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# Report SFRC-86/09
# Long Term Recovery of Experimental Off-Road Vehicle Impacts and Abandoned Old Trails in the Big Cypress National Preserve

NATIONAL PARK SERVICE
DEPARTMENT OF THE INTERIOR

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# LONG TERM RECOVERY OF EXPERIMENTAL OFF-ROAD VEHICLE IMPACTS AND ABANDONED OLD TRAILS IN THE BIG CYPRESS NATIONAL PRESERVE

Report SFRC-86/09

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identical to those used in 1979. One major change was the number of replicate samples collected in each experimental lane, each old trail, and each set of site control samples. In 1985, measurements were taken at 10 locations for visual rating, rut depth, and ridge height, and in 6 plots for soil compressive strength and the vegetation and litter parameters, as compared to 30 and 3 measurements, respectively, in 1979.

Field and Laboratory Methods

The visual rating system used in 1985 was the same as that used in fall 1979. A "0" rating indicated we could not see any differences between the appearance of the test lane and adjacent habitat at that particular location. Thus, a lane could be visible, but still have all "0" ratings in the locations where we measured them. A "1" indicated the lane was visible but there was no soil disturbance and very little difference in the appearance of vegetation in the lane as compared to adjacent undisturbed habitat. A "2" indicated that up to one half of the vegetation was missing in the trail and there could be some soil disturbance. A "3" was used when more than one half the vegetation was missing and there was moderate soil disturbance. A "4" indicated no vegetation in the trail and moderate to severe soil disturbance.

Three methods were used to measure rut depth and ridge height depending on water levels and width of the lane. If there was standing water, the water surface was used as a level from which we measured the distance down to the undisturbed soil surface and the centers of the rut and ridge. Ridge height and rut depth were the differences between the distances to the undisturbed soil surface and the centers of the ridge and the rut, respectively. In the narrower lanes in the test plots without standing water we placed a 1 m board horizontally across the ridge top and measured the distance to the rut and adjacent undisturbed habitat. We then used the distance to undisturbed soil as ridge height and subtracted that distance from the rut reading to arrive at rut depth. In the old trail plots and experimental test lanes that were too wide to lay a 1 m long board across, we used a 2.5 power hand level, with a tape measure as a level rod, to measure relative elevations of the rut, ridge, and adjacent undisturbed habitat.

Vegetation was sampled in six 10 by 100 cm plots in each test lane and old trail. A total of six controls per site were sampled in adjoining undisturbed habitat. The individual plots were randomly selected and delimited by narrow boards held in place by removable pins at the corners. Average height of the vegetation was then measured, percent cover estimated, and all plant taxa noted. A rating system was used to indicate relative abundance of plant taxa. "Occasional" was used when one to just a few plants of a taxon were found in the plot. "Common" indicated that stems of that taxon were numerous but did not dominate the sample. "Abundant" was used when one or more taxa clearly dominated the sample. In addition, common was restricted to plots with more than 10 percent cover and abundant could be used only when percent cover was greater than 40 percent. Although some of the more distinctive plants could be identified to genus, the lack of key characters on many individuals frequently made identification to genus impossible. As a result, we developed a nomenclature designed to allow us to pick out major differences in abundance of taxa in lane or trail samples as compared to control samples. All live aboveground vegetation and standing litter were then removed and placed in separate bags which were dried for at least 24 hours at 105 C. The samples were then removed from the oven, allowed to stand for one half hour to stabilize moisture content, and then weighed.

Soil compressive strength was measured with a Soil Test Inc. Model CL 700 penetrometer in the same plots as the vegetation. It was necessary to use different methods in different habitats depending on their soil characteristics. In the small cypress and wheeled vehicle marl marsh sites we measured the force required to push a penetrometer rod to a soil depth just short of bedrock. This was possible because of a slight crunching feel to the rod just before bedrock was reached. In the pine and the airboat and track vehicle plots, bedrock was not consistently near enough to the surface to use this method, so we measured the force needed to push the penetrometer rod 6 cm into the soil. In the pine this worked well, but in the very loose marl and peat of the airboat and track vehicle plots the rod sometimes went deeper than 6 cm from its own weight. As an alternative, in these habitats we dropped a 91.5 cm long, 0.6 cm diameter steel rod from approximately 1.7 m and measured its depth of penetration into the soil. Since interpretation of the results was based solely on differences or lack of differences between impacted and control lanes within each plot, the variations in the methods used at different sites did not affect the outcome of our analyses.

