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Revetment clearing, its influence on riparian mammal communities

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Over 115 miles of rock revetment have been constructed in the Willamette Basin to protect river banks. This study examines the effect on riparian mammals of maintaining these revetments by vegetation and debris clearing. Differences between cleared and uncleared revetments were measured using a canopy coverage method of vegetation analysis; mammals were studied by trapping, by direct observation, and by noting such signs as scats, tracks, etc.

It was found that while revetment clearing reduced, to varying degrees, the vegetational and physiognomic diversity of revetments, no major differences in the mammals sampled could be attributed to the clearing. During the period of sampling, population fluctuations were noted for Peromyscus maniculatus and Mus musculus. In addition, the sex ratio for Peromyscus maniculatus trapped was skewed toward the males (1.32:1). Possible explanations for these findings are discussed.

REVETMENT CLEARING: ITS INFLUENCE ON RIPARIAN MAMMAL COMMUNITIES

by

ROBERT E. WILLIS

A thesis submitted in partial fulfillment of the requirements for the degree of

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TO THE OFFICE OF GRADUATE STUDIES AND RESEARCH:

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INTRODUCTION

The U. S. Army Corps of Engineers has constructed many miles of rock revetments along the river channels of the Oregon Willamette Basin during the last several decades. These bank protection structures are to limit stream meanders that may adversely affect riverine property. The effects on riparian wildlife of these bank protection structures have been of concern to environmental and wildlife groups and agencies. Of particular concern is the long-term effect of the Corps' revetment maintenance policy once the structures have been constructed.

Deposition of alluvial sediment among the rock riprap that composes a revetment allows herbs, shrubs and trees to become established on the revetment. The periodic clearing of woody vegetation from the revetment is needed, according to the Corps of Engineers, to allow access to and visual inspection of the revetment, and to prevent damage and displacement of stone if trees or shrubs are felled or uprooted by flood. To this end, blackberry vines and all woody growth 2 inches (5 cm.) or more in diameter or 6 feet (1.8 m.) or more in height is removed from the entire revetment surface (U. S. Corps of Engineers, 1975).

All revetments constructed prior to 1953, about one-half of the total number of revetments, are maintained by the Corps. Revetments constructed in the Willamette Basin since 1953 are maintained by the local sponsors of these bank protection works at their own expense. Although the federal government does not directly compel local sponsors to follow their revetment maintenance policies, they do recommend maintenance practices and may refuse to undertake further bank protection works in a district where revetment maintenance does not meet with federal approval. As the agency of expertise, the Corps may also advise the clearing of privately constructed revetments. Since Corps of Engineers-constructed revetments in the Willamette Basin alone total over 115 miles, this maintenance policy may greatly influence the character of the basin's riparian communities.

The questions raised by environmental and wildlife groups and agencies regarding the effects of revetment clearing on riparian wildlife communities prompted the Corps of Engineers to contract with Portland State University to investigate the impact of this maintenance practice. The results of this study have been completed (Forbes et. al. 1976). This thesis presents and interprets data for the mammalian populations investigated.

METHODS AND MATERIALS

Study Sites

The study sites were Corps of Engineer-constructed revetments located on four rivers within the Willamette Basin, Oregon. The structural features and locations of these rock revetments, as well as the bank conditions leading to their construction, have been described elsewhere (Corps of Engineers, 1975). A schematic diagram showing a typical revetment with defining terms used in this report is shown in Figure 1.

After an initial orientation and site selection period, field investigations began 21 August 1974 and were concluded on 24 October 1975. Six study areas, each consisting of a pair of revetments, were selected. The six pairs of study sites are not completely independent; Half Moon Bend serves as the uncleared site for both Coon Creek and Upper Half Moon Bend. The revetment pairs under study consisted of a revetment cleared in the summer of 1974 (the experimental site) and a revetment sufficiently overgrown to be considered for clearing in 1975 or 1976 (the control site). In addition to selecting the revetment pairs for close proximity, each pair of revetments was selected for geographic, physiographic and other similarities. The study areas and study sites, by revetment name, are as follows:

Study Area	Experimental Site	Control Site
Willamette River	Stoutenberg	Grand Island
Willamette River	Upper Half Moon Bend	Half Moon Bend
Willamette River	Coon Creek	Half Moon Bend
Molalla River	Location 6	Location 4
Santiam River	Wickham	Tomasek

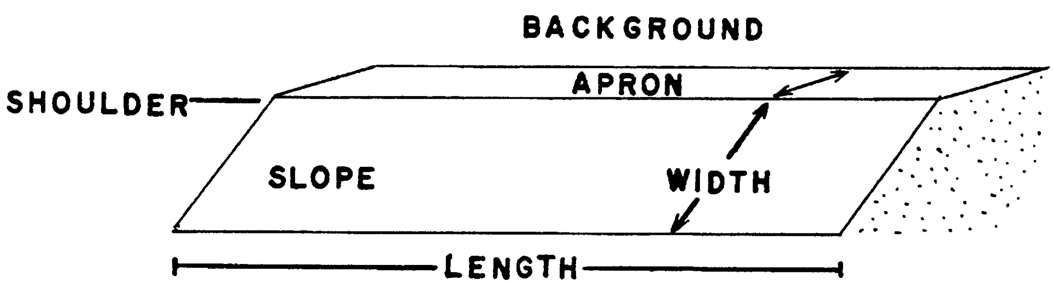

Figure 1. Diagram of a revetment showing structural features of concern in this study.

Study Area	Experimental Site	Control Site
McKenzie River	Blankton	Armitage

In addition to these sites, Millar location, on the Santiam River between Wickham and Tomasek revetments, was also studied in the spring, summer, and fall of 1975. This revetment was built in 1948 as an emergency bank protection project, and has never been cleared.

The fourteen months of field work included investigation of the six study areas before and after each experimental site had been cleared (August through September 1974), and intensive trapping of all six study areas from January through September 1975. The exception to this investigation schedule was the McKenzie River sites; application of an herbicide at Armitage location curtailed final trapping of these revetments. In addition to these investigations, the Molalla and Santiam River areas were investigated during November 1974. Table 1 lists the day each site was investigated.

While the design and construction of the revetments are limited by engineering constraints, there was some variation from revetment to revetment. The length of the revetments studied varied from 250 to 1,627 meters. The width of slope and apron also varied, both from revetment to revetment and seasonally, as the water level of the river fluctuated. The physiognomy of revetments varied, even without the establishment of vegetation, due to silt filling the interstices between stones or even burying the stones completely. Besides variation occurring between revetment surfaces, the environments behind the revetments can differ significantly. Consequently, revetting a stream bank does not mean a monotypic habitat type is established. With the establishment of vegetation on the revetments, the differences between revetments become even greater.

