UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
Glacier National Park
West Glacier, Montana

LOGAN PASS WOODEN WALKWAY STUDY

NATIONAL PARK SERVICE PROGRESS REPORT, 1974

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INTRODUCTION

Logan Pass is located on the Continental Divide at an elevation of 6,646 feet. Reynolds Creek drains eastward to St. Mary Lake and the Hudson Bay drainage. Logan Creek drains westward to McDonald Lake and the Columbia River system (Fig. 1). About 65% of the Logan Pass area is occupied by meadowy depressions with the remainder consisting of rocky ledges, fell-fields and moraines (Choate and Habeck, 1967). Vegetation is primarily alpine with scattered zones of krummholz.

Completion of the Going-to-the-Sun Road in 1933 marked the beginning of easy access to Logan Pass. It is unique in that it is the only alpine area in Glacier National Park accessible by road. As a result, Logan Pass is one of the most popular attractions in the park. In 1964 the parking lot was expanded to a capacity of 198 vehicles and in 1965 a visitor center and new restroom facilities were constructed to provide interpretive information and accommodate the ever-increasing numbers of visitors (Fig. 2).

In 1938 the transmountain telephone line was laid down by the Civilian Conservation Corps over much of what is now the Hidden Lake Trail. While adequate when constructed, the trail is not sufficient to withstand the heavy use it now receives (as many as 400 people per hour). Groups were forced to step off the trail while passing other groups and many accidentally step off the trail while enjoying the scenery. Heavy use has compacted the trail bed resulting in some areas of serious erosion.

These factors and the apparently irresistible desire of people to short-cut switchbacks have created a badly abused trail. It was the need for effectively channeling visitor use that resulted in the wooden walkway proposal and study plan (Appendix 1).

STUDY AREA

The Hidden Lake Trail passes through several alpine plant communities as first described by Sammons (1959) and used by Choate (1962) and Choate and Habeck (1967). Approximately one-half of the 1.5 mile trail passes through level to gently sloping dry meadow type community that is well-drained, becoming dry in later summer. Dry meadow vegetation is characterized by glacier lilies (*Erythronium grandiflorum*), wood rush (*Luzula glabrata*), sedge (*Carex nigricans*), sibbaldia (*Sibbaldia procumbens*), and St. John's wort (*Hypericum formosum*) with alpine timothy (*Phleum alpinum*) and fleabane (*Erigeron peregrinus*) usually present less frequently.

About one-third of the trail passes through moraine and fell-field type communities. Moraines are included in communities having more than 80% rock cover. Conditions are usually dry and windswept. Characteristic plants include lichens, alpine forget-me-nots (*Myosotis alpestris*), shrubby cinquefoil (*Potentilla fruticosa*), saxifrage (*Saxifraga bronchialis*), hawksbeard (*Crepis nana*), moss campion (*Silene acaulis*), and common stonecrop (*Sedum stenopetalum*).

Fell-fields have very little soil development and are characterized by white dryad (Dryas octopetala), moss campion (S. acaulis), saxifrage (Saxifraga bronchialis), fleabane (Erigeron compositus), rock cress (Arabis lyalli) and sandwort (Arenaria obtusiloba).

The rest of the trail passes through krummholz, composed of subalpine fir (Abies lasiocarpa) and wet meadow type. Wet meadows are moist and relatively level. Characteristic plants include willow (Salix commutata), anemone (Anemone parviflora), buttercup (Ranunculus eschscholtzii), mitrewort (Mitella breweri), saxifraga (Saxifraga rhomboidea), grass-of-parnassus (Parnassia fimbriata), gentian (Gentiana calycosa), Lewis monkey-flower (Mimulus lewisii), bistort (Polygonum viviparum), groundsel (Senecio traingularis), sedge (Carex tolmei), false asphodel (Tolfieldia glutinosa), and mountain laurel (Kalmia polifolia).

Representative herbivores of talus slopes and other rocky areas include the hoary marmot (Marmota caligata), golden mantled ground squirrel (Spermophilus lateralis), pika (Ochotona princeps) and mountain goat (Oreamnos americanus). Ptarmigan, Rosy Finches and Columbian ground squirrels (Spermophilus columbianus) are characteristic of meadow communities. The Golden Eagle is a representative predator. The grizzly bear (Ursus arctos), better considered an omnivore than a predator, is also characteristic of alpine meadows.

The Hidden Lake Trail is four feet wide, 1.5 miles long and has five switchbacks. The first 0.1 mile of trail is paved with macadam. Drainpipes and ditching were used to divert the natural drainage pattern around and under the trail. This method has resulted in an alteration of the natural drainage pattern with subsequent trail erosion occurring on the steeper parts of the trail and drainpipe outlets.

The trail has received considerable use resulting in severe impact. All of the switchbacks have been shortcutted and in some cases the shortcut trail is more obvious than the switchback. Trail braiding is extensive in the wetter parts of the trail and most of the trail has been widened from trampling, even along the paved section. Some areas have been widened to as much as 12 feet.

The wooden walkway is designed to provide a defined edge and cause minimal alteration of the drainage system by being up off the ground. The initial test section constructed in September, 1971 is eight feet wide and 820 feet long. It is constructed of planks 2" x 12" x 96" and 4" x 6" stringers. The wood is treated with pentachlorophenol dissolved in diesel oil. The walkway ranges from a few inches off the ground on level areas to three feet off the ground across depressions. Steps have been used to cross rock ledges or across switchbacks. Other than switchbacks, the walkway follows the old trail bed.

METHODS

Project Description

The purpose of the project is to evaluate the effectiveness of the wooden walkway. Evaluation will be made in terms of five hypotheses. Rejection of one or more hypotheses during the three year study period will be sufficient cause to re-evaluate the management program. The hypotheses are as follows:

1. The program will provide an effective means of safely channeling visitor travel over alpine meadows.

2. The program will permit recovery to a natural state of previously denuded sites along the trail.

3. The program will permit natural ecological processes to continue with the exception of the trail bed itself.

4. Engineering procedures or structural deficiencies of the walkway will not contribute to environmental or esthetic degradation of the alpine ecosystem.

5. Routine maintenance of the walkway will not be sufficiently complex nor costly to detract from the practicability of the project.

General Data

An avalanche probe was used to try to determine location of the trail while snow-covered. Approximate snowdepths and general snowmelt rate and pattern were recorded throughout June. Moisture content and density were determined.

Visitor Use Data

Counts of one hour duration were made each day during the first (1972) season of study to determine the number of people stopping at Logan Pass. In 1973, weekly counts were made beginning July 10. Counts were made at the only designated access (marked A on Figure 2) to the Pass area from the parking lot.

Counts were made at the trailhead and at various trail markers to determine the gradient of use as a function of distance from the visitor center.

Trail counts of 15 minutes duration were made along sections of each type of trail surface and at Hidden Lake Overlook. Tallies were made of the number of people stepping off the section in that period. Beginning July 31, 1972, apparent reasons for leaving the trail were also tallied. In 1973 sample counts were made about once a week. Counts were made only on exposed portions of the trail, not snow-covered portions.

In an attempt to quantify an esthetic evaluation, visitors were interviewed at random about their trail surface preferences. They were asked "what type of trail surface do you prefer?" Mention of a specific type of surface in the preliminary question was carefully avoided in order not to bias visitor response.

Ecological Data

A map of the trail depicting landmarks and drainage pattern was developed (Figure 3).

Temperature measurements were taken of each type of trail surface. The thermometer was shaded from direct sunlight for all measurements. Readings were taken at intervals of 2 to 5 cm both vertically and horizontally from each type of surface. On the wooden walkway, readings were also taken underneath and between the planks. Each set of readings were repeated ten times at randomly chosen sites.

Six 10 foot transects, perpendicular to the wooden walkway were made to determine plant composition. Height, numbers and apparent condition of each species were recorded. An orange map pin was inserted in the edge of the planks to identify the beginning of each transect. The location of transect points is marked (A - F) in Figure 3.

Engineering Data

Observations and photographs were made of structural and procedural aspects of the wooden walkway to monitor for any possible adverse effects.

Thirteen points along the walkway were marked by driving a nail into the side of the understructure. A plumb line was used to determine the corresponding spot on the ground and a nail was driven to mark the spot. The ground nail was marked with fluorescent orange paint (but not in such a way as to be visible to visitors on the walkway). These locations will be tested in the 1974 season to determine if and to what extent any movement of the walkway has occurred.

RESULTS

General

Locating the trail with a probe was not feasible. The ice layer on the trail made it nearly impossible to distinguish the trail from the rest of the area. Snowdepth in early June 1972 ranged from six to twelve feet. Snow melted at an average rate of about six inches per day, with benches and ledges becoming exposed first. In 1972, snowdepths were about half those of 1972. Average water content was 21 inches (10 samples) and average density was 50%.

Visitor Use

Table I relates Logan Pass Visitor Center use to total park use and Going-to-the-Sun Road use for the months of July and August, 1972 and 1973. Logan Pass Visitor Center receives an average of 36%of total park travel and an average of 59% of the Going-to-the-Sun Road travel. Complete data are unavailable for 1971 visitor center use, however, it is doubtful that there was any substantial increase. Figures for July and August 1973 show a decrease of 1% in parkwide travel, a decrease of 8% in Going-to-the-Sun Road travel and a decrease of 5% in visitor center use, from 1972 figures.

Average hourly use at the visitor center for the period of July and August 1972 and 1973 has been plotted in Figure 4. In 1971, hourly use was taken by Reed (1971) for one day only (July 17) and has been plotted for comparison. It is not too surprising to note that the basic pattern for each year is very similar. In 1972 the greatest number of visitors between 0900 and 1800 was 812 (1100 - 1200) and the least number was 130 (1700-1800).

In a preliminary report, Hartley (1970) presented Hidden Lake Trail use figures for August 4, 1969, a typical, good weather day. Table 2 compares those figures with figures for comparable days in 1972 and 1973. It is obvious that trail use has greatly increased since 1969, averaging 25% per year. Logan Pass Visitor Center use figures are not available for 1969, however, it is doubtful that use has increased by as great a degree. Overall park travel has only increased at an average rate of 10% per year since 1969. Because the parking lot is self-limiting, it is unlikely that visitation to the pass itself will increase significantly. About 35% of Logan Pass visitors use at least part of the Hidden Lake Trail, thus the possibility exists for a great increase in use. The decrease of 5% in trail use on August 9, 1973, corresponds with the 5.8% decrease in total park travel for August.

Figure 5 diagrams the general weather pattern for July and August, 1972. A comparison of this generalized pattern can be made with those of the Going-to-the-Sun Road travel (Figure 6), Logan Pass Visitor Center use (Figure 7) and Hidden Lake Trail use (Figure 8). There is no obvious correlation between road use and weather, however, there appears to be a slight relationship with visitor center use and an obvious correlation with trail use.

