Monitoring of *Oreohelix strigosa cooperi* in the Black Hills
Year-End Report

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Introduction

Oreohelix strigosa cooperi is included among the rare species monitored by the South Dakota Natural Heritage Database (2005) and is given an S2 status in South Dakota meaning it may be vulnerable to extinction (NatureServe 2003). In 2003, a petition was submitted to the USFWS requesting *O. s. cooperi* be granted threatened or endangered species status (Biodiversity Conservation Alliance *et al.*). One aspect of deciding whether to declare a species rare or endangered is based on how many individuals exist. However, very little is known about the size of the populations of *O. s. cooperi* that exist in the Black Hills.

Density estimates have been made for some populations of *O. s. cooperi* in the Black Hills (Frest and Johannes 2002). These estimates were mostly based on counts from single visits. The accuracy of these estimates is unknown, in part because the activity patterns of these snails have not been clearly determined in the Black Hills.

Information on trends in population size is also useful for managing species of interest. Frest and Johannes (2002) hypothesized that habitat changes were causing declines in Black Hills snail populations. Baseline population estimates from a repeatable protocol are required in order to track population trends over time.

In this study a mark-recapture protocol was developed for obtaining population estimates for *O. s. cooperi*. That protocol was used to obtain baseline population estimates for segments of four *O. s. cooperi* populations in the Black Hills. Secondly, data from the marked individuals provide information on snail activity across the summer.

Methods

Grids were set up at four locations (Table 1) previously scouted for the presence of snails. Grids consisted of four rows of five sampling stations placed 2m apart. At each sampling station, a 0.5 m x 0.5 m plywood or pressboard board was placed flat on the ground and functioned as "traps". Boards were left in place at least 24 hours before the first trapping session.

Table 1. Sites included in the study.

Site Name	*GPS E*	*GPS N*	*First Trapping Date*
Iron Creek	0589010	4919347	Jun 6
Beaver Creek	*	*	May 26
Trebor Draw	0589557	4890338	May 26
Timon Campground	0580904	4908940	Jun 27

*GPS data not properly recorded. The site is directly across the creek and upslope from campsites 4-7 at the Beaver Creek campground.

At each trapping session, individual snails seen for the first time were marked with fingernail polish and an individually numbered bee tag (www.beeworks.com). For each snail,

the trap location, the number of whorls, and the diameter (measured with Mitutoyo digimatic calipers) were recorded. Recaptured individuals were also recorded and measured. After being marked, snails were returned to the location they were found.

Soil temperature and moisture at each board was also recorded using a Weksler soil thermometer and a Quick Draw 2900FI SoilMoisture Probe (SoilMoisture Equipment Corp.). Moisture was measured as the soil suction in centibars, so a lower reading indicates more moisture is contained in the soil. When sites became too dry or were too rocky, the moisture probe could not be inserted and readings were not taken. Late in the season the moisture probe malfunctioned so readings could not be taken on the last sampling visit at some locations.

Each site was initially visited on three consecutive days and then at approximately two-week intervals thereafter. Sampling did not begin until snails were observed to be "active" (i.e. some snails found moving around on the surface or at least extended out of their shells). Due to cold late spring temperatures, snail activity was not observed until late May, so the first trapping sessions began then. Snow and closed roads also impacted early access to some sites so initial sampling days are not the same for all sites. For example, the road leading towards the Timon Campground area was closed for repairs until very late spring, so sampling at that site did not begin until late June. Sampling continued at all sites until the end of September. (A copy of the detailed sampling protocol is found in Appendix A.)

Mark-recapture data were analyzed using the program MARK (White & Burnham 1999) to obtain population estimates. The model-selection and robustness of the estimates are discussed in the results section. Size, whorl number, and temperature data were analyzed using Microsoft Office Excel 2003 (Microsoft Corp.) and JMP Version 4.0.2 (SAS Institute, Inc.).

Results

Population estimates

The estimates obtained for each population are shown in Table 2. The reported estimates were obtained using a closed model with heterogeneity (model M_h in MARK), which allows individuals to differ in their capture probability. The closed model option that considers different capture rates for each time period and each individual (M_{tbh}) was not selected because for all four sites it gave a population estimate exactly equal to the number of individuals caught (with a standard error of zero), which does not seem logical when new individuals continued to be caught even at the later trapping sessions. Open models may be more realistic for these populations, since some mortality was observed and movement off the grid may also have occurred. However, estimates could not be obtained using the Jolly-Seber option in MARK, as the program could not reach numerical convergence. Further model selection needs to be evaluated for this data set.

It should be noted that these estimates only predict the number of snails on the trapping grid itself and not the entire population. The area that the snails actually inhabit at each site was not measured (and, indeed, is difficult to determine), so the grid population estimate has not been extrapolated to a wider area.

Although some sites appear to have denser populations than others, direct comparisons of population sizes among sites may be suspect from the limited data available. Although the grid sizes were equal at each site, the sampling sessions were not conducted on the same days. As discussed below, snail activity varied across the summer and this may have affected the number of snails observed at a particular time.

In addition, grids at all sites may not cover the same amount of "ideal" habitat. For example, grids at some sites may have been placed at the edge of the population, rather than the center, which might reduce the number of snails observed. Although attempts were made to place grids in areas where shells or live snails were observed, it was impossible to predict the snail activity across the entire grid before sampling began. See discussion below about variation in captures among boards.

Table 2. Population estimates for subsets of four *Oreohelix strigosa cooperi* populations.

Site	*M_h Estimate*	*Standard Error*	*95% confidence interval*	*Total # of unique individuals caught*	*Number of sampling sessions*	*Recapture rate (#ind recaptured/ total ind)*
Beaver Creek	573	55.1	484-704	292	12	29%
Iron Creek	175	25.9	137-242	86	11	29%
Timon	775	149	579-1201	415	10	33%
Trebor Draw	149	23.3	115-210	74	12	26%

Survival

Some mortality was observed in marked individuals recovered dead at later sampling periods (see Table 3). These recoveries certainly do not represent all mortality, but only those individuals dying while visible under the sampling boards.

Survival rates between sampling sessions were estimated using MARK (Table 3). The general Cormack-Jolly-Seber model (using live recaptures only) was used to generate these estimates. This model does take into consideration the differences in time between sampling sessions in figuring the estimates.

Table 3. Survival rates between sampling sessions.

Site	*Range of survival rates*	*Number of dead recoveries*
Beaver Creek	0.70 to 1.0	18
Iron Creek	0.15 to 1.0	1
Timon	0.75 to 1.0	6
Trebor Draw	0.57 to 1.0	1

Note the survival rates are not overall survival rates but are an estimate of survival from one sampling period to the next. The rates vary widely, showing that there was a large difference between sampling times as to whether snails were captured or not. This also lends support to using a population estimate model that allows for variation in capture probability among sampling sessions.

