Large Mammal Survey and Investigation of Culvert Use in the Coal Creek Riparian Area

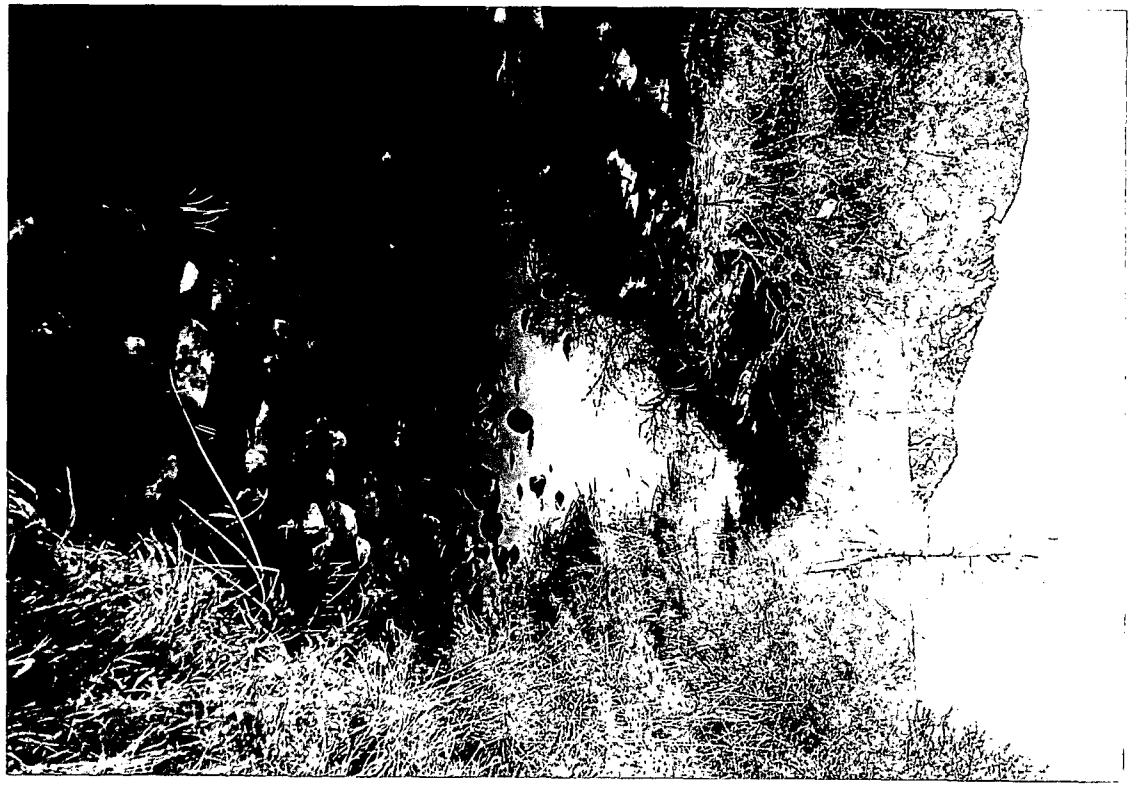
Produced for City of Boulder Open Space and Mountain Parks, Boulder Colorado,

and

for the Science and Technology Department, Front Range Community College, Westminster, Colorado

John Tumasonis
Louisville, Colorado

May 2001



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Acknowledgments

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Abstract:

Sections of the Coal Creek riparian area, in Jefferson and Boulder counties, Colorado, have recently become part of the City of Boulder Open Space and Mountain Parks properties. To help management make decisions related to the Coal Creek riparian area in these properties, I conducted a baseline inventory of large mammals that are using the drainage for forage, cover, and travel. Also, I investigated the use of culverts by large mammals, along Coal Creek within the study area. The culverts run under routes 128 and 93 and junction with Coal Creek in south Boulder County.

I have found that black bear (*Ursus americanus*), coyote (*Canis latrans*), and raccoon (*Procyon lotor*), are using the Coal Creek riparian area fairly frequently, whereas use by white-tailed deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemionus*), red fox (*Vulpes vulpes*), porcupine (*Erethizon dorsatum*) and bobcat (*Felix rufus*) are infrequent or have not been detected. Coyote occurrences in the area greatly outnumbered all other mammal occurrences combined.

Use of the culverts under routes 93 and 128 by the mammals targeted in this study has proven to be limited. Several data points collected indicate that mammals are going over the roads as much, or more, than they are using the culverts.

Results of this study have implications for management decisions. Management can use this data as a baseline to determine what mammals are present now and make comparisons in the future to find out what species become absent or present over time. Future studies could use the data from this report to more closely examine how habitat fragmentation is affecting the large mammal species that use the Coal Creek riparian corridor.

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Introduction:

The City of Boulder Open Space and Mountain Parks has large sections of land along the Coal Creek drainage in the front range corridor in Colorado. Most of these sections provide wide buffers around Coal Creek. In its ongoing Coal Creek Restoration Project, established to improve the ecological health of the riparian of Coal Creek, the City of Boulder Open Space department will incorporate the findings of this study to widen its database and knowledge about the large mammal species that use the area. This survey, in combination with the department's bird monitoring, small mammal monitoring, and vegetation monitoring, will contribute to more informed management decisions related to Coal Creek. Until now, no formal targeted of large mammals species has been done. Target species for this study included black bear (*Ursus americanus*), mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*), elk (*Cervus elaphus*), mountain lion (*Felis concolor*), bobcat (*Felis rufus*), red fox (*Vulpes vulpes*), gray fox (*Urocyon cenereoargenteus*), coyote (*Canis latrans*), porcupine (*Erethizon dorsatum*) and raccoon (*Procyon lotor*), (Table 1).

During the time of this study (October 2000 through April 2001) Coal Creek was an intermittent stream. Where surface water was present, it would freeze solid during cold periods (generally below 25^0 F) and stop flowing altogether. In some sections, water would flow downstream and disappear from the surface for several hundred yards and then resurface and begin flowing again. With the arrival of spring surface water increased throughout the Coal Creek drainage.

Properties of City of Boulder Open Space along the Coal Creek riparian corridor contain a wide variety of plant life. Most of the riparian sections in this study include large patches of hawthorn (*Crataegus erythropoda*) and willow (*Salix spp.*), as well as smaller patches of skunkbrush (*Rhus americana trilobata*), chokecherry (*Padus irrorata*) and wild plum (*Prunus americana*), all of which provide valuable forage for several of the mammal species in this study. Plains cottonwood (*Populus deltoides monolifera*) and narrow leaf cottonwood (*Populus angustifolia*) are the predominant large tree species along the corridor. They provide adequate to scant cover throughout the riparian area. In some places the creek braids out into marshy areas that create cattail and willow habitat; in other places the creek narrows to a rocky channel only a few feet wide. Other species of plants in the area included ponderosa pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga menziesii*), peachleaf willow (*Salix amygdaloides*), and introduced species such as russian olive (*Elaeagnus angustifolia*), and honeylocust (*Gleditsia triacanthos*). The landscape varies from nearly flat with little water flow, to small, rocky drop-offs with running water.

Human impact on the riparian area is noticeable in most sections. This is primarily due to cattle grazing and introduced species of weed plants, such as knapweed (*Centaurea sp.*), canada thistle (*Cirsium arvense*), burdock (*Arctium minus*) and russian olive. Some of the riparian areas in particular, show extreme grazing impact on the vegetation along the creek, with trampled shrubs, cattle trails, cattle dung, and browsed shrubs.

The objectives of this study included:

1. **Establishing a baseline inventory of large mammals using the Coal Creek riparian area.**
2. **Determining if the culverts under routes 93 and 128 are being utilized as thoroughfares by large mammals.**
3. **Conducting a preliminary study to investigate the impact of habitat fragmentation by routes 93 and 128 on large mammals as they move up and down the Coal Creek riparian area.**

Methods:

I collected data for this study through a series of field surveys conducted from October 10th 2000 through April 30th 2001. I divided the Coal Creek riparian area into eight sections (Figure 1). Each of the first seven sections consisted of a non-linear route that was surveyed by walking up one side of the creek and back down the other side. I defined each section as follows:

1. Section One starts at the far southwest portion of Open Space. This section starts at intersection of Plainview Drive (in Jefferson county) and Coal Creek. The creek flows northeast from here to the boundary of Jefferson County Open Space where this section ends.
2. Section Two is the next northeast parcel of Boulder Open Space, where Coal Creek starts at Jefferson County Open Space and Boulder Open Space boundaries and flows northeast to the Denver Water Board canal. The canal consists of a large aqueduct above ground, which crosses over the top of Coal Creek.
3. Section Three starts at the Jefferson County and Boulder County lines, where Coal Creek is flowing northeast. This section ends where Coal Creek intersects Route 93 at a large culvert running under the road.
4. Section Four starts where Coal Creek runs under Route 93 and proceeds northeast to where it intersects Route 128 at a large culvert running under Route 128.
5. Section Five starts where Coal Creek intersects Route 128 and flows northeast through Boulder Open Space and easement properties. It ends where Coal Creek flows under a small dirt road, through a five foot diameter diversion pipe.
6. Section Six starts on easement property, where Coal Creek runs under a dirt road and continues northeast to a private property fence line. The fence line is well marked as being a private inholding.
7. Section Seven starts on the northeast side of the private inholding fenceline, where Coal Creek flows northeast. It ends where Coal Creek intersects the W. K. Hale Ditch just past the high power wires.
8. Section Eight (Figure 2) consisted of four sets of smaller transect lines along Route 128. Each set of transects consisted one line across the road from each other. I surveyed each transect according to Brower, et al. (1989). Observations were made by walking down each

transect line and looking for tracks that had crossed the road by intersecting the transect lines. The locations of each transect line are as follows:

1. First set of transects - 4/10 of a mile west from Coal Creek on Route 128.
2. Second set of transects - 2/10 of a mile west from Coal Creek on Route 128.
3. Third set of transects - 2/10 of a mile east from Coal Creek on Route 128.
4. Fourth set transects - 4/10 of a mile east from Coal Creek on Route 128.

Both sides of the road were checked for mammal tracks, indicating a road crossing. For sampling methods the Section Eight line transects were a random selection. They were set up this way in order to compare use of the culvert on route 128 with use of random sections along the road, for mammal crossings. Both sides of the road were checked, 15 feet away from the road. Each transect line paralleled the road for 180 feet.

I would try to complete a survey of all eight sections at least once a month. Generally, all eight sections were done twice a month. The sections were not done at regular intervals due to tracking conditions. Snowfall would determine the best conditions to see and identify tracks, so I attempted to do the field work at times after a fresh snow. I also looked for signs and tracks in conditions without snow, since some animal signs (such as bear scat) could be found more easily without snow cover on the ground. The sections were surveyed on a rotating basis so that no section was surveyed more than another. All eight sections were rotated numerically, starting with Section One and going to Section Seven. Section Eight (small transect lines) was done between Sections Four and Five, however, as that was the most convenient time to accomplish it.

Along with the section survey routes, motion sensitive cameras were pointed at the mouth of the culverts going under Routes 93 & 128. The culverts are made of concrete, five and a half to seven feet in height, and have three adjoining sections at each of the highway crossings (Figure 3). The cameras (Figure 4) were used to collect direct evidence of animals using the culverts.

