Examining seed removal rates by granivores in varying habitats in the Northern hardwood forest

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Abstract

Granivorous rodents are plentiful in the Northern hardwood forests. They remove their food source from parent trees and disperse it across their habitat by hoarding it in caches. Hoarding behavior both costs the animals energy and benefits them when food is scarce. I hypothesized seed removal rates will be different between forested habitats that are predominately coniferous and those that are predominately deciduous. I employed an observational study at eight sites of four different vegetation quantities on the UNDERC property. I found through my observations in the forest that granivore behavior is different in dissimilar habitats though the difference did not prove to be significant statistically. Granivorous rodents removed peanuts faster in deciduous and mixed plots and slower in sites that were predominately coniferous.

Introduction

Small granivorous (seed eating) mammals have marked affects on plants through their seed predation. Seed dispersal by small granivorous rodents is a crucial phase of plant regeneration (Pijl, 1972; Howe & Smallwood, 1982), by enabling movement of seeds to other habitats and expanding the potential range of the plants. Secondary seed dispersal by scatter hoarders is important for the survival of some large seeded species (represented by my peanuts) (Forget, 1988). Tree richness and forest age strongly affect seed removal and seed burial rates in forest habitats (Forget & Milleron, 1990).

Adverse effect on plants due to seed predation occurs as well. If the seeds are eaten and digested they are not viable and cannot grow (Jones, 1997). Rodent preference is indicated by seed size and nutritional value (Manson *et al.* 1998).

Granivores are hoarders. Hoarding is an evolved technique of food storage based on cost-benefit logic, the individual needs to be able to retrieve an adequate amount of food to pay for the cost of hoarding (Steele *et al*. 2006). The cost of hoarding is the energy spent hiding the food (Moore *et al.* 2007). Seed fate depends on the benefit, or the nutritional value of a seed. Granivores must weigh the benefits of eating the seed immediately or saving it for a time when food is scarce. If they choose to save the food, the granivore is not gaining any energy at that time but must spend energy to hide the food.

The main cost of hoarding is the energy spent to excavate a hole. When hoarding a nut or seed the animals first excavate a shallow pit with their front paws while holding the food in their mouth. They place the seed into the hole and cover it by dragging dirt over the nut and camouflaging the recently disturbed ground with debris (Clarke & Kramer, 1994). Hoarding animals often excavate several separate places before declaring one proper for their food. These animals also pretend to be hoarding food when their competition is watching as a decoy but expending energy in the process (Steele *et al*. 2006). When granivores scatter hoard, they are essentially planting individual seeds across their habitat.

Morris (1962) began using the term “scatter hoarding” to describe the behavior of separating and hiding food into multiple lesser components. Seed dispersal by scatter hoarders can be important for the survival of some large seeded species of plants because larger seeds

are less likely to blow great distances in wind (Forget, 1988). Larder hoarding is similar except more than one piece of food, in this case a peanut, is put in close proximity. However, the energetic loss from pilfering is greater.

Primary seed dispersal is a consequence of gravity, wind and water. Seeds on the ground attract some secondary seed dispersers, or animals that influence the seeds location (Forget, 1993). Scatter hoarding rodents space food caches to maximize cache recovery and minimize loss to pilferers relative to the energetic cost of carrying food items great distances (Moore *et al*. 2007). Larder hoarding rodents do not expend much energy in carrying food, but larder hoarding requires more energy to defend the large cache from of pilferers because the granivore would lose all its nutritional seeds if the cache was found (Vander Wall, 1020).

Forgotten caches increase forest health because they are placed where the seeds can germinate and grow (Hsia & Francl, 2009). Due to burial, seeds are allowed to escape consumption by larger terrestrial mammal seed-eaters; promoting germination and seedling establishment (Sork, 1985; Smythe, 1989; Forget 1990).

An abundance of animals that prey on small granivorous rodents promotes the survival of dispersed seeds, for if rodents are preyed upon after they cache a seed and before they recover it the plant can grow (Janzen, 1970, 1971, 1978; Symthe, 1970; Howe & Smallwood, 1982; Clarke & Clarke, 1984). It is important to consider hoarding with removal rates because of its influence on forest structure.