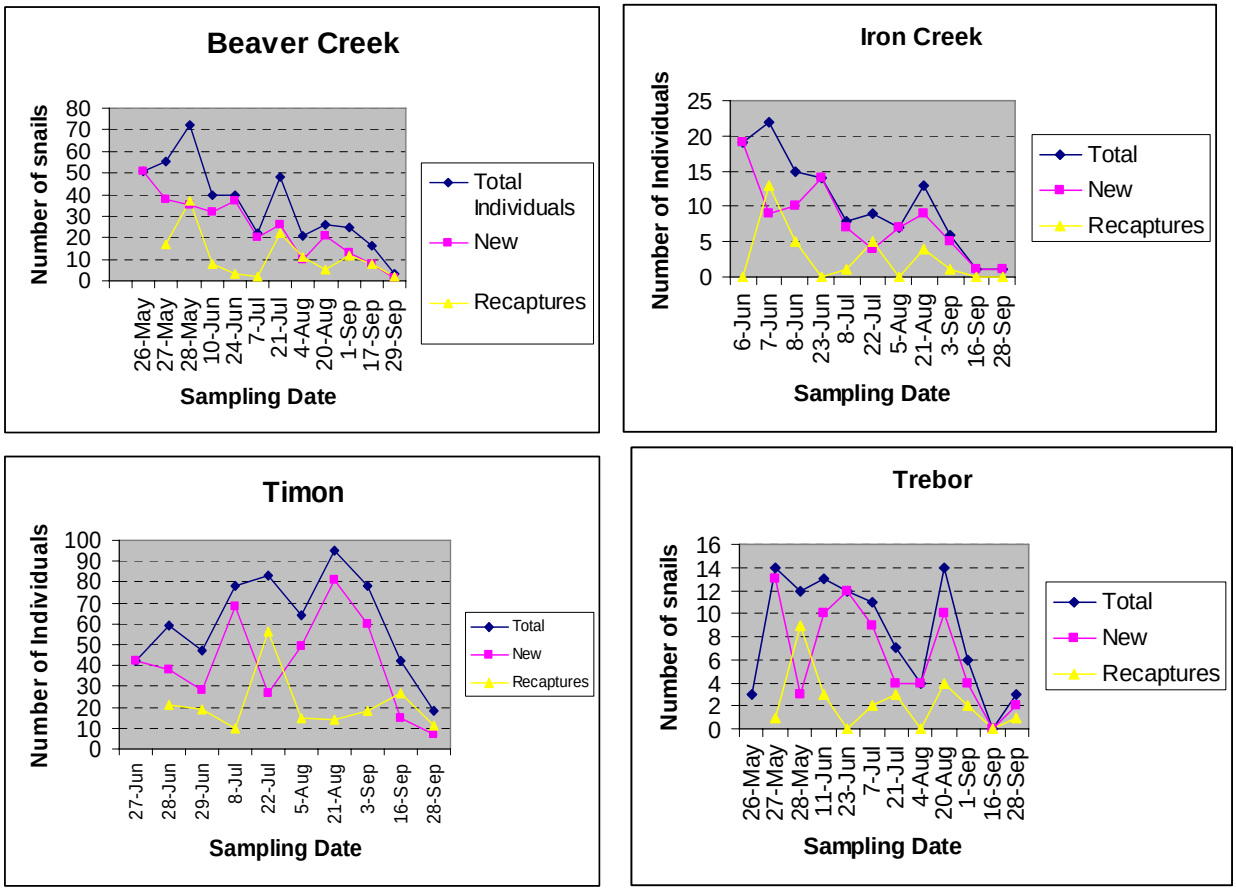
These estimates are not particularly useful at this point for developing an understanding of the overall survival rate of these snails since they give no indication of over-winter survival.

Snail Activity

The number of snails caught varied among sampling sessions across the summer (Figure 1). All sites showed peaks in number of snails in late May or early June (except the Timon Campground site where sampling did not begin until late June). It appears that snails become less active as the summer progresses, although a secondary peak occurred in late July (Beaver Creek) or late August (Iron Creek, Timon, and Trebor) before numbers plummeted in September.

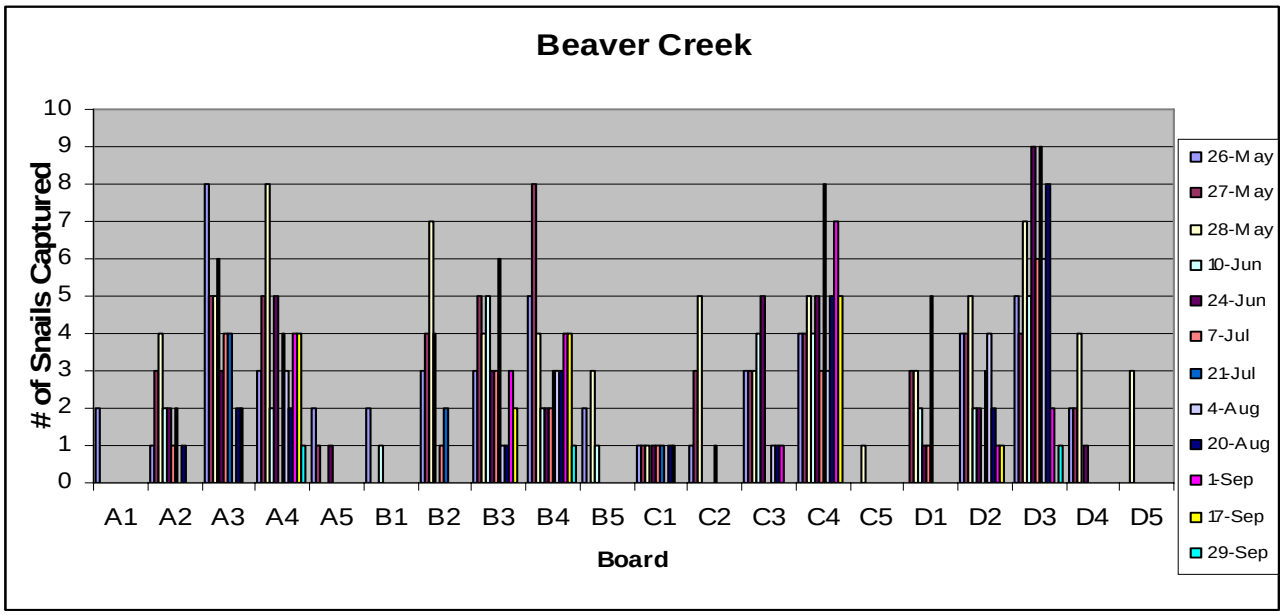
New, unmarked individuals and recaptured individuals are also shown in Figure 1. The patterns shown by these groups are not easily interpreted. New snails do not contribute a constant proportion to the population, nor does the percentage of recaptures uniformly increase across the season. Instead there is some variation with time in the percentage of new vs. recaptured snails.

