74	3.61	33.29	0.00
Myodes gapperi	mfit_idgrid_AVAIL_DOY_BA	397.62	32.32	10.88	3.60	32.14	0.00
Myodes gapperi	mfit_idgrid_AVAIL_DOY	397.74	32.05	10.99	3.59	31.16	0.00
Myodes gapperi	mfit_idgrid_AVAIL_DOY_Moon	398.72	32.32	11.97	3.65	32.46	0.00
Myodes gapperi	mfit_idgrid_AVAIL_Moon_Stems_BA_Rain	404.06	30.97	17.31	6.30	33.86	0.00
Myodes gapperi	mfit_idgrid_AVAIL_Moon_Stems_Rain	404.76	31.02	18.01	6.11	33.27	0.00
Myodes gapperi	mfit_idgrid_AVAIL_Moon_Stems_BA	404.90	31.11	18.15	6.06	33.47	0.00
Myodes gapperi	mfit_idgrid_AVAIL_Moon_Stems	405.65	31.10	18.90	6.03	33.07	0.00
Myodes gapperi	mfit_idgrid_AVAIL_Stems_BA_Rain	406.11	30.91	19.36	7.00	32.30	0.00
Myodes gapperi	mfit_idgrid_AVAIL_Moon_BA_Rain	406.42	30.81	19.68	6.89	33.34	0.00
Myodes gapperi	mfit_idgrid_AVAIL_Stems_Rain	406.70	30.85	19.95	6.81	31.58	0.00
Myodes gapperi	mfit_idgrid_AVAIL_Moon_Rain	406.79	30.91	20.04	6.61	32.67	0.00
Myodes gapperi	mfit_idgrid_AVAIL_Moon_BA	407.06	30.96	20.32	6.74	33.13	0.00
Myodes gapperi	mfit_idgrid_AVAIL_Moon	407.25	30.96	20.50	6.58	32.40	0.00
Myodes gapperi	mfit_idgrid_AVAIL_Stems_BA	407.87	30.92	21.13	7.02	31.83	0.00
Myodes gapperi	mfit_idgrid_AVAIL_Rain	408.21	30.61	21.47	7.38	30.69	0.00
Myodes gapperi	mfit_idgrid_AVAIL_BA_Rain	408.37	30.66	21.63	7.53	31.54	0.00

Myodes gapperi	mfit_idgrid_AVAIL_Stems	408.55	31.02	21.80	6.70	31.42	0.00
Myodes gapperi	mfit_idgrid_AVAIL	410.54	30.87	23.79	7.20	30.77	0.00
Myodes gapperi	mfit_idgrid_AVAIL_BA	410.58	30.83	23.84	7.51	31.61	0.00

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04-May-2018

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IACUC *#:* 180401
Project: The Population and Community Ecology of Small Mammals in the White Mountain National Forest
Approval Date: 19-Apr-2018

The Institutional Animal Care and Use Committee (IACUC} reviewed and approved the protocol submitted for this study under pain or distress category D - *Animal use activities that involve accompanying pain or distress to the animals for which appropriate anesthetic, analgesic, tranquilizing drugs or other methods for relieving pain or distress are used.*

Approval is granted for a period of three years from the approval date above. Continued approval throughout the three year period is contingent upon completion of annual reports on the use of animals. At the end of the three year approval period you may submit a new application and request for extension to continue this project. Requests for extension must be filed prior to the expiration of the original approval.

Please Note:
1. All cage, pen, or other animal identification records must include your IACUC # listed above.
2. Use of animals in research and instruction is approved contingent upon participation in the LINH Occupational Health Program for persons handling animals. Participation is mandatory for all principal investigators and their affiliated personnel, employees of the University and students alike. Information about the program, including forms, is available at http://unh.edu/researcho/ccupational-health-program-animal-handler.s

If you have any questions, please contact either Dean Elder at 862-4629 or Julie Simpson at 862-2003.

For the IACUC,

Jessica A. Bolker, Ph.D.
Chair

cc: File