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Reducing Theft of Petrified Wood at Petrified Forest National Park

A Final Research Report

submitted to

Petrified Forest National Park
National Park Service
Petrified Forest, Arizona

by

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Introduction

The Petrified Forest National Park (PFNP), located in northeast Arizona, has been protected since 1906 when Theodore Roosevelt set it aside as a national monument to help protect "the mineralized remains of Mesozoic forests" (U.S. Department of the Interior, National Park Service, 1992). The U.S. Congress declared the area a national park in 1962, and today, the 93,533-acre park contains some of the most valuable paleontological resources in the world. About 230 million years ago, the high desert of the existing park area was a vast floodplain. To the south and on somewhat higher ground, tall pine-like trees, cycads, and ferns grew in abundance. Periodically, high stream waters in this forest washed huge logs down to the floodplain. There, the logs decayed. Sometimes the logs were covered with mud, silt, or volcanic ash before the process of decay could run its course. When this happened, oxygen was cut off from the logs, and silica-bearing ground waters slowly seeped into the logs. Slowly, over long periods of time, silica deposits filled the original wood tissue, and gradually the silica crystallized into quartz. In this fashion, the logs became petrified wood.

In the millions of years since the Triassic period, the land containing the layers of petrified wood subsided and was covered with freshwater and further layers of sediment. Still later, in relatively recent geologic time, pressures deep within the earth pushed the land upward, eventually pushing the petrified wood sediments high above sea level. These pressures cracked, twisted, and broke up many of the crystallized logs, and exposed the earth to further wind and water erosion. Gradually, these erosional processes exposed the great amounts of petrified wood and sculpted the landscape that we see today.

The park today is thus a nonrenewable treasure of Triassic fossils of enormous scientific value. It also contains an archaeological record of human habitation that covers at least 10,000 years. Some 500 archeological and historic sites exist in the park today that demonstrate prehistoric trading among cultures and the historic use of the Puerco River valley as a transportation corridor.

The park has also become a land of haunting beauty. The same erosional processes that helped form the petrified wood and then to lay it bare, have created the contorted shapes and colors of the Painted Desert, the Haystacks, Blue Mesa, Agate Bridge, and Rainbow Forest. Broad vistas of this scenic landscape and the crystalline beauty of chips, chunks, and giant logs of petrified wood today attract approximately 900,000 visitors per year to the park.

Park Management Goals

The following general goals guide National Park Service management of the park:

1. Protect the paleontological resources, the prehistoric sites, the recovered shortgrass prairie ecosystem, and the scenic lands for future generations;

2. Allow visitors to experience and understand the paleontological, cultural, ecological, and scientific resources in the context of the earth's history; and

3. Encourage and support scientific inquiry into the Triassic period of earth's history (USDI, NPS, 1992).

The Park Service has encountered a variety of problems in its efforts to meet these goals. For example, prompting park visitors to look beyond the beauty of petrified wood to gain an understanding of the ecological and geologic processes that formed the wood; educating the visitors to recognize the interdependence of the cultural story and the landscape conditions of the park; coordinating and balancing the park mandate of protection, visitor enjoyment, and scientific inquiry; fending off threats to the park from outside its boundaries; and, finally, reducing theft of petrified wood by park visitors have all been serious management challenges.

The park's recent General Management Plan (USDI, NPS, 1992) identified petrified wood theft as the park's number one resource protection problem. Over the years, park managers have tried a number of methods to reduce wood theft, but the amount of theft has remained at an unacceptably high level. It is estimated that about 12 tons of petrified wood are removed from the park each year (USDI, NPS, 1992), and this is believed to be the cumulative effect of thousands of uninformed, careless, or deliberate acts by large numbers of visitors.

Problem Statement and Study Objectives

The general problem that this study addresses is the apparent unacceptable rate of theft of petrified wood at Petrified Forest National Park. More specific problems are the lack of an accurate estimate of actual amounts of wood theft, an understanding of the characteristics of thieves and non-thieves among park visitors, and knowledge of interventions effective in reducing wood theft.

Specific study objectives were thus as follows:

1. Describe the demographic, motivational, attitudinal, normative, and behavioral characteristics of park visitors that might shape their propensity to steal petrified wood;

2. Describe any differences between thieves and non-thieves in their demographic, motivational, attitudinal, normative, and behavioral characteristics;

3. Estimate the amount of petrified wood taken from high wood/high use areas in the park; and

4. Experimentally test the effectiveness of various interventions to reduce the amount of wood theft.

Objective 1: Describe Park Visitor Characteristics

Study Population

Ideally, our efforts to describe the characteristics of park visitors that might shape petrified wood theft would have sampled all months of the year. Constraints of funding and staffing made this impossible. Instead, we focused on those months of the year with high visitor use: May, June, July, and August 1993. Technically, then, we can only generalize our findings to the population of park visitors during these four months. In practice, however, we will speak of the "general park visitor" in our results regarding Study Objective 1. This is only a problem to the extent that park visitors come in sizable numbers and have different characteristics during the September-to-April time period. We do know that "off-season" visitors are more common in the "snowbird" parks of states like Arizona, and these visitors are more likely to be retirees, visit in recreational vehicles, and stay longer.

Study Site

Several characteristics of the park make it ideal for surveying visitors. The park has only two entrances/exits, one at the north end off I-40 and the other at the southern boundary of the park off U.S. Highway 180 (Figure 1). These two access points are connected by a 27-mile park road, the only road in the park. Thus, all park visitors are concentrated on and along this road. Finally, the park is essentially a day-use park. Gates close the park to visitor use from about 7:00 p.m. to 7:00 a.m. each day. The only overnight visitors to the park are infrequent wilderness and backcountry users who must obtain a permit.

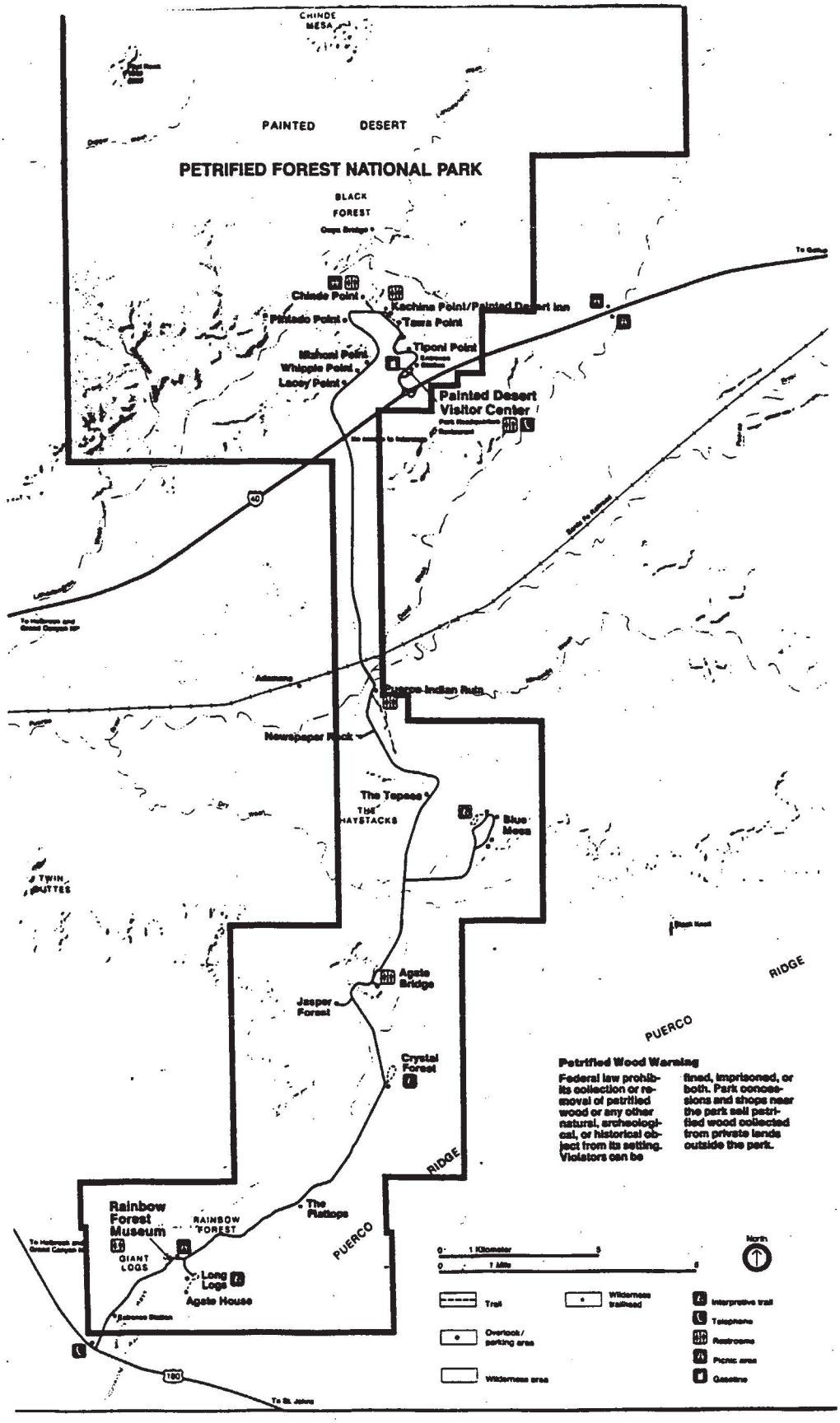


Figure 1. Map of Petrified Forest National Park.

Sampling Plan

A sample from the total population of park visitors was drawn using a stratified clustering scheme. Stratification was done by month (May, June, July, and August), time of day (morning [9:00 a.m. to 12:00 noon], mid-day [12:30 p.m. to 3:30 p.m.], and late afternoon [4:00 p.m. to 7:00 p.m.]), and exit location. This resulted in 24 sampling blocks. We initially believed that we only had the financial and staffing resources to sample each of these blocks once for a total of 72 hours of sampling (4 months x 6 sampling blocks per month x 3 hours per sampling block = 72 hours). Within these constraints, the sampling blocks were randomly selected.

A systematic sampling interval *(k)* was used to select vehicles as they exited the park and individuals to be surveyed within the vehicles for each of the sampling blocks. The desired sample size for the study was determined using a standard confidence interval formula (Hays 1988, p. 238). This formula requires specification of (1) the desired confidence interval, and (2) the degree of precision desired. A confidence interval of 95% and a precision of 0.5σ was selected. Using these values, approximately 100 responses per month (or 400 in total) were needed to obtain the desired degree of accuracy in our conclusions. Assuming an 80% response rate, about 500 individuals needed to be contacted in the field.

To achieve this desired sample size, a systematic sampling interval *(K)* was determined using the following steps:

1. The number of vehicles exiting the park at the north and south exit points for the months of May, June, July, and August (124,828 vehicles) was determined from PFNP's 1991 volume estimates.

2. The combined total number of possible sampling hours (i.e., total number of hours the park was open) for the north and south exit points (3,014 hours) was calculated for the same months.

3. The number of proposed sampling hours was then divided by the number of total possible sampling hours (72 hours ÷ 3,014 hours = 2.4%) to determine percentage of the time either the north or south exits would be sampled.

4. The number of vehicles exiting during the sampling blocks was determined by multiplying the total number of vehicles by the sampling percentage determined in the previous steps (123,828 vehicles x 2.4% = 2,982 vehicles).

5. The systematic sampling interval *(k)* was determined by dividing the calculated total number of vehicles exiting during the sampling blocks by the desired sample size *(k* = 2,982 vehicles ÷ 500 vehicles = 6).

This calculation suggested we should sample every sixth car as it exited the park. However, consultations with park managers indicated that sampling at this intensity would be disruptive to traffic flows leaving the park during peak use periods. Therefore, we doubled the number of sampling blocks per month (two each of the possible time/exit location combinations per month [144 sampling hours]), resulting in a systematic sampling interval of 12 *(k* = 5,964 ÷ 500 vehicles = 12). We used the sampling ratio of every 12th car during the months of May and June. It then became apparent that we would not achieve our desired sample size for the study. We therefore increased our sampling interval to every 9th car for the months of July and August. Thus, visitors to the park in July and August were somewhat over-sampled.

The systemic sampling interval was operationalized in the field in the following manner. First, we randomly selected the first vehicle to be surveyed within any sampling block by randomly picking a number between 1 and k (for May and June, k = 12; for July and August, k = 9). After the first car was selected, every kth car was stopped throughout the remainder of the sampling block. Second, one individual in each vehicle was randomly selected and asked to participate in the study. This was accomplished by using the random start number to determine who would be interviewed first. If the random start number was odd, the driver of the first vehicle was interviewed. If the random start number was even, the front-seat passenger of the first vehicle was interviewed. After the first vehicle, the interviews alternated between the driver and the front-seat passenger.

Data Collection Procedures

Survey participants were contacted as they ended their visit at the park's two exit stations. A National Park Service ranger made the initial contact when he or she asked the park visitor to participate in the study. If the person agreed, the ranger asked him or her to pull over to a waiting Virginia Tech research assistant. The research assistant then selected a person in the vehicle to be interviewed, explained the study to him or her, and asked again for willingness to participate in the study. Those willing to participate were asked a few questions to determine basic visitor use and user characteristics (Appendix A). The research assistant then handed the respondent a survey packet containing a cover letter (Appendix B), a much longer questionnaire (Appendix C), and a postage-paid return envelope.

Names and addresses of participants were also collected for mailing follow-up reminders to increase response rate. Three reminders were sent. The first was a postcard mailed approximately one week after the initial contact (Appendix D). The second was mailed about three weeks after initial contact and included another cover letter (Appendix E), questionnaire, and postage-paid return envelope. The final mailing was a second postcard reminder (Appendix F) mailed about four weeks after the initial contact.

Data Collection Instruments

The on-site interview forms (Appendix A) were designed to gather information on length of stay; travel patterns; amount of time spent at visitor centers, gift shops, petrified wood sites, and other popular park features; group size, vehicle type; and home address. Two different forms were used for the post-visit interviews, one for the north exit and one for the south exit. The main difference between the two forms was the ordering of the park features; we attempted to list the park attractions on the interview form in the order that the respondent likely visited them.

An 11-page mailback questionnaire (Appendix C) was used to collect data on:

1. Socio-demographic characteristics;
2. Where information about the park and its rules were obtained;
3. Perceptions of resource, social, and management problems;
4. National park involvement;
5. Importance of souvenir collecting;
6. Attitudes pertaining to appropriate behavior in national parks;
7. Judgments of relative seriousness of various illegal or inappropriate park behaviors;
8. Levels of moral reasoning regarding possible theft of petrified wood; and
9. Feelings about possible park management intervention programs used to reduce petrified wood theft.

To facilitate Office of Management and Budget (OMB) approval, questions from the National Park Service catalog of pre-approved questions (Q-Cat 1991: Questions for Visitor Surveys) were incorporated into the questionnaire whenever possible. A pre-test of the initial questionnaire was conducted on March 12 and 13, 1993. Forty PFNP visitors were contacted during this period. From this pre-test, several minor changes were made to the final questionnaire, and the OMB approved the questionnaire in its final form.

Participation and Response Rates

About 603 PFNP visitors were asked by National Park Service rangers to participate in the study survey. Of these, 456 (75.6% of the 603) agreed to be interviewed by the Virginia Tech research assistants and were given a questionnaire. Of this number, 80%, or 365, returned the completed questionnaire.

Results

Study results regarding the characteristics of the Petrified Forest National Park visitor population will be summarized in five ways: (1) visitor demographics; (2) group characteristics; (3) visit characteristics; (4) visitor sources of information; (5) and visitor perceptions, attitudes, and preferences.

Visitor Demographics

Age and Gender. Table 1 indicates that the average age of study participants was 44.8 years. Almost 60% of all respondents were between 40 and 65; another 24% were in their 30's, and about 7% were 65 or older. These numbers, of course, are skewed upward because individuals under 16 by definition were not asked to participate in the survey. Also, young people in family settings are less likely to sit in the front of the car, and thus were less likely to be asked to participate in our survey. Table 2 suggests that about 53% of our survey respondents were women.

Education, Employment, and Income. As is the case for most visitors to national parks, PFNP visitors are highly educated. More than 55% have college degrees; almost 38% have at least some graduate work (Table 3). About two-thirds of all respondents were employed outside the home (Table 4). Only 3% were unemployed, well below the national average at the time of the study. About 17% reported they were retired, significantly more than the 7% that are 65 years of age or older. Again, because children and adolescents are under-represented in the study, these numbers are biased somewhat in an upward direction. Finally, household incomes for PFNP visitors were high, as is the case for many national parks (Table

5). The most common household income was between $40,000 and $60,000; about 30% of all our respondents reported this level of income. But another 23% made between $60,000 and $100,000, and 14% had annual household incomes over $100,000.

Table 1. Age[a] of PFNP respondents.

Age	Number	Percentage (%)
Below 20	9	2.5
20-29	32	8.9
30-39	88	24.4
40-49	108	29.9
50-64	98	27.1
65 and older	26	7.2
Total	361	100.0

[a]Mean age = 44.8; standard deviation = 13.3

Table 2. Gender of PFNP respondents.

Gender	Number	Percentage (%)
Male	171	47.4
Female	190	52.6
Total	361	100.0

Table 3. Education of PFNP respondents.

Years	Number	Percentage
8 or less	5	1.4
9-11	10	2.8
12	60	16.7
13-15	82	22.8
16	67	18.7
More than 16	135	37.6
Total	359	100.00

Table 4. Employment status of PFNP respondents.

Status	Number	Percentage (%)
Employed outside the home	242	66.9
Unemployed	11	3.0
Retired	62	17.1
Full-time homemaker	30	8.3
Student	17	4.7
Total	362	100.0

Table 5. Annual household income of PFNP respondents.

Income ($)	Number	Percentage (%)
Less than 13,000	10	2.9
13,000 to 24,999	26	7.6
25,000 to 39,999	76	22.4
40,000 to 59,999	101	29.7
60,000 to 99,999	79	23.2
100,000 and over	48	14.1
Total	340	100.0

Ethnic Origin. Somewhat surprisingly, given the high numbers of Native Americans and Hispanics living in Arizona, over 88% of all PFNP visitors were whites. Native Americans and Hispanics numbered only 4.2% and 2.8%, respectively (Table 6).

Marital Status and Children. Almost ¾ of all park visitors were married (Table 7). However, few visitors (only 6.1%) had children under five living with them. Petrified Forest National Park is often visited as part of an extended and long-distance vacation to the Southwest; apparently, few families with young children take such holidays. In contrast, over 40% of respondents reported children between five and 17 living with them.

Table 6. Ethnic origin of PFNP respondents.

Ethnic category	Number	Percentage (%)
Native American	15	4.2
Asian or Pacific Islander	6	1.7
Black	2	0.6
White	319	88.4
Hispanic	10	2.8
Other	9	2.5
Total	361	100.0

Table 7. Marriage and children status of PFNP respondents.

	Yes		No	
	Number	Percentage (%)	Number	Percentage (%)
Married	266	73.5	96	26.5
Children under 5 living with you	22	6.1	340	93.9
Children between 5 and 17 living with you	148	41.0	213	59.0

Group Characteristics

Group Size and Type. We had two measures of group size, one taken at the exit from the park and the other reported by respondents when they returned the questionnaire (Table 8). (The on-site measure should be the more accurate; it avoids any non-response bias.) Both of our measures indicated a group size of just over three persons per party. (Please note that we did not include tour buses and their guests in our survey.)

Petrified Forest National Park, like most national parks, is a family attraction. More than ¾ of all groups visiting the park were families. Another 7% were family/friends groups. Somewhat surprisingly, about 5% of all parties visiting the park were lone individuals (Table 9).

Table 8. Group size of PFNP respondents.

	Number	Mean	Standard deviation
On-site contact	594	3.14	1.46
Mailback questionnaire	325	3.35	1.58

Table 9. Type of group PFNP respondent was with.

Group type	Number	Percentage (%)
Alone	19	5.3
Family only	278	77.0
Friends only	36	10.0
Friends and family	25	6.9
Other	3	0.8
Total	361	100.0

We asked respondents who were not traveling alone whether they had children, adolescents, or elderly individuals with them. Again, the family nature of the PFNP visit became clear. Almost half of all user groups had at least one five- to 12-year-old with them; another 1/3 had at least one teenager with them. And about ¼ of all groups had someone past 62 years old with them (Table 10).

Visit Characteristics

Past Experience. Petrified Forest National Park visitors have very little previous experience at the park. For 75%, the visit where we polled them was their first one. For another 18%, it was their second visit (Table 11).

Primary Destination. Petrified Forest National Park was seldom the primary destination for its visitors. For 94.2% of study respondents, the park was merely a stop along the route to other attractions in the Southwest (Table 12).

Table 10. Presence of children, adolescents, and elderly within the group that the PFNP respondent was with.

Age group	Number of groups with at least one person present	Percentage (%)[a]
Less than 5 years old	19	7.4
5 to 12 years old	124	43.1
13 to 19 years old	91	32.7
Over 65 years old	78	26.9

[a]Percentages add up to more than 100% because groups can have individuals in more than one age category.

Table 11. Total number of visits to PFNP by park visitors.[a]

Total visits, including this one	Number	Percentage (%)
1	273	75.2
2	65	17.9
3-5	21	5.8
more than 5	4	1.1
	363	100.0

[a]Mean total visits = 1.4; standard deviation = 1.0.

Table 12. Primary destination of PFNP visitors.

Primary destination	Number	Percentage (%)
Petrified Forest NP	21	5.8
Not Petrified Forest NP	342	94.2
Total	363	100.0

Length of Visit. Almost all visits to Petrified Forest National Park are for a day or less. Only eight (or 2.2%) of our respondents were overnight or backcountry visitors. Among the

day users, the average length of the visit was 2.39 hours, with a standard deviation of 1.14 hours.

Length of Stay at Park Attractions. Table 13 summarizes time spent at various attractions in the park. The two most frequently visited sites were the Painted Desert Visitor Center and Agate Bridge; more than 60% of all park visitors stopped at these attractions. However, more than 50% visited several other park attractions: Crystal Forest, Newspaper Rock, Long Logs, Jasper Forest, Rainbow Forest Museum, and Puerco Indian Ruin. Length of stay for individuals who visited an attraction was typically very short. Time spent per visit on the Blue Mesa Nature Trail was about ½ hour. Visits to the petrified wood sites at Giant Logs, Long Logs, Crystal Forest, and the Painted Desert Visitor Center averaged about 20 minutes.

Table 13. Length of stay at park attractions by PFNP respondents (N = 601).

Site	Percentage who visited	Average length of stay (minutes)	Standard deviation
Painted Desert Visitor Center	62.6	21.0	13.7
Painted Desert Gift Shop	39.8	15.1	10.4
Painted Desert Restaurant	12.0	19.6	9.7
Painted Desert Inn	35.8	14.4	10.5
Puerco Indian Ruin	50.4	15.1	9.3
Newspaper Rock	56.4	10.0	5.5
Blue Mesa Scenic Loop	46.4	17.8	10.5
Blue Mesa Nature Trail	22.8	29.7	21.5
Agate Bridge	62.2	10.2	5.5
Jasper Forest	51.4	11.0	7.6
Crystal Forest	56.2	16.9	12.5
Long Logs	51.7	19.4	12.0
Rainbow Forest Museum	50.9	20.3	11.2
Giant Logs Trail	35.3	19.7	11.4
Gift Shop/Snack Bar near south entrance	33.4	17.0	11.5

Gift Shop Purchases. Almost half of all PFNP visitors purchased at least one item at one of the two park gift shops. About 21% purchased petrified wood, 11% bought books or travel guides, and 7% purchased Native American jewelry. The most dollars spent per purchase was for Native American jewelry, with an average of $30.38. Variance around this mean was very high (standard deviation = 43.51). Petrified wood sales averaged $14.91 per purchase, less than that for clothing (Table 14).

Table 14. Gift shop purchases by PFNP respondents.

Type of purchase	Number	Percentage who purchased	Average $ spent per purchase	Standard deviation
Purchased something	178	49.7		
Clothing	14	3.9	19.00	7.82
Native American jewelry	25	7.0	30.28	43.51
Petrified wood	75	20.9	14.91	20.31
Books, magazines, travel guides	41	11.5	13.78	13.16
Film	7	2.0	9.43	3.41
Glassware	13	3.6	7.77	3.85
Other	82	22.9	10.74	14.22

Purchase of Petrified Wood Outside the Park. About 22.1% of all park visitors reported they purchased petrified wood outside the park. This is about the same number of individuals who said they bought petrified wood at gift shops in the park (see Table 14).

Visitor Sources of Information

Information Sources About the Park Before Arrival. Almost 2/3 of all park visitors received information about the park before their arrival. Sources of this information varied. About 32% indicated a travel guide; just over 20% said an auto club or friends/relatives. A highway map or sign was the next most frequent source at about 19%. Almost no one received information directly from the park.

Table 15. Sources of information about the park used by PFNP respondents before their arrival.

Information source	Number	Percentage (%)
Used a source	223	62.3
Magazine	16	4.5
Book	32	8.9
Travel guide	114	31.8
Highway map or sign	68	18.9
Tourist brochure	42	11.7
Auto club	76	21.2
Friends, relatives	84	23.4
Wrote/called park for information	4	1.1
Other	19	5.3

Information Sources About the Park Story. Table 16 summarizes PFNP visitors' use of interpretive sources to learn the park story. It also lists the percentage of all respondents who felt that each source was most helpful. Several different sources were used frequently, with the PFNP brochure/map being the most common at almost 90% of all visitors. Four other sources were used by more than 45% of all respondents: the Painted Desert Visitor Center exhibits, self-guided walks, entrance station information, and interpretive signs. Interestingly, while large numbers of study participants rated the park brochure/map as the most helpful, a far smaller percentage of those who used the Painted Desert Visitor Center exhibits, self-guided walks, interpretive signs, and entrance station information rated them as the most helpful. In contrast, while few people participated in ranger-led walks, ranger talks, and film or slide shows, a high percentage of those who did rated these programs as the most helpful.

Information Sources About Park Rules and Regulations. While more than three-fourths of all study respondents used the PFNP brochure/map to learn park rules and regulations, fewer than half cited any of the other sources (Table 17). The use of entrance station information, while second in rank at 48.3%, was surprisingly low, given the messages about petrified wood protection provided to all parties entering the park. Only the "rules and regulations" messages of two other park sources were used by at least 30% of the visitors: the Painted Desert Visitor Center exhibits and interpretive signs.

A large percentage of study participants (i.e., about 50%) who used the park brochure and entrance station information rated these sources as the most helpful. Indeed, far more people rated the entrance station information as most helpful for learning rules and regulations than rated it most helpful for understanding the park story. About 1/3 of the respondents who used interpretive signs and ranger talks rated them the most helpful for learning rules and regulations.

Table 16. Use of interpretive sources by PFNP respondents to learn the park story.

	Used source		Felt source was the most helpful	
Interpretive source	Number	Percentage (%)	Number	Percentage (%)
PFNP brochure/map	322	89.0	127	39.8
PFNP newspaper	110	30.4	6	1.9
Painted Desert Visitor Center exhibits	212	58.6	31	9.7
Painted Desert Inn exhibits	74	20.4	2	0.6
Rainbow Forest Museum exhibits	135	37.3	27	8.5
Rangers at points of interest	69	19.1	10	3.1
Ranger-led walks	7	1.9	2	0.6
Ranger talks	57	15.7	29	9.1
Films or slide shows	76	21.0	29	9.1
Self-guided walks	206	56.9	13	4.1
Interpretive signs	165	45.6	12	3.8
Entrance station information	168	46.4	19	6.0
Other	33	9.1	12	3.8
Total			319	100.0

Visitor Perceptions, Attitudes, and Preferences

Attitudes and Involvement with National Parks. We have already noted that almost all PFNP visitors were first-time visitors to the park (see Table 11 on page 13). Table 18 indicates that our respondents had low involvement with national parks in general. National parks did not play a very central role in their lives. On the other hand, a slight majority agreed that visiting national parks was one of the most satisfying things they do, and only about 20% said they seldom took time to visit national parks.

Table 17. Use of interpretive sources by PFNP respondents to learn the park's rules and regulations.