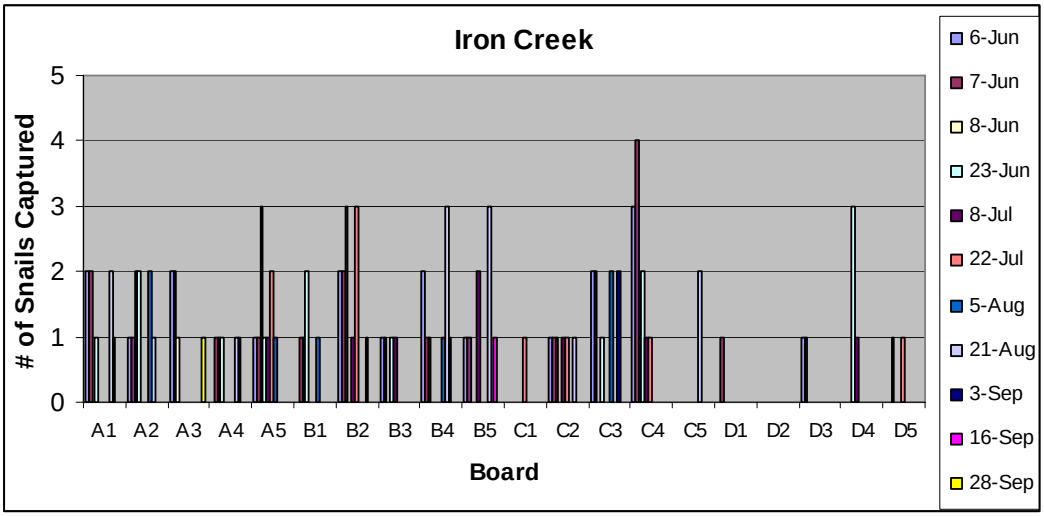
Figure 1. Total individuals captured at each sampling date at each site. Newly captured individuals and recaptured individuals are also charted.

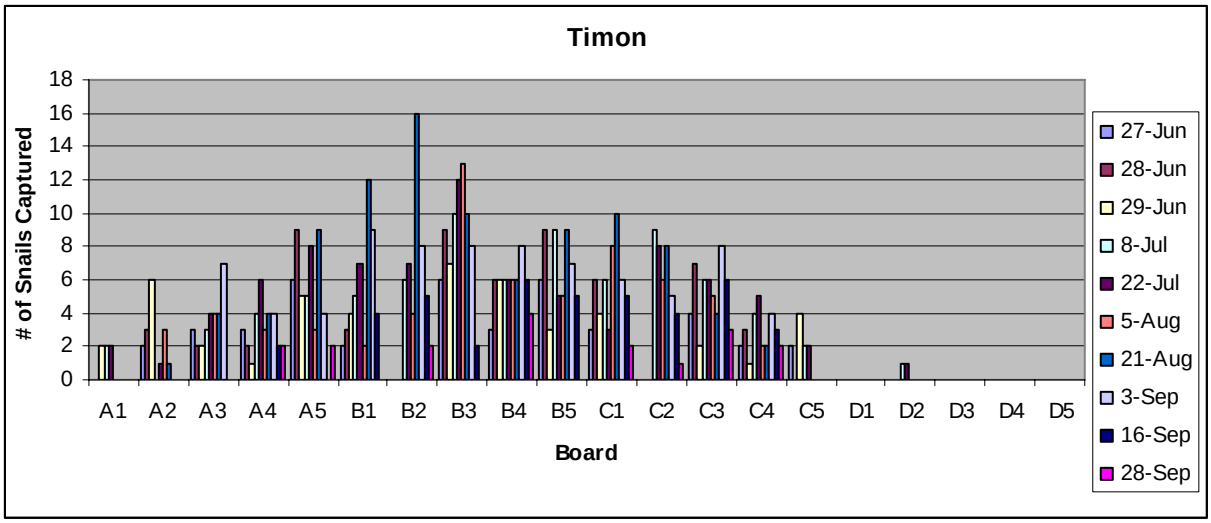


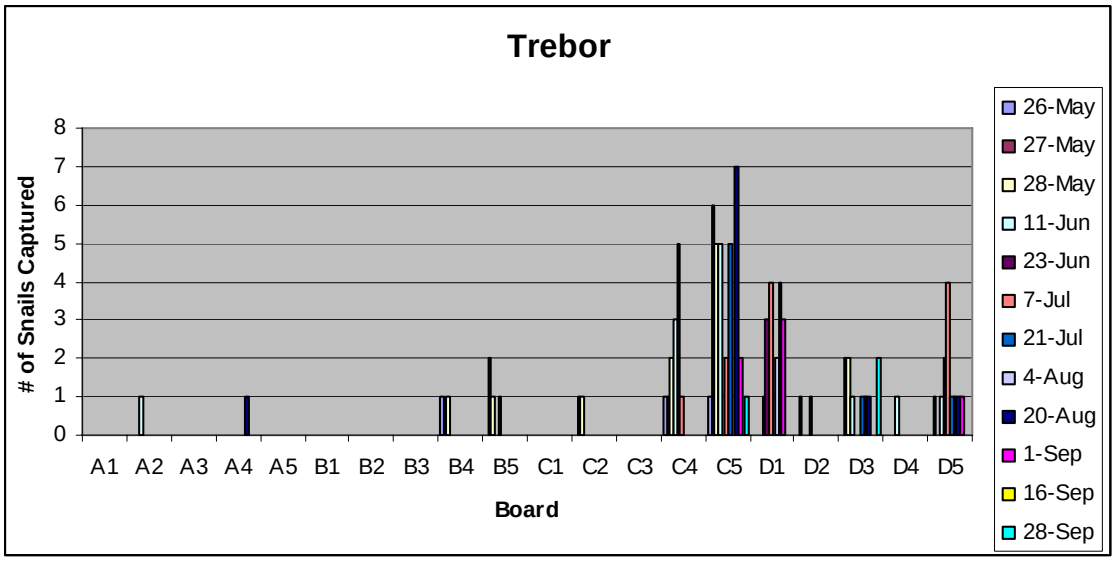
Snails also were not uniformly active across an area. The number of snails captured differed among the boards on a grid (Figure 2). At three sites (Iron Creek, Timon, and Trebor) there were some boards where no snails were captured on any of the sampling occasions. This indicates that for some reason, some boards were not as desirable for snail activity as others. Moisture and temperature data provide some insight into this phenomenon (see discussion below). Note that at some sampling times, boards were out of place, either through animal disturbance or from sliding downhill. When the board had moved, no data were available for that sampling occasion. Those dates and the boards affected were: 1) Beaver Creek 6/24: B2 and C2, 8/4: A1, A2, and A3, 8/20: C2, and 9/29: A2; 2) Iron Creek 7/8 D1, 9/3 B5; 3) Timon 6/27, 6/28, and 6/29: B1, C2, D1, and D5; 4) Trebor 6/11: C1, D2, 6/23: B1, C1, C2, 7/7: B1, B3, 8/20: B3.