Small granviores found on the University of Notre Dame Environmental Research Center (UNDERC) property, apply both types of hoarding depending upon the species. For examples, Northern flying squirrel (*Glaucomys sabrinus)* uses mostly larder hoarding (Muul, 1968), Eastern

gray squirrel (*Sciurus carolinensis)* and the red squirrel (*Tamiasciurus hudsonicus)* prefer to scatter hoard (Gurnell *et al. 2004;* Kemp, 1970)*,* Eastern chipmunk (*Tamias striatus)* mostly larder hoards but sometimes scatter hoards (Elliot, 1978)*,* deer mice (*peromyscus maniculatus)* and white footed mice (Peromyscus leucopus) also larder and scatter hoard (Gray, 1979; Elkinton, 1996).

Seed removal by rodents often represents seed predation, but some proportion of removed seeds reflects seed dispersal (Janzen 1969, 1970, 1971 Morris, 1962). Generally, greater seed removal rates occur in communities where the parent plant occurs at low densities (Rankin, 1978). When using removal rates of seeds, it is difficult to determine what species is visiting the seeds and if they are removing them to be cached. Removal rates, however, can be used as an indicator of rodent abundance.

The objective of my study was to examine the removal rates and hoarding by granivores between different habitats. Types include 1) coniferous forests, 2) deciduous forests, 3) mixed coniferous and deciduous forests, and 4) open fields. Previous studies show there are differences in the distribution of various rodent species in different plant communities and forest phases, such as mature forest and reforestations (Hansson, 1978). So, I proposed that removal rates would be slower in areas with conifers, as opposed to areas with deciduous trees, because conifers do not depend on granivorous rodents for seed dispersal.

Materials and Methods

Eight sites were selected on the University of Notre Dame Evironmental Research Center property based on their coniferous and deciduous proportions of trees. For convenience

the eight sample sites were labeled by location (Figure 1). Two sites of every forest category were examined: 1) coniferous forests, 2) deciduous forests, 3) mixed coniferous and deciduous forests, 4) two open field. Each site was equipped with two 60X60 cm foam boards with flagging separated by a 20m transect. At the start of the study 100 unsalted unshelled peanuts were placed on each board. The peanuts were marked with painted 1.9cm wire brads in order to recover them with ease using metal detection. The sites were checked one week after the initial placement and again after three weeks. The peanuts were found using a Fisher 1225-X metal detector. When I found caches I recorded and removed them (see Hsia & Francl, 2009).

Habitat measures

Sites were selected with a GIS map of habitat types of the UNDERC property. However, within the 10x10m plot around each board I determine plant composition for each site (Figure

2). I only recorded trees with a DBH > 5cm and noted whether a tree was coniferous or deciduous; also noting snags and fallen trees with at least 50% of their mass in the plot.

Data was not normal so a Kruskal-Wallis test was run to determine the differences in seed removal between sites. Statistic results were a p-value of 0.0618 assuming chi-squared distribution with 3 degrees of freedom.

Results

I found that there was no difference in seed removal rates in different habitats. (test stat= 7.3369, p-value=0.0618, and df=3; Figure 3) However, Habitats that were predominately coniferous demonstrated a trend of slower removal rates. For statistics I used the number of peanuts remaining on the board as opposed to ones removed so the higher bar on Figure 2 means a slower removal rate, not faster.

Another thing, though I did not run statistical tests about it is whether or not small mammals are more effective seed predator or seed dispersers in my varying habitats. Seed predator being when they immediately eat the bait, dispersers being when they distribute the bait across my study area. Hoarding, or dispersal, only occurred at two types of habitats, mixed and deciduous. Small mammals are more effective seed predators with bait of peanuts. I cannot say the same about any native seed or nut I did not use for my observations.

Discussion

Removal rates could be slower at conifer sites because conifer trees do not depend on rodents for seed dispersal. Conifer seeds are either dispersed by the wind or by birds (Knee, 2009).

Future study could look at fate changes between seasons or years. A broader spectrum of variables (i.e canopy cover, light penetration) should be measured within each habitat type to determine the role of the environment in relation to granivores (Forget, 1992). In addition, we still know little about the interaction between post dispersal seed predation and seed dispersal.