	Used source		Felt source was the most helpful	
Interpretive source	Number	Percentage (%)	Number	Percentage (%)
PFNP brochure/map	274	76.5	126	37.1
PFNP newspaper	75	20.9	9	2.6
Painted Desert Visitor Center exhibits	114	31.8	19	5.6
Painted Desert Inn exhibits	25	7.0	1	0.3
Rainbow Forest Museum exhibits	60	16.8	14	4.1
Rangers at points of interest	34	9.5	4	1.2
Ranger-led walks	2	0.6	1	0.3
Ranger talks	64	17.9	26	7.6
Films or slide shows	36	10.1	9	2.6
Self-guided walks	67	18.7	1	0.3
Interpretive signs	113	31.6	34	10.0
Entrance station information	173	48.3	90	26.5
Other	19	5.3	6	1.8
Total			340	100.0

Table 19 summarizes PFNP visitors' attitudes about 18 separate park behaviors. In general, our respondents were very supportive of actions protecting the park's resources. For example, about 90% or more agreed that taking petrified wood reduced the beauty of the park and that it was wrong to remove Indian arrowheads from the park. The same high percentage disagreed that it was all right to pick wildflowers in a national park, all right to collect fossils from a national park, and all right to take a piece of petrified wood from the park as long as it was a small piece. Between 70% and 90% felt it was wrong to walk off trails when trails were provided, felt it was wrong to collect ordinary rocks while visiting the park, and felt they could tell the difference between a piece of petrified wood and a rock. Attitudes about the appropriateness of selling petrified wood in park gift shops were generally mixed, but support usually exceeded opposition.

Table 18. Involvement by PFNP visitors with national parks.

Involvement item	Strongly disagree or disagree		Neutral		Strongly agree or agree	
	Number (N)	Percentage (%)	N	%	N	%
I get greater satisfaction out of visiting national parks than other vacation destinations	29	8.0	127	35.3	204	56.7
I find a lot of my life is organized around national park use	183	51.5	132	37.2	40	11.3
One of the major reasons I now live where I do is that it has opportunities for visiting national parks	248	70.3	81	22.9	24	6.8
I seldom take time to visit national parks	217	61.1	68	19.2	70	19.7
Visiting national parks is one of the most satisfying things I do	51	14.2	113	31.6	194	54.2
National parks play a central role in my lifestyle	178	50.1	134	37.8	43	12.1

Levels of Moral Reasoning and Park Norms. In an effort to determine how serious a violation of personal norms was the theft of petrified wood, we asked our respondents to rate on a 0-to-100 scale the seriousness of several different problem behaviors in parks. (This was not a measure of the prevalence of the acts but rather a measure of the seriousness of doing such a problem behavior.) Table 20 indicates that, while the act of petrified wood theft was seen as a serious norm violation, it was not seen as the worst park offense. Purposely harming an endangered plant or animal and defacing Indian rock art in the park both received a seriousness rating of 89%. Other acts with ratings in the 80's were removing prehistoric Indian pottery and pot sherds from the park, taking a handful of petrified wood from the park, purposely harming a prairie dog, and collecting Indian arrowheads in the park. Taking one small piece of petrified wood from the park had a seriousness rating of 77.

Table 19. Attitudes of PFNP visitors about appropriate national park behavior.

Attitude	Strongly disagree or disagree		Neutral		Strongly agree or agree	
	Number (N)	Percentage (%)	N	%	N	%
It is all right to pick wildflowers in a national park	321	89.4	22	6.1	16	4.5
It is wrong to walk off trails when trails are provided	64	17.9	34	9.5	260	72.6
It is all right to walk off the trail to get a closer look at Indian rock art	212	59.1	63	17.5	84	23.4
It is wrong to pick up petrified wood, even if you put it back where you found it	110	30.8	65	18.2	182	51.0
Selling souvenirs made out of petrified wood in the park gift shops encourages people to collect a piece of petrified wood from the park	159	44.7	73	20.5	124	34.8
Taking petrified wood reduces the beauty of the park	5	1.4	5	1.4	346	97.2
I don't think I could tell a piece of petrified wood from an ordinary rock	250	70.2	48	13.5	58	16.3
It is all right to collect fossils from a national park	329	92.4	8	2.2	19	5.3
Being able to buy petrified wood in the park gift shops reduces the temptation to take a piece from park grounds	60	16.8	63	17.6	235	65.6
It is wrong to sell petrified wood in the park, even though it does not come from the park	189	53.1	92	25.8	75	21.1

Table 19 (continued).

Attitude	Strongly disagree or disagree		Neutral		Strongly agree or agree	
	Number (N)	Percentage (%)	N	%	N	%
It is all right to enter prehistoric Indian pueblo and pit house ruins in national parks	174	49.7	90	25.7	86	24.6
It is all right to pick up petrified wood as long as you leave it in the park	220	61.6	55	15.4	82	23.0
It is wrong to remove Indian arrowheads from the park	29	8.1	9	2.5	319	89.4
It is all right to take a piece of petrified wood from the park as long as it is a small piece	321	89.9	7	2.0	29	8.1
Seeing polished petrified wood in the visitor center encourages people to collect a piece from the park grounds	189	53.2	85	23.9	81	22.8
It is all right to collect ordinary rocks while visiting the park	275	79.3	41	11.8	31	8.9
It is all right to hike/climb on the top of the buttes or ridges near the park's petrified wood areas	156	44.7	114	32.7	79	22.6
It is all right to climb or sit on logs of petrified wood	210	59.1	73	20.6	72	20.3

Park visitors might have various levels of moral reasoning for resisting the temptation to take petrified wood from the park. They might simply not be interested in the wood. Or they might want some wood but not take any because of fear of punishment, social pressure from significant others, a concern about the resource, or the needs of future generations. Table 21 indicates that about half of all PFNP visitors did not take wood because they did not want it. Only about 14% listed fear of being caught by a ranger as a very or extremely important deterrent. Somewhat more feared a fine. About 1/3 said that the opinions of others were very important or extremely important reasons. Ninety percent or more said their desire to

protect wood for future generations or to preserve the park in pristine condition were most important reasons for the good behavior.

Table 20. PFNP visitors' norms about the seriousness of specific problem behaviors in the park.

Problem behavior	Number	Mean[a]	Standard deviation
Purposely harming an endangered plant or animal	345	89.4	19.9
Traveling 55 miles per hour in a 45-mile-per-hour zone in the park	343	40.0	28.7
Defacing Indian rock art in the park	343	89.9	18.0
Picking wildflowers in the park	345	60.0	28.3
Taking one small piece of petrified wood from the park	345	77.2	24.1
Littering in the park	344	68.9	26.9
Removing prehistoric Indian pottery or pieces of pottery from the park	343	88.4	19.0
Purposely harming a prairie dog	340	83.2	23.3
Taking a handful of petrified wood from the park	342	86.3	20.4
Collecting Indian arrowheads in the park	343	82.1	21.6
Feeding wildlife in the park	343	51.7	30.1

[a]Scores could range from 0 = not a problem to 100 = extremely serious problem.

Table 21. Levels of moral reasoning about petrified wood theft among PFNP visitors.

	Importance of various rationale for decisions to not take petrified wood					
	Not at all		Somewhat or moderately		Very or extremely	
Rationale	Number (N)	Percentage (%)	N	%	N	%
I want petrified wood to be there for future generations	0	0	16	4.5	342	95.5
I fear I will be caught by a park ranger	160	45.3	143	40.5	50	14.2
I want national parks to be preserved in their most pristine condition	1	0.3	14	3.9	342	95.8
Other people that I care about wouldn't like me to take petrified wood	128	36.3	111	31.4	114	32.3
I want to follow park rules	8	2.2	73	20.4	276	77.3
I want to set a good example for others	7	2.0	53	15.0	294	83.0
I don't want petrified wood	159	46.2	120	34.9	65	18.9
I don't want to be caught and fined for taking a piece of petrified wood	94	26.8	108	30.9	148	42.3
I want to leave the petrified wood there for others to enjoy	0	0	11	3.1	595	96.9
My religious beliefs prevent me from taking a piece of petrified wood	185	52.9	71	20.3	94	26.9
I want to leave the petrified wood there for my family and friends to enjoy	12	3.4	31	8.8	310	88.8

Interest in Collecting Park Souvenirs. We also attempted to measure the extent to which Petrified Forest National Park visitors collected souvenirs to take home from their vacation travels. We thought this might provide insight into those individuals who had a propensity to take pieces of petrified wood.

Table 22 indicates that, while about 60% of park visitors often collect a souvenir of their trip, for most the keepsake was a photograph. When visitors purchased or obtained a souvenir, most looked for an authentic object to help them remember the special places they had visited. Few brought such objects home to impress their friends. About 40% reported not buying souvenirs in gift shops because there they seemed artificial. Finally, only about 15% admitted to thoughtless, spontaneous collection or purchase of interesting objects just because they caught the eye.

Table 22. PFNP visitors' interest in vacation souvenirs.

	Strongly disagree or disagree		Neutral		Strongly agree or agree	
Souvenir behavior	**Number (N)**	**Percentage (%)**	**N**	**%**	**N**	**%**
I like to collect souvenirs of my visit so I can remember my travels better	82	22.6	69	19.1	211	58.3
Objects I collect during my travels impress my friends	174	48.6	115	32.1	69	19.3
When I visit a place, I try to collect a keepsake that captures the meaning of that place	62	17.3	67	18.7	230	64.1
When I find curious or unusual objects on trips, I like to collect them	87	24.4	102	28.7	167	46.9
I collect items when I travel to let people know more about me	259	72.5	77	21.6	21	5.9
I usually don't buy things in gift shops because they seem so artificial	128	35.6	78	21.7	154	42.8
I take photographs mostly to help me remember the places I visit	22	6.1	16	4.4	322	89.4
When an object catches my eye, I often experience an immediate desire to possess it even though I have no real use for it	245	68.2	56	15.6	58	16.2

Table 22 (continued).

Souvenir behavior	Strongly disagree or disagree		Neutral		Strongly agree or agree	
	Number (N)	Percentage (%)	N	%	N	%
When I travel, I carefully search for authentic objects that truly express the places I have visited	79	22.0	91	25.3	189	52.7
I like to collect souvenirs from my travels to show others about the places I visited	129	36.1	92	25.8	136	38.1
I like to keep objects that remind me of special places I have been	63	17.6	64	17.8	232	64.6
When I visit places on vacation, I often pick up knick-knacks that grab my imagination	163	46.0	114	32.2	77	21.8
I like to return from my travels with some unique souvenir	75	21.2	99	28.1	179	50.7
I like to relive experiences through the objects I collect when I travel	108	30.5	113	31.9	133	37.6
An important reason for taking photographs of the places I visit is so I can tell others about my trip	68	19.0	68	19.0	222	62.0
When something I see catches my fancy, I often feel an irresistible urge to collect it	227	63.4	78	21.8	53	14.8

Perceptions of Park Problems. Table 23 provides a summary of park visitors' perceptions of the severity of 22 possible problems in the park. The overwhelming finding is that visitors viewed the park as problem-free. No problem was seen as serious or very serious by 8% or more of the visitors. The only problem rated as slight, moderate, serious, or very serious by more than 40% of respondents was an insufficient number of rangers to answer questions about the park. More than 30% felt the same about not enough signs to help understand park

features, not enough scheduled ranger talks, too many rock shops just outside the south entrance station, lack of a campground at the park, and not enough interpretive/nature trails.

Preferences for Management Actions. Table 24 summarizes park visitors' support for 15 different actions to protect the park and its resources like petrified wood. In general, park visitors favored active intervention, including more aggressive law enforcement. More than 80% favored more signs and visitor center information on rules and regulations and the reasons for them, more aggressive law enforcement, and increased penalties for damaging park resources. The only interventions not favored by a majority of visitors were bans on the sale of petrified wood in the park, the searching of vehicles as they left the park, allowing only ranger-guided walks in petrified wood areas, building boardwalks with railings to keep people on the trails, and putting up fences around important park resources. However, about 50% supported putting up a low railing along foot trails in petrified wood areas.

Open-Ended Comments. At the end of the mailback questionnaire, we thanked the respondents and provided space for any comments they wished to make. Of the 365 respondents, 134 commented on the study or park. We have included those comments, just as they were written, in Appendix F of this report.

Table 23. PFNP visitors' perceptions of park problems.

Problem	Not at all		Slight or moderate		Serious or very serious	
	Number (N)	Percentage (%)	N	%	N	%
Litter along the roads	322	90.7	32	9.0	1	0.3
Litter along the trails	299	85.2	51	14.5	1	0.3
Vandalism	300	86.4	44	12.7	3	0.9
Not enough law enforcement rangers	254	75.6	74	22.0	8	2.4
Inadequate visitor center information	301	87.5	34	9.9	9	2.6
Poorly maintained trails	310	92.0	25	7.4	2	0.6
Not enough hiking trails	262	81.4	55	17.1	5	1.5
Petrified wood for sale in the park	279	85.3	37	11.3	11	3.4

Table 23 (continued).

Problem	Not at all		Slight or moderate		Serious or very serious	
	Number (N)	Percentage (%)	N	%	N	%
People collecting petrified wood	290	84.1	46	13.3	9	2.6
Too many people at the Painted Desert Visitor Center	268	81.0	59	17.8	4	1.2
Too many people at the Rainbow Forest Museum	258	81.4	55	17.4	4	1.3
Waiting at the entry/exit station	306	87.4	40	11.4	4	1.1
Too many people on petrified wood nature trails	291	86.1	45	13.3	2	0.6
Not enough signs to help understand park features	217	61.5	114	32.3	22	6.2
Not enough rangers to answer questions about the park	182	52.3	147	42.2	19	5.5
Too many people hiking off trails	265	78.6	58	17.2	14	4.2
Developed areas too close to major natural features	291	84.3	51	14.8	3	0.9
Too many rock shops just outside the south entrance station	231	68.1	88	26.0	20	5.9
Not enough wheelchair-accessible trails	245	83.3	38	12.9	11	3.7
Not enough interpretive/nature trails	227	69.4	88	26.9	12	3.7
Not enough scheduled ranger talks	208	62.7	109	32.8	15	4.5
Lack of campground at the park	227	69.2	75	22.9	26	7.9

Table 24. PFNP visitors' preferences for management actions.

Problem	Strongly oppose or oppose		Neutral		Strongly support or support	
	Number (N)	Percentage (%)	N	%	N	%
Provide more aggressive enforcement of park rules and regulations	14	3.9	48	13.6	292	82.5
Require people to stay on the paved paths	30	8.5	51	14.5	271	77.0
Have more signs telling people what the rules are	8	2.3	67	19.0	278	78.7
Put up fences around important park resources	155	44.3	70	2.0	125	35.7
Put up a low railing along foot trails	85	24.2	90	25.6	176	50.1
Put up more signs that help educate visitors on the rules and the reasons behind them	10	2.8	31	8.7	315	88.5
Have more rangers patrol the sites that are experiencing high levels of resource damage and/or theft	9	2.5	34	9.6	313	87.9
Provide more information in the visitor center on the rules and why it is important to follow them	5	1.4	37	10.5	312	88.1
Allow only ranger-guided walks in petrified wood areas	177	49.7	84	23.6	95	26.7
Prohibit visitors from picking up petrified wood	51	14.4	58	16.4	245	69.2
Build boardwalks with railings to keep people on the trails	138	39.4	102	29.1	110	31.4
Search vehicles as they leave the park	167	47.7	86	24.6	97	27.7

Table 24 (continued).

Problem	Strongly oppose or oppose		Neutral		Strongly support or support	
	Number (N)	Percentage (%)	N	%	N	%
Increase the penalties for damaging and/or stealing park resources	20	5.7	47	13.3	286	81.0
Provide park visitors with more information in appropriate park behavior	5	1.4	53	15.0	296	83.6
Ban the sale of petrified wood in the park	155	43.7	124	34.9	76	21.4

Objective 2: Describe Differences Between Thieves and Non-Thieves

Study Population and Study Sites

Data were collected on the demographic, motivational, attitudinal, normative, and behavioral characteristics of thieves and non-thieves for two time periods at two locations in PFNP during 1993. Between May 17 and June 17, we observed visitor behavior at Long Logs; we did the same at Crystal Forest from June 23 to July 2, 1993. Our study population on this phase of the study was thus the visitors to Long Logs for a one-month period and to Crystal Forest for a 10-day period. Our observation periods were restricted to these time periods because of limited funds, a small research staff, and our desire to disrupt visitor flow patterns and park staff as little as possible. Also, we felt we would observe a sufficient number of thieves and non-thieves during this study period to draw valid conclusions about their characteristics.

Five characteristics of the study sites caused us to select them: (1) the sites had large concentrations of petrified wood; (2) large numbers of park visitors stopped at these sites (i.e., our population survey suggested that 52% of all park visitors spent some time at Long Logs; 56% visited Crystal Forest); the terrain and trail system at these sites were such that all visitors could be observed with a small study team; (4) entrances to these sites were relatively restrictive; only one parking lot was available per site and only one or two trails led into each site; and (5) the sites were located close enough to park boundaries that observers could radio or phone thief or non-thief descriptions to research technicians working at the park entrance/exit booths. The Crystal Forest site contained about a ½-mile-long loop trail that

provided visitor access to large amounts of petrified wood. The loop trail was shorter at Long Logs, but there an additional trail led about 1/3-mile to the Agate House.

Selecting the Sample

At Long Logs, sampling was done in three-hour time blocks. A total of 30 time blocks were selected, and within certain constraints, this was done randomly. Typically, two time blocks, separated by an hour, were scheduled per day. Observation starting times were varied to sample all park operating hours. Finally, observation times did not overlap the sampling periods of the general park visitor population study described in Objective 1. Thus, no observed visitor could be part of the general park visitor population study.

Sampling periods at Crystal Forest were four hours long. Eight time blocks were randomly assigned to days and times in a manner similar to that described at Long Logs. However, only one time block was scheduled for observation per day.

During each observation time block, an effort was made to track and record every theft occurrence. Individuals who were observed removing petrified wood from the study sites became part of the "thief" sample. The "non-thief" sample was obtained by unobtrusively observing the behavior of one randomly selected visitor per hour. If this person did not remove petrified wood from the study site, he or she became part of the non-thief sample. If the visitor did remove a piece of petrified wood, he or she was assigned to the thief sample.

Data Collection Procedures

Two kinds of information were collected from the thief and non-thief sample: observational and survey data. The observation procedures used to record theft and non-theft among park visitors endeavored to be as unobtrusive as practical. Techniques used included the observer being completely hidden, the observer posing as a park visitor, and an unmanned video camera in the back of a vehicle. The purpose of the observer was to record as much information as possible about the theft and provide an adequate description of the observed person and his or her vehicle for tracking purposes. The video camera was used to provide an estimate of the amount of use while the site was under observation and to provide information on the average length of stay of the visitor.

At Long Logs, observers worked in teams of two. One observer was stationed out of sight, while the other posed as a park visitor. The observers could communicate with each other by

means of two-way radio. The observations at Crystal Forest were operationalized with only one observer who posed as a park visitor.

At Long Logs, an observer was assigned to monitor the site from a rock formation approximately 100 yards from the nearest trail and parking lot. Using binoculars, the observer would scan the site looking for possible theft behavior. Once a person was spotted removing petrified wood, the observer would fill out a theft observation coding form (Appendix G) and alert the other observer, who was on-site and posing as a visitor, of the behavior.

At Long Logs, the observer who posed as a park visitor wore a backpack containing a two-way radio and "walk-man" type earphones while on the trails. This person would attempt to behave in every way like a "typical" visitor by taking pictures, looking in the distance with binoculars, reading about the park, and bending over to look at petrified wood, but all the time watching for possible theft behavior. If a visitor was spotted removing petrified wood from the site or if a visitor was part of the randomly selected non-thief sample, an observer posing as a park visitor would follow this person back to the parking lot and note the description of the visitor's vehicle. At this point, the observer would get into his or her vehicle and record information about the "tagged" person's behavior, appearance, and vehicle.

With the information about the tagged person and his or her vehicle, the observer used a two-way radio (Long Logs) or cellular phone (Crystal Forest) to inform the research assistant located at the south entrance/exit station. The research assistant at the south entrance/exit station recorded the information and called the research assistant located at the north entrance/exit station. Neither the research assistants at the entrance/exit stations nor the park ranger working there was informed of status (thief or non-thief) of the tagged person. When the tagged vehicle was spotted, the research assistant would request the ranger working the exit window to ask the tagged vehicle party to participate in a survey of park visitors. Participation was voluntary for the tagged person. The post-visit contact interview and mailback questionnaire procedures included the same data collection instruments and were conducted in the same manner as the general park visitor study.

Crystal Forest differed from Long Logs by having only one observer posing as a park visitor. This person functioned in much the same way, only there was not a second person, and thus the backpack, radio, and earphones were not required.

While a petrified wood site was being observed, a video camera was recording the visitor entrances and exits at the trailhead at Crystal Forest and the entrance/exit point of the Long

Logs parking lot. The camera was set up on a tripod in the back of the vehicle used by the observer(s). No effort was made to conceal the camera. The tapes were later analyzed to determine the number of people using the site while the thefts were occurring and an average visitor length of stay at the two sites observed. This information permitted us to estimate the number of thefts occurring per 100 visitors for the site under observation.

Data Collection Instruments

A two-page thief observation coding form (Appendix G) provided a means to document petrified wood theft. Specifically, information was obtained on (1) apparent socio-demographic characteristics of the thief, (2) the thief's behavior, (3) situational variables, and (4) information on the thief and his or her vehicle to facilitate tracking the person for a post-visit contact.

A similar observation coding form (Appendix H) was used for the random sample of non-thieves. The information recorded for socio-demographics, situational variables, and tracking information was identical to the thief form. The behavior section was similar; however, it did not incude any theft information.

The post-visit interview form (Appendix A) and mailback questionnaire (Appendix C) were exactly the same as those for the general park visitor population. This permitted a comparison of thief characteristics to both the observed non-thieves and to the larger visitor population.

Participation and Response Rates

In total, 226 park visitors were observed (125 thieves and 101 non-thieves). Of these, 145 (64.2% of 226, including 77 thieves and 68 non-thieves) agreed to be interviewed and were given a questionnaire. Of the 81 who were not interviewed, 39 (17.3%) were not seen by the research assistants at the two exit/entrance stations, 30 (13.3%) slipped through the exit stations without being contacted for various reasons, 16 (7.1%) refused to participate in the study, and 1 (0.4%) was intercepted by a Park Service law enforcement ranger. One-hundred-sixteen (80.0% of 145) returned a completed questionnaire. Of these 116, 61 were thieves for a thief response rate of 79.2% and 55 were non-thieves for a non-thief response rate of 80.9%. Table 25 summarizes the post-visit interview participation and the questionnaire response rates.

Table 25. Participation and response rates for the general park visitor study, observed thieves, and observed non-thieves.

Sample population	Number asked to participate/ number observed	Number receiving questionnaire	Participation rate (%)
Park visitor study	603	456	75.6
Observed	226	145	64.2
Thieves	125	77	62.1
Non-thieves	101	68	67.3

Sample population	Number returning questionnaire	Response rate (%)
Park visitor study	365	80.0
Observed	116	80.0
Thieves	61	79.2
Non-thieves	55	80.9

After a careful comparison of the thief socio-demographic information recorded on the observation coding forms and reported in the mailback questionnaires, 10 of the 61 thieves who returned a completed questionnaire were removed from the "thief" data set. A thief was removed when his or her description on the questionnaire did not match the same information on the observation coding form. For example, if an observation coding form recorded the thief as being a white male in his 30's and the questionnaire was filled out by a white female in her 30's, the questionnaire was removed from the thief data set. In this case, apparently another household member or companion on the trip completed the post-trip questionnaire and not the thief observed in the field.

Results

Three kinds of results will be reported here. First, we will report our observed rate of theft during our observation periods at Long Logs and Crystal Forest. Second, the same characteristics used to describe the general park population in Objective 1 will be used to explore for any differences between observed thieves and observed non-thieves and between observed thieves and the general population. These include visitor demographics; group characteristics; visit characteristics; visitor sources of information; and visitor perceptions, attitudes, and preferences. Finally, we report general summaries of certain behavioral characteristics of thieves and non-thieves and of use conditions on-site at the time of any theft.

Amount of Petrified Wood Theft

We spent 122 hours of observation of theft behavior at Long Logs and Crystal Forest in 1993. During this time, we observed 125 persons who stole petrified wood. This rate averages about 1.02 thieves per hour. Also, the thief rate was 1.2%, i.e., there were 1.2 thieves per 100 visitors at these two popular petrified wood sites. Finally, our best guess is that thieves averaged 1.6 pieces of petrified wood stolen per theft act. (This estimate may have a fairly large margin of error because it was often difficult to see the exact number of pieces taken.)

Comparison of Thief and Non-Thief Characteristics

We are providing two comparisons of study participants (i.e., comparison between observed thieves and observed non-thieves and between observed thieves and the general population of park visitors) because each offsets a weakness of the other. Conceptually, the comparison of observed thieves and observed non-thieves should give us the cleanest comparison of the two. But we do not know for sure if those whom we observed to be non-thieves at our study sites did not steal petrified wood at some other location in the park. Also, our sample of observed thieves and non-thieves who returned the mailback questionnaire is somewhat small, just over 50 in each category. With our comparison of thieves to the general population, we have a far larger sample size in our general park visitor category. However, this population estimate would include some small percentage (presumably about 1% or 2%) of thieves. This muddies our search for differences between thieves and non-thieves because we are comparing known thieves to a population that includes a few thieves. This provides a conservative estimate of differences between thieves and non-thieves. Any differences we find between thieves and the general park visitor population would suggest a relatively strong difference between thieves and non-thieves.

Visitor Demographics

Age. We found a difference in age of thieves compared to the general park visitor population at $p \leq 0.10$ (Table 26). (At the $p = 0.10$ level, we have a 1 in 10 chance of concluding a difference exists when, in fact, none does.) Table 26 suggests that thieves were a bit older with an average age of 48.3 years than the population, which averaged 44.8 years. There were no significant differences between observed thieves and observed non-thieves in age and gender.

Table 26. Comparison of age of thieves and the park visitor population.

	Number	Mean	Standard deviation	t	Significance
Thieves	52	48.3	14.0		
Population	361	44.8	13.3	1.76	0.078

Education, Employment, and Income. Table 27 suggests that thieves had somewhat less education than the population of park visitors. The thieves averaged 14.0 years of education; for the general population, this number was 15.0. There were no significant differences in the education levels of observed thieves and non-thieves and no differences between thieves and observed non-thieves or the general park visitor population in employment or income.

Table 27. Comparison of education level of thieves and the park visitor population.

	Number	Mean	Standard deviation	t	Significance
Thieves	51	14.0	2.58		
Population	358	15.0	2.24	-2.84	0.005

Ethnic Origin. We had too few non-whites in our sample to draw conclusions with certainty, but there appears to be no difference in the ethnic breakdown of thieves and non-thieves in our study.

Marital Status and Children. The presence of children under age five or between five and 17 living with the respondent did not influence the likelihood of him or her being a thief.

However, 78.0% of observed thieves were married, but only 63.6% of observed non-thieves had a similar status (Table 28). This difference was significant at p = 0.10.

Table 28. Comparison of the marital status of observed thieves and observed non-thieves.

		Thieves	Non-Thieves	Total
Married				
Yes	Count	39	35	74
	%	78.0	63.6	70.5
No	Count	11	20	31
	%	22.0	36.4	29.5
Total	Count	50	55	105
	%	100.00	100.00	100.00

Pearson chi-square test: significant at $p = 0.10$.

Group Characteristics

Group Size and Type. As mentioned in our discussions of overall park visitor characteristics, we had two measures of respondents' group size, one taken on site during the exit interview and the other asked on the mailback questionnaire. The on-site measure should be the more accurate because it avoids any non-response bias of the mailback survey. It will be used here. Table 29 indicates that the group size of thieves was significantly larger than those of the observed non-thieves or the general park population.

We also asked our respondents whether they were alone, with family only, with friends only, with family and friends, or with other types of companions. While there were too few respondents in several cells to draw conclusions with certainty, it appears that thieves did not visit the park alone and that they were more likely to be with family and friends than was the general park visitor population (Table 30).

For those study participants who were not traveling alone, the age category of persons they were with seemed to affect their likelihood of being a thief. Presence of children (five to 12 years old) and teenagers did not seem to make a difference, but presence of the elderly in the group did. Respondents who had at least one person in the group past 62 years of age were more likely to be thieves (Table 31).

Visit Characteristics

Past Experience. Thieves, non-thieves, and the general population did not differ in their total number of visits to PFNP.

Primary Destination. The percentage of thieves, non-thieves, and the general park visitor population who said that PFNP was or was not their primary trip destination did not vary.

Length of Visit. Length of total visit to the park did not vary by thief, non-thief, and general park visitor population.

