# MONITORING ANIMAL USE OF MODIFIED DRAINAGE CULVERTS ON THE LOLO SOUTH PROJECT

FHWA/MT-01-004/8117-15

*Final Report*

*prepared for*
THE STATE OF MONTANA

*in cooperation with*
THE U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

*November 2001*

*prepared by*
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**Final Report For:**

# Monitoring Animal Use of Modified Drainage Culverts on the Lolo South Project

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**October 22, 2001**

TECHNICAL REPORT DOCUMENTATION PAGE

| | | |
|---|---|---|
| 1. Report No. **FHWA/MT-01-004/8117-15** | 2. Government Accession No. | 3. Recipient's Catalog No. |
| 4. Title and Subtitle **Monitoring animal use of modified drainage culverts on the Lolo South Project.** | 5. Report Date **September 2001** | |
| | 6. Performing Organization Code | |
| 7. Author(s) **Kerry R. Foresman** | 8. Performing Organization Report No. | |
| 9. Performing Organization Name and Address **University of Montana Missoula, Montana 59812** | 10. Work Unit No. | |
| | 11. Contract or Grant No. **8117-15** | |
| 12. Sponsoring Agency Name and Address **Research, Development, & Technology Transfer Program Montana Department of Transportation 2701 Prospect Avenue PO Box 201001 Helena MT 59620-1001** | 13. Type of Report and Period Covered **Final January 2001-September 2001** | |
| | 14. Sponsoring Agency Code **5401** | |

15. Supplementary Notes **Research performed in cooperation with the Montana Department of Transportation and the US Department of Transportation, Federal Highway Administration.**

16. Abstract A highway reconstruction project is currently underway in west-central Montana expanding Hwy 93 from 2 lanes to 4 over a distance of approximately 45 miles. Portions of this highway bisect wetlands which support a variety and abundance of wildlife. As one wildlife mitigation approach 3 drainage culverts were modified to encourage movement between fragmented wetlands. Metal shelves were installed to allow animal movement during periods of high water. The current project evaluated the effectiveness of these shelves.

Six culverts were studied, 3 with shelves (experimentals) and 3 without (controls), from January to September, 2001. Passive infrared TrailMaster® cameras were mounted on the roof of each culvert 15 m from one entrance. Cameras were positioned so that mammals traversing culverts either on the floor or on shelves would be photographed. Cameras were checked weekly and film was replaced as needed. Each month small mammal populations adjacent to each culvert were censussed using Sherman® live traps. Habitat characteristics adjacent to each entrance were described. This experimental design provided data on which mammal species were present and which were using culverts to move between wetland sites. Seasonal use and use of shelves during high water were assessed.

Trapping identified 7 mammal species adjacent to culverts; of these, photographs demonstrated culvert use by deer mice, skunks, short-tailed weasels, muskrats, raccoons, and domestic cats. During wet periods smaller species (e.g., deer mice, short-tailed weasels) used the shelves.

Tentative conclusions suggest that several species readily use shelves when water would otherwise prevent movement. However, movement occurs along the solid frame supporting the shelf rather than over the floor surface. Meadow voles, though abundant close to culverts, fail to use them suggesting a barrier effect. Species presence is clearly affected by vegetative characteristics at these sites.

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| 17. Key Words **modified drainage culvert, mammals** | | 18. Distribution Statement **Unrestricted. This document is available through the National Technical Information Service, Springfield, VA 21161.** | |
| 19. Security Classif. (of this report) **Unclassified** | 20. Security Classif. (of this page) **Unclassified** | 21. No. of Pages **21** | 22. Price |

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**Introduction**

This is the final report for research which was begun in January, 2001 summarizing an 8 month pilot project along the Lolo South Project from Lolo to Florence, Montana. When highways bisect wetland habitats small diameter culverts are often used to provide drainage so that water does not erode the roadbed. During periods when these drainage culverts carry water animal use is prohibited. In order to provide a travel corridor for small animals under the highway during periods of high water, ramp/shelf structures were mounted inside such drainage culverts. The stated goals of this research were to compare small mammal use of drainage culverts with (experimental) and without (control) these animal walkways (Fig. 1). Animal activity in 3 paired sets of culverts (Fig. 2) was monitored on a daily basis using roof-mounted remote sensing cameras (TrailMaster®). Animal populations adjacent to the culverts were assessed by live

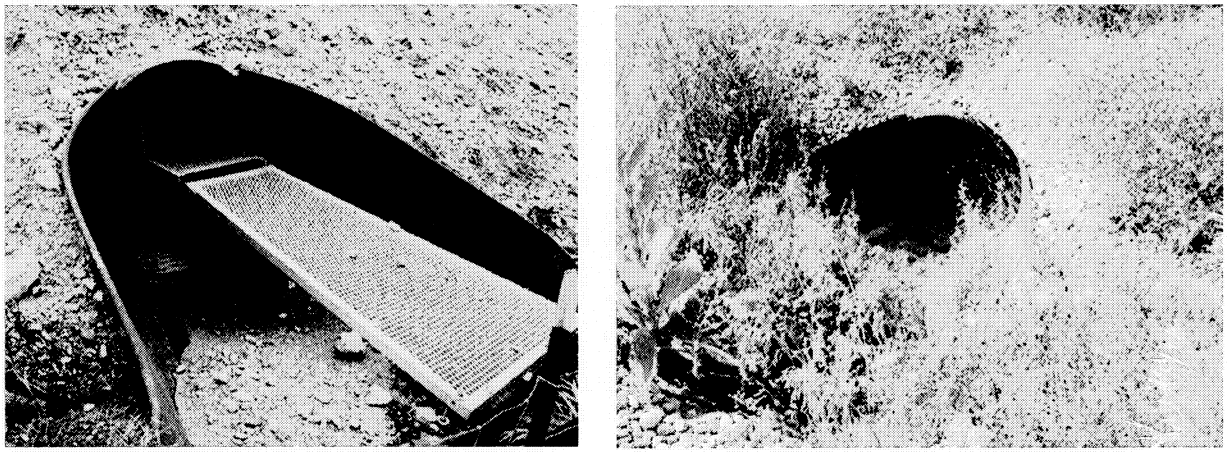

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Figure 1. (a) Example of a culvert containing a ramp/shelf animal walkway (Carleton Creek experimental), and (b) one not containing a walkway (Carleton Creek control).

trapping along transect lines (Sherman traps) so that a comparison could be made between the species actually using each culvert and those present. Activity patterns were assessed on a temporal basis as well as in correlation with temperature, light, and humidity levels. Such an approach allowed for an analysis of seasonal variation in animal presence and activity patterns. Vegetative changes between spring and summer were also noted at each culvert.

