Effects of Recreational Use on Lake Shore Conditions in the Sawtooth National Recreation Area

Abstract: In an effort to determine the effects of recreational use on lakeshore conditions within the Sawtooth National Recreation Area (NRA), surveys were completed on numerous large morainal lakes from 1999 – 2007. Lakeshores were initially divided into large scale segments that where subjectively deemed to be uniform in physical lakeshore characteristics. Within these segments, survey units were defined and two individuals walked survey units and recorded a variety of characteristics of "in-water", "bank", and "shore" zones. Alturas, Perkins, Pettit, Redfish, Little Redfish, and Stanley Lakes were surveyed. Comparisons between units with recreational use vs. those without recreational use allowed for a determination of recreational effects on lakeshore conditions. Recreational use of lakeshore areas resulted in increased occurrence of exposed and scouring trails, increased occurrence of bank alterations, increased frequency of bank exposure, and decreased abundance of upland down and dead large wood. The effects of recreation on in-water counts of large wood and well on measures of lodgepole pile regeneration were more varied and effects were not consistent across lakes. This information can help managers predict the effects of providing new recreational opportunities along lakeshores in the Sawtooth NRA.

Although these data could be used to describe a variety of lakeshore characteristics, this analysis will focus on particular attributes which were deemed potentially sensitive to the effects of nearby

recreational use. The intention of the analysis is to quantify lakeshore changes associated with recreation by comparing areas containing recreational development to those without. For the purposes of this study, "recreational development" including constructed sites (including developed campgrounds, constructed roads or trails, recreation residences, etc) as well as dispersed sites. Constructed sites were relatively easy to identify and dispersed sites were defined as those campsites/areas that contained fire rings.

Lakeshore survey methods were developed by Mark Moulton and include a nested survey design. Lakeshores were initially divided into large scale segments that where subjectively deemed to be physically uniform in lakeshore characteristics (see segment data sheet – Appendix 1). Within these segments, survey units were defined and two individuals walked survey units and recorded a variety of characteristics of "in-water", "bank", and "shore" zones (see unit data sheet – Appendix 2). Because lakeshore segments were subjectively identified and because lakes may differ in large scale characteristics, segment lengths and number of segments per lake varied dramatically between groups or survey years.

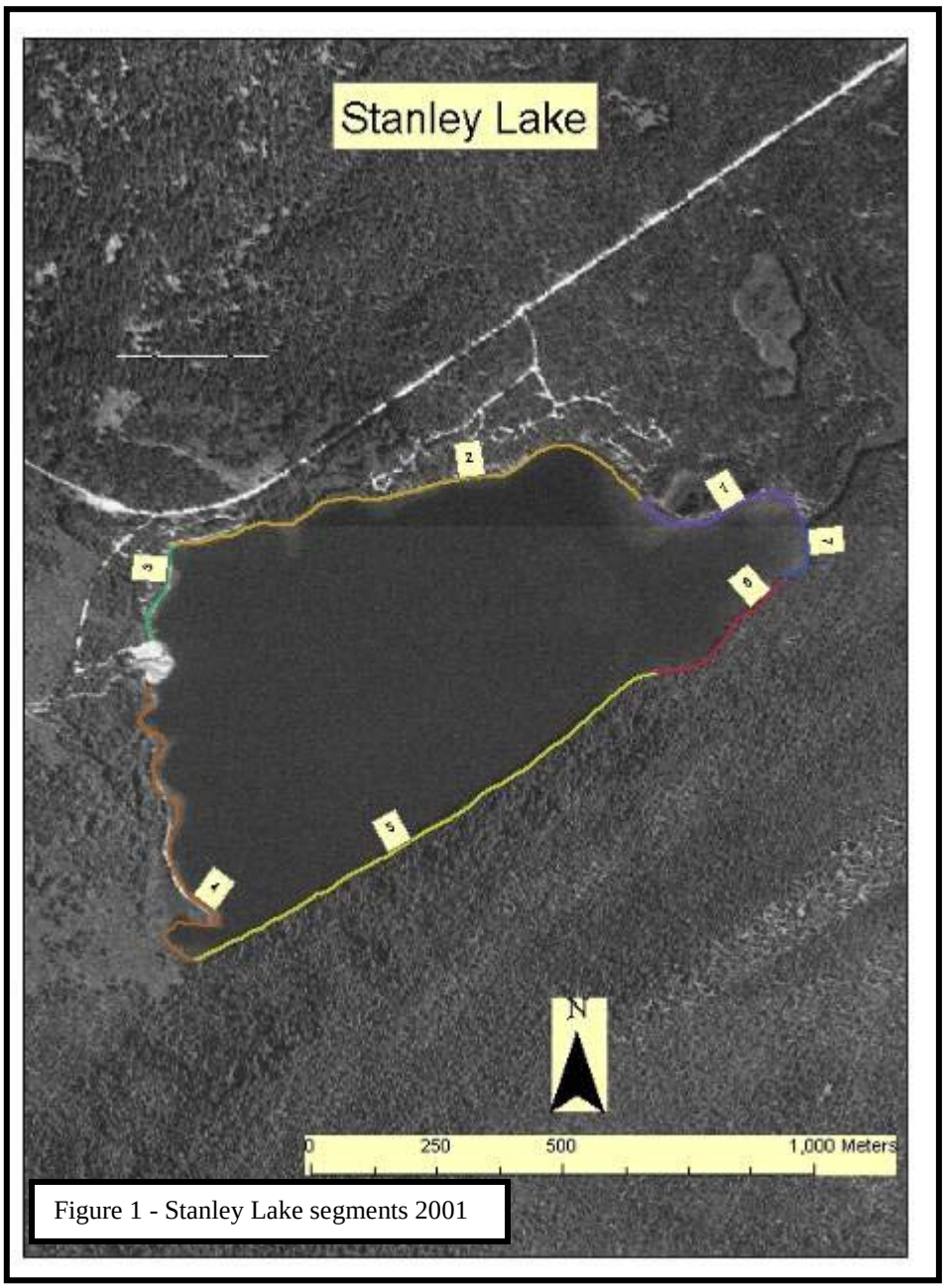

Figure 1 - Stanley Lake segments 2001

Due to the data collection methods, spatial autocorrelation was certainly present among units, so no statistical analyses were completed. Nevertheless, the data do depict strong associations between development and a variety of lakeshore conditions.