TABLE I

SMALL MAMMAL TRAPPING DATES AND LOCATIONS

Revetment	Before	After	Fall	Winter	*Spring	No. 1	No. 2	No. 3	Total/Revetment
Molalla No. 6	8/21-23/74 195 Days	10/8-10/74 195 Days	11/12-14/74 195 Days	1/21-23/75 195 Days	5/16-18/75 150 Days	6/26-28/75 150 Days	7/29-31/75 150 Days	9/10-12-75 150 Days	1380 Trap Days
Molalla No. 4	8/21-23/74 195 Days	10/8-10/74 195 Days	11/12-14/74 195 Days	1/21-23/75 195 Days	5/16-18/75 150 Days	6/26-28/75 150 Days	7/29-31/75 150 Days	9/10-12/75 150 Days	1380 Trap Days
Stoutenberg	8/14-16/74 195 Days	10/1-3/74 195 Days	Not Trapped	**2/12-13/75 130 Days	6/7-9/75 150 Days	7/3-5/75 150 Days	7/23-25/75 150 Days	9/14-16/75 150 Days	1120 Trap Days
Grand Island	8/14-16/74 195 Days	10/1-3/74 195 Days	Not Trapped	**2/12-13/75 130 Days	6/7-9/75 150 Days	7/3-5/75 150 Days	7/23-25/75 150 Days	9/14-16/75 150 Days	1120 Trap Days
Wickham	8/8-10/74 195 Days	9/18-20/74 195 Days	11/27-29/74 195 Days	2/5-7/75 195 Days	5/9-11/75 150 Days	7/2-4/75 150 Days	7/23-25/75 150 Days	9/13-15/75 150 Days	1380 Trap Days
Tomasek	8/8-10/74 195 Days	9/18-20/74 195 Days	11/27-29/74 195 Days	2/5-7/75 195 Days	5/9-11/75 150 Days	7/2-4/75 150 Days	7/23-25/75 150 Days	9/13-15/75 150 Days	1380 Trap Days
Millar						7/2-4/75 150 Days	7/23-25/75 150 Days	9/13-75 150 Days	450 Trap Days
Coon Creek	***7/30-8/2/74 140 Days	9/3-5/74 195 Days	Not Trapped	2/22-24/75 195 Days	6/10-12/75 150 Days	7/9-11/75 150 Days	8/68/75 150 Days	9/23-25/75 150 Days	1130 Trap Days
Upper Half Moon	***7/30-8/2/74 140 Days	9/3-5/74 195 Days	Not Trapped	2/22-24/75 195 Days	6/10-12/75 150 Days	7/9-11/75 150 Days	8/6-8/75 150 Days	9/23-25/75 150 Days	1130 Trap Days
Half Moon Bend	***7/30-8/2/74 140 Days	9/3-5/74 195 Days	Not Trapped	2/22-24/75 195 Days	6/10-12/75 150 Days	7/9-11/75 150 Days	8/6-8/25 150 Days	9/23-25/75 150 Days	1130 Trap Days
Blankton	8/28-30/74 195 Days	10/5-7/74 195 Days	Not Trapped	2/28-3/2/75 195 Days	5/10-12/75 150 Days	7/9-11/75 150 Days	8/6-8/75 150 Days	****	1035 Trap Days
Armitage	8/28-30/74 195 Days	10/5-7/74 195 Days	Not Trapped	2/28-3/2/75 195 Days	5/10-12/75 150 Days	7-9-11/75 150 Days	8/6-8/75 150 Days	****	1035 Trap Days

* - 8 x 8 x 25 cm. galvanized steel line trap no longer used.
** - Trap line out only two days due to high water.
*** - 30 museum specials and five 13 x 13 x 40 cm. live traps out for four days.
**** - Not trapped due to application of Herbicide at Armitage revetment.

Total = 13,670

To determine the effect of clearing vegetation from a revetment on mammalian species, it was necessary to identify and quantify the mammals frequenting the revetments. It was also necessary to measure the vegetational and physiognomic differences between revetments. The methods by which mammals and revetment vegetation/physiognomy were studied are set forth in the following subsections.

Vegetation/Physiognomy

In August of 1975, canopy cover of the mammal survey areas was investigated using the techniques of Daubenmire (1959), with some modifications. A canopy coverage method was used in agreement with Lindsey (1956) that "canopy coverage is the most important single parameter of a species in its community relations." I believe that the Daubenmire canopy coverage method of vegetational analysis simply and accurately depicted the major vegetational and physiognomic interrevetment differences.

Canopy cover was measured for the revetments in eight categories. Herbaceous plants were measured as one group, while woody plants were divided, by height, into four layers. In addition to the vegetation, the surface of the revetment was also described as percent rock, silt or debris, using Daubenmire cover classes to represent these percentages. The eight categories investigated and the Daubenmire cover classes with corresponding percentages, are shown in Table II.

Rectangular quadrats considerably larger than those suggested by Daubenmire were used when estimating canopy cover. The larger quadrat size was used in order to include the gradations in vegetation and revetment surface from the waterline to the stone apron. Even with quadrats as large as 126 m^2, the canopy cover could be easily estimated.

TABLE II

ANALYSIS OF CANOPY-COVER
ON ELEVEN MAMMAL SURVEY TRANSECTS

Classes	Percent Coverage	Strata
6	95-100%	W1 = Woody plants greater than 15 m
5	75-95%	W2 = Woody plants between 5 and 15 m
4	50-75%	W3 = Woody plants between 2 and 5 m
3	25-50%	W4 = Woody plants less than 2 m
2	5-25%	H = Herbaceous vegetation

CLEARED REVETMENTS

	Molalla #6	Stoutenberg	Wickham	Coon Creek	Upper Half Moon	Blankton
W1	--	--	--	--	--	--
W2	--	--	--	--	--	--
W3	--	--	2	--	--	--
W4	2	1	2	2	2	5
H	4	3	5	2	2	1
Rock	1	4	4	5	6	4
Silt	4	2	2	2	1	1
Debris	2	1	1	1	1	3

UNCLEARED REVETMENTS

	Molalla #4	Grand Island	Tomasek	Millar	Half Moon Bend	Armitage*
W1	--	--	--	5	--	
W2	1	--	3	3	--	
W3	2	2	3	2	2	
W4	3	2	2	3	3	
H	3	3	4	2	2	
Rock	2	5	4	4	5	
Silt	4	2	3	2	1	
Debris	2	1	2	2	2	

* Application of Herbicide Prevented Analysis.