Collection of data in the field consisted of visual observations -- checking both sides of the riparian zone, to 10 meters on both sides -- for tracks, trails, scat, scent markings, browse, dead animals, parts of carcasses, bones, and direct observations of live animals. I would walk each of these riparian survey routes, up one side of the creek and down the other side, and complete each section in one sweep. In sections where the creek braided out into two or more channels, I ensured that all sections of the creek were investigated thoroughly.

An *occurrence*, for the purpose of this study, is defined as one set of evidence at a particular location. For example, one occurrence of porcupine in Section Three could include tracks, browse, and scat at one particular point on the survey route. Another occurrence of porcupine in Section Three could include browse and tracks at a different location on the route. Occurrences do not indicate the number of individuals in a certain section or sections. Occurrences only give an indication of amount of use by a particular species in a given area along the riparian corridor, not the true number of individuals. Where use by a particular species was extremely heavy in a section, I listed the occurrences as greater than or equal to three. For example, coyote tracks found throughout an entire section on a particular day would be marked as greater than or equal to three occurrences for that section.

Film rolls were collected from cameras at the culverts as soon as the camera roll was full. The camera at the route 128 culvert was vandalized midway through the field study, and I was left with only one other camera mounted at the culvert at route 93.

Results:

Coyotes were prevalent on all sections (Figure 6). Coyote occurrences outnumbered all other mammal occurrences combined. Coyote data included tracks (Figures 7 & 8) which were numerous in all sections, along with scat, urine, diggings, trails, direct sightings of live animals, and vocalizations (howling and calling). All direct observations of live coyotes were of adults. Many sightings of live animals were 30 or more feet away from the creek, and were not part of the defined data collection.

Black bear used Section One heavily in October as indicated by the presence of scat (Figures 9 & 10). Black bear sign were also found in Sections Two, Six and Seven (Figure 11). A total of eleven occurrences for black bear were found for all the sections. Much of the black bear scat had hawthorn seeds in it, and lesser amounts of choke cherry seeds and wild plum. Hawthorn is the predominant shrub in all of the sections. There was no evidence that black bear are using the culverts at routes 93 and 128.

Mule deer were not found in abundance (Figure 12), as they are in other parts of Boulder Open Space and Mountain Parks properties. A total of nine occurrences for mule deer were found for all the sections. Mule deer occurrences were indicated by scat, tracks, and direct observations. All direct observations of mule deer were of adults.

Porcupine signs (Figures 13 & 14) were found in Section Three on three separate occasions, and section 4 on one occasion (Figure 15). There were five total occurrences for porcupines in all sections. The occurrences were caused by one individual that I back-tracked to an irrigation pipe, approximately 75 feet from the creek. The animal was using the irrigation pipe as a resting area regularly, as evidenced by the increasing amount of droppings at the entrance to the pipe. Signs included scat, urine, tracks in snow, and browse. Browse occurred frequently on willows in the creek as well as on four different ponderosa pine trees -- two of which had been girdled around the trunks.

Two occurrences of bobcat signs (Figure 16) were found in Section Three. These included two separate scrapes with scat covered in them (Figure 17), as well as good tracks in sand in the creek bed. These were the only evidence of bobcat that I was able to record from any of the surveyed sections.

Raccoon signs were found in three sections (Figure 19). A total of twelve occurrences were found for all the sections. Raccoon signs tended to be sporadic. For instance, I found raccoon occurrences in Sections Three, Six and Seven in November - and then no signs for several months, and only in Section Seven. Signs included tracks in mud and snow (Figure 18). One photo of a raccoon coming out of the culvert under route 93 was taken by the motion-sensitive camera.

Red fox, gray fox, mountain lion, and white-tailed deer signs were all absent from all the sections studied.

The only evidence of culvert use was by raccoons. At the culvert under route 93, two occurrences of raccoon use were recorded -- a photo of the raccoon captured by the motion sensitive camera, and a set of tracks going in one end and out the other. No other evidence of culvert use by any of the other species was collected at either culvert.

There was no evidence that coyotes were using either of the culverts at highway 93 or 128, but tracks indicated they crossed over both highways, sometimes within 100 yards of the culverts. Two occurrences of coyote road crossings were found at route 128, on the same date (2/10/01). Evidence consisted of two separate sets of tracks seen in snow, crossing from one side of route 128 to the other side. Both sets of tracks were found at the first transect line (Figure 2), putting them approximately 4/10 of a mile away from the culvert on route 128. There was insufficient evidence to prove whether the tracks were from the same individual. Although other tracks of mule deer and coyote were found paralleling route 128 on other occasions, no evidence of their having crossed the road was found.

Discussion:

The most noticeable statistic is the number of occurrences of coyote signs in all the sections, outnumbering all other species combined (Figure 20). This is a startling data point. It would imply a large prey base on which the coyotes can feed to support themselves. I found evidence of fairly large populations of smaller mammals along the riparian zone, which are a prey base for some of the larger mammals (coyotes, foxes, bobcats). These included: deer mouse (*Peromyscus maniculatus*), meadow voles (*Microtus spp.*), eastern cottontail (*Sylvilagus floridanus*), northern pocket gopher (*Thomomys talpoides*) and black-tailed prairie dog (*Cynomys ludovicianus*). Large occurrences of coyotes may also indicate that they could be feeding on larger prey species, such as mule deer, which were notably absent or in scant numbers throughout the sections. Evidence in Colorado shows that coyotes will prey on both young and adult deer (Fitzgerald, et. al. 1994). Deer populations in the Coal Creek area may be scarce due to coyote predation.

High coyote numbers may also explain the absence or few occurrences of other predators such as bobcat and red fox. The coyotes compete with these predators for small prey species such as mice and cottontails, and could easily be out-competing the bobcats and red fox, by their sheer numbers. Even if large numbers of individual coyotes are not present in the Coal Creek drainage, the evidence suggests that coyotes are ubiquitous throughout the riparian area and other predators are not. Coyotes could also be limiting the numbers of these species through predation. Coyotes have been known to prey on bobcats, and bobcat populations may be suppressed where coyotes are prevalent (Fitzgerald, et. al 1994).

Coyotes are having a major impact as a top food chain predator simply by the amount of foraging visits along Coal Creek. It is apparent that they use the creek as a travel route (trails along the creek), a foraging area (scrapes and digs near the creek), and as a walkway when frozen in the winter.

Black bear are definitely using the Coal Creek area as a foraging stop in fall. Their numbers are difficult to estimate without further investigation. Occurrences were only recorded from scat samples. There were no direct sightings, nor tracks found to compare sizes of individuals. By scat samples alone, Section One is the most favored area (seven occurrences). There is no direct evidence that the bear(s) are using the riparian area as a direct travel route. They may be coming in from different angles across open space to reach select foraging areas, or they may be following the riparian corridor also. Most of the scat seen contained hawthorn seeds. Since hawthorn (*Crataegus*

erythropoda) is present in all of the study sections, there is reason to believe they may be using the entire riparian corridor as a foraging area in fall. Until more data is collected, it would be hard to conclude what pathways the bears are using. The area may also be a spring foraging area for bears, but since this study is ended in April, no evidence was collected to determine if that is the case.

Three elk were seen above Section Two on one occurrence (Table 2), and were not included as data because they were outside the limits of the defined study area. I found elk sign approaching the creek at the end of Section Two on another occasion, but not close enough to the required 10 meter limit. With the elk activity in the area, it is likely that some of them may be crossing or using the riparian area, either on the Boulder Open Space side of the property or the Jefferson County Open Space side, since the two join in one long continuous section from route 72 east to the water aqueduct (Figure 1).

Section comparisons show interesting trends with indications that the riparian habitat may be affected by highways 128 and 93 in a major way. There were more species found on the southwest side of highways 128 and 93 than on the northeast side. Porcupine and bobcat signs were not found on the northeast side of route 128. The number of species recorded reaches its peak in section 3 (Figure 21), to the west of highway 93. Activity increases again about a mile away from the highways to the east in sections 6 and 7, where coyote occurrences reach a peak. A raw data sheet is included in Table 3 that shows all the occurrences throughout the sections. A discussion of each section follows:

Section One, which is closest to the mouth of Coal Creek near highway 72, shows surprisingly few mammal species (Figure 21). Only black bear, coyote, and mule deer are recorded here. This section is only about ½ mile long and adjoins the Jefferson County Open Space properties. It is heavily grazed and has a dirt road (Plainview Drive) running closely parallel to the creek. Both these factors are likely to affect the number of species and occurrences. The undergrowth is trampled and broken in many places, and cattle trails weave their way in and out of the stream bed. Nonetheless, this has not inhibited the black bear(s) from using the area in the fall.

Section Two is a small ½-mile area sandwiched between Jefferson County Open Space and the Denver Water Board aqueduct, where private property begins. It too is heavily grazed by cattle, and shows broken and trampled shrubs, with lots of cattle dung and trails winding through the riparian area. Only three species' signs were found here (Figure 22) – coyote, mule deer and black bear. There is indication that others may be here also (possibly elk). Occurrences here are low, with coyote having the highest use. This is an isolated small section, away from human activity (excluding cattle) and roads, and shows potential to be a prime area of animal activity. It has dense understory, large trees,

a densely covered ridge to the east, and is bordered on three sides by Jefferson and Boulder open space properties.

Section Three proved to be the most interesting section in terms of numbers of different species (Figure 23). Although it is a little over a quarter of a mile long, it yielded signs of five species, including bobcat and porcupine. The understory is not remarkable, being about the same as most of the other sections, with dense hawthorn thickets, some narrow leaf cottonwoods, and a few scattered ponderosa pine trees. It is bordered to the west by private property and by route 93 to the east. I registered at least 21 occurrences in this area, with coyote being the most numerous. It may be that route 93, with it's large flow of car traffic, is acting as a barrier where species will not or cannot cross. This could explain the "pooling" effect of number of species to the west of route 93 in this small section.

Section Four, sandwiched between highways 93 and 128, shows the least amount of use by different mammal species (Figure 24). Only coyote and porcupine signs were found. Since Section Four is sandwiched between two main thoroughfares, it would be expected to have the least amount of mammal use. Traffic noise is nearly constant during the day, and cars are visible through most of the survey route along the creek. Also, human activity appears to be greatest in this section - people hiking and walking their dogs were encountered several times and domestic dog prints were found in the riparian area frequently. There is no prairie dog activity in this section, lessening the prey base for predators. Cover is good here, with dense understory of wild plum, hawthorn, thick stands of willow, and some wild grape. There are good sections of narrow leaf cottonwood and plains cottonwood. Cattle have recently been fenced out of this area. Despite the good habitat and lack of cattle grazing, the fact of fragmentation by two major highways, human activity, and the closeness of the highways, are probably having a large impact on mammal use.

Section Five is located on the north east side of route 128 and is currently fenced off from cattle use. This is one of the larger sections, extending for almost one mile long. This section offers good cover and plant diversity, some isolation from human activity, and a number of prey items (cottontails, pocket gophers, mice). It incorporates a small cattail and willow marsh where the creek braids out and floods a large flat area. Despite the good habitat it is inconclusive why more mammal sign has not been found in this section. Only coyote and mule deer sign were found. Again, highways 128 and 93 may be acting as a barrier.

Section Six borders Section Five to the southwest and private land to the northeast. It is a bit smaller in size than Section Five and offers more isolation, as it is away from any major thoroughfare.