Several attributes were selected that were deemed to more strongly reflect recreation impacts on lakeshores and these attributes are discussed below. They include: parallel and perpendicular trails, bank alterations, bank exposure, upland lwd (dead and down), inshore lwd, and lodgepole pine regeneration.

Stanley Lake

Stanley Lake was surveyed in late-September of 2001 and 84 units and 7 segments were identified (see Figure 1.) Development was restricted to segments 1, 2, and 3 but nearly 43% of lakeshore length had development present. When development was present within a unit, 100% of those units had severe or moderate bank alterations (88% severe, 12% moderate). In contrast, when development was not present in a lakeshore unit, only 21% of units had severe or moderate bank alterations. Excluding vertical banks (which, due to physical shape are relatively less altered, regardless of development) 100% of units with development in or adjacent to a unit had severe or moderate bank alterations, while 50% of units with no development had similar alterations. In those cases where bank alterations were present even though development was absent, nearly all of the alterations occurred in association with user-created trails. Average number of pieces of large wood per meter was also associated with the presence or absence of development. For example, in units where development was absent, 0.15 pieces/m were documented. When development was present or adjacent to a unit, wood occurrence was reduced to 0.03 pieces/m. A similar relationship was noted with upland large wood, where no units had abundant large wood and development occurring concomitantly. In contrast, nearly 70% of units without development had the presence of abundant quantities of downed wood.

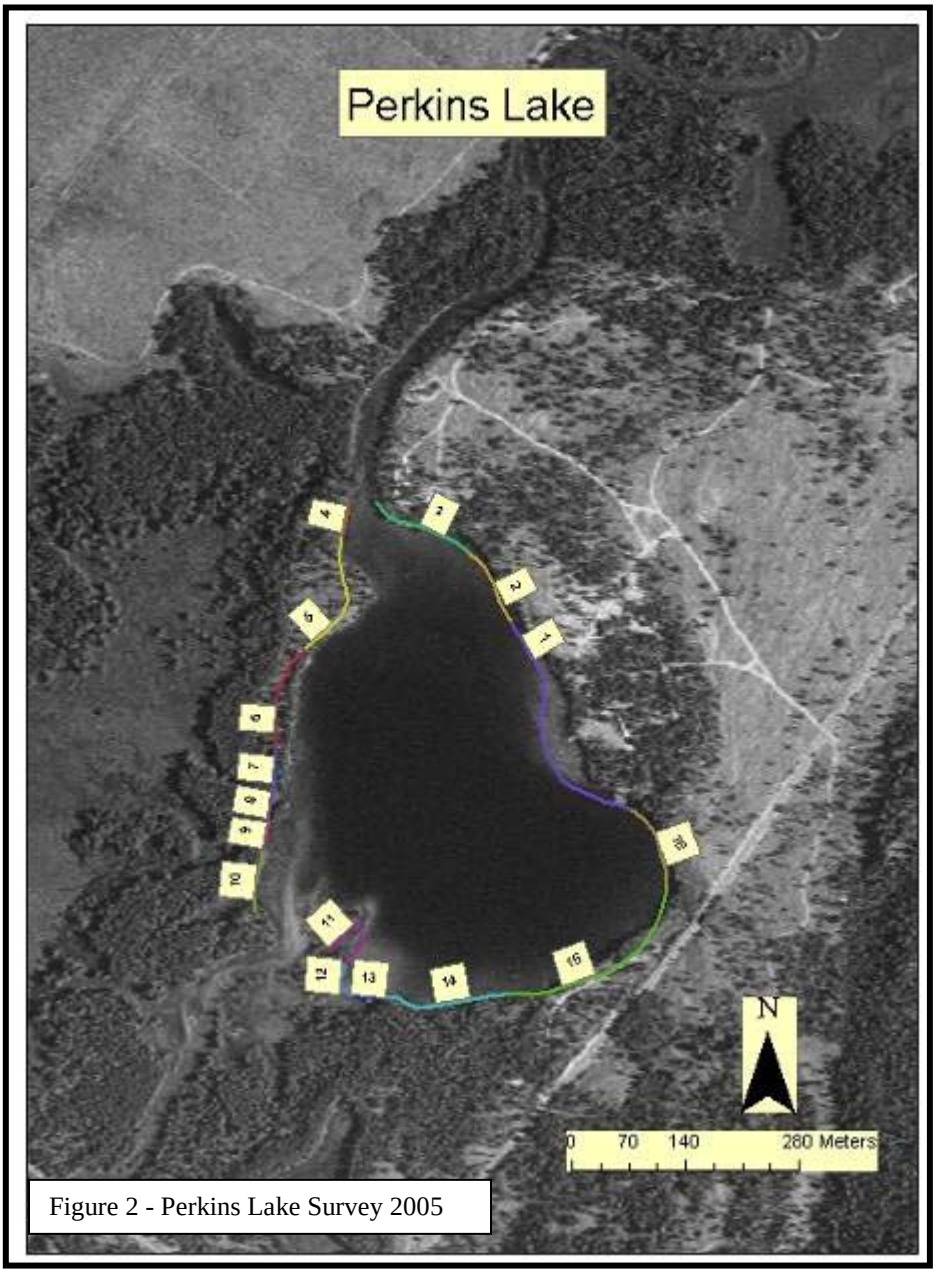

Figure 2 - Perkins Lake Survey 2005

Perkins Lake

Perkins Lake was surveyed in early-September of 2005. Sixty-one units were delineated, and, despite the lakes small size, 16 segments were identified. As might be expected, the inlet and outlets of Perkins Lake and the associated road access, strongly influence recreational use of the area.