The rectangular quadrats were laid out every 50 m along the mammal transect area of the revetment. These quadrats were 5 m in length on the side parallel to the river and the width was the distance of the slope plus apron. Since the width of slope plus apron varied, the size of the quadrats correspondingly varied. Therefore, the methods of Daubenmire were modified to accommodate these differences in quadrat size. Rather than treating each quadrat equally when calculating the average cover class values for that revetment, each quadrat was weighted according to its area. The weighting of quadrats according to area did not significantly alter the data since the intrarevetment width of slope and apron was fairly uniform.

Approximately ten percent of each mammal survey area was sampled using these techniques. No data on Armitage location was gathered because, as previously mentioned, this revetment was sprayed with a herbicide before this revetment could be studied completely.

Mammal Surveys

Mammals were surveyed by trapping, by direct observation and by noting signs such as tracks, scats, etc., at each of the study sites. Two trap lines, each 210 m long, were established on each revetment studied. Each line consisted of fifteen two-trap stations set linearly along the revetment every fifteen m. One trap line was set on the shoulder of the revetment. One museum special rodent trap (Woodstream Corp., Lititz, PA) and one 8 x 8 x 25 cm galvanized steel live trap (Tomahawk Live Trap Co., Tomahawk, WI) were set at each station along this line. The live traps were subsequently omitted due to their low success rate (see Table I for dates). The second trap line was set on the slope of the revetment. Each station on this line was set either with two museum specials or with one museum special and one rat trap (Animal Trap Co., Lititz, PA), alternating along the line, with the rat trap at each odd-numbered station. At each station of this trap line, one trap was set toward the bottom of the slope and one toward the middle of the slope. In addition to these two trap lines, five 13 x 13 x 40 cm livetraps (Tomahawk Live Trap Co., Tomahawk, WI) were set at irregular intervals along the shoulder of the revetment.

Each trap survey period consisted of maintaining the trap lines for three consecutive nights. The traps were checked each morning, and the species, sex, age class and reproductive condition of each specimen taken were recorded on an especially prepared data sheet (Figure 2). The study sites were trapped in such a manner for 13,670 trap nights. Table I shows any exceptions to the aforementioned methods.

In addition to the data gathered by trapping, during each survey period attention was also given to other indication of mammals frequenting the revetments under survey. Direct observation of mammals on or near the revetment, scats and tracks found on the revetments, and other such signs were recorded. Other methods, such as scent posts and live-trapping snares as described by Keith (1965) were tried but abandoned because they yielded poor results.

Mammals

LOCATION: ____________ **DATE:** ________ **INITIALS:** ________

WEATHER:

temperature: ____________

precip/hum: ____________

wind: ____________

comments: ____________

previous days weather: ____________

TIME BEGIN: ________

TIME END: ________

DATE SET: ________

CHECK# ________

TRAP RESULTS:
- X=trap sprung
- B=bait gone
- M=trap missing
- ∅=no change
- C=capture

AGE:
- J=juvenile
- A=adult
- G=gravid
- L=lactating
- T=fully developed testes
- N=testes not developed

Station#	Location	trap type	trap results	Species	Sex	Age	Comments
1	lower slope						
	upper slope						
	apron						
2	lower slope						
	upper slope						
	apron						
3	lower slope						
	upper slope						
	apron						
4	lower slope						
	upper slope						
	apron						
5	lower slope						
	upper slope						
	apron						
6	lower slope						
	upper slope						
	apron						
7	lower slope						
	upper slope						
	apron						
8	lower slope						
	upper slope						
	apron						
9	lower slope						
	upper slope						
	apron						
10	lower slope						
	upper slope						
	apron						
11	lower slope						
	upper slope						
	apron						
12	lower slope						
	upper slope						
	apron						
13	lower slope						
	upper slope						
	apron						
14	lower slope						
	upper slope						
	apron						
15	lower slope						
	upper slope						
	apron						
National							
National							
National							
National							
National							

COMMENTS: ____________

Figure 2. Sample mammal data sheet.

RESULTS

Vegetation/Physiognomy

The results of the vegetational/physiognomic analysis of the mammal study transects are summarized in Table II. It should be noted that the vegetational analysis was conducted in August 1975, so that some growth subsequent to the 1974 clearing occurred. Photographs of the revetments as they appeared in 1975 may be found in the appendix.

As one would expect, the cleared revetments lack Daubenmire cover class layers W1 and W2, and show poor representation of plants in the W3 layer. In comparison, the uncleared revetments show greater variation in both the number of layers present, and the amount of cover within each layer. The direct effect on revetments of the present clearing practice is to reduce, to varying degrees, the vegetational and physiognomic diversity.

Mammals

A summary of mammal trap data is shown in Table III with evidence, other than from trapping, of mammals on revetments shown in Table IV. Trap data, by revetment, may be found in the appendix.

Data shown in Table III indicate that in terms of total numbers, more small mammals were trapped on uncleared than on cleared revetments. It is obvious, however, that this trend was not uniform among all pairs of revetments and that large numbers caught on one revetment or during one trap period tended to skew the final totals. The totals show that two species of mammals were trapped only on uncleared revetments and one species was trapped only on a cleared revetment, but each of these was a single occurrence. In addition, evidence other than trapping revealed

TABLE III

TOTAL MAMMALS CAPTURED ON
ALL CLEARED AND UNCLEARED REVETMENTS

Revetment	*Peromyscus maniculatus*	*Sorex spp.*	*Spermophilus beecheyi*	*Mus musculus*	*Microtus spp.*	*Eutamias townsendii*	*Didelphis virginiana*	*Zapus trinotatus*	*Neurotrichus gibbsii*	*Sylvilagus bachmani*	*Sciurus niger*	*Mephitis mephitis*	TOTAL
Molalla No. 6 Cleared	90	9			4	6	1	5	2				117
Molalla No. 4 Uncleared	122	12	1		2	3		1	1				142
Stoutenberg Cleared	153	19		1	2		3				1		179
Grand Island Uncleared	131	5	13	1	1								151
Wickham Cleared	41	4		4	1								50
Tomasek Uncleared	63	32		5	5		1		1			1	108
Coon Creek Cleared	67	20		12			1						100
Upper Half Moon Cleared	60	2	3				1						66
Half Moon Bend Uncleared	95	16	1	1						1			114
Blankton Cleared	59	8	1	1			1						70
Armitage Uncleared	69	6	6				1	1					83
CLEARED TOTAL	470	62	4	18	7	6	7	5	2		1		582
UNCLEARED* TOTAL	575	87	22	8	8	3	2	2	2	2		1	712

* Half Moon Bend totals doubled since it acts as a control for two cleared revetments.