Not everyone starting out on the trail goes all the way to Hidden Lake Overlook. A correlation study in 1973 showed that 56% of the visitors coming to the trailhead started out on the trail and 33% continued to the end of the trail at the overlook. Considering just the starters on the trail, 64.5% go as far as stake 7 (0.5 mi.) and 59% go to the end of the trail (1.5 mi.). A graphic representation is in Figure 9.

Table 3 presents data indicating effectiveness of each type of trail surface for channeling use. It is obvious that the wooden walkway is much more effective in channeling use than the natural trail. The large percentage of visitors stepping off the wooden walkway in the July 2 - July 29,1972 period resulted from a large snowbank across the trail. Visitors would come to the edge of the snowbank and congregate, rather than continue on across the snow. This would force those wishing to continue to step off the trail and onto the vegetation in order to get around. Obviously, early snow removal would prevent this problem and reduce the incidence of stepping off the trail.

There is a higher incidence of stepping off the trail in the early season (July) because of the great amount of snow, mud and water on the trail. Unfortunately, this is a period when leaving the trail causes great impact on the newly germinating plants.

Weekly visitor sampling in 1973 showed 2% stepping off the wooden walkway compared to 19% stepping off the natural trail.

In the period from July 30 to August 28, 1972, apparent reasons for leaving the trail were recorded. The results appear in Table 4. The greatest problem with the natural trail is shortcutting switchbacks. By building the wooden walkway across the switchbacks, this problem is alleviated. On the macadam, the greatest problem is careless straying. With the wooden walkway from six inches to several feet off the ground; this factor is also eliminated. Thus the wooden walkway is proving effective in reducing off trail use.

Safety is difficult to analyze as few people report falls even with injuries. It was observed that on hot days the wood treatment material bubbled up on the surface creating a slick walkway. If there was rain or a layer of snow (as occurred July 19, 1972) the wooden walkway was very slippery. Because of this, the walkway was closed to visitors from July 19 through July 28, 1972, and a CAUTION SLIPPERY sign was made to be used only when conditions were hazardous. Crushed pumice was used to absorb the material in an attempt to mitigate the slipperiness, but met with limited success. There has been no conclusive evidence to demonstrate that the wooden walkway is any more or less hazardous than the other types of trail surface.

A total of 650 visitors were interviewed at random to determine what preferences, if any, they had regarding the three types of trail surface encountered. Table 5 shows the results of this survey. Most visitors accept the wooden walkway concept when the problems and alternatives are explained. Eighty-eight percent of the people interviewed found the odor of the walkway offensive. They were not asked about it, but volunteered the information.

Ecological

Figure 3 illustrates the drainage pattern. Three metal drains were removed during walkway construction and the ground smoothed. The result was the resumption of a more normal drainage pattern with water flowing smoothly over a widened area. Other alterations,positive or negative have not as yet become apparent.

Temperature measurements revealed some difference in various types of trail surfaces (Table 6). The most obvious difference is seen in the treated wooden walkway which has an average temperature four to six degrees higher than any of the other trail surfaces. The untreated wood averages one degree higher than dirt and pavement averages two degrees higher than dirt. As can be seen in Table 6, practically no gradient exists and regardless of surface temperatures, adjacent temperatures, vertical and horizontal are nearly the same for all types of trail surface. This is probably due to the generally windy conditions on Logan Pass. Even though the treated wood acts as a blackbody and absorbs more heat, it is apparently not enough to significantly affect adjacent vegetation.

The possible long range effects will remain unknown since, for reasons to be discussed later, treated wood is to be replaced with untreated wood and all further construction will be with untreated wood.

Table 7 lists composition and percentages of plant species in ten foot transects perpendicular to the wooden walkway. The data from control transects was accidentally destroyed and will have to be redone in the 1974 season.

Transects B and E are sections of the old trail and have been included to follow rehabilitation progress. Transects A, C and D exhibit most damage in the first three feet from the trail edge. In this section plants are trampled and on the average smaller than those beyond three feet. In transect A, 30% of the plants flowered, while in transect C, 50% of the plants flowered and in transect D, 70% of the plants flowered. Transect F was 100% Juncus which appeared vigorous with nearly 100% flowering. Transect D was the only one having glacier lilies. There were none present within about five feet. Those beyond five feet had about 85% flowering. This finding is similar to Hartley"s (1970) which showed that glacier lily flowers are few or nonexistent within an area of six feet on either side of the trail.

The wooden walkway passes through a grove of sub-alpine fir (Abies lasiocarpa). Two trees are immediately adjacent to the walkway, and in winter the snowladen branches come in direct contact with the walkway (Figure 10). In the spring of 1972, the needles of those branches were observed to be dead and photographs were taken. It is known that the wood treatment material (Pentachlorophenol dissolved in diesel oil) is toxic to vegetation on direct contact (Thomson, 1967), thus it is reasonable to assume that the penta and/or oil was responsible for the dead branches.

Later in the summer, the new season's growth was observed to be chlorotic. The chlorosis was only observed in this particular grove of trees and only in proximity to the wooden walkway. The worst chlorosis was observed nearest the walkway with a gradual lessening as the distance from the walkway increased. On the north side of the walkway, chlorosis was observed to occur about 10 feet from the walkway and only on the south sides of the trees. On the south side of the walkway, chlorosis was observed for nearly 60 feet from the walkway and on all sides of most of the trees within about 35 feet. Wind is usually from the northwest. Because of the strong odor of the penta and diesel oil all summer, it was hypothesized that the chlorosis was a result of fumigation from the treatment material. Representative samples were taken for analysis.

Another concern is the possible cumulative effect of the presence of penta and oil on the surface of snowmelt and rain runoff. The treatment material is not soluble in water, thus as the waters soak into the soil, the surface film is left on the ground. What effect this may have on the alpine vegetation is unknown as is the concentration necessary to have any effect. It is known that penta interferes with mitosis in plant cells (Amer and Enaam, 1969); diesel oil sprayed at a rate of five gallons per acre kills young Douglas fir cones (Koerber, 1963); the phytotoxicity of penta is inversely related to temperature and moisture of soil (Loustalot and Ferrer, 1950); penta in diesel oil produces abortion of seeds in cotton (Miller and Aboul-Ela, 1969); penta has long residual effects and is used as pre- and post-emergence herbicide (Thomson, 1967). In a personal communication, Dr. John Krier, Forestry School, University of Montana, Missoula, stated that the school used treated wood in the flats for growing seedlings with no ill effects. Information on penta is often conflicting and difficult to evaluate in terms of the effects of the wooden walkway.

There are a few areas where the penta and oil mixture has dripped onto vegetation and killed it or sawdust impregnated with treatment material from construction has been left and killed vegetation with which it came in contact. These areas have been photographed but are not extensive and may recuperate in time. However, they are in direct view of the visiting public.

In September 1972 Dr. Gary Beaver of Eastern Montana College, Billings, Montana, was contracted by Glacier National Park to conduct a research study concerning these questions. Results from one winter of study showed that pentachlorophenol was responsible for the chlorosis, but that the condition was reversible if the source of penta was removed. Field studies were conducted in the summer of 1973 and research continues to determine what other effects, either short or long-term, may occur. A current report is not yet available on this research.

It was felt that there was sufficient evidence to warrant replacing treated wood with untreated wood for all further construction. Additionally, the section passing through the trees was replaced with untreated wood and eventually all treated wood already constructed into walkway will be replaced with untreated wood.

The raised surface of the wooden walkway eliminates most trail compaction which should eventually permit some plants to return. This also permits earlier use and maintenance. Several seasons will have to elapse before a full evaluation can be made of the reduced compaction.

Engineering

Some structural difficulties were noted after the first winter. There were several sections that were sagging due to improper support and in one case there was a broken stringer. These appeared to be a result of inadequate construction. At the upper end of the walkway the upright supports were observed to be leaning downhill at approximately a 20 degree angle. Whether this was caused by a structural deficiency, winter snow movement, or both could not be determined. The upright supports have been straightened and presumably strengthened.

It will be several seasons before any significant evaluation can be made concerning the effects of snow load, snow movement and frost heaving on the stability of the wooden walkway. The plumb line test set up in the 1973 season should give some indication significant movement. None of the deficiencies noted so far have contributed to environmental or esthetic degradation.

Some sawdust from the 1971 construction remained on the ground. The sawdust was impregnated with the penta/oil material which through direct contact had an adverse effect on the 1972 vegetation. As much sawdust as possible was removed. It is probable that eventually these spots will recover. During subsequent construction, care was taken to remove sawdust right away to avoid further adverse effects.

While construction was in progress, visitors were forced to leave the established trail in order to by-pass construction. Little permanent damage results from this occurrence, however, the situation was a paradox from the standpoint of visitors who are constantly admonished to stay on the trail.

Both the odor of the treatment material and sight of an oily surface film on runoff water are esthetically displeasing and were voluntarily remarked about by many visitors. The oily leachates have not diminished as has been predicted at the beginning of the season, thus the problem can be expected to continue until replacement of treated wood is completed.

The wooden walkway is still under construction, thus actual per foot maintenance costs have not been derived. Snow generally remains on Logan Pass well into July so a plan for early trail detection and snow removal will be devised and will be included in maintenance costs. At

present, routine maintenance costs have been estimated to run about $1,000 per year.

Discussion of Hypotheses

1. The program will provide an effective means of safely channeling visitor travel over alpine meadows.

The data clearly show the wooden walkway to be more effective than a natural trail in channeling use. A valid safety analysis is difficult to make, however, there has been no evidence to indicate that the wooden walkway is any more hazardous than any other type of surface. The safety of treated planks when wet was questionned, but these are being replaced by untreated planks eliminating this as a factor.

2. The program will permit recovery to a natural state of previously denuded sites along the trail.

Several seasons will be necessary to make an adequate evaluation of this hypothesis.

3. The program will permit natural ecological processes to continue with the exception of the trail bed itself.

Of concern is the effect of the treatment material (pentachlorophenol dissolved in diesel oil) on some of the vegetation. Studies are underway to determine the degree and reversibility of damage.

Depending on the final outcome of this study, this hypothesis may or may not be rejected. Other than the treatment material question, no other adverse effects were observed. Where drains were removed, the drainage system resumed a more normal pattern. The raised aspect of the wooden walkway will in most places allow the complete resumption of a near normal drainage pattern.

4. Engineering procedures or structural deficiencies of the walkway will not contribute to environmental or esthetic degradation of the alpine ecosystem.

Some minor structural deficiencies were observed and later corrected, but did not contribute to esthetic or ecological degradation. Detailed construction plans are being prepared to avoid the possibility of future deficiencies.

5. Routine maintenance of the walkway will not be sufficiently complex nor costly to detract from the practicability of the project. There is no evidence that would cause the rejection of this hypothesis.

Table 1. Relationship of Logan Pass Visitor Center Use to Total Park Travel for July and August, 1972 and 1973.