Two additional companion projects were initiated by undergraduate students during the middle of the summer, following their successful grant efforts. One student began a study to determine how the shelf surface may affect small animal use and the second began a more detailed study on the use of culverts by short-tailed weasels (*Mustela erminea*) through the use of radiotelemetry. These students will be conducting their research throughout the fall of 2001; reports will be submitted once these projects are completed.

It should be recognized that this project was conducted while construction efforts were being completed. Throughout the spring and early summer considerable activity occurred along the areas adjacent to the highway in order to prepare the grounds for grading and reseeding. The lands west of the highway were more greatly disturbed (it was in this direction that lane expansion


a

Figure 2. Paired culverts spaced along U.S. Highway 93 between Lolo and Florence, Montana (this page and following two pages) (a) Overview of study sites, and closeup (b,c, & d) images of individual pairs illustrating placement of trap transects.

b


c


[refer to figure legend page 1 above]

d


[refer to figure legend on page 1 above]

occurred since railway tracks lay to the east) and thus had little if any ground cover during most of the study. Ramps were adjusted during the middle of the summer and the plastic sheeting used to limit erosion and highway runoff were reestablished during this time. All of these activities were beyond the control of this researcher and the results will be interpreted with these in mind.

**Results**

**Culvert Use**

During the period from January 15th to August 23rd, a total of 485 photographs were obtained of animals in or at the entrance to the 6 culverts (Table 1). Three hundred eighty-eight photographs within the culverts were obtained, 210 in experimental culverts and 178 in the controls. An additional 47 photographs were obtained at the entrance to a culvert, which was 3/4 filled with ice during the winter and spring and then remained filled to this level during the spring melt (McKlay Creek experimental). During the period that this water was frozen, the culvert remained accessible and all external observations made during this period were thought to have resulted in animal movement through this particular culvert. A camera could not be mounted inside during this period due to the ice, but the raccoons observed at the entrance were obviously moving into the culvert and plenty of space was available for their passage. A camera was moved inside this culvert when the ice melted but the shelf remained under approximately 6 inches of water throughout the study. An additional 45 photographs were obtained of animals (often multiple animals) at the entrance to the sixth culvert (McKlay Creek control), which was inaccessible due to free-standing ice/water levels throughout the study. A total of 5 species (4 wild and 1 domestic) were documented using the experimental culverts; 6 species (5 wild and 1

domestic) were observed using the controls (Table 1). One additional culvert north of the Gravel Pit experimental culvert was monitored by camera throughout the study, though it was not included in the analyses because it was much larger (approximately 5 feet in diameter) and did not contain a ramp/shelf. Two additional species, the Columbian ground squirrel (*Spermophilus columbianus*) and a bat (most likely the big brown bat, *Eptesicus fuscus*) were observed using this culvert (Appendix I).

The purpose of the animal walkways is to provide use of the culverts even when they are carrying water. Three species [deer mouse (*Peromyscus maniculatus*), short-tailed weasel (*Mustela erminea*), and domestic cat (*Felis catus*)] were documented using these shelves when water was present; when these same culverts were dry, these species as well as 2 others [raccoon (*Procyon lotor*) and striped skunk (*Mephitis mephitis*)] moved along the floor (Figs. 3 & 4). The smaller species to use the shelves, deer mice and short-tailed weasels, did so by carefully walking along the outside frame rather than over the shelf mesh surface (Fig. 3 a,b). This is an important observation as it suggests that a more solid floor surface may be preferred by these smaller animals. Muskrat (*Ondatra zibethicus*) were observed not only walking through a dry culvert but also swimming through culverts when water was present (Fig. 5).

Species such as the raccoon seem to pay particular interest in the culverts and use them even when nearly full (Fig. 6). Ninety-eight percent of all animal use of the culverts during this study occurred during darkness. No correlation was observed between activity patterns and

**Table 1. Mammal Species Observed**

| Species | Experimental Culvert # photos | Control Culvert # photos | Culvert Entrance* # photos |
|---|---|---|---|
| Deer mouse (*Peromyscus maniculatus*) | 87 | 133 | 0 |
| Short-tailed weasel (*Mustela erminea*) | 25 | 2 | 0 |
| Raccoon (*Procyon lotor*) | 19 | 3 | 89 |
| Striped skunk (*Mephitis mephitis*) | 29 | 24 | 0 |
| Muskrat (*Ondatra zibethicus*) | 0 | 3 | 0 |
| Coyote (*Canis latrans*) | 0 | 0 | 1 |
| Domestic cat (*Felis catus*) | 50 | 13 | 0 |
| Domestic dog (*Canis familiaris*) | 0 | 0 | 2 |

*Camera which was originally outside was moved inside once the culvert was accessible.

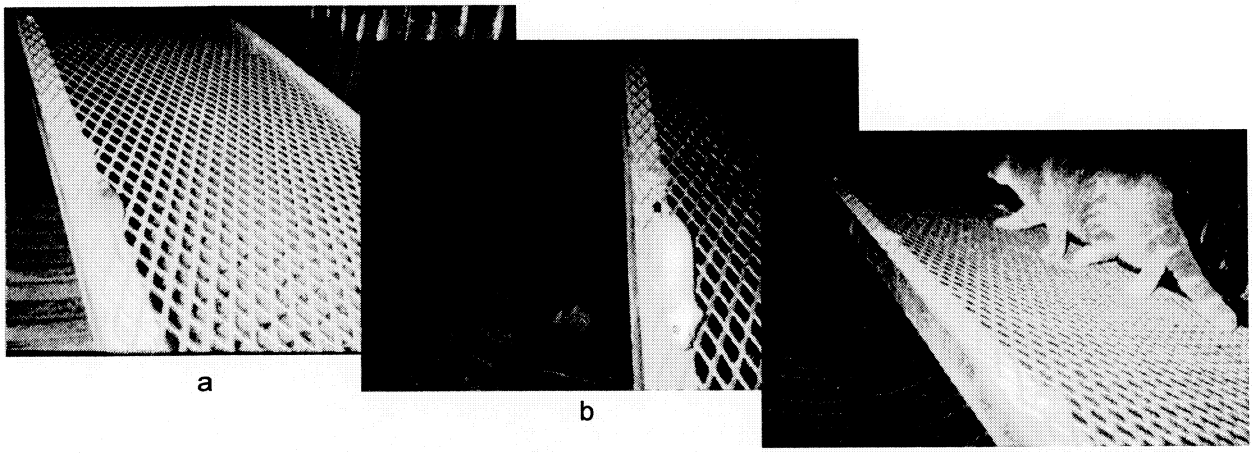


Figure 3. Deer mouse (a), short-tailed weasel (b), and domestic cat (c) use of shelves when culverts were carrying water. (Note use of frame by deer mouse and weasel)