TABLE IV

EVIDENCE, OTHER THAN TRAPPING, OF MAMMALS ON REVETMENTS

SPECIES	Molalla No. 6	Molalla No. 4	STOUTENBERG	GRAND ISLAND	WICKHAM	TOMASEK	MILLAR	COON CREEK	UPPER HALF MOON	HALF MOON BEND	BLANKTON	ARMITAGE
Didelphis virginiana Opossum	tracks							tracks	tracks			
Sylvilagus bachmani Brush Rabbit		sighted	sighted	sighted	sighted	sighted	sighted			sighted		scats
Eutamias townsendii Townsend's Chipmunk	sighted	sighted					sighted					sighted
Spermophilus beecheyi Cal. Ground Squirrel				many sighted			sighted		few sighted		sighted once	few sighted
Sciurus niger Fox Squirrel					one sighted							
Tamiasciurus douglasii Douglas' Squirrel					one sighted							
Castor canadensis Beaver	tracks	tracks				sighted			sighted	cuttings	cuttings	
Myocastor coypus Nutria					← tracks on most →							
CANIDS					← tracks on most →							
Vulpes vulpes Red Fox										sighted		
Ursus americanus Black Bear						scats barking						
Procyon lotor Raccoon	tracks	tracks		sign	many tracks	many tracks	tracks scats		tracks, many scats	tracks scats		
Mustela frenata Long-tailed Weasel					sighted							
Mustela vison Mink		tracks										
Mephitis mephitis Striped skunk						sighted		scent tracks				
Odocoileus hemionus Blacktailed Deer	tracks	many tracks	tracks	tracks	tracks	many tracks	sighted, tracks scats	tracks	tracks			

the presence of some species on cleared or uncleared revetments only; however, it is difficult to attach any significance to incidental evidence of this nature.

In all, twelve species of mammals were trapped on the revetments studied; however, trapping data was dominated by four species. The results, by species, follows:

Peromyscus maniculatus

Peromyscus maniculatus is overwhelmingly the most abundant mammal trapped on the revetments. In fact, more deer mice were caught than all other mammals combined. While more deer mice were captured on uncleared revetments than on cleared ones, this trend was not completely uniform among all revetment pairs. The high degree of variability in the trapping data between cleared and uncleared pairs further obfuscates the results. Comparison of mean and standard deviation of this data illustrates this variability: cleared revetments $\bar{x}$ = 78.3 SD = 39.9, uncleared revetments $\bar{x}$ = 95.8 SD = 27.3. From this data, no difference between uncleared and cleared revetments can be ascertained.

In addition to the variation in trap data, a large population fluctuation was noted. During the winter of 1975, an influx of deer mice were trapped on the Stoutenberg and Grand Island revetments; this fluctuation accounted for almost half of all Peromyscus caught at these locations.

From the trapping records, the sex ratio of Peromyscus was calculated to determine if revetment clearing had any effect on this aspect of this species' population structure. Comparison of both cleared and uncleared revetments showed identical sex ratios; a ratio of 1.32:1 males to females, or 57 percent males.

Sorex spp.

Shrews were the second most numerous mammal caught on revetments. The majority of the shrews caught were *Sorex vagrans* though a few were *Sorex trowbridgii*. Again, in total number more shrews were caught on uncleared than on cleared revetments. However, when revetment pairs are examined individually, no clear difference was obvious. Comparison of mean and standard deviation of this data illustrates high variability in the data: cleared revetments $\bar{x}$ = 10.3 SD = 7.6, uncleared revetments $\bar{x}$ = 14.5 SD = 9.8. From the data, no difference between cleared and uncleared revetments can be ascertained.

Spermophilus beecheyi

The capture totals seemingly present a clear delineation between cleared and uncleared revetments for *Spermophilus beechyi*; eighty five percent of all the California ground squirrels caught were on uncleared revetments. When the occurrence of this squirrel is related to the presence of woody vegetation, however, no relationship is apparent. When the trap data is examined by revetment pair, we find that 50 percent of the squirrels were trapped on the Grand Island revetment. The vegetational analysis of this revetment (Table II) shows very little woody growth on this uncleared revetment or the other main revetments on which this squirrel was trapped. Since diurnal nature and conspicuous habits of this squirrel allowed visual observation, it was relatively easy to see that this colonial squirrel lived in vegetative cover behind the revetments and only made furtive excursions onto the revetments. From these visual observations plus the uneven trapping data, it is obvious that these squirrels were isolated populations. Based upon this data, no difference between cleared and uncleared revetments can be ascertained.

Mus musculus

Although more *Mus musculus* were found on cleared than uncleared revetments, the data is obviously biased by the large number caught on the Coon Creek revetment. The majority of the mice caught on this revetment and the Wickham and Tomasek revetments were due to a population fluctuation of the September 1975 trap data; during this singular trap set, the majority of *Mus* were caught. Again, based upon this data, no difference between cleared and uncleared revetments can be ascertained.

Other species

Little can be determined from the trapping data for other species of mammals caught on the revetments as to how these species are affected by clearing. Similar numbers of individuals were caught on both cleared and uncleared revetments, or too few individuals of a species were caught to draw any conclusion. However, I should note that from my visual observations of *Eutamias townsendii* at the Molalla 6 revetment site that these chipmunks lived in the vegetative cover behind this revetment rather than on the revetment as the trap data might indicate.

Summary

The results may be summarized as follows:

1. The direct effect on revetments of present clearing practices is to reduce, to varying degrees, the vegetational and physiognomic diversity of the revetment.

2. Twelve species of mammals were trapped on the revetments studied; however, the data was dominated by four species: *Peromyscus maniculatus*, *Sorex* spp., *Mus musculus*, and *Spermophilus beecheyi*.

3. No differences between mammals occurring on cleared compared to uncleared revetments could be ascertained from the data. The high variability of the data, however, does not allow specific conclusions to be reached.