Some dirt roads run through the area, but mainly stay clear of the creek. It is a more open habitat with a few small stands of plains cottonwood trees and small areas of willow and hawthorn interspersed with mixed grasses. Four species signs were recorded here, with the largest amount of occurrences from coyote (Figure 26). One isolated black bear scat was recorded here along a trail parallel to the creek.

Section Seven is the longest of all the sections extending over one mile. It has some of the thickest areas of plant growth in the Coal Creek study area, with dense stands of hawthorn, wild plum, wild grape, and large plains cottonwood trees. Two occurrences of black bear scat were found out here (Figure 27), which is curious because this area almost reaches the township of Superior, a populated suburb with newly built strip malls, some cattle ranches, and frequent traffic. Coyote used this area heavily throughout the winter months, including using the creek as a walkway when it froze. The dense cover, the fact that it has adjoining prairie dog towns, its large size, and the open space areas to the north and south may all contribute to the mammal activity found here. There is some cattle grazing but it is not as intense as in Sections One and Two. I found little evidence of people entering the area. Most people, such as joggers and dog walkers, keep to the dirt road 100 yards above the riparian corridor. It may be that the fences and dense vegetation are acting as a deterrent, which in turn makes this area more attractive to mammal use.

Although it was not formally included in the study, I did periodic random checks for animal signs along route 93 near the culvert. There was evidence (tracks) of coyote traveling over the road from section 3 to 4, on several occasions. The tracks crossing the road were less than 100 yards south from the culvert on route 93. This observation, coupled with the evidence of the line transects along route 128, indicated that the coyotes showed no inclination to use the culverts in either location during the time of this study. The lack of culvert use by large mammals is currently unexplained. As mentioned earlier, the only evidence of culvert use was by raccoons, and only at the culvert at highway 93. Bear culverts built in Florida are much larger than the culverts in this study, and need a clear view from one side to the other, with vegetation planted along both sides to help guide the animals through (Finch, G. 2000). It may be that larger culverts with more cover are needed for larger animals to use them. Underpasses for animals designed in Banff National Park, Canada, are large but effective, once the animals discover them (Ingram, D.C. 1998), shuttling wolves, coyotes, mountain lions, bears, elk and deer under roads with heavy traffic.

Conclusions and Recommendations:

1. A baseline inventory of large mammal species has been established in the Coal Creek riparian area for the City of Boulder Open Space and Mountain Parks. It includes use by black bear, mule deer, coyote, raccoon, bobcat, and porcupine. Previous observations by members of other study groups and individuals have indicated white-tailed deer and red fox have been present in this study area also (Richardson, C. 2000), but have not been observed during this study.
2. Culvert use was limited to raccoons, and only two occurrences of use by that species were recorded.
3. This study serves as a preliminary investigation of habitat fragmentation caused by highways 128 and 93. The effects of fragmentation on the large mammals using the Coal Creek riparian are inconclusive, but many new questions have been raised and a need for further investigation established.

More precise information on mammal activity along the Coal Creek riparian area is needed to have a better determination of mammal occurrences. To do this, a more intensive, long-term study is needed. Assigning a similar project to two or more people over the course of a full year would gather a greater amount of needed data to answer several questions, such as:

How much use by a specific species along the riparian corridor, changes over the course of a year? Gathering data through the spring and summer would address whether black bear and mule deer begin to use the area more as a seasonal foraging area. For instance, seasonal migrations take place in mule deer to some extent (Armstrong, D. M. 1987) and may explain the lack of deer activity in the study area in fall and winter.

Is fragmentation, due to highways 93 and 128, a deterrent to travel between Section Three and Section Four, (Figure 1)? This question posses a whole series of needed data collection. In order to determine which mammal species are getting across the highways, we would have to examine which of them are actually using the riparian corridor as a habitual travel route. Also, random samplings and point counts throughout the entire area surrounding the riparian corridor would give a broader picture in comparing the mammal occurrences on one side of route 93 and 128 to the other side. This would give us a better idea on how many species are on both sides of the highways, along with a better idea of frequency of occurrence for each species.

Why isn't there more evidence of animals using the culverts? Could larger or more concealed culverts increase their use? I mentioned use of more cameras in different locations in the Discussion section above. Investigation of the Florida bear culverts and large mammal culverts in Washington state and Banff National Park, (Turbak, G. 1999) might lead to a better understanding of what coyotes, bears, mountain lions and other large mammals might need to begin using the culverts along the Coal Creek area. Items that are important are the size and shape of culverts, and good cover and vegetation.

Are the coyotes throughout the area having a detrimental effect on other species such as mule deer and red fox? Or are the coyotes simply being opportunistic? To answer these two questions would be a major study by itself. It could start with analysis of coyote scat samples to see what major food items are being used. From there, many hours of direct observation of how the coyotes are interacting with the other species in the Coal Creek area would be needed to confirm if they are preying on deer, out-competing other predators and/or preying on other predators such as fox and bobcat.

If cattle are kept out of Sections One and Two will large mammal occurrences increase? Will more species be seen using these areas because of this? I made the inference in the Discussion section that both these areas have the potential to have more large mammal use. If shrubs and undergrowth are allowed to regenerate there will be more cover and forage for the mammals, especially mule deer which depend on browse for 73% of their diet (Armstrong, D. 1987).

Time constraints for a field study like this were obvious from the beginning. A more rigorous continuation of this study could allow for section areas to be surveyed on a daily basis. This would allow data to be captured for species such as mountain lion, which are know to have large home ranges and seasonal changes in those ranges (Fiztgerald, J. P., et al. 1981). Missing snow days due to time constraints was also a factor in collecting data. I was not always available to collect data on days after a snowfall and a second person could have proven beneficial, if only to cover more days out in the field so that species activity was captured.

Disappearance of the motion-sensitive camera at route 128 also proved to be a loss, since we do not know what animals may have moved through the culvert there. Likewise, placement of the cameras only covered one side of the culvert. More cameras at the culverts and at strategic areas along the creek might have captured important data.

This study was conducted to help inform management decisions related to the Coal Creek riparian area. It is my recommendation that the Department of Open Space and Mountain Parks use

the findings of this investigation as a guide for continued riparian mammal studies, and that more aggressive and comprehensive studies continue for the goal of restoring Coal Creek into a more ecologically sound wildlife habitat.

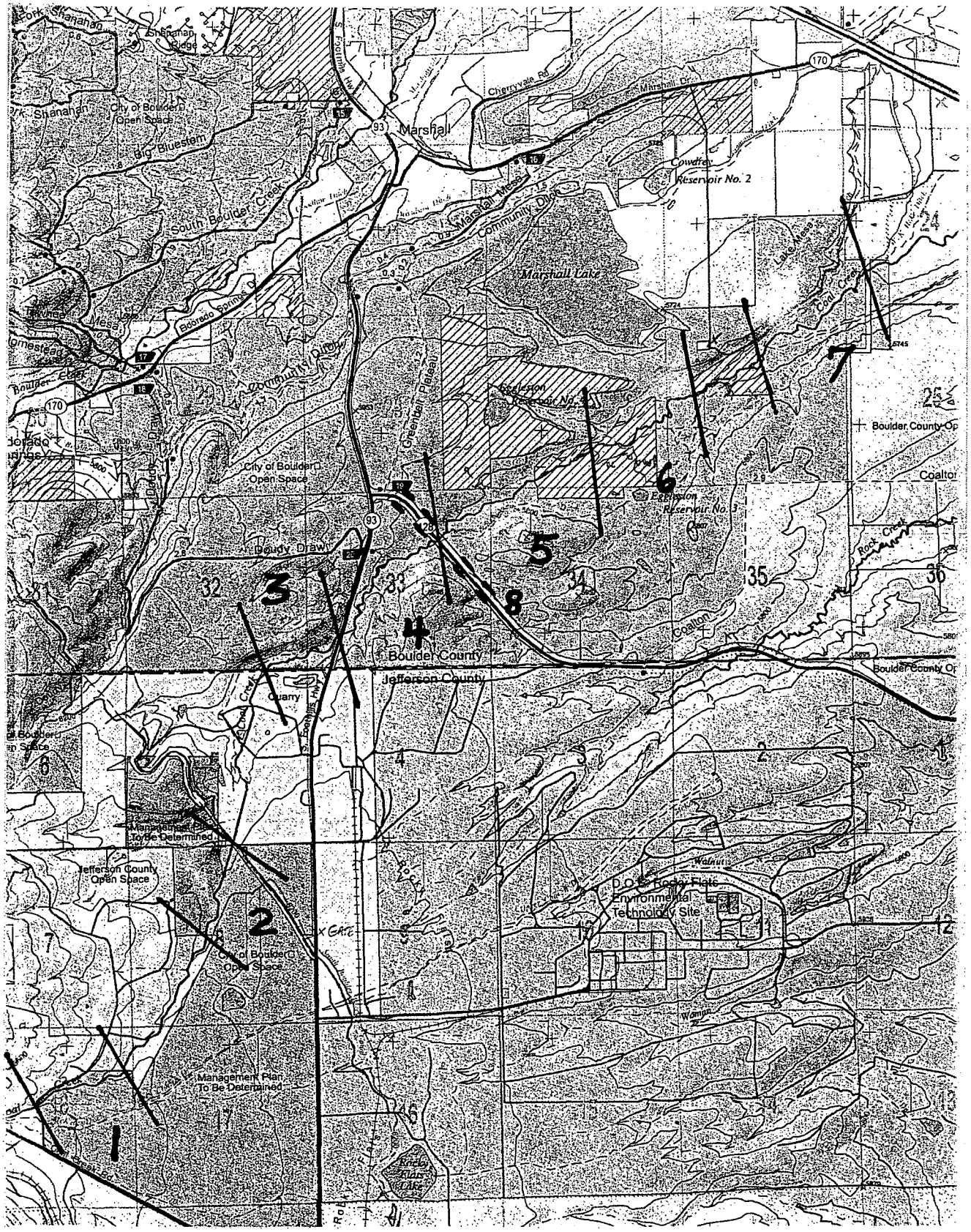


Figure 1. Locations of sections in the Coal Creek study area.

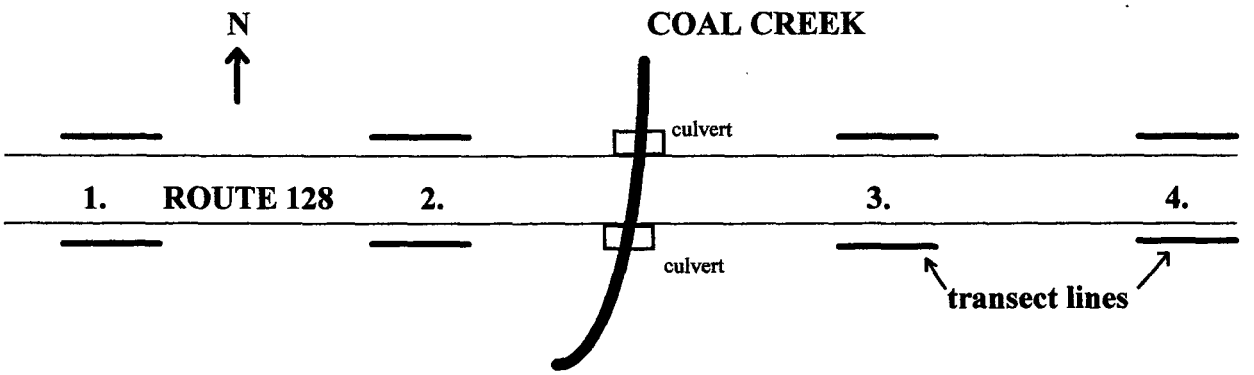


Figure 2. Section Eight transect line locations, from culverts along route 128 (not to scale).