Recreational developments are concentrated in segments 1-3 and 14-16 with no development occurring on the west side of the lake. In all, 58% of lakeshore was deemed "developed." One-hundred percent of units with development had exposed or scouring parallel trails and 78% had exposed or scouring perpendicular trails. Virtually all of these units were associated with the recreational developments in segments 1-3 and 14-16. In contrast, in units without development, these percentages were reduced to 12% (parallel) and 0% (perpendicular) respectively. Average number of pieces of large wood per meter was not strongly influenced by development and ranged from 0.39 pieces/m (for developed units) to 0.55 (for units adjacent to development). In units that were lacking in development, 0.48 pieces/m were documented. Many of the undeveloped units were located in segments with relatively high shrub cover which may result in reduced lodgepole density and, ultimately, reduced wood recruitment. A similar pattern was noted in upland LWD with wood being abundant in a higher percentage of units adjacent to vs. none vs. containing development (33% vs. 20% vs. 6% respectively). Though the presence of development is associated with reduced large wood, again, larger scale vegetation patterns may be partially responsible for these results. As is generally the case, exposed or scouring trails, as well as bank alterations were associated with development.

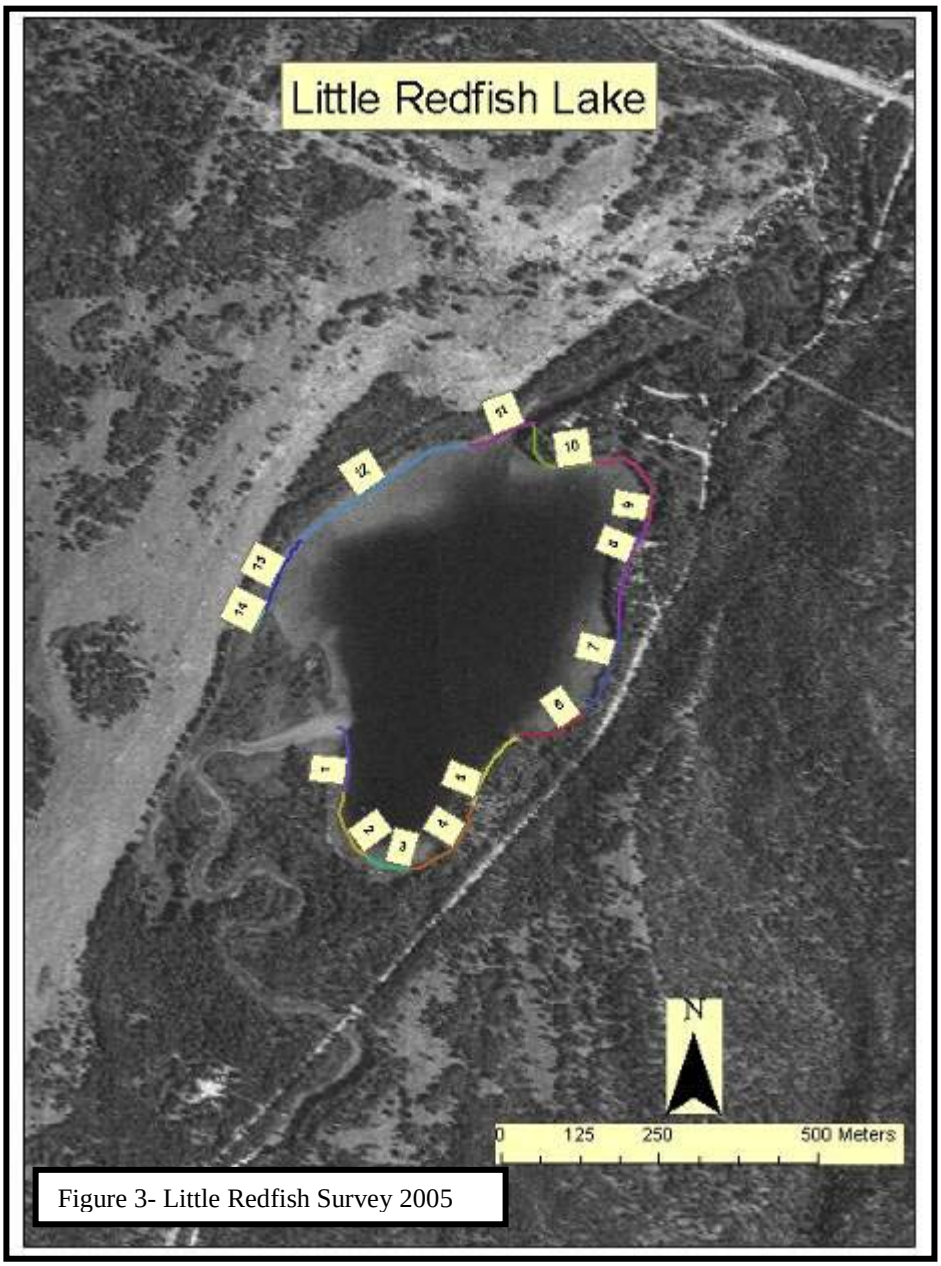

Figure 3- Little Redfish Survey 2005

Little Redfish Lake

Little Redfish Lake was surveyed in mid-September of 2005. Sixty-three units and fourteen segments were identified and 1890 m of shoreline was surveyed. Sixty-three percent of the lakeshore (by length) was influenced by development. As expected, most development was concentrated along the eastern shore, though a heavily used trail did impact some units on the western side of the lake. A trend was apparent where development was associated with reduced levels of LWD as counts of wood decreased from 0.34, 0.29, 0.26 pieces/m as development increased from none, to adjacent, to

within a unit. Similar effects were observed in upland LWD because 30% of units without development had abundant wood, while 8% of units adjacent to development and 0% with development also had abundant measures of upland wood. In addition, when development was present in a unit, 80% of those units had severe bank alterations, compared to 12% or 4% for units with adjacent development or none at all. Likewise 93% parallel trails in units with development and 56% adjacent to development were exposed or scouring, compared to 26% when development was absent. With perpendicular trails, the percentage of trails that were exposed and scouring were 93%, 16%, and 0% as development ranged from within, to adjacent, to none.

