Will Continued Monitoring Of Beaver Damaged Resources Minimize Future Damage?

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WILL CONTINUED MONITORING OF BEAVER DAMAGED RESOURCES MINIMIZE FUTURE DAMAGE?

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ABSTRACT: The purpose of this study was to determine if continued monitoring and removal of beavers (*Castor canadensis*) from previously controlled beaver damage sites resulted in less additional damage than not monitoring such sites. Beavers were removed from 34 sites in nine southeast Texas counties from August 1996 through March 1997. Sixteen sites subsequently were monitored monthly and, if beavers had reinvaded, they were removed and the additional damage value was recorded. The remaining 18 sites were not monitored monthly, but they were visited for a final survey at the end of the study. The value of additional damage was recorded at that time. Damage following reinvasion occurred more often when sites were not monitored (5 of 7 sites, compared to only 2 of 7 reinvaded, monitored sites). In addition, when damage occurred at reinvaded sites, monetary value appeared to be greater without monitoring (average $940, n=5) than with monitoring (average $125, n=2). The larger average damage values for reinvaded unmonitored sites compared to reinvaded monitored sites would be important to landowners when deciding if property should be monitored. Factors that made some sites susceptible to reinvasion were also evaluated. Significantly more beavers were taken initially, per site, in the reinvaded sites compared to all other sites. This implies that better habitat and higher beaver density were the most important factors in determining a site's susceptibility to reinvasion.

KEY WORDS: beaver, damage, monitoring, primary removal, secondary removal, reinvasion

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INTRODUCTION

A growing beaver (*Castor canadensis*) population and subsequent resource damage have become a problem in much of the southeastern United States, including Texas (Woodward 1983; Ramsey and Wade 1986). Beaver numbers are high, especially in the eastern third of Texas, and their range is expanding (Ramsey and Wade 1986). According to Ramsey and Wade (1986), damage is severe in eastern parts of Texas, and beaver control is legal year round.

Damage values associated with beaver activities have been estimated for parts of the U.S. and Texas. Woodward (1983) reported that the estimated value of damage (including value of finished wood products) on 400,000 hectares in the southeastern U.S. exceeded four billion dollars during the last 40 years. The Texas Agricultural Extension Service estimated that beavers caused $34 million in damage during 1994 in a 42-county area in the eastern third of the state (Douglas 1995; Upshaw 1995). The U.S. Department of Agriculture - Wildlife Services Program in Texas reported $2.4 million in beaver damage in its State Damage Summary for beavers for the period October 1996 through September 1997 (Anonymous 1996).

When Texas Wildlife Services Program personnel remove beavers from damage sites, landowners are urged to monitor their property to minimize additional damage by reinvading beavers. Many times landowners do not monitor their property after beavers are removed. Population dynamics help explain why monitoring is important. As numbers of beavers within colonies increase, there is more pressure on younger beavers to disperse. They may travel only 2 to 3 km but usually travel up to 8 to 16 km and have been known to travel as much as 161 km in search of new homes (Jackson 1996). Also, their dispersal rate has been reported to be about 0.7 to 1 km per night (Weaver 1986). Beavers can travel great distances in a short period of time. Due to this fact and the fact that beaver numbers are large and continue to increase in Texas, property can be reinvaded quickly. Beavers have been known to quickly reinvade previously controlled sites.

This project attempted to answer the following questions: Can landowners minimize additional damage from reinvading beavers by periodically monitoring sites after initial removal of beavers? Conversely, is the damage going to be the same whether resources are monitored or not? If damage can be minimized by continued monitoring, then how great is the difference in the amount of additional damage between monitored and "neglected" (unmonitored) sites? In addition, what factors made some sites more susceptible to reinvasion than others?

STUDY AREA

The sites were located in nine southeast Texas counties. Total area for the nine counties is 2,003,573 ha. The Brazos and Navasota Rivers are the major drainage systems for the eight contiguous counties in this study area and are probably the primary sources of beavers.

METHODS

Beaver damage surveys and initial removal of beavers from damage sites (primary removal) began in August 1996. Removal of reinvading beavers (secondary removal) continued until March 1997. Removal methods included: body grip traps, leghold traps, neck snares and shooting. Thirty-four sites were included in this study. Each site contained only one family group of beavers and all sites were within the parameters identified by Buech (1985) for one beaver colony.