Figure 3. Culvert at highway 128.

Figure 4. Motion-sensitive camera mounted on post at culvert location by highway 128.

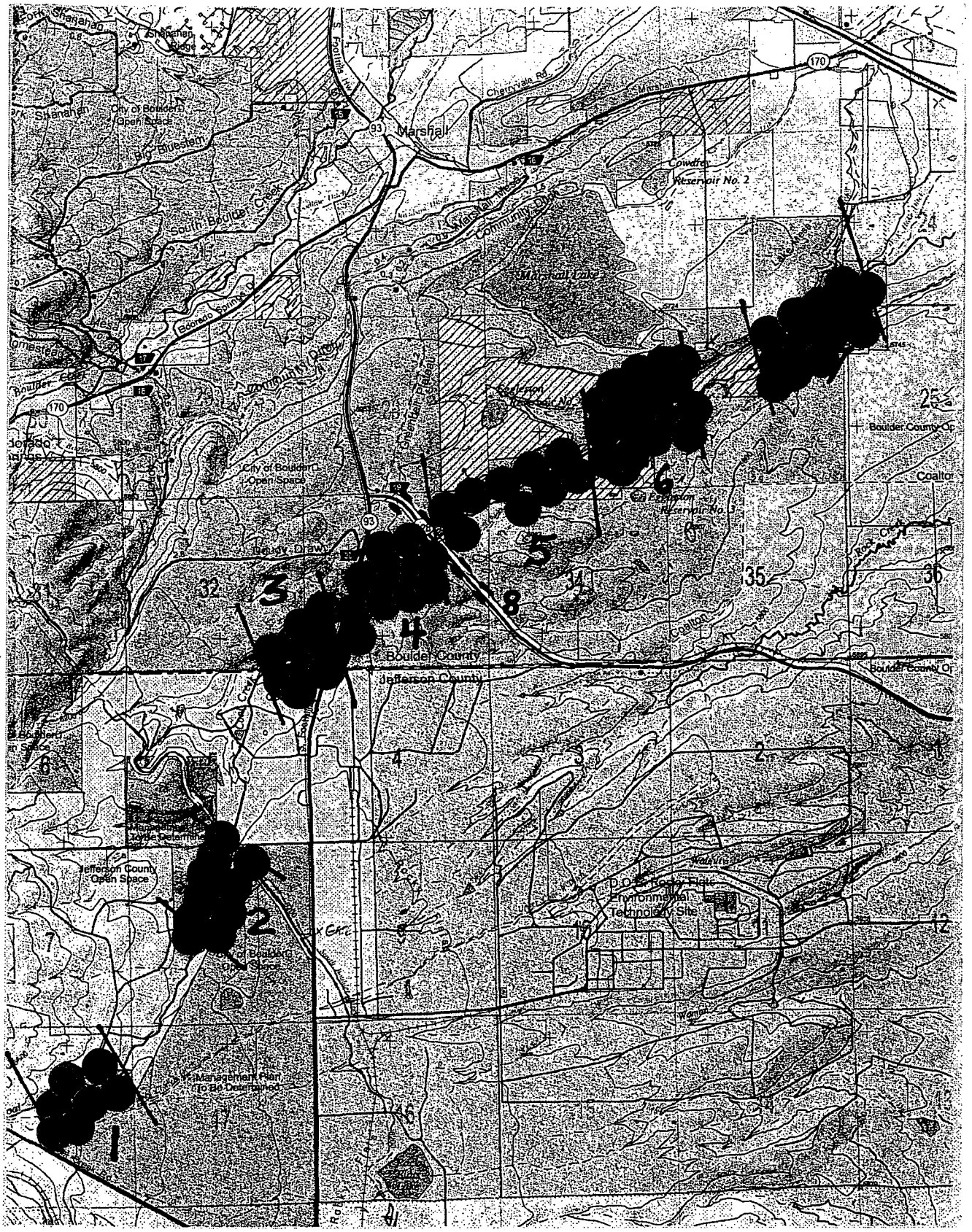


Figure 6. Coyote occurrences across all sections of the study area.

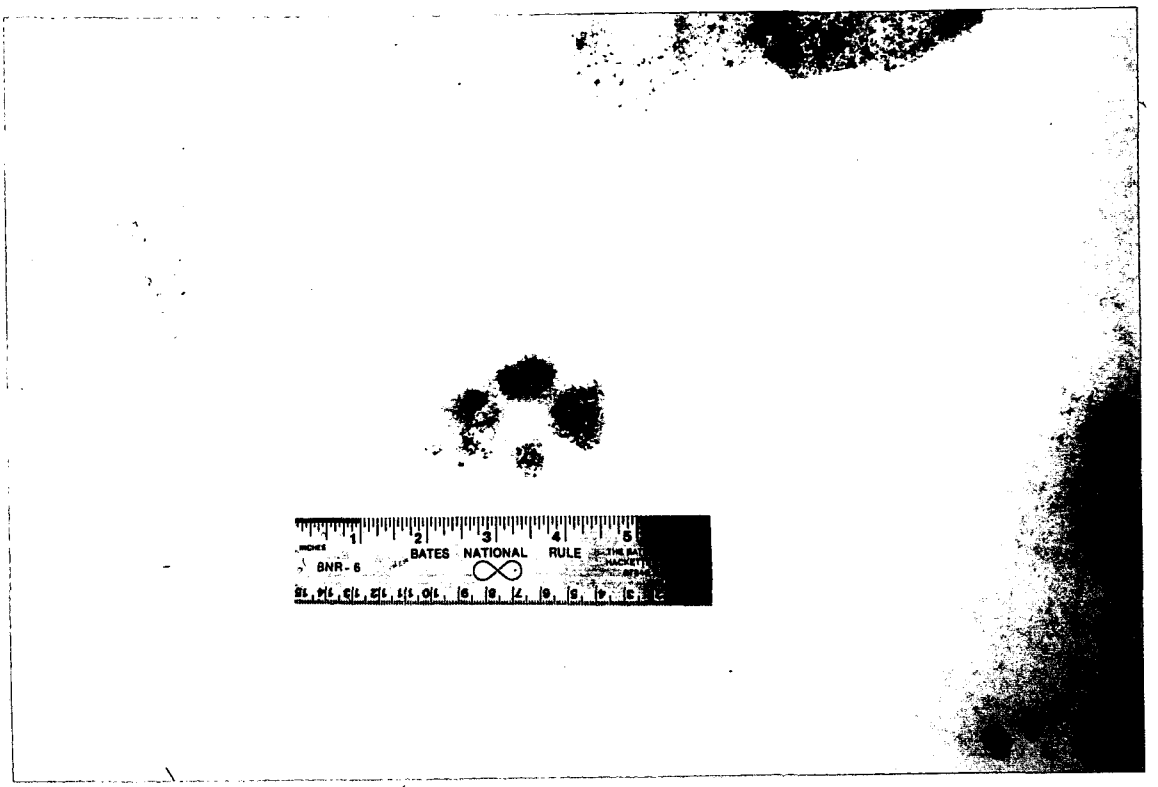


Figure 7. Coyote track found in section 7 in the creek bed.

Figure 8. Coyote tracks as evidence of use of the frozen creek as a walkway during mid-winter. Photo taken at Section Seven.

Figure 9. Black bear scat found in Section One.

Figure 10. Black bear scat found in Section One. Most of the visible seeds in the scat are from hawthorn (*Crataegus erythropoda*)

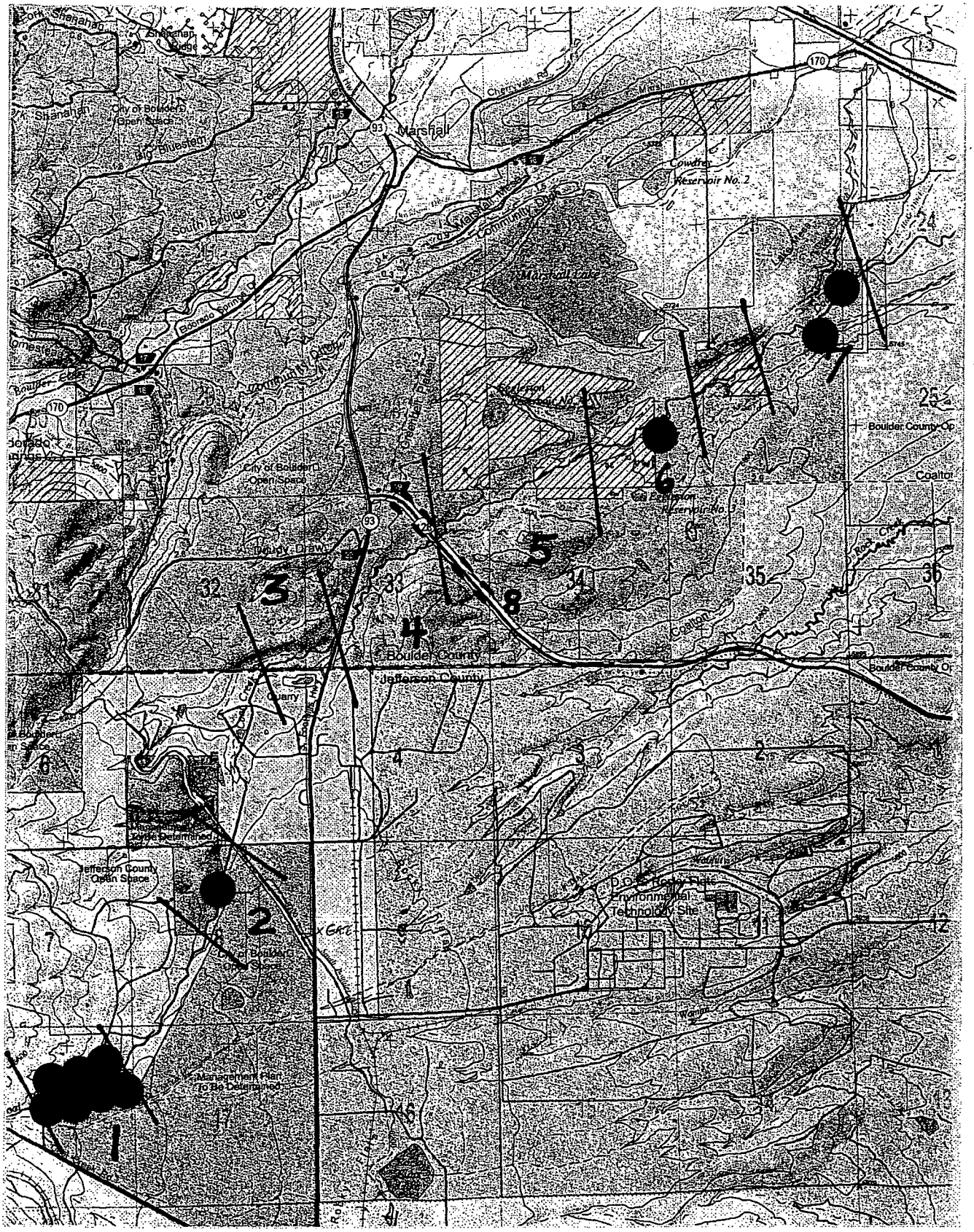


Figure 11. Black bear occurrences across all sections of the study area.