Location		People Per Day					
		Average Daily Number		Minimum and Maximum Days			
		July	August	Minimum	Date	Maximum	Date
Parkwide	1972	13,400	14,700	5,765	8/31	16,868	7/2
	1973	15,025	13,366				
Going-to-the-Sun Road	1972	9,750	8,690	4,110	8/30	12,600	7/2
	1973	9,027	7,975	-	-	-	-
Logan Pass VC	1972	5,655	5,040	2,384	8/30	7,308	7/2
	1973	5,401	4,791	-	-	-	-
Logan Pass VC	1971	complete data unavailable				7,120	8/8

Table 2. Comparison of 1969 and 1972 Hidden Lake Trail use figures using similar date and weather conditions.

Date	People Per Hour (Period of 0800 - 1500)							
	Average	Percent Change		Minimum	Percent Change		Maximum	Percent Change	
		1969	1972		1969	1972		1969	1972
August 4, 1969	65	-	-	33	-	-	172	-	-
August 5, 1972	274	+76	-	52	+36	-	412	+ 60	-
August 8, 1973	260	+ 75	-5%	49	+33	-6	390	+ 56	-5

Table 3. Percentage of Visitors Stepping Off Hidden Lake Trail in 1972.

Trail Surface	Sample Size	Off Trail No.	Off Trail Percent	Season
Macadam	929	119	13)	
Boardwalk	1284	257	20)	July 2 - July 29
Natural	169	56	34)	
Macadam	1848	103	6)	
Boardwalk	1478	97	7)	July 30 - August 28
Natural	1721	341	20)	
Macadam	2777	222	8)	
Boardwalk	2762	353	13)	TOTALS
Natural	1890	397	21)	

Table 4. Reasons for leaving trail. Figures are for the period of July 30 through August 28, 1972, none were taken before this except for casual observation. Sample size indicated in parenthesis.

Reason	Percent Macadam (103)	Percent Boardwalk (97)	Percent Natural (341)
Play in snow	0	9	7
Carelessness	41	0	9
Photos or view	23	13	4
Rowdy Children	19	16	13
Rest	2	46	8
Passing People	13	0	13
Mud	0	0	2
Shortcut	3	0	45
Drink water	0	0	1
Miscellaneous	0	16	0

Table 5. Visitor survey of trail surface reactions in 1972. The qualification of the accept category is based on the premise of no other alternative except limiting people.

Reaction (%)	Macadam	Boardwalk	Natural
Prefer	2	17	77
Accept with qualification	19	55	8
Dislike	59	23	3
No opinion	20	5	6

Table 6. Average temperatures of each type of trail surface. Air temperature was 21° C.

Trail Surface	Temp. o C.	Trail Surface	Temp. o C.
Pavement:		Wooden-untreated:	
Surface	24	Surface	23
Adjacent Dirt	24	Between Boards	21
Dirt 20 cm	20	Underneath	14
Dirt 40 cm	20	Adjacent vegetation	19
Vegetation (80 cm)	21	Vegetation 20 cm	20
Vertical 2 cm	20	Vertical 2 cm	20
Vertical 5 cm	20	Vertical 5 cm	20
Vertical 10 cm	20	Vertical 10 cm	20
Vertical 20 cm	20	Vertical 20 cm	20
Wooden - Treated:		Dirt:	
Surface	28	Surface	22
Between boards	23	Adjacent Veg.	19
Underneath	19	Vegetation 20 cm.	20
Adjacent veg.	19	Vertical 2 cm	20
Vegetation 20 cm	20	Vertical 5 cm	20
Vertical 2 cm	19	Vertical 10 cm	20
Vertical 5 cm	19	Vertical 20 cm	20
Vertical 10 cm	19		
Vertical 20 cm	19		

Table 7. Composition of plant species for 5 representative 10-foot transects perpendicular to the wooden walkway.

SPECIES COMPOSITION (%)

Location	0 - 30''	31 - 60''	61 - 90''	91 - 120''	Total (10 ft.)
A	46.7 bare 33.3 Poa alpina 10.0 heather 6.7 pussy toes 3.3 Carex	40.0 pussy toes 16.7 Juncus 13.3 St.Johns wort 10.0 Poa alpina 10.0 heather 6.7 Carex 3.3 bare	23.3 pussy toes 23.3 moss (2 sp.) 20.0 St.Johns wort 20.0 Juncus 6.7 fleabane 6.7 bare	46.7 moss 16.7 lichen 10.0 St.Johns wort 10.0 Juncus 6.7 squirrel hole 6.6 Poa alpina 3.3 Sibbaldia	17.5 pussy toes 17.5 moss 14.6 bare 12.4 Poa alpina 11.6 Juncus 10.8 St. Johns wort 5.0 heather 4.1 lichen 2.5 Carex 1.6 fleabane 1.6 squirrel hole 0.8 Sibbaldia
B	100 bare	100 bare	100 bare	100 bare	100 bare
C	83.3 bare 16.7 Juncus	50.0 Juncus 26.7 St. Johns wort 23.3 bare	96.7 Aster 3.3 Juncus	100.0 Aster	49.2 Aster 26.6 bare 17.5 Juncus 6.7 St. Johns wort
D	56.6 bare 16.7 Carex 13.3 rock 6.7 Poa alpina 6.7 Aster	43.3 bare 26.7 St.Johns wort 13.3 Sitka valerian 10.0 Senecio 6.7 glacier lily	50.0 glacier lily 50.0 Senecio	50.0 glacier lily 50.0 Senecio	27.5 Senecio 26.6 glacier lily 25.0 bare 6.7 St. Johns wort 4.2 Carex 3.3 Sitka valerian 3.3 rock 1.7 Poa alpina 1.7 Aster
E	100 bare	100 bare	100 bare	100 bare	100 bare
D	100 Juncus	100 Juncus	100 Juncus	100 Juncus	100 Juncus

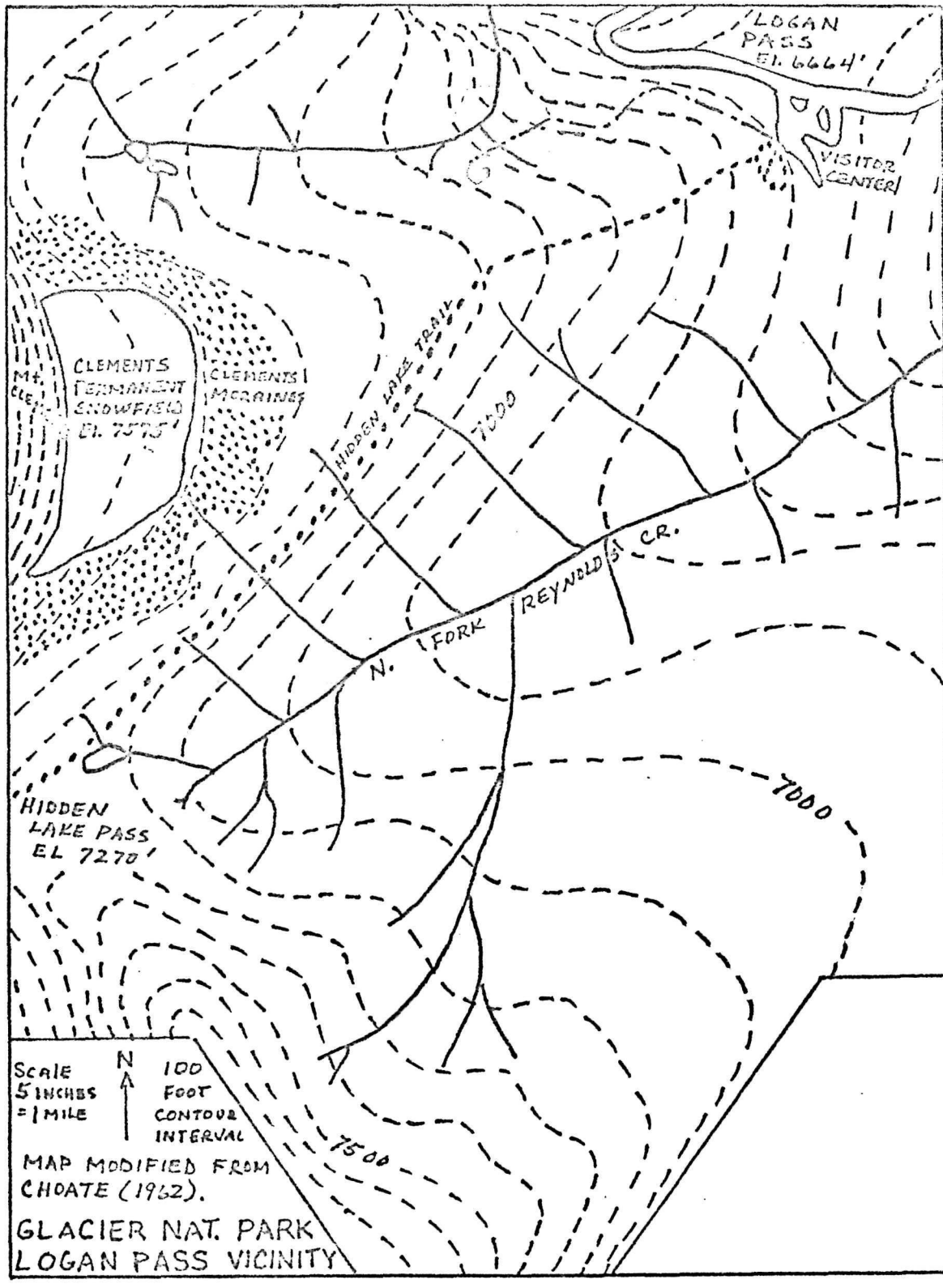
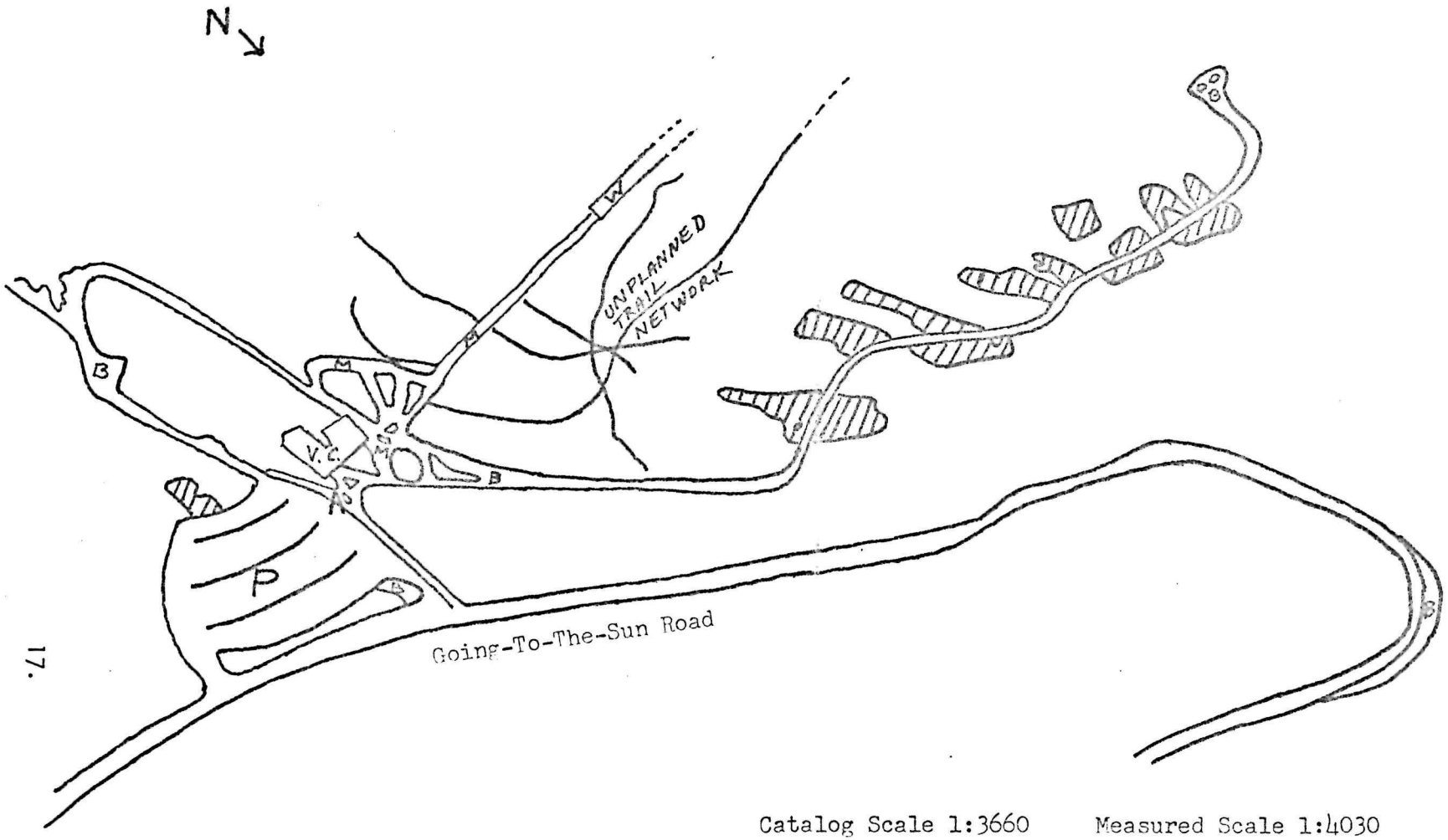