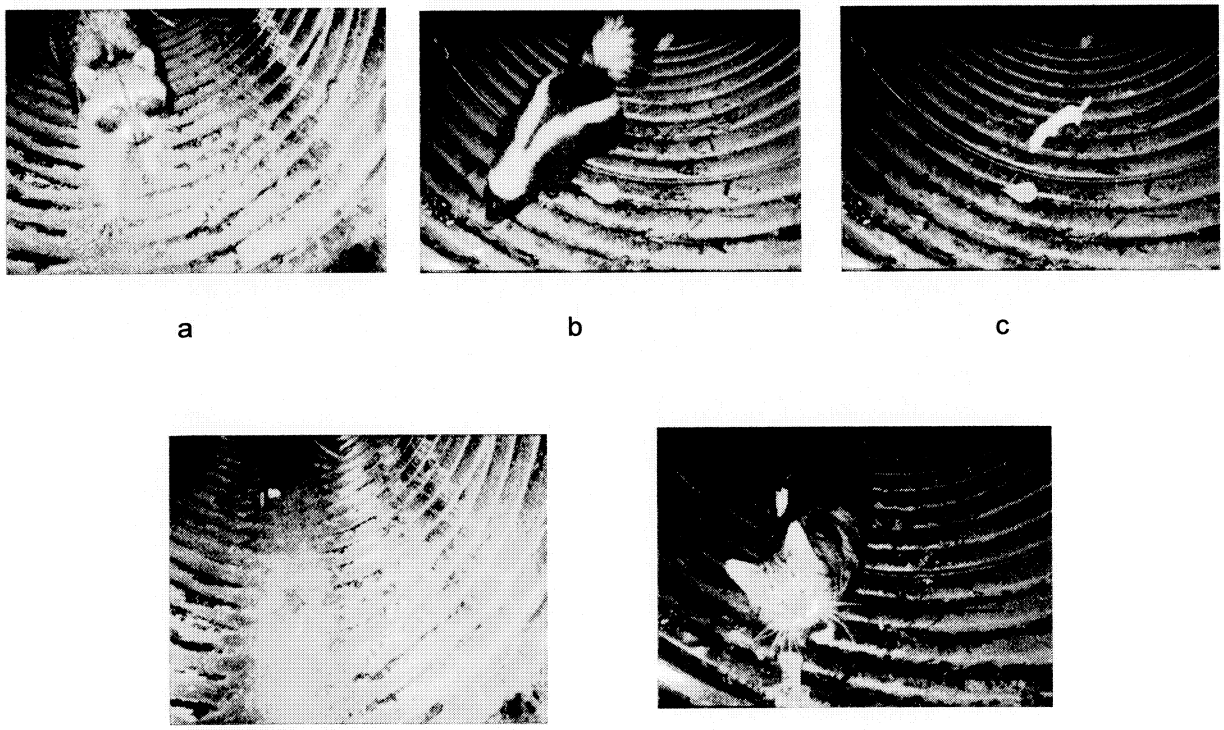


Figure 4. Raccoon (a), striped skunk (b), short-tailed weasel (c), deer mouse (d), and domestic cat (e) using culverts when dry.

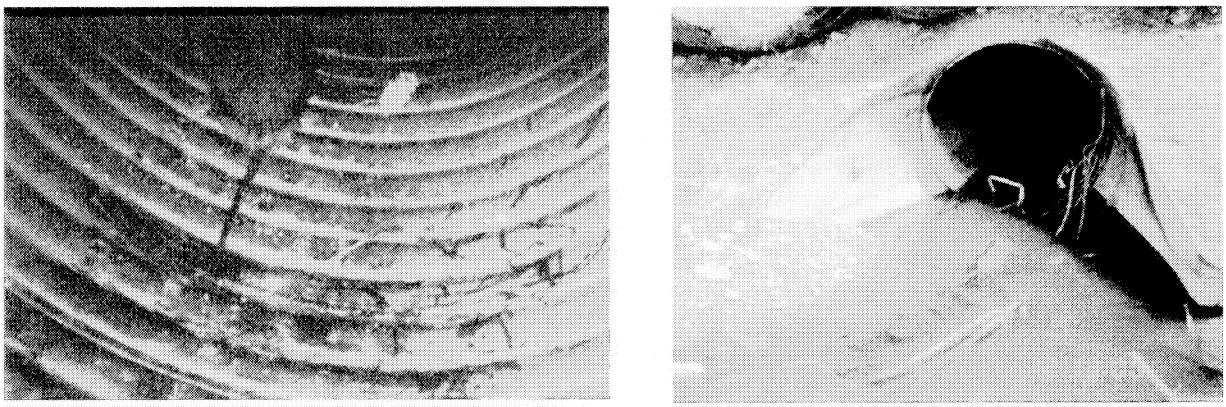

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Figure 5. Use of culverts by muskrat during dry (a) and wet (b) periods.