4. Population fluctuations were noted for *Peromyscus maniculatus* and *Mus musculus*.

5. The sex ratio for *Peromyscus maniculatus* was skewed toward the males (1.32:1).

DISCUSSION

Similar Investigations

As this study appears to be the first attempt to make a quantitative estimate of the effects associated with revetment clearing on riparian mammal populations, similar studies were not available for comparison. Yet, many habitat alteration studies which investigated changes in small mammal populations have been completed. The more applicable of these investigations have been compared to this study to determine if any particular trends, in regard to small mammals, have been described.

The majority of revetments investigated were surrounded by farm land, therefore, studies which relate farming practices to small mammal populations may be directly applicable to this study. Ogilvie and Furman (1959), investigating the difference in small mammal populations in relation to weedy, shrubby or bare fence rows, found no statistically significant differences between these vegetation types and the total small mammal populations. They found that *Peromyscus maniculatus*, the most frequently caught small mammal, was equally abundant in all three types of fence rows. In contrast, *Microtus montanus* was found to be more abundant in the weedy type of fence row than either the brushy or bare types. Dambach (1944) when studying grazed and ungrazed farmlands found an apparent increase in abundance of mammals paralleled the development of new woody growth and better distribution of leaf litter in the ungrazed woods. LoBue and Darnell (1959) investigating the effect of habitat disturbance on small mammals as produced by farming practices, found that changes in *Microtus pennsylvanicus* and *Peromyscus maniculatus bairdi* populations were directly related to the stages of an alfalfa crop. They found that as the vegetation increased in height and cover, *Microtus* showed an increased use of the field while *Peromyscus* use declined. Following cutting of the field, there was an increase in numbers of *Peromyscus* in the sparse vegetation cover and a decrease in *Microtus* numbers. The poor use of heavily vegetated regions by *Peromyscus* was also demonstrated by Hays (1958); when he compared small mammal populations in an open grassland to a wooded ravine, he found a greater number of small mammals in the grassland. By far the most abundant of the small mammals captured in the open grassland was *Peromyscus maniculatus*, but these mice were seldom captured in the wooded ravine.

The effect of forest practices on small mammal populations may also be compared to this study since there is a clear similarity between several of these forest practices (fire, herbicide application, clear-cutting) and revetment clearing. The effect of these practices on small mammal populations has received considerable attention (Black and Hooven, 1974; Gashwiler, 1959; Gashwiler, 1971; Harris, 1968; Hooven, 1973). In general, it has been reported that *Peromyscus* populations and most *Microtus* and *Sorex* populations increase as the habitat changes from coniferous forest to clearcut; however, exceptions to this generality occur. For example, Tevis (1956) found that logging caused an increase in the numbers of *Peromyscus* and a decrease in the number of *Sorex*, and Harris (1968) found fewer *Peromyscus* were caught on the cutting than in the nearby timber. Similarly, other species responded to habitat changes according to their habitat preferences. For some, as the sciurids, clearcutting reduced their numbers; for other species, only limited changes occurred.

While the examples from the literature search are far from conclusive, general trends can be seen. *Peromyscus*, *Sorex* and *Microtus* seemingly prefer grassland type environments to heavily wooded ones. *Peromyscus* is usually associated with areas of sparse vegetation, *Sorex* prefers areas with considerable leaf litter, *Microtus* inhabits areas with many stems and shrubs. In general, according to the literature, the other mammals found in association with revetments prefer areas of interspersion where forest, shrubby and grassland areas are all present. However, the data from this present study stands somewhat in contrast to these examples from the literature, making it difficult to reconcile the situation on revetments with these studies.

In contrast, the trap data relating to the sex ratio of *Peromyscus maniculatus* closely corresponds to that described in the literature. Previous investigations of the sex ratio of this mouse have revealed that a preponderance of males in natural populations of this species is regularly recorded. The trap data from this study of 57% males is similar to trap data from the Trojan nuclear site in Oregon where a sex ratio of 54% males was obtained (Battelle, 1974) and to the North American census of small mammals were a sex ratio of 56% males was calculated (Terman, 1968). Terman hypothesized that the greater catch of male mice may be due to greater mobility of the males, and to a disproportionate production of male young.

Studies relating the overall practice of river channelization and stream bank alteration to declines in fish and wildlife have been published (Campbell, 1970; Funk and Robinson, 1974; and U.S.D.A., 1977). These publications address the ecological importance of riparian areas and how alteration of these areas may affect fish and wildlife populations; the majority of these reports emphasize avian communities, however. In addition, a number of investigations have addressed channel alterations and the impact on fish populations (Boussu, 1954; Elser, 1968; Gebbhards, 1970; Gunderson, 1968; and Lewis, 1969). While the applicability of these investigations to the present study of riparian wildlife is limited, these investigations imply a larger ecological importance of the riparian community structure.

Mammal Use of Revetments and the Effect of Clearing

The direct effect on revetments of present clearing practices is to reduce vegetational and physiognomic diversity. Although this observation appears obvious and insignificant, the fact that riprapped banks readily revegetate is important from a riparian management standpoint; bank stabilization by the construction of revetments can coexist with natural riparian plant communities. In fact, revetments that had not been cleared for a number of years are similar in nature to and difficult to differentiate from unaltered riparian plant communities. Restoration of revetment sites to "natural" riparian communities can be accomplished simply by not maintaining the revetment by the practice of clearing vegetation.

The effect on mammals of the current clearing practices is not as straightforward as the effect on the vegetation. From our sampling, it is difficult to ascertain any significant difference between mammals found associated with cleared and uncleared revetments. While the simplest explanation is that revetment clearing has no effect at all on riparian mammal community structure, the null hypothesis, this facile conclusion is difficult to reconcile with the drastic habitat alteration that occurs due to revetment clearing. It seems more likely that the lack of evidence may be due to a multitude of factors associated with revetments in general, and with the habitat preferences of the dominant mammals found on these structures.

The variance of the data, and consequently the confidence we may place in this data, is a major reason we cannot ascertain any significant difference between mammals found on cleared and uncleared revetments. I do not believe, however, that increasing sampling size is necessarily the best mechanism to advance our understanding of the impacts associated with revetment clearing on mammals; first, the sample size would be impractical, and secondly, many other factors may affect these riparian mammal communities beyond simply clearing vegetation from a revetment. Some of the more obvious of these factors are presented in the following discussion.

The severe habitat alteration associated with the construction of revetments may limit the kinds of mammals found on revetments. Since riverine flora is frequently the only natural vegetation in an area, for some specialized species the removal of this vegetation prior to construction may destroy their only available utilizable habitat. After construction, when vegetation has had a chance to establish itself on the revetment, the lack of dispersal routes may prohibit many species from immigrating to these vegetated areas. In addition, the structural characteristics of revetments excludes many mammalian species, e.g., denning and hoofed mammals (Corps of Engineers, 1975).