LOGAN PASS El. 6664'
VISITOR CENTER
CLEMENTS PERMANENT SNOWFIELD El. 7575'
CLEMENTS MORAINES
HIDDEN LAKE TRAIL
7000
REYNOLDS CR.
N. FORK
HIDDEN LAKE PASS EL 7270'
7000
7500
Scale 5 INCHES = 1 MILE
N
100 FOOT CONTOUR INTERVAL
MAP MODIFIED FROM CHOATE (1962).
GLACIER NAT. PARK
LOGAN PASS VICINITY

Fig. 1



Catalog Scale 1:3660 Measured Scale 1:4030

500 0 500 1000 1500
Feet

Logan Pass Visitor Center and immediate vicinity. Map traced from enlarged aerial photo 22A-17 without correction for camera altitude or terrain elevation. Probable error for distances measured between points chosen at random will be within 3 percent.

▨	Sod Removal Sites	P	Parking Lot
B	Administrative Roads or Bare Soil	M	Macadam
VC	Visitor Center	W	Wooden Walkway

Fig. 2

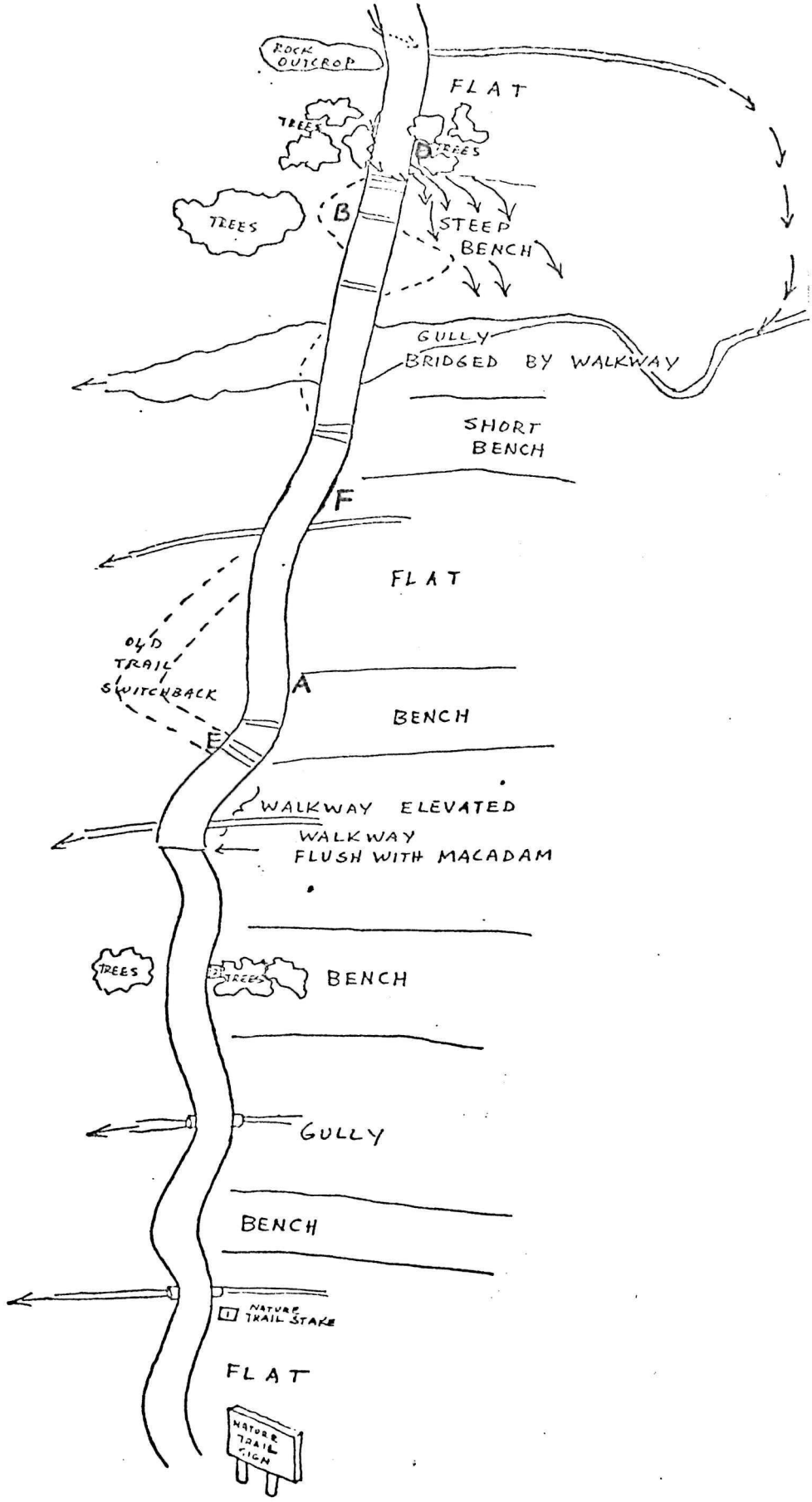


Fig. 3. Hidden Lake Trail. Original drawing by Robert Frausen, with minor additions by the author.

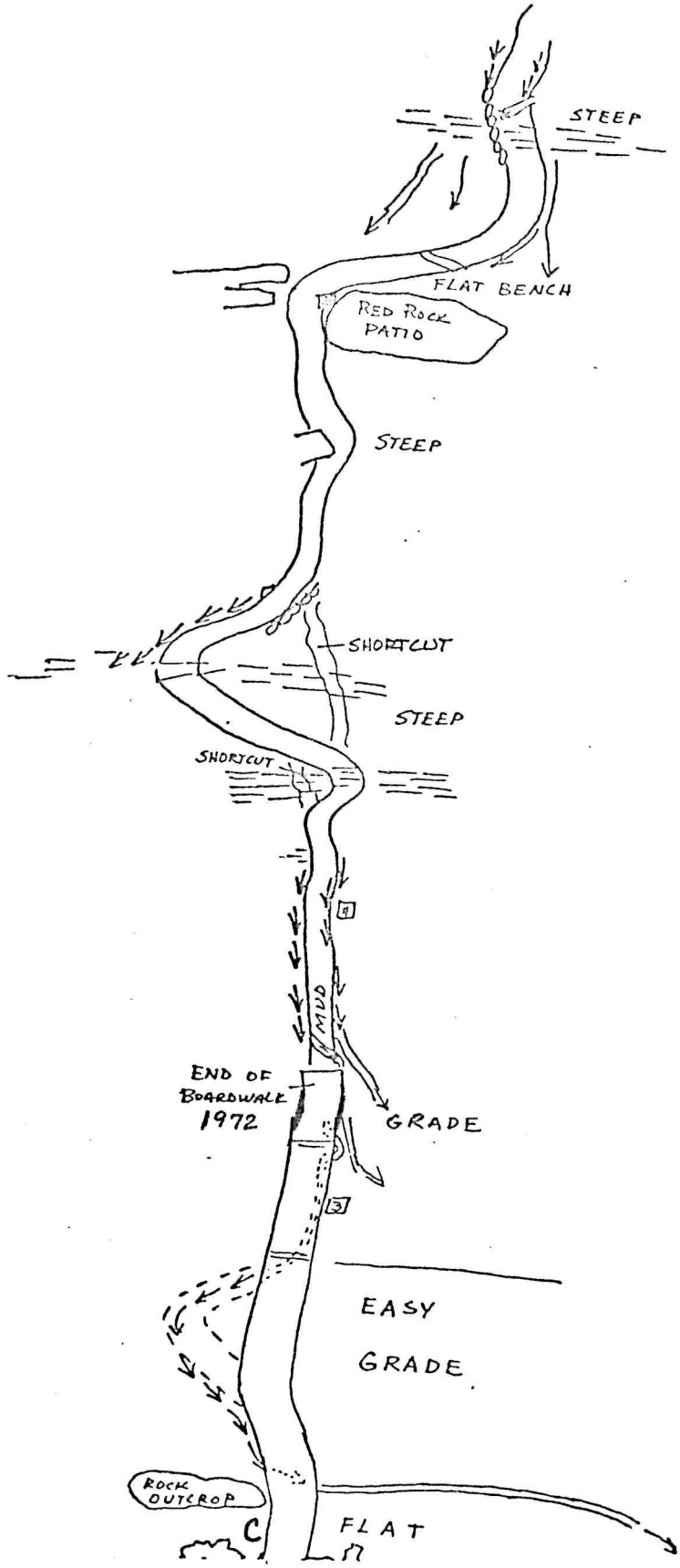

STEEP
FLAT BENCH
RED ROCK PATIO
STEEP
SHORTCUT
STEEP
SHORTCUT
4
MUD
END OF BOARDWALK 1972
GRADE
3
EASY
GRADE
ROCK OUTCROP
C
FLAT

Fig. 3 (cont.)

