The Impact of Mountain Goat Migration on Unconsolidated Slopes in Glacier National Park, Montana

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ABSTRACT

Native mountain goats must cross U.S. Highway 2 in order to gain access to a natural salt lick along the southern boundary of Glacier National Park, Montana. Prior to 1981, goats approached through forest cover and then crossed over the highway. Reconstruction of the highway incorporated two goat underpasses which substantially altered the migration pattern. Large numbers of goats now utilize an open, south-facing slope, and cause extensive erosion. Repeat photography illustrates the extent of erosion over the period since 1981, and provides estimates of the amount of sediment removed. Erosion rates are startlingly high, and are a direct result of well-meaning human interference associated with construction of the goat underpasses.

KEY WORDS: erosion, mountain goat, Glacier National Park, Montana, geomorphology, sedimentation.

INTRODUCTION

Designation of an area as a national park or wildlife preserve may ironically exacerbate erosion by allowing animal populations to reach high densities that exceed normal carrying capacity. The erosional efficacy of both natural and introduced large-animal populations is well established (e.g. Trimble, 1988; Butler, 1991, 1992), and several recent papers address the question of the impact of introduced species on national park environments (Veblen et al., 1989, 1992; Perez, 1992a, 1992b). Erosion can be especially troublesome in mountains, where environmental conditions are delicately balanced and food resources are limited. Here, the erosional effects of a native population of mountain goats (Oreamnos americanus) are examined in an American national park where humans have created highway underpasses specifically for goat migration and protection.

Adult mountain goats (Figure 1) are large hoofed animals, with weights typically ranging from 54–73 kg for females, and 68–102 kg for males (Chadwick, 1983). Like other ungulates, they
require salts in their diet, and thus utilize natural salt licks accessible to them (Jones and Hanson, 1985). Erosion occurs as mountain goats develop established trails (Eaton, 1917) that lead to natural lick sites. Erosion may also occur along pathways where goats temporarily "bed down" or wallow (Pack, 1928).

STUDY AREA AND BACKGROUND

The Walton Goat Lick is located near the southern tip of, and within, Glacier National Park (GNP), Montana, USA (Figs. 2, 3). It is located on a cut bank of the Middle Fork of the Flathead River. The mountain goat population in this part of GNP is at least 100, with a density (calculated for area of observed use only) of 15.4 goats km\(^{-2}\), five times higher than any other reported densities in the literature (Singer and Doherty, 1985b). These goats make frequent use of the Walton Goat Lick (Fig. 2), but in order to gain access to the lick, they must first negotiate a passage of U.S. Highway 2.

Singer (1975, 1978) reported on the difficulties encountered by mountain goats as they attempted to cross U.S. 2 and gain access to the lick site. Data from 1975 showed that over a period of 90 days, 328 of 334 crossing attempts occurred over the highway on the way to the lick site, and 6 passed underneath a highway bridge spanning a large avalanche path locally called Snowslide Gulch. Singer believed that the dimensions of this underpass were insufficient for attracting the goats, hence the preponderance of surface crossings. On surface crossings, Singer (1978) reported that the goats preferred to approach the road through forest cover to the north of the Gulch bridge rather than through the open avalanche-path vegetation characterizing the south-facing slope of Snowslide Gulch (Malanson and Butler, 1986). All but 35 of the 328 across-road passages occurred north of Snowslide Gulch along a stretch of highway offering forest cover, and the remaining
35 surface crossings occurred south of the Snowslide Gulch bridge (Singer, 1975, 1978). Similar figures were obtained on counting return passages from the lick site—over the same 90-day period, 345 of 358 passages occurred across the highway, and 13 occurred under the Snowslide Gulch bridge. All but one of the highway crossings took advantage of the forest cover north of the Gulch (Singer, 1975, 1978).

Singer’s work (1975) was funded by the Federal Highway Administration and Glacier National Park, which were planning to upgrade the 1930s-era stretch of highway crossed by mountain goats. Frequent encounters and occasional collisions with automobiles during highway passages led Singer to recommend that goat underpasses be expanded in number and size to accommodate the migrations to and from the Walton Goat Lick.