The 34 sites were divided into two categories, monitored and unmonitored. The sites were alternately designated monitored or unmonitored as requests for assistance were received. Sixteen sites were selected for monthly monitoring, and the remaining 18 sites were not monitored (unmonitored). After primary removal, monitored sites were evaluated monthly until March 1997. If beavers had returned to a site, they were removed. Additional damage since the time of primary removal was recorded for each site. For unmonitored sites, a final survey was completed some time between January 12, 1997 and March 15, 1997; no beavers were removed from these sites after primary removal. In the final survey of unmonitored sites, if reinvasion had occurred, additional damage was assessed. A checklist was used to assess resource damage and to record numbers and ages of beavers taken. Beaver age was estimated based on body weight.

Differences in damage estimates between monitored and unmonitored groups were evaluated using a standard t-test (significance was determined in all t-tests using $P \leq 0.05$.) The non-reinvaded sites in both groups were given $0 values. The original hypothesis was that additional damage for unmonitored sites would be larger.

Delorme Map Expert® software was used to determine distance to a permanent water source (river, major tributary, etc.) for each site (Table 1). These distances represent waterway distances, when waterways could easily be followed on the maps. The difference in distances to a permanent water source between all reinvaded and all non-reinvaded sites was tested for significance with a standard t-test. The original hypothesis for the test was that the distance was smaller for reinvaded sites. Exposure days were also calculated for each site (Tables 2 and 3). These were the number of days a site was susceptible to reinvading beavers. The total exposure days for sites were from the last day of primary removal to the last visit. A standard t-test was used to determine if there was a significant difference in exposure days between monitored and unmonitored groups. Also, the difference between exposure days for reinvaded unmonitored sites and non-reinvaded unmonitored sites was tested for significance with the standard t-test. The original hypothesis was that the number of exposure days would be greater for reinvaded unmonitored sites. Correlation between exposure days and amount of additional damage for reinvaded, unmonitored sites was evaluated with a linear regression analysis.

Difference in numbers of beavers taken in primary removal between reinvaded sites and non-reinvaded sites was tested for significance with the standard t-test. The original hypothesis was that reinvaded sites had more beavers taken in primary removal.

RESULTS

The total number of beavers taken in primary removal was 121; 52% were adults, 16% were juveniles, and 32% were of unknown age (Table 2). The average number of beavers taken per site was 4 ± 2. Numbers of beavers taken at sites ranged from 1 to 12. The total initial damage estimate before primary removal began was $52,865. The average for each site was $1,555 ± $1,523.

Seven of 16 monitored sites (44%) were reinvaded by beavers (Table 3). Two of the seven sites were reinvaded within two months and the other five were reinvaded within one month. The total number of reinvading beavers taken in secondary removal was 22; 68% were adults, 14% were juveniles, and 18% were of unknown age. The average number of beavers taken in reinvaded sites was 3 ± 1. Six of seven reinvaded sites were reinvaded only once; one site was reinvaded three times. The total additional damage estimate for monitored sites was $250 (Table 4). The average damage estimate for these sites was $36 ± $55. Seven of 18 unmonitored sites (39%) were reinvaded (Table 5). The total additional damage estimate was $4,700. The average damage estimate for these sites was $671 ± $947.

Seven monitored and seven unmonitored sites were reinvaded by beavers (14 of 34 sites). Damage following reinvasion occurred more often when sites were not monitored (5 of 7 sites compared to only 2 of 7 reinvaded monitored sites). When damage occurred at reinvaded sites, monetary value appeared to be greater without monitoring (average $940, $n=5$) than with monitoring (average $125, $n=2$). However, a t-test using $P \leq 0.05$ to determine significance indicated that there was no significant difference in damage values between monitored and unmonitored sites ($P=0.08$).

The average distance to a permanent water source for all sites was 2.4 ± 2.4 km (Table 1). The average distance for all reinvaded sites was 1.9 ± 2.7 km. The average distance for all non-reinvaded sites was 2.6 ± 2.2 km. No significant differences were found in distances to permanent water sources between reinvaded sites and non-reinvaded sites ($P=0.24$).