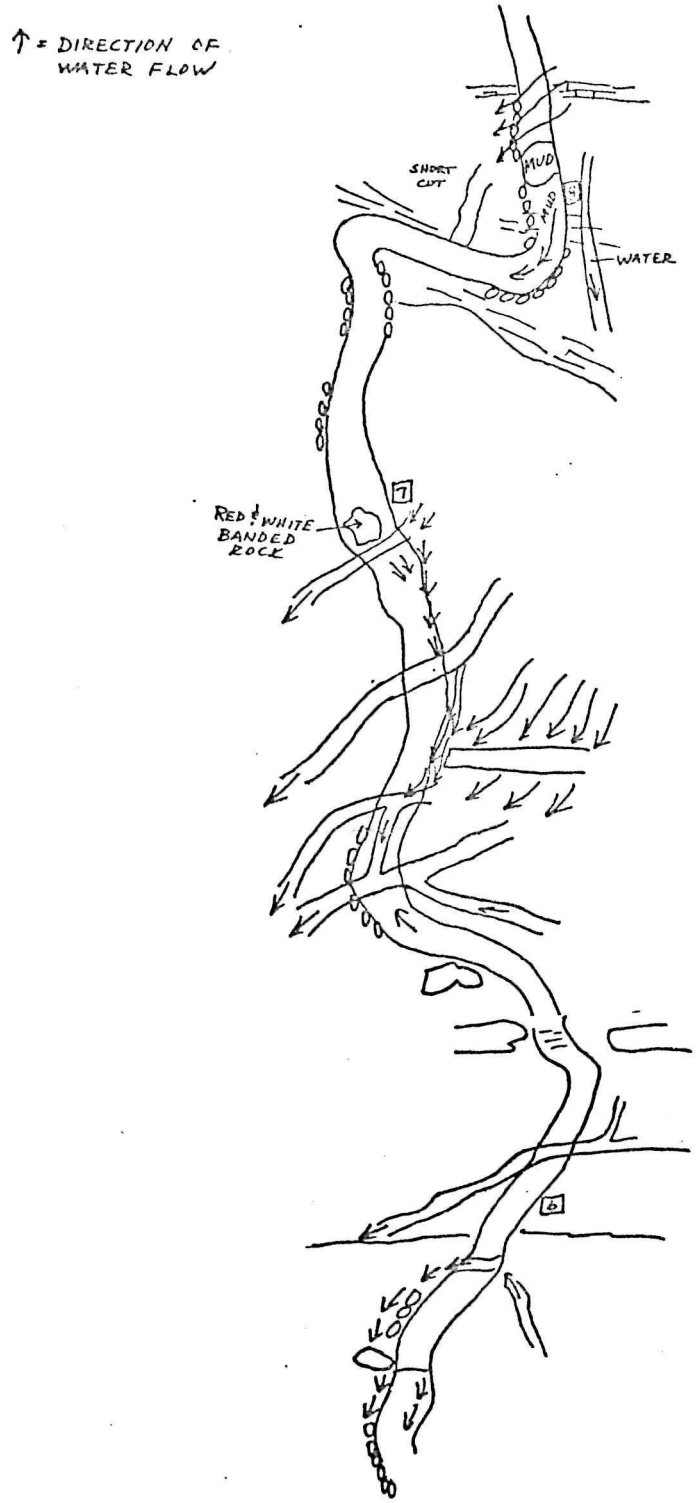

↑ = DIRECTION OF WATER FLOW
SHORT CUT
MUD
MUD
WATER
RED & WHITE BANDED ROCK
7
6

Fig. 3 (cont.)

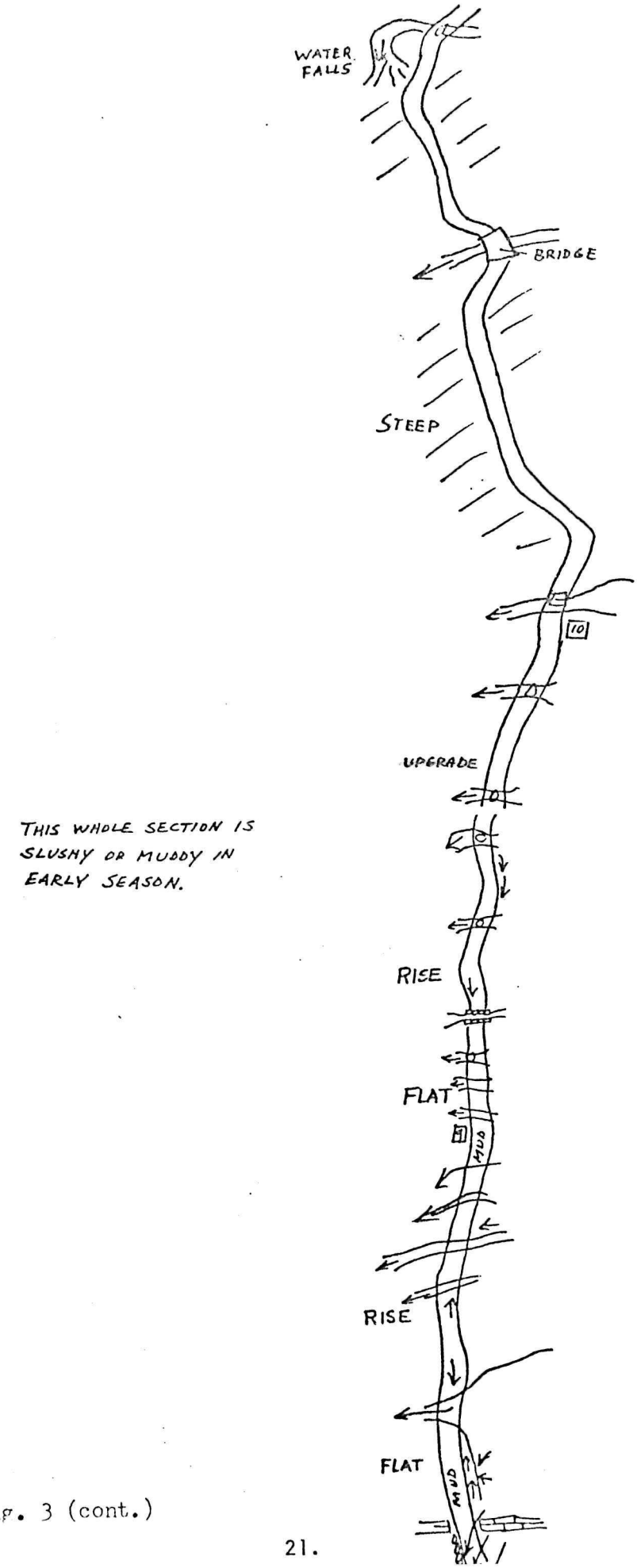

WATER FALLS
BRIDGE
STEEP
10
UPGRADE
THIS WHOLE SECTION IS SLUSHY OR MUDDY IN EARLY SEASON.
RISE
FLAT
MUD
RISE
FLAT
MUD

Fig. 3 (cont.)

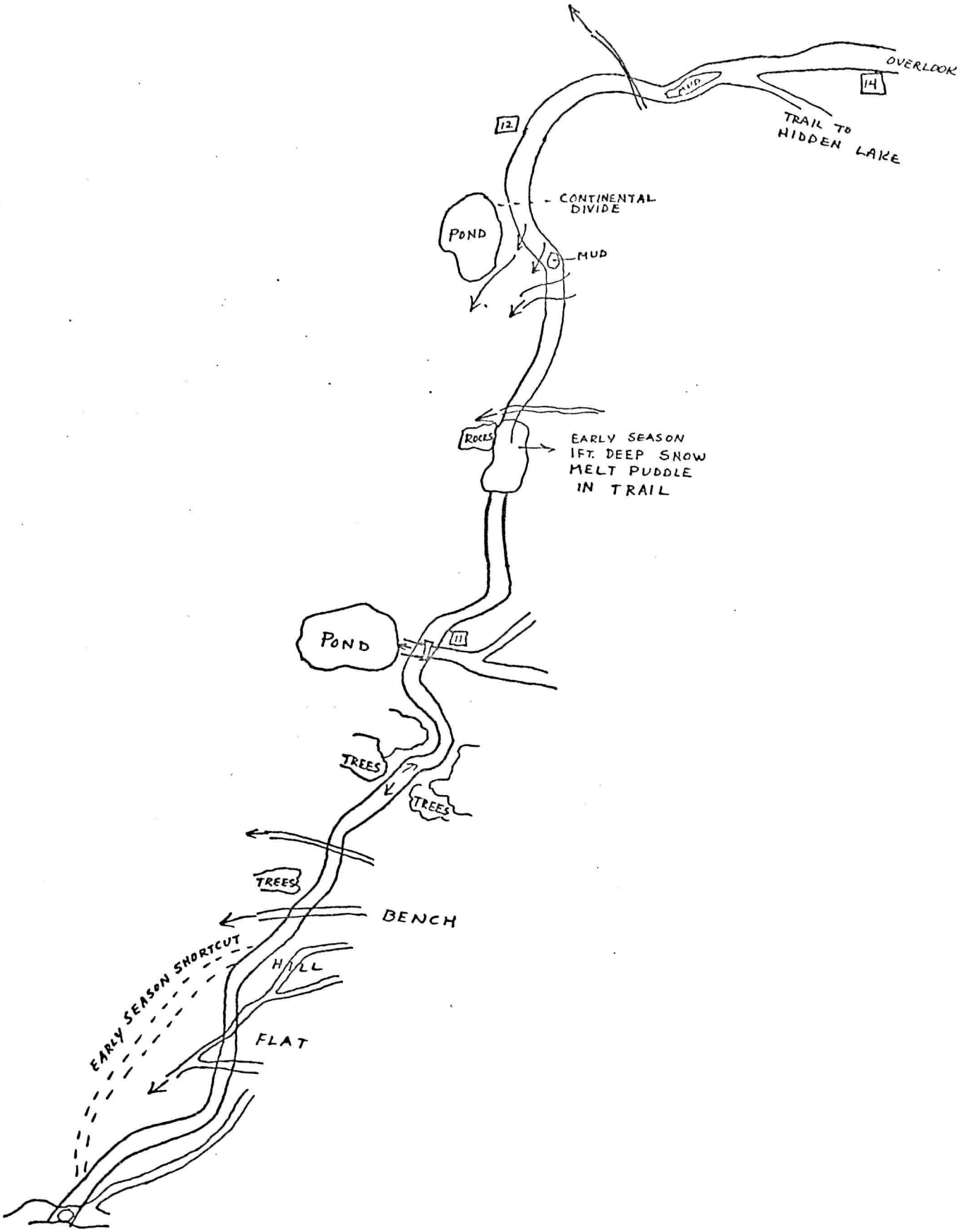

OVERLOOK
14
MUD
TRAIL TO
HIDDEN LAKE
12
CONTINENTAL
DIVIDE
POND
MUD
ROCKS
EARLY SEASON
1FT. DEEP SNOW
MELT PUDDLE
IN TRAIL
POND
11
TREES
TREES
TREES
BENCH
EARLY SEASON SHORTCUT
HILL
FLAT

Fig. 3 (cont.)