Highway reconstruction was spurred on 13 February 1979, when a massive snow avalanche completely removed the old highway bridge spanning Snowslide Gulch and deposited it on the floodplain of the Flathead River (Butler and Malanson, 1985). This destruction provided the opportunity for beginning the reconstruction of U.S. 2, through the entire goat migration zone, earlier than anticipated. Opened in early 1981 (Ruder, 1981), the new section of U.S. 2 (Figure 3) incorporated a new Snowslide Gulch Bridge (SSGB) with a greatly enlarged goat underpass; a second, new, Goat Bridge (GB) with underpass specifically designed for goat migration; and retaining walls and fences designed to restrict goat access from the surface of U.S. 2 and instead channel the migrating goats through the two underpasses (Singer and Doherty, 1985a; Singer, 1986; Pedevillano and Wright, 1987). All pre-existing goat trails leading to highway crossing sites were obliterated (Singer and Doherty, 1985a). In steep areas these trails had been entrenched 30–45 cm into the soil (Singer, 1975).
POST-U.S. 2 RECONSTRUCTION AND GOAT MIGRATION

Since highway reconstruction was completed in 1981, drastically different patterns of goat migration have developed. These patterns in turn have created a significant and unsightly erosion problem in Snowslide Gulch. Each issue is addressed below.

Singer and Doherty (1985a) and Singer (1986) described the post-reconstruction goat migration patterns from the first season of use, 1981. Over twice as many goat passages downslope, 697, were recorded than had occurred in 1975, and 488 successful return passages were also observed. Of the passages downslope to the lick site, 283 utilized the new Goat Bridge underpass, 3 crossed the surface of the highway south of SSGB, and fully 411 used the newly broadened underpass under the new SSGB. Return trips saw 259 passages underneath GB, 227 underneath SSGB, and one each across the highway north of GB and south of SSGB. These data represent a dramatic increase in the number of goats passing through the low herbaceous and shrubby vegetation on the south slope of Snowslide Gulch, and illustrate that forest cover, while desirable for camouflage prior to a surface crossing, was not deemed necessary for utilizing the broad goat underpasses.

Similar post-reconstruction migration patterns were recorded for 1984 (from May through August) by Pedevillano and Wright (1987). The data from that study were not broken down into downslope versus upslope trips. Pedevillano and Wright (1987) showed that SSGB had statistically significantly higher rates of crossing than did GB (paired t-test, t = 3.03, p < 0.05). A total of 699 goat crossings were recorded under SSGB, and 300 for GB.
GOAT-INDUCED EROSION IN SNOWSLIDE GULCH

Goat trails associated with movements of mountain goats to and from the Walton Goat Lick, by way of the SSGB underpass, were first noticed by the author in 1983 (two years after highway reconstruction). Erosion probably began during 1981 and continued through 1982, however, fieldwork in Snowslide Gulch began after 1983.

On-site measurements of erosion and sediment movement in Snowslide Gulch would disrupt goat migration and interfere with tourist enjoyment of the goats in their "natural" setting. Therefore repeat technique in physical geography (Byers, 1987; Ives, 1987), were taken to document landscape changes associated with goat-related erosion between 1983 and 1991. Recognizable rock outcrops and trees provided "benchmarks" in Snowslide Gulch from which erosion effects could be determined. Photographs from 1983, 1987, 1988, 1990, and 1991 provide the framework for the following discussion (photos from 1983, 1987, and 1991 are reproduced to illustrate changes).

By July 1983, goat movement along the south-facing slope of Snowslide Gulch had produced a nearly barren patch of exposed sediment to the right of outcrop A on Figure 4, as well as an established trail below (and out of sight of) outcrops A and B. An incipient linear scar (C on Figs. 5 and 6) was visible, with an estimated width of ca. 1 m, and ca. 15-20 cm depth of incision. In 1983, this scar did not extend as far downslope as outcrop B.

