SNAILS' RESPONSE TO FIRE IN THE BLACK HILLS

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Background

Four land snail species (*Vertigo arthuri, Vertigo paradoxa, Catinella gelida*, and *Oreohelix strigosa cooperi*) are included on South Dakota's list of species of greatest conservation concern (www.sdgfp.info/wildlife/diversity/Comp_Plan/species_concern.pdf). All four have been reported from the Black Hills previously (see Anderson 2004a). Conservation Assessments for three of these species, *Vertigo arthuri*, *Vertigo paradoxa*, and *Oreohelix strigosa cooperi* indicate fire is a potential concern for the survival of populations in the Black Hills and that understanding their responses to fire should be a research priority (Anderson 2004b, 2004c, 2005). Very little information is available to address the impact of fire on forest-dwelling land snails. Snail species dependent on the leaf litter layer for food and shelter may be particularly susceptible to fire if leaf litter is destroyed in the fire. Due to their limited dispersal ability and the recently increased rate of fire occurrence, snails may also have difficulty re-colonizing areas if intervening habitat is unsuitable.

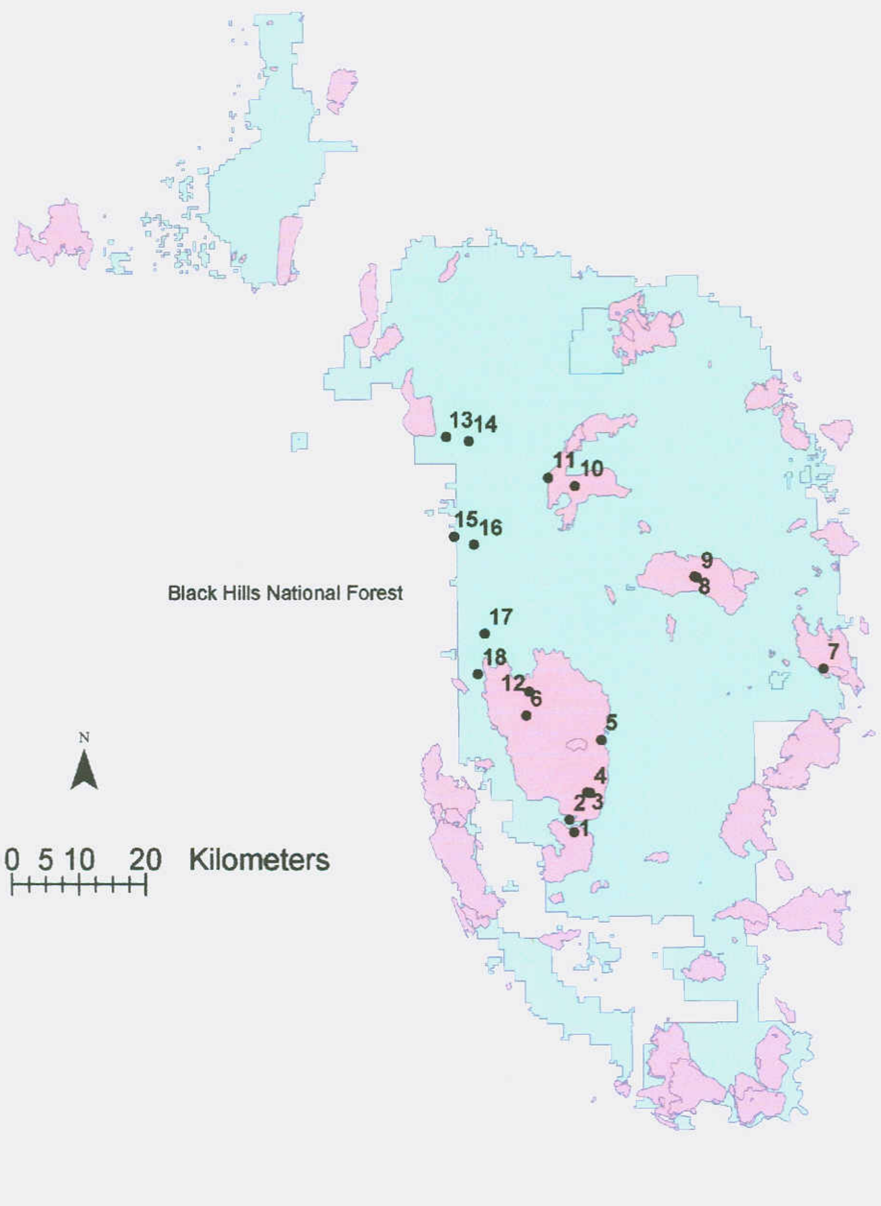
Snail abundance was reduced (sometimes reduced to zero) after fires in several studies conducted elsewhere (Beetle 1997, Karlin 1961, Kiss *et al.* 2004). However, snail populations in a Maine deciduous forest were not found to be permanently affected by fire (Strayer *et al.* 1986). Different species may respond differently to fire, even within the same genera (Nekola 2002). Therefore, it is important to have an understanding of how the snail community in the Black Hills may respond before using fire as a management tool where species of concern are found.