Figure 2. Snails captured at each board at each sampling occasion.









Movement

Most individuals that were recaptured were recaptured under the same board. However, twenty individuals showed some movement between sampling occasions (Table 4). The amount of mobile individuals differed among populations. Percent movement (number of individuals that moved/total number of individuals recaptured) ranged from 5% at the Timon site to 10% at Iron Creek.

Observed movements were mostly to adjacent boards, which would be a distance of approximately 2m. Exact distances cannot be calculated because the path traveled is not known. Only 3 individuals were recaptured at a board that required movement of a greater distance than 2m. The longest movement recorded was by individual G19 at the Timon site. This individual moved a minimum of 7.2m between sampling occasions on July 8 and July 22. Interestingly, this individual also showed two other movements of greater than 2m.

Table 4 illustrates horizontal movement, but vertical movement is also likely since new snails would appear at a board at subsequent sampling occasions at a higher rate than one would logically expect if horizontal movement rates of only 5 to 10% are allowed.

Table 4. Individuals Recaptured at Different Locations

Trebor Draw (74 total individuals, 25 recapture events, 8%movement)

Individual	Date	Location	Previous Capture	Location
B11	July 7	D5	June 11	C5
B12	July 7	D5	May 28	C5

Beaver Creek (292 total individuals, 127 recapture events, 7%movement)

Individual	Date	Location	Previous Capture	Location
B28	Aug 4	A4	Jul 21	B2
O18	July 21	C4	May 26	B5
O22	Jul 7	C4	May 27	B4
O43	Jun 24	C3	May 28	D3
O43	Sept 17	B3	Jun 24	C3
O59	Aug 20	B4-dead	May 28	A4
G7	Jul 21	D1	May 28	C1
G42	Aug 4	B4	Jun 10	B3
G73	Aug 4	B4	Jun 24	B3

Iron Creek (86 total individuals, 29 recapture events, 10%movement)

Individual	Date	Location	Previous Capture	Location
G18	Aug 21	C5	Jun 7	C4
G48	Sept 3	B4	Jun 23	B3
G61	Jul 22	D5	Jul 8	D4

Timon Campground (415 total individuals,191 recapture events, 5% movement)

Individual	Date	Location	Previous Capture	Location
G19	Jul 8	C1	Jun 27	B3
G19b	Jul 22	A4	Jul 8	C1
G19c	Aug 5	C1-dead	Jul 22	A4
G23	Jul 22	A4	Jun 29	B3
G57	Jun 29	A1	Jun 28	B3
G67	Sept 3	B3	Jun 28	B4
B18	Aug 21	B2	Jul 22	A3
B81	Sept 3	B3	Jul 22	C3
B97	Aug 21	C2	Jul 22	D2

Growth Rates

Growth was evaluated from diameter and whorl number data. Overall trends in diameter for the population over the summer are plotted in Figure 3. There is a statistically significant increase in average diameter across the summer at the Beaver Creek (average diameter = -108 + 3.66e-8 date, r2=0.52, linear regression p=0.0082) and Trebor (average diameter=-534 + 0.0000002 date, r2=0.80, linear regression p=0.0002) sites. The Timon site appears to have a flattening out at the end of the summer (average diameter = -55 + 1.98e-8 date, r2=0.38, linear regression p=0.0559). The late start date at this site may have affected the strength of these

results. The Iron Creek site did not show a linear increase (average diameter =-112 + 3.88e-8 date, r2=0.034, linear regression p=0.58). The results on Iron Creek were surely biased by the small sample sizes in September.

Also note the difference in shell size among sites. The slight seasonal increases in size in the other populations never reach the average size in the Iron Creek population. The range in average diameter also differs among populations. The Timon site shows only a 0.3 mm difference in average diameter, while the Iron Creek and Trebor sites show ranges of more than 2.0 mm.

Figure 3. Average diameter of captured individuals across the season. Average diameter is represented by dots and N is represented by columns on each of the graphs below. Only individuals with recorded diameter measurements are included, so N may differ than the total number of individuals caught on some occasions.