As had been demonstrated with a number of species, the background environment played an important role in affecting the mammals found associated with revetments. The lack of a suitably vegetated background environment limits the area of utilizable wildlife habitat for some species. This lack of suitable habitat contiguous to revetments is due not only to the fact that revetments are generally built in areas of high human activity, but also frequently due to the conversion of riparian woodlands to agriculture and pasture behind newly constructed revetments. Consequently, little natural vegetation behind the revetments is the case in general, and riparian vegetation is often the only natural vegetation in an area that meets the needs of some species. Conversely, in some instances, natural vegetation in the background environment remained intact, playing an important role in the presence of other species. In this study, we found this to be true with Spermophilus beecheyi and Eutamias townsendii. Apparently, in these cases, the background environment supplied the needed habitat requirements that permitted habitation of the area.

In all probability, the presence or absence of a suitable background played an important role in determining the presence or absence of all the mammals found associated with revetments in this study. Even Peromyscus and Sorex, the most numerous mammals found on revetments, have home ranges of up to several acres (Wise, 1967; Stickel, 1968). With home ranges so many times larger than the revetment surface area, it is highly unlikely that these mammals spent all their lives only on the revetment. In addition, the extensive rehabitation of the mammal transect areas by immigration, after trapping, demonstrates that a number of these small mammals were in the surrounding area. The above information tends to support the assumption that mammals found on revetments may be highly dependent on the background environment.

All the above factors tend to limit the types of mammals found associated with revetments to a few cosmopolitan and opportunistic species. These species may, in fact, be more dependent upon the ground cover than the upper vegetational strata. Since the herbaceous vegetation and revetment surface was only slightly altered by revetment clearing, these species were not drastically affected by the incurring habitat change. If these species utilized the background environment to any great extent, it may be that to an opportunistically feeding small mammal the presence of interstices among the rocks for refugia are more appealing than the species composition of the vegetation on the revetment.

The difficulty in correlating the presence of the major species found on revetments with vegetational parameters and the cosmopolitan nature of these species is well documented. King (1968), who presents an extensive survey of the literature on the genus Peromyscus, found this mouse to be the most widely distributed small mammal in North America. Verts (1957) found no correlation between the distribution of P. maniculatus and percent bare ground, annuals, grasses, woody vegetation, perennials, biennials and stems per square meter. Shrews, the second most numerous mammal caught on revetments, exhibit similar tendencies. The lack of correlation with biotic parameters is presented in the findings of Brown (1967) who found the vagrant shrew to be cosmopolitan in distribution.

As presented, many factors may have influenced the mammal populations studied, beyond just the clearing of vegetation from revetments. Habitat alteration from the construction of the revetment may have greatly affected the species we found associated with revetments. The background environment may play an important role in influencing the presence of these species. And, the habitat requirements of the predominant species found on revetments may not be affected by revetment clearing. All of these factors may have contributed toward the end results: no difference in mammal populations due to revetment clearing were found in this study.

Population Fluctuations

While populations of *Peromyscus maniculatus* are generally stable, showing the lowest fluctuations when compared to other small mammals (Terman, 1966), an influx of deer mice on Stoutenberg and Grand Island revetments occurred during the winter of 1975. Since this influx corresponded to a period of high water, it was believed that the elevated nature of these revetments in relation to the surrounding lowland offered refuge during flooding. Previous instances of flooding or high soil moisture causing seasonal changes in mammal distributions have been described by Ingles (1949) for pocket gophers, by Genelly (1965) for mole rats and by Gottfried (1972) for Townsend's voles. When investigating the effect of flooding on *Peromyscus gossypinus* and *Peromyscus nuttalli*, McCarley (1959) found that flooding had little detrimental effect on these mice and that there was a remarkable tendency on the part of the mice to remain within their established home range, as reported previously by Stickel (1948). The supposition was that these mice lived in trees while the areas were flooded. In contrast, the lack of trees or any other suitable refugia in the study area most likely caused a movement of mice to the only available high ground, the revetment; this would account for the subsequent population increase found in this study.

In addition to the population fluctuations in *Peromyscus*, there was also an influx of *Mus musculus* at Wickham, Tomasek and Coon Creek locations in September 1975. Unlike the deer mouse fluctuation, the influx of *Mus* at these revetments did not seem to be correlated with any specific environmental parameter. Brown (1953), found their populations on Maryland farms peaked in early spring and autumn; he correlated this with changes in farm practice. While recently harvested wheat fields were behind Coon Creek and Wickham locations, the lack of any wheat or recently harvested crop near Tomasek revetment obfuscates the hypothesis that this influx was a direct result of farming practices. Populations of this mouse, however, may be correlated with other farm practices which altered food availability. If so, a seasonal high population during September may have triggered a migration of this mouse due to intraspecific competition, and resulted in the increase in captures. In addition to migration of this mouse due to intraspecific competition, Caldwell (1964) postulated that the migration of *Mus* may be a mechanism which reduced competition between *Mus* and the more sedentary *Peromyscus*. For whatever reason, the movement of *Mus musculus* in September caused more of them to be caught during this trap period than in all other trappings combined.

Conclusions and Recommendations

While revetment clearing greatly affects the seral stage of vegetation found on revetments, no major difference in the mammals sampled could be attributed to the clearing. It was proposed that many factors, beyond just vegetation, may influence mammals that use revetments. Future investigations should include experimental designs that include these other environmental factors. One possible methodology would include a before-and-after study. By using such a method, the effects of areas bordering the revetment could then be held reasonably constant. In addition, the impact of revetment construction should also be investigated. We had hypothesized that the revetment, even more than the clearing of vegetation, affected the presence of riparian mammals.

During the course of this study, we did not notice any significant damage to the structural integrity of any of the revetments due to vegetation. Further, to my knowledge, there is no substantiated evidence that revetment clearing practices are necessary. The effect of vegetation on revetments and the cost effectiveness of clearing vegetation from revetments should be evaluated.