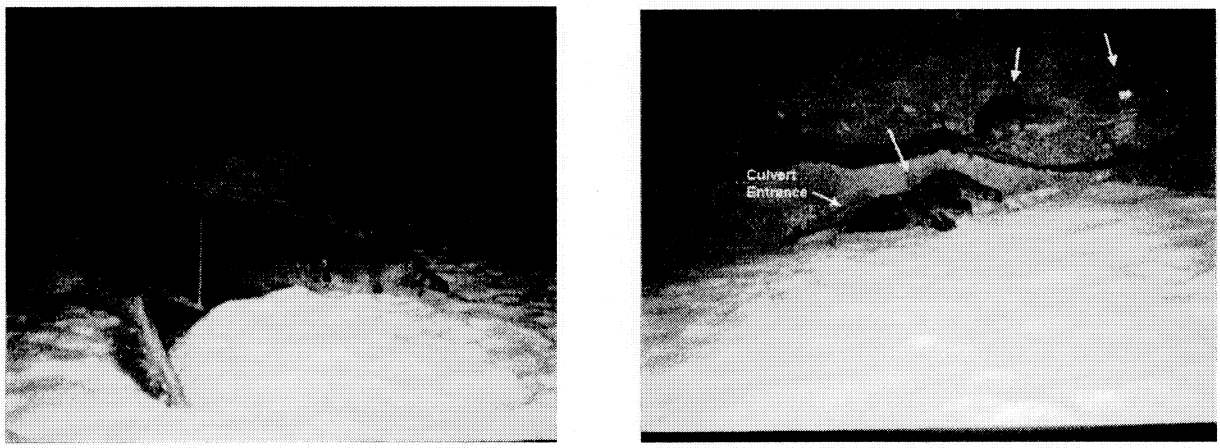


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Figure 6. Raccoons photographed at the entrance to an experimental (a) and control (b) culvert. The experimental culvert contained ice up-to-and-covering the shelf though adequate space was available for movement through. The control culvert angled downward to such a degree that its entrance on the east side was completely underwater throughout the 3-month period from January to March. Raccoons, however, still visited it on nearly a nightly basis.

temperature or humidity levels. Traffic pattern information throughout this study was not available. It was obvious that traffic increased during the summer months, but activity of animals appeared to remain relatively constant. No noticeable differences in animal activity occurred on a monthly or seasonal basis. During the time period between mid-January and the end of April, a total of 249 photographs were obtained of animals; between May 1st and August 23rd, 236 photographs were obtained. All of the mammal species photographed in the study culverts are active year-round.

**Mammal Populations Adjacent To Culverts**

During January, February, and March, the snow levels were too deep to permit small mammal sampling with the transect lines. On March 31st, live-trap transects were placed at a 90° angle along both entrances of 4 culverts (2 control and 2 experimental; Carleton Creek and Gravel Pit sites) as well as at the west entrance of a 3rd experimental culvert (McKlay Creek). The east entrance to this last culvert was adjacent to a residence and was not sampled. The remaining control culvert was completely filled with ice when the study was initiated and it was thought that the water levels would drop during the summer months making this culvert accessible. However, the water levels remained high during the entire study rendering this culvert inaccessible so these entrances were also not sampled. Traps transects were run for a 3-day period from late March through August. Animals captured were identified to species, sexed, weighed, and their reproductive condition noted. All animals were temporally marked for population assessment. Deer mice were marked with colored ear tags beginning in June, in conjunction with one undergraduate study, so that it could be determined from which population (east or west of the highway) individuals originated. A total of 7,650 trapping opportunities were recorded during the study [1 trapping opportunity = 1 trap accessible over a 12 h period. Traps were checked each morning and evening (March - June sampling) to minimize mortality thus during this period each trap recorded 2 trapping opportunities per day. During July and August traps were only opened in the evening and closed during the day due to extreme heat; thus only one 12 h period was sampled each day. This was not thought to alter trapping information since the species being captured were essentially nocturnal]. A total of 1,017 captures were recorded representing 7 species (Table 2). Four of 7 species (deer mice, meadow voles, vagrant shrews, and short-tailed weasels) were captured on both sides of the highway; the house mouse and Columbian ground squirrels were captured only on the west side, while the single capture of the western jumping mouse occurred on the east side. Some variation in total number of captures occurred between sites most likely as a result of vegetative differences, but, in general, eastern sides were similar to one another and western sides were similar to one another. Sixty-two percent of the total captures were on the east side, while 38% were on the west.

**Table 2. Species Captured On Transect Lines**

| Species | Total Number Captured |
|---|---|
| Deer mouse (*Peromyscus maniculatus*) | 309 |
| Meadow vole (*Microtus pennsylvanicus*) | 654 |
| Short-tailed weasel (*Mustela erminea*) | 14 |
| Columbian ground squirrel (*Spermophilus columbianus*) | 14 |
| House mouse (*Mus musculus*) | 1 |
| Western jumping mouse (*Zapus princeps*) | 1 |
| Vagrant shrew (*Sorex vagrans*) | 24 |

Though population estimates for deer mice and meadow voles (the only two species with enough captures for analysis) were not calculated due to incomplete recapture records, general trends in population size can be interpreted from overall trapping numbers. Population numbers for both species increased from spring to summer, though a much more significant increase was observed in meadow voles (Fig. 7).

The most significant result of the trapping sessions was that a large vole population was found to exist adjacent to these culverts; however, no evidence of culvert use was documented. Several instances of the movement of marked deer mice from one side of the highway to the other were recorded.

**Highway Mortalities and Other Observations**

Based upon weekly observations during this study, no species capable of using the culverts were noted to have been killed on the highway across the study sites. However, systematic searchs along both sides of the entire study area were not made. Two deer were hit over this stretch. No additional observations were made of any species adjacent to the culverts. A few tracks of coyotes and raccoons were observed during the winter months.