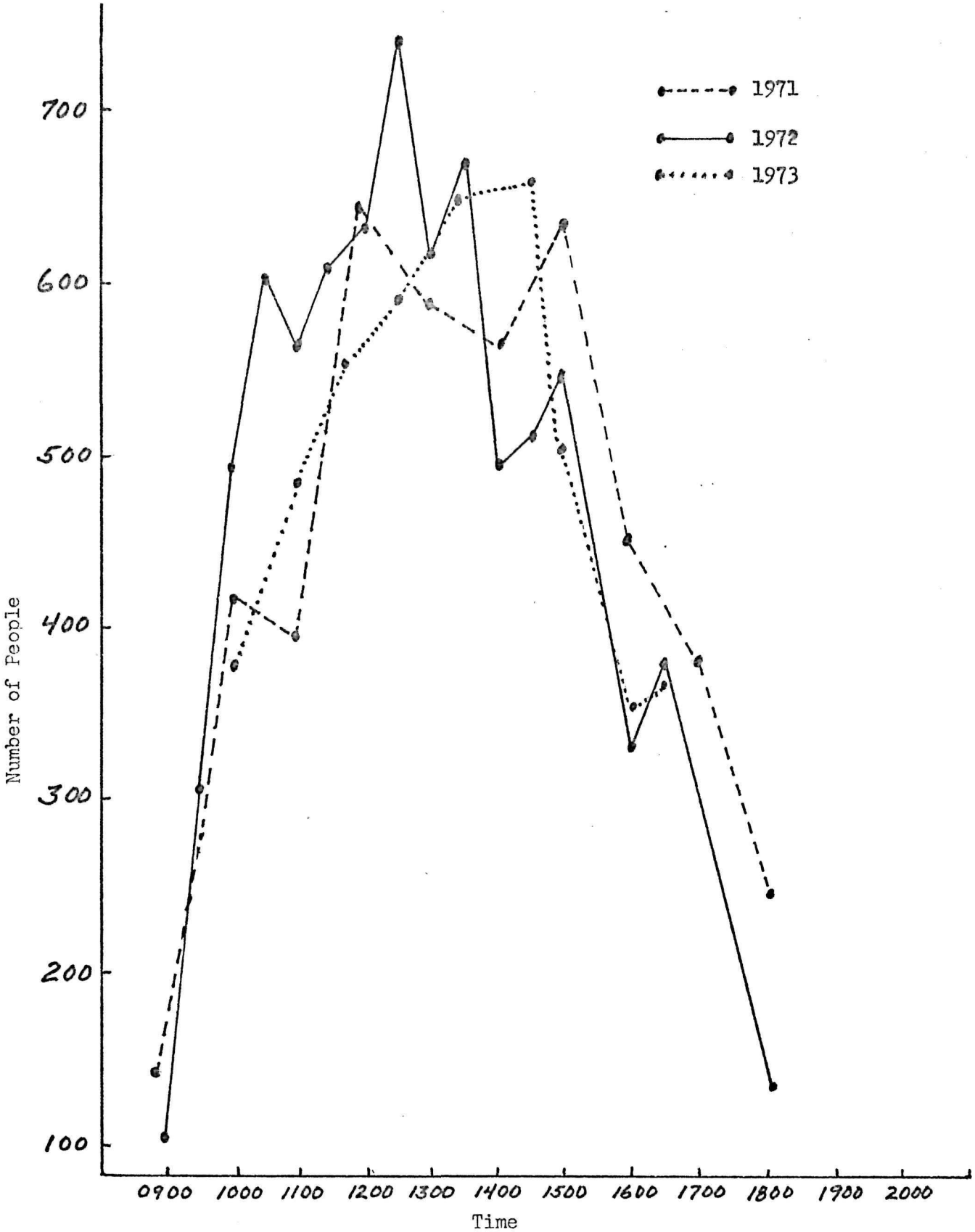


Fig. 4. Hourly use at Logan Pass Visitor Center. Figures based on averages for the months of July and August, 1972 and 1973. Figures for 1971 are based on one day (July 17).

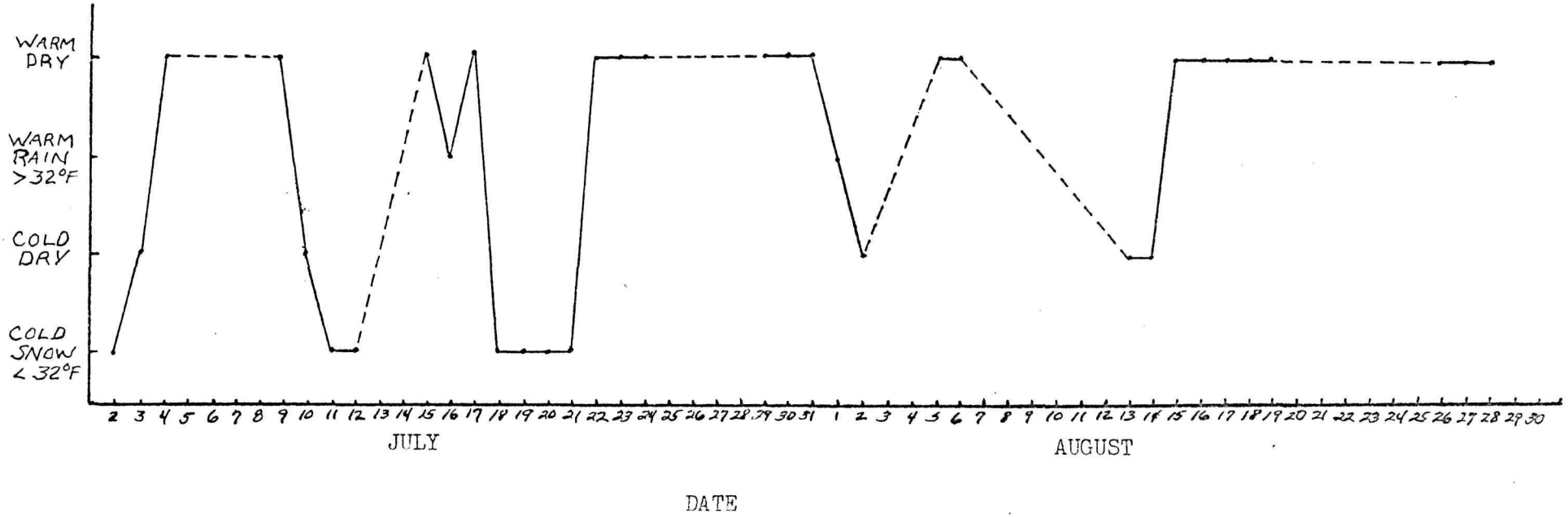


Fig. 5. General weather pattern for July and August, 1972. The dotted lines indicate periods when data was not collected.

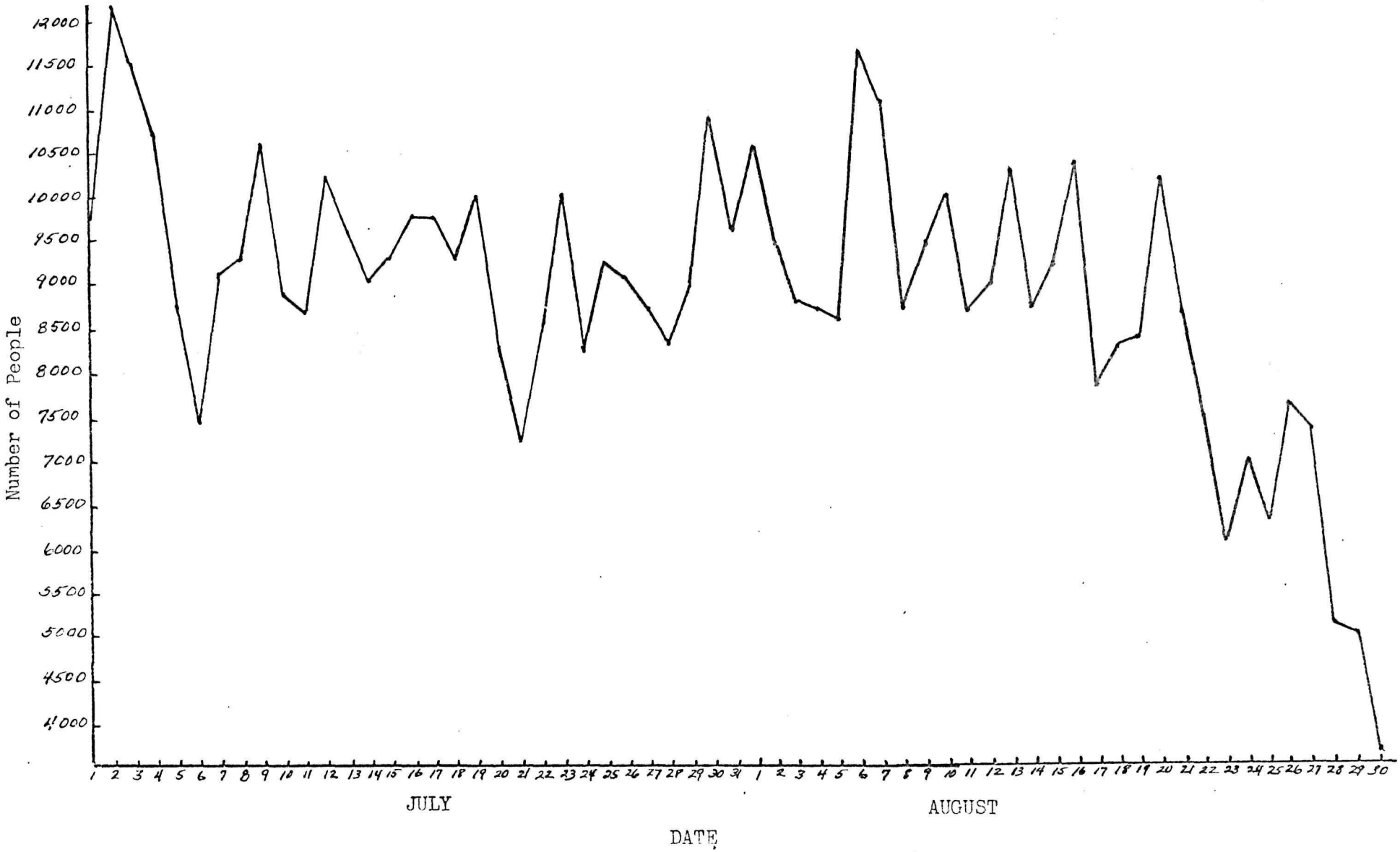


Fig. 6. Going-to-the-Sun Road travel for July and August, 1972.