Length of Stay at Park Attractions. We also performed analyses to see whether thieves and non-thieves indicated in their exit interview that they went to different attractions in the park. We inquired about visits to 15 sites and performed two comparisons for each (i.e., we compared thieves to non-thieves and thieves to the general park visitor population). Of the 30 tests run, we found seven differences (Table 32). Thieves were more likely than the population to have visited Crystal Forest and Long Logs (this is in part an artifact of how we captured thieves; we only observed thieves at these two places, while inclusion in the general park survey did not necessarily require a stop at these study sites). More interesting was our finding that thieves visited the Blue Mesa Nature Trail less frequently than non-thieves and visited the Rainbow Forest Museum and the Giant Logs trail less frequently than either the non-thieves or the general park visitor population. Thieves are apparently avoiding the strong park ranger presence at the museum and the Giant Logs trail, whose entrance is through the museum.

In addition to whether thieves and non-thieves differed on the attractions and programs in the park that they visited, we also looked for differences in length of stay between the two groups in the places they did visit. Observed thieves differed from observed non-thieves on only one of the 15 attractions we measured. Thieves spent slightly more time at Jasper Forest than did the non-thieves (about 13 minutes compared to just under 10 minutes). However, finding only one difference out of 15 tests suggests that this difference could have been a chance finding. Also, a difference of only a few minutes seems to have little managerial relevance.

When we compared the time spent at attractions by thieves to our general park visitor population, we found more differences. The general park population spent slightly more time at the Painted Desert Inn and considerably more time on the Blue Mesa Scenic Loop and the Blue Mesa Nature Trail. In contrast, the thieves spent slightly more time per visit at Long Logs (Table 33).

Table 29. Comparison of the group size of observed thieves with observed non-thieves and the park visitor population.

	Number	Mean	Standard deviation	t	Significance
Thieves	67	3.67	1.80		
Non-Thieves	68	2.84	1.22	3.15	0.002
Population	450	3.09	1.40	2.52	0.014

Table 30. Comparison of group type of observed thieves and park visitor population.

		Thieves	Population	Total
Alone	Count	0	19	19
	%	0	5.3	4.6
Family only	Count	41	277	318
	%	75.9	76.9	76.8
Friends only	Count	4	36	40
	%	7.4	10.0	9.7
Friends and family	Count	7	25	32
	%	13.0	6.9	7.7
Other	Count	2	3	5
	%	3.7	0.8	1.2
Total	Count	54	36.0	414
	%	100.0	100.0	100.0

Pearson chi-square: significant at $p = 0.07$, but 40% of cells have an expected count less than 5.

Gift Shop Purchases. Thieves and non-thieves did not differ in the percentage who purchased any items in the park's gift shops. Thieves were, however, more likely than the population of park visitors to purchase petrified wood in park gift shops (Table 34). Among those who did purchase gift shop items, thieves and non-thieves did not differ in the amount they spent for clothing, Native American jewelry, petrified wood, books and magazines, film, glassware, and other items.

Table 31. Comparison of presence of elderly in the party of observed thieves and the park visitor population.

		Thieves	Population	Total
Elderly present				
No	Count	28	211	239
	%	58.3	73.0	70.9
Yes	Count	20	78	98
	%	41.7	27.0	29.1
Total	Count	48	289	337
	%	100.0	100.0	100.0

Pearson chi-square test: significant at $p = 0.04$.

Purchase of Petrified Wood Outside the Park. About 22% of all PFNP visitors purchased petrified wood outside the park; for observed thieves, only 9.4% did so. This difference is significant at $p = 0.032$ (Table 35).

Table 32. Comparison of visitation to park attractions by thieves, non-thieves, and the park visitor population.

		Thieves	Non-Thieves	Population	Significant difference
Blue Mesa Nature Trail					
No	Count	64	57		
	%	94.1	83.8		
Yes	Count	4	11		T vs. NT at
	%	5.9	16.2		p = 0.10
Crystal Forest					
No	Count	24		220	
	%	35.3		48.2	
Yes	Count	44		236	T vs. Pop. at
	%	64.7		51.8	p = 0.05
Long Logs					
No	Count	15		262	
	%	22.1		57.5	
Yes	Count	53		194	T vs. Pop. at
	%	77.9		42.5	p < 0.0005
Rainbow Forest Museum					
No	Count	46	33	213	T vs. NT at
	%	67.6	48.5	46.7	p = 0.04
Yes	Count	22	35	243	T vs. Pop.
	%	32.4	51.5	53.3	p = 0.002
Giant Logs Trail					
No	Count	63	47	273	T vs. NT at
	%	92.6	69.1	59.9	p = 0.001
Yes	Count	5	21	183	T vs. Pop. at
	%	7.4	30.9	40.1	p < 0.0005

Table 33. Comparison of time spent at park attractions by thieves versus non-thieves and the park visitor population.

	Number	Mean[a]	Standard deviation	t	Significance
Jasper Forest					
Thieves	39	12.9	9.8		
Non-thieves	44	9.6	5.6	1.87	0.07
Blue Mesa Scenic Loop					
Thieves	398.9	14.3			
Population	196	16.2	11.0	-3.06	0.004
Blue Mesa Nature Trail					
Thieves	284.6	14.1			
Population	77	25.6	23.1	-5.59	0.000
Long Logs					
Thieves	53	22.2	13.1		
Population	194	18.1	11.3	2.25	0.03
Painted Desert Inn					
Thieves	28	11.3	5.7		
Population	157	15.1	11.6	-1.71	0.09

[a]Mean as expressed in minutes.

Table 34. Comparison of the percentage of thieves and the general park visitor population who purchased petrified wood in park gift shops.

		Thieves	Population	Total
Purchase wood				
No	Count	32	278	310
	%	65.3	77.7	76.2
Yes	Count	17	80	97
	%	34.7	22.3	23.8
Total	Count	49	358	407
	%	100.0	100.0	100.0

Pearson chi-square test: significant at $p = 0.06$.

Table 35. Comparison of number of observed thieves versus the park visitor population who purchased petrified wood outside the park.

		Thieves	Population	Total
Purchased wood				
No	Count	48	277	325
	%	90.6	77.8	79.5
Yes	Count	5	79	84
	%	9.4	22.2	20.5
Total	Count	53	356	409
	%	100.0	100.0	100.00

Pearson chi-square test = significant at $p = 0.03$.

Visitor Sources of Information

Information Sources About the Park Before Arrival. Thieves, non-thieves, and the population of park visitors did not differ on whether or not they received information about the park before their arrival. We then ran tests to determine, among those who did receive information, whether thieves differed from the non-thieves or the general population on nine

sources of information used. Thieves did not differ from the population on any of the nine sources; thieves differed from the observed non-thieves on one source. About 40% of non-thieves used a travel guide to learn about the park before arriving; for thieves, the number was about 23% (Table 36). Only one difference among the 18 tests run could have occurred due to chance, so we conclude that our subgroups did not differ from each other in sources of information used.

Table 36. Comparison of source of information about PFNP for observed thieves and non-thieves.

		Thieves	Non-Thieves	Total
Travel guide				
No	Count	39	33	72
	%	76.5	60.0	67.9
Yes	Count	12	22	34
	%	23.5	40.0	32.1
Total	Count	51	55	106
	%	100.0	100.0	100.0

Pearson chi-square test: significant at $p = 0.07$.

Information Sources About the Park Story. Once inside the park, we compared observed thieves, non-thieves, and the general park visitor population on the kind of information used to learn the park story. We found only one source of 13 listed differed among our study groups. About 37% of the general park visitors and 35% of observed non-thieves used the Rainbow Forest Museum exhibits as a source; only about 22% of thieves did so (Table 37). While low cell values made interpretation difficult, our three groups did not appear to differ on which of the 13 sources listed they found most helpful in learning the park story.

Table 37. Comparison of observed thieves, observed non-thieves, and the park visitor population on whether they used the Rainbow Museum exhibits as a source of information about the park story.

		Thieves	Non-Thieves	Population	Total	
Used Rainbow Museum exhibits					T + NT	T + Pop.
No	Count	42	36	226	78	268
	%	77.8	65.5	62.6	72.9	64.6
Yes	Count	12	19	135	29	147
	%	22.2	34.5	37.4	27.1	35.4
Total	Count	54	55	361	107	415
	%	100.0	100.0	100.0	100.0	100.0

Pearson chi-square test: significant at $p = 0.03$ for thieves versus population.
Pearson chi-square test: significant at $p = 0.08$ for thieves versus non-thieves.

Information Sources About Park Rules and Regulations. We found more differences in whether our observed thieves, non-thieves, and the general park visitor population differed in sources used to learn park rules and regulations. More of the visitor population than thieves used the official park brochure/map and park newspaper. In contrast, the thieves more often than the general population used rangers at points of interest, films or shows, self-guided walks, and entrance station information as their source of information about park rules. Observed thieves differed from observed non-thieves on four of the 13 information sources used. Non-thieves were more likely than thieves to use the park brochure/map and the Rainbow Forest Museum exhibits. In contrast, the thieves were more likely than non-thieves to cite the Painted Desert Visitor Center exhibits and rangers at points of interest as sources of information used (Table 38).

Once again, the three groups did not appear to differ on which source of information about park rules and regulations was judged the most helpful.

Table 38. Comparison of observed thieves, observed non-thieves, and the park visitor population on whether they used various sources of information to learn about park rules and regulations.

		Thieves	Non-Thieves	Population	P-value (Significance level)
Used:					
Park brochure map					
No	Count	19	10	84	T vs. NT
	%	35.2	18.2	23.5	p = 0.05
Yes	Count	35	45	273	T vs. Pop
	%	64.8	81.8	76.5	p = 0.07
Park newspaper					
No	Count	48		282	
	%	88.9		79.0	
Yes	Count	6		75	T vs. Pop.
	%	11.1		21.0	P = 0.09
Painted Desert Visitor Center exhibits					
No	Count	33	43		
	%	63.5	78.2		
Yes	Count	19	12		T vs. NT
	%	36.5	21.8		p = 0.09
Rainbow Forest Museum exhibits					
No	Count	48	45		
	%	92.3	81.8		
Yes	Count	4	10		T vs. NT
	%	7.7	18.2		p = 1.0

Table 38 (continued).

		Thieves	Non-Thieves	Population	P-value (Significance level)
Rangers at points of interest					
No	Count	43	51	323	T vs. NT
	%	79.6	92.7	90.5	p = 0.04
Yes	Count	11	4	34	T vs. Pop.
	%	20.4	7.3	9.5	p = 0.02
Films or slide shows					
No	Count	43		321	
	%	79.6		89.9	
Yes	Count	11		36	T vs. Pop
	%	20.4		10.1	p = 0.03
Self-guided walks					
No	Count	38		291	
	%	70.4		81.5	
Yes	Count	16		66	T vs. Pop.
	%	29.6		18.5	p = 0.6
Entrance station info					
No	Count	21		184	
	%	38.9		51.5	
Yes	Count	33		173	T vs. Pop.
	%	61.1		48.5	p = 0.08

Visitor Perceptions, Attitudes, and Preferences

Attitudes and Involvement with National Parks. In our general park visitor study, we attempted to measure the involvement of our respondents with national parks. We did this by asking questions about how often they visited national parks, how satisfied they were with national park visits, and how central national parks were to their lives.

In general, we found low involvement with the national parks. In this phase of our analyses, we explored for differences among observed thieves, non-thieves, and the general park visitor population in their national park involvement. We found no differences on six measures of involvement between thieves and non-thieves. We found two small differences in importance of national parks to one's life between thieves and the general park visitor population. While both groups disagreed with the items, "I find a lot of my life is organized around national park use" and "One of the major reasons I now live where I do is that it has opportunities for visiting national parks," the general park visitors disagreed more than did the thieves (Table 39).

Table 39. Comparison of the level of national park involvement between observed thieves and the general park visitor population.

	Number	Mean[a]	Standard deviation	t	Significance
I find a lot of my life is organized around national park use					
Thieves	52	2.90	1.11		
Population	354	2.47	0.99	2.87	0.004
One of the major reasons I now live where I do is that it has opportunities for visiting national parks					
Thieves	52	2.33	1.02		
Population	352	2.02	0.99	2.09	0.04

[a]1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree.

We also examined the attitudes of observed thieves, non-thieves, and general park visitors about appropriate national park behavior and found many differences. Table 40 indicates four differences among 18 attitude measures between thieves and non-thieves. In all cases, non-thieves had more favorable attitudes toward protecting petrified wood or park resources than thieves, although often thieves agreed with the park protection attitude. When we compared thieves to the general population, they differed from the typical park visitors on nine of the 18 attitude measures. The general park visitors' attitudes toward petrified wood and park protection were more favorable than were the thieves' attitudes (Table 41).

Table 40. Comparison of the attitudes of observed thieves and non-thieves about appropriate park behavior.

Attitude	Number	Mean[a]	Standard deviation	t	Significance
I don't think I could tell a piece of petrified wood from an ordinary rock					
Thieves	51	2.47	0.99		
Non-Thieves	54	2.09	1.01	1.93	0.06
It is all right to pick up petrified wood as long as you leave it in the park					
Thieves	51	3.12	1.18		
Non-Thieves	55	2.36	1.25	3.19	0.002
It is all right to take a piece of petrified wood from the park as long as it is a small piece					
Thieves	51	1.94	1.12		
Non-Thieves	55	1.55	0.86	2.05	0.04
It is all right to collect ordinary rocks while visiting the park					
Thieves	49	2.24	0.95		
Non-Thieves	54	1.85	0.81	2.27	0.03

[a]1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree.

Table 41. Comparison of the attitudes of observed thieves and the park visitor population on appropriate park behaviors.

Attitude	Number	Mean[a]	Standard deviation	t	Significance
It is wrong to pick up petrified wood, even if you put it back where you found it					
Thieves	53	2.96	1.32		
Population	356	3.31	1.23	-1.88	0.06
Taking petrified wood reduces the beauty of the park					
Thieves	53	4.34	0.65		
Population	355	4.56	0.61	-2.39	0.02
I don't think I could tell a piece of petrified wood from an ordinary rock					
Thieves	53	2.47	0.97		
Population	355	2.22	1.04	1.65	0.10
It is all right to enter prehistoric Indian pueblo and pit house ruins in national parks					
Thieves	52	2.35	0.95		
Population	349	2.60	1.15	-1.76	0.08
It is all right to pick up petrified wood as long as you leave it in the park					
Thieves	53	3.08	1.17		
Population	356	2.40	1.17	3.90	0.00

Table 41 (continued).

Attitude	Number	Mean[a]	Standard deviation	t	Significance
It is all right to take a piece of petrified wood from the park as long as it is a small piece					
Thieves	53	1.91	1.11		
Population	356	1.65	1.02	1.70	0.09
Seeing polished petrified wood in the visitor center encourages people to collect a piece from the park grounds					
Thieves	53	2.98	1.05		
Population	354	2.60	1.08	2.39	0.02
It is all right to collect ordinary rocks while visiting the park					
Thieves	51	2.24	0.93		
Population	346	1.96	0.97	1.93	0.06
It is all right to climb or sit on logs of petrified wood					
Thieves	53	2.64	1.13		
Population	354	2.36	1.11	1.74	0.08

[a]1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree.

Levels of Moral Reasoning and Park Norms. Just as we found some differences between thieves and non-thieves on their attitudes about appropriate national park behavior, we anticipated that these groups would differ in their norms about the seriousness of specific acts that seem unacceptable in parks. We asked our respondents to rate the seriousness of 11 acts (see Table 20 on page 22). Contrary to our expectations, observed thieves and non-thieves did not differ on any of their judgments. Thieves and the general visitor population did differ on two of the 11 norms, but neither act involved theft of petrified wood. Instead, the general

park visitors rated purposely harming an endangered plant or animal and purposely harming a prairie dog as a more serious violation than did the thieves (Table 42).

Table 42. Comparison of the norms of observed thieves and the park visitor population regarding the seriousness of specific problem behaviors in parks.

Norm	Number	Mean[a]	Standard deviation	t	Significance
Purposely harming an endangered plant or animal					
Thief	46	82.4	27.7		
Population	344	89.4	19.9	-1.66	0.10
Purposely harming a prairie dog					
Thief	47	71.6	25.5		
Population	339	83.3	23.3	-3.18	0.002

[a]Seriousness ratings could range from 0 (not a violation) to 100 (an extremely serious violation).

We believed that thieves and non-thieves might have different ethical rationales for taking or not taking petrified wood, ranging from acting or not acting out of fear of punishment, the desire to please significant others, or the desire to protect the earth or to provide for future generations. Table 43 indicates that thieves were somewhat more concerned than non-thieves about being caught and fined by a ranger and were more likely to attribute any ethical behavior to this rationale. However, even the thieves disagreed that their behavior regarding wood theft was shaped very much by the threat of punishment.

Interest in Collecting Park Souvenirs. We explored the extent to which park visitors at PFNP sought to collect souvenirs of their trip and their reasons for collecting souvenirs. Table 44 suggested that, while observed thieves and observed non-thieves differed on only two of 16 reasons listed, both suggest that thieves were more impulsive collectors than non-thieves. This begins to suggest that wood theft may not be a reasoned action for all thieves, but instead may be a very spontaneous, thoughtless act. When we compared our observed thieves to our population of park visitors, we found that impulsiveness did not differentiate these two groups. Instead, the general park visitor often collected souvenirs to help remember

the authentic nature or meanings of the places they visited; thieves were more likely to collect souvenirs so that others would know them better and know about their travels (Table 44).

Table 43. Comparison of the ethical rationale for petrified wood theft behavior of observed thieves, non-thieves, and the park visitor population.

Ethical rationale	Number	Mean[a]	Standard deviation	t	Significance
I fear I will be caught by a park ranger					
Thieves	50	2.60	1.46		
Non-thieves	54	1.98	1.07	2.48	0.02
Population	352	2.04	1.21	2.44	0.02
I don't want to be caught and fined for taking a piece of petrified wood					
Thieves	51	3.27	1.47		
Non-thieves	53	2.51	1.42	2.70	0.008

[a]Values could range from 1 = not at all, 2 = somewhat, 3 = moderately, 4 = very, and 5 = extremely important rationale.

Perception of Park Problems. We listed 22 possible park problems on our survey and asked our respondents to assess their seriousness. Thieves, non-thieves, and the general park visitor population had almost no differences in their judgments. Non-thieves did rate the sale of petrified wood in the park as a slightly greater problem than did non-thieves; in contrast, thieves rated lack of enough interpretive/nature trails as a slightly more serious problem (Table 45). However, neither group rated these problems as even slightly serious, and we would expect to find about two statistically significant differences among 22 tests by chance alone. Likewise, we found only three differences between thieves and the general park visitor population on perceptions of problems. Data suggest that thieves rated litter along the road and too many rock shops just outside the south entrance to the park as slightly more serious than did the typical park visitor, while the general visitor rated petrified wood sale as a slightly more serious problem. But again, no problem was rated by any group as even slightly serious, and these few differences could be due to chance alone.

Table 44. Comparison of the rationale for collecting vacation souvenirs among observed thieves, non-thieves, and the general park visitor population.

Souvenir Collecting Rationale	Number	Mean[a]	Standard deviation	t	Significance
When an object catches my eye, I often experience an immediate desire to possess it even though I have no real use for it					
Thieves	49	2.16	0.96		
Non-thieves	54	1.74	0.76	2.48	0.02
When something I see catches my fancy, I often feel an irresistible urge to collect it					
Thieves	50	2.50	1.07		
Non-thieves	54	1.98	1.05	2.48	0.02
I like to collect souvenirs of my visits so I can remember my travels better					
Thieves	51	3.04	1.08		
Population	361	3.46	1.09	-2.56	0.01
When I visit a place, I try to collect a keepsake that captures the meaning of that place					
Thieves	51	3.18	1.01		
Population	358	3.56	1.04	-2.46	0.01
I collect items when I travel to let people know more about me					
Thieves	50	2.34	0.85		
Population	356	2.09	0.86	1.91	0.06

Table 44 (continued).

Souvenir Collecting Rationale	Number	Mean[a]	Standard deviation	t	Significance
When I travel, I carefully search for authentic objects that truly represent the places I have visited					
Thieves	52	3.04	1.01		
Population	358	3.39	1.08	-2.21	0.03
An important reason for taking photographs of the places I visit is so I can tell others about my trip					
Thieves	52	4.06	0.98		
Population	357	3.62	1.08	2.94	0.004

[a]Response range is 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree.

Preferences for Management Actions. Table 46 indicates that thieves, non-thieves, and the overall park visitor population varied somewhat in their support for park management actions. While all groups supported providing more information on appropriate park behavior, the non-thieves and the general population supported this more than did the thieves. The non-thieves and park visitor population also supported increasing penalties for damaging and stealing park resources; the thieves as a group gave only mild support for this action. All groups opposed vehicle searches, but the thieves' opposition was stronger. Finally, while both the thieves and the general population were about neutral in their support of boardwalks with railings, the thieves were slightly more positive.

Table 45. Comparison of the perceptions of park problems among observed thieves, non-thieves, and the general park visitor population.

Problem	Number	Mean[a]	Standard deviation	t	Significance
Petrified wood for sale in the park					
Thieves	44	1.00	0.00		
Non-thieves	53	1.21	0.66	-2.29	0.03
Population	326	1.29	0.76	-6.8	0.00
Not enough interpretive/nature trails					
Thieves	46	1.65	1.02		
Non-thieves	51	1.35	0.69	1.68	0.10
Litter along the road					
Thieves	51	1.24	0.47		
Population	354	1.10	0.35	1.98	0.05
Too many rock shops just outside the south entrance station					
Thieves	46	1.78	1.03		
Population	338	1.53	0.92	1.70	0.09

[a]Problem range is 1 = not all, 2 = slight, 3 = moderate, 4 = serious, and 5 = very serious.

Table 46. Comparison of preferences for park management actions among thieves, non-thieves, and the general park visitor population.

Management Action	Number	Mean[a]	Standard deviation	t	Significance
Provide more information in the visitor center on the rules and why it is important to follow them					
Thieves	50	4.02	0.68		
Non-thieves	54	4.26	0.68	-1.79	0.08
Population	353	4.20	0.69	-1.71	0.08
Build boardwalks with railings to keep people on the trails					
Thieves	53	3.17	1.10		
Population	349	2.88	1.11	1.77	0.08
Search vehicles as they leave the park					
Thieves	49	2.45	0.87		
Non-thieves	54	2.94	1.22	-2.39	0.02
Increase the penalties for damaging and/or stealing park resources					
Thieves	51	3.82	1.03		
Non-thieves	54	4.19	0.87	-1.94	0.06
Population	352	4.11	0.90	-2.18	0.03

Table 46 (continued).

Management Action	Number	Mean[a]	Standard deviation	t	Significance
Provide park visitors with more information on appropriate park behavior					
Thieves	51	3.94	0.58		
Non-thieves	54	4.24	0.70	-2.40	0.02
Population	353	4.13	0.72	-1.85	0.07

[a]Response range is 1 = strongly oppose, 2 = oppose, 3 = neutral, 4 = support, and 5 = strongly support.

Observed Characteristics of Thieves and Non-Thieves. Table 47 summarizes our on-site observations of thief characteristics and of conditions of the site at the time of the theft. As might be expected, thieves spent more time searching the ground and less time walking on trails and taking photos than did our observed non-thieves. The thieves also did not typically express fear or discomfort about their theft. In addition, in almost all cases of theft, there were other groups of park visitors nearby. Finally, other members of the thief's group seemed to condone the theft.

Summary. While it may appear that we found many differences in the characteristics of thieves and non-thieves, we must point out the very large number of comparisons run. We compared the two groups on almost 200 variables, and we made two comparisons for each variable (i.e., observed thief versus observed non-thief and observed thief versus general park visitor). Thus, we made almost 400 comparisons. We selected a p value of 0.10 as our level of declaring significant difference, i.e., we would accept a 10% chance of declaring the two groups in any comparison as different when, in fact, they were not. This seemed reasonable, given the nature of subject matter, the data, and any penalty for being wrong. However, since we did not have specific hypotheses about how thieves would compare to non-thieves before we ran specific tests, this study must be considered exploratory. Thus, with a possibility of making the wrong decision (declaring groups different when, in fact, they were not) 10% of the time, we would look for more than 40 differences between our groups, given the almost 400 tests run, if we were to declare thieves and non-thieves to have very different characteristics.

Table 47. On-site behavior of thieves.

Observational data	Thieves (compared to non-thieves)	Significant difference
Searching behavior	more	$p < 0.000$
Taking photos	less	$p = 0.001$
Walking on the trails	less	$p = 0.001$

	Thief Characteristic (%)
Looked about before theft	26
Put wood in pocket	64
Looked about after theft	42
Talked about theft with party members	75
Positive response of other group members to theft	90
No evident discomfort	82
At least one other person nearby	88

We, in fact, found about 75 differences among our group comparisons. Thus, we must conclude that, while there are some differences between thieves and non-thieves, these differences are surprisingly few. We can get an indication of the nature of real differences between the two groups by examining the number of differences found per tests run *within* specific types of characteristics (i.e., demographics, group characteristics, visit characteristics, sources of information used, involvement with national parks, attitudes about national park behavior, norms about appropriate park behavior, kind of moral reasoning or ethical rationale for park behavior, souvenir collecting behavior, perceptions of park problems, and preferences for management action). Also, when observed thieves versus observed non-thieves and observed thieves versus the general park visitor differed on the same variable, this provides additional evidence that the variable is an important differentiating one. Finally, we need to look at the magnitude of the differences between groups in any comparison. A difference may

indeed be real, but it may be so small as to have little relevance for park managers or park interpreters.

Given these criteria, it appears that thieves and non-thieves differ most on the characteristics of their group and in their attitudes toward appropriate park behavior. Thieves compared to non-thieves tend to visit the park in larger groups, are somewhat more likely to be in a group of family and friends, and are more likely to include a person over 62 years of age. In terms of attitudes about appropriate park behavior, including appropriate behavior regarding protecting petrified wood, the thieves often had attitudes congruent with park regulations, but the non-thieves typically had much stronger agreement.

The type of characteristic where thieves and non-thieves seem to differ next most is in preference for management actions. While both groups want more information about appropriate park behavior, the non-thieves support the use of information as a management tool more strongly. The thieves also appear to depend much more strongly on non-written messages (like ranger contacts) than do the non-thieves. The non-thieves more frequently used the park brochure for important information about the park. As would be expected, thieves opposed more, or did not support as much, various penalties for theft of petrified wood.

The apparent third-most important group of differentiating characteristics are demographics and souvenir collecting behavior. Although the differences were not large, thieves were slightly older, slightly less educated, and somewhat more likely to be married. On souvenir collecting behavior, thieves were somewhat more likely than non-thieves to be spontaneous, thoughtless collectors or purchasers. This may mean that promoting proper attitudes about appropriate wood protection behavior may not be effective for some thieves. They may not be accessing their attitudes at the time of theft.

One other distinguishing feature of thieves and non-thieves seems important. Thieves avoid the Rainbow Forest Museum, its exhibits, and its trail through Giant Logs both as a place to visit and a source of information, compared to non-thieves. Perhaps the strong ranger presence and the greater security around Giant Logs (i.e., the fence) are threats to the potential thief.

Objective 3: Estimate the Amount of Petrified Wood Taken From the High-Wood/High-Use Areas in the Park

Overview

Two general approaches were used in this study to estimate loss of petrified wood from the park: observations of theft behavior by park visitors and inventory of change in petrified wood on the ground in the park. We have already described our methods and results of observations of theft behavior at Long Logs and Crystal Forest in 1993. We did additional on-site observations of theft behavior when we tested interventions to reduce the rate of theft at Crystal Forest in 1995 and 1996. These findings will be reported under Objective 4 of this report.

On-Site Inventory of Petrified Wood

The inventory study of change in the amount of petrified wood on the ground in PFNP has the advantage over visitor observation studies of taking into account change (loss or gain) of petrified wood due to wind and water erosion. We completed our initial wood inventory at Blue Mesa, Jasper Forest, Crystal Forest, Long Logs, and Giant Logs during 1993, then re-inventoried these sites for possible change in wood concentrations in 1994. We reported our findings in a December 1994 unpublished report to the park superintendent. We have included the paper in Appendix I of this report. Additional detailed information about this phase of the study project can be found in a thesis by Monkevich (1994), available at Petrified Forest National Park and at the Department of Forestry, Virginia Tech, Blacksburg, Virginia.

Appendix I provides a detailed description of change in density, percentage of cover and volume of petrified wood for each of three particle size classes (size class 1 = 0.25 inches $\leq$ particle length $<$ 1 inch, size class 2 = 1 inch in particle length $<$ 5 inches, size class 3 = 5 inches $\geq$ in particle length) for each of the five study sites.