Alturas Lake

Almost 9000m of shoreline (8770m) and 17 segments were surveyed at Alturas Lake in late August of 2006. As in other lakes, development was associated with exposed and scouring trails, with 69%, 61%, and 24% exposed and or scouring when development was present, adjacent, or not found within the unit, respectively. Upland woody debris was also heavily influence by recreation as only 3% and 6% of units within or adjacent to development having abundant large woody debris in upland areas. In contrast, when development was absent, 51% of the units had abundant upland wood. This pattern was not reflected in lodgepole regeneration or in bank or in water wood counts. Lodgepole regeneration was common in most units, regardless of the presence of development (80%, 76%, 76%, for development within, adjacent or not present in a unit respectively). In addition, bank and in water wood counts were also similar, regardless of presence of development (average lwd/m = 0.09, 0.10, and 0.09 for development within, adjacent, or not present in a unit respectively). Curiously, in Alturas Lake, exposed banks were fairly common across all levels of development and were even most common in areas with no development (exposed banks accounted for 68%, 57%, and 70% as development ranged from within, adjacent, to not present).

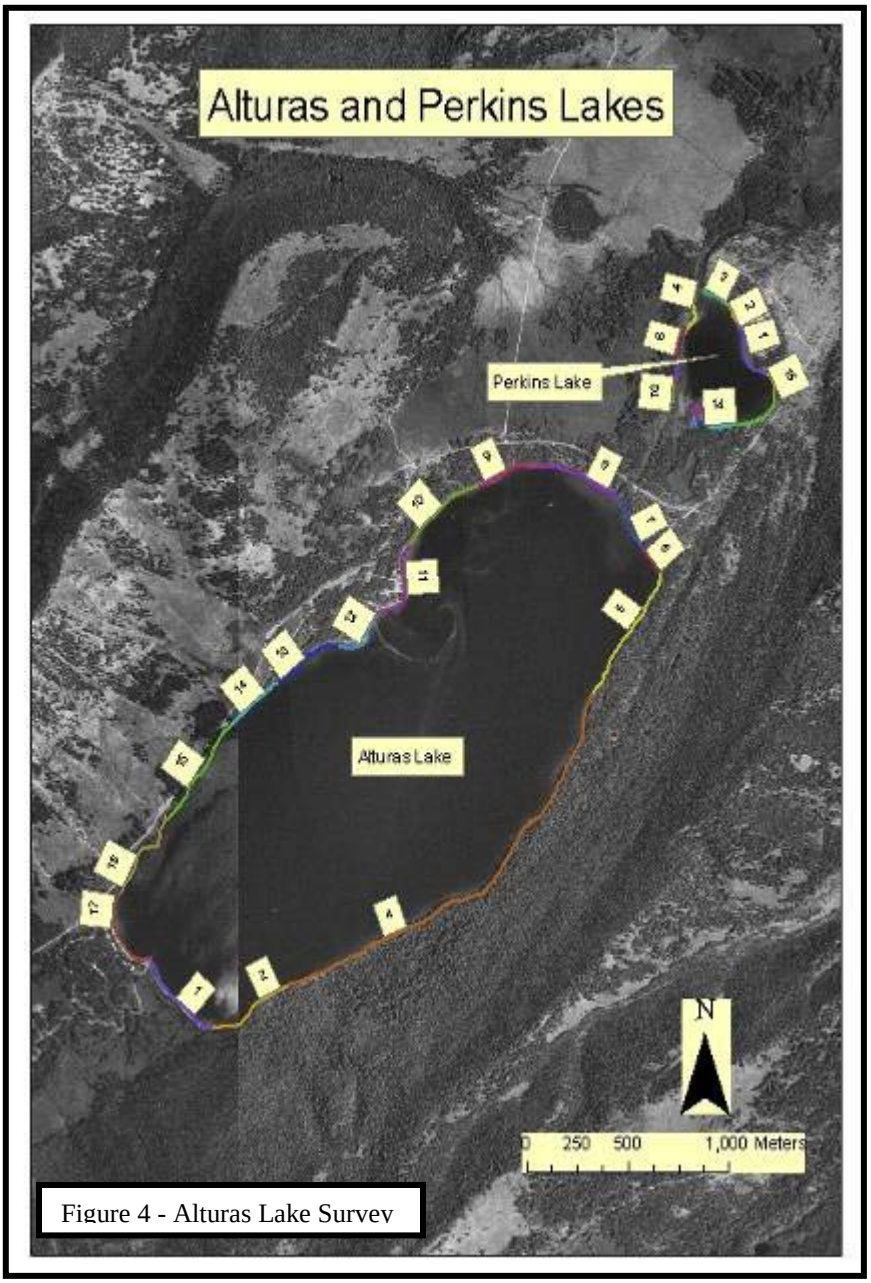

Figure 4 - Alturas Lake Survey

These results may represent bias amongst yearly crews as similar "high" exposure rates were recorded

by the 2006 crew in Pettit Lake. In contrast, in all other years, bank exposure in non-developed units is generally very rare, averaging just 6%. It is therefore possible that the 2006 crew was overestimating bank exposure. Bank alteration in Alturas Lake Creek fit the general pattern because and development pressure decreased the percentage of units with moderate or severe alterations decreased from 75%, 64%, and 21%.