By 1987 (Fig. 5), a large bare patch had developed immediately upslope of outcrop A, indicating serious erosional deterioration since 1983. Even more apparent is the extension of linear scar C to a point well downslope of outcrop B and nearly reaching between outcrops E and F, and the development of a new, major linear scar D. Scar D, although not visible on Figure 4, did not exist in 1983. By 1987 (Fig. 5), however, scar D had reached the level downslope of tree G, and small amounts of sediment had washed beyond G toward tree H. Numerous goat paths can be seen cutting diagonally across the south-facing slope of Snowslide Gulch in Figure 5. Some patchiness of the vegetation between outcrops A and B is also apparent.

Conditions in 1988, although not illustrated here, reflected a continuation of the erosional trends of 1987. The vegetation between outcrops A and B had become sufficiently disrupted to expose bare ground, and scars C and D were somewhat more deeply incised.

By 1990, erosion had nearly reached the level illustrated in the 1991 photo, Figure 6. In 1990, the erosional patch upslope of outcrop A was completely barren of vegetation, a second distinct bare patch had developed below outcrop B, linear scar C extended downslope nearly into the dual rock outcrops E and F, and scar D almost reached tree H.

Figure 6 illustrates the conditions in Snowslide Gulch in 1991, the 11th season in which mountain goats heavily used the SSGB underpass. Linear scars developed beneath outcrops A and B from the bare patches described earlier. Linear scar C extended into the gap between outcrops E and F, and scar D had passed tree H and a wedge of sediment actually reached the intermittent stream channel at the base of the slope. In addition, a diagonal goat trail from A to beyond D, only suggested by vegetation patchiness in Figure 5, had become well established and extended far beyond D (Figure 6). The vegetation below letters G-E-F was very patchy, and when viewed in color, it is apparent that major barren areas of exposed soil exist, boding ill for the future of that portion of the slope.

The total volume of goat-induced sediment erosion since 1981 on the south-facing slope of Snowslide Gulch was initially estimated for the linear scars beneath outcrops A and B (hereafter referred to as scars A and B), and linear scars C and D. Erosion volume was estimated through binoculars, using mature mountain goats for scale. Estimates are, therefore, accurate only at a gross level, and because only the linear scars
are examined the volume data underestimate the total amount of sediment removed from the slope during the period 1981–1991. The estimates do, however, provide a rudimentary indication of the amount and rate of erosion that can be induced by a concentrated population of mountain goats.

Linear scar D is by far the largest source of sediment on the south face of Snowslide Gulch. At approximately 20 m long, 1.5 m wide, and 50 cm deep, at least 15 m³ of sediment have been eroded due to the goats. Scar C (ca. 12 m × 1 m × .5 m) has lost 6 m³ of sediment. Scars A (2.5 m³) and B (2.25 m³) are approximately equal in size. The four scars collectively account for 25.75 m³ of sediment loss, and additional non-calculated losses from goat trails and smaller patches would probably push the total up to ca. 30 m³. Over the period 1981–1991, that is an annual sediment-loss rate of 2.73 m³.

CONCLUSIONS

Projected over a 1000-year time span (and the present animal population), erosion would allow for 2,730 m³ of sediment removal, caused by concentrating mountain goats along a migratory path to and from the SSGB. This value is more than a factor of ten greater than rates associated with snow avalanches in the same environment (Butler and Malanson, 1990). The rate of erosion on avalanche paths in Glacier National Park, expressed in Bubnoff units (Young and Saunders, 1986), is 1000 B. Rates of mountain goat-induced erosion in Snowslide Gulch alone therefore exceed 10,000 B. Additional unknown quantities of sediment may be eroded in association with the passage of goats through the coniferous forest leading to the GB underpass; however, this erosion already existed at even greater levels during the pre-1981 era as greater numbers
FIGURE 6. Goat-induced erosion at same location as in Figure 5, 22 August 1991. Letters A–H as described in text.

...of goats passed through the forest prior to crossing over the highway. The erosion associated with the SSGB underpass is, however, directly a result of human interference. As is frequently observed in nature, human “assistance” may have far-reaching, unforeseen negative ramifications.

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