Forest fires and controlled burns have occurred several times in the last ten years on the Black Hills National Forest impacting thousands of acres of land. This study examined the effects these burns have had on the snail community in these areas. Specifically, this study asked four main questions: (1) Are snails (based on observation and sampling of live individuals as well as shells) less likely to be present in burned areas than in unburned areas? (2) How do snail abundance and diversity vary between burned and unburned areas? (3) How do snail populations persist at a location over time (with or without a fire event)? (4) How does snail detection vary between visual survey methods and soil sampling in these areas?

Methods

Study sites were selected for sampling using Forest Service maps of recent burn areas and documented snail sites (with data from Frest and Johannes 2002, Anderson *personal observation*, and Forest Service personnel). Unburned sites with documented snail populations were also included in the study as a control group. On the ground, three sites supposedly within burn boundaries did not necessarily show evidence of burns. It is unknown whether this is because burns were spotty and missed these areas or if burn evidence is no longer easily detectable in some areas. So sites without some evidence of burn activity were put into a separate category, leaving nine sampled sites in the burn category and six sampled sites in the unburned category. Sampled sites are shown in Figure 1.

Figure 1. Sample Sites



At each site, the snail community was evaluated using visual survey techniques and soil sampling. Two 10 m transects were placed at the sample site. A 0.25 m^2 quadrat was placed every 2 m along the transect lines. Each quadrat area was visually inspected and any snails or shells noted. Any species not identifiable in the field were placed in a vial for later identification. Two soil samples were also taken (one from each transect line). The soil samples consisted of filling a 2.5L (1 gallon) plastic bag with soil and litter from within a quadrat placed at the middle of the transect. The soil was later sifted through sieves to detect snails. Shells and live individuals were identified to species using a microscope.

Field surveys and collecting was done June 20-22, 2009. Spring storms prevented access for earlier collecting. However, this time period is still within the time when live snails would be expected to be active and visible at the surface based on previous work with *Oreohelix cooperi* in the Black Hills (Anderson and Schmidt 2007).

Data were analyzed using JMP statistical software. To determine presence or absence of snails at a site, data from soil samples and visual surveys were combined. Data from burned sites were compared to data from unburned sites to test whether differences exist. In addition, species diversity at each site in this study was compared to earlier sampling records (Frest and Johannes 2002) at the same site to determine if diversity changed over time. Finally, results from soil sampling and visual surveys were compared to test whether snails are equally detectable with either method.

Results

A total of 741 snails and shells were counted in this study (Table 1). Twenty-one different snail species were observed (Table 2). All of the species identified had been previously reported from the Black Hills. Individual sites varied in the number of shells observed from 0 to 159 and in the number of species from 0 to 8.

Table 1. Snails and shells found at each site

Site	Burn or Unburned Site	Live snails	Total Snails/Shells in Quadrats	Total Snails/Shells in Soil Samples	Total Species Diversity	Frest Species Diversity
1	B	0	0	159	8	11
2	U	0	0	3	2	12
3	B	0	0	2	1	Unknown
4	B	0	0	50	8	13
5	B	1	0	13	2	8
6	B	0	0	26	2	7
7	B	0	0	0	0	0
8	?	3	4	5	1	6
9	B	0	0	3	2	7
10	?	8	0	30	2	5
11	?	0	14	32	4	6
12	B	14	1	70	5	9

13	U	1	0	11	3	7
14	B	0	0	0	0	9
15	U	7	11	79	6	1
16	U	13	38	102	5	4
17	U	3	0	50	3	11
18	U	1	0	106	3	7

Table 2. Species identified in this study.