Pettit Lake

Pettit Lake was surveyed in late 2006 and 117 units, 10 segments, and 8400m of lakeshore were surveyed. In contrast to other surveys, the presence of development did not have a clear influence on trail exposure or erosion. Forty-three percent of units with development had exposed or scouring trails. When development was adjacent to a unit or when no development was present, 25% and 31% of units had exposed and scouring trails, respectively. As in Alturas Lake, there was an association between development and reductions in the percent of units with abundant upland LWD (2% - within, 0% - adjacent, 21% - none). And, also similar to Alturas Lake, this pattern was not present in other measures of wood, with in water and bank wood counts actually higher with the presence of development (0.21 pieces/m - within, 0.19 pieces/m - adjacent, 0.15 pieces/m – none).

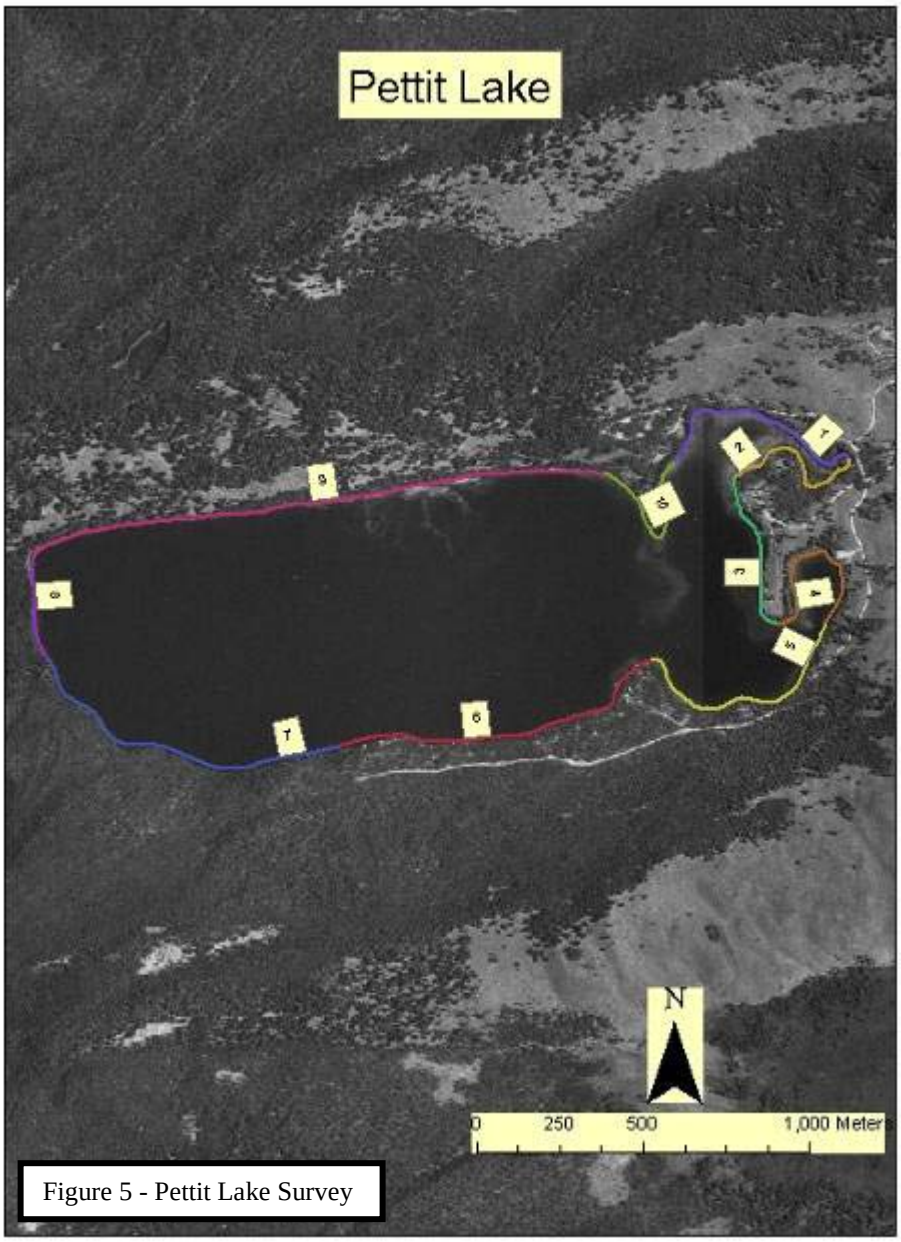

Figure 5 - Pettit Lake Survey

Regeneration of lodgepole pine stands was occurring in most units, regardless of development (71% - within, 95% - adjacent, 79% - none). Banks were impacted be development as the percent of units with moderate or severe bank alterations and units with exposed banks increased with development pressure (alterations = 63% - within, 32% - adjacent, 7%- none; exposure = 84% - within, 60% - adjacent, 58% - none).

Redfish Lake

Redfish Lake was surveyed in early August of 2007 and 159 units, 14 segments, and 14630m were surveyed. The presumption that development would increase the presence of exposed and or scouring trails was again confirmed at Redfish Lake with 21% of units containing development having exposed or scouring trails, compared to 9% or 4% when development was adjacent to the unit or was lacking, respectively. The abundance of upland LWD was reduced in units with development since 0% of those units had abundant wood present, compared to 17% and 38% of units when development was adjacent or not present in the unit. As is commonly the place, lodgepole regeneration was more likely to occur in units with development than in those where development was absent, occurring in 78% of units with development present, and in 67% and 49% of units when development was adjacent or absent from the unit. A trend associating decreased in water bank wood with development was present as counts ranged from 0.19 pieces/m (when development was absent) to 0.16 and 0.10 (when development was adjacent or present in a unit, respectively). Moderate or severe bank alterations occurred in 86% of units where development was present and in 67% and 15% of units where development was adjacent or lacking, respectively. Bank cover mirrored effects noted in most lakes where development strongly influenced the percentage of units with exposed banks. In this case, 73% of units with development had exposed banks while 33% and 1% of units adjacent to or without development were in similar condition, respectively.