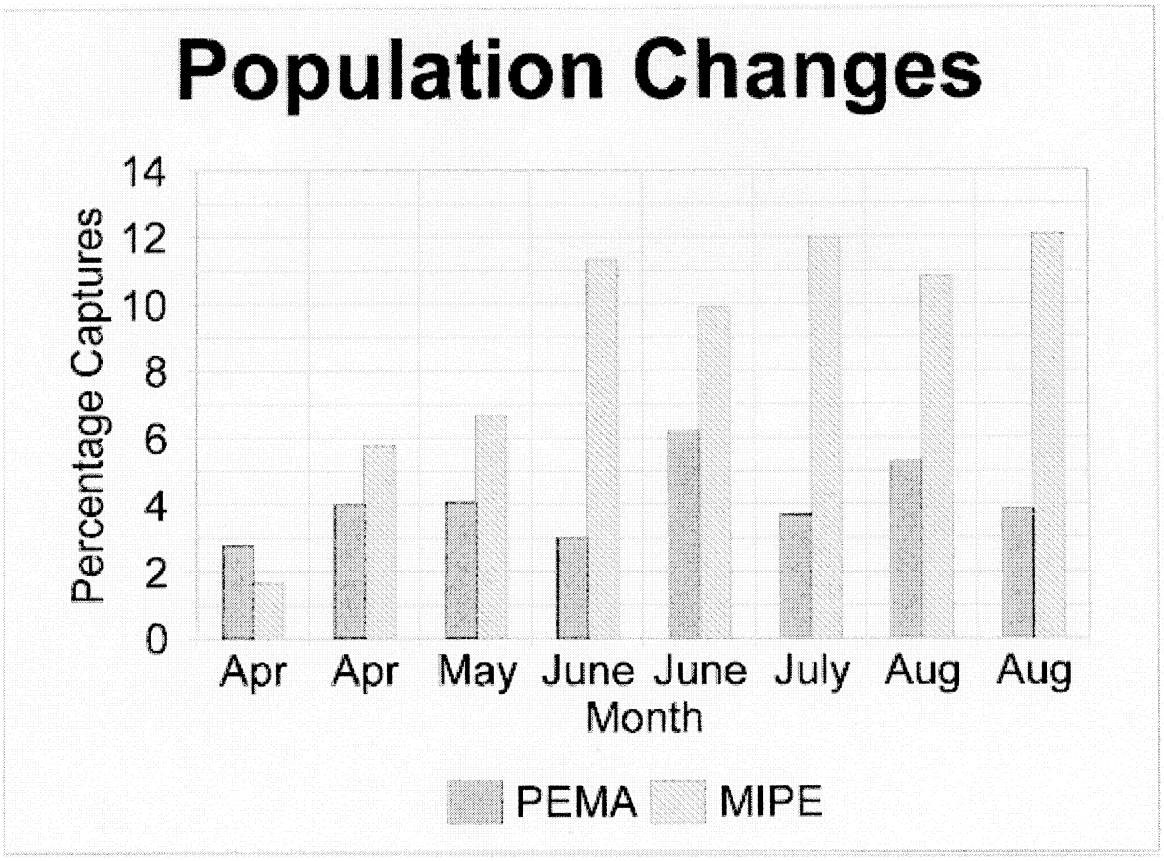


Figure 7. Population changes observed in deer mice (PEMA) and meadow voles (MIPE) during the spring and summer expressed as percentage of captures.

**Vegetation Analyses**

Vegetation analyses indicated that in most respects ground cover at the east entrance to the culverts was greater and more consistently established than that at the west entrances (Fig. 8). During a majority of the initial 3-month period, these areas were covered by snow (Fig. 9).

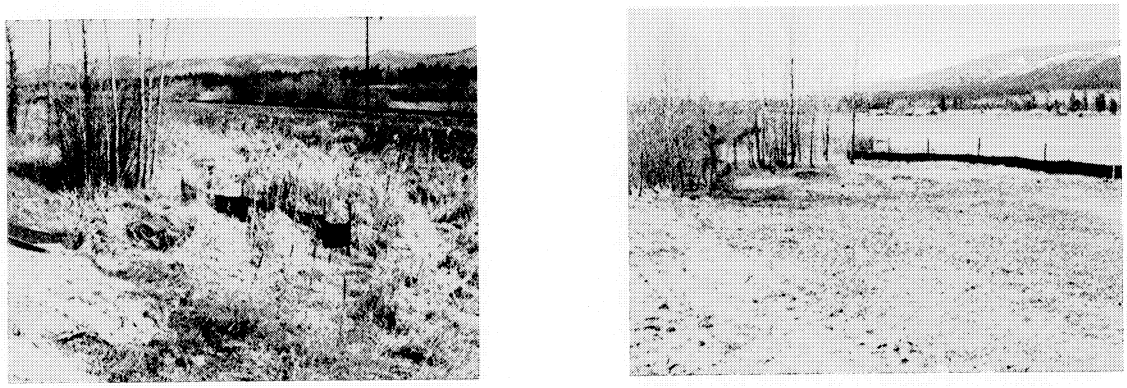

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Figure 8. Example of the vegetative cover at the east (a) and west (b) entrances to one culvert in April (Gravel Pit experimental).

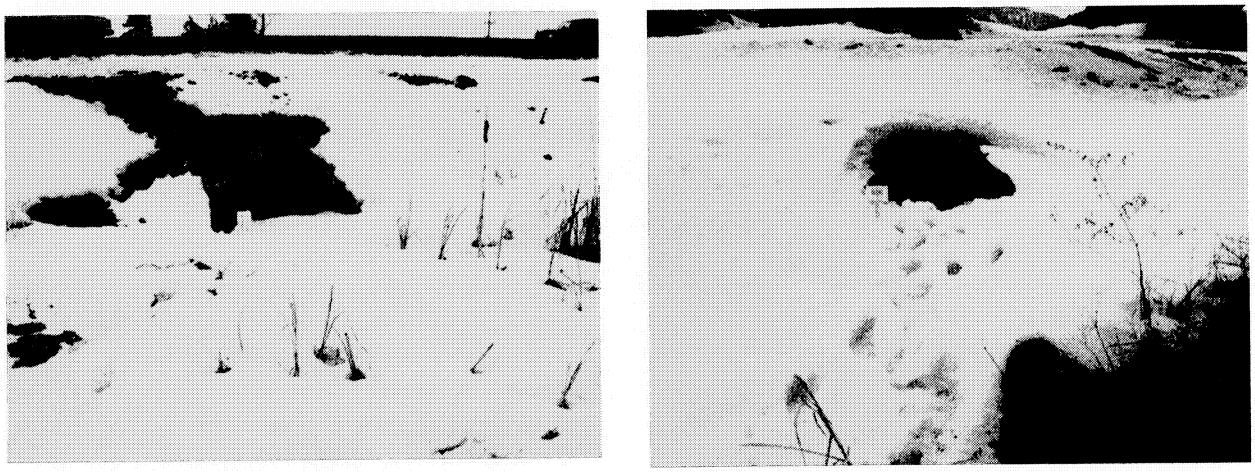

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Figure 9 (a and b). Example of the snow cover at the entrances to culverts during a majority of this initial study period.