Linear regression analysis showed little correlation between number of exposure days and amount of additional damage for reinvaded unmonitored sites. The correlation coefficient ($r=-0.3$) was not significant.

Average number of exposure days for monitored sites was 104 ± 42. The average number of exposure days for unmonitored sites was 95 ± 40. There was no significant difference in exposure days between the two groups ($P=0.53$). The average number of exposure days for reinvaded unmonitored sites was 73 ± 26 days. The average number of exposure days for non-reinvaded unmonitored sites was 109 ± 44 days. The original hypothesis was rejected, as non-reinvaded rather than reinvaded unmonitored sites were found to have a significantly larger number of exposure days ($P=0.02$).

A significant difference was seen in the number of beavers taken in primary removal between reinvaded sites and non-reinvaded sites ($P=.003$). Seventy beavers were initially taken in the 14 reinvaded sites (Avg.=5 ± 3 beavers/site). Fifty-one were taken from the other 20 sites (Avg.=3 ± 1 beavers/site).

Table 1. Beaver damage site information.

Site Name	County	Area (ha)	Monitored monthly (yes/no)	Distance from major stream/river (km)	Name
Bower's Lake	Burleson	12	yes	0.2	Davidson Cr.
Camp Creek Lk.	Robertson	304	yes	4.8	Camp Cr.
CCWD #19	Fayette	13	yes	0.3	Spencer Pool Cr.
CCWD #22	Fayette	11	yes	1.3	Spencer Pool Cr.
CCWD #26	Fayette	6	yes	0.5	Cummins Cr.
Chick Ln. Stables	Brazos	1	yes	0.6	Turkey Cr.
CIC Agency, Inc.	Brazos	1	yes	5.6	Peach Cr.
Clay Place	Washington	2	yes	0.8	Yegua Cr.
TMPA DP-1	Grimes	18	yes	2.7	Gibbons Cr.
Fletcher/Koening	Washington	2	yes	3.2	Independence Cr.
McCully	Brazos	1	yes	0.0	Bee Cr.
McDaniel Farm	Fayette	1	yes	2.7	Clear Cr.
Moore Ranch	Brazos	18	yes	2.9	Brazos River
Nicholson Club	Polk	1	yes	0.2	Piney Cr.
Schumacher	Washington	1	yes	5.1	Yegua River
TAMU Annex	Brazos	1	yes	1.8	Thompson's Cr.
TMPA 6A	Grimes	15	no	1.6	Gibbons Cr.
TMPA 7A	Grimes	9	no	1.3	Gibbons Cr.
Bourn/Goodwin	Brazos	1	no	1.0	Little Cedar Cr.
Breaux	Milam	1	no	1.1	Sixmile Cr.
Ferguson	Burleson	1	no	4.5	Cedar Cr.
Hill Creek Ranch	Burleson	5	no	4.5	E. Yegua Cr.
Howard Smith	Leon	2	no	0.0	E. Caney Cr.
Kellas	Leon	1	no	4.2	Lwr. Keechi Cr.
Knight Ranch Rd.	Leon	1	no	1.4	Malochomy Cr.
Kristoff	Burleson	2	no	1.9	Davidson Cr.
Marge Nelson	Leon	6	no	10.1	Navasota River
Oakwood Sewer	Leon	1	no	0.0	E. Caney Cr.
TMPA P12	Grimes	1	no	0.3	Panther Cr.
Prince	Grimes	2	no	4.0	Gibbons Cr. Res.
TMPA SP-10	Grimes	15	no	0.5	Gibbons Cr.
Tract 1080 (VLB)	Burleson	4	no	1.6	E. Yequa Cr.
Pike Tree Farm	Leon	2	no	1.0	Mustang Cr.
Truelock	Leon	1	no	8.7	Brushy Cr.
Total		463			
Average		14		2.4	
Standard deviation		51		2.4	

Table 2. Primary removal results and exposure days.