The overall estimated loss of petrified wood from the park through the ground inventory study appears much larger than what we obtained through our visitor observation studies. For example, in our 1993 observation study, we estimated that 1.2% of all visitors to Crystal Forest were thieves and, on average, each act of theft included 1.6 pieces of petrified wood. About 900,000 people visit Petrified Forest National Park each year, and 56.2% of these visit Crystal Forest. This gives an estimated loss of petrified wood at Crystal Forest of 9,677 pieces (900,000 x 0.56 x 0.012 x 1.6 = 9,677). In our 1995 theft observation study at Crystal Forest (see Objective 4), we estimated the theft rate of 2.65%. This would result in a total estimate of

annual theft of wood of about 21, 400 pieces (900,000 x 0.56 x 0.0265 x 1.56 = 21,370). Our 1996 observations of wood theft at Crystal Forest would suggest an estimated annual loss of about 18,300 pieces of wood (900,000 x 0.56 x 0.0324 x 1.12 = 18,289). The ground sampling and inventory estimated the annual loss of pieces of petrified wood at Crystal Forest to be 172,880 pieces (Appendix I). While there are large confidence intervals around this ground estimate and we could have missed some theft during our observation studies, there does appear to be considerable loss of petrified wood from the site due to erosional or other non-park visitor sources.

The estimated overall annual loss of petrified wood from the five study sites contained in the ground inventory study was about 290,000 pieces (Appendix I).

Objective 4: Test the Effectiveness of Interventions to Reduce Wood Theft

Tests of the effectiveness of interventions to reduce theft of petrified wood at PFNP were conducted during the 1995 and 1996 tourist visitation seasons. We begin by describing the 1995 study.

1995 Field Season

Background

Noncompliant visitor behavior is a significant problem facing natural resource managers. In a recent survey, 72% of national park superintendents reported that noncompliance of rules and regulations by visitors caused significant, irreparable damage to park resources (Johnson, Vande Kamp, and Swearingen 1994). About 2/3 of the park superintendents reported damage to cultural or historical resources or theft of paleontological or cultural objects. This type of resource damage was estimated to exceed $80 million (Johnson et al. 1994).

Considering the frequency and intensity of reported damage to parks as a result of depreciative behavior, it is surprising that so little empirical work has been conducted in this area. Compounding the difficulty of developing effective interventions is the inconsistency of findings of the few studies that have been conducted. In addition, the variability of studied behaviors (e.g., theft, vandalism, off-trail hiking, and littering) makes comparisons of results difficult.

Two ways of examining these past studies are to consider what behaviors researchers were trying to influence and what method of influence they were testing. Most existing research

has focused on the noncompliant behaviors of off-trail hiking (Swearingen and Johnson 1988, Johnson and Swearingen 1994), campsite impacts (Clark, Hendee, and Burgess 1972; Oliver, Roggenbuck, and Watson 1985; Fazio 1979) and littering (Clark, Hendee, and Burgess 1972; Muth and Clark 1978; Iso-Ahola and Niblock 1981). Martin's (1987) study examined the effect of interventions on the theft of pumice from the Mount St. Helens National Volcanic Monument. Martin's study tested four interventions— three types of trailhead signs and a brochure. The most effective method was a sanction sign that threatened prosecution for removing pumice. Swearingen and Johnson (1988) also reported the most effective sign message to deter off-trail hiking was a sanction message. In contrast, Clark et al. (1972) found threats of citations or fines ineffective in controlling littering.

Methods of influence tested include interpretive signs with various text messages, symbolic signs, signed petitions, on-site uniformed presence, and brochures. For example, in Swearingen and Johnson's (1988) study, off-trail hiking was decreased by using various sign messages, including a sanction message, but the most effective method was the presence of a uniformed interpreter. Oliver et al. (1985) also found personal delivery of information to be the most effective method of deterring tree damage and litter. In contrast, other studies have found little to no increase in effectiveness of interventions due to personal contact (Neilson 1981, Roggenbuck and Berrier 1982). Roggenbuck and Berrier (1982) concluded that sometimes rangers are effective in influencing behavior and sometimes they are not.

Another way of examining behavior change research is to consider the particular theory being tested. Attempts to change behavior have been grounded in norm theories (Gramann, Christensen, and Vander Stoep 1992; Schwartz 1970; Noe, Hull, and Wellman 1982), attitude-based theories (Vincent and Fazio 1992, Ajzen and Fishbein 1989, Swearingen and Johnson 1988), moral reasoning theories (Stratton 1995; Swearingen 1989; Dustin 1985; Kohlberg, Levine, and Hewer 1983), and theories of positive and negative reinforcement (or applied behavioral analysis). The effectiveness of these approaches both across and within theories has been mixed. This is due in part to the complexity of behavior change itself. For example, within attitude-based approaches to behavior change, such variables as motivations, strength of held attitudes, foreseeability of consequences, accepting responsibility for those consequences, and perceived freedom of choice are thought to determine the effectiveness of persuasion techniques (Vincent and Fazio 1992, Chiaken and Eagly 1993, Petty and Cacioppo 1984, Swearingen 1989).

Vande Kamp, Johnson, and Swearingen (1994), after a review of depreciative behavior studies in parks, recommended that, due to the complexities of controlling noncompliant behavior, a multi-pronged approach should be used. Many have concluded that no one strategy will likely

be found to effectively control all depreciative behaviors in parks (Vande Kamp et al. 1994). Johnson and Swearingen (1994) concluded that, not only should multiple interventions be used, but that "rather than adopting a single theoretical viewpoint, research should draw from as many theories as possible in searching for interventions to be tested" (p. A-4).

Existing Behavior Change Interventions at PFNP

At the PFNP, several intervention strategies were already in place. All visitors entering the park were informed that removal of wood was illegal. Additional anti-theft interventions were found throughout the park and included the following: a video, several informational and educational brochures, numerous signs, and two visitor centers filled with several exhibits all aimed at reducing the theft of wood from the park. Intervention techniques appealed to visitors' consciences, their pocketbooks (i.e., fines), their responsibility to future generations, and the scientific value of the resource. These multiple interventions would seem to reach most visitors. In fact, results of our 1993 observation study indicated a theft rate of only 1.2%.

Given the inconsistent findings of past behavior change research and the situation existing at the park, we asked ourselves two general questions. First, what can we do in the park that is different and likely better than what currently exists? Second, how can we use theory to create the most effective interventions? In response to these questions, we decided to develop and test three different interventions, each incorporating several different theoretical approaches to behavior change.

Theoretical Grounding for Interventions

The Uniformed Volunteer. One intervention was to place a uniformed volunteer at our study site, Crystal Forest. To reduce depreciative behavior, the success of a uniformed presence on site is well documented (Vande Kamp et al. 1994). However, given budgetary constraints, this is often not a very practical intervention. As a result, we tested the effect of a uniformed volunteer on visitor behavior. The uniformed volunteer wore a volunteer shirt and hat and carried binoculars and a radio. She looked and acted much like a roving park ranger or interpreter.

The presence of a uniformed officer could invoke principles of normative social influence where behavior is influenced by the expectations of others (Chiaken and Eagly 1993). It could also serve as a prime for visitors' held attitudes that "stealing" is bad (Johnson et al. 1994, Petty and Cacioppo 1994; Chaiken and Eagly 1993). This intervention could also activate the schema or personal norm that theft of petrified wood is wrong (Schwartz 1970).

Applied behavior analysis (a theory of positive and negative reinforcement) and deterrence theories consider the uniformed presence to serve as a discriminative stimulus. For example, just as a police officer in the median strip serves to remind us that if we break the speed limit we get a ticket, the uniformed volunteer on site likely acts to strengthen the realization that a particular behavior (i.e., stealing petrified wood) results in a particular consequence (i.e., getting a fine) (Geller 1994, Vande Kamp et al. 1994).

Attitude researchers would interpret the same phenomenon as a product of priming a visitor-held attitude that "stealing" is bad (Petty and Cacioppo 1984, Schwartz 1970, Johnson and Swearingen 1994, Vincent and Faxio 1993). Normative research suggests that a uniformed volunteer intervention will be successful because it would serve to prime the exiting norm regarding theft behavior (Cialdina 1992, Chaiken and Eagly 1993).

The Sign. The second intervention was an interpretive sign. The sign was located next to the trail at the entry point to the study site. Near the top of the sign were three photographs of the Crystal Forest site depicting the progressive loss of petrified wood from 1965 to 1995. The third photograph was bare ground, and underneath the photo was a question mark indicating the uncertainty of how long the petrified wood would remain in the park. The sign read as follows:

> *Someone is Stealing Petrified Wood.*
>
> *Only YOU can protect the park treasures.*
>
> *At the present time, 99% of all park visitors DO NOT steal petrified wood. But 1% are thieves. One percent does not sound like much, but at this rate all of the wood would disappear in 15 years. Do not steal even one small piece. The minimum fine for petrified wood theft if $275. The fine for future generations is far larger.*

On the side of the sign's text was a mirror. Thus, the park visitor sees himself or herself as he or she reads the sign, reinforcing the statement that "Only YOU can protect the park treasures."

In keeping with the theoretical shotgun approach, the sign incorporated personal and injunctive normative theories, sanction messages, and ethical appeals, which have all been shown to impact behavior (Chiaken and Eagly 1993; Friedland, Thibaut, and Walker 1973; Schwartz 1970).

The sign was located next to the entry point of the study site. Research shows that signs placed at or near the impact site are more effective than those farther removed from the site (Fishbein and Manfredo 1992, Vincent and Fazio 1992, Geller 1994).

Attitude research indicates that if interventions are to affect behavior through attitudes, the appropriate attitude must be primed and made applicable to the situation (Vincent and Fazio 1992, Fishbein and Manfredo 1992, Petty and Cacioppo 1984). This literature prompted the inclusion of the photographs and the use of the word "steal." The use of the word "steal" conveys to visitors that taking petrified wood from the ground is stealing and is similar to stealing wood from the shelves of the visitor center. The photographs visually convey the message that stealing petrified wood is harming the resource, thus making the primed attitude regarding theft applicable to this situation.

Once an attitude is primed, many elements come into play to determine if it impacts behavior. Dissonance theorists claim two of these elements are responsibility for consequences and foreseeability of those consequences (Petty and Cacioppo 1984, Latane and Darlye 1975, Chaiken and Eagly 1993, Heider 1958, Aronson 1992). This literature prompted the inclusion of the message, "Only YOU can protect the park treasures. At the present time, 99% of all visitors DO NOT steal petrified wood. But 1% are thieves. One percent does not sound like much, but at this rate all of the wood would disappear in 15 years." This text serves the purpose of preventing the diffusion of responsibility and conveying what will happen if a visitor takes petrified wood (Chaiken and Eagly 1993).

Cooper and Fazio (1984) demonstrated that, to prevent attitude-behavior discrepancies, subjects must be able to predict what will happen after a behavior and must be willing to accept responsibility for those consequences. The text was written to tell visitors what will happen if they take wood, and the photographs were included to visually convey the same message. The mirror was also used to reinforce the visitors' responsibility for the consequences, thus helping to prevent the diffusion of responsibility.

Research on norms also supports the inclusion of the above text. Cialdini (1996) indicates that persuasive messages are more successful if injunctive and descriptive norms are in agreement. Congruent with this theory, what we tell visitors to do, i.e., "Do not steal even one small piece" (injunctive norm), is in agreement with the descriptive norm of what we say others are doing, i.e., "99% of all park visitors do not steal petrified wood."

The final part of the message is a sanction message. The effectiveness of a sanction message in deterring noncompliant behavior has been examined through applied behavioral analysis (ABA) theories, attitude-behavior theories, deterrence theories, and moral reasoning theories.

Applied behavioral analysis theories have been used to examine the effectiveness of threats of fines and citations for controlling littering (Heberlein 1971; Clark, Hendee, and Burgess 1972), illegal handicapped parking (Jason and Jung 1984), and off-trail hiking (Swearingen and Johnson 1988). While the results for littering were inconsistent, both illegal parking and off-trail hiking were most affected by a message that contained a sanction message (Vande Kamp et al. 1984). ABA would interpret this result as a product of the strong discriminative stimulus provided by the threat.

Attitude researchers could interpret the success of a threat as the result of priming or accessing the desired attitude (Chaiken and Eagly 193, Vincent and Fazio 1992). The sanction messages could also be considered by attitude research to fill the need of explaining the consequences of an action (Latane and Darley 1975, Chaiken and Eagly 1993).

Moral reasoning theories prompted the inclusion of two sanction messages, one addressing pre-conventional moral reasoning (rationale for behavior is to enhance personal reward or reduce likelihood of personal pain) and the other addressing higher levels of moral reasoning (or to act for the good of significant others, the group, future generations, or simply because it is the right thing to do) (Kolhberg, Levine, and Hewer 1983; Christensen and Dustin 1989). Kolhberg's stages of moral development indicate that persuasive messages should be tailored to the stage of moral reasoning held by the target individual. Since individuals at the park could be in any stage of moral development, we tried to include as many stages as possible. Addressing individuals in the pre-conventional stage of moral reasoning is the message, "The minimum fine for petrified wood theft is $275." The second sanction message included in the sign reads, "The fine for future generations is far larger." This is a sanction message that has an ethical appeal designed to reach those individuals in the conventional or post-conventional moral reasoning stages.

The Pledge. The third intervention tested was a signed pledge. When this intervention was in place, visitors were asked to voluntarily sign a pledge before entering the park. The pledge read, "I understand that petrified wood theft in the park is a problem. I agree not to take any wood from the park." Pledges were given at both entry points into the park. All individuals in each vehicle entering the park were asked to sign the pledge. Visitors were told the pledges would be displayed in the visitor centers; thus, visitors give a freely written, public commitment.

This intervention was based primarily on consistency and commitment theories. According to Cialdini (1992), individuals have internal and external pressure to be consistent with commitments, especially if those commitments are made in public and in writing. Research has demonstrated that written statements are very powerful in promoting behavior consistent with commitments (Jones and Harris 1967, Bem 1972, Freedman and Fraser 1966, Iso-Ahola and Niblock 1981). People tend to "live up to what they have written down" (Cialdini 1992, p. 67).

In a study conducted by Iso-Ahola and Niblock (1981), a signed pledge was found to reduce litter in a campground by 52%. These results could be interpreted in the above manner as a product of consistency and commitment pressures. However, demonstrating the interconnectedness of much of the world of theory, this result could also be interpreted as a product of norms. Iso-Ahola and Niblock (1981) noted an interesting twist to their results. The commitment, or signing a petition agreeing not to litter, was only effective in a cleaner campground. Cialdini (1996) might suggest that this is the result of a discrepancy between descriptive and injunctive norms. The injunctive norm that littering is unacceptable and wrong, which is emphasized through the petition, is undermined by the descriptive norm that everyone else is littering, which is evident in the littered campground. When the norms are in agreement, as in the cleaner campground, the intervention was successful.

Study Site. Since a 28-mile road traverses the park and visitors are able to stop in a variety of places where wood is accessible, monitoring wood theft and the effectiveness of any interventions throughout the park was not possible. As a result, we chose one site to conduct this study.

Crystal Forest proved to be the best site for several reasons. First, Crystal Forest has large supplies of highly accessible petrified wood, allowing for a theft to occur. Second, Crystal Forest receives approximately 56% of all visitors to the park. This high visitor usage should provide enough potential thieves and non-thieves to draw valid and reliable conclusions about our interventions. The site also provided places for discreet observation, which was necessary for the study.

It should also be noted that one existing National Park Service anti-theft sign was located on the site through the entire study. It read, "Removal of petrified from the park is prohibited," and was located near the entrance to the Crystal Forest site.

Study Design. A field experiment was conducted to determine the interventions' effectiveness in reducing the theft of petrified wood. Each of the three interventions was

randomly tested for 10 days during the summer of 1995. A control period, where no tested intervention was in place, was also tested for 10 randomly selected days. This resulted in 40 days of sampling. Each sampling day ran from 7:00 a.m. until 2:30 p.m., with a half-hour off for lunch at 11:30 a.m.

Data Collection. Data collection was conducted using on-site field observation of behavior. On-site observation of the site, because of its size, required that the site be divided into two sections. Two observers worked each sampling day, with one observer randomly assigned to each section of the site. A third observer, the counter, worked each sampling day to monitor use levels on the site, thus enabling an accurate estimate of the theft rate. In this case, we have reported the number of thieves and number of theft acts per 100 visitors to the site.

Observers had two primary directives for conducting data collection. First, all observers were to collect data in as unobtrusive a manner as possible. Observers dressed and acted like visitors to the park. Maintaining an unobtrusive presence was necessary to avoid any biasing effect of observation. For example, a visitor who noticed an observer with a pair of binoculars watching him or her would be unlikely to steal petrified wood.

The second requirement was that observers must be 100% sure that the person was indeed a thief. Given the task of observing theft and assessing the interventions' effects on theft, this many seem to be an obvious requirement. However, once in the field, it became clear that many thieves were very good at stealing. Many times, observers were almost sure a theft had occurred but did not actually see the wood go into a pocket or go off-site. If our observers were not 100% sure, we did not call it a theft.

We were especially concerned about the consistency or reliability of theft judgments across our field observers. To reduce any differences of variability in recorded thefts depending on observer, we took several precautionary measures. First, observers were instructed to be 100% sure and to record where the wood was as it left the site (e.g., in the left hand or in the front right pocket). In addition, observers were trained for three days, during which cross-validation of the observation of acts of theft occurred among all observers. Finally, observers were stratified across all four observation conditions (i.e., the three interventions and the control) so that they each observed an equal number of days for each condition.

Interventions' Effectiveness. Results of our experiment revealed that the interventions significantly lowered the theft rate below that of control conditions. Under the control condition, the number of thieves per 100 visitors was 2.09. This rate was significantly reduced to 1.43 for the sign, 1.41 for the pledge, and 1.38 for the uniformed volunteer interventions

(Table 48). None of our interventions was any more effective than another; in fact, it is remarkable how similar they were.

Table 48. Test of the effectiveness of three interventions to reduce the number of thieves of petrified wood.[a]

Group	Number of sampling days	Total number of visitors	Total number of thieves	Mean thief rate
Control	10	5674	118	2.09
Uniformed volunteer	10	5439	74	1.38
Interpretive sign	10	5369	75	1.43
Signed pledge	10	5596	80	1.41

[a]ANOVA contrast: control versus interventions: significant difference is $p = 0.017$. Uniformed volunteer, interpretive sign, and signed pledge were all more effective than control; no intervention was more effective than any other.

Table 49 indicates that there were more acts of theft than thieves. Several thieves picked up wood more than one time or at more than one location on the site. (Indeed, our observation of total acts of theft is slightly under-counted. We only recorded a maximum of three theft acts per thief, and we saw a few thieves take wood more than three times.) Our interventions, taken as a whole, did reduce theft rate. When we looked at individual comparisons of interventions to control, we found the sign and the uniformed volunteer to significantly reduce the total acts of theft, but the signed pledge did not. None of the three interventions differed from each other.

Observed Thief and Theft Characteristics. Tables 48 and 49 indicate that we observed 347 thieves and 449 acts of theft during the 1995 study season. Among the thieves, 61% were male; they averaged an estimated age of about 30, and average group size was 4.68. These numbers indicate that thieves were more likely to be male, young, and in larger groups than indicated by our 1993 field study.

Table 49. Test of the effectiveness of three interventions to reduce the number of acts of theft of petrified wood.[a]

Group	Number of sampling days	Total number of visitors	Total number of thieves	Mean theft rate
Control	10	5674	150	2.65
Uniformed volunteer	10	5439	89	1.66
Interpretive sign	10	5369	93	1.76
Signed pledge	10	5596	117	2.06

[a]ANOVA contrast: control versus interventions: significant difference at $p = 0.017$. Uniformed volunteer and interpretive sign more effective than control.

The average number of pieces of wood taken per act of theft was 1.56. The median distance to the next group of park visitors at the time of the theft was an estimated 23 feet, but for about 30% of all acts of theft, the next group was 10 feet away or less. The median number of people on site at the time of the theft was 20. About 71% of all acts of wood theft took place in the front portion of the Crystal Forest site in clear view of the parking lot— 35.5% in zone 1 and 35.6% in zone 2 (see Appendix J). About 11.2% of wood theft occurred in zone 3 and 17.9% in zone 4, well away from the parking lot (Appendix J). About 22% of all wood theft occurred on or immediately adjacent to the trail; 24% took place within 10 feet of the trail. Almost half (49%) occurred between 10 feet and 100 yards of the trail, and only 5% occurred more than 100 yards from the trail. Finally, about 47% of thieves showed their wood to others in the group. This is a somewhat lower involvement of the group in the wood theft than we found in the 1993 field season.

If we assume that the gender breakdown of visitors coming to Crystal Forest was the same across all interventions and control, then it appears that the uniformed volunteer on site was most effective for males compared to the other interventions. The uniformed volunteer worked equally well for females and males, but females responded to the sign and pledge more favorably than did the males (Table 50). Age and group size did not appear to vary among the control and various intervention conditions.

Table 50. Effectiveness of interventions by gender.

		Male	Female	Total
Control	Number	66	52	118
	%	55.9	44.1	100.00
Uniformed volunteer	Number	37	36	73
	%	50.7	49.3	100.0
Sign	Number	50	25	75
	%	66.7	33.3	100.0
Pledge	Number	57	23	80
	%	71.3	28.7	100.0
Total	Number	210	136	346
	%	100.0	100.0	100.0

Pearson chi-square: significant at $p = 0.04$

The three interventions and control also differed on their number of pieces taken per act of theft (Table 51), the zone on the site where the theft occurred (Table 52), and on whether the thief showed the stolen piece of petrified wood to other members of his or her party (Table 53). Table 51 indicates that the interpretive sign had significantly fewer pieces of petrified wood taken per act of theft than did the signed pledge. Under the control condition, 40% of the thefts took place in zone 1 near the parking lot, while the percentage of thefts there under the interventions was lower. However, wood theft was high in zone 2 (the other zone next to the parking lot) under the three interventions compared to the control condition (Table 52). As expected, under the control condition, thieves were more likely to show their stolen piece of wood at the time of the theft to their party members than they were under intervention conditions (Table 53).

Table 51. Number of pieces of petrified wood taken per act of theft under control and intervention conditions.

Experimental condition	Number (N)	Mean	Standard deviation	F	Significance
Control	150	1.51	1.32		
Uniformed volunteer	87	1.45	1.40		
Interpretive sign	92	1.22[a]	0.59		
Signed pledge	111	1.99[a]	2.52	4.134	0.007

[a]Signed pledge significantly larger than interpretive sign.

Table 52. Comparison of the zones of theft acts under control and intervention conditions.

		Control	Uniformed volunteer	Interpretive sign	Pledge
Zone 1	Number	61	24	30	25
	%	40.7	27.0	32.3	21.7
Zone 2	Number	34	27	32	43
	%	22.7	30.3	34.4	37.4
Zone 3	Number	15	13	5	11
	%	10.0	14.6	5.4	9.6
Zone 4	Number	20	13	16	21
	%	13.3	14.6	17.2	18.3
Do not know	Number	20	12	10	14
	%	13.3	13.5	10.8	12.2

Pearson chi-square test: significance at $p = 0.002$.

Table 53. Comparison of the percentage of theft acts where the thief showed the wood to party members under control and intervention conditions.

Showed wood to party members		Control	Uniformed volunteer	Interpretive sign	Pledge	Total
Yes	Count	80	37	42	51	210
	%	54.1	42.0	45.7	43.6	47.2
No	Count	55	47	43	64	209
	%	37.2	53.4	46.7	54.7	47.0
Do not know	Count	13	4	7	2	26
	%	8.8	4.5	7.6	1.7	5.8
Total	Count	148	88	92	117	445
	%	100.0	100.0	100.0	100.0	100.0

Pearson chi-square: significant at $p = 0.03$.

Discussion

Given the low control level of the rate at 2.65%, reducing the theft rate to as low as 1.66% may not seem like much. However, given an estimated 900,000 visitors to the park each year, this reduction in theft equates to about 8,000 pieces of wood not stolen each year. In addition, given the barrage of anti-theft messages aimed at visitors, it is very promising that our interventions reduced theft even further. To shed some light on why our interventions may be affecting theft, we turn to a brief discussion each of the three interventions.

What is different about our sign than the existing sign on the site at Crystal Forest? Research shows that our sign should be more effective for several reasons. The existing sign contains one written sanction message. In addition, the sanction message is general: "Removal of petrified wood is prohibited," and targeted only to those in the pre-conventional stage of moral reasoning. The interpretive sign tested in this research incorporated many theories of behavior change, including those found in the existing sign. As indicated in the literature review, by increasing the amount of theoretical grounding of a single intervention, in this case a sign, we should increase its overall effectiveness.

As with the existing sign, our sign contained a pre-conventional moral reasoning message and was located near the entrance to the site. However, recognizing that individuals can be in any

stage of moral reasoning, our sign also contained a conventional and post-conventional moral reasoning anti-theft message. Research also shows that persuasive messages should be specifically linked to the target behavior (Vande Kamp et al. 1994, Ajzen 1988, Chiaken and Eagly 1993). The existing sign says, "Removal of petrified wood is prohibited." Why is it prohibited? Are all the little chips included in the warning? What happens if wood is taken? Our sign should be more effective because it conveys the specific behavior we desire, "Do not steal even one small piece."

Second, we clearly communicate, through text and visual photographs, what will happen if just a few visitors steal wood. The foreseeability of consequences of a particular behavior is important if messages are to impact an individual's attitude toward the performance of that behavior (Latane and Darley 1975 Chaiken and Eagly 1993). Our sign clearly tells visitors what will happen— "All of the wood would disappear in 15 years"— if the behavior is performed.

Third, it is important that visitors not only be able to predict the consequences of an action but that they also accept responsibility for those consequences (Latane and Darley 1975, Petty and Cacioppo 1984, Chiaken and Eagly 1993). By using the text, "Only you can protect the park treasures," and the mirror, our sign conveys to each visitor that he or she is responsible for the condition of the resource.

Finally, the literature indicates that attempts to influence behavior are more effective if they are located closely in time and space to the opportunity to perform the behavior (Geller 1994, Aronson 1992).

We also found that the uniformed volunteer was an effective method to reduce the theft of petrified wood. Research suggests that this intervention was successful because of the strong discriminative stimulus it provided (Geller 1994, Vande Kamp et al. 1994). If we assume that most visitors to the park received the anti-theft message at the gate, then the success of a uniformed officer is due to the strong prime provided by her presence. Whether the uniformed presence primes an existing norm regarding theft behavior or an attitude that "stealing" is bad is unclear. It could also be that her presence sends a pre-conventional sanction message, "If you steal wood, I will catch and fine you." Although this is a message visitors may be receiving at the gate, the proximal presence of the uniformed officer may inhibit the performance of the prohibited behavior.

The effectiveness of the pledge intervention provides some interesting insights. While the other two interventions occurred on the study site, the pledge was more removed in time and

space from the study site. For example, some visitors entering the park on the north end may not have reached the study site for three or four hours. Much of the theory would suggest that, for this reason, the pledge would not be as effective as the on-site uniformed officer. This was indeed the case for number of theft acts. However, we found no difference in effectiveness between the tested interventions on number of thieves per 100 visitors. The pledge, although not proximal in nature, required visitors to make a commitment to be consistent with a statement not to take wood any time while in the park. The findings of this study support the theory that freely written, public commitments can be effective in promoting compliance with the commitment (Cialdini 1993, Freedman and Fraser 1966, Iso-Ahola and Niblock 1981).

We were surprised to find no difference between the tested interventions on number of thieves per 100 visitors. For example, unlike prior studies, we found that a good interpretive sign can be as effective as an on-site uniformed officer. The incorporation of many theories of behavior change into our sign could be the reason for this finding. Swearingen and Johnson (1988) found a uniformed officer to be more effective in deterring off-trail hiking that any sign text tested. However, examination of the text they tested reveals each message conveyed only one primary persuasive message. For example, "Off-trail hikers may be fined," and "No hiking— meadow repairs," were two signs they tested. Our sign may be as effective as a uniformed officer because it included many techniques shown to increase the effectiveness of persuasive messages. In any case, this finding is beneficial to managers who may not be able to place a uniformed presence on site but who need to protect the resource.

Another possible explanation for similar effectiveness of the interventions is found in the population itself. It could be, as some have indicated, that a certain percentage of noncompliant visitor behavior may be malicious and impossible to change (Vande Kamp et al. 1994). If this the case, then perhaps 1.4% is the lower threshold of theft that we can possibly hope to reach and any well-designed intervention could result in this level of theft.