Initial vegetative maps were constructed for each site so that the relationship between vegetative cover and animal populations could be assessed (Fig. 10). It became apparent that only a general overview of vegetative cover could be developed since sites particularly along the western side of the highway were greatly disturbed and were being modified throughout the study (grading and reseeding during the spring and early summer; mowing during mid-to-late summer). Considerable vegetative growth occurred, however, at the entrances to the culverts on the western side as well as all along the eastern side during the summer (Fig. 11).

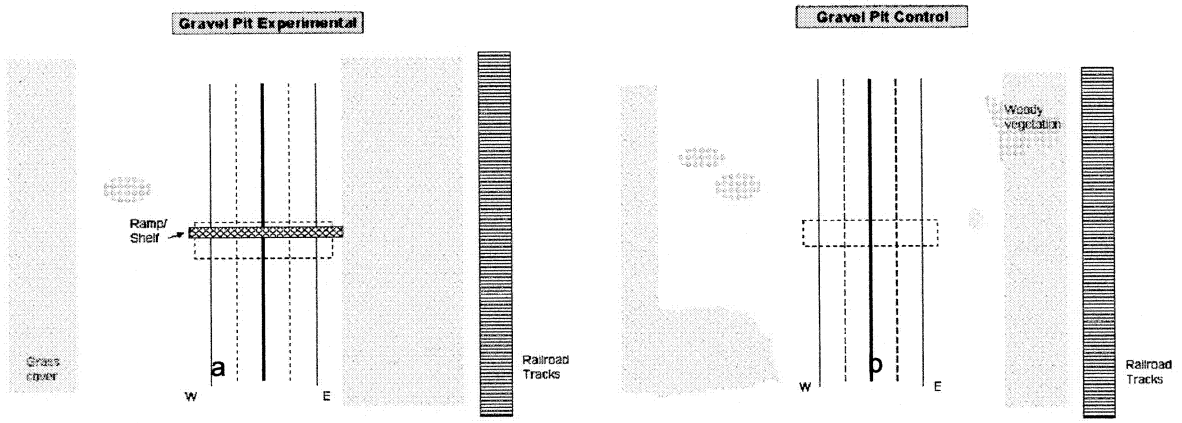


Figure 10. Example of vegetative maps developed for experimental (a) and control (b) culverts.


Figure 11. Examples of summer vegetative growth both at the entrances to culverts on the western side (a and b) and along the entire eastern side (c).

**Ramp adjustments**

When the ramps accessing the culverts were first put in place, they angled down from the shelves to the ground surface (Fig. 12a). During the summer the ramps were adjusted by MDT and welded in place so that they projected directly outward from the shelves causing them to open approximately 2.5 feet above the ground surface (Fig. 12b). It is unclear why this modification was made, but presumably this was to provent any debris from being trapped under the ramp during periods of water flow. No indication was given prior to this change that this was to occur. Obviously when water is moving through the culvert, the ramps, as initially placed, would be covered and thus inaccessible to animals. However, when no water is present the elevated ramps would also prevent most animal use since the ramps are suspended too high above the ground for access. In order to address water flow and debris concerns while at the same time keeping the ramps accessible to smaller animals a modification of the entrance ramps is proposed. The modification would entail expansion of the elevated ramp to the side of the culvert so that it contacts the sloping hillside, while remaining above water level. This modification will be tested in the continuing study.

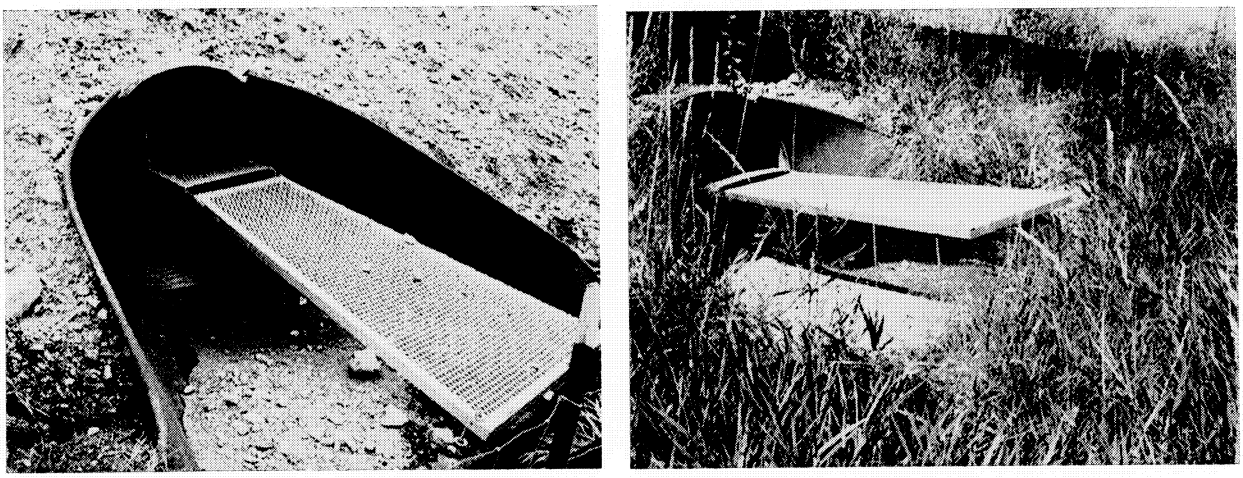

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Figure 12. Ramp adjustments made during the study by MDT. (a) Initial ramp placement so that it contacts the ground and (b) final placement so that it sits above the ground surface.

**Discussion**

This research was designed to study the effectiveness of ramp/shelf structures placed within drainage culverts for allowing the movement of small mammals under the highway during periods of water flow. Providing such a travel corridor would protect these species and at the same time would provide added protection for motorists. Attempts by motorists to avoid animals crossing the highway often lead to accidents. In this regard, the shelves appeared to be effective for many species. In particular, this study demonstrated the following:

1) Several species of small mammal (specifically deer mice, short-tailed weasels, striped skunks, and raccoons) routinely used these culverts to transcend the barrier produced by this 4-lane highway. These culverts appear to provide a safe means for such movements as no highway mortalities were observed along the area in which the culverts were found.