Data Analyses

While conducting the fall 1985 data analyses, we became aware of a number of discrepancies between this data set and those from 1978-79. As a result we went back to our original field notes and identified a number of errors in the data included in the 1981 report. This was a particular problem with the rut depth data. Thus, we have incorporated in the appendices to this report all of the corrected 1978 and 1979 data, as well as the 1985 data. For the experimental plot data, these include average values (Appendix A), percent recovery (Appendix B), and Duncan's new multiple range test results (Appendix C). Appendix D provides similar data for the old trails.

Statistical analyses of the experimental test plots utilized the Duncan's new multiple range test. The Duncan's analyses for the 1985 data were done using the SAS ANOVA procedure (SAS Institute Inc. 1985), while the Duncan's analyses of the earlier data were done using the SAS GLM procedure (SAS Institute Inc. 1979). These analyses allowed us to determine which vehicle type - impact level combinations were significantly more or less impacting as compared to each of the other combinations. However, we only compared data from an individual sampling period for all vehicle types at all impact levels within a single replicate plot. No statistical comparisons were made of any vehicle type impact level combinations between either replicate plots or sampling periods.

Statistical differences between the old trail samples and their adjacent controls were determined using the non-paired T-test.

Probability levels were always 0.05 for both the Duncan's new multiple range test and the T-test analyses.

## Definition of Impact Levels

### Experimental Lanes

In our 1981 report, we included a figure showing the number of runs required to achieve medium and heavy levels of impact in the major Big Cypress National Preserve habitats by the different types of ORVs used in the preserve. The figure showed the number of runs on a logarithmic scale so that all of the data would fit on one figure. While this format was useful for showing the relative number of runs needed to create certain levels of impact by different vehicles in different habitats, it was difficult to precisely determine the actual number of passes required to create these impacts. This was a particular problem where only a small number of passes were made. Because this information was so important to our data analyses, we have reproduced this figure with the number of runs on an arithmetic scale to make it easier to see the exact number of runs made by each vehicle. This required dividing the original figure into seven separate figures, which are here included as Appendix E.

One important aspect of these data was that some runs were not made or achieved for a variety of reasons (Appendix F).

(1) Some vehicles became stuck where they could not maintain traction on slippery substrates, such as marl or organic soils. These conditions normally occurred where either rock or sand was not near the ground surface and there was only sparse vegetation. This was particularly true of the smooth-tire buggy in both small cypress and marl marsh habitats. Swamp buggies typically do not operate in the extensive Everglades peat marshes for these reasons, and the water there is frequently too deep for three wheel all terrain cycles (ATCs) to operate effectively.

(2) Certain habitats are too destructive of vehicles or just too uncomfortable to drive through frequently. Pine rockland with a dense understory of palmetto is an example of a habitat through which vehicles can drive cross country, but which are normally traversed along established trails to avoid vehicle damage and an extremely rough ride.

(3) Although attempted, some vehicles were not able to create heavy impacts in some habitats. These treatments are indicated in the

Appendix E figures by the broken bars. ATCs were unable to create heavy impacts in two of the three marl marsh and sand marsh habitats, or in any of the pine plots. Swamp buggies were unable to create heavy impacts in two of the three sand marsh and pine habitats, and several buggies were unable to create heavy impacts in one marl marsh site. Airboats were unable to create heavy impacts in either marl or peat marshes. The reasons for an inability to create heavy impacts were a function of lack of impacting ability of the vehicle in the case of the airboat and ATC, and relative insensitivity of the substrate at certain sites, such as the rock substrate in the pineland and one marl marsh site and the sand substrate in the sand marsh.

There were a variety of reasons for why different numbers of passes were attempted when we were unable to achieve a heavy impact. At a minimum, we made twice as many passes as was required to produce a medium level of impact by the same vehicle in the same replicate plot. With the airboats, we made almost six times as many passes because it was the first vehicle tested and we wanted to be very certain we were not going to be able to create a heavy impact. At one of the wheeled vehicle marl marsh sites, an ATC required 2.6 times as many passes to make a heavy impact as it did to make a medium impact. At the other two marl marsh sites, we stopped making passes in the ATC heavy impact lanes at 2.5 times the number required to make a medium impact. However, at this point we had made 100 passes in each lane and it still appeared to be far from heavily impacted. In thirteen of the other situations where heavy impacts were not achieved, we made 2.85 - 4 times as many passes as it took to make the medium impacts before we quit. Among the remaining three treatments, from 2 - 2.6 times as many passes were made as in the medium impact lanes. In these instances, we did not have sufficient time to make additional passes with a rented buggy, and the lanes were still far from being heavily impacted.