My sites being predated upon by larger mammals was an issue. The board was made of sturdy foam in which teeth and scratch marks are easy to identify. There were two sites with boards broken and teeth marks believed to be a bears, another had scratch marks that looked as if they were raccoons. Around all those boards the peanuts were devoured on and less than one foot away from them. My rates were skewed because those were not my sought after granivorous rodents. Mammals masks secondary seed dispersal by rodents so that should be controlled for (Forget & Milleron, 1991).

Conclusion

Rodents increase chances of less prominent trees being dispersed though an area because seeds of trees that occur at low densities have greater chances of being hoarded (Rankin 1978). For example, that could help morph a forest that is predominately aspen into one with an increased concentration of a maple. Conifer and deciduous plants have their own anatomies therefore different types of seeds. Deciduous seeds are preferred by rodents

because they don't have to break through a stroibus to obtain them. Rodents occur in greater abundance in deciduous forests because predominately coniferous forests do not sustain the rodent's livelihood.

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Works Cited

Chapman CA (1989) Primate seed dispersal: the fate of dispersed seeds. Biotropica 21 : 148-154

Covich AP, 1987. Optimal use of space by neighboring central place foragers: when and where to store surplus resources. In: Advances in behavioral economics, vol 1 (Green L, KagelJH, eds). Norwood, New Jersey: Ablex; 249-294.

Daly M, Wilson M, Behrends PR, Jacobs LF, 1990. Characteristics of kangaroo rats, *Dipodomys merriami,* associated with differential predation. Anim Behav 40:380- 389.

Elkinton, J. (1996). Interactions among gypsy moths white footed mice and acorns. *Ecology*, *77*(8), 2332-2342.

Elliot, Land. (1978). Social behavior and foraging ecology of the eastern chipmunk (tamias striatus) in the adirondack mountaints. *Smithsonian Contributions to Zoology*, *265*, 82-97.

Estrada A, Coates-Estrada R (1986) Frugivory by howling monkeys *(Alouatta palliata)* at Los Tuxtlas, Mexico: dispersal and fates of seeds. In: Estrada A, Fleming TH (eds). Frugivores and seed dispersal, Dr W Junk, Dordrecht, pp 93-104

Forget P-M (1988) Dissemination et rrg~nrration naturelle de huit esp+ces d'arbres en for6t guyanaise. Th~se de Doctorat de l'Universit6 Paris 6

Forget P-M (1991 a) Comparative recruitment patterns of two nonpioneer canopy tree species in French Guiana. Oecologia 85: 434-468

Forget P-M (1990) Sedd dispersal of *Vouacapoua americana* (Caesalpiniaceae) by caviomorph rodents in French Guiana. J Trop Ecol 6: 459-468

Forget, P, & Milleron, T. (1990). Evidence for secondary seed dispersal by rodents in panama.*Oecologia: short communications*, (87), 596-599.

Forget P-M (1990) Sedd dispersal of *Vouacapoua americana* (Caesalpiniaceae) by caviomorph rodents in French Guiana. J Trop Ecol 6: 459-468

Gray, L. (1979). Feeding diversity in deer mice.*Journal of comparative and Physiological Psychology*, *93*(6), 1118-1126.

Gurnell, J, Wauters, L, Lurz, P, & Tosi, G. (2004). Alien species and interspecific conpetition: effects of introduced easter grey squirrels on red squirrel population dynamics. *Journal of Animal Ecology*, (73), 26-35.

Howe HE, Smallwood JA (1982) Ecology of seed dispersal. Ann Rev Ecol Syst 13:201-228

Hurly TA, Robertson RJ, 1990. Variation in the food hoarding behaviour of red squirrels. Behav Ecol Sociobiol 26:91-97.

Hurly TA, Robertson RJ, 1990. Variation in the food hoarding behaviour of red squirrels. Behav Ecol Sociobiol 26:91-97.

Jacobs LF, 1991. Memory for cache locations in Merriam's kangaroo rats. Anim Behav, in press.