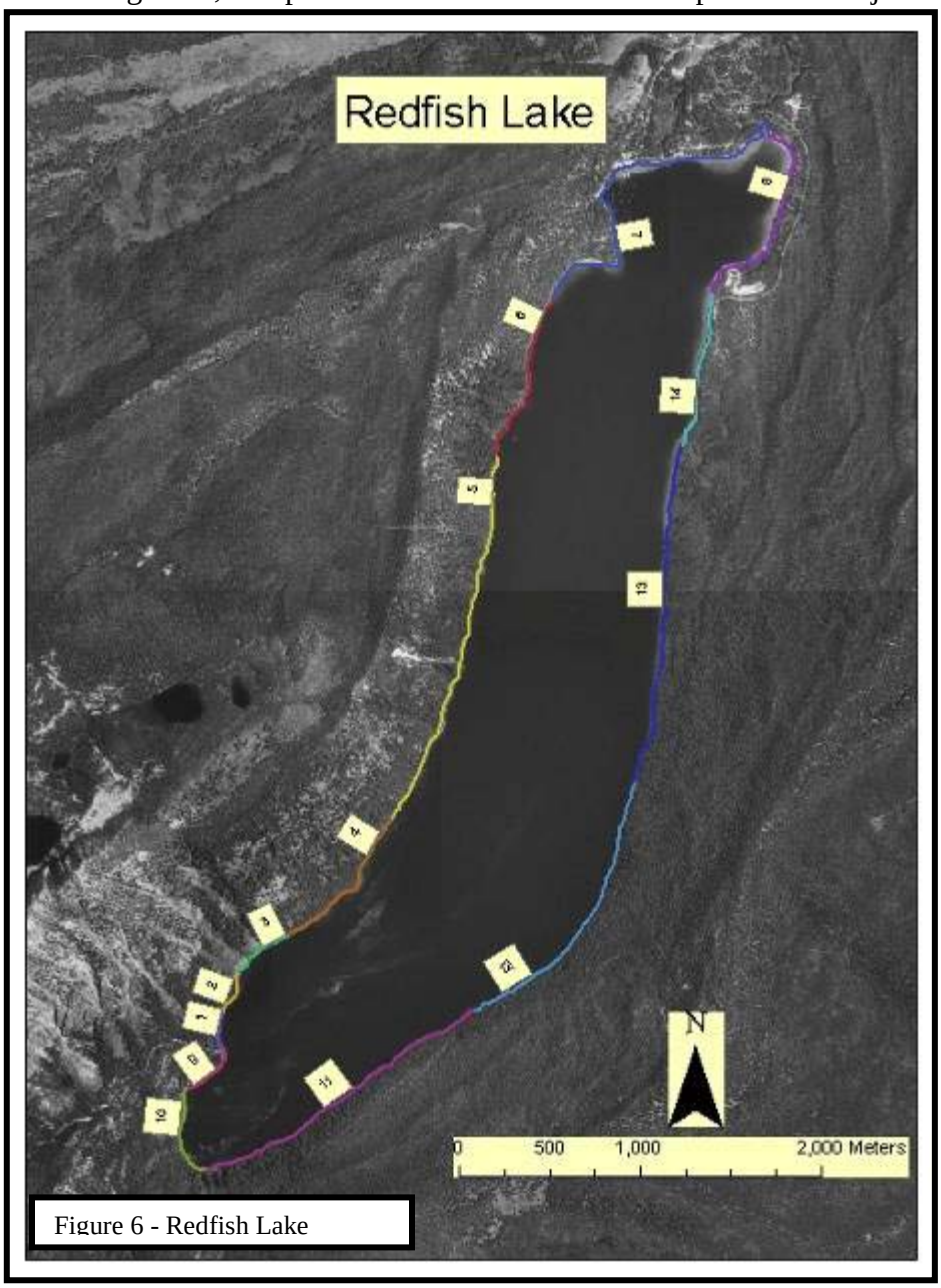

Figure 6 - Redfish Lake

All Lakes

Across all lakes, from 2001 through 2008, 632 units, 78 segments, and 39740 m of lakeshore were surveyed. Segments ranged from highly developed campgrounds containing paved roads, to remote and inaccessible lakeshores that receive very few forest visitors. Several associations are clear in the data.

Trail Scouring and Exposure

The presence of development along the lakeshore dramatically increases the occurrence of exposed and scouring trails. This observation was generally consistent across all lakes and with all sampling crews and is therefore well established. Additional analyses indicated that for parallel trails, the shape of the lakeshore influenced the occurrence of scouring or exposed trails. Interestingly, trail "damage" was more likely to occur in units with gentles shores (shores <5% continuous slope) than in units with steeper shores (shores >5% continuous slope). This observation occurs despite the fact the there were generally an equal number of units that had the presence of trails between the two groups. One potential explanation is that more traffic would occur on those trails in the vicinity of gentle beaches as these beaches might be considered more favorable for recreation by forest visitors. Nevertheless, an opposite, though somewhat weaker association was noted with perpendicular trails, where units with steep shores were more likely to have scouring or exposed trails when recreation was present in the unit. This weak association might simply occur because steep shores may generally have steeper uplands that would result in an increase in scouring and exposure due to land slopes.