(4) Some possible treatments were not made when the one pass treatment also turned out to represent the medium impact level. This was the case for three of the buggies in all three of the small cypress plots, for the light buggy in one of the small cypress plots, for the tractor buggy in two of the three marl marsh plots, and for the track vehicle in all of the marl marsh plots.

Interpretation of the study results requires a clear understanding of how we defined the impact levels we actually achieved. The study design allowed us to compare relative impacts of and recovery from one pass by almost all vehicle types in all major preserve habitats. It was the only impact level involving an equal number of passes in each habitat. The study design also allowed us to assess the number of passes required to make a certain level of impact and the recovery from these impacts. Since the medium impact tests were stopped when severe vegetation damage was achieved, by definition we also have to include in our medium impact analyses those tests where a medium impact was achieved with only one pass. Similarly, where heavy impacts were never achieved, even though they were attempted, these attempts cannot fairly be included within the analysis of heavy impacts. Thus, our analyses discuss (1) all one pass treatments as one pass treatments; (2) all medium impact treatments, and some one pass treatments which caused severe vegetation damage but little or no soil disturbance, as medium impact treatments; and (3) only those heavy impact treatments which actually caused severe soil disturbance as heavy impact treatments (Table 1). All of the analyses in this report are based on these definitions of impact levels. This includes the analyses of the 1979 data as well as the 1985 data.

### Old Trails

The old trails we selected for the recovery study were characteristically the most impacted examples of trails through each habitat. However, none were included which had been "improved" by the addition of fill.

Unfortunately, there was no clear documentation on when, why, or how the old trails used in our study were originally created. Although all were used by ORV's at the time this study began, a number of them, and possibly all, were not simply a product of ORV use. Just as we did not attempt to create experimental lanes in more than sparsely forested habitats, it is unlikely that ORV's initiate old trails through the large and small cypress forests, hardwood hammocks, and some pine forest sites. The origin of these types of trails has been associated with a variety of activities in the Big Cypress Swamp. These include providing access to camps, and commercial activities such as oil and gas exploration, logging, agriculture, and land surveys. Cut stumps along many of these trails clearly indicate that large trees had to be removed before ORV's were able to pass. In addition, bulldozers were used to clear trails through portions of the Big Cypress in the past. However, the old trails monitored for recovery in our study were specifically selected because they had not been created with heavy equipment.

## RESULTS AND DISCUSSION - EXPERIMENTAL LANES

### Condition of Experimental Plots in 1985

#### Small Cypress

When the test lanes were initially established, compass bearings were recorded for the base line from which the lanes began and for each test lane. When searching for lanes in 1985, it was often possible to locate the more obvious sections of a lane by using the original ground photos and compass bearings. This technique was not possible in the small cypress sites because of the need for test vehicles to maneuver around trees in the plots. The small cypress habitat also seems to be a favorite area for hogs, and their extensive rooting destroyed many sections of test lanes or the adjacent control areas. However, in some lanes there was still much less vegetation in the trail as compared to the adjacent control areas, and ruts were still obvious.

Table 1. The total number of experimental lanes at each impact level in each habitat. These totals were the basis for determining the percentages of recovered lanes in Figures 1-6 and for all other analyses presented in this report. Appendix F can be consulted to see which treatments were excluded and why.

| Habitat Code Number | Habitat | Total Number of Lanes: One Pass | Medium Impact | Heavy Impact |
|---|---|---|---|---|
| 1 | Small Cypress | 15 | 15 | 15 |
| 2 | Wheeled Vehicle Marl Marsh | 14 | 14 | 10 |
| 3 | Sand Marsh (1985) | 18(9) | 18(11) | 6(0) |
| 4 | Pine | 18 | 9 | 2 |
| 5 | Airboat Marl Marsh | 3 | 6 | 0 |
| 6 | Airboat Peat Marsh | 3 | 6 | 0 |
| 7 | Track Vehicle Marl Marsh | 3 | 3 | 3 |
| 8 | Track Vehicle Peat Marsh | 3 | 3 | 3 |