Hsia, J, & Francl, K. (2009). Postdispersal sugar maple (*acer sccharum*) seed predation by small mammals in a northern hardwood forest. *The American Midland Naturalist*, *162*(2), 213-222.

Kemp, G, & Keith, Lloyd. (1970). Dynamics and regulation of red squirrel (tamiasciurus hudsonicus) populations. *Ecology*, *51*, 763-779.

Knee, Michael Gymnosperms. Retrieved July 17, 2009, from Horticulture and Crtop Science: Ohio State University Web site: http://www.hcs.ohio-state.edu/hcs300/gymno.htm

Janzen DH (1983) Dispersal of seeds by vertebrate guts. In: Futuyma D J, Slatkin M (eds). Coevolution, Sinauer Associates, Sunderland, pp 232-262

Janzen, D. H. 1969. Seed-eaters versus seed size, number, toxicity and dispersal. Evolution 23: 1-27.

Janzen. 1970. Herbivores and the number of species in tropical forests. Am. Nat. 104: 501-528.

Janzen. 1971. Seed predation by animals. Annu. Rev. Ecol. Syst. 2: 465-492.

Jones, C, Lawton, J, & Shackak, M. (1997). Positive and negative effects of organisms as physical ecosystem engineers. *Ecology*, *78*(7), 1946-1957.

Kramer DL, Nowell W, 1980. Central place foraging in the eastern chipmunk, *Tamias striatus.* Anim Behav 28: 772-778.

Manson, R, & Stiles, E. (1998). Links between microhabitat preferences and seed predation small mammals in old fields. *OIKOS*, *82*, 37-50.

Morris D, 1962. The behaviour of the green acouchi *(Myoprocta pratti)* with special reference to scatter hoarding. Proc Zool Soc Lond 139:701-732.

Muul, I. (1968). Behavioral and physiological influences on the distribution of the flying squirrel, glaucomys volans. *Miscellaneous Publications Museum of Zoology, University of Michigan*, (134), 1-66.

Pijl Van der L (1972) Principles of dispersal in higher plants. 2nd edn, Springer Verlag, New York

Sherry DF, 1985. Food storage by birds and mammals. Adv Study Behav 15:1-68.

Kramer, D, & Clarke, M. (1994). The placement, recovery, and loss of scatter hoards by eastern chipmunks, tamias striatus. *International Society for Behavioral Ecology*, 353-361.

Smith CC, Reichman OJ, 1984. The evolution of food caching by birds and mammals. Annu Rev Ecol Syst 15: 329-351.

Smythe N, Glanz WE, Leigh Jr EG (1982) Population regulation in some terrestrial frugivores. In: Leigh Jr EG, Rand AS, Windsor DM (eds). The ecology of a tropical rain forest, Smithsonian Institution Press, Washington, pp 227-238

Steele, M, Halkin, S, Smallwood, P, Mckenna, T, & Mitsopoulos, K. (2006). Cache protection strategies of a scatter-hoarding rodent: do tree squirrels engage in behavioural deception?.*ScienceDirect*, (75), 705-714

Sork VL (1985) Germination response in a large-seeded neotropical tree species: *Gustavia superba* (Lecythidaceae). Biotropica 17:130-136

Vander Wall, S. B. 1990 *food hoarding in animals.* Chicago, IL: University or Chicago Press.

Vander Wall, S. (2010). How plants manipulate the scatter hoarding behaviour of seed-dispersing animals. *Phil. Trans. R. Soc. B*, (365), 989-997.

Vander Wall SB, 1990. Food hoarding in animals. Chicago: University of Chicago Press.