Bank Alterations and Exposure

As might be expected, the presence of development also leads to a dramatic increase in the occurrence and severity of bank alterations as well as the increases likelihood of the presence of exposed banks. As with trail scouring, this observation was consistent across lakes and crews and is well supported by the data. Overall, having development in a unit increased the likelihood of having severe or moderate bank alterations by 66% when compared to units without any development adjacent to or within the unit. It is clear that bank shape has an affect on the occurrence of bank alterations because the frequency of severe bank alterations was 4-7 times higher when banks were sloping versus vertical. Nevertheless, increasing recreational use (as determined by the presence of development), resulted in an increase in the occurrence of bank alterations regardless of bank shapes. Similar patters were noted in the data of bank exposure. Across all lakes, nearly 62% of units containing development had exposed banks while only 32% and 27% of units were in a similar condition when development was adjacent or not present in a unit, respectively. Bank shape also influenced bank exposure. When development was present in a unit, 78% of those units had exposed banks if the bank was sloping and only 22% were exposed if vertical. When development was adjacent to the unit, the difference was even greater, with 52% of units with sloping banks having exposed soils compared to only and 3% of units with vertical banks. In the absence of development, a similar effect is noted (32% to 18%), though the smaller difference (twice as much, as compared to 4 times or nearly 20 times in the other situations) indicates that effect of bank shape does influence the effects of development on bank exposure. All in all, development is less likely to result in bank exposure or bank alterations if vertical banks are present along the lakeshore.

Wood – Upland down and dead, lodgepole regeneration, and lakeside LWD

Across all lakes, the presence of development increase likelihood that immediate areas will have no upland wood presence. Nearly 41% of units containing development have no upland wood while only 14% of units without development are in a similar condition. Likewise, nearly 41% of units without nearby development had abundant upland down and dead and only 9% when development is nearby and 2% when development is in a unit. The relationship between development and downed in water or shoreline wood was less clear, ranging from 0.19 pieces/m in units adjacent to development to 0.14 pieces/m in units containing some development attribute. Because units without development had 0.17 pieces/m, no linear relationship was noted between in water wood and recreational use. Similarly, no clear relationship existed between development and use and lodgepole pine regeneration across all lakes. In some cases, such as at Stanley Lake, no units with development or adjacent to development had adequate lodgepole pine regeneration. In other locations, regeneration was more likely to occur in developed units than in units with no development. It is likely that lodgepole pine regeneration was assesses differently from year to year. For example, during 2001, under the supervision of Mark Moulton, Stanley Lake was sampled with the results noted above. For sampling of all of the other lakes, Jeb Wofford trained crews in sampling protocols and lodgepole pine regeneration results appear to contrast sharply. Because regeneration was subjectively assessed, it is possible that Wofford and Moulton provided different guidance for crews when evaluating lodgepole pine stands.

Table 1. Percentage of units that had exposed or scouring parallel trails. (Dev = development (W=within, A=adjacent, N=none; D = duff, E = exposed, N = no trails present, X = scouring).

		Parallel Trails				
	Dev	D	E	N	X	Percentage exposed and/or scouring
Alturas Lake	W	7	31	2	0	77.50%
	A	6	27	4	0	72.97%
	N	38	26	7	0	36.62%
Little Redfish Lake	W	1	13	0	1	93.33%
	A	11	10	0	4	56.00%
	N	17	0	0	6	26.09%
Perkins Lake	W	0	18	0	0	100.00%
	A	1	17	0	0	94.44%
	N	0	1	22	2	12.00%
Pettit Lake	W	27	16	1	1	37.78%
	A	12	6	2	0	30.00%
	N	29	16	6	1	32.69%
Redfish Lake	W	26	11	1	2	32.50%
	A	5	1	0	0	16.67%
	N	60	8	45	0	7.08%
Stanley Lake	W	0	23	0	2	100.00%
	A	0	11	0	0	100.00%
	N	31	11	5	1	25.00%

Table 2. Percentage of units that had exposed or scouring perpendicular trails. (Dev = development (W=within, A=adjacent, N=none; D = duff, E = exposed, N = no trails present, X = scouring).

		Perpendicular Trails				
	Dev	D	E	N	X	Percentage exposed and/or scouring
Alturas Lake	W	4	24	12	0	60.00%
	A	6	17	12	0	48.57%
	N	12	8	51	0	11.27%
Little Redfish Lake	W	0	14	1	0	93.33%
	A	9	4	12	0	16.00%
	N	2	0	21	0	0.00%
Perkins Lake	W	4	9	0	5	77.78%
	A	7	5	1	5	55.56%
	N	3	0	22	0	0.00%
Pettit Lake	W	14	17	10	4	46.67%
	A	7	4	9	0	20.00%
	N	11	8	26	7	28.85%
Redfish Lake	W	20	1	17	2	7.50%
	A	1	0	5	0	0.00%
	N	0	0	113	0	0.00%
Stanley Lake	W	1	10	0	14	96.00%
	A	5	3	0	3	54.55%
	N	32	3	12	1	8.33%

Table 3. Percentage of units that had abundant Upland LWD. (Dev = development (W=within, A=adjacent, N=none; A = abundant, N = none, S = some).

		Upland LWD			
	Dev	A	N	S	Percentage with abundant upland LWD
Alturas Lake	W	1	23	15	2.56%
	A	2	15	19	5.56%
	N	36	15	20	50.70%
Little Redfish Lake	W	0	9	6	0.00%
	A	2	8	15	8.00%
	N	7	8	8	30.43%
Perkins Lake	W	1	2	15	5.56%
	A	6	0	12	33.33%
	N	5	4	16	20.00%
Pettit Lake	W	1	10	34	2.22%
	A	0	4	16	0.00%
	N	11	2	39	21.15%
Redfish Lake	W	0	12	28	0.00%
	A	1	1	4	16.67%
	N	43	5	65	38.05%
Stanley Lake	W	0	19	6	0.00%
	A	0	6	5	0.00%
	N	33	11	4	68.75%

Table 4. Percentage of units with moderate or severe bank alterations. (Dev = development (W=within, A=adjacent, N=none); M = moderate (a few nick points), L = no mature nick points, na = not applicable (rock, etc), S = severe (nick points common to continuous).