### Wheeled Vehicle Marl Marsh

Marl Marsh 1 was completely recovered probably because it was the driest site when the lanes were created and bedrock is at the surface over much of the site. The ridges and furrows which remained from farming during the 1950's are still evident in Marl Marsh 3, and during 1985 the test lanes were often more obvious in the lower and wetter furrows. Width of the tire on the various test vehicles influenced the visual ratings because, the narrower the tire and thus the lane, the more the adjacent vegetation was able to camouflage the track.

### Sand Marsh

None of the three Sand Marsh plots were sampled in 1985. Two had been destroyed and one had completely recovered. Sand Marsh 1 had been heavily grazed which masked any potential vegetation differences, and the ground had been trampled which obliterated any ruts that might otherwise have been present. A new gate in the fence along the baseline of Sand Marsh 2 resulted in enough ORV traffic to destroy most of the test lanes at this site. Only two lanes, ATC and tractor heavy, were relatively unimpacted and no trace of either was found. Sand Marsh 3 was unimpacted but no lanes remained, possibly because this was the driest of the three sand marsh sites when the lanes were created.

### Pine

Pine 1 and 2 had completely recovered by 1985, but four lanes in Pine 3 were found. This was the wettest of the three sites when the lanes were originally created, and had the deepest ruts. No vegetation impacts were still present in three of the lanes which were located only because the rut was still visible. The chain buggy heavy impact lane was not found largely because most of the run was across palmettos which minimized impacts to the soil surface. The ATC heavy impact lane was found due to an almost total lack of small pines in the trail. At the time of the initial tests, there were numerous pine seedlings in the area and these were killed by the repeated passes made in our unsuccessful attempt to create an ATC heavy impact. With the wide swath that an ATC makes, the absence of these pines was more obvious here than in the buggy lanes. The remaining small pines in the plot were killed by a fire in the fall of 1984 so this effect will disappear shortly. The ATC heavy impact lane was not found in 1979, possibly because the pine seedlings were not yet tall enough to be obvious by their absence from the lane.

### Airboat and Track Vehicle Marl Marsh

In 1985 we found only the track vehicle heavy impact lanes at these three sites. There were no obvious vegetation differences between the lanes and adjacent undisturbed habitat, but ruts were still evident along the entire length of the lanes.

Airboat and Track Vehicle Peat Marsh

The track vehicle heavy impact lane in Peat Marsh 2 was the only lane we found in this habitat during 1985. Searching for the test lanes was hampered by the tall, thick sawgrass that characterizes this habitat. One researcher walked along in the sawgrass perpendicular to the test lanes, while the other walked in the shorter vegetation along the baseline telling the first when they should both be in a test lane. The individual in the sawgrass would then check for any evidence of vegetation impacts or ruts well to either side of the lane center. It proved quite difficult to obtain accurate samples of standing litter in the peat marshes because the dead stems of the dominant vegetation, sawgrass, frequently broke off when we were setting up the sample plots.

## Comparison of Vehicle Types

In conducting the recovery analyses we attempted several approaches to evaluate which of the vehicles had shown more or less recovery. A strictly quantitative comparison was impossible because of (1) the variability of environmental characteristics among the replicates of each habitat and between habitats; (2) the several months that it took to complete all of the tests; and (3) the inability of some vehicles to either operate in some habitats or make the desired impacts. The following analysis comparing the types of wheeled vehicles, although not as rigorous as might be desired, does provide an objective comparison that sheds some light on the topic.

The analysis involved first determining individually for each combination of parameter and habitat, the total number of recovered lanes among the three replicate plots for each type of wheeled vehicle at each impact level within each sampling period. These results were based on the Duncan's new multiple range test tables in Appendix C. The medium impact data in these tables were supplemented by data from the one pass treatments where a medium impact had been achieved with only one pass by that vehicle in that replicate plot (see Appendix F). For each parameter evaluated, recovered lanes included those which had completely recovered (R) and those for which the parameter values were not significantly different from the control values, i.e. they had statistically recovered. Next, we compared these total numbers of recovered lanes among the various vehicle types within each impact level and sampling period. If a particular vehicle type had a distinctly higher or lower number of recovered replicate lanes relative to the other vehicles, we tallied a +1 or -1, respectively, for that vehicle. This was done individually for each parameter in each habitat. Then within each impact level for each year, we totalled the number of +1's and the number of -1's for each vehicle type (Table 2).