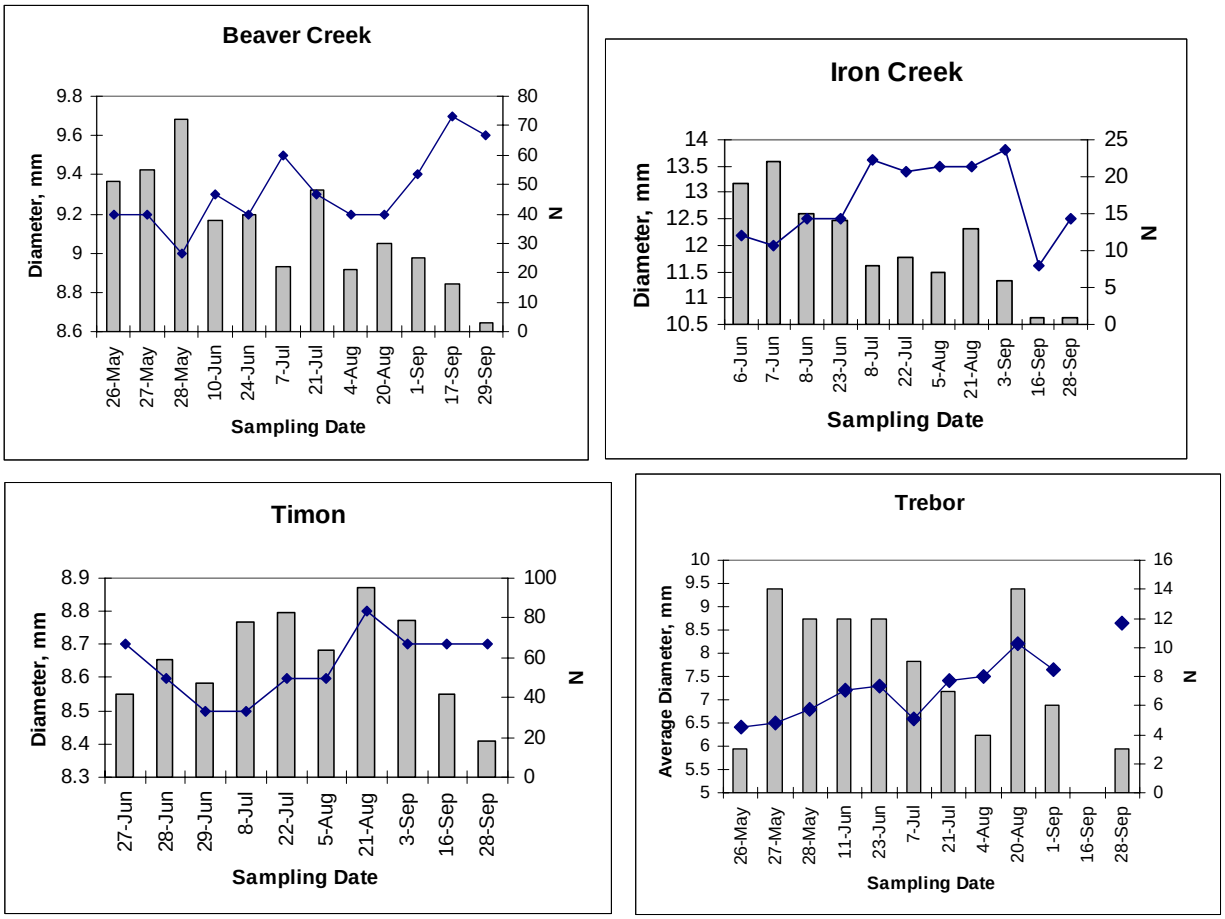
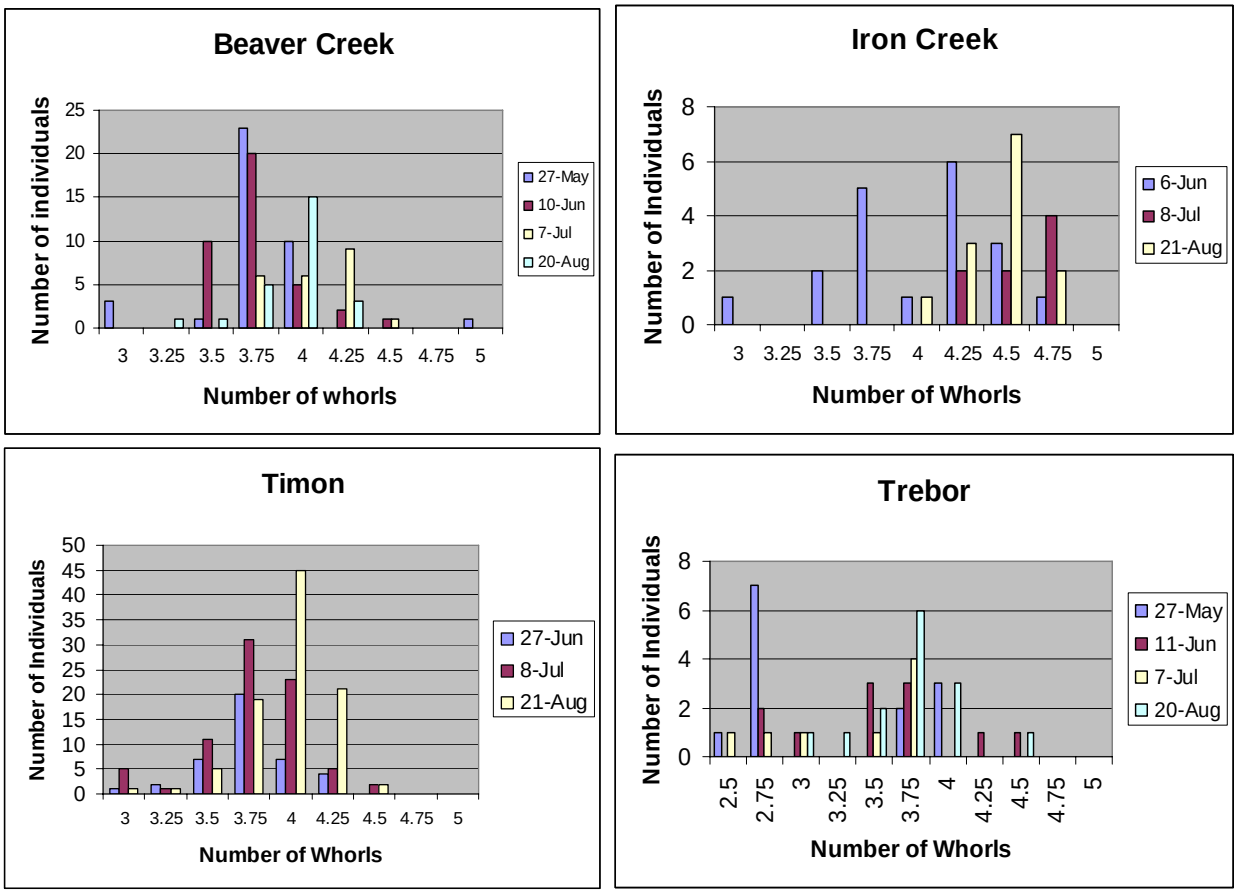


Figure 4 illustrates how the whorl number distribution varied across the summer. Due to a learning curve for counting whorls, May whorl counts may be less reliable than those conducted in June or later. Some problems with properly identifying juveniles in the early capture sessions, could also affect these results. The shift in whorl size to larger classes as summer progresses suggests growth in whorl number. Not enough data is available to determine if growth reaches a maximum or if growth continues as conditions allow. Distinct size classes

for previous years' cohorts would be expected if there was continual growth, but that does not seem readily apparent in this data.

Figure 4. Distribution of whorl sizes at selected sampling dates. Early, middle, and late summer dates are shown for comparison.



Soil temperature and moisture

Soil temperature and moisture varied among and within sites (Figures 5 and 6). A comparison of sites shows that the range of temperatures experienced by the snails on the grids varied slightly among sites (Table 5).

Temperature apparently did not strongly influence the number of snails captured. A regression analysis of the average temperature per board versus the average number of captures per board was not significant ($p>0.05$) for any of the four sites. Using the average temperature across boards per sampling date versus the total captures gave a significant relationship at the Timon site only ($p=0.0140$), but combining all sites showed no significant relationship.