2) The most important question being addressed by this research has been answered: small mammals do use the ramp/shelf when the culvert floor is covered with water. Deer mice and short-tailed weasels, which would otherwise be too small to use these culverts when any water was present, freely used the shelves under these conditions. Raccoons, an obviously larger species and one adapted to forage in water, freely walked through culverts even when 6-8 inches of water was flowing. Striped skunks were not observed using the shelf during water flow. This may have been due to the fact that during much of this time, the ramps accessing the shelves were mounted over two feet above the ground. Deer mice and weasels are excellent jumpers, while skunks are not.

3) Nearly all of the observations of the smaller mammals using the shelves indicates that preference is given to the solid floor provided by the shelf frame. Few observations have been recorded of these species walking on the grate surface. This observation is currently

being tested further by one undergraduate student (one shelf has been covered with a solid plastic sheet; Appendix II), but results of this research will not be available until later this fall.

4) Animal use of the culverts is predominantly occurring during nighttime hours. A few observations of deer mice, and the Columbian ground squirrel observed in the larger (non-study) culvert, occurred during daytime hours.

5) Though the meadow vole is the predominant species existing along the barrow pits adjacent to the culverts (particularly on the east side where more vegetative cover is found), no individuals were ever observed using the culverts (either on the floor or on the shelves). This is most likely due to the behavioral characteristics of this species. Voles, unlike deer mice, prefer to live under a vegetative cover and will rarely move across an open, exposed area.

6) Vegetative measurements indicate that the east side of the highway currently provides a more established habitat than does the west. This is surely due to the fact that construction during highway expansion occurred in the westerly direction (the east side is bounded by railroad tracks). This difference is very important as it controls the establishment and maintenance of small mammal populations. A majority of small mammals captured (62%) occurred on the eastern side of the highway. Meadow voles were captured more often on this side (72% of the time), while deer mice were more often captured on the west side (58%). These differences surely are a result of the vegetative differences. Deer mice, though somewhat ubiquitous in their habitat requirements, readily invade disturbed areas. Meadow voles, on the other hand, require a dense, established vegetative ground cover.

7) No seasonal changes in culvert use were noted. All species documented within culverts were active throughout the study. This is not surprising since none of these species hibernates.

8) Though culvert use was documented, it was impossible in this study to determine what, if any, movement of small animals occurred over the highway.

**Concerns raised and possible solutions.**

The observations made have raised several issues which need to be addressed in future studies. First is the fact that the shelf surface is probably not appropriate for most of the smaller species. The 1+ inch openings in the shelf grate appear to discourage small mammal movement. Most observations of deer mice and short-tailed weasels illustrated that they preferred to travel along the solid metal frame which supports the shelf. This is not surprising. The grate surface obviously needs to be porous to allow water to flow through during periods of water flux; however, the size of the openings may discourage use by such small species. Even larger species (e.g., dogs) are known to avoid such grate surfaces (personal observation). A solid surface is currently being tested; results will be provided when they are completed (Fig. 13; refer also to

Appendix II).

Secondly, voles, though abundant, are not using the culverts and thus their populations appear to be effectively isolated by the highway. Not a single vole was observed within a culvert over the course of the study though they were the most abundant species. This is not entirely

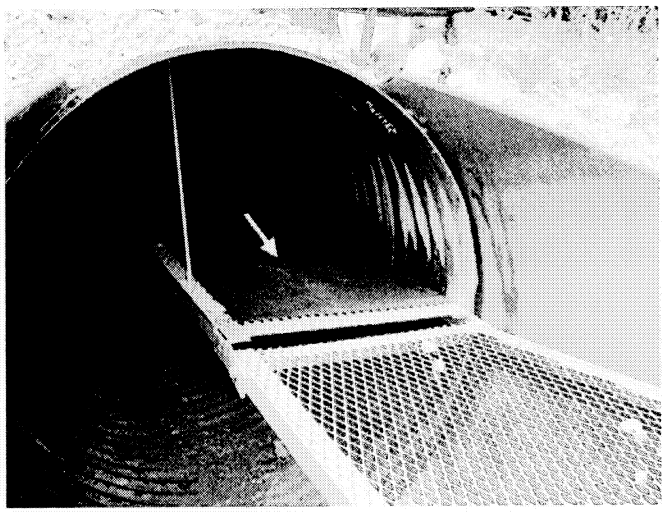


Figure 13. The shelf surface has been covered with heavy gauge plastic (truck bed liner material; yellow arrow) to provide a solid surface for smaller species.

surprising since voles are known to have a strong behavioral preference to move about under dense vegetative cover, most likely to minimize predation. Suggestions for possible modifications of the shelf structure are discussed in Appendix II.

Thirdly, the final position at which the ramps accessing the shelves were set seems problematic. The assumption is that the ramps were welded in to this position to facilitate movement of debris through the culverts; however, this defeats their purpose to serve as a ramp to the shelf. Species such as the striped skunk, which routinely used the culverts during dry conditions, were never observed using a ramp. It is very possible that they could not jump the required 2.5 feet to the ramp surface. The shelf texture, as described above, may also have contributed to their lack of use. One possible way to modify the ramp so that debris could still freely move beneath while allowing access to small animals would be to extend the ramp surface sideways so that it came in contact with the adjacent hillside.

The culverts which were available for use in the current study consisted of two sizes; the control culverts were roughly 36" in diameter, while those in which shelves had been mounted were ~ 48". No difference in animal use was noted that could be attributed to culvert size, but it is clear that a minimum 48" diameter is needed if a shelf is to be included.

Vegetative cover adjacent to and at the entrance of the culvert is obviously an important variable that influences small animal movement to and through the culvert. It is recommended that revegetation of such sites occur as quickly after highway development as possible. Furthermore this vegetative cover should be left to grow, where possible, rather than mown to provide

protective cover for these species.

**Implementation**

Three main concerns identified in this initial study will be addressed in the next phase of this research which is currently on-going.

**1) Shelf surface:** Metal grating with a smaller mesh size (¼ inch openings as opposed to the current 1 inch openings) will be tested. This mesh will still allow water drainage whenever the shelf becomes covered but should be fine enough to provide a more solid surface for smaller species.