1996 Field Season

Background

In 1996 we field-tested the effectiveness of strategically placed symbolic fencing at Crystal Forest in reducing petrified wood theft. Park managers had placed such fencing at suspected high-volume theft sites in the past. They thought it was likely to be effective. Past research had shown such fencing to reduce off-trail hiking at Mt. Rainier National Park (Swearingen and Johnson 1988), and our research had shown that park visitors would likely accept this

small amount of visual intrusion on the landscape. (About 50% supported putting up a low railing along foot trails; another 26% were neutral. See Table 24 on page 28.)

The Intervention: Symbolic Fencing

Our symbolic fencing was about three feet tall and consisted of portable segments of our strand or rail fencing made of wood. Each rail was held in place by portable wood tripods. The wood was designed to blend into the desert landscape. Park managers placed the fencing along the trail that looped through the Crystal Forest site at places of high wood concentration and/or places where park visitors had a tendency to wander off the trail. See Appendix J for a map of the fencing location.

Study Design and Data Collection

We used the same design and methods to test the effectiveness of symbolic fencing in 1996 as we had used to test the interpretive sign, the pledge, and the uniformed volunteer during the 1995 season, with one exception. In 1996 we only performed five days of observations under the control (no intervention) condition, and this was done on consecutive days late in July. Then the fencing was installed, and we carried out field observation of theft rate in 10 days in August.

As in 1995, we placed three observers on site. All dressed as tourists. Two unobtrusively watched for and recorded acts of theft and characteristics of the thieves. Two recorded the number of visitors entering the site during sampling periods. Each sampling day ran from 7:00 a.m. until 2:30 p.m. with a half-hour off for lunch at 11:30 a.m. Observers were trained as in the 1995 season.

Results. During our five days of control sampling, a daily average of 582 visitors entered the Crystal Forest site. On the 10 days of symbolic fencing, visitor counts averaged 567 per day. This difference was not significant. Our observers spotted a total of 181 thieves and 294 acts of theft across all 15 days of the study season. They spotted more thieves on control days in 1996 than our study team saw on comparable days in 1995 (i.e., 2.46 thieves per 100 visitors in 1996 compared to 2.09 in 1995). About 57% of the 1996 thieves were male; they averaged 29 years of age, and average group size was 3.82. These numbers are quite similar to thief characteristics observed in the 1995 field season.

The average number of pieces of wood taken per act of theft was 1.12. The median distance to the next group of park visitors at the time of the theft was an estimated 20 feet; but for about 27% of all acts of theft, the next group was 10 feet away or less. The median number of people on site at the time of the theft was 17, and the mean was 18.4. About 67% of all acts of

theft took place in the front portion of the Crystal Forest site (i.e., in zones 1 and 2; see Appendix J) in clear view of the parking lot. About 21% of wood theft occurred on or immediately adjacent to the trail; 38.5% took place within 10 feet of the trail. About 41% occurred beyond 10 feet of the trail. Finally, about 49% of thieves showed their wood to others in the group. These findings of the characteristics of theft acts are quite similar to those we observed in 1995. However, in 1996 the estimated number of pieces of wood was 1.12 pieces. For 1995 this number was 1.56.

Tables 54 and 55 indicate that symbolic fencing did not reduce the number of thieves nor the acts of theft below the control condition. There appeared to be several interaction effects between person characteristics and response to the symbolic fencing. For example, Table 56 suggests that women responded much more favorably to the fencing than did men. Also, group size of thieves appeared to be larger under the fencing condition than under the control (Table 57). The two groups did not differ by age.

Table 54. Test of the effectiveness of symbolic fencing to reduce number of thieves of petrified wood.

Group	Number of sampling days	Mean number of thieves per 100 people	Standard deviation	t	Significance
Control	5	2.46	0.87		
Symbolic fence	10	2.67	0.75	-0.49	0.63

Table 55. Test of the effectiveness of symbolic fencing to reduce the number of acts of theft of petrified wood.

Group	Number of sampling days	Mean acts of theft per 100 people	Standard deviation	t	Significance
Control	5	3.24	1.23		
Symbolic fence	10	3.46	1.00	-0.37	0.59

Table 56. Effectiveness of intervention by gender.

Gender		Control	Fencing	Total
Male	Count	27	70	97
	%	47.4	62.5	57.4
Female	Count	30	42	72
	%	52.6	37.5	42.6
Total	Count	57	112	169
	%	100.0	100.0	100.0

Pearson chi-square: significant at $p = 0.07$

Table 57. Comparison of group size of thieves under symbolic fencing versus control.

	Number	Mean	Standard deviation	t	Significance
Control	57	3.05	1.56		
Fencing	111	4.22	4.62	-2.40	0.02

The number of people on site at the time of theft and the zone of the theft also differed between the fencing and the control. The average number of people present on site during thefts under the fencing condition was 19.5; under the control, it was slightly smaller at 16.4 (Table 58). Table 59 indicates that, under the control condition, somewhat more wood theft acts occurred in zone 1 (near the parking lot; see Appendix J) than in any of the other three zones, and theft was quite evenly distributed among the other three zones. When the fencing was installed, there was a dramatic shift in the location of theft acts. There were far fewer thefts in zone 4 and a sharp increase in percentage of all thefts in zone 2. Zone 4 had substantial fencing, while zone 2 had almost none. Thus, while the amount of overall theft did not decline because of fencing, in at least one of the two zones where there was substantial fencing, theft rate appears to have gone down. Some contrary evidence occurred in zone 3. In that zone, there also was considerable fencing with no apparent decline in theft acts. Table 60 also suggests that there was a difference between the distance from the trail to the location of theft acts under fencing versus no fencing. The fencing did not seem to alter the number of theft acts that occurred at the very edge of the trail, but it seemed to increase the proportion of

all theft acts that occurred within 10 feet of the trail. In contrast, there was a smaller proportion of all theft acts more than 10 feet form the trail under the fencing condition than under the control condition. An interpretation of this finding is not immediately obvious. It may be that fencing encourages people to gather any wood quickly for fear of being seen "across the fence." Thus, they might not wander far from the trail.

Table 58. Comparison of the number of people on site at the time of theft acts under the fencing versus no fencing condition.

Experimental condition	Number	Mean	Standard deviation	t	Significance
No fencing	96	16.43	7.91		
Fencing	186	19.46	9.59	-2.83	0.005

Table 59. Comparison of the location of theft acts under the fencing versus the no fencing condition.

Zone		Fencing	No Fencing	Total
Zone 1	Count	33	57	89
	%	34.7	30.4	31.9
Zone 2	Count	22	76	98
	%	23.2	41.3	35.1
Zone 3	Count	21	44	65
	%	22.1	23.9	23.3
Zone 4	Count	19	8	27
	%	20.0	4.3	9.7
Total	Count	95	184	279
	%	100.0	100.0	100.0

Pearson chi square: significant at $p = 0.000$.

Conclusion

Summary of Park Visitor Characteristics

In our 1993 survey, we found that summer visitors to Petrified Forest National Park had the following characteristics:

Demographics

- Park visitors were typically highly educated, had relatively high incomes, were white, and married.

Group Characteristics

- Average size of visitor groups was 3.14.
- The vast majority visited the park in family groups with children or adolescents with them; about ¼ of all groups had a party member over 65 years of age.

Visit Characteristics

- For about 94%, PFNP was not their primary trip destination.
- About ¾ of all visitors were first-time visitors.
- Average length of stay was short, about 2.4 hours.
- More than 50% of all visitors spent some time at the Painted Desert Visitor Center, Agate Bridge, Crystal Forest, Newspaper Rock, Long Logs, Jasper Forest, Rainbow Museum, and Puerco Indian Ruins. Average length of stay at each place was short.
- About half of all visitors purchased at least one item at park gift shops.
- About 21% purchased petrified wood inside the park; 22% purchased petrified wood outside the park.

Visitor Sources of Information

- About 2/3 received information about the park before their arrival, but for about 20% of these, that information was a highway sign or map.

- Almost no visitor received park information directly from the park staff before their arrival.

- The official park brochure/map was by far the most common source of information about the park story and about park rules and regulations.

- Fewer than half of the visitors said they received information about park rules and regulations from the entrance station contacts, but they said they learned much more about rules and regulations there than they did about the park's story.

Visitor Perceptions, Attitudes, and Preferences.

- Park visitors were not very involved with national parks, but they enjoyed visiting them and were generally highly satisfied with them.

- Park visitors were generally very supportive of appropriate park behavior.

- Support for selling petrified wood in the park was mixed, but support generally exceeded opposition.

- Park visitors typically defined the act of taking petrified wood as a serious violation of ethics (i.e., they gave this a score of about 80 on a 0-100 seriousness scale), but harming endangered species or destroying Indian rock art or pots were rated worse.

- More than 90% of park visitors claimed they did the right thing out of concern for protecting park resources or for future generations, but a minority did admit that fear of rangers or fines altered their wood theft behavior.

- A small majority of park visitors liked to collect souvenirs of their park visits, but for most, the souvenir was a photograph. About 15% admitted to spontaneous, thoughtless purchases or collection to get a souvenir of their visit.

- The park was viewed as essentially problem-free. The need for additional rangers was seen as the greatest need, but even this issue was seen as not a problem or only a slight problem by most.

- More than ¾ of all park visitors support more aggressive law enforcement (except for searching of vehicles), increased visitor information on rules and regulations and reasons for them, and increased penalties for theft of petrified wood. About 50% supported putting up a low railing along the trails, and another ¼ were neutral about this intervention.

Summary of Thief and Non-Thief Comparisons

In 1993 we collected survey and observational data on thieves at Long Logs and Crystal Forest. In 1995 and 1996 we conducted additional observations of thieves at Crystal Forest. From these studies we were able to compare thieves and non-thieves:

- Thieves and non-thieves were much more similar in their characteristics then they were different. Thieves seem to come from all segments of the park visitor population.

- Possible differences between thieves and non-thieves included the following; thieves were more likely to:

  - Be male.
  - Be slightly less educated.
  - Visit in larger groups, visit in groups of families and friends, and have someone older than 65 in their group.
  - Have attitudes supportive of appropriate behavior in parks but to be less supportive of such behaviors than non-thieves.
  - Want information on rules and regulations in the park and rationale for them but to want these less than non-thieves.
  - Be dependent on non-written information about the park and its rules and regulations.
  - Oppose, or not support as much, various penalties for rule violation compared to the non-thieves.
  - Be spontaneous, thoughtless collectors of souvenirs.
  - Visit Rainbow Forest Museum and the trail through Giant Logs less often.

- Thieves typically did not seem to express fear of being seen. Other groups were typically on site at the time of the theft, and they were often close by.

- About 70% of all thefts occurred in zones close to the parking lot, and the majority of thefts occurred within 10 feet of the trail.

- One-half or more of the thieves showed their petrified wood to group members at the time of the theft, and group response typically was favorable.

Summary of Estimates of Petrified Wood Loss

Two approaches to estimate loss of wood were used: observation of visitor behavior at Crystal Forest and ground inventory of wood conditions at Crystal Forest, Blue Mesa, Jasper Forest, Long Logs, and Giant Logs in 1993 and 1994. Annual wood loss was estimated to be as follows:

Based on the ground survey and re-survey:

- For the park, 290,000 pieces (caution must be used in interpreting this figure because confidence intervals around this estimate were large).

- For Crystal Forest, 172,880 pieces (again, the estimate included large confidence intervals).

Based on observational studies:

- For Crystal Forest, about 20,000 pieces annually.

- Possible explanations for the large differences between the two estimates are

  - Observations were done at Crystal Forest for relatively brief time periods and did not include all the hours of the day.
  - Observers likely missed some theft.
  - Ground surveys covered all sources of loss or change in petrified wood conditions, including change due to wind or water erosion.
  - Sampling and measurement error in both types of studies.

Summary of the Effectiveness of Interventions to Reduce Theft

We compared the number of thieves and theft acts under conditions of control (no additional interventions beyond those already in place by the National Park Service) versus placing a uniformed volunteer on site, placing an interpretive sign about the problem of wood theft at the trailhead to the site, and asking visitors to sign a pledge at the park entrance not to take petrified wood. We later tested the effectiveness of symbolic fencing. Results of the field experiment were:

- All three interventions, i.e., the uniformed volunteer, the interpretive sign, the signed pledge, apparently each reduced the rate of thieves per 100 visitors by about 1/3, from 2.09 under the control condition down to about 1.4.

- None of the three interventions was better than any other one in reducing rate of thieves.

- Two of the three interventions—the uniformed volunteer and the interpretive sign—apparently reduced the number of acts of theft by about 35%, from 2.65 thefts per 100 visitors down to about 1.70.

- The signed pledge's apparent drop in acts of theft over control was not statistically significant. This was probably due to small sample size, rather than its lack of success.

- All three interventions appeared to work well for women. Only the uniformed volunteer appeared to be highly effective for men.

- The sign appeared to reduce the number of pieces of wood taken per theft compared to the signed pledge.

- All interventions seemed to sharply reduce theft in one zone near the parking lot, but none did very well in a second zone near the parking lot.

- When interventions were in place, thieves showed their stolen wood to party members less often than they did under control conditions.

- The symbolic fencing did not reduce either the number of thievess or the acts of theft below that of the control condition. We believe that this was because not enough fencing was installed, and what was installed may have been located in the wrong place.

- Women appeared to respond more favorably (i.e., steal wood less often) to the fence than did men.

- The fencing appeared to shift the location of theft from a zone of high fencing to a zone of low fencing.

- The fencing seemed to concentrate theft within 10 feet of the trail.

Recommendations to Reduce Petrified Wood Theft

Based upon the findings of this research project, we recommend that park staff at Petrified Forest National Park consider the following actions to further reduce petrified wood theft:

- Identify a standard of acceptable theft rate at the park or at different sites in the park. Park staff might develop a different standard at different sites. We think that if the acceptable standard was about one thief per 100 visitors, that standard could be achieved through the "light-handed" interventions of the type we tested in the study. If the standard is placed below one thief per 100 visitors, then more intrusive interventions will likely have to be implemented.

- Park staff should implement interventions with grounding in multiple theories of behavior change, such as the ones we tested in this study. This is because a variety of motives and visitor/site characteristics seem to prompt acts of theft. Thus, a single intervention should include grounding in, for example, attitude, normative, and behavior change theories.

- It is almost certainly best to implement multiple interventions so that visitors with various motives for theft will be reached. For example, the combined effectiveness of the signed pledge, the interpretive sign, and the uniformed volunteer should be tested.

- Interventions should clearly state what the expected appropriate behavior is and that virtually all visitors currently willingly do the expected behavior.

- Interventions should be located as close in place and in time to the desired behavior opportunity. Thus, when possible, the intervention should be introduced at the petrified wood site, rather than or in addition to the intervention being implemented at the entrance stations or at visitor centers.

- If symbolic fencing is introduced, it should line both sides of the trail through all or the vast majority of the site. It should especially be located along both sides of the trail near the parking area; most people visit this portion of wood sites and most wood is stolen there. Also, Swearingen and Johnson (1988) found a yellow nylon rope barrier to be about twice as effective as a split-rail barrier.

- If interpretive signs are implemented to reduce wood theft, they should be located on site, at a place where all or nearly all visitors will see them, and their messages should be chosen carefully. We think the message should be similar to the one we used on our sign, but park interpreters should not make the message too long.

- While the signed pledge was effective in reducing the number of thieves, we think it would be more effective if it could be administered in closer proximity to actual petrified wood sites.

- Park staff should re-evaluate the extent, type, and context of anti-theft messages given to park visitors at entrance stations. Surprisingly few park visitors said this contact provided them information about park rules and regulations or said it was their most important source of information about such rules.

- Thieves do not seem to be reading the park brochure and other written texts as much as non-thieves. Instead, they depend more on personal contact with rangers or on other more visual media. If possible, more rangers, including volunteer rangers, should be placed at petrified wood sites.

- Park staff should not avoid a more aggressive law information presence out of fear of negative reaction from the public. Park visitors support such intervention, with the exception of car searches.

- Some or perhaps most theft acts appear to be thoughtless or spontaneous. Given this, the park staff should do whatever it can to "prime" the proper attitude about park theft that virtually all park visitors seem to have. The problem appears to be that thieves do not access their appropriate attitude at the time of the theft. These actual and potential thieves need reminders on site, and the presence of a ranger, even a volunteer one dressed appropriately, would likely be most effective.

- Finally, park staff needs to establish a system to monitor the loss of petrified wood from the wood sites and from the park. Only then will the park know whether management and interpretive interventions are keeping park petrified wood conditions within acceptable standards.

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Appendix A

Exit Interview Contact Sheet

North Exit Contact Sheet
1993 Petrified Forest National Park Visitor Survey

Exit Information

Date: _____ Time: _____ AM / PM Contact # _____

Number of people in group: _____ Vehicle Type: _____

Entry Information

Date: _____ Time: _____ AM / PM Location: ( ) North (I-40) ( ) South (U.S. 180)

1. Approximately how much time did you spend at the following areas?
   Please enter the number of minutes you spent at <u>EACH</u> area.

   1. Gift Shop / Snack Bar (near South Entrance) _____
   2. Rainbow Forest Museum _____
   3. Giant Logs Trail (behind Museum) _____

   ---

   4. Long Logs _____
   5. Crystal Forest _____
   6. Jasper Forest _____

   ---

   7. Agate Bridge _____
   8. Blue Mesa Nature Trail _____
   9. Blue Mesa Scenic Loop _____

   ---

   10. Newspaper Rock _____
   11. Puerco Indian Ruins _____
   12. Painted Desert Inn _____

2. Approximately how much time do you plan to spend at the following areas?
   Please enter the number of minutes you plan to spend at <u>EACH</u> area.

   13. Painted Desert Visitor Center _____
   14. Painted Desert Gift Shop _____
   15. Painted Desert Restaurant _____

3. Please print your name and home address.

   Name _____

   Street Address _____

   City State Zip Code _____

South Exit Contact Sheet
1993 Petrified Forest National Park Visitor Survey

Exit Information

Date: _____ Time: _____ AM / PM Contact # _____

Number of people in group: _____ Vehicle Type: _____

Entry Information

Date: _____ Time: _____ AM / PM Location: ( ) North (I-40) ( ) South (U.S. 180)

1. Approximately how much time did you spend at the following areas?
   Please enter the number of minutes you spent at <u>EACH</u> area.

1. Painted Desert Visitor Center	_____
2. Painted Desert Gift Shop	_____
3. Painted Desert Restaurant	_____
4. Painted Desert Inn	_____
5. Puerco Indian Ruin	_____
6. Newspaper Rock	_____
7. Blue Mesa Scenic Loop	_____
8. Blue Mesa Nature Trail	_____
9. Agate Bridge	_____
10. Jasper Forest	_____
11. Crystal Forest	_____
12. Long Logs	_____
13. Rainbow Forest Museum	_____
14. Giant Logs Trail (behind Museum)	_____
15. Gift Shop / Snack Bar (near South Entrance)	_____

2. Please print your name and home address.

Name _____

Street Address _____

City _____ State _____ Zip Code _____

Appendix B

First Cover Letter

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE
AND STATE UNIVERSITY

Department of Forestry
School of Forestry and Wildlife Resources
Blacksburg, Virginia 24061-0324 USA
(703) 231-5482 FAX (703) 231-3330

1993

Dear Petrified Forest National Park Visitor:

We appreciate your participation in this study. From the Painted Desert to the Rainbow Forest, Petrified Forest National Park contains many important geological and archeological sites. The National Park Service is responsible for both protecting these unique resources and providing visitors with a high quality experience. This responsibility often presents complex management challenges. Understanding the park visitor is a critical element in meeting these challenges.

The following questions refer to your recent visit to Petrified Forest National Park. Please take the time to carefully fill out the questionnaire so that our results can be truly representative of all park visitors. When you have finished, please send the questionnaire back to us in the self-addressed, postage-paid envelope as soon as possible. While your participation is voluntary, and you are not required to respond, your cooperation is very important in making the survey results comprehensive, accurate, and timely.

This questionnaire has an identification number for mailing purposes only. Your responses will be held in strictest confidence. All results will be analyzed in such a way that your answers on any single question cannot be identified with you.

Thank you for your cooperation.

Sincerely,

Joseph W. Roggenbuck
Associate Professor of
Forest Recreation

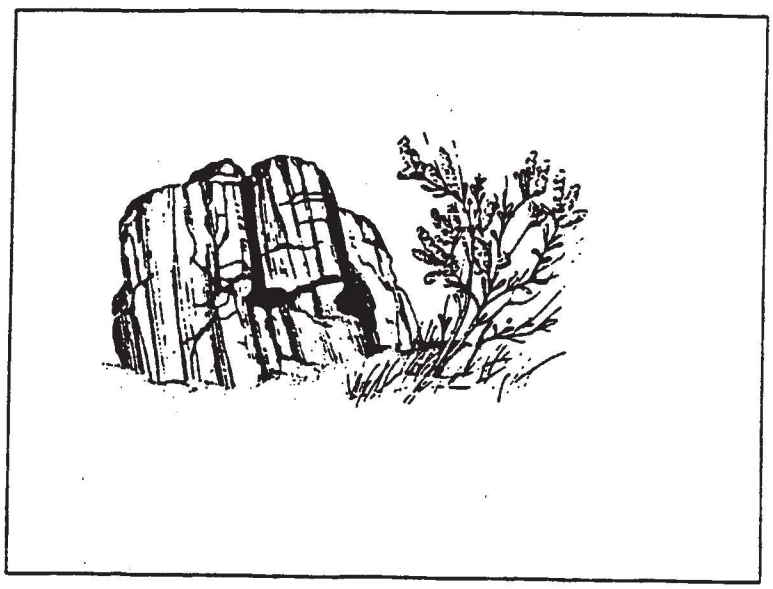
Dennis Stratton
Research Assistant

A Land-Grant University—The Commonwealth Is Our Campus
An Equal Opportunity / Affirmative Action Institution

Appendix C
Mailback Questionnaire

Petrified Forest National Park

Visitor Survey 1993



Virginia Tech

Department of Forestry
Virginia Polytechnic Institute and State University
Blacksburg, VA

Western Regional Office
National Park Service
San Francisco, CA

OMB #1024-0140 Exp. 9/30/94

Your Visit to Petrified Forest National Park

1. How would you describe the group you were with when you visited Petrified Forest National Park? Please check one.

   ( ) Alone—If alone, go to Question 3.
   ( ) Family only
   ( ) Friends only
   ( ) Friends and family
   ( ) Tour group
   ( ) Other organized group (e.g. school or church group, Scouts, etc.)
   ( ) Other, please describe: _____

2. Please tell us the number of people in your group and the number of group members in each age category listed below.

   _____ Total number of people in your group

   Were you traveling with any:

   Preschoolers (less than 5 years old)?
   ( ) No
   ( ) Yes—If yes, how many? _____

   Children (5 to 12 years old)?
   ( ) No
   ( ) Yes—If yes, how many? _____

   Teenagers (13 to 19 years old)?
   ( ) No
   ( ) Yes—If yes, how many? _____

   Anyone over 62 years old?
   ( ) No
   ( ) Yes—If yes, how many? _____

3. How many times have you visited Petrified Forest National Park, including this visit?

   _____ Total number of visits

4. Was Petrified Forest National Park your primary destination on this trip away from home?
   ( ) Yes
   ( ) No—If no, what other park and outdoor attractions have you visited in the four-corners region (NM, AZ, CO, UT) on this trip? _____

5a. People learn about the story of Petrified Forest National Park from different sources while at the park. Which of the following park information sources did you use? Please circle all that apply.

1 Official Petrified Forest National Park brochure/map
2 Official Petrified Forest National Park newspaper
3 Painted Desert Visitor Center exhibits
4 Painted Desert Inn exhibits

5 Rainbow Forest Museum exhibits
6 Rangers at points of interest (overlooks, archeological sites, geological sites, etc.)
7 Ranger-led walks
8 Ranger talks

9 Films or slide shows
10 Self-guided walks
11 Interpretive signs
12 Entrance station information
13 Other, please specify:_____

5b. Which of the above information sources was most helpful in learning the Petrified Forest National Park story? Write the number corresponding to the most helpful source.

_____ Most helpful

6a. People learn about the park's rules and regulations from many sources while at the park. Which of the following park information sources helped you learn about the park's rules and regulations? Please circle all that apply.

1 Official Petrified Forest National Park brochure/map
2 Official Petrified Forest National Park newspaper
3 Painted Desert Visitor Center exhibits
4 Painted Desert Inn exhibits

5 Rainbow Forest Museum exhibits
6 Rangers at points of interest (overlooks, archeological sites, geological sites, etc.)
7 Ranger-led walks
8 Ranger talks

9 Films or slide shows
10 Self-guided walks
11 Interpretive signs
12 Entrance station information
13 Other, please specify:_____

6b. Which of the above information sources was most helpful in learning the park's rules and regulations? Write the number corresponding to the most helpful source.

_____ Most helpful

7. Did you receive any information about the park before arriving?
( ) No
( ) Yes—If yes, from what source(s)? Please check all that apply.
( ) Magazine
( ) Book
( ) Travel guide

( ) Highway map or sign
( ) Tourist brochure
( ) Auto club

( ) Friends/Relatives
( ) Wrote/Called park for information
( ) Other, please specify: _____

8. Approximately how much time did you spend at the following areas?
Please enter the number of minutes you spent at EACH area.

Minutes

_____ Painted Desert Visitor Center
_____ Painted Desert Gift Shop
_____ Painted Desert Restaurant

9a. On this trip to Petrified Forest National Park, did you purchase any items from either of the two gift shops (Painted Desert Gift Shop or the Rainbow Forest Gift Shop) in the park? Do not include any items purchased from shops outside the park.

( ) No
( ) Yes—If yes, please tell us how much you spent on the following items.

$_____ Clothing (T-shirts, hats, etc.)

$_____ Native American jewelry

$_____ Petrified wood

$_____ Books, magazines, travel guides, etc.

$_____ Film

$_____ Glassware

$_____ Other, please specify: _____

9b. On this trip to Petrified Forest National Park, did you purchase any petrified wood from souvenir or rock shops outside of the Park?

( ) No
( ) Yes

10. To what extent did you find each of the following to be a problem during your visit to Petrified Forest National Park? Please circle the appropriate number.

	How much of a problem?				
	Not at all	Slight	Moderate	Serious	Very Serious
Litter along the road	1	2	3	4	5
Litter along the trails	1	2	3	4	5
Vandalism	1	2	3	4	5
Not enough law enforcement rangers	1	2	3	4	5
Inadequate visitor center information	1	2	3	4	5
Poorly maintained trails	1	2	3	4	5
Not enough hiking trails	1	2	3	4	5
Petrified wood for sale in the park	1	2	3	4	5
People collecting petrified wood	1	2	3	4	5
Too many people at the Painted Desert Visitor Center (northern I-40 end)	1	2	3	4	5
Too many people at the Rainbow Forest Museum (southern end)	1	2	3	4	5
Waiting at the entry/exit station	1	2	3	4	5
Too many people on petrified wood nature trails	1	2	3	4	5
Not enough signs to help understand the park features	1	2	3	4	5
Not enough rangers to answer questions about the park	1	2	3	4	5
Too many people hiking off the trails	1	2	3	4	5
Developed areas too close to major natural features	1	2	3	4	5
Too many rock shops just outside the south entrance station	1	2	3	4	5
Not enough wheel chair accessible trails	1	2	3	4	5
Not enough interpretive/nature trails	1	2	3	4	5

	How much of a problem?				
	Not at all	Slight	Moderate	Serious	Very Serious
Not enough scheduled ranger talks	1	2	3	4	5
Lack of a campground at the park	1	2	3	4	5

Your Feelings About National Parks

11. We would like to have an understanding of your general feelings about national parks. Please circle the number that best describes how much you agree or disagree with EACH of the following statements.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I get greater satisfaction out of visiting national parks than other vacation destinations.	1	2	3	4	5
I find a lot of my life is organized around national park use.	1	2	3	4	5
One of the major reasons I now live where I do is that it has opportunities for visiting national parks.	1	2	3	4	5
I seldom take the time to visit national parks.	1	2	3	4	5
Visiting national parks is one of the most satisfying things I do.	1	2	3	4	5
National parks play a central role in my lifestyle.	1	2	3	4	5

Your Feelings About Vacation Souvenirs

12. The following statements relate to your interest in vacation souvenirs. The statements may seem similar to each other, so please read each one carefully and respond to each one as honestly as you can. Please circle the appropriate number.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I like to collect souvenirs of my visits so I can remember my travels better.	1	2	3	4	5
Objects I collect during my travels impress my friends.	1	2	3	4	5
When I visit a place, I try to collect a keepsake that captures the meaning of that place.	1	2	3	4	5
When I find curious or unusual objects on trips, I like to collect them.	1	2	3	4	5
I collect items when I travel to let people know more about me.	1	2	3	4	5
I usually don't buy things in gift shops because they seem so artificial.	1	2	3	4	5
I take photographs mostly to help me remember the places I visit.	1	2	3	4	5
When an object catches my eye, I often experience an immediate desire to possess it even though I have no real use for it.	1	2	3	4	5
When I travel I carefully search for authentic objects that truly represent the places I have visited.	1	2	3	4	5
I like to collect souvenirs from my travels to show others about the places I visited.	1	2	3	4	5
I like to keep objects that remind me of special places I have been.	1	2	3	4	5
When I visit places on vacation, I often pick up knickknacks that grab my imagination.	1	2	3	4	5
I like to return from my travels with some unique souvenir.	1	2	3	4	5
I like to relive experiences through the objects I collect when I travel.	1	2	3	4	5
An important reason for taking photographs of the places I visit is so I can tell others about my trip.	1	2	3	4	5
When something I see catches my fancy, I often feel an irresistible urge to collect it.	1	2	3	4	5

Attitudes About Park Behavior

13. We would like to know your feelings on some general park issues. Please circle the number that best describes how much you agree or disagree with EACH of the following statements.