Catinella sp.
Cionella lubrica
Discus catskillensis
Discus shimekii
Discus whitneyi
Euconulus fulvus
Gastrocopta armifera
Gastrocopta holzingeri
Hawaii minuscule
Nesovitrea binneyana
Nesovitrea electrina
Oreohelix cooperi
Punctum minitissimum
Pupilla blandi
Pupilla muscorum
Vallonia gracilicosta
Vallonia parvula
Vallonia pulchella
Vertigo modesta
Vertigo paradoxa
Vitrina alaskana

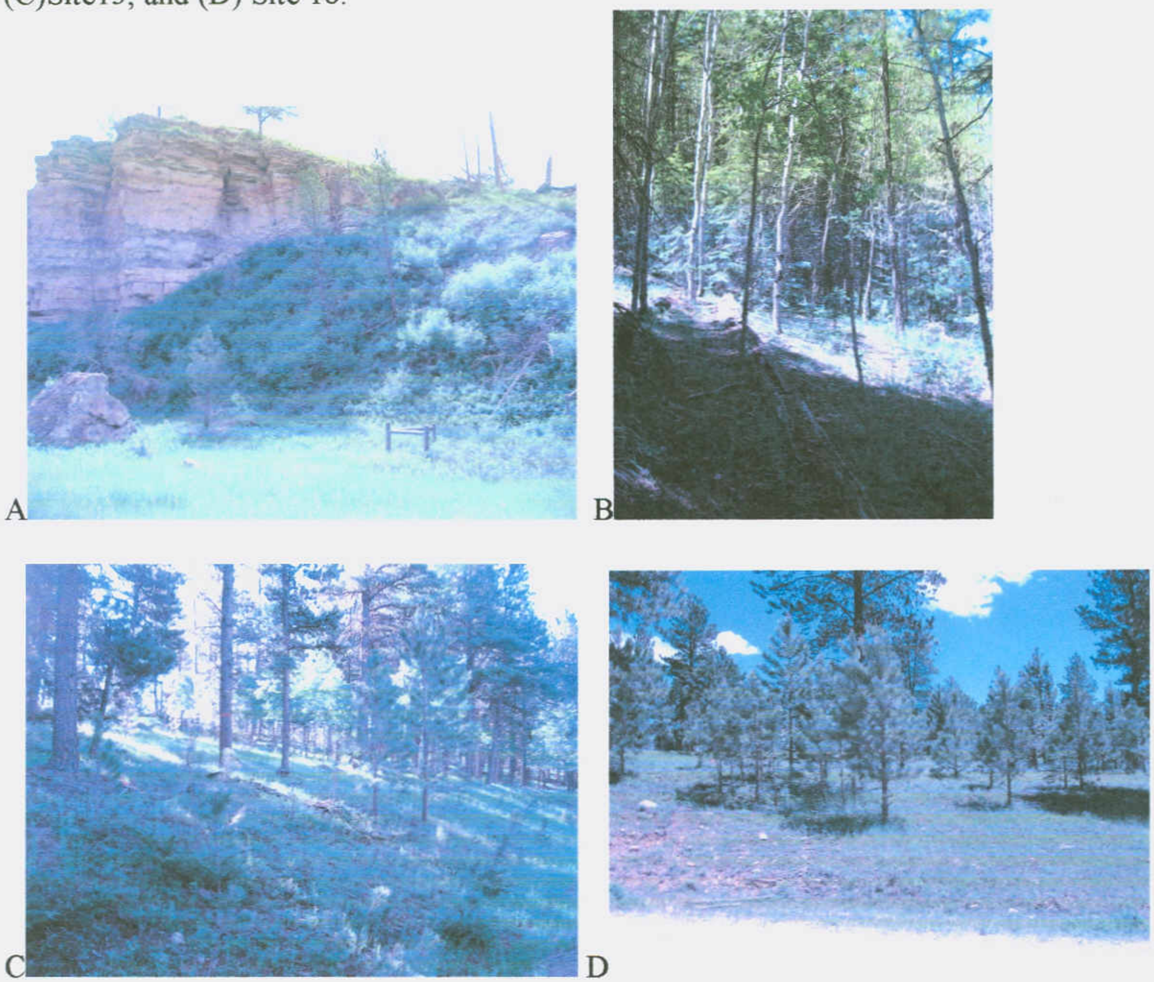
Burned and unburned sites in this study did not significantly vary in the presence, abundance, or diversity of snails (chi-square prob >0.05). Significantly fewer snails were observed in quadrats at than in soil samples (prob<0.05). All but one site where Frest had previously recorded snails still showed evidence of snails. However diversity was significantly lower than previously reported.