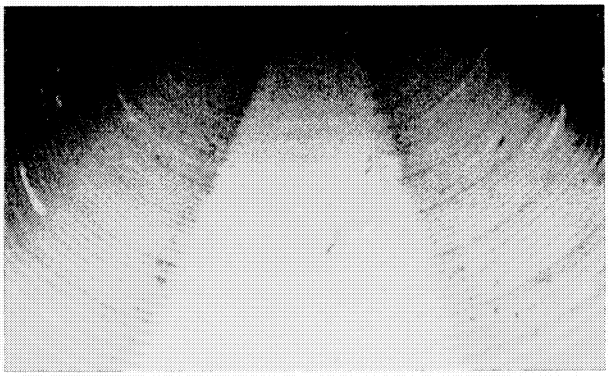
**2) Vole movement:** In this initial study, no vole movement was detected through the culverts so tubular structures which might provide a more protected environment were proposed for testing. Within the past month several photographs of voles traversing one culvert have been obtained. This information is currently being assessed to determine whether or not this may be correlated with vegetative cover at this site, excessively high vole numbers which may force dispersal at this time of year, or a combination of the two.

**3) Ramp position:** A ramp extension sideways to interface with the sloping hillside will be tested.

4) An attempt is being made to add additional culverts to boost sample size, and further studies to address the importance of vegetation at the culvert entrances are proposed over the coming year.

## Appendix I - Additional Species Observed in Non-Study Culvert

One additional culvert which sits approximately 100 meters north of the Gravel Pit experimental culvert was monitored with a remote camera. This culvert was larger than the others (approximately 5 feet in diameter) and thus was not appropriate for comparisons in the current study. Many of the same species using the study culverts also used this culvert. In addition, 2 new species, the Columbian ground squirrel (Fig. 14a; *Spermophilus columbianus*) and a bat (Fig. 14b; most likely the big brown bat, *Eptesicus fuscus*) were observed using this culvert.



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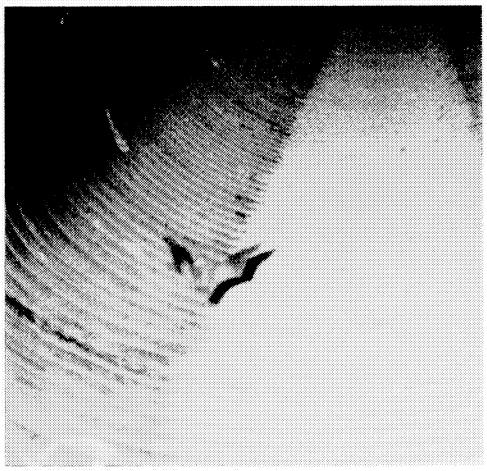

b

Figure 14. (a) Columbian ground squirrel and (b) bat using the large culvert at the Gravel Pit site.

## Appendix II - Peripheral Studies and Tests of Shelf Modifications

In order to further test the observation that small species seem to prefer a more solid surface, one shelf was covered with a solid, heavy gauge plastic (a polypropylene material used for truck bed liners; refer to Fig. 13 above; Fig. 15 below) on July 15th. A comparison is thus being made between animal use prior to and following this installation. An undergraduate currently has funding through a university-sponsored grants program (IBS-CORE) to study this aspect throughout this summer and fall. As part of this study live-trapped deer mice have been marked with colored ear tags to designate on which side of the highway they were caught.

a b

Figure 15. Animals using modified ramp surface. (a) Deer mouse, and (b) short-tailed weasel.

Tests of a vole tube which could be placed below and supported by the existing shelves that would allow voles to move through the culverts in an enclosed space are being considered. These tubes would extend from the culvert entrances along the existing ramps so that they would open into the vegetation providing adequate cover for this species (Fig 16).

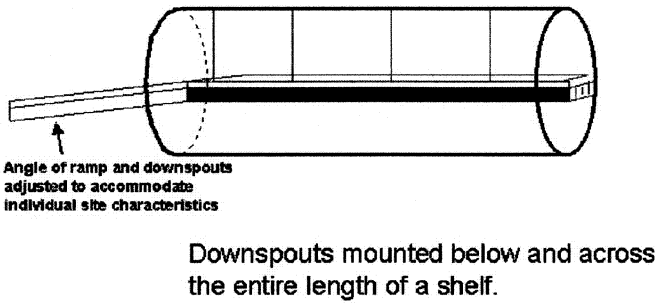


Figure 16. Suggested design of vole tubes to allow for movement under existing ramps.

A second undergraduate who worked on the current project received funding through NASA and the Forestry School this summer to expand upon our observation on short-tailed weasel use of these culverts. This student will conduct preliminary studies on how the home range of this species has been affected by the 4-lane highway and how it travels across its home range using the culverts as a ready means to access the adjacent, bisected wetlands. Currently one animal has been radiocollared (Fig. 17) and attempts will be made to radiocollar at least 2 additional animals over the next several weeks. These animals will be monitored throughout the coming fall and winter. Since funding for this project is limited, sample size will necessarily be small, but this study should provide us with preliminary information which may be expanded upon in the future.

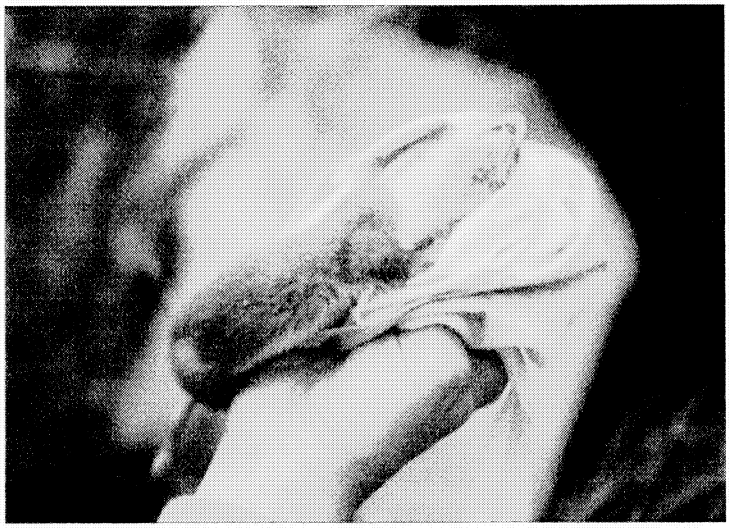

Figure 17. Short-tailed weasel to which a radiocollar was later attached.

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