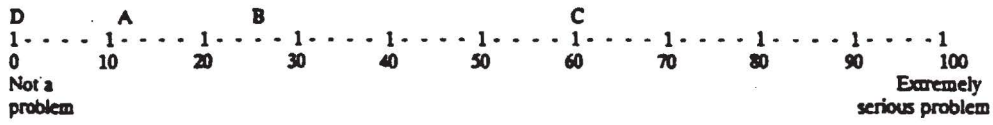
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
It is all right to pick wildflowers in a national park.	1	2	3	4	5
It is wrong to walk off trails when trails are provided.	1	2	3	4	5
It is all right to walk off the trail to get a closer look at Indian rock art.	1	2	3	4	5
It is wrong to pick up petrified wood, even if you put it back where you found it.	1	2	3	4	5
Seeing souvenirs made out of petrified wood in the park gift shops encourages people to collect a piece of petrified wood from the park.	1	2	3	4	5
Taking petrified wood reduces the beauty of the park.	1	2	3	4	5
I don't think I could tell a piece of petrified wood from an ordinary rock.	1	2	3	4	5
It is all right to collect fossils from a national park.	1	2	3	4	5
Being able to buy petrified wood in the park gift shop reduces the temptation to take a piece from park grounds.	1	2	3	4	5
It is wrong to sell petrified wood in the park, even though it does not come from the park.	1	2	3	4	5
It is all right to enter prehistoric Indian pueblo and pit house ruins in national parks.	1	2	3	4	5
It is all right to pick up petrified wood as long as you leave it in the park.	1	2	3	4	5
It is wrong to remove Indian arrowheads from the park.	1	2	3	4	5
It is all right to take a piece of petrified wood from the park as long as it is a small piece.	1	2	3	4	5
Seeing polished petrified wood in the visitor center encourages people to collect a piece from the park grounds.	1	2	3	4	5
It is all right to collect ordinary rocks while visiting the park.	1	2	3	4	5
It is all right to hike/climb to the top of the buttes or ridges near the park's petrified wood areas.	1	2	3	4	5
It is all right to climb or sit on logs of petrified wood.	1	2	3	4	5

14. Park visitors differ in their opinions on what actions are acceptable in national parks. Below, we have listed 11 things that visitors might do in a park. Each action is different, and each might be considered an unacceptable or problem behavior. We would like to know your feelings on the degree of seriousness of the actions. Rate the seriousness of the actions in relation to each other—not in relation to other possible problem behaviors that might occur.

If you believe the behavior would not be a problem—it would be acceptable in the park—assign it to 0. However, you do not have to assign a behavior to 0; nor do you have to assign the most serious problem behavior to 100. Be sure to assign a letter representing each behavior to a unit on the scale. This is not a test. The important thing is how you feel about each behavior.

HUNTING EXAMPLE

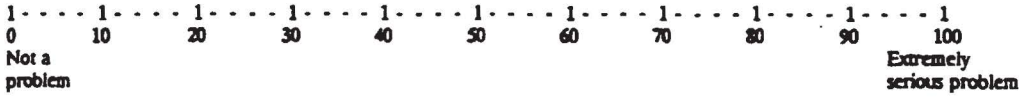
The following example of a hunter's evaluation of the seriousness of four behaviors on a 100-point scale should help you understand your task.



Hunter Behaviors:

A. Hunting on private land without landowner's permission
B. Shooting from a road
C. Carrying a loaded gun in a motor vehicle
D. Carrying a gun that is not in a case or not broken down in a motor vehicle

REMEMBER: We are interested in the seriousness, not the frequency, of park visitor actions. Please assign the letter representing EACH action to its appropriate place on the scale.



Park Visitor Actions:

A. Purposely harming an endangered plant or animal
B. Travelling 55 miles per hour in a 45 miles per hour speed zone in the park
C. Defacing Indian rock art in the park
D. Picking wildflowers in the park
E. Taking one small piece of petrified wood from the park
F. Littering in the park
G. Removing prehistoric Indian pottery, or pieces of pottery, from the park
H. Purposely harming a prairie dog
I. Taking a handful of petrified wood from the park
J. Collecting Indian arrowheads in the park
K. Feeding wildlife in the park

15. We are interested in what are the most important reasons visitors have for not taking petrified wood from the park. Please tell us how important each of the following reasons were in influencing you not to take petrified wood from the park. Please circle the appropriate number.

	How important?				
	Not at all	Somewhat	Moderately	Very	Extremely
I want petrified wood to be there for future generations.	1	2	3	4	5
I fear I will be caught by a park ranger.	1	2	3	4	5
I want national parks to be preserved in their most pristine condition.	1	2	3	4	5
Other people that I care about wouldn't like me to take petrified wood.	1	2	3	4	5
I want to follow park rules.	1	2	3	4	5
I want to set a good example for others.	1	2	3	4	5
I don't want petrified wood.	1	2	3	4	5
I don't want to be caught and fined for taking a piece of petrified wood.	1	2	3	4	5
I want to leave the petrified wood there for others to enjoy.	1	2	3	4	5
My religious beliefs prevent me from taking a piece of petrified wood.	1	2	3	4	5
I want to leave the petrified wood there for my family and friends to enjoy.	1	2	3	4	5

16. If a scientific study determined that an unacceptable level of park resources were being damaged or removed from the park, how would you feel about each of the following management actions? Please circle the number that shows how much you support or oppose EACH action.

	Strongly Oppose	Oppose	Neutral	Support	Strongly Support
Provide more aggressive enforcement of park rules and regulations.	1	2	3	4	5
Require people to stay on the paved paths.	1	2	3	4	5
Have more signs telling people what the rules are.	1	2	3	4	5
Put up fences around important park resources.	1	2	3	4	5
Put up a low railing along foot trails.	1	2	3	4	5
Put up more signs that help educate visitors on the rules and the reasons behind them.	1	2	3	4	5
Have more rangers patrol the sites that are experiencing high levels of resource damage and/or theft.	1	2	3	4	5
Provide more information in the visitor center on the rules and why it is important to follow them.	1	2	3	4	5
Allow only ranger-guided walks in petrified wood areas.	1	2	3	4	5
Prohibit visitors from picking up petrified wood.	1	2	3	4	5
Build boardwalks with railings to keep people on the trails.	1	2	3	4	5
Search vehicles as they leave the park.	1	2	3	4	5
Increase the penalties for damaging and/or stealing park resources.	1	2	3	4	5
Provide park visitors with more information on appropriate park behavior.	1	2	3	4	5
Ban the sale of petrified wood in the park.	1	2	3	4	5

Some Information About You

17. Your age? _____ Years

18. Gender?
( ) Male
( ) Female

19. What is the highest educational level you have attained? Please circle the highest grade completed.

1 2 3 4 5 6 7 8	9 10 11 12	13 14 15 16	17+
Primary School	High School	College	Graduate Work

20. Which of the following income levels best describes your total household income before taxes?
( ) Less than $13,000
( ) $13,000 to $24,999
( ) $25,000 to $39,999
( ) $40,000 to $59,999
( ) $60,000 to $99,999
( ) More than $100,000

21. What is your ethnic origin?
( ) Native American
( ) Asian or Pacific Islander
( ) Black
( ) White
( ) Hispanic
( ) Other

22. Are you currently married?
( ) Yes
( ) No

23. Do you have children under 5 years old living with you?
( ) Yes
( ) No

24. Do you have children between 5 and 17 years old living with you?
( ) Yes
( ) No

25. What is your present employment status?
( ) Employed outside the home
( ) Unemployed
( ) Retired
( ) Full-time homemaker
( ) Student

Thank you for your time and effort. We appreciate your willingness to respond to our questionnaire and welcome any comments you wish to make. We have provided space below for your convenience.

16 U.S.C. 1a-7 authorizes collection of this information. This information will be used by park managers to better serve the public. Response to this request is voluntary. No action may be taken against you for refusing to supply the information requested. Your name is requested for follow-up mailing purposes only. When analysis of the questionnaire is completed, all name and address files will be destroyed. Thus, the permanent data will be anonymous. Please do not put your name or that of any member of your group on the questionnaire. Data collected through visitor surveys may be disclosed to the Department of Justice when relevant to litigation or anticipated litigation, or to appropriate Federal, State, local, or foreign agencies responsible for investigating or prosecuting a violation of law.

Public reporting burden for this form is estimated to average 20 minutes per response. Direct comments regarding the burden estimate or any other aspect of this form to the Information Collection Clearance Officer, National Park Service, P.O. Box 37127, Washington, D.C. 20014-7127; and to the Office of Management and Budget, Paperwork Reduction Project 1024-0091, Washington, D.C. 20503.

Appendix D
Postcard Reminder

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE
AND STATE UNIVERSITY

Department of Forestry

College of Forestry and Wildlife Resources
Blacksburg, Virginia 24061-0324 USA
(703) 231-5483 Fax: (703) 231-3330

Dear Petrified Forest National Park Visitor,

We recently contacted you requesting your participation in the 1993 Petrified Forest National Park General Visitor Survey. If you have already completed and returned the questionnaire to us, please accept our sincere thanks. If not, we would appreciate you doing so as soon as possible. The survey has been given to only a small number of Petrified Forest National Park Visitors. If the results are to accurately represent the opinions of all park visitors, it is extremly important that your opinions be included in the study.

Thank you for contributing to this important project.

Sincerly,

Joseph W. Roggenbuck
Associate Professor of
Forest Recreation

Dennis W. Stratton
Reseach Assistant

Appendix E

Second Cover Letter

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Department of Forestry
School of Forestry and Wildlife Resources
Blacksburg, Virginia 24061-0324 USA
(703) 231-5482 FAX (703) 231-3330

During your recent visit to Petrified Forest National Park, we contacted you and asked you to complete a survey on park management issues. You were one of a few visitors randomly selected for this study, therefore your participation in it is essential if the results are to be useful in guiding future decisions about the use and protection of the park. This study is an opportunity to express your personal experiences and feelings as a visitor. If the results are to accurately represent the opinions of all park visitors, it is extremely important that your opinions be included in the study.

As of today, we still have not received your completed questionnaire. If you have already completed and returned the questionnaire to us, please accept our sincere thanks. If not, we would appreciate you doing so as soon as possible. If you would like to know what other users think, please print your name and address on the back of the return envelope.

Sincerely,

Joseph W Roggenbuck

Dr. Joseph W. Roggenbuck
Associate Professor, Forestry

Appendix F
Respondents' Written Comments

"I would like to see more signs on the road to the Painted Desert. Maybe a mid-point rest area would be ideal. A sign suggesting 'entering Painted Desert,' for example, should be posted so people would know the following points of interest are in the desert. I enjoyed the Petrified Forest thoroughly. It is educational and natural. Keep it up."

"The park was great. We were very pleased with what we saw and did."

"We enjoyed our visit to our National Park. The Ranger and Crew were very helpful and polite and cheerful. We did notice, even though it was well marked, people did not stay on the walks—parents should set a better example for their children. We saw them taking their children with them off the walks, picking up petrified wood, and throwing it. Maybe you should charge more for children. Also, there are a lot of us senior citizens that wouldn't mind paying $1.00 to go into the parks. They are so beautiful and well maintained. I would like to see more Rangers on duty but realize it takes lots of money. How about some teenage Rangers who could be teaching other teens about our beautiful country? Thank you."

"Enjoyed the video at the information center –this would be a good item to sell."

"Petrified Forest—very informational, amazing that trees turned to stone. Painted Desert - beautiful, amazing sites. Colors were incredible. Fascinating park—a definite visit back. Will have to come soon."

"We enjoyed the Park very much."

"My family and I enjoyed our visit to the Park. We did stop a few times at various points, but this visit was more of a 'drive through' for us. Based upon the number of visitors I observed, I can see that Park preservation is a real challenge."

"Visitors from England and Canada were very awed by the sights they experienced. Will come back again."

"Tell parents to keep children off of Pueblo ruins. The kids do not know what they do."

"This was my first visit to Grand Canyon and Petrified Forest. The beauty cannot be accurately described in words or through pictures. Hopefully, the Parks can be preserved without fences, etc., because these would detract from the beauty."

"I will return to the Park as I had hurt my knee and could hardly walk. I usually take in all the sites and visit everything. The Park is a beautiful place and should be here for generations to come. Once it is gone it cannot be replaced. I feel people from other countries do not realize the importance of our National Parks and Monuments. Please help to safeguard them. Thank you."

"The questionnaire seemed long and redundant. Thanks."

"Dear Dr. Roggenbuck: Please excuse my late answer, but I just came back from a six-week vacation which brought me to 70% of all American National Parks. As you recognize in my written letter, I am not an American citizen. I'm living only a short time (4 years) in the U.S. and I enjoyed all these famous parks, and my opinion is that the American people can be very proud to have these parks and they should do all that is necessary to protect and support them. I hope I could help you with my opinions about rules and behavior in the park."

"I really enjoyed visiting that very special national park. I'm very interested in archeology, so I understand the problems you're confronted with, but I trust many people, so I think/hope that no aggressive enforcement of rules and regulations through higher fines will be necessary to keep the National Park in the same condition as when I've visited it. I hope (and my family and friends too) that we could help you with your researches. Sometimes the questions were asked in a strange way; we hope that we have answered them correctly."

"I have one comment or suggestion. While we were in the Park, we saw only one Park Ranger, and as it happened, he was arriving at each stop as we were arriving. This was because he was picking up trash with some other workers. I think there should be more guides along the way to ask questions of and also keep an eye on people if there is a problem with people not obeying the Park rules."

"It is a beautiful park. Keep it that way. Need more information on its history."

"You do a thoroughly adequate job of informing visitors that they are not to take petrified wood. Your displays in the Visitor Center showing the woes of those who have taken petrified wood are humorous yet effective. Keep up the good work and simply enforce consistently the rules you have."

"The Park is really strict about stealing the wood. That's the way it should be, but it's really a shame that anyone would steal it. The sale of petrified wood outside the Park discourages stealing, I think. If you are able to buy some, why steal it. It seems that the gift shops have more of it than the Park. The Park has to preserve what it has for the future. To see and touch trees that have turned to rock is a sight to see. Thank you for the memories."

"We enjoyed our visit to the Park. We hope it stays as is for future generations to enjoy. Keep up the good work."

"I believe all parks should have more information (signs) about each site."

"Touch Tables are a wonderful resource for 'curious' tourists and can help curb the destruction of resources accidentally. Also, guilt photos and information of past destruction posted at the beginning of trails, entrance, etc., could help to 'remind' people of their responsibility to the parks and their continued accessibility to these natural resources."

"We enjoyed our visit to the Petrified Forest and enjoyed being able to walk through the Park. I was disappointed to see people carved their initials along with the Indian drawings."

"We visited 30 years ago and it is much as it was then. Keep up the good work. Thank you."

"I thought everything was great—managed well."

"I love your 'area' out here and visited 21 years ago. The one sign that I saw at another national park that stuck with me all these years was: 'Take only pictures, leave only footprints.' Sums it up, wouldn't you say? I might add that in buying souvenirs I do like authentic things such as what the Native Americans make. I hate shipped-in stuff."

"I'd only wish my fellow Italian politicians in charge of territory and art treasures to be so proud and careful as you are, for pebbles as well! We unfortunately had (in Italy) some Rome and B.C. sites concrete-restored/paved. Awful. Thank you."

"I believe selling petrified wood in the shops is great. When my children asked if they could take some, we explained the rules of the Park. It was nice because we could also tell them we would buy some at the end of the forest. Which we did before we left. My son has already shown them to his class (second grade). It was hot the day we visited the Park, but we enjoyed it immensely."

"I work in Hungary. Translating park brochures into some of the secondary European and Asian languages would be helpful. Of course, I would prioritize the task based on the volume of visitors from a given language area."

"Good luck on your graduate work! We loved our trip and visited over 16 National Parks and/or Monuments with our children."

"I wish we were not as rushed to get to our destination and could have spent more time in the Petrified Forest. We realized afterwards we had not allowed enough time. It was most enjoyable. Everyone was very helpful. This was our first trip out west. All the beautiful sights we saw made us realize what a beautiful country we have. We enjoyed the view, whether it was mountains or salt flats. It was something different."

"The contract vendor (I forget his name) at many parks should be required to implement waste reduction efforts (less use of disposables). Education is very important. Perhaps an explanation of an archeological 'dig' would impress on people the importance of not disturbing artifacts."

"We weren't there for very long, but it seems to me that the people who want to take the petrified wood are going to do so no matter how many signs you put up unless you have a ranger there to stop them."

"Enjoyed the Park very much."

"I thought the Park was very clean. I was really impressed. However, I visited before the rush began—not many people at Park at this time. I didn't see many Rangers in Park, but I guess not many were needed to patrol because of low number of visitors. This visit was a most enjoyable trip."

"I enjoy visiting national parks and know if people pick up items there, then it won't be long until nothing will be left to see. Also, I'm a retired U.S. military and retired from 20 more years in law enforcement, so know the problems with theft, etc."

"The only complaint that we had was that the gift shop was over-priced. We found the park employees friendly and helpful and the restrooms clean. I enjoyed the Painted Desert more than the Petrified Forest."

"I wonder if the sale of petrified wood and other natural 'wonders' and organic rock formations encourages visitors to retrieve a personal souvenir of the area??? I especially enjoyed the film about how the Petrified Forest was formed (at the visitor's center). Thank you for allowing me to express my opinions. I am a sociologist and appreciate your survey work and data collection."

"I never saw a Park Ranger at any of the sites. They would and could drastically reduce losses of our national parks assets. Their presence establishes the expected decorum by park patrons."

"While some of my responses seem to contradict other answers, my philosophy is that:

A) I respect this property
B) I'm honest
C) I'm a cheapskate
D) I like nature on the water (ocean, bays, etc.)
E) I'm a sailor (sailboat type, not a camper/hiker)
F) I'm curious—get a closer look, but do not disturb
G) My daughter is a Park Ranger in RI and studying Environmental Sciences in college.

Hope you understand my response better now!"

"When our family approached the north end, we watched the 17-minute film and bought some books and the Petrified Forest Road Guide. The tape was extremely helpful in enabling our family to fully appreciate the natural formations and understand the history behind them. My daughter suggested that the tape or a similar information system be made available at a nominal fee—something that would be returned at the end of the visit. Our family would have found it helpful to have had drinking fountains available, especially at the areas where there were trails. We really appreciated the help we received from the Ranger on duty at the north end visitor center June 13 (we did not get his name). He explained the junior ranger program and the rangers at the south end were great in giving our kids their badges."

"I really enjoyed the Petrified Forest."

"We really did enjoy our trip! My dog was with us and I always carry a 'mister' to keep her (me too!) cool. It would be nice to have areas where one may sit in the shade. I have fibrocitis and need areas of shade—the car gets very hot! Also, elderly people sometimes have trouble with the heat. I want to enjoy our parks and so would my mother-in-law, age 83. My husband loves going on the trails and we must stay behind. I hope my comments are of some value."

"[Entering prehistoric Indian pueblo ruins] is allowed in some cases in some places (Mesa Verde). Under supervision, I don't see anything wrong with visiting a pueblo. It is not a sacred place (sacred places should be respected). I try to respect the speed limits everywhere, but I don't think Park Rangers should waste time ambushing tourists with their radars at 9 am when there is virtually no traffic. I found the many changes from 35-mph to 45-mph zones rather confusing and distracting and sometimes did not know anymore where I was. One way to improve this would be to put more signs, reminding tourists of the speed limit applicable where they are. This comment is 'free of charge.' I did not get stopped for speeding or anything else, but again, I found the system confusing."

"I would appreciate more signs identifying the rocks, plants, etc. that we saw, plus signs reminding us of the rules and the reasons for them. I would also like to see more handicapped paths without steps and steep inclines—possibly even a battery-operated shuttle to the best places for the elderly and handicapped."

"The 'film' (17 minutes) at visitor center was poor—not very informative, not to the point on how petrified wood was formed! Music in film was distracting! Anything you buy at a National Park is a rip-off—such as food, gas, lodging, gifts, etc. Gas at the Painted Desert was terrible at $1.39 a gallon!! Why is this so? I resent it and that's why I don't go to national parks. The cost of gasoline at the Painted Desert was higher than anyplace else in New Mexico!"

"A trail to the Indian rock art would be appropriate. It would make it easier to take pictures. More signs about the Indian ruins, also about the Petrified Forest while on the trails, maybe even a brochure corresponding to numbered areas on trails. I enjoyed the scenery and sights very much. Overall, this was a very good experience."

"You can have all the rules and regulations you want, but it is up to each individual to have responsible behavior. To encourage this, people must know the reasons why the national parks are important for all of us to preserve. But, as with everything else, it only takes a few to ruin it for the rest of us. We have been to 6 National Parks this summer and found them well managed and 'Ranger friendly'. Good luck with your survey."

"For a European like myself, this particular park was amazing both in size and for its content."

"We enjoyed our visit to the Petrified Forest National Park. Our only regret was not being able to spend more time there. Hopefully, we can visit again in the near future. Thank you to the National Park Service for maintaining this important part of our archeological history."

"(1) We enjoyed the picnic area in the north end of the Park. (2) We witnessed more than one group of people removing petrified wood in the Rainbow Forest Museum by putting it in their backpacks and camera cases. It would be simple to ban such items from that area, especially since a fence already exists. (3) As we entered the Park, we were told not to remove wood, etc. When we left we were asked if we had removed anything. The rules couldn't be much clearer. The theft that occurs is deliberate."

"On our approach to one of the hiking areas in the Petrified Forest, we observed a Ranger vehicle parked facing the wrong way on the side of the highway. On further observation we spotted two Rangers obscuring themselves on one of the mounds—quite a distance from the trails—and observing the visitors with binoculars! We felt this type of surveillance to be underhanded and undignified. Their mere presence among the visitors in that area would have served a sufficient and more friendly purpose. Other than this small incident, our visit to the Painted Desert and Petrified Forest were most enjoyable, as we stood in awe of God's handiwork. You didn't ask for comments on the Grand Canyon but I would like to note that the Park Service could provide more adequate facilities there to handle the overcrowding of people (parking, visitors center, rest rooms, lookout points, etc.). We didn't get to spend as much time there as we would have liked because of the congestion."

"I visited the Park approximately 20-25 years ago and it was painfully obvious the vandalism that has occurred during that span of time. I told my children what it looked like when I was there years before."

"The wife of the researcher was the one who asked us for time to do the questionnaire as well as gave us this questionnaire to fill out. Why didn't or doesn't the researcher himself do the work???"

"I found your survey interesting. I hope people take care of our National Parks. I hope my kids and their kids have great National Parks to visit when they grow up. We have enjoyed over 20-25 parks with our kids so far. Our kids are 6, 8, 11, 12. Keep up the good work with the Parks. Hopefully, more money will go into our National Parks."

"The Junior Ranger program is great!"

"Save the National Parks for future generations!"

"National Parks are important for future generations of mankind!"

"We enjoyed the Forest."

"We enjoyed the Park. We would appreciate better explanation of the sites in the official map/guide. For example: Agate Bridge is not described and appears only as a restroom facility on the map. Since we didn't need to use the facilities we skipped the stop. As we exited, we learned there was an attraction and we were disappointed to have missed it. Good luck with your thesis."

"I found the Park to be truly fascinating and filled me with a real sense of awe and didn't show any sign of wanting to exploit tourism. My only regret was being unable to spend more time there; however I plan to return in the future. Keep up the good work. Thank you."

"We enjoyed our trip in the Park very much. We hope to return one day."

"Enjoyed the Park/features tremendously. Plan future visits. Keep up the good work. Ask for pay raises (another federal employee)."

"I think that with more Rangers visible at appropriate sites, some of the vandalism would lessen. Newspaper Rock is so hard to see, and with it being exposed directly to weather and elements, it would make sense to me if you took the picture graphs out of the canyon and into the Visitor's Center or museum in a glass case for all to enjoy close up."

"People are too often judged by what they look like. While visiting the Park we were interrogated by a Park Ranger. It is actions like this that prevent people from enjoying the Park and wanting to come back again. And furthermore, little things like this [reference to 'Data collected through visitor surveys may be disclosed to the Department of Justice when relevant to litigation or anticipated litigation, or to appropriate Federal, State, local, or foreign agencies responsible for investigating or prosecuting a violation of law.'] make me tend to hesitate filling out this questionnaire."

"In our visit to the Grand Canyon, we took the train. I believe there should be more of this and the banning of cars and motor homes. My only complaint in our visit is the lack of drinking water and very poor service at food concessions. My daughter is an asthmatic and we had trouble locating water for her. This is unacceptable!!"

"I enjoyed the Park very much and the Rangers are doing an excellent job!"

"Giving a small piece of petrified wood for each car (if people want it!) would limit wild pick up."

"Enjoyed the Park's variety of colors and landscapes. Hoping to visit the Park again to explore all of its beauty. Also to understand the Park's existence and to share this with some of my friends."

"You need signs announcing the Teepees Formations. I could not find any on the roadside as you approach them from either direction."

"I came to the Petrified Forest twice as a youngster, once in my 20's, and on this trip I brought my son. We were in Mesa Verde headed to the Grand Canyon and we came out of our way because I wanted him to see this. I feel that the way this is set up is excellent. I would be turned off if there were fences and boardwalks. My feelings are that it doesn't matter if you sell the wood in the Park or not and if they sell it outside the Park or not. If a person wants to steal or deface the property they're going to. I really would hate to see fences go up and take away from its natural beauty—it's a beautiful park!"

"We have done very little traveling in the last few years and as we live in Michigan we are not close to the major parks. It was good to get the chance to see them. Thank you."

"We were traveling with a pet and were very limited because of the pet rules. I feel it would have been OK to take our leashed pet on the trails. We would have enjoyed our visit much more. We enjoyed the picnic tables at the Rainbow Forest. My favorite site was the Painted Desert. How beautiful!"

"I am French and regret that not any brochure is written in French. We do it our country for visitors of other countries in several languages."

"Compared to European standards, I was thrilled by the U.S. National Parks, by the freedom given to the visitor to discover on his/her own. The visitors are treated with respect and goodwill. I found this pedagogically rewarding. My kids—although very tempted by the beauty of the petrified wood—considered it unfair to exploit this given freedom and trust. I was equally impressed by the friendliness and patience of the Rangers."

"I apologize for taking so long with this questionnaire. I support studies and learning."

"Observed many people not observing the 'Stay on Path' signs, crawling over rare petroglyphs (adults and children). No Rangers whatsoever to enforce Park rules. Only evidence of Ranger activity was at entrance and the Rainbow Museum. Would be nice to provide some interpretations of the various petroglyphs."

"Over the years I have seen the National Parks subjected to greater and greater abuse, possibly from a 'less educated' populace. More education and, if necessary, more enforcement of current rules. I believe the current rules are adequate if enforced. My grandson, age 8, who visited with us is being taught to appreciate our Parks and to take nothing from them and to leave nothing (trash) behind him. It is working! Thank you for a nice visit!!"

"I hope this survey is not a waste of taxpayers' dollars and that it is serving a useful purpose."

"We participated in the random survey at the Park and were not informed that there was an additional 11-page survey. You are taking advantage of our generosity and I am annoyed at the time spent filling this out. Many questions are redundant, merely reworded. But . . . we enjoyed the Park."

"This is the second questionnaire I have completed and sent to you. That should be enough."