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APPENDIX

TABLE V

MAMMAL TRAPPING DATA FOR MOLALLA NO. 6 AND MOLALLA NO. 4

Molalla No. 6 (Cleared)

	Peromyscus maniculatus	*Sorex* spp.	*Spermophilus beecheyi*	*Mus musculus*	*Microtus* spp.	*Eutamias townsendii*	*Didelphis virginiana*	*Zapus trinotatus*	*Neurotrichus gibbsii*	*Sylvilagus bachmani*	*Sciurus niger*	*Mephitis mephitis*
Before	29	2			1	5						
After	19	1										
Fall	16	1			2	2			1			
Winter	16	4			1							
Spring	14	1				1	1					
1	6					1		2				
2	4	1							1			
3	15	1			1	2		3				
TOTAL	90	9			4	6	1	5	2			

Molalla No. 4 (Uncleared)

	Peromyscus maniculatus	*Sorex* spp.	*Spermophilus beecheyi*	*Mus musculus*	*Microtus* spp.	*Eutamias townsendii*	*Didelphis virginiana*	*Zapus trinotatus*	*Neurotrichus gibbsii*	*Sylvilagus bachmani*	*Sciurus niger*	*Mephitis mephitis*
Before	5				1			1				
After	7	1						1				
Fall	26				1							
Winter	22	1				1						
Spring	18	2	1			1						
1	21	2			1							
2	13	1							1			
3	15	5				1						
TOTAL	122	12	1		2	3		1	1			

TABLE VI

MAMMAL TRAPPING DATA FOR
STOUTENBERG AND GRAND ISLAND

Stoutenberg (cleared)

	Peromyscus maniculatus	*Sorex spp.*	*Spermophilus beecheyi*	*Mus musculus*	*Microtus spp.*	*Eutamias townsendii*	*Didelphis virginiana*	*Zapus trinotatus*	*Neurotrichus gibbsii*	*Sylvilagus bachmani*	*Sciurus niger*	*Mephitis mephitis*
Before	10	2										
After	17	10		1							1	
Winter	72	1										
Spring	29				1							
1	14	3			1							
2	8	3					2					
3	13	2					1					
TOTAL	153	19		1	1		3				1	

Grand Island (uncleared)

	Peromyscus maniculatus	*Sorex spp.*	*Spermophilus beecheyi*	*Mus musculus*	*Microtus spp.*	*Eutamias townsendii*	*Didelphis virginiana*	*Zapus trinotatus*	*Neurotrichus gibbsii*	*Sylvilagus bachmani*	*Sciurus niger*	*Mephitis mephitis*
Before	24		2									
After	13	1	5	1								
Winter	58				1							
Spring	24		2									
1	11	1	2									
2	6	3	2									
3	19		2									
TOTAL	131	5	13		1							

TABLE VII

MAMMAL TRAPPING DATA FOR WICKHAM AND TOMASEK

Wickham (cleared)

	Peromyscus maniculatus	*Sorex spp.*	*Spermophilus beecheyi*	*Mus musculus*	*Microtus spp.*	*Eutamias townsendii*	*Didelphis virginiana*	*Zapus trinotatus*	*Neurotrichus gibbsii*	*Sylvilagus bachmani*	*Sciurus niger*	*Mephitis mephitis*
Before		3										
After	3	3										
Fall	15											
Winter	12	1										
Spring	7				1							
1	3											
2	1											
3				4								
TOTAL	41	4		4	1							

Tomasek (uncleared)

	Peromyscus maniculatus	*Sorex spp.*	*Spermophilus beecheyi*	*Mus musculus*	*Microtus spp.*	*Eutamias townsendii*	*Didelphis virginiana*	*Zapus trinotatus*	*Neurotrichus gibbsii*	*Sylvilagus bachmani*	*Sciurus niger*	*Mephitis mephitis*
Before	5	2										
After	6	9										
Fall	20											
Winter	13	3		1								
Spring	4	4			2							1
1	7	4			1							
2	4	6			1				1			
3	9	6		4	1		1					
TOTAL	63	32		5	5		1		1			1

TABLE VIII

MAMMAL TRAPPING DATA FOR
WICKHAM AND MILLAR

Wickham (cleared)

	Peromyscus maniculatus	*Sorex spp.*	*Spermophilus beecheyi*	*Mus musculus*	*Microtus spp.*	*Eutamias townsendii*	*Didelphis virginiana*	*Zapus trinotatus*	*Neurotrichus gibbsii*	*Sylvilagus bachmani*	*Sciurus niger*	*Mephitis mephitis*
Before		3										
After	3	3										
Fall	15											
Winter	12	1										
Spring	7				1							
1	3											
2	1											
3				4								
TOTAL	41	4		4	1							

Millar (uncleared)

	Peromyscus maniculatus	*Sorex spp.*	*Spermophilus beecheyi*	*Mus musculus*	*Microtus spp.*	*Eutamias townsendii*	*Didelphis virginiana*	*Zapus trinotatus*	*Neurotrichus gibbsii*	*Sylvilagus bachmani*	*Sciurus niger*	*Mephitis mephitis*
1	24											
2	14	6										
3	10	3	2									
TOTAL	48	9	2									

TABLE IX

MAMMAL TRAPPING DATA FOR
UPPER HALF MOON BEND AND HALF MOON BEND

Upper Half Moon (cleared)

	Peromyscus maniculatus	*Sorex spp.*	*Spermophilus beecheyi*	*Mus musculus*	*Microtus spp.*	*Eutamias townsendii*	*Didelphis virginiana*	*Zapus trinotatus*	*Neurotrichus gibbsii*	*Sylvilagus bachmani*	*Sciurus niger*	*Mephitis mephitis*
Before	1											
After	3	1										
Winter	19						1					
Spring	17											
1	3		2									
2	4	1	1									
3	14											
TOTAL	60	2	3				1					

Half Moon Bend (uncleared)

	Peromyscus maniculatus	*Sorex spp.*	*Spermophilus beecheyi*	*Mus musculus*	*Microtus spp.*	*Eutamias townsendii*	*Didelphis virginiana*	*Zapus trinotatus*	*Neurotrichus gibbsii*	*Sylvilagus bachmani*	*Sciurus niger*	*Mephitis mephitis*
Before	8	4										
After	7	2	1									
Winter	24			1								
Spring	25	6										
1	11	1										
2	6	4								1		
3	22	3										
TOTAL	95	16	1	1						1		

TABLE X

MAMMAL TRAPPING DATA FOR
COON CREEK AND HALF MOON BEND

Coon Creek (cleared)

	Peromyscus maniculatus	*Sorex spp.*	*Spermophilus beecheyi*	*Mus musculus*	*Microtus spp.*	*Eutamias townsendii*	*Didelphis virginiana*	*Zapus trinotatus*	*Neurotrichus gibbsii*	*Sylvilagus bachmani*	*Sciurus niger*	*Mephitis mephitis*
Before	7	2										
After	6	7		1								
Winter	20	1										
Spring	12											
1	8	3		1								
2	11	5		2								
3	10	4		8			1					
TOTAL	67	20		12			1					