Discussion

Although the number of snail shells did not differ significantly between burned and unburned sites in this study, this should not be taken as an indication that fire does not impact snails without further thought. Two main factors confound the results of this study: differences in fire activity among locations and shell decomposition.

Fire intensity on the ground at the precise sampling locations was not known. Even though sites were burned, a crown fire or spot fire may have affected litter-dwelling species differently. Burn sites currently look very different on the ground (Figure 2). Sample sites were also located within different burn events. The time since the burn is known, but cannot be analyzed separately because the sample sizes then become too small to be meaningful statistcally.

Figure 2. Photos showing differences on the ground at sampling sites. (A) Site 1, (B) Site9, (C)Site13, and (D) Site 18.



The number of shells in a sample may parallel the number of live specimens at a location, but if a catastrophic event occurs at a location, the number of shells may be much higher than the actual living snail population. In this study, the location with the highest number of shells (site 1) was a burn site where NO live specimens were noted. Although land snails in Costa Rica decomposed in 5 months (Barrientos 2000), shells in a recent North American study found much slower decomposition rates with unbroken shells having an average half-life (having lost half of their mass) of 11.5 years (Pearce 2008). All of the sites (forests in Michigan and Delaware) in the Pearce study are presumably moister than the Black Hills, so shells in the Black Hills could potentially persist longer, and certainly could be intact since the recent fire events.

Due to the possible persistence of shells from before fire events, it is probably more robust to include only live specimens in analyses of the effects of fire on snail populations. Unfortunately, snail populations at many locations are not very dense, so few living snails were noted in this study. In fact, one site in this study (site 11) where only shells were noted in the quadrats and soil samples, had several live specimens elsewhere in the immediate area (personal observation). Live snails noted did not differ between burned and unburned sites, but analysis of the live snails found in this study was also confounded by the length of time it took to process soil samples. Some snails alive at the sampling time could have been dead before the samples were sorted, thereby further reducing the number of live snails recorded at a site.

The difference in total shells observed between the quadrat method and the soil method is not surprising due to the large number of shells observed in some soil samples. Although this would indicate soil sampling may be the more efficient sampling method, it was mostly shells that were being picked up in the soil samples. If live snails are being studied, the methods were more equal with 28 live snails being detected in soil samples and 23 detected visually. However, some small species may not be easily sighted on the surface, so soil samples may still be necessary for picking up those species.

The decrease in species diversity between this study and the earlier work by Frest and Johannes is interesting to note. Differences could be the result of more intense sampling in the earlier study or environmental factors. Frest and Johannes sampled in some moist years with many dry years since. So some locations that may support particular species in moist years, may not currently be conducive to allow those species to reside there. In addition, although presence of species could be compared to samples by Frest and Johannes, they did not have equivalent abundance numbers, so changes in abundance over time could not be noted. Perhaps increases in some species occurred which out-competed other species.

Conclusions/Recommendations

Unfortunately, the results from this study are not as robust as one would like in order to make conclusions on the issue of how snail populations are impacted by forest fires. Therefore, it seems useful to make recommendations that would lead to a more scientifically sound study. Ideally, live snail abundance would be quantified at sampling sites before a planned fire event. Then fire monitoring devices would be placed at the site to record the fire intensity at that specific location. Afterwards, only live snails would be counted to eliminate issues of recording snail shells that may have been alive before the fire, but perished during or immediately following the fire event. Not only would this allow for more direct observation of the effect on the snail population, it would also provide samples from the same fire event, allowing for a larger sample size from the same time period.

Acknowledgements

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