		Bank Alteration				
	Dev	M	L	na	S	Percentage with moderate or severe
Alturas Lake	W	15	10	0	15	75.00%
	A	16	13	1	7	63.89%
	N	12	46	13	0	20.69%
Little Redfish Lake	W	8	3	0	4	80.00%
	A	2	22	0	1	12.00%
	N	1	22	0	0	4.35%
Perkins Lake	W	5	4	0	9	77.78%
	A	10	5	0	3	72.22%
	N	0	23	0	0	0.00%
Pettit Lake	W	18	15	4	8	63.41%
	A	6	13	1	0	31.58%
	N	3	40	9	0	6.98%
Redfish Lake	W	5	5	3	27	86.49%
	A	0	1	3	2	66.67%
	N	1	11	99	1	15.38%
Stanley Lake	W	3	0	0	22	100.00%
	A	6	1	0	4	90.91%
	N	4	34	5	5	20.93%

Table 5. Percentage of units with exposed banks. (Dev = development (W=within, A=adjacent, N=none); E = exposed, R = rock, V = vegetated.

		Bank Cover			
	Dev	E	R	V	Percentage of units with exposed banks
Alturas Lake	W	27	4	9	67.50%
	A	21	10	6	56.76%
	N	50	11	10	70.42%
Little Redfish Lake	W	1	0	14	6.67%
	A	0	1	24	0.00%
	N	0	0	23	0.00%
Perkins Lake	W	2	0	16	11.11%
	A	0	0	18	0.00%
	N	2	0	21	8.70%
Pettit Lake	W	38	2	5	84.44%
	A	12	0	8	60.00%
	N	30	17	5	57.69%
Redfish Lake	W	29	9	2	72.50%
	A	2	4	0	33.33%
	N	1	111	0	0.89%
Stanley Lake	W	23	0	2	92.00%
	A	5	0	6	45.45%
	N	6	1	41	12.50%

Table 6. Percentage of units with lodgepole regeneration. (Dev = development (W=within, A=adjacent, N=none); n/a = unit not mature lodgepole, no = lodgepole regeneration inadequate for stand replacement, yes = lodgepole regeneration adequate for stand replacement).

		Lodgepole Regeneration			
	Dev	n/a	No	Yes	Percent of units with adequate lodgepole regeneration
Alturas Lake	W	0	8	32	80.00%
	A	0	9	28	75.68%
	N	0	17	54	76.06%
Little Redfish Lake	W	0	0	15	100.00%
	A	0	1	24	96.00%
	N	0	4	19	82.61%
Perkins Lake	W	0	0	18	100.00%
	A	0	0	18	100.00%
	N	0	4	21	84.00%
Pettit Lake	W	0	13	32	71.11%
	A	0	1	19	95.00%
	N	0	11	41	78.85%
Redfish Lake	W	0	9	31	77.50%
	A	0	2	4	66.67%
	N	10	53	50	48.54%
Stanley Lake	W	2	23	0	0.00%
	A	1	10	0	0.00%
	N	27	14	6	30.00%

Table 7. Average number of pieces of LWD per meter. (Dev = development (W=within, A=adjacent, N=none).

		Avg LWD /m
	Dev	
Alturas Lake	W	0.09
	A	0.11
	N	0.09
Little Redfish Lake	W	0.26
	A	0.29
	N	0.34
Perkins Lake	W	0.39
	A	0.55
	N	0.48
Pettit Lake	W	0.21
	A	0.19
	N	0.15
Redfish Lake	W	0.10
	A	0.16
	N	0.19
Stanley Lake	W	0.03
	A	0.03
	N	0.15

Table 8. Percentage of units that had exposed or scouring perpendicular trails, summed across all lakes. (Dev = development (W=within, A=adjacent, N=none; D = duff, E = exposed, N = no trails present, X = scouring).

Dev.	% exposed or scouring
W	54.64%
A	35.65%
N	8.13%

Table 9. Percentage of units that had exposed or scouring parallel trails, summed across all lakes. (Dev = development (W=within, A=adjacent, N=none)).

Dev.	% exposed or scouring
W	64.48%
A	64.96%
N	21.69%

Table 10. Upland LWD abundance, summed across all lakes. (Dev = development (W=within, A=adjacent, N=none)).

Dev.	% of units with no upland lwd	%of units with moderate upland lwd	% of units with abundant upland lwd
W	41.21%	57.14%	1.65%
A	29.31%	61.21%	9.48%
N	13.55%	45.78%	40.66%

Table 11. Bank Alteration, summed across All Lakes. (Dev = development (W=within, A=adjacent, N=none).

Dev.	% of units with no bank alterations	% of units with moderate bank alterations	% or units with severe bank alterations
W	21.02%	30.68%	48.30%
A	49.11%	35.71%	15.18%
N	86.70%	10.34%	2.96%

Table 12. Lodgepole Regeneration, summed across all lakes (Dev = development (W=within, A=adjacent, N=none)).

Dev.	% of units with stand replacing lodgepole regeneration
W	29.28%
A	19.83%
N	35.03%

Table 13. Bank Exposure, summed across all lakes (Dev = development (W=within, A=adjacent, N=none)).

Development	% of units with exposed banks
W	61.75%
A	32.48%
N	26.75%

Table 14. In-shore and bank counts of LWD, summed across all lakes (Dev = development (W=within, A=adjacent, N=none)).

Dev.	average # of pieces of lwd/m
W	0.167668488
A	0.22965812
N	0.189678715