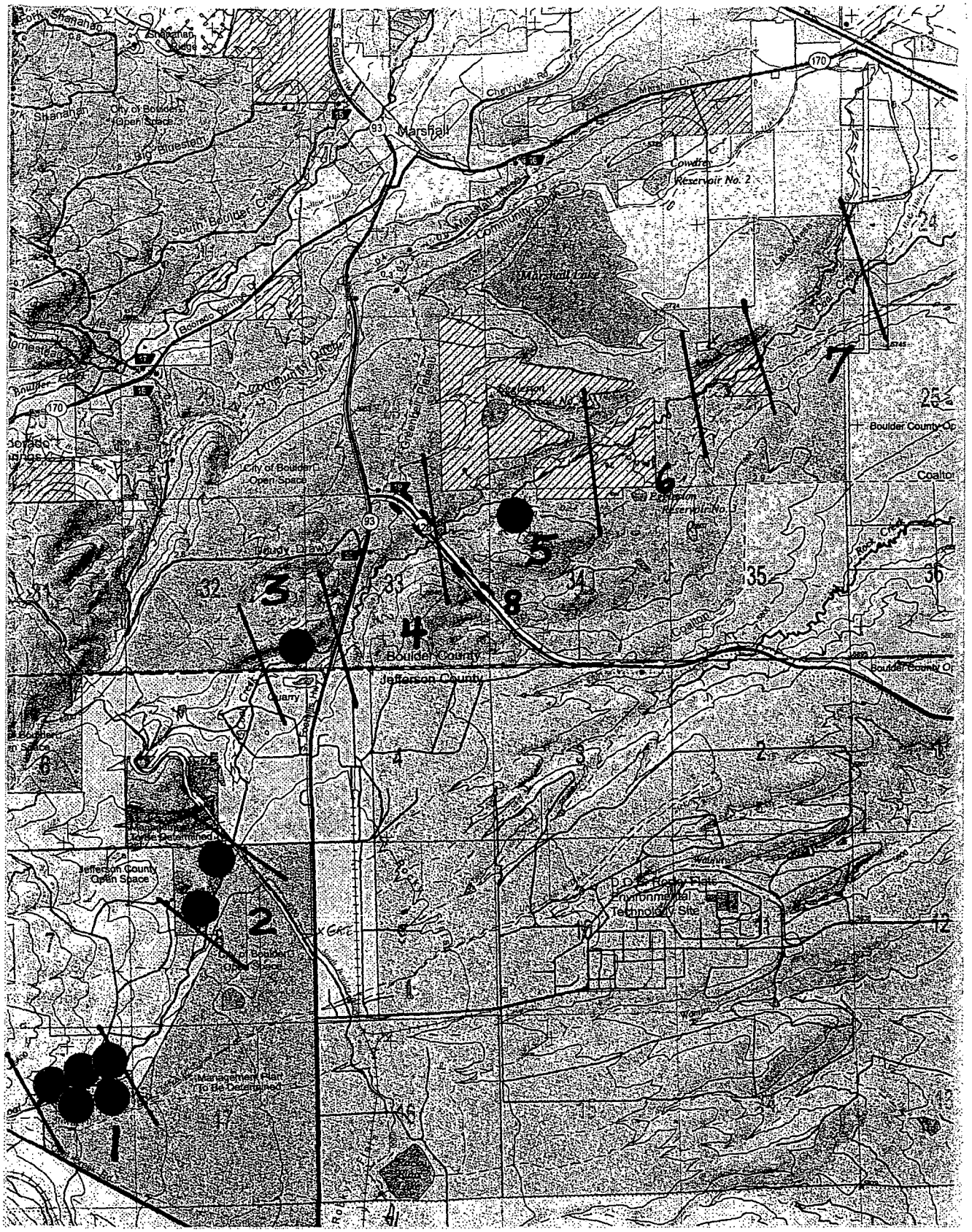


Figure 12. Mule deer occurrences across all sections of the study area.

Figure 13. Porcupine browse on willow and tracks in the creek found in Section Three.

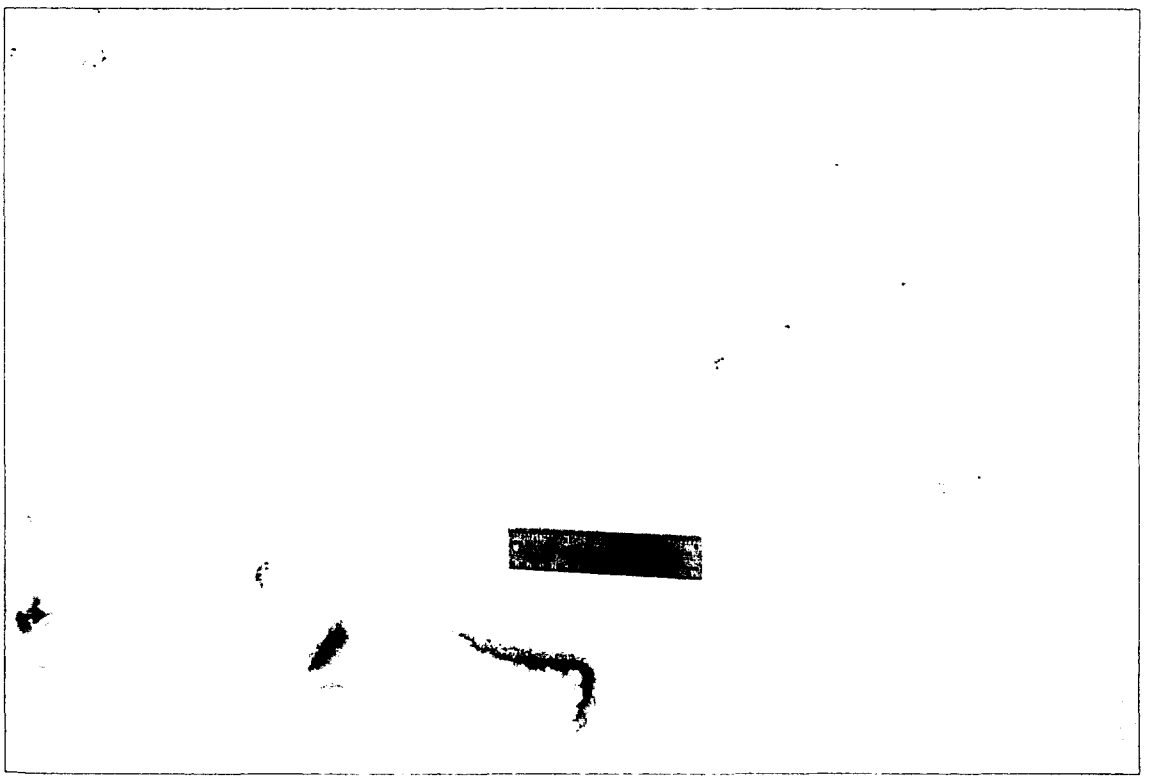


Figure 14. Porcupine tracks in the creek in Section Three.

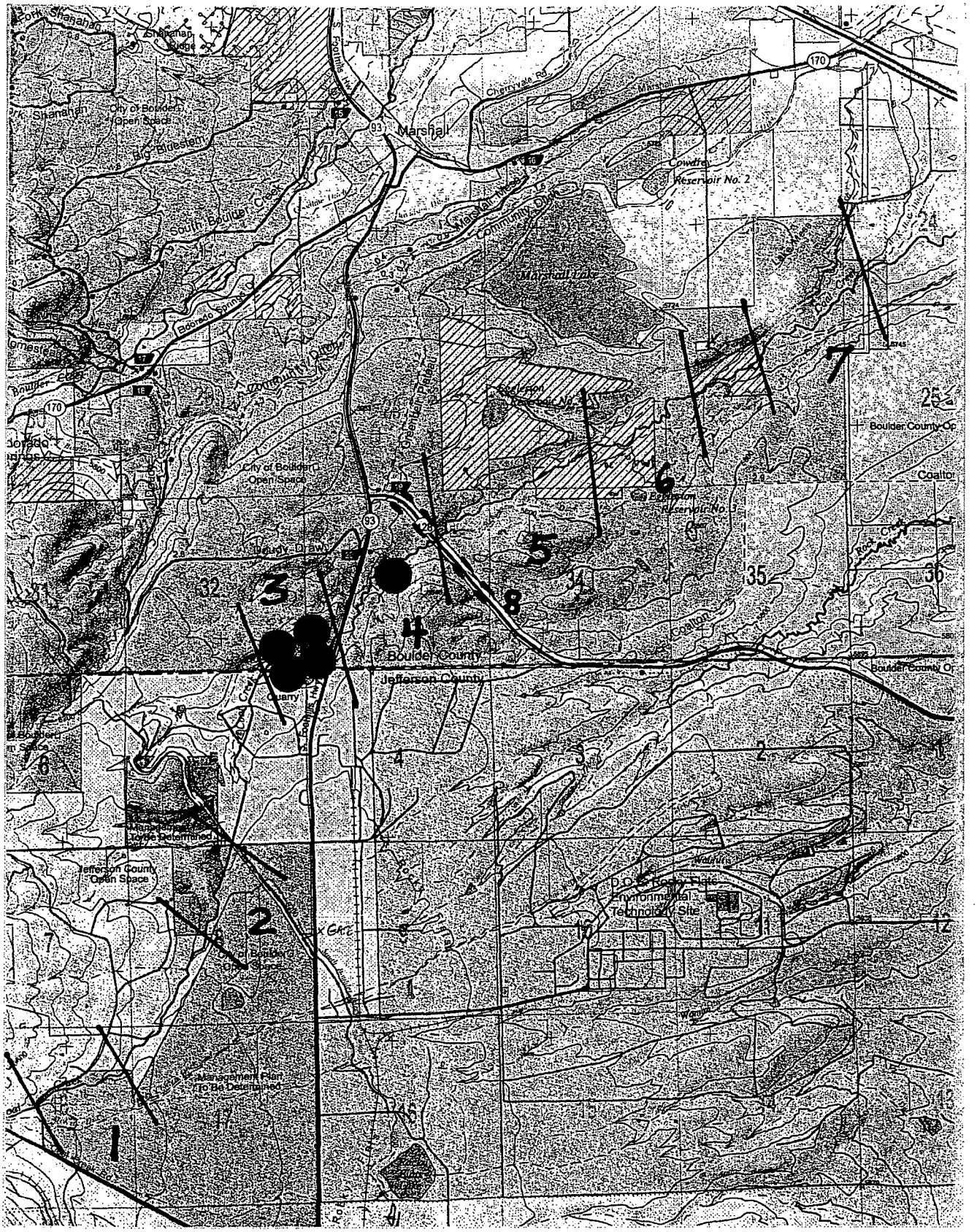


Figure 15. Porcupine occurrences across all sections of the study area.