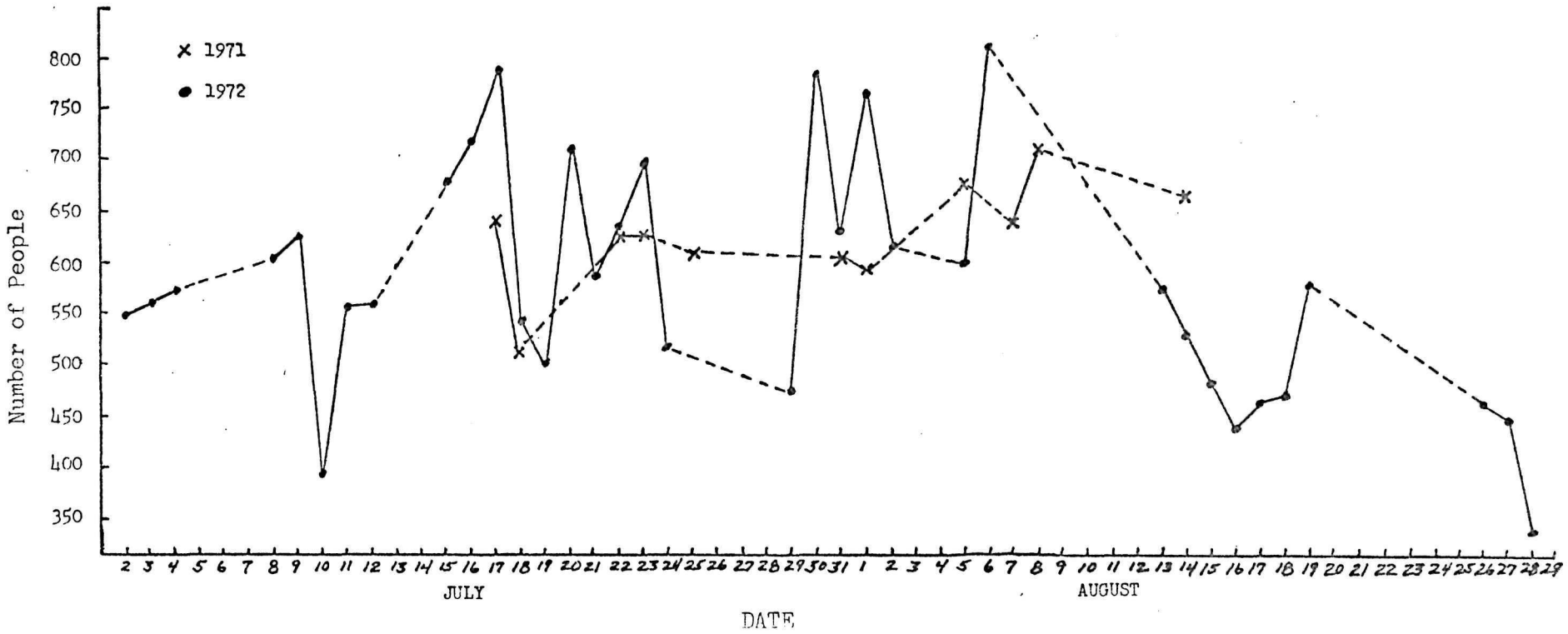


Fig. 7. Maximum number of people per hour at Logan Pass Visitor Center for July and August, 1972. Available figures from 1971 have also been plotted for comparison.

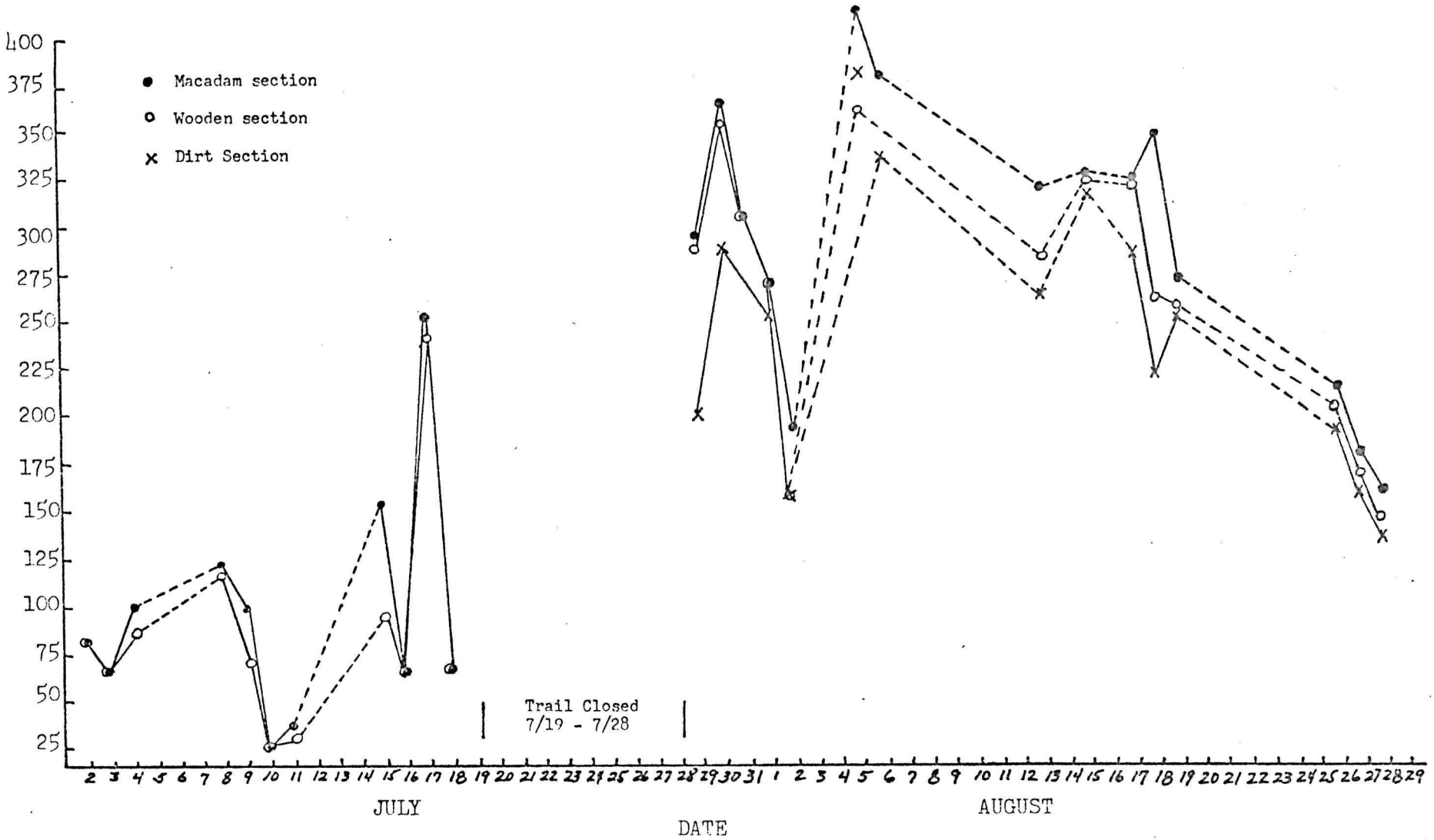


Fig. 8. Average number of people per hour on the Hidden Lake Trail for July and August, 1972. Dotted lines indicate periods when data not collected.