"For a foreigner it is very difficult and time-consuming to answer this questionnaire. Please take into consideration my limited English experience when evaluating this questionnaire."

"I'm proud of my country and its National Parks! Bless you all!"

"The Petrified Forest was one of the most beautiful places I have ever visited. I have a strong belief that the only thing that I or my family should take from nature preserves are photos and wonderful memories. Please do not raise the price on the audiotapes! It was wonderful. Just like having our own tour guide. His explanations of the rules and regulations were very meaningful to us."

"I found the Park a wonderful experience. The sheer beauty of the Painted Desert portion was a delight and amazement. I might have enjoyed an exhibit there (either at the Visitor's Center or even better along the trail) to tell some of the scientific names of the composition of the colorful sands. The video show there (Painted Desert) put me to sleep–really—and the Center was too crowded. The gift shop, as with the cafeteria,seemed overpriced. We had full meals in Winslow and in Payson for only $1.00 to $1.50 more than a ready-made stuffed tomato, piece of cake, 2 coffees and a lemonade; however, we were hungry so we bought and ate. However, these are small objections to a glorious visit at the Petrified Forest National Park."

"I hope you receive enough surveys. It appears to be an important endeavor; however, this survey was much too long. Perhaps a shorter survey would have a higher return rate and cross over a more diverse population. I also think some of the questions in this survey could have been asked at the 'in-person' survey when exiting the Park. People feel more obliged at this point and don't mind a few extra minutes. P.S. Weren't you interested in demographics of people surveyed?"

"I am sorry, but I do not feel comfortable completing this survey in the way that is obviously expected. I am nearly 70 years old, and when I started my schooling, kindergarten was not an option; therefore, the part of my education that would qualify me to answer these clever little drills, most of which have to do with my perception of right and wrong, is missing.
If you want my feelings about Petrified Forest National Park, they are this: The overlooks and the Visitor's Center on the north end were very nice (the Visitor's Center this time of year, of course, was overcrowded). My eleven-year-old grandson and I both thought that the petrified forest part was not nearly up to National Park standards. The reconstruction of the Indian ruins was shoddy; signs and explanations were inadequate; the pictographs were vandalized and completely unprotected, and again with little or no explanation. We found no place with shade to eat our lunch outdoors. We saw no rangers out of their cars or air-conditioned buildings. We did enjoy one good lecture inside the Rainbow Forest Museum. The gift shop there had some nice things. All in all, my feelings about the petrified forest per se were not good. It was almost as though the people in charge had given up and abandoned

it—at least for the summer. I see no reason that my response should be held in the 'strictest confidence'. P.S. I didn't pilfer as much as one teensy petrified twig—cross my heart."

"Preserve our national parks for future generations!"

"I would have liked to have taken a piece of petrified wood from the Park only because it would have had more meaning. The petrified wood bought outside it does not mean the same, not to mention how expensive it can be. I understand that if every visitor were allowed to take a small piece then we'll have not much left to see. It will all be on someone's wall unit."

"We are only here in America on holiday, so my answers in section II may be less relevant. We are very impressed by the management of the Parks generally."

"I'd be interested in the results. Do people really believe the sale of petrified rock encourages its collection? Does it indeed affect behavior? We bought our son a piece on his first visit 4 years ago and it didn't make him want to collect it. On the other hand, the only pieces of wood left in the Park are just too big to haul away."

"Selling wood in the Park would be OK except the prices were too high. You should make it a little more attainable; that might keep others from stealing it from the Park."

"Our family enjoyed the Park tremendously. I am an avid plant and rock lover and finally having an opportunity to see the Petrified Forest was a great treat. All Rangers encountered did a great job—if you could afford to have more of them it would probably have a significant impact on theft problems. Keep up the great work! My father was an old CCC's man from Ohio who taught his children to have respect for the wonders of nature–we try to do the same with our children."

"I was impressed with the Rangers at the Petrified Forest who encourage children with their learning booklets and enabling them to become Rangers."

"The Visitor Centers at both ends of the Park have been sadly neglected (compared to Grand Canyon, etc.). They provide little information. The buildings have been allowed to deteriorate. Information on what will be seen was difficult to come by. The gift shop was better staffed than the center. Visitors traveling south to north find out little of what is to be found in Painted Desert from the people at Petrified Forest. Signs along the route are too few to provide planned stops, well ahead of time. Newspaper Rock requires some guidance for people who cannot readily see the markings."

"I don't always have the time to spend (that I would like to have) at National Parks, Forests, etc. Every time I am at a national or state outdoor (even underwater at Key Largo) facility I am so proud that the country or state is able to provide such nice facilities. The public needs to be better educated about preserving these areas and for the most I do believe people will really 'CARE' and do a better job of preserving for the future."

"I feel the National Parks are an important part of America and should be maintained for our future generations. It's sad to say that we need so much policing to maintain our parks. The ignorant need to be educated as to what it is all about and be considerate of others. Thank you for a hard job, well done."

"Since I'm not quite sure of the extent the Park is being damaged, I cannot answer if rails on boardwalk would be necessary. While protecting the Park's natural resources we must make it accessible to all! Souvenirs are another problem! While visiting the Southwest I found that all gift shops are virtually the same and very over-priced. We enjoy buying books."

"I visited the area in 1958. I plan to return and spend much more time. The Park appears to be well organized and is very unique."

"There is only one Petrified Forest and one beautiful Painted Desert. They are both awesome, breathtaking. We should do everything in our power to keep them beautiful for as long as we can!!"

"My family and I recently toured the Park for the second time. We didn't have as much time to spend as we would have liked this visit. So we toured the area we didn't see our first visit. Our whole family has enjoyed both our trips to the Park. There is so much natural beauty to enjoy. Things that we haven't seen elsewhere. We appreciate being able to tour the Petrified Forest/Painted Desert. Thank you."

"I have difficulty with questions regarding fences. If they did not become a visual obstacle or some reminder of the trail presence, they might be good. At the ruins site, climbing and off-trail walking was out of control. Often younger visitors have been in the car a long time and need an outlet. Could you perhaps recreate a pueblo from obvious non-rock material that can be climbed? If it is an obvious recreation they won't get confused. After all, thousands climb the ruins at Mesa Verde daily. Maybe this is a Park for more VIP guides. Perhaps guided trips every 20 minutes during high-volume days."

"Humans are by nature possessive, self-centered, careless, and temporally short-sighted. Measures to improve the Park may usefully be designed to counter these traits. Educate the visitors and control the scope for them falling foul of acceptable Park behavior, but without offending their dignity."

"I believe that most people who would damage or steal from a national park do it out of ignorance and the values formed by a lack of understanding of humans in relation to their environment. It is the responsibility of Park Rangers to educate the visitors to gradually change attitudes, values, and actions. It's a tall order, I realize; however it's the only real answer to the problem. Searching vehicles would be very offensive to the majority of visitors who are innocent, time-consuming for busy Rangers, and relatively ineffective against those determined to steal from all of us."

"We entered the Park from the south end, so when we exited from the Painted Desert area we didn't spend the time in that area had we entered there. We greatly enjoyed it!"

"I find it somewhat contradictory to have petrified wood for sale in the Park, especially that made into novelty items, and then ban people from picking it up. I think this encourages them to pick up the wood in the Park. I would strongly recommend against it. Additionally, I think having petrified wood for sale from private lands just outside the Park encourages people to take their own and squander a resource, especially since the companies are actively mining it. I would encourage the Department to desist the sale of wood in the Park and discourage its sale near the entrances. I would also suggest actively lobbying against the mining of wood on private land."

"Traveling through the Park was a delightful experience, but I did feel a shortage of Rangers. Unfortunately, people will not follow rules and I understand that a lot of wood is being stolen—I think the presence of Rangers would aid in holding down theft. The expense (and it is expensive) of the petrified wood might cause a person to try and steal some. Perhaps a sign indicating that the Park has someone present (other than a uniformed Ranger) taking note of people's actions would curtail some theft. Fencing would help; then if anyone wanted to handle the wood, they can do so in the Gift Shop. Adults are only older children and without supervision, unfortunately, they act like immature children."

"This particular park was well-managed and regulated; visitor volume was moderate. One can only guess what the result of heavy use would result in. I rather imagine it would remain orderly, however. I would like to see the Park Service tackle the really popular parks (i.e., Yellowstone, Yosemite, Grand Canyon) and the attendant high traffic and crowding. Actually, I am sure corrective efforts are ongoing concerning those very problems. All in all, the Park Service does a fantastic job!"

"Our whole family enjoyed the Park immensely—thank you!"

"I think it would be nice to have a program like the Jr. Rangers for adults. We learn so much more when we're looking for something in particular. If rules are being broken, perhaps a reminder before and/or after the movies or video programs would help. Rangers could also tell people the rules when they enter. If it slows up the line, that's too bad—people have to know the rules so they treat the Park well. We don't really buy a lot of souvenirs except T-shirts and teaching aids. We tend to travel to places which we are going to be teaching about. We buy lots of slides. I also try to buy gifts while I'm on vacation. Jewelry, books, or T-shirts that represent the place I'm at. Park behavior can really be a problem. My 5-year-old tells a lot of people to stay on the trails, don't feed the animals, etc. I wish other people were as conscientious as he is. Perhaps if it's a real problem, Rangers could be posted about to do interpretive stuff and watch out for violators—like in Mesa Verde self-guided walks. By the way, we love the self-guided walk pamphlets. Hope this helps you."

"We were disappointed to not have been permitted entrance into the last section at the south end."

"Rather difficult survey. If gift store took Amex, I would have spent $50 - $100. Saw "fossils" in gift store marked 'Made in Morocco'!!!"

"(1) In some places there were 'trails' leading off in interesting places (not paved). It was confusing to know if these were OK to use—we didn't. A few more adventurous trails would be nice. (2) More pieces of wood to touch would be nice and might keep people from being tempted 'in the field'. (3) More Rangers at various scenic stops would help—to answer questions and clarify rules. (4) I wondered why it was OK for some to harvest and sell the wood—I didn't realize the items for sale were not from the Park—advertising this would help with the temptation to take samples. (5) I don't think people read the whole Park brochure—a bit at a time—so being told rules by the Ranger at gate would be the most effective. (6) I would like more signs identifying the vegetation and also when possible, the animals. Thanks!"

"Very much enjoyed our visit—only sorry we did not allow more time in our schedule to see the Park at a slower pace. Staff—very pleasant and helpful."

"When you ask people not to remove petrified wood from the Park, they should have enough respect for others not to do so. We purchased a small bag of petrified wood at our hotel lobby and simply did not open the bag until our return trip home. Have more Rangers looking out, impose stiffer fines, let the word get out that you mean business, then you won't have to search cars (which I think is a bad idea)."

"I also think age requirements (no children under 12) should be in effect, as small children do not understand the rules. Also, ban all sales of petrified wood and fossils!"

"Please keep the Petrified Forest and Painted Desert beautiful!"

"The day we visited the Petrified Forest it was extremely hot so we did not take time to really stop long at each station and did not stop at the gift shop. Next time we will stop to purchase a video."

"I am fully in favor of harsh fines and penalties, but would prefer to see natural resources in their native state."

"If the taking of petrified wood is really a problem, simply put more security measures in place (i.e., Rangers, TV monitors, etc.). But I think the idea of searching vehicles is ridiculous. When we stayed at a commercial R.V. park nearby in Holbrook, petrified wood was everywhere on the ground. We saw pieces as big as baseballs and down to matchbox size. We took some home."

"Charge a little more and give everyone a small piece of petrified wood - especially children."

"We enjoyed our visit and thought the Park to be well-kept. The Rangers and people working at the Park were very friendly and informative. We are thankful for these parks and appreciate work done to preserve them."

"I think it is important to allow people to touch and explore as much as is consistent with preserving the Park. I also think it would increase my enjoyment of this and other parks to have more of the local flora identified; it certainly is very different than the plants and wildflowers of Georgia. At the cliff ruins near Sedona, Montezuma's Castle, I enjoyed reading signs about trees, shrubs, and wildflowers."

"Propose Rangers at key areas to be available to answer questions. More lay-bys required."

"When we entered the South entrance we were hoping for a gas station, but there was none. We went through on an empty tank. We had no other choice. We couldn't enjoy everything. Starting and stopping engine uses more gas. A gas station is needed at South entrance!"

"I enjoyed the beauty I saw in all the parks I visited. I don't want anything that is not for me to have. If I have to steal it, it is not worth having. I think people have a temptation to just have a piece of wood but if they would just think if I took one and all the people that visited it took one there would be nothing to see. Leave it for all people to see and enjoy. If I want anything I buy it or just don't have it. I always go by the rules—If I didn't I couldn't sleep at night. Thanks for all the regulations and the up-keeping of the Parks. Keep up the good work."

"There must be a way to protect natural resources other than cluttering up with more signs. If the message on the sign is not enforced, it is just more clutter."

"The Petrified Forest and Painted Desert was much more interesting than I anticipated. It was not a planned stop on our itinerary, but only a spur-of-the-moment stop. It should be promoted more to the public. I enjoyed it more than the Grand Canyon."

"My family and I didn't know that our nation had a Petrified Forest National Park. We sure were glad to have the opportunity to tour the Park. At first, we weren't going to stop (because of travel time). We learned a lot, and we won't hesitate to encourage anyone to visit this great National Park. Please do everything possible to preserve the Petrified Forest National Park."

"I would pay for a tape I can listen to in my car and get the money back at the exit when I give the tape back. Or could you provide a tape recorder?"

"The Petrified Forest is a beautiful place. I teach photography to college students and I enjoy taking them out to the Petrified Forest for photo field trips. I would like to preserve the beauty for generations to come!"

"Very informational place to visit."

"I just completed this road trip with my 23-year-old daughter as a college graduation present to her. It was one of the most wonderful and memorable things I have ever done. Most of the places we visited I had been to before, either with my parents or with my late husband, in the early years of our marriage, before children (BC). It was spectacular to see the wonders of nature through the eyes of a loved one who is experiencing it for the first time. In case you didn't notice, we were very happy campers!! My hat is off to park rangers across the nation for a job well done."

"I am in the USAF. Being a 'servant' of this nation, I feel that I should be able to visit such places without fees, upon proof of government employment (government or military ID). We give for the U.S.; it would be nice and greatly appreciated to have something given in return."

"Have busses turn off their motors when they park to avoid air and noise pollution. Don't sell so much 'junk' in gift shops."

Appendix G
Thief Observation Forms

OBSESERVATION CHECK SHEET

Date: _____ Your Name: _____ Tagger _____

Time: _____ [Caller's Name : _____]

PERSON

Gender	Age	Clothing	Language	Race	Features
		Tops			
Male	10s	T-shirt	Ger / Scan	White	Facial H _____
Female	20s	Button D	French	Black	Hair lgth_____
Don't Know	30s	Halter/B	Italian	Hispanic	Col _____
	40s	Col _____	Span / Port	Asian / P	
	50s	Other:_____ Lg / Sh	Oriental	Native	Accessories_____ _____
		Bottoms			
	60s	Lg / Sh / Skt	English	Other	Size/wt_____
	70s	Col _____	Other	Don't Know	Other_____
		Hat			
	Don't Know	Y / N	Don't Know		
		Des: _____			
		Don't Know			

VEHICLE

Color	Type	Doors	Size	Frt. Plate	Passengers	Features
Red	Sed / HB	2	Small	Yes / No	1	Front:
Orange	Wagon	3	Medium	Co:_____	2	_____
Yellow	P-U	4	Large	State: _____	3+	_____
Green	Jeep / Ut	5		Tag:_____		Top:
Blue	Van			Other:_____		_____
Violet	MiniVan			_____		_____
Brown	VW-Van			Rear Tag:		Tow:
Gray	Van - RV			_____		_____
Black	Trk - RV					_____
White	MotorH					Body:_____
	Make:					_____
Light	_____					Rental:
Medium	Model:					Y /N
Dark	_____					_____
Bright						
Metallic						

THEFT INFORMATION

Comments

What were they doing : Looking at log _____

Searching _____

Photo _____

Walking _____

Other : _____

Did they look around before : Yes / No / Don't Know

Number of pieces taken : _____ / Don't Know

Where did they put it : Pocket

Hand Hand bag

Bag - Type : Fanny Pack

Back Pack

Carry Bag

Don't Know Other : _____

Did they look around after : Yes / No / Don't Know

Did they talk about it : Yes / No / Don't Know

How did the others respond : _____

Discomfort ? : Yes / No / Not evident

What did they do next : No change in pattern / pace

Hurried back to car

Other _____

No. of other people (not in their group) visible nearby :

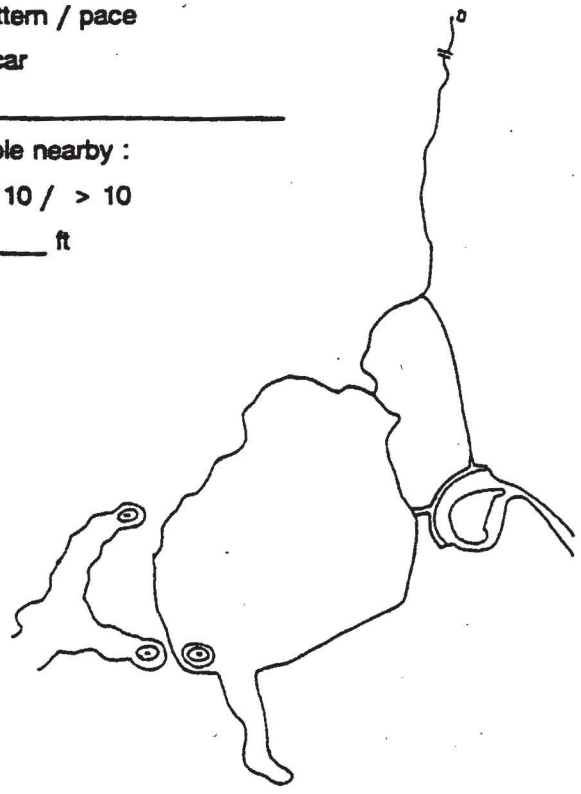
0 / Just me / 1 - 5 / 6 - 10 / > 10

Distance from other group : _____ ft

Location of theft (X)

Location of other groups (O)

Location of me (*)



Group Info

Age	Gender	Age	Gender
____	M / F	____	M / F
____	M / F	____	M / F
____	M / F	____	M / F
____	M / F	____	M / F

Appendix H
Non-Thief Observation Form

OBSESERVATION CHECK SHEET

Date: _____ Your Name: _____ Tagger _____

Time: _____ [Caller's Name : _____]

PERSON

Gender	Age	Clothing	Language	Race	Features
		Tops			
Male	10s	T-shirt	Ger / Scan	White	Facial H _____
Female	20s	Button D	French	Black	Hair lgth_____
Don't Know	30s	Halter/B	Italian	Hispanic	Col _____
	40s	Col _____	Span / Port	Asian / P	
	50s	Other:_____ Lg / Sh	Oriental	Native	Accessories_____ _____
		Bottoms			
	60s	Lg / Sh / Skt	English	Other	Size/wt_____
	70s	Col _____	Other	Don't Know	Other_____
		Hat			
	Don't Know	Y / N	Don't Know		
		Des: _____			
		Don't Know			

VEHICLE

Color	Type	Doors	Size	Frt. Plate	Passengers	Features
Red	Sed / HB	2	Small	Yes / No	1	Front:
Orange	Wagon	3	Medium	Co:_____	2	_____
Yellow	P-U	4	Large	State: _____	3+	_____
Green	Jeep / Ut	5		Tag:_____		Top:
Blue	Van			Other:_____		_____
Violet	MiniVan			_____		_____
Brown	VW-Van			Rear Tag:		Tow:
Gray	Van - RV			_____		_____
Black	Trk - RV					_____
White	MotorH					Body:_____
	Make:					_____
Light	_____					Rental:
Medium	Model:					Y /N
Dark	_____					_____
Bright						
Metallic						

NON THIEF CODING FORM. Date : Time :

Your name :

What were they doing most of the time ?

(Check all categories)

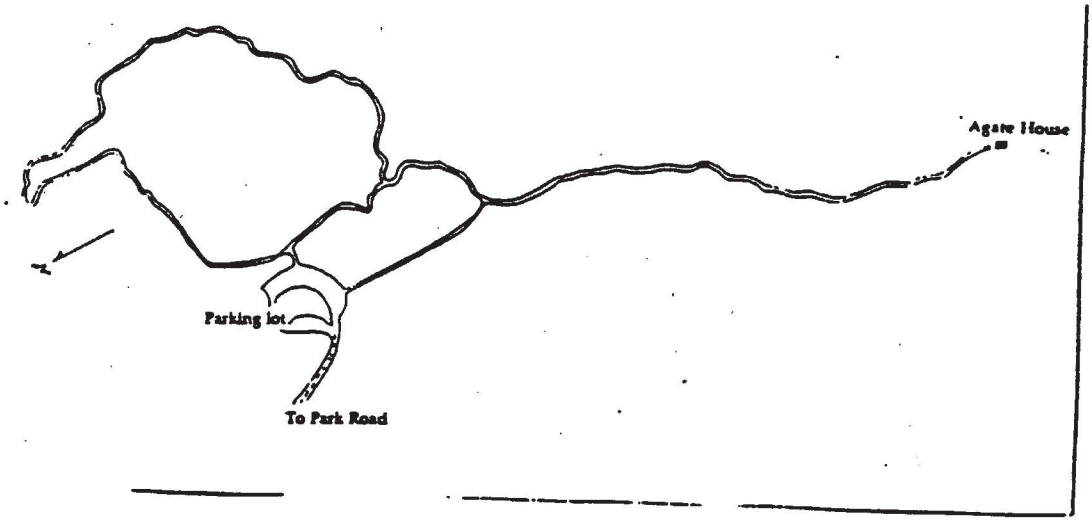
Searching	_____	Looking at	_____
Photos - group	_____	Photos - wood	_____
Walk - stroll	_____	Photos - view	_____
		Walk - hiking	_____

No. of others within sight (most of the time) :

B/n Park Lot & Ramada	_____	Trail to Agate	_____
On rest of Trail	_____	Near observer	_____

Group Info [Include tagged person *]

Age	Gender	Race	Age	Gender	Race
*__	M / F	_____	___	M / F	_____
___	M / F	_____	___	M / F	_____
___	M / F	_____	___	M / F	_____



_____ _____ _____

Appendix I

Executive Summary

Assessing Petrified Wood Change in Petrified Forest National Park

Executive Summary of

Assessing Petrified Wood Change In

Petrified Forest National Park

Submitted to: Michelle M. Hellickson

Superintendent, Petrified Forest National Park

Submitted by: Nicholas S. Monkevich

Timothy G. Gregoire

Joseph W. Roggenbuck

December, 1994

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Introduction

Problem Justification

The problem of petrified wood protection has existed from as early as 1906, when the Petrified National Forest Monument was established. The establishment of the Monument terminated commercial mining of petrified wood within the Park boundaries, but introduced new problems. The Monument attracted tourists wishing to see the petrified wood. Unfortunately, many of these tourists also wished to collect a small memento in remembrance of their visit. The Park's history is replete with programs aimed at minimizing the pilfering of petrified wood by souvenir collectors. Regardless of deterrence programs, park rangers still report numerous cases of petrified wood theft. Until now, relatively little has been done to quantify the amount of petrified wood that leaves the Park. Scher (1990) attempted to quantify petrified wood theft using 45 baited plots along visitor footpaths. Scher's efforts reported the following.

(1) 8,129 pounds of petrified wood lost per day

(2) 1.01 pound of petrified wood stolen per person

(3) 2.73 pounds of petrified wood stolen per vehicle

(4) 416 pounds of wood stolen per pound recovered

Although Scher's "baited plot" study produced provoking numeric conclusions, the monitoring may not reflect true amounts of petrified wood stolen from the Park. The petrified wood used in these baited plots had already been stolen and recovered at vehicle inspection stations during car searches or along roadsides before the stations. These pieces of petrified wood were probably near gem quality and undoubtedly captured the attention of visitors along the trail. Scher's study may permit valid inferences regarding irregular pieces

of petrified wood along visitor trails, but not across the entire Park's petrified wood population. It is also hard to determine actual figures that reflect petrified wood stolen versus relocated within the Park. A tourist may pick up a piece of petrified wood to examine it and return it to the desert floor in a new location. This potential petrified wood displacement by tourists further clouds true figures of wood stolen each year. An unbiased estimate of the amount of petrified wood stolen from the Park is needed to aid park managers in developing theft reduction strategies for the Petrified Forest. Park officials know of the petrified wood theft problem but not its magnitude. An inventory of the Park's high use areas is needed to estimate actual petrified wood densities in the Park. Further, monitoring the high use areas will furnish estimates of how much wood is displaced. This project fulfills these demands.

Objectives

This study had three objectives. The first objective was to design a feasible inventory methodology for sampling five high use regions of the Petrified Forest National Park that contain petrified wood. The second objective was to establish permanent sampling locations under the design that can be revisited one year in the future. The final objective was to implement the inventory design and furnish estimates of the amount of petrified wood displaced in the park during a one year time frame (August 1993 - August 1994).

Methods

Introduction

The Petrified Forest National Park had never been inventoried to determine the amount of the petrified wood resource. Because this study was an inaugural attempt to

estimate the petrified wood resource, the sampling strategy was designed to estimate multiple characteristics of the petrified wood resource and provide estimates for several size classes of petrified wood. The following description of the sampling methodology is quite broad. Much of the sampling methodology and mathematical detail has been neglected. For a more detailed description, see Monkevich (1994).

Sampling Design Description

Five high use areas within The Petrified Forest National Park were designated to be sampling locations (strata). These five areas are Blue Mesa, Jasper Forest, Crystal Forest, Long Logs and Giant Logs. Line intersect sampling was chosen as the sampling method to sample the petrified wood. Line intersect sampling is a practical way of measuring attributes of irregular populations, such as the petrified wood population. It has the advantage of estimating a population attribute without actually measuring that attribute. For example, to estimate the percent ground cover of petrified wood, one must only measure the length of intersection of petrified wood particles along the line. Line intersect sampling is also very time efficient compared to traditional plot sampling methods. In most cases, line intersect sampling units take fewer and easier measurements than with plot sampling.

Thirty five line intersect samples were placed in each of the five high use areas (strata) during the summer of 1993. Sampling locations were monumented by wooden dowels left in the ground and inscribed on aerial photography of each stratum. Twenty of the sampling locations were randomly placed in areas away from established trails and parking lots. The remaining 15 sampling locations were allocated along visitor trails. The 20 sampling units away from the trails were intended to robustly estimate inventory totals, while the 15 trailside samples were envisioned to estimate change over the one year study period.

The sampling design chosen for the Petrified Forest National Park gave a multitude of total estimates. The design yielded estimates of density (count), volume (cubic feet), and percent cover (percentage of the ground covered by petrified wood particles) for the three size classes listed below:

Size Class 1 $\Rightarrow$ .25" $\leq$ particle length $<$ 1"

Size Class 2 $\Rightarrow$ 1" $\leq$ particle length $<$ 5"

Size Class 3 $\Rightarrow$ 5" $\leq$ particle length.

It should be emphasized that the sampling strategy was designed to be as comprehensive of multiple attributes of the petrified wood resource as time and budget permitted. Had this study only been concerned with estimating, say, the density of petrified wood particles with no distinction among various size classes, sampling could have been conducted more intensely to yield more precise estimates for the single attribute. This study's strengths are in the diversity of sampling attributes and size classes. Futures inventories may concentrate on only one sampling attribute, in which case design modifications from this study may be advisable.

Field Techniques

For each line intersect sample, a wire cable was randomly located and oriented on the ground. The cable was held at each end with large pins that were driven into the ground with a hammer. A petrified wood particle was sampled if the wire cable intersected any part of the particle. Three measurements were made on each sampled particle. First the intersection length was measured. Intersection length gave an estimate of the percent ground cover of petrified wood. Second, the vertical circumference of the particle along the cable was measured. This measurement gave rise to the volume estimates. Finally, the

horizontal circumference of the particle was measured. This measurement allowed estimates of density. Measurements were taken on hands and knees. Intersection length was measured with a dial-caliper for petrified wood pieces smaller than 5 inches and with a tape measure for larger pieces. Circumferences were measured by wrapping a rope or string around the petrified wood particles and then comparing the wrapped distance to a ruler.

Results

Inventory

The data (collected during the summer of 1993) were compiled and summarized for each high use stratum. Estimates and corresponding confidence intervals of density, percent cover, and volume of petrified wood were computed for each size class and each stratum. A thorough explanation of all statistical theory and estimation procedures for each sampling attribute is given by Monkevich (1994). This *Inventory* section will concentrate on the estimates from the first summer of sampling and how valid these estimates are. Tables 1, 2, and 3 summarize the 1993 inventory estimates for the density, percent cover and volume sampling attributes, respectively.