Moisture had a slightly stronger influence on the number of snails captured. A regression analysis of the average moisture across dates per board versus the average number of captures per board was significant only for the Timon site ($p<0.0001$). Using the average moisture reading across boards per sampling date versus the total number of captures per sampling date was not significant for any individual sites. However, when data from all sites were combined,

the average moisture reading per sampling date was significantly related to the total number of captures per sampling date (p=0.0073). Some of the moisture analyses may be slightly biased because moisture readings were not taken late in the season after the probe malfunctioned or when sites became too hard to insert the probe and captures at these times were very low. Likely a stronger relationship would have been observed if these data were available.

Figure 5. Temperature and moisture measurements at each location. The average temperature and moisture are an average of the measurements from under each board on one particular sampling date.

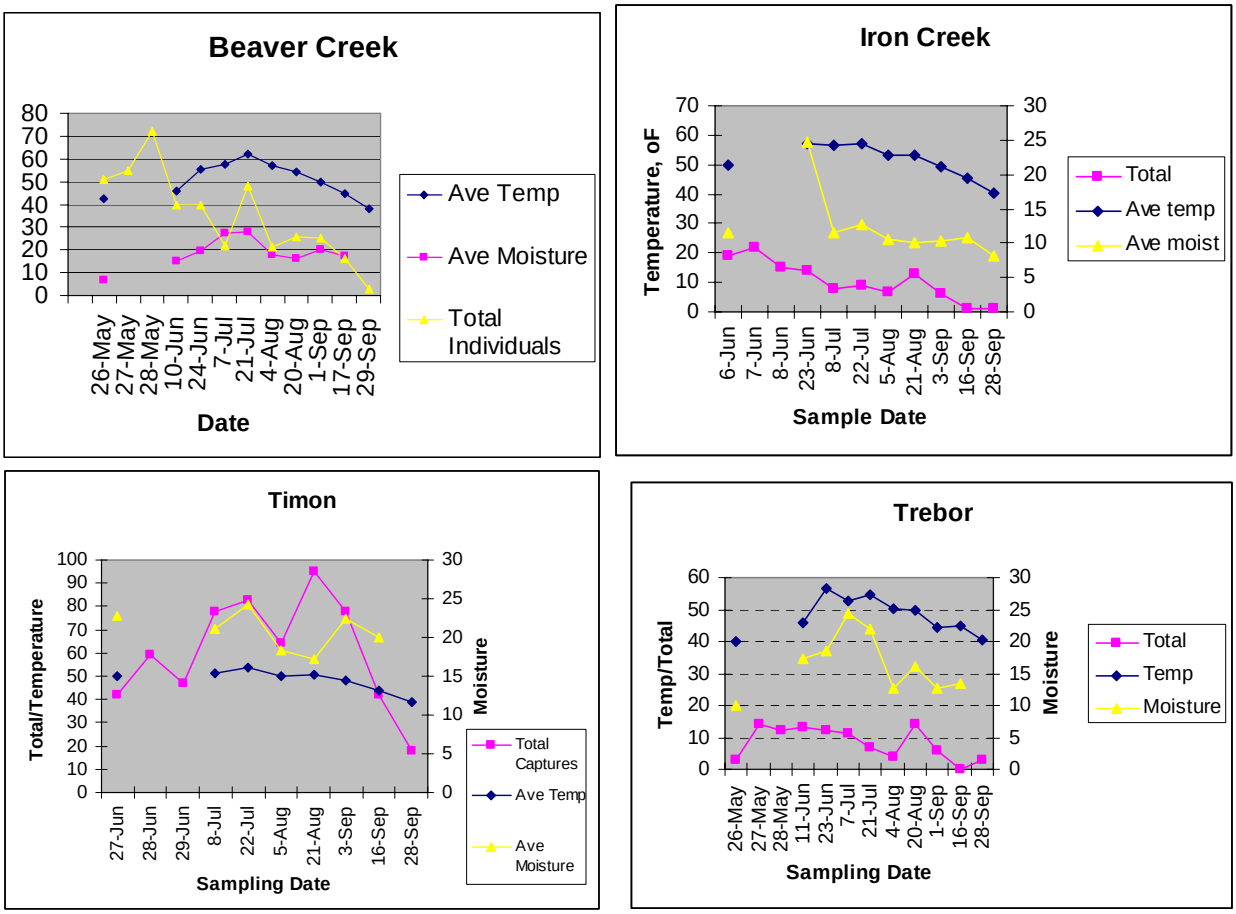
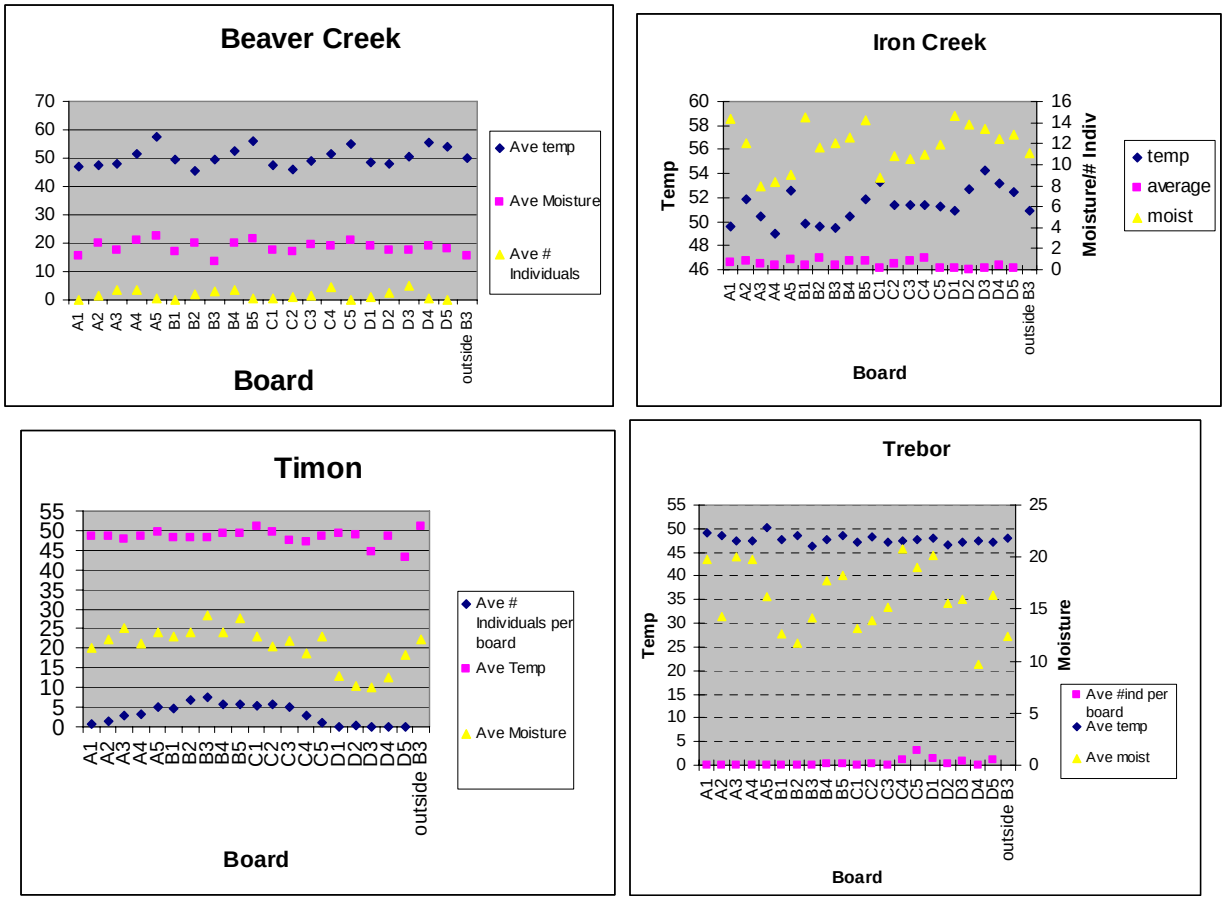