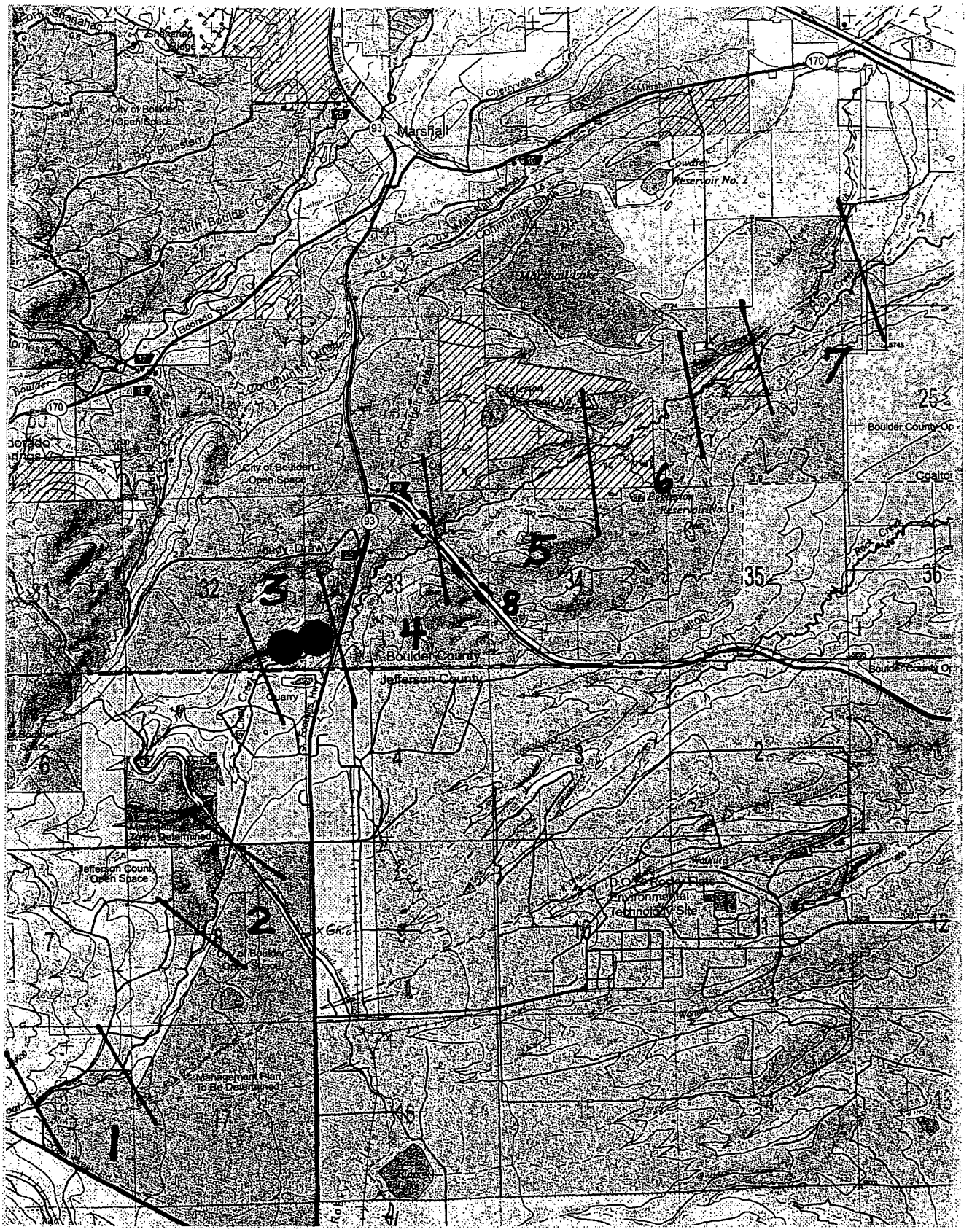


Figure 16. Bobcat occurrences across all sections of the study area.

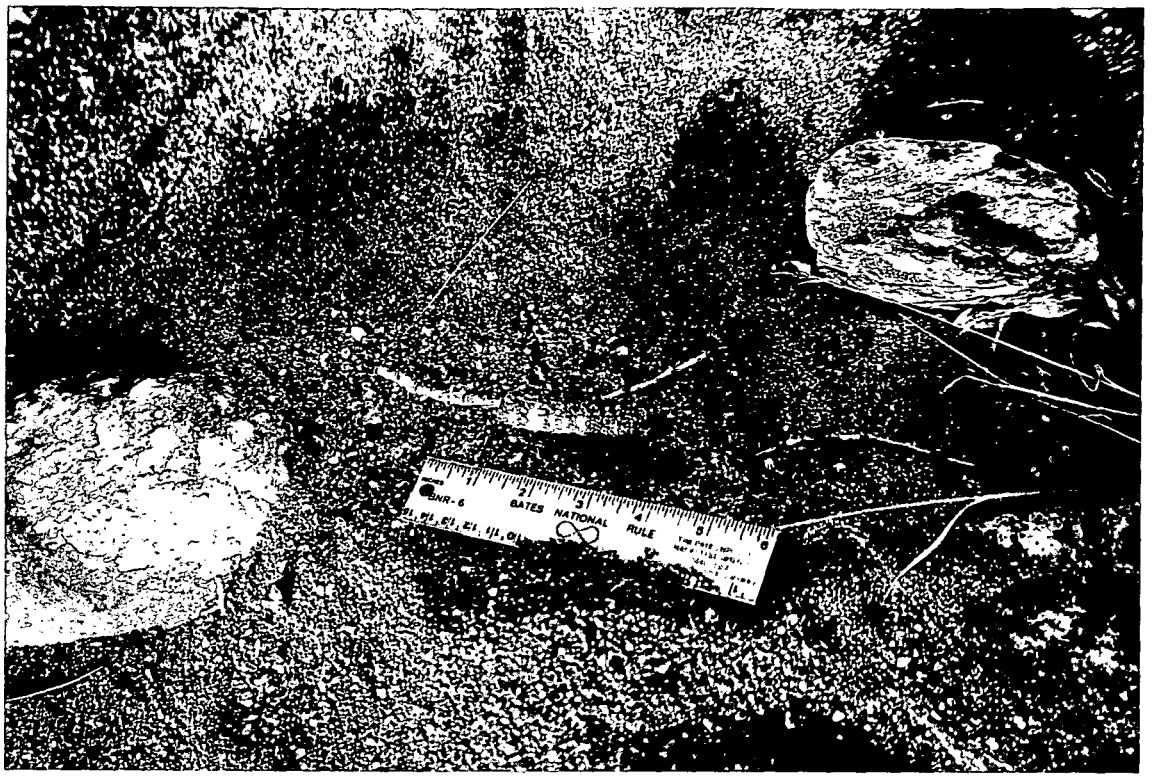


Figure 17. Bobcat scrape and scat found in the creek bed in Section Three.

Figure 18. Raccoon tracks coming out of the culvert at route 93, in Section Four.

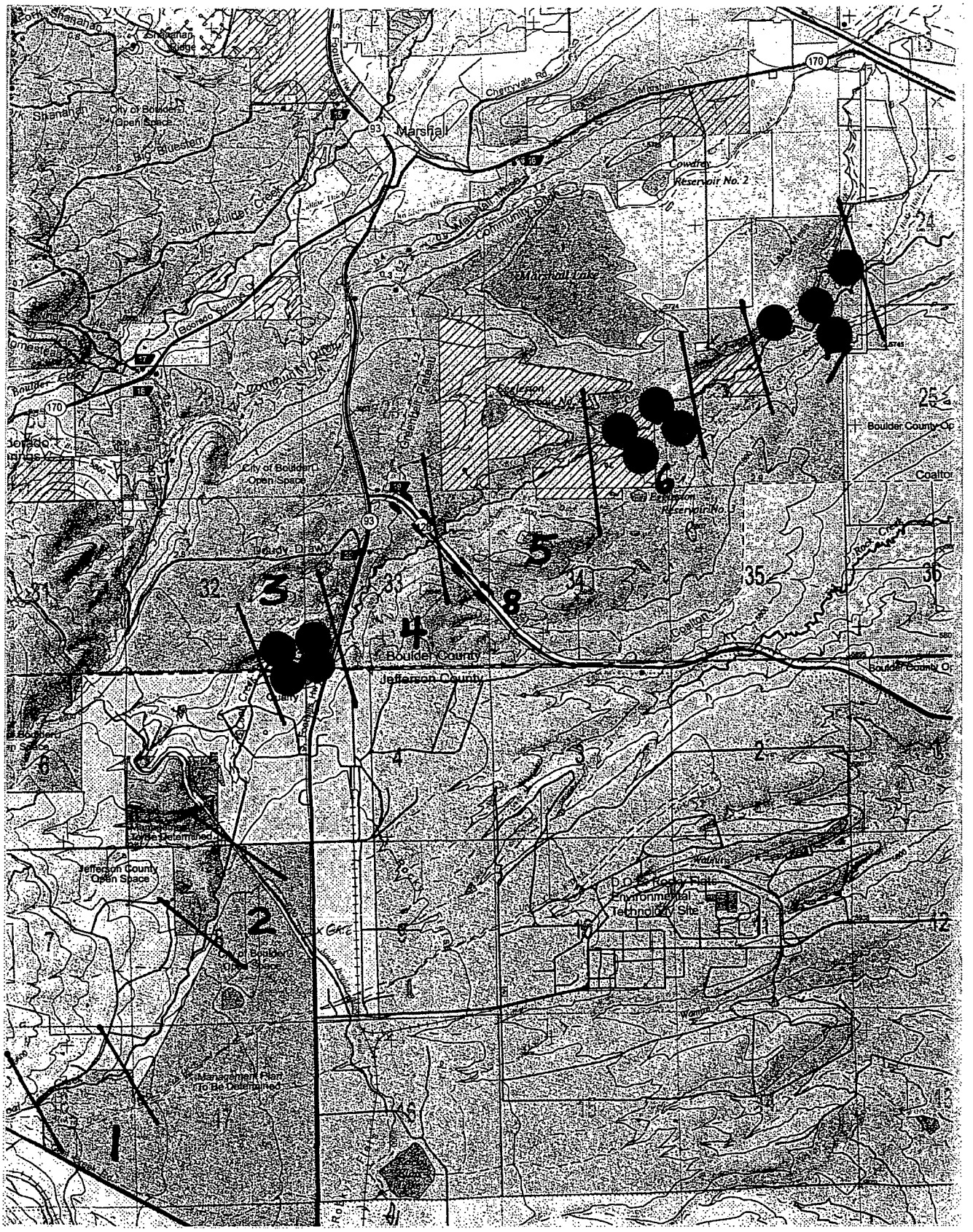


Figure 19. Raccoon occurrences across all sections of the study area.