Site Name	Age Group: Adult	Juvenile	Unknown	Total	Initial damage estimate ($)	Exposure Days
Bower's Lake	3	0	0	3	1,000	47
Camp Creek Lake	2	1	0	3	3,000	114
CCWD #19	0	0	5	5	1,500	116
CCWD #22	2	2	0	4	2,000	132
CCWD #26	2	0	0	2	1,000	107
Chick Ln. Stables	1	0	0	1	300	173
CIC Agency, Inc.	0	1	0	1	0	116
Clay Place	1	1	0	2	1,500	79
TMPA DP-1	1	0	3	4	1,154	87
Fletcher/Koening	2	4	0	6	2,925	57
McCully	3	0	0	3	500	186
McDaniel Farm	0	0	2	2	500	111
Moore Ranch	0	0	12	12	4,000	37
Nicholson Club	2	1	0	3	300	52
Schumacher	1	0	0	1	150	154
TAMU Annex	2	0	0	2	150	103
TMPA 6A	4	1	0	5	2,308	39
TMPA 7A	3	0	0	3	1,154	93
Wayne Bourn/Goodwin	2	0	0	2	55	56
Breaux	3	1	0	4	650	86
Ferguson	0	0	1	1	500	183
Hill Creek Ranch	2	2	0	4	1,000	93
Howard Smith	0	0	4	4	300	99
Kellas	2	0	0	2	1,000	40
Knight Ranch Road	2	0	0	2	550	46
Kristoff	4	2	0	6	450	93
Marge Nelson	0	0	7	7	3,000	63
Oakwood Sewer	2	0	0	2	1,400	114
TMPA P12	2	1	0	3	3,462	113
Prince	1	1	0	2	500	184
TMPA SP-10	0	1	5	6	3,462	93
Tract 1080 (VLB)	8	0	0	8	6,600	85
Pike Tree Farm	4	0	0	4	5,000	135
Truelock	2	0	0	2	1,000	99
Total	63	19	39	121	52,865	
Average	2	1	1	4	1,555	
Standard deviation	2	1	3	2	1,523	

Table 3. Secondary removal results for monitored sites.

Site Name	Reinvaded (yes/no)	Adults	Juvenile	Unknown	Total	No. of times removed	Time to reinvasion (months)
Bower's Lake	yes	1	2	0	3	1	1
Camp Creek Lake	no						
CCWD #19	yes	0	0	4	4	1	2
CCWD #22	no						
CCWD #26	no						
Chick Ln. Stables	no						
CIC Agency, Inc.	no						
Clay Place	no						
TMPA DP-1	yes	4	0	0	4	1	2
Fletcher/Koening	no						
McCully	yes	3	1	0	4	3	1
McDaniel Farm	no						
Moore Ranch	yes	0	0	0	0	1	1
Nicholson Club	yes	3	0	0	3	1	1
Schumacher	no						
TAMU Annex	yes	4	0	0	4	1	1
Total		15	3	4	22		
Average		2	0	1	3		1
Standard deviation		2	1	1	1		0.5

Table 4. Amount of additional damage after primary removal on monitored sites.

Site Name	Reinvaded (yes/no)	Additional damage ($)	Type of Damage
Bower's Lake	yes	0	Damage threat, digging in dam
Camp Cr. Lake	no		
CCWD #19	yes	0	Damage threat, digging in dam
CCWD #22	no		
CCWD #26	no		
Chick Ln. Stables	no		
CIC Agency, Inc.	no		
Clay Place	no		
TMPA DP-1	yes	0	Damage threat, draw down pipe
Fletcher/Koenig	no		
McCully	yes	0	Damage threat, draw down pipe
McDaniel Farm	no		
Moore Ranch	yes	0	Damage threat, dammed drainage
Nicholson Club	yes	150	Plugged culvert, damaged road
Schumacher	no		
TAMU Annex	yes	100	Dammed drainage
Total no. reinvaded	7		
Total damage		250	
Avg. dmg. reinvaded		36	
STD for damage		58	

Table 5. Amount of additional damage after primary removal on unmonitored sites.