Table 5. Ranges in temperature and moisture by site.

Site	*Low Temp, °F (Date)*	*High Temp, °F (Date)*	*Moistest, in centibars (Date)*	*Driest, in centibars (Date)*
Beaver Creek	38 (Sept 29)	62 (July 21)	7 (May 26)	28 (July 21)
Iron Creek	40 (Sept 28)	57 (July 8 & 22)	8 (Sept 28)	19 (June 23)
Timon	39 (Sept 28)	54 (July 22)	17 (Aug 21)	23 (June 27)
Trebor	40 (May 26 & Sept 28)	57 (June 23)	10 (May 26)	24 (July 7)

The boards did provide a slightly different microenvironment than the surrounding uncovered habitat. Temperature and moisture readings were taken under board B3 and adjacent to the board, but still within that section of the grid, during each sampling occasion. In a matched pairs comparison, a significant difference ($p<0.05$) exists for both temperature and moisture between the readings under B3 and adjacent to B3. Temperature averaged 1.37 degrees higher outside the board than under the board. Moisture readings averaged 2 centibars lower outside the board than under the board. Recall a lower pressure in centibars refers to less moisture available. Therefore, the boards provided a slightly cooler and moister environment than the adjacent area.

Figure 6. Variation in temperature and moisture within sites. Averages are taken from each board across all the sampling occasions during the summer.



Discussion

Evaluation of Protocol

This study provides important data on population size and snail activity across the summer. The results show that using a mark-recapture protocol with grids of cover-board traps can be an effective way to sample *Oreohelix strigosa cooperi* in the Black Hills. The snails are not avoiding the boards so they serve as a useful "trap". The protocol described here is

repeatable and could easily be adapted for long-term monitoring, if desired. A precedent for such monitoring exists in Iowa where a mark-recapture protocol is being used for monitoring of the endangered land snail, *Discus macclintocki* (Henry *et al.* 2003).

Reliability of population estimates

As mentioned previously, the proper model for population estimation is this case will be reviewed further. The snail populations technically violate some assumptions for closed population modeling (i.e. no migration and no mortality), and an open model would be ideal if a technically feasible model were available. However, given that the observed migration distances are low compared to the grid size and that observed mortality is low, closed models can still provide useful estimates (White *et al.* 1982). According to White *et al.* (1982), the coefficient of variation of population estimates (se(N)/N) should be less than 20% for precise estimates. All four population estimates reported in this study fall below the 20% level, so the estimates are presumably realistic. However, the estimates of the probability of capture (p) are low, which reduces the reliability of the model.

Compared to published studies of land snails with similar methods, the present study provides estimates at least as reliable. A mark-recapture study of an endangered land snail in Iowa, *Discus macclintocki*, used a closed model, M(th), to estimate population size (Anderson 2000). In that study, sample sizes were smaller (from 16 to 297 per site) and the maximum number of sampling occasions was 8 (compared to 10-12 in this study). Probabilities of capture were low in that study (0.01 to 0.23) as well. Recapture rates for *Discus macclintocki* were generally lower (from 0 to 48%, with 7 populations having recapture rates under 10%).

Another snail study of marked *Arianta arbustorum* in roadside areas in Sweden did not use cover-boards, but searched grids by hand (Baur & Baur 1990). Their recapture rates averaged 29.4% one month after marking.

Comparison with previous estimates

Comparisons between these results and the density estimates provided by Frest and Johannes (2002) are difficult to interpret (Table 6). Their estimates are based on averaging counts from 0.25 m^2 quadrats randomly placed around a site on one particular day. For comparison with this study, two different calculations were made. First the M_h population estimates were used. For this purpose, I assumed that the area sampled included not just the area under the boards, but also between the boards and a slight buffer around the boards, for a total of a 10 m x 10 m area. So the population estimates were divided by 100 for the number of snails per m^2. Note that the population size estimates are based on recapture probabilities and not just numbers of snails from a sample. For perhaps a more direct comparison to Frest's methods, numbers from each sampling occasion were examined individually and were divided by 20 (the number of 0.25 m^2 boards used as traps) then multiplied by 4 to obtain an estimate per m^2. The lowest and highest of these estimates are also reported in the table to see the range.

Table 6. Comparison to density estimates by Frest and Johannes (2002).

Site	*Frest's 1999 estimates of snails/m^2 (nearest Frest location)*	*Snails/m^2 derived from the population estimates in this study*	*Low sample snails/m^2 (date)*	*High sample snails/m^2 (date)*
Beaver Creek	5-10 (82) 2-10 (83)	5.7	0.6 (Sept 29)	14 (May 28)
Iron Creek	4 (11)	1.8	0.2 (Sept 16 & 28)	4 (June 6)
Timon	10-15 (19)	7.8	4 (Sept 28)	19 (Aug 21)
Trebor Draw	Up to 20 (87)	1.5	0 (Sept 16)	3 (May 27 & Aug 20)

Exact reasons for differences between these estimates are unknown, but there are several methodological possibilities. First, collection sites from Frest and Johannes (2002) are not an exact overlay of the areas that the grids were placed in this study. In fact, in some cases their samples were done at quite a distance from the sites in this study (i.e. the Beaver Creek site, where Frest and Johannes had no samples from near the campground, but did supply estimates from other sites along the creek). Since the distribution of the snails is patchy, it is difficult to make comparisons from different locations.