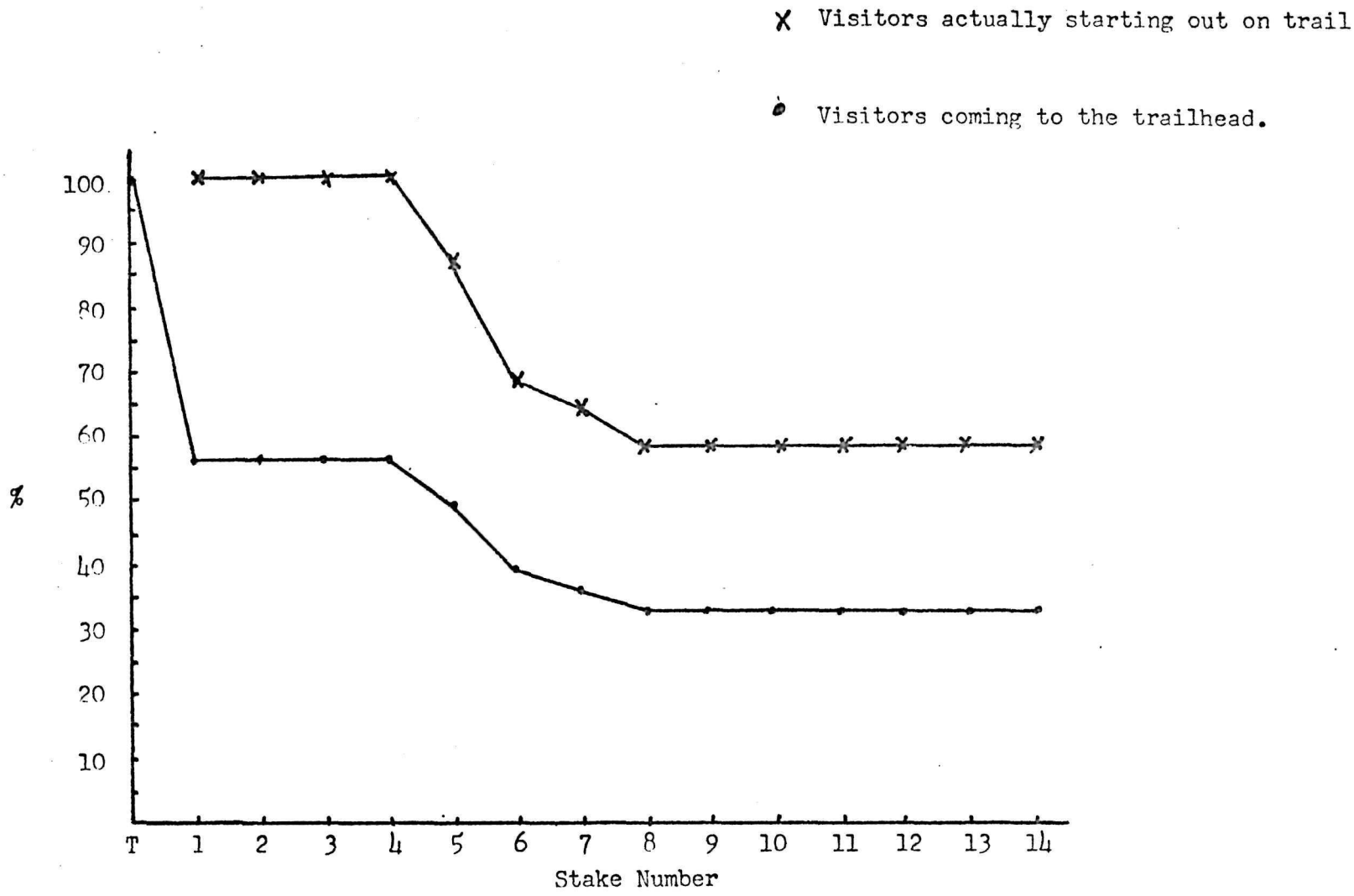
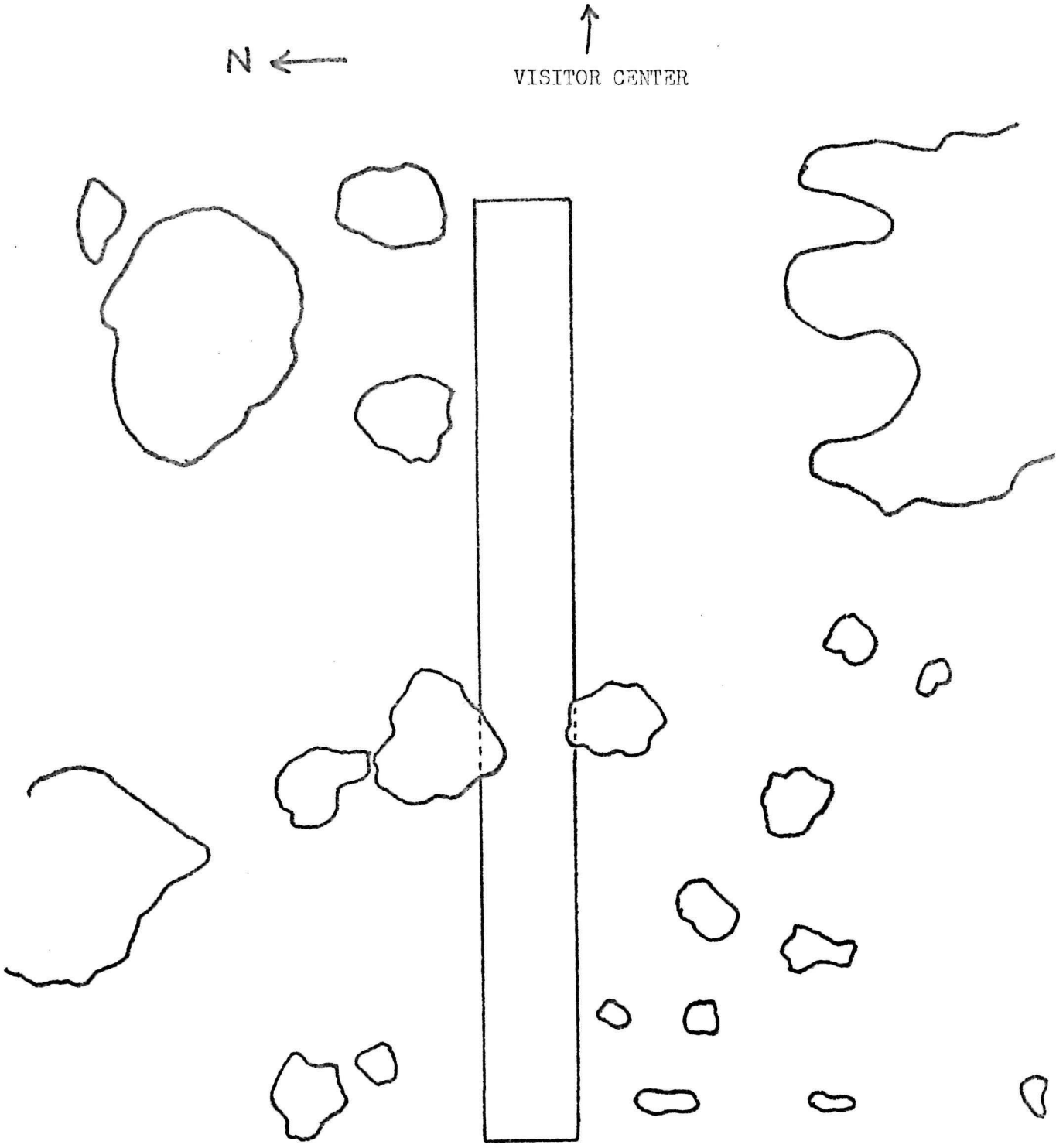


Fig. 9. A gradient of use on the Hidden Lake Trail where T is the trailhead and 14 is Nature stake 14 at the end of the trail (1.5 miles). Trail stakes are generally evenly distributed.



Scale: 2mm = 1 foot

Fig. 10. Map of tree grove through which the wooden walkway passes.

UNITED STATES
DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE
Glacier National Park
West Glacier, Montana 59936

A PLAN TO REDUCE THE ADVERSE ECOLOGICAL IMPACT OF HUMAN TRAVEL ALONG THE HIDDEN LAKE TRAIL ON LOGAN PASS

Introduction

Logan Pass provides the only opportunity for motoring visitors to closely view an alpine ecosystem in Glacier National Park. The presence of a large parking area, restrooms, and a visitor center create an attractive stop for large numbers of visitors each summer. A portion of these visitors also hike along the trail which traverses alpine meadows from the visitor center to a point overlooking Hidden Lake. These meadows reflect human use rapidly and the impact of uncontrolled visitor travel on the Hidden Lake Trail has accelerated during recent years.

Management Objectives

To permit continued foot travel by visitors over the Hidden Lake Trail while reducing the ecological impact currently resulting from uncontrolled foot travel.

Management Procedures

1. Construct a raised wooden walkway over the existing trail bed and across switchbacks beginning near the visitor center and extending for a distance to be determined by need as well as test section evaluations.

2. Mark the trail location beneath the snow by appropriate means to guide both hikers and maintenance operations during spring.

3. Initiate a program to inform hiking visitors of proper on-trail travel procedures.

Study Design

Evaluation of management procedures will involve testing of five hypotheses. Rejection of one or more hypotheses at any time during a three-year monitoring period (1972 through 1974) will be considered sufficient cause for re-evaluation of program objectives and procedures. Appropriate monitoring will continue thereafter.

1. The program will provide an effective means of safely channeling visitor travel over alpine meadows.

2. The program will permit recovery to a natural state of previously denuded sites along the trail.

3. The program will permit natural ecological processes to continue with the exception of the trail bed itself.

4. Engineering procedures or structural deficiencies of the walkway will not contribute to environmental or aesthetic degradation of the alpine ecosystem.

5. Routine maintenance of the walkway will not be sufficiently complex nor costly to detract from the practicability of the project.

Evaluation Techniques

1. Secure basic data on walkway travel using enumeration techniques based on a sampling procedure. Maintain complete records relating to accidents resulting from walkway use. Compare these travel data with similar data from control segments of the trail.

2. Determine response of denuded sites, effects on natural processes, and degradation of environmental or aesthetic values relative to the walkway using a combination of visual, photographic and/or measurement procedures each year.

3. Maintain complete records of routine walkway maintenance procedures and costs.

Personnel

Evaluation of the project will be directed by a resident Research Biologist with field assistance provided by a Research Technician.

Reporting

Procedural details and results will be summarized in annual progress reports.

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Effect of Pentachlorophenol Treated Lumber on Alpine Ecology

Investigators: Dr. Gary Beaver
Ms. Patricia Meinhardt

Institution: Eastern Montana College, Billings

Objectives: To obtain qualitative and quantitative data on the effects of pentachlorophenol on alpine fir, other associated plant species, native animals species and general impact on the ecology of the sub-alpine area of Logan Pass.

Methods: The chemical damaging alpine fir trees growing near the wooden walkway on Logan Pass was identified by bioassay techniques under greenhouse conditions. Young alpine fir and grand fir were subjected to volatile fractions of the wood preservative under isolation hoods. Gas chromatographic techniques were used to confirm the bioassay results.

Data on the growth of alpine fir trees was obtained by measuring the yearly growth increment at the tips of branches at random locations on two sides of the tree representing 3 verticle sections. The degree of chlorosis and/or mecrosis of the foliage was also recorded in relation to distance from wooden walkway.

Soil samples were collected from undisturbed areas and areas near and under lumber stacks and wood walkway. These samples were assayed and compared for the presence of micro-organisms. Detailed visual comparisions were made between plant species in the area of the walkway and in undisturbed areas.

Statistical analysis are currently being run on these data to determine spread and extent of damage to plant and micro-organisms in the area of the wooden walkway.

Results and Discussion: Volatilizing Pentachlorophenol was confirmed as the agent damaging alpine fir and other vegetation adjacent to the wooden walkway. The extent of damage appears to be dependent upon the distance of the plant from the walkway and the direction of wind currents in the area. The sides of trees away from the walkway appeared to be less damaged than adjacent sides. Severity of damage was also dependent on wind currents and distance from the walkway. This data is currently being re-analysed in light of new statistical tecnhiques.

Broadleaf vegetation was affected within one meter of the walkway but no visible damage occurred at greater distances. Damage within the one meter area was typical of herbicidal action. Plants located beneath walkway were killed or severely burned where the penta-oil mixture bled onto them from the boards above. This penta-oil mixture was also carried in the run-off water for many yards below the walkway. Foot traffic was also effective in spreading the oil mixture from the walkway up and down the soil footpath at the ends of the walkway. Traces of the penta-oil mixture could be seen for hundreds of feet along the soil trail where it also collected in pools of run-off water.

The effect of the penta-oil mixture on soil micro-organisms in areas adjacent to the walkway is currently being determined. Initial tests were inconclusive and are being re-run.

Replacement of treated planking with non-treated lumber on the treated understructure failed to stop damage to adjacent alpine fir although severity of damage was reduced.

Conclusions:

Data collected to the present time, show that alpine fir (*Abies lasiocarpa*) are extremely sensitive to low levels of vapor from penta-treated lumber. This data also suggests that any above ground construction should be accomplished with non-treated materials. Investigations at this time have not yet revealed the long range effects of pentachlorophenol on plant and animal life in the sub-alpine areas of Logan Pass.

Accumulation of toxic levels of penta exuded from treated lumber has not been ruled out and could severely damage if not eliminate certain native plant and animal species from the run-off areas. Further still, the distance to which penta may be moved by foot traffic or run-off water is unknown.

Reports from the American Industrial Hygiene Association list skin contact with pentachlorophenol as dangerous and lethal under prolonged contact. This fact alone is sufficient to warrant complete removal of all surface planking on the walkway since many tourists spend prolonged periods standing on the treated lumber with bare feet. Uptake through the skin can occur in as little as 10 minutes with continual contact.

Based on data collected, personal observations and hazard warnings published on pentachlorophenol, we strongly recommend that use of pentachlorophenol treated lumber in all above ground construction be discontinued and that all facilities constructed with penta-treated lumber be removed where contact with the general public is likely.