Table 1. Total 1993 Inventory Density Estimates For Each Stratum at Petrified Forest National Park

Blue Mesa			
	Size Class 1	Size Class 2	Size Class 3
Total	45,072,876	2,719,018	135,220
Standard Error	26,620,687	904,270	59,334
95 % C. I.	(-10,005,325, 100,151,077)	(848,083, 4,589,953)	(12,458. 257,982)
Crystal Forest			
Total	31,912,831	3,223,126	49,675
Standard Error	17,295,350	997,492	13,716
95 % C. I.	(-3,871,248, 67,696,910)	(1,159,314, 5,286,938)	(21,297, 78,053)
Giant Logs			
Total	25,494,706	2,812,775	37,719
Standard Error	10,317,849	1,553,904	15,716
95 % C. I.	(4,147,076, 46,842,336)	(-402,253, 6,027,803)	(5,203, 70,235)
Jasper Forest			
Total	82,788,603	2,989,310	109,271
Standard Error	30,250,208	1,283,882	30,713
95 % C. I.	(20,200,922, 145,376,284)	(332,958, 5,645,662)	(45,725, 172,817)
Long Logs			
Total	47,031,345	3,261,785	82,395
Standard Error	16,535,752	924,593	24,373
95 % C. I.	(12,818,874, 81,243,816)	(1,348,802, 5,174,768)	(31,968, 132,822)

Size Class 1 = .25″ ≤ intersection length < 1″
Size Class 2 = 1″ ≤ intersection length < 5″
Size Class 3 = 5″ ≤ intersection length

Table 2. Total 1993 Inventory Percent Cover Estimates for Each Stratum at Petrified Forest National Park

Blue Mesa			
	Size Class 1	Size Class 2	Size Class 3
Total	6.61	7.73	4.55
Standard Error	1.24	3.72	1.72
95% C. I.	(4.05, 9.17)	(0.04, 15.42)	(0.99, 8.11)
Crystal Forest			
Total	7.71	5.91	3.64
Standard Error	1.86	2.11	1.02
95% C. I.	(3.86, 11.56)	(1.55, 10.27)	(1.52, 5.76)
Giant Logs			
Total	4.52	5.33	6.27
Standard Error	2.03	2.04	1.91
95% C. I.	(0.31, 8.73)	(1.11, 9.55)	(2.33, 10.21)
Jasper Forest			
Total	13.75	4.28	7.77
Standard Error	2.29	1.14	1.39
95% C. I.	(9.01, 18.49)	(1.93, 6.63)	(4.89, 10.65)
Long Logs			
Total	6.15	5.94	9.82
Standard Error	1.87	2.70	2.60
95% C. I.	(2.28, 10.02)	(0.35, 11.53)	(4.44, 15.20)

Size Class 1 = .25″ ≤ intersection length < 1″
Size Class 2 = 1″ ≤ intersection length < 5″
Size Class 3 = 5″ ≤ intersection length

Table 3. Total 1993 Inventory Volume (ft^3) Estimates For Each stratum at Petrified Forest National Park

Blue Mesa			
	Size Class 1	Size Class 2	Size Class 3
Total	9,605	33,312	411,390
Standard Error	12,746	12,755	255,925
95% C. I.	(-16,767, 35,977)	(6,923, 59,701)	(-118,119, 940,899)
Crystal Forest			
Total	9,246	10,775	82,939
Standard Error	3,895	3,882	37,358
95% C. I.	(1,187, 17,305)	(2,744, 18,806)	(5,646, 160,232)
Giant Logs			
Total	13,010	36,080	163,454
Standard Error	5,233	15,843	94,366
95% C. I.	(2,183, 23,837)	(3,300, 68,860)	(-31,788, 358,696)
Jasper Forest			
Total	21,787	51,458	626,081
Standard Error	7,632	18,475	386,964
95% C. I.	(5,996, 37,478)	(13,233, 89,683)	(-174,548, 1,426,710
Long Logs			
Total	12,070	32,944	217,994
Standard Error	4,619	13,544	91,202
95% C. I.	(2,513, 21,627)	(4,922, 60,966)	(29,297, 406,691)

Size Class 1 = .25" ≤ intersection length < 1"
Size Class 2 = 1" ≤ intersection length < 5"
Size Class 3 = 5" ≤ intersection length

Table 1 summarizes the density estimates for each size class for each stratum. The size class 1 density estimates are all in the tens of millions, with the Jasper Forest estimate being the largest at 82 million. The size class 2 density estimates are all between 2 and 4 million pieces, while the size class 3 density estimates are all under 150,000 pieces. The

Blue Mesa and Crystal Forest size class 1 confidence intervals contain 0. The Giant Logs size class 2 density estimate also encompasses 0. Practically, this means that there is considerable uncertainty in estimation owing both to the naturally large variation in the location of petrified wood and to the comparatively sparse sampling permitted by the design. Because there exists a positive amount of petrified wood in all classes, the inclusion of zero is more of a reflection of the non-normality of the sampling distribution than it is of anything else.

Table 2 summarizes the percent cover results for the 1993 inventory. Estimates for all size classes fall between 3 and 14 percent, and none of the confidence intervals bound zero. Although the percent cover estimates are similar in magnitude between size classes, they seem reasonable. Common sense dictates that it takes many more small pieces of petrified wood to cover the same percentage of the desert floor as one large log. The density results suggest that there is indeed a plethora of smaller size pieces compared to the larger pieces of petrified wood. The combination of the density results and common sense suggests that the percent cover estimates should be similar in magnitude.

Table 3 summarizes the volume results for the 1993 inventory. Size class 1 volume estimates fall within the range of 9,000 to 22,000 cubic feet. Size class 2 volume estimates increase to within 10,000 to 37,000 cubic feet. Size class 3 volume estimates all fall between 82,000 and 415,000 cubic feet. Volume is expected to increase as the size class of petrified wood increases. Because the physical size of petrified wood particles increases with greater size classes, greater volume is expected in the larger size classes.

Change

To assess change during the 1993 to 1994 study period, the line intersect sampling units were revisited during the summer of 1994 and remeasured. Recall that 35 line intersect sampling units were established during the summer of 1993 and monumented with wooden markers in the ground and inscribed on aerial photography. During the summer of 1994, we attempted to relocate each of the 35 line transects in each stratum. Unfortunately, some of the line transects placed in the trailside areas could not be relocated. Many of the wooden markers were missing (presumably due to tourist intervention) and thus the true location of some 1993 line transects could not be established. Line transects were lost in each of the five strata. Table 4 lists the resulting sample sizes for each stratum.

Table 4. Sample Sizes For Each Stratum For The 1994 Remeasurement

Stratum Name	Number of Line Transect Lost	Resulting Sample Size
Blue Mesa	5	30
Crystal Forest	6	29
Giant Logs	8	27
Jasper Forest	4	31
Long Logs	5	30

The inventory process was much simpler to do than the initial 1993 inventory. Once the wooden markers were found, the cable was restrung across the ground using the same anchoring points as in 1993. A list of what was measured during the 1993 inventory

was used to traverse the cable again recording missing or added pieces of petrified wood. The measurements made on each individual piece of petrified wood in 1993 were not done in 1994. This was done to eliminate noise that would be introduced through measurement error. The individual pieces of petrified wood tallied during 1993 were simply checked off against a list if they were there. Individual pieces of petrified wood were distinguished from each other on the basis of the 3 measurements taking during 1993 (intersection length, vertical circumference and horizontal circumference). If a new piece of petrified wood was introduced into one of the line transects, it had the original three measurements taken on it. This made the re-inventory process much faster than the initial establishment time, and virtually free of measurement error.

The 1994 data were compiled and summarized for each high use stratum in a fashion similar to the 1993 data. The 1994 total estimates were subtracted from the 1993 estimates (Tables 1, 2, and 3) to estimate that change of the petrified wood resource over the 1 year study period. Estimated change amounts are graphically depicted in Figures 1, 2, and 3 for density, percent cover and volume, respectively. Note that a positive number indicates a loss of petrified wood, while a negative number suggests a gain.

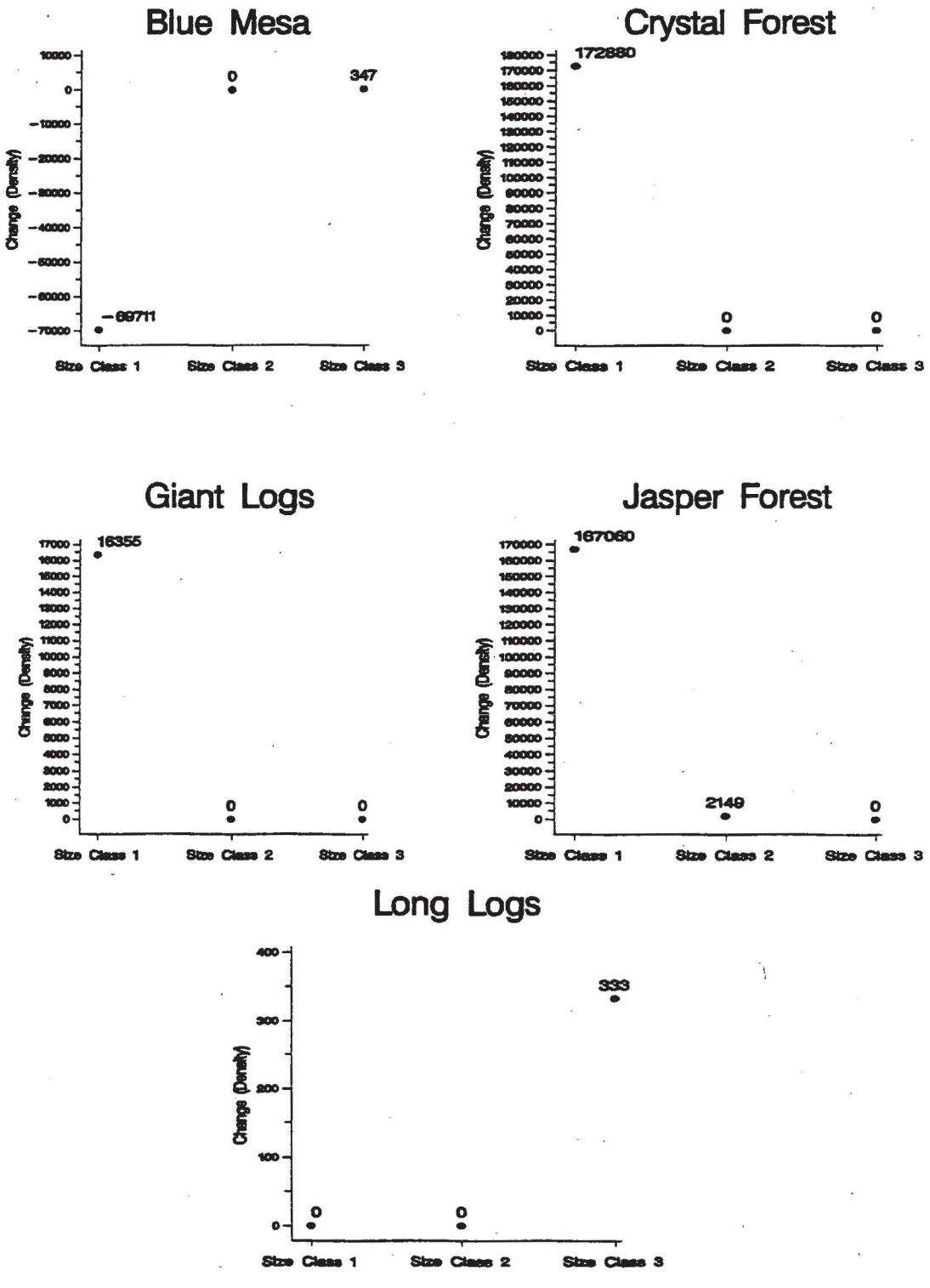


Figure 1. Overall Change in Density as Estimated From Line Intersect Data

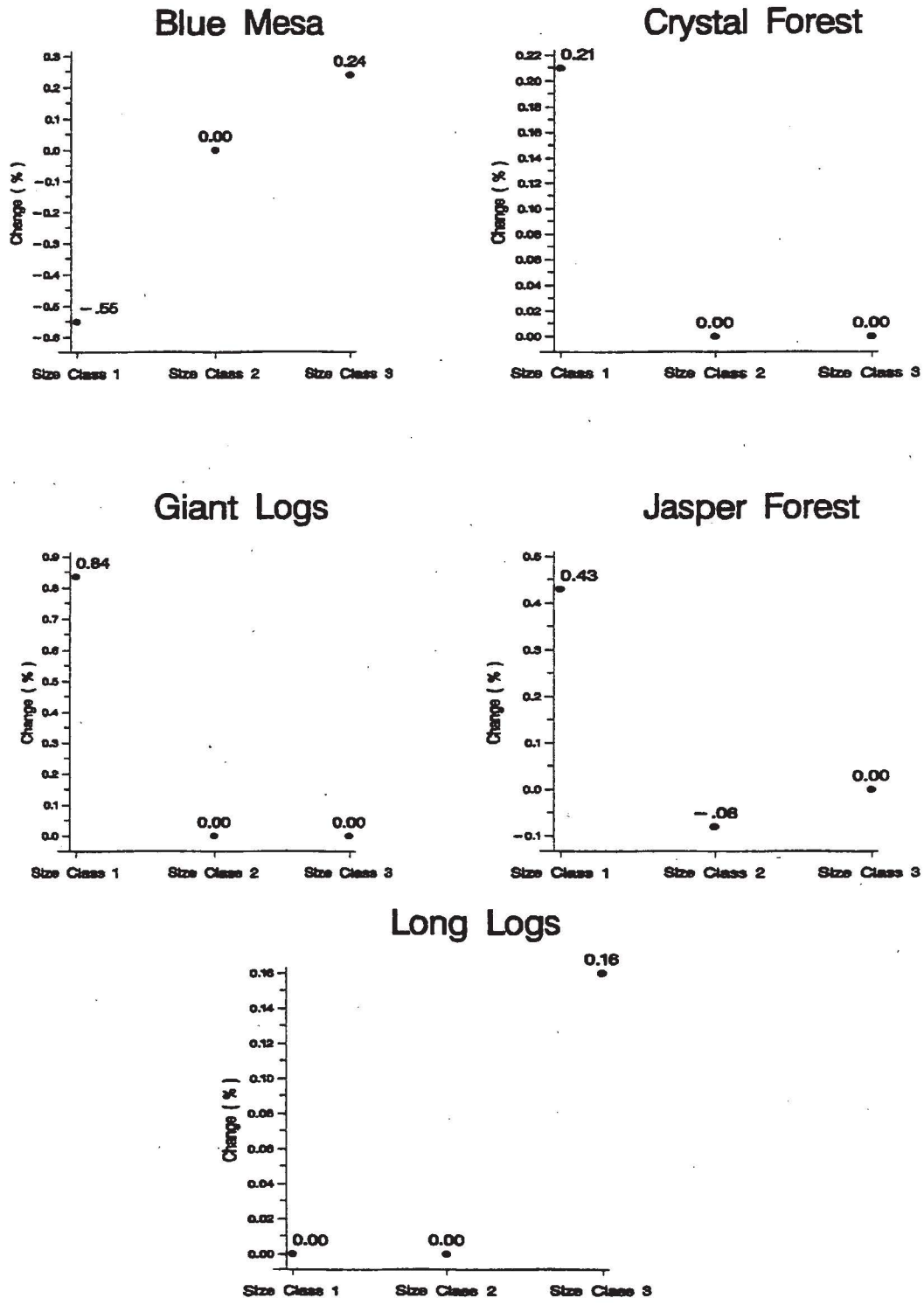


Figure 2. Overall Change in Percent Cover as Estimated From Line Intersect Data

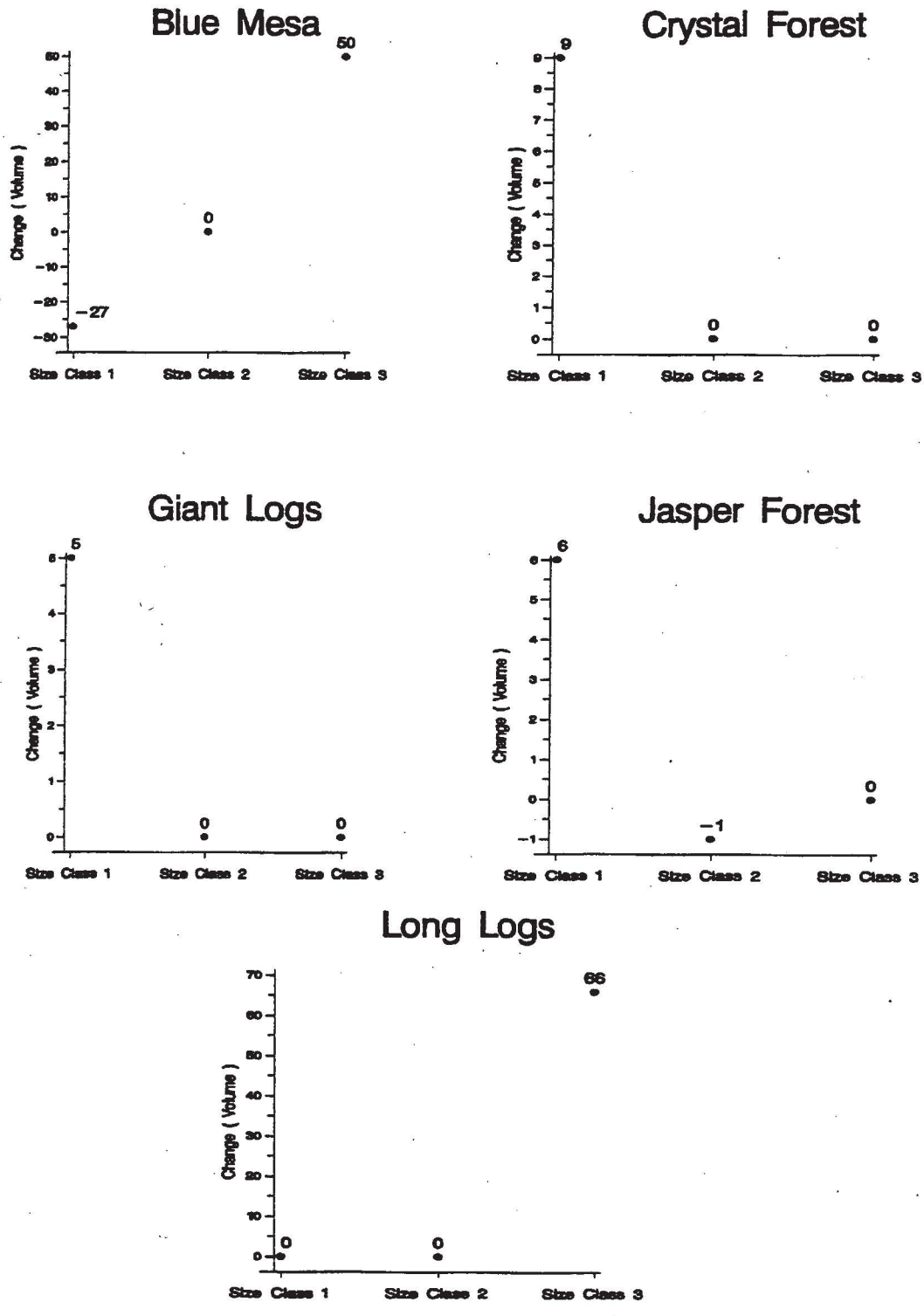


Figure 3. Overall Change in Volume (cubic feet) as Estimated From Line Intersect Data

Figure 1 displays the overall change in the petrified wood density attribute. Density of size class 1 petrified wood particles changed the most. The Jasper Forest and Crystal Forest Strata had a large loss of size class 1 petrified wood particles (around 170,000 pieces). The Giant Logs stratum indicated a modest size class 1 loss, while the Blue Mesa stratum suggests a small gain of petrified wood particles into line intersect sampling units. The Long Logs stratum size class 1 density showed no change over the 1 year study period. Only the Jasper Forest stratum showed change for the size class 2 density estimates (2,100 pieces lost). Blue Mesa, Crystal Forest, Giant Logs and Long Logs size class 2 density estimates were unchanged during the study. The Blue Mesa and Long Logs size class 3 density change estimates suggest a small loss of petrified wood (about 350 pieces), while the Crystal Forest, Giant Logs and Jasper Forest size class 3 estimates were unchanged over the one year study period.

Figure 2 depicts the overall change in the petrified wood percent cover estimates. The Crystal Forest, Jasper Forest and Giant Logs strata all suggest a small loss of size class 1 percent cover (less than 1.0%). The Blue Mesa stratum indicates a small gain in petrified wood size class 1 percent cover, while the Long Logs stratum was unchanged. The only size class 2 percent cover change detected was in the Jasper Forest stratum. This change was a small increase in percent cover (about .10%). The Blue Mesa and Long Logs strata suggest small size class 3 losses of percent cover, while the remaining size class 3 strata estimates were unchanged.

Figure 3 displays the overall change in the petrified wood cubic foot volume attribute. The Crystal Forest, Jasper Forest and Giant Logs strata indicate a small size class 1 loss in cubic foot volume (less than 10 ft^3). The Blue Mesa stratum showed a sizable increase in size class 1 volume (27 ft^3). The Long Logs stratum did not change in the size

class 1 volume attribute over the study period. The only stratum to show a change in the size class 2 volume attribute was Jasper Forest (a negligible 1 ft^3 gain). Two strata showed change in the size class 3 volume attributes. The Blue Mesa and Long Logs strata showed losses in the size class 3 volume attributes (around 50 ft^3).

In general the size class 1 estimates displayed the most change for each stratum for all sampling attributes. The size class 3 estimates showed the second most amount of change while the size class 2 estimates changed the least in each stratum. This pattern may not be expected. One might expect the pocket sized (size class 2) petrified wood pieces to have been the most disturbed during the study period. However, this is within stratum change. The overall total change (added across all 5 stratum) should portray a clearer picture. For simplicity, the density (number of pieces) will be used to expound this point. The total density change is listed below in Table 5. Recall that a positive number indicates a loss while a negative number suggests a gain.

Table 5. Total Density Change in Petrified Wood For All Strata

Size Class	Change	95% Confidence Int.
1	286,584	(75,263, 497,904)
2	2,149	(265, 4,032)
3	680	(314, 1,045)

The overall pattern observed in the density inventory estimates is also present in the density change. As the size of the petrified wood particle increases, the total change estimate decreases. In terms of totals, the density change estimates seem plausible. Although the size class 2 petrified wood particles were not disturbed as much as the other

two size classes, the total change estimates are reasonable. Recall that there were many more size class 1 particles from the 1993 inventory results. There are more size class 1 particles to be disturbed by tourists, and within stratum change amounts support this. As the size of the petrified wood particle increases, there are fewer particles and therefore less tourist disturbance is possible.

Discussion

Recommendations for Future Sampling

This section summarizes some recommendations we have regarding further or future sampling of the petrified wood resource.

The first topic has to do with time and efficiency of field sampling. In our opinion, three major improvements can be made to the sampling design in terms of efficiency. First, field sampling goes much more smoothly and quickly when there are two people conducting the sampling. It took approximately 6 weeks of field sampling for one person during the first summer, and only 2 weeks to remeasure the same locations during the second summer with two people. Not only can field work be divided into individual responsibilities for two people, but motivation and morale are also heightened with a partner. Second, choosing one sampling attribute to focus on will greatly increase field productivity. Making one measurement (instead of 3) on each petrified wood particle will surely save time in the field. The time saved in the field could be used to lay out more sampling locations which would strengthen estimate precision. Also, perhaps only one sampling attribute needs to be estimated.. Perhaps volume and percent cover are hard to conceptualize for some users and only density is needed. Thus, the park manager might simply use the density measures and disregard the volume and percent cover methodology. Finally, choosing fewer size classes

of petrified wood will increase field productivity and the precision of sampling estimates. For the same reasons as listed for decreasing the sampling attributes estimated, decreasing the size classes of petrified wood will significantly reduce field sampling time. We recommend that the fleck size pieces (< 1") not be inventoried in the future. Not only is it hard to get accurate measurements on small pieces of petrified wood, but these pieces are easily moved by natural forces (rain, erosion, and wind).

A final suggestion follows. The wooden dowels wrapped in pink flagging (used to mark the ends of the line transect on the ground) did not work well. It was often difficult to get the dowel into the hard desert floor and the intense sun quickly disintegrated the flagging. The combination of these two shortcomings often made it difficult to relocate line transects in 1994. We recommend that painted metal spikes be used to keep track of sampling locations in the future.

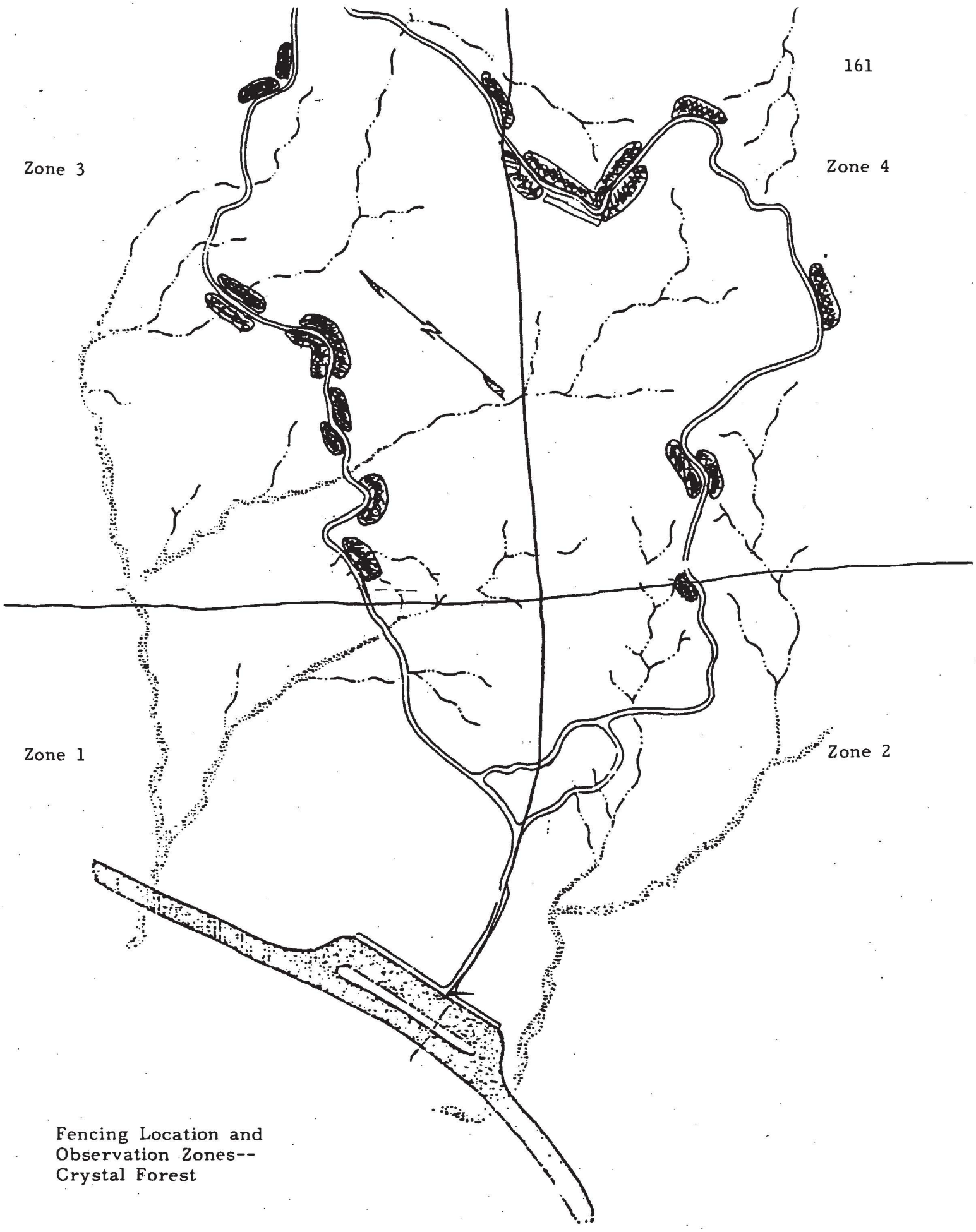
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Appendix J

Observation Zones at Crystal Forest



Fencing Location and
Observation Zones--
Crystal Forest