Site Name	Reinvaded (yes/no)	Additional damage($)	Type of Damage
TMPA 6A	yes	200	Dammed drainage
TMPA 7A	no		
Bourn/Goodwin	no		
Breaux	no		
Hill Creek Ranch	no		
Kristoff	yes	0	Dammed drainage
TMPA P12	no		
Prince	no		
TMPA SP-10	yes	300	Plugged drain
Tract 1080 (VLB)	yes	0	Flooded timber
Ferguson	no		
Marge Nelson	yes	2,900	Timber and roads
Knight Ranch Road	no		
Truelock	no		
Howard Smith	yes	500	Timber
Kellas	yes	800	Timber and roads
Oakwood Sewer	no		
Pike Tree Farm	no		
Total no. reinvaded	7		
Total damage		4,700	
Avg.damage for reinvaded		671	
STD for damage		947	

DISCUSSION

Lack of significant difference in additional damage between monitored and unmonitored sites was most likely due to the high variance in damage values for the unmonitored sites. Less variance in damage values might be achieved in the future by obtaining a larger sample size. Although there was not a significant difference between the two groups, $\underline{P}=.08$ suggests that monitoring may have been important. The difference in damage values between the two groups (average damage for reinvaded unmonitored sites was \$671, average damage for reinvaded monitored sites was \$36) would be important to landowners. Also, five of seven reinvaded sites in the monitored group had \$0 damage compared to only two of seven with \$0 damage for the reinvaded sites in the unmonitored group. Monitored sites were left unchecked for only a month at a time, and reinvaded sites in this group with \$0 damage were controlled again before beavers had time to cause additional damage. Unmonitored sites, on the other hand, were all left unchecked longer than a month. Beavers had a longer time to cause damage, and they did.

Among unmonitored sites that were reinvaded, there was no significant correlation between number of exposure days and amount of additional damage ($r=-0.3$). Some sites had relatively few exposure days, but, at the same time, had relatively large additional damage values. This was related to variability among sites because properties and resources were different, and resources differed in value.

The evaluation of differences in exposure days between monitored and unmonitored sites was used to determine if biases existed that resulted in the unmonitored group having more exposure days, increasing the likelihood of reinvasion. However, no significant difference was found between the two groups.

The authors' data suggests that additional damage was minimized and sometimes totally prevented by evaluating sites for the presence of beavers and promptly removing new beavers. Further study is needed to determine if damage is significantly different between monitored and unmonitored sites. The results of this project support the concept that landowners will be able to minimize additional damage by regularly monitoring their property and removing reinvading beavers quickly.

The second question addressed in this study was, "What factors made some sites more susceptible to reinvasion than others?" One possible factor could have been shorter distance to permanent water sources for some sites. Assuming beavers were in a permanent water source, dispersers could return to the site more quickly. However, distance to a permanent water source for reinvaded sites was not significantly less than the distance for all the other sites.

A second factor related to reinvasion susceptibility might have been the number of days between surveys for unmonitored sites. Reinvaded, unmonitored sites could have had more exposure days, compared to non-reinvaded unmonitored sites, which would allow more time for reinvasion. However, a t-test showed that in this case, the opposite was true. For the unmonitored group, non-reinvaded sites had significantly more exposure days compared to reinvaded.

A third factor in susceptibility to reinvasion could have been alteration of the site which made it unsuitable for beavers. One site was altered after primary removal, which could have prevented reinvasion. A larger culvert was installed, and the area was drained. Alteration to prevent beaver reinvasion at other sites was either not desired by the landowners, or was too costly.

A final factor could have been differences in quality of habitat for certain areas. Better habitat should support more beavers and possibly hasten reinvasion into a previously controlled site. The importance of this factor was tested, indirectly, by comparing the number of beavers taken in primary removal between reinvaded sites and all other sites, with the assumption that better habitat would support more beavers for a given site or colony. Buech (1985) stated that habitat quality is an important factor in determining family (colony) size. The authors' data support this by showing significantly more beavers taken in primary removal, per site, in the reinvaded sites compared to other sites.

Every site in this study, except Camp Creek Lake, was less than 20 ha, which fit into the home range for one beaver family (Buech 1985). Camp Creek Lake measured 304 ha, but had only one family group of beavers. Some of the sites had more than one beaver lodge, but within each site all lodges were used by the same family of beavers.