Half Moon Bend (uncleared)

	Peromyscus maniculatus	*Sorex spp.*	*Spermophilus beecheyi*	*Mus musculus*	*Microtus spp.*	*Eutamias townsendii*	*Didelphis virginiana*	*Zapus trinotatus*	*Neurotrichus gibbsii*	*Sylvilagus bachmani*	*Sciurus niger*	*Mephitis mephitis*
Before	8	4										
After	7	2	1									
Winter	24			1								
Spring	25	6										
1	11	1										
2	6	4								1		
3	22	3										
TOTAL	95	16	1	1						1		

TABLE XI

MAMMAL TRAPPING DATA FOR
BLANKTON AND ARMITAGE

Blankton (cleared)

	Peromyscus maniculatus	*Sorex spp.*	*Spermophilus beecheyi*	*Mus musculus*	*Microtus spp.*	*Eutamias townsendii*	*Didelphis virginiana*	*Zapus trinotatus*	*Neurotrichus gibbsii*	*Sylvilagus bachmani*	*Sciurus niger*	*Mephitis mephitis*
Before	6											
After	3	1										
Winter	34	2		1			1					
Spring	16	3	1									
1	3	1										
2	3	1										
TOTAL	59	8		1			1					

Armitage (uncleared)

	Peromyscus maniculatus	*Sorex spp.*	*Spermophilus beecheyi*	*Mus musculus*	*Microtus spp.*	*Eutamias townsendii*	*Didelphis virginiana*	*Zapus trinotatus*	*Neurotrichus gibbsii*	*Sylvilagus bachmani*	*Sciurus niger*	*Mephitis mephitis*
Before	13	1	1									
After	8	1	1									
Winter	36	2					1					
Spring	20	1	1					1				
1	3	1	1									
2	2	1	3									
TOTAL	69	6	6				1	1				

Figure 3. Photographs of Molalla No. 4 (top) and Molalla No. 6 locations.

Figure 4. Photographs of Stoutenberg (top) and Grand Island locations.

Figure 5. Photographs of Wickham (top) and Tomasek locations.

Figure 6. Photograph of Millar location.

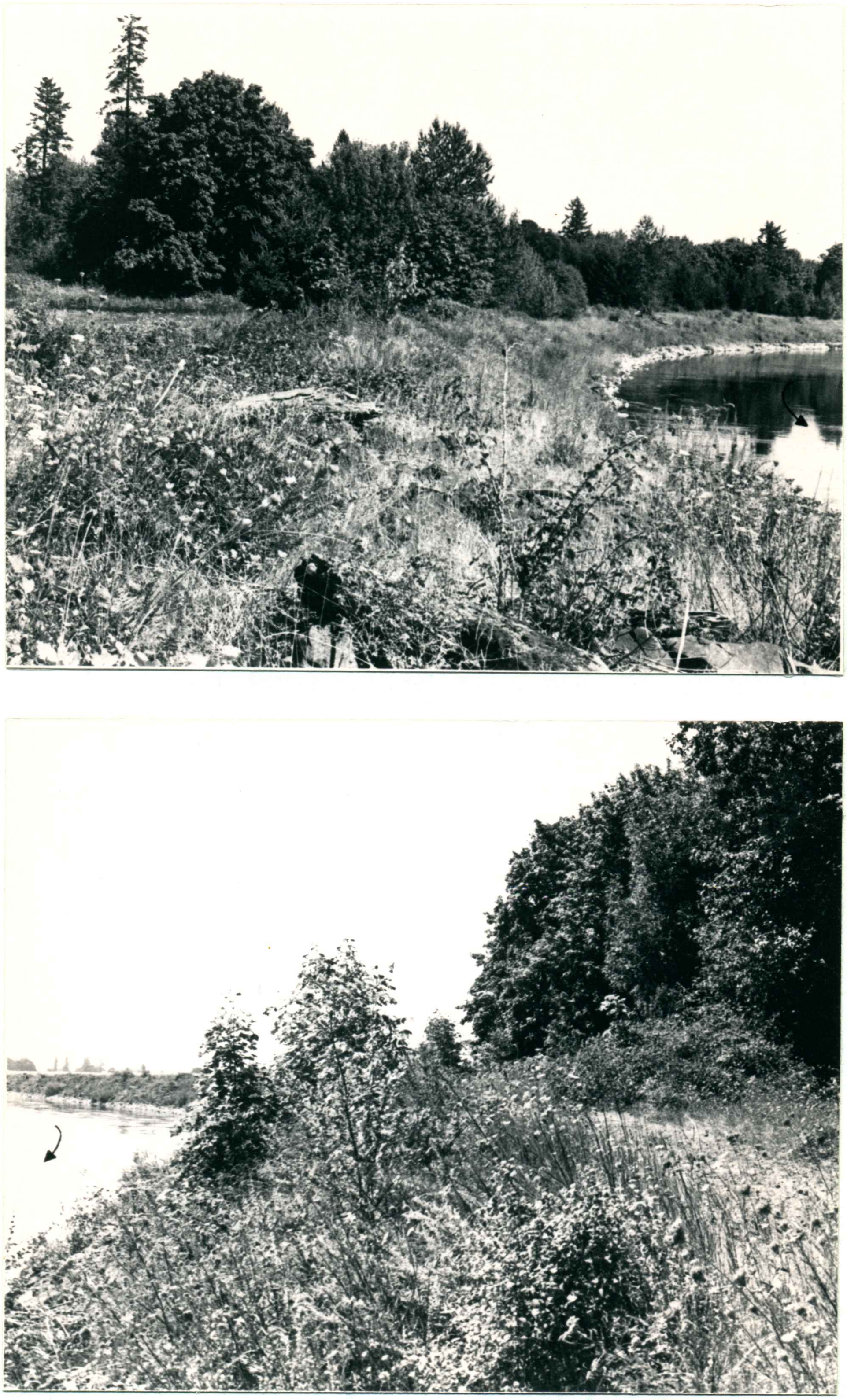

Figure 7. Photographs of Upper Half Moon Bend (top) and Half Moon Bend locations.

Figure 8. Photographs of Coon Creek (top) and Half Moon Bend locations.

<u>Figure 9</u>. Photographs of Blankton (top) and Armitage locations.