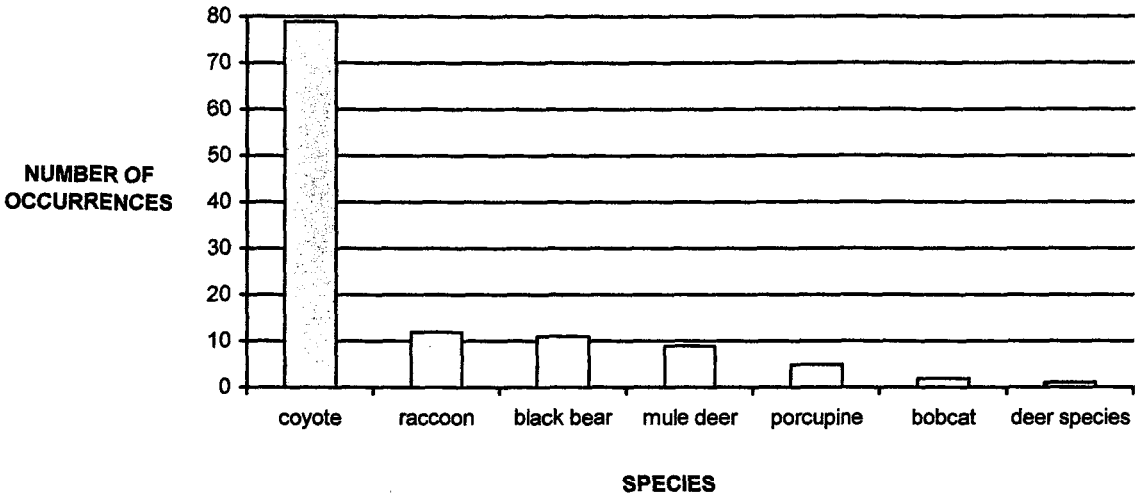
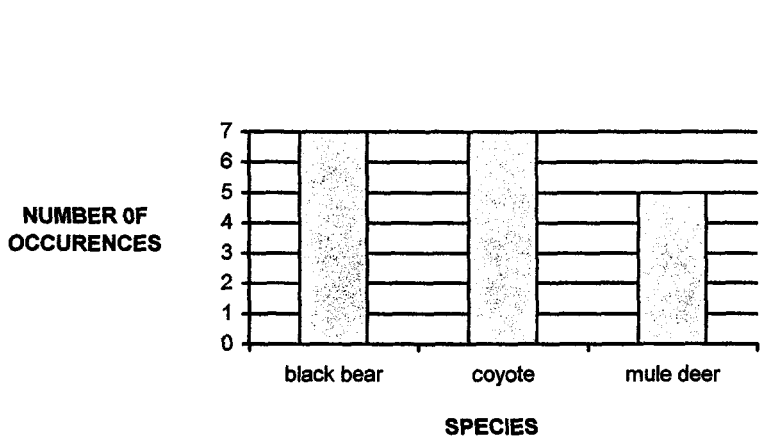


Figure 20. Total mammal occurrences across all sections. This does not include data from Section Eight transect lines.



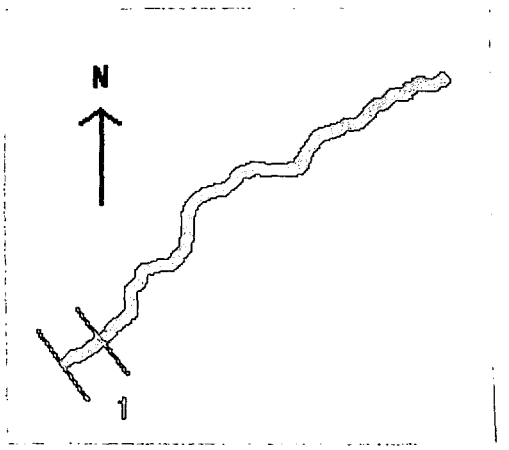
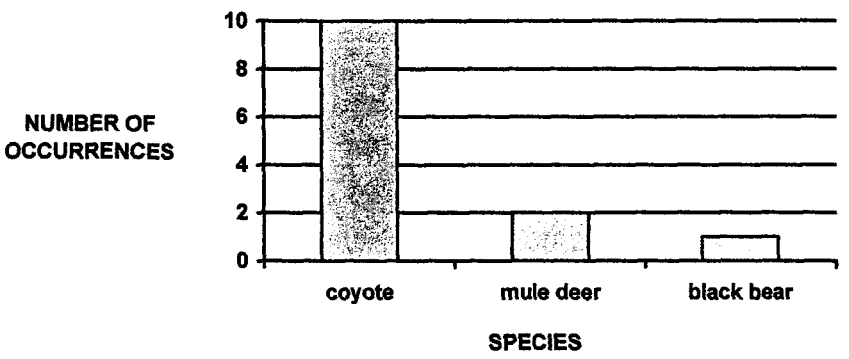


Figure 21. Section One occurrences for each mammal species found.



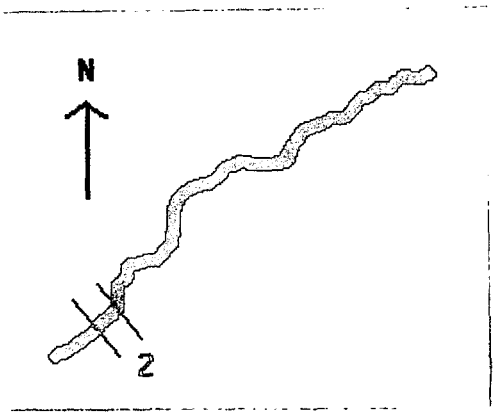


Figure 22. Section Two occurrences for each mammal species found.

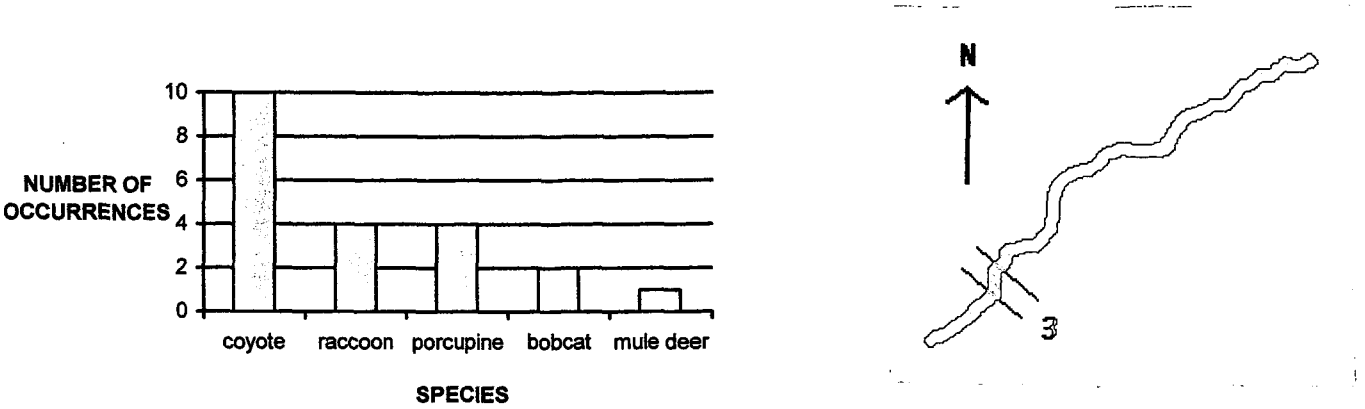


Figure 23. Section Three occurrences for each mammal species found.

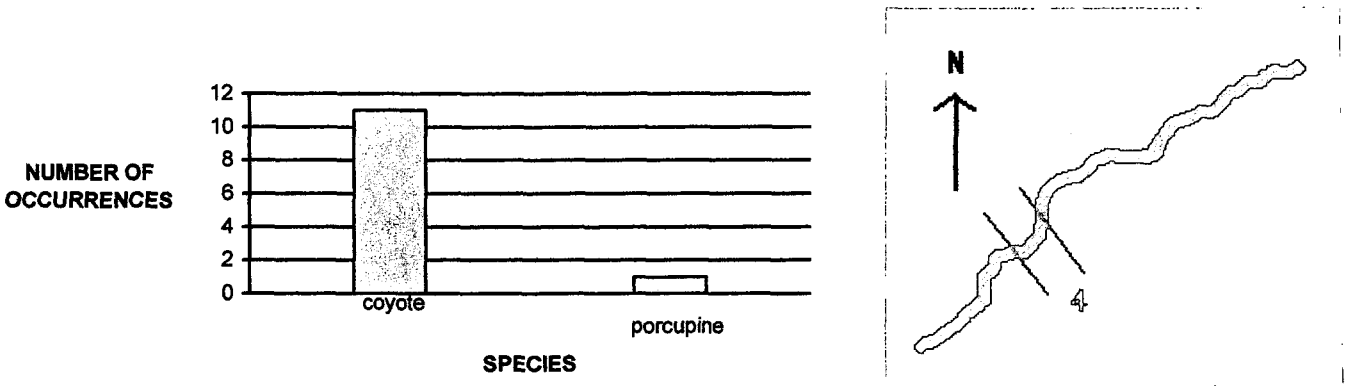


Figure 24. Section Four occurrences for each mammal species found.

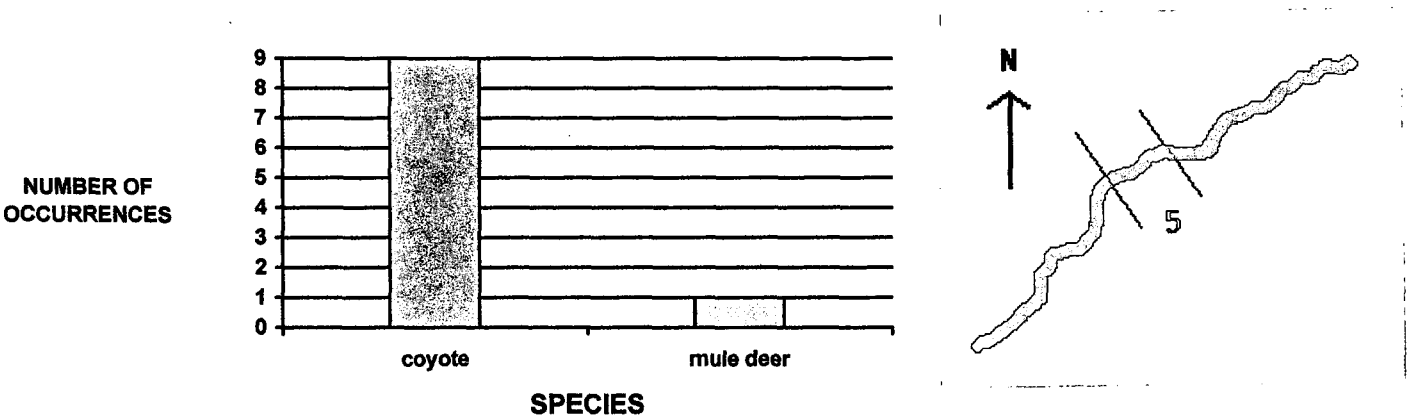


Figure 25. Section Five occurrences for each mammal species found.

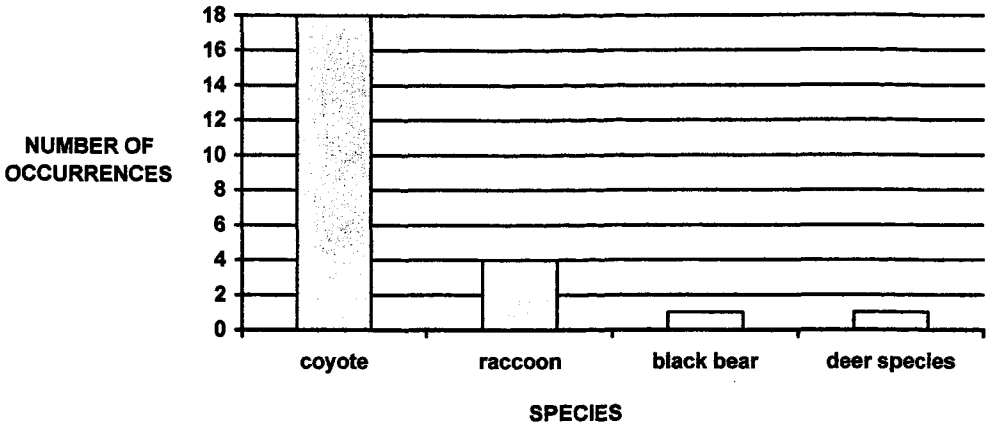


Figure 26. Section Six occurrences for each mammal species found.