Second, as can be seen from the low/high estimates, the date of sampling can heavily influence the results when estimates are based on data from a single day. In addition, it is unknown if the cover boards used in this study would increase the probability of viewing snails across the summer over what would be seen in a quadrat without a cover board. These issues illustrate the importance of using a repeatable protocol at a fixed location in order to monitor the population over time.

Importance of temperature and moisture

Moisture is apparently more important than temperature to the presence of *Oreohelix strigosa cooperi* underneath a board. However, the temperature and moisture measurements in this study are limited because they were only taken at specific time points and would likely vary at other times of the day. Further examination of temperature and moisture using environmental recorders across the summer would be useful.

The range of conditions experienced at a site may be important and should be examined further. The moistest environment overall belonged to Iron Creek where the largest individuals were found.

Life history information (movement, survival, growth)

The movement rates and distances in this study are comparable to the rates found in other snail studies. Between 0 and 17% of *Discus macclintocki* migrated between cover boards on different cold-air slopes in Iowa (Anderson 2000). The furthest movement was 8m. Average linear movement by *Arianta arbustorum* along roadside areas ranged from 1.5 to 4.9 m at different sites in Sweden were recorded by Baur and Baur (1989). Average distances moved by *Arianta arbustorum* in subalpine areas in Sweden ranged from 7 to 12 m per year (Baur 1986).

Longer dispersals of up to 500m in 6 months are known from an African giant snail, *Achatina fulica*, which was fitted with a radio-transmitter (Tomiyama and Nakane 1993).

More information is needed to understand dispersal and other movement in this species. Some *Oreohelix strigosa cooperi* are moving horizontally out from underneath the boards, based on observations of marked individuals both on and off the grid, but no longer under a board. Vertical movement is also likely. Snails are probably burrowing into the soil or retreating into crevices more readily than expected.

The survival rates presented here are not very robust. Longer-term monitoring, including some winter sampling would be helpful to better understand survival in this species.

Size data indicate that the snails are not "born" at full size but are growing during the season. The range in average size across the summer is much narrower in two populations, which also show smaller diameter individuals. Whether snails of different size morphs are born at the same size is unclear from this data since very few juveniles were observed. The size "at birth" is currently being investigated with brood data from individuals collected for a separate study.

Plans/Suggestions for future work

The results presented help to fill in several gaps in information identified in the species assessment document for the R2 Region of the USFS (Anderson 2005). Additional work would further strengthen these data and provide more information on this interesting species.

Model selection and goodness of fit for the population estimates will be further examined. Further attempts will be made to model the populations with M(th) models and with open models.

Additional field seasons would greatly increase the reliability of population estimates, provide a greater understanding of survival, and possibly increase understanding of movement of these snails. Should additional field seasons be conducted, a few recommendations follow. Automatic temperature and moisture recorders should be placed at each site to allow a better understanding of the range of conditions experienced by the snails and to more accurately compare conditions between years. Some soil cores should be taken to provide an understanding of whether (and how far) snails are moving down into the soil and when (presumably when surface conditions are less favorable). Site boundaries should be defined to allow extrapolation of grid population estimates to actual location estimates. If sites are especially large, secondary grids could be set up to monitor the variation in density across the site as well as allow for more information on movement. Radio tagging a few individuals is another possibility that would allow a better understanding of movements off the grid.

Results from this study will be formatted and submitted in the next few months to a scientific journal for publication. In any publications, South Dakota Department of Game, Fish, and Parks will be acknowledged as providing funding. Upon publication, copies will be made available to South Dakota Dept. of Game, Fish & Parks.

Acknowledgements

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Appendix I. Mark-Recapture Protocol

1) Marking the grids

Set up grids at each site. Grids consist of 4 rows of 5 boards spaced two meters apart. (See diagram below, where 'x's represent placement of cover boards)

		0m	2m	4m	6m	8m	10m
Row D	6m	x	x	x	x	x	
Row C	4m	x	x	x	x	x	
Row B	2m	x	x	x	x	x	
Row A	0m	x	x	x	x	x	

Post a "Wildlife Study" sign at each site and write a description of the site in the notebook and record the GPS location. For future reference, boards will be referred to as board A1 (row A, first column at 0m), board B3 (row B, 3rd column at 4m), etc. If it is easier for you, go ahead and use a sharpie or paint to mark the boards A1, A2, etc. on the side that faces up.

2) Setting the board "traps"

When placing boards, they should be in as much contact with the ground as possible, so if there are rocks preventing them from laying flat, try to shift the rock slightly. Also, wet the boards either in the creek or with other water before placing for the first time. Boards should be in place at least 24 hours before first checking them. Write down the date you wet the boards in the notebook.

3) Initial marking period

The initial marking period will consist of 3 consecutive days revisiting the same site. In the notebook, use one page for each visit to each slope. Write down the date and time of the visit and conditions (i.e. hot, dry, rainy, etc.).

Examine each board and the area under the board. Take a soil moisture and soil temperature reading under each board. If any Oreohelix are present, measure their diameter, count the number of whorls, and mark them with a bee tag and a dot of fingernail polish that corresponds with that slope. Record this information in the notebook. Replace the snails where you found them and put the boards back in place. Also record other snails present on the board if possible (try to record the genus if you cannot tell the species). Then move on to the next board.

On subsequent days, again examine each board and the area under the board. Take a soil moisture and soil temperature reading under each board. If any marked snails are found, record their tag numbers. If any new snails are found, mark them as described above. After the 3 days, leave the boards in place for the next marking period.

A hypothetical notebook entry:

May 15, Iron Creek site (White fingernail polish)
- Board A1: 3 Oreohelix and 1 Vallonia and 1 slug
  - Blue 1 (7mm), Blue 2 (10 mm), Blue 3 (9 mm)
- Board A2: none
- Board A3: 1 Oreohelix
  - Blue 4 (7 mm)
- Etc.

May 16, Iron Creek site
- Board A1: 2 Oreohelix
  - Previously marked: Blue 2
  - New: Blue 20 (8 mm)

4) Subsequent marking periods

After the initial marking period, wait two weeks and then visit each site again. Again check each board. Record all snails found, including any dead. Measure all live snails. Mark any new Oreohelix. Record diameter of all Oreohelix (both recaptured and newly marked).

NOTE: If the summer is extremely hot and dry, we may need to wet the boards again a day or 2 before subsequent marking periods. You can get a feel for this with the first marking period after the 2-week interval and we can decide this then.

Continue to revisit the sites every two weeks until October.