Appendix

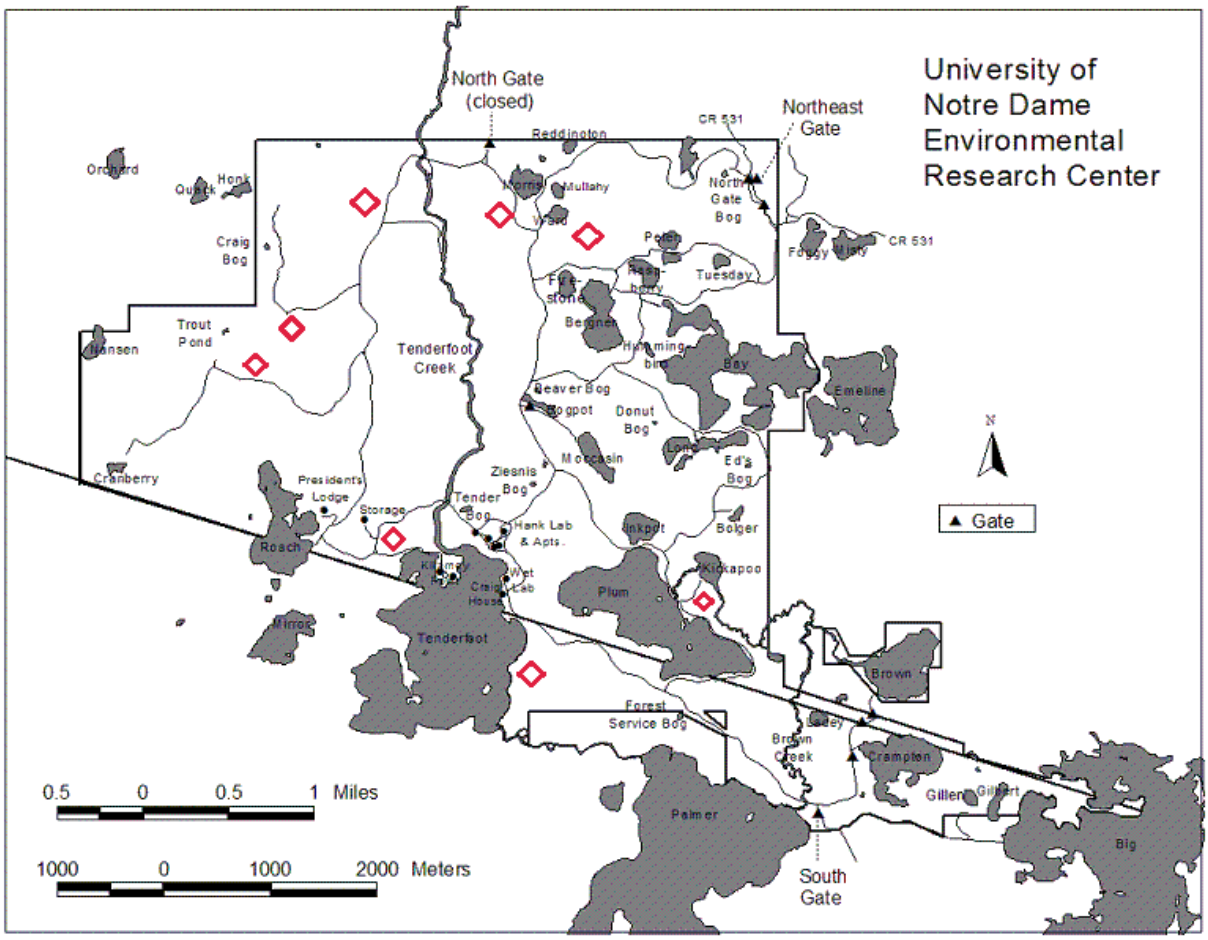

Figure 1: sites studied are indicated by the red diamonds

Table 1: four types of sites with the average number of peanuts remaining on the board after one week and the standard error of each mean.

habitat	mean	s e
CONIFER	26.25	15.53
DECID	0.00	0.00
MIXED	9.25	5.53
OPEN	0.00	0.00