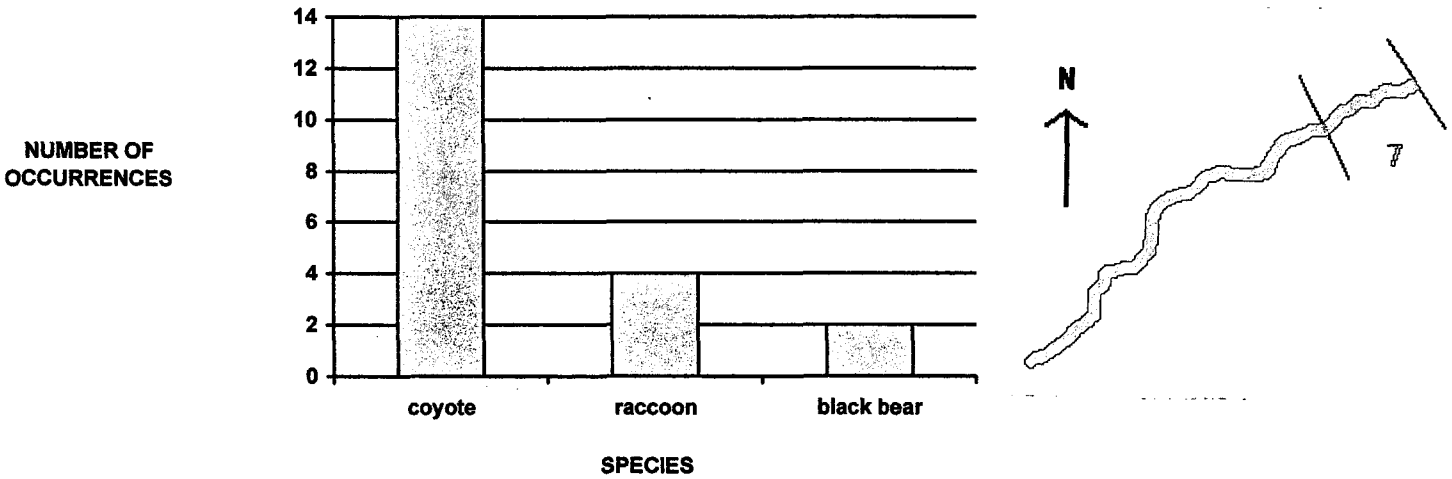


Figure 27. Section Seven occurrences for each mammal species found.

Table 1. Targeted mammal species for this study.

Common name	Scientific name
black bear	*Ursus americanus*
mule deer	*Odocoileus hemionus*
white-tailed deer	*Odocoileus virginianus*
elk	*Cervus elaphus*
mountain lion	*Felis concolor*
bobcat	*Felis rufus*
red fox	*Vulpes vulpes*
gray fox	*Urocyon cenereoargenteus*
coyote	*Canis latrans*
porcupine	*Erethizon dorsatum*
raccoon	*Procyon lotor*

Table 2. Recorded mammal signs found near particular sections that were outside the defined parameters for the study (i.e. further than the 10 meter limit from either side of the creek).

Species	Near section	Date	Type of sign	Number of occurrences
mule deer	3	10/12/00	direct observation	1
mule deer	2	11/02/00	direct observation	1
coyote	5	10/19/00	direct observation	1
coyote	7	10/26/00	direct observation	2
coyote	1	10/31/00	direct observation	1
coyote	2	11/02/00	direct observation	1
coyote	3	12/06/00	direct observation	1
coyote	6	12/25/00	direct observation	1
coyote	8	02/10/01	tracks	3
coyote	6	03/11/01	direct observation	1
coyote	7	04/07/01	direct observation	1
porcupine	3	01/28/01	scat, browse	1
porcupine	3	03/04/01	scat, browse	1
porcupine	3	03/25/01	scat, browse	1
elk	2	03/25/01	direct observation	1

Table 3. Collected data totals for Sections One through Seven.

Species	Location	Date	Type of observation	# of occurrences
black bear	Section 1	10/10/00	scat	7
black bear	Section 2	10/11/00	scat	1
black bear	Section 6	10/24/00	scat	1
black bear	Section 7	11/23/00	scat	2
bobcat	Section 3	3/4/01	scat/scrapes	2
coyote	Section 1	11/23/00	tracks	3
coyote	Section 1	1/27/01	tracks	3
coyote	Section 1	4/14/01	tracks	1
coyote	Section 2	11/24/00	tracks	3
coyote	Section 2	1/27/01	tracks	3
coyote	Section 2	3/25/01	scat	1
coyote	Section 2	4/14/01	tracks	1
coyote	Section 2	4/14/01	tracks	1
coyote	Section 2	4/14/01	tracks	1
coyote	Section 3	12/6/00	tracks	3
coyote	Section 3	1/28/01	tracks	3
coyote	Section 3	3/4/01	tracks	3
coyote	Section 3	3/25/01	tracks	1
coyote	Section 4	11/11/00	tracks	3
coyote	Section 4	11/25/00	tracks	1
coyote	Section 4	11/25/00	scat	1
coyote	Section 4	12/17/00	tracks	3
coyote	Section 4	1/28/01	tracks	3
coyote	Section 5	11/11/00	tracks	3
coyote	Section 5	12/17/00	tracks	1
coyote	Section 5	2/10/01	tracks	3
coyote	Section 5	3/31/01	tracks	2
coyote	Section 6	10/24/00	direct observation	1
coyote	Section 6	11/23/00	scat	2
coyote	Section 6	11/23/00	tracks	3
coyote	Section 6	11/26/00	scat	2
coyote	Section 6	12/25/00	scat	1
coyote	Section 6	2/10/01	tracks	3
coyote	Section 6	2/10/01	heard howling	3
coyote	Section 6	3/11/01	tracks	3
coyote	Section 7	11/23/00	tracks	3
coyote	Section 7	11/26/00	scat	1
coyote	Section 7	11/26/00	tracks	1
coyote	Section 7	1/27/01	tracks	3
coyote	Section 7	3/3/01	tracks	1
coyote	Section 7	3/3/01	direct observation	1

Table 3 continued: collected data totals for Sections One through Seven.

Species	Location	Date	Type of observation	# of occurrences
coyote	Section 7	3/11/01	tracks	3
coyote	Section 7	4/7/01	direct observation	1
deer species	Section 6	10/24/00	bones / carcass	1
mule deer	Section 1	4/14/01	tracks	1
mule deer	Section 1	4/14/01	tracks	1
mule deer	Section 1	4/14/01	tracks	1
mule deer	Section 1	4/14/01	tracks	1
mule deer	Section 1	4/14/01	scat	1
mule deer	Section 2	11/2/00	direct observation	1
mule deer	Section 2	11/24/00	tracks and scat	1
mule deer	Section 3	11/24/00	tracks	1
mule deer	Section 5	10/19/00	carcass	1
porcupine	Section 3	1/28/01	tracks/browse	1
porcupine	Section 3	3/4/01	browse	1
porcupine	Section 3	3/25/01	browse	1
porcupine	Section 3	4/14/01	browse	1
porcupine	Section 4	4/15/01	browse	1
raccoon	Section 3	11/24/00	tracks	1
raccoon	Section 3	11/28/00	tracks	3
raccoon	Section 6	10/24/00	skull	1
raccoon	Section 6	11/23/00	tracks	3
raccoon	Section 7	11/23/00	tracks	3
raccoon	Section 7	4/7/01	tracks	1

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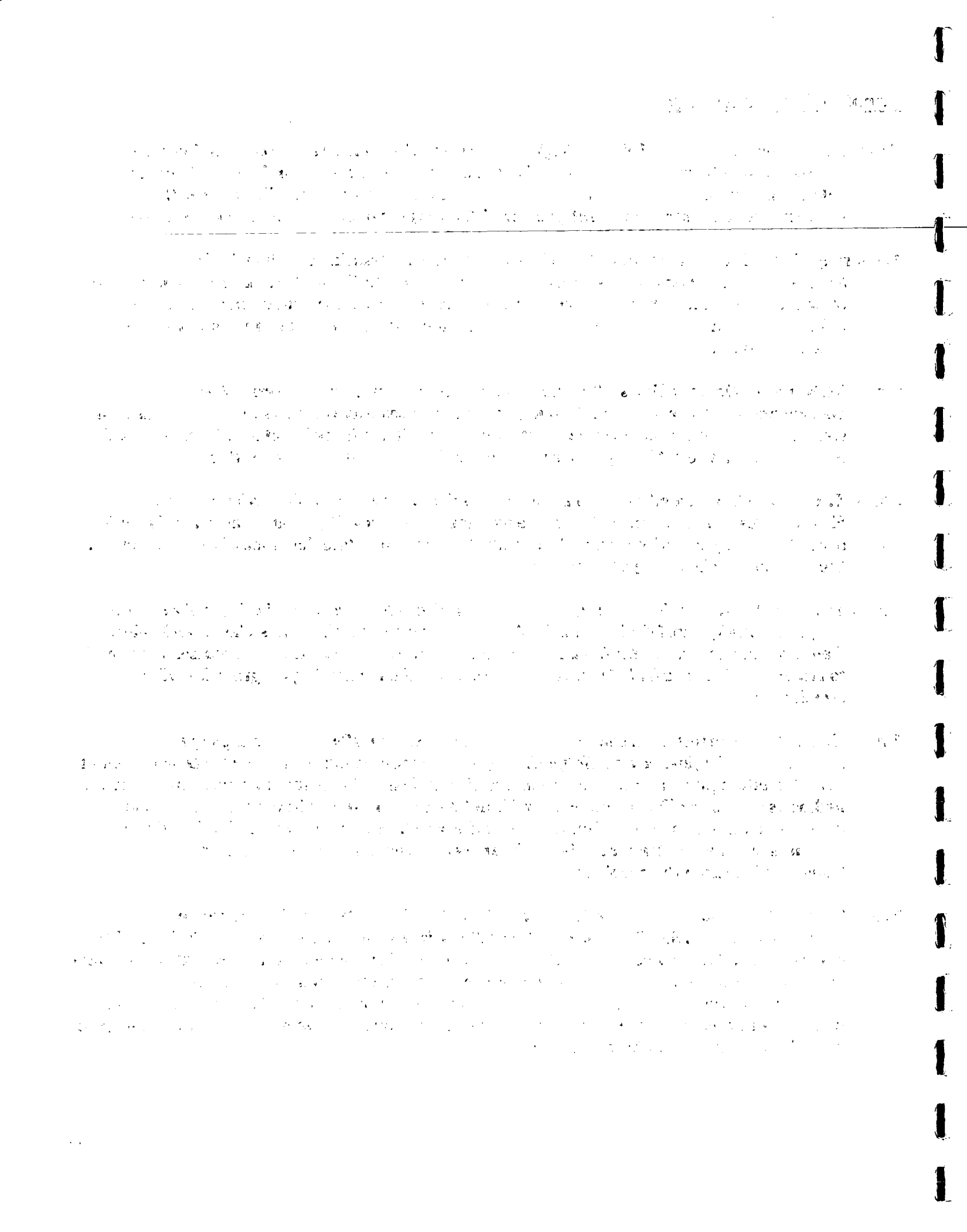

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