If a reinvaded site had relatively better habitat quality, then surrounding habitat may have also been of better quality. Therefore, beaver density in the whole area may have been relatively high. It appears likely that quality beaver habitat recently opened up by removal would be reinvaded sooner in a high beaver density area. Aleksiuk (1968) found a Canadian population of transient two-year old beavers ready to permanently settle in suitable sites when they became available. A high beaver density area would have a higher population of transients, and reinvasion would occur sooner.

Weaver (1986) also discussed the importance of sub-adult (two-year old) beaver dispersal in the overall expansion of beaver populations. He suggested that the reason this particular age class is so important is because of possible delayed dispersal due to unsuitable colonization sites. Delayed dispersal is due to the fact that as beaver densities in an area increase, less sites are available for new colonization, and dispersal by young beavers decreases. Resident beavers may instinctively build more scent mounds as the relative number of dispersers passing through their territories increases. Dispersers may react to the prevalence of scent mounds encountered as they pass through territories. Young beavers may explore surrounding territories but withdraw when they encounter large numbers of fresh scent mounds. Young beavers who delay dispersal and grow larger have a better chance of being successful once they do disperse. They may not disperse until they are two years old or older. Therefore, in high beaver density areas, most beavers that reinvade newly opened territories should be two-year old sub-adults (Weaver 1986).

Adults comprised 68% of the reinvading beavers taken in this project. Non-breeding adults (sub-adults) were not differentiated from breeding adults as long as they were close to the same size. The percentage of adults probably would have been larger if the age of all beavers had been known. Because most reinvading beavers were adults or sub-adults, it could be hypothesized that the sites from which they were taken were high beaver density areas. Delayed dispersal along with better habitat quality can also help explain higher numbers of beavers initially taken per site for reinvaded sites. Additionally, another indication of relatively high beaver densities in the areas of reinvaded sites is that monitored sites were reinvaded so quickly, five sites within one month and the other two sites within two months.

It appears from this study that varying habitat quality and subsequent beaver density are the most important factors in determining a site's susceptibility to reinvasion. However, all damage sites are at risk of reinvasion and monitoring is appropriate at all sites where damage has occurred. Threshold density per unit area, which would cause a site to be reinvaded in a given time period, is unknown and warrants further investigation.

CONCLUSIONS

Reported beaver damage has increased in Texas in recent years. However, many resource managers do not realize how quickly beavers can reinvade sites, and some have experienced extensive beaver damage because of this lack of knowledge. Resource managers have often believed that once beavers were removed from a site, they would be gone forever, or it would take years for other beavers to return. They tend not to sufficiently evaluate their property because they lack knowledge of beaver densities in the area and are not aware of beaver population structure and dynamics.

Beavers will travel great distances in search of a suitable colony site, and resource managers should be informed that when beavers are removed from a site, a favorable site for reinvasion is created. Using continued monitoring of beaver damaged resources as a beaver damage management tool can minimize additional beaver damage.

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LITERATURE CITED

ALEKSIUK, M. 1968. Scent-mound communication, territoriality, and population regulation in the beaver (*Castor canadensis*) Kuhl. Journal of Mammalogy. 49(4): 759-762.

ANONYMOUS. 1996. State damage summary by beavers. Fact sheet from Texas Animal Damage Control Service, San Antonio, TX.

BUECH, R. R. 1985. Beaver in water impoundments: understanding a problem of water-level management. U.S. Forest Service General Technical Report. p. 95-105.

DOUGLAS, T. 1995. Memo dated February 27, 1995 to Linda Morton, East Texas Council of Governments.

JACKSON, J. September-October 1996. Beaver population dynamics. Wildlife Control Technology. 3(5): 10-11.

RAMSEY, C. W., and D. A. WADE. 1986. Identifying and managing aquatic rodents in Texas: beaver, nutria, and muskrats. Publ. B-1556. Texas A&M University.

UPSHAW, R. 1995. Memo dated February 27, 1995 to Linda Morton, East Texas Council of Governments.

WEAVER, K. M. 1986. Dispersal patterns of subadult beavers in Mississippi as determined by implant radio-telemetry. Masters Thesis, Mississippi State University.

WOODWARD, D. K. 1983. Beaver management in the southeastern United States: a review and update. Proceedings of the Eastern Wildlife Damage Control Conference. 1: 163-165.