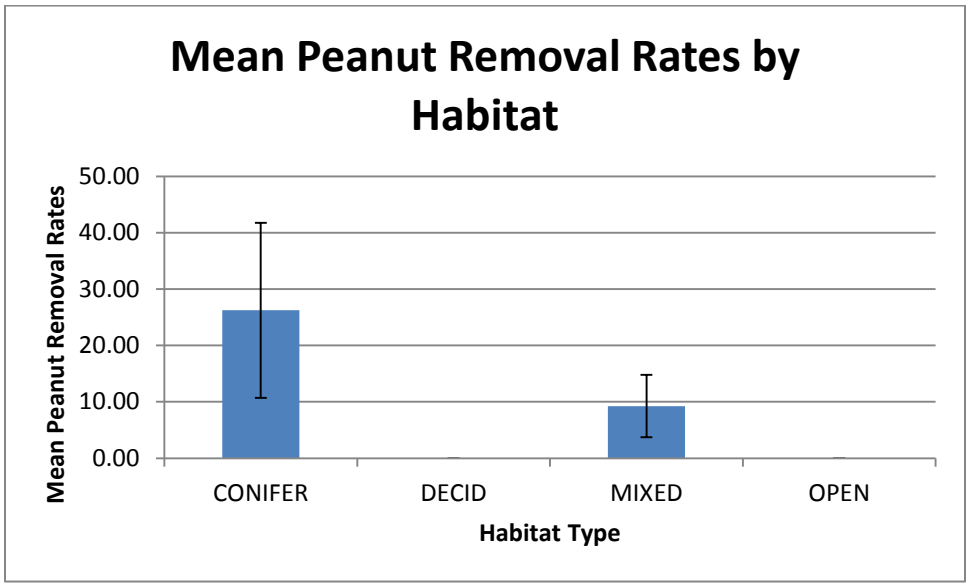

Figure 2: illustrates removal rates recorded. Deciduous and open habitats rates were faster than 14.32857 peanuts per day. Sites including conifer trees had much slower rates therefore, had more peanuts left on the board after 7 days.

Figure 3

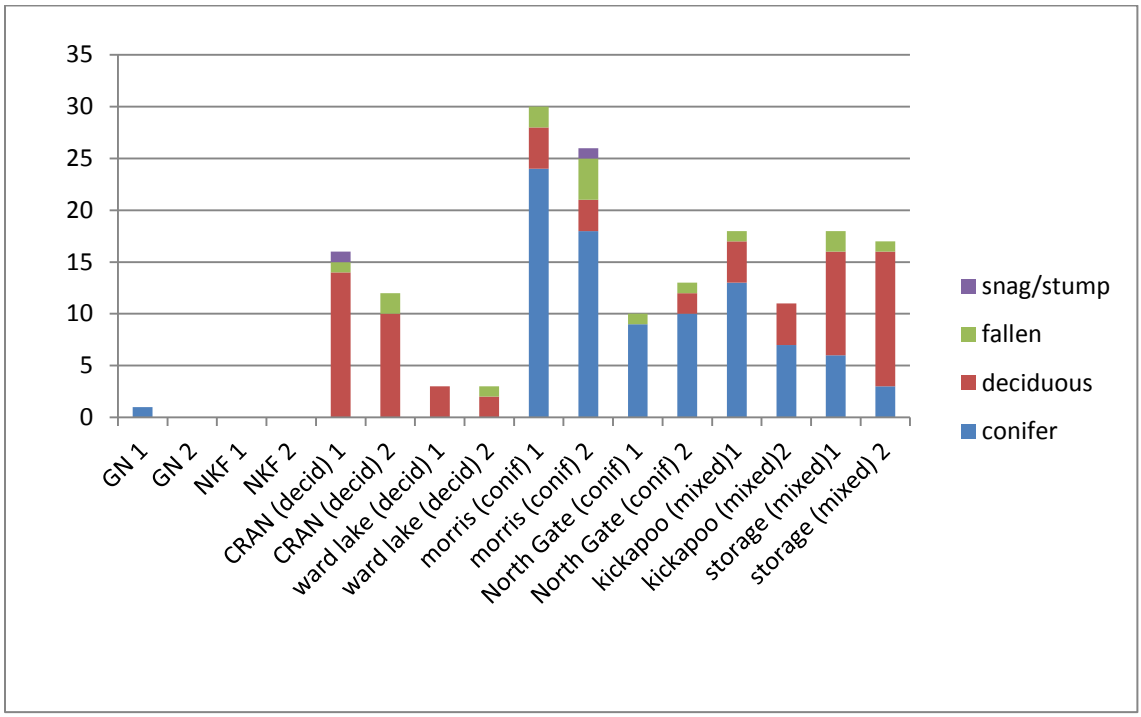

Figure 3 illustrates proportions of types of trees both alive and dead at each site