As we reported in 1981, recovery from ATC impacts was slightly better and recovery from the tractor buggy impacts was slightly poorer than was recovery from impacts made by any of the other wheeled vehicles (Table 2). For the ATC, the relatively better recovery was more pronounced at

Table 2. Number and percentage of parameter - habitat combinations when a particular wheeled vehicle type had a distinctly higher (+) or lower (-) number of replicate lanes that had recovered as compared to other wheeled vehicle types. The more positive the number, the greater the recovery from impacts created by that vehicle type.

| | Higher Number of Recovered Replicates | | | Lower Number of Recovered Replicates | | | Number of Possible Parameter - Habitat Combinations | | | | Net Distinctly Different | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Winter 1979 | Fall 1979 | Fall 1985 | Winter 1979 | Fall 1979 | Fall 1985 | Winter 1979 | Fall 1979 | Fall 1985 | Total | Number | Percent |
| **One Pass** | | | | | | | | | | | | |
| ATC | +2 | +7 | 0 | 0 | 0 | 0 | 20 | 30 | 33 | 83 | +9 | 11 |
| Light | +1 | 0 | 0 | 0 | 0 | 0 | 20 | 30 | 33 | 83 | +1 | 1 |
| Smooth | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 14 | 16 | 40 | 0 | 0 |
| Chain | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 30 | 33 | 83 | 0 | 0 |
| Tractor | 0 | 0 | 0 | -1 | -3 | 0 | 20 | 30 | 33 | 83 | -4 | -5 |
| Heavy | 0 | 0 | 0 | -1 | 0 | 0 | 20 | 30 | 33 | 83 | -1 | -1 |
| **Medium Impact** | | | | | | | | | | | | |
| ATC | +3 | +5 | 0 | 0 | 0 | 0 | 20 | 30 | 33 | 83 | +8 | 10 |
| Light | +1 | +1 | 0 | 0 | 0 | 0 | 15 | 23 | 24 | 62 | +2 | 3 |
| Smooth | 0 | 0 | 0 | -2 | -1 | 0 | 10 | 14 | 16 | 40 | -3 | -8 |
| Chain | +1 | 0 | 0 | -1 | 0 | 0 | 20 | 30 | 33 | 83 | 0 | 0 |
| Tractor | +1 | 0 | 0 | -1 | -2 | 0 | 15 | 23 | 24 | 62 | -2 | -3 |
| Heavy | 0 | 0 | 0 | 0 | -2 | 0 | 15 | 23 | 24 | 62 | -2 | -3 |
| **Heavy Impact** | | | | | | | | | | | | |
| ATC | 0 | 0 | +1 | 0 | 0 | 0 | 15 | 23 | 24 | 62 | +1 | 2 |
| Light | 0 | 0 | 0 | 0 | 0 | -1 | 15 | 23 | 24 | 62 | -1 | -2 |
| Smooth | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 14 | 16 | 40 | 0 | 0 |
| Chain | +1 | 0 | +2 | -1 | -3 | 0 | 20 | 30 | 33 | 83 | -1 | -1 |
| Tractor | 0 | 0 | 0 | -1 | -3 | 0 | 15 | 23 | 24 | 62 | -4 | -6 |
| Heavy | 0 | 0 | 0 | 0 | 0 | -2 | 15 | 23 | 24 | 62 | -2 | -3 |

the one pass and medium levels of impact. This was at least partially because this vehicle was only able to create heavy impacts in 5 of the 12 possible lanes, and it was difficult to detect distinctly better recovery with only one replicate plot in a habitat type. There was little difference among impact levels in the relatively poorer recovery of the tractor buggy lanes. None of these differences were associated with any particular parameter or habitat. However, they were most pronounced one year after, and least pronounced seven years after the impacts were made. Considering the large number of possible instances when a vehicle could have been distinctly more or less impacting than the other wheeled vehicles, the small number of instances we found in this analysis suggests that there are only relatively minor differences in recovery rates of impacts produced by the various types of wheeled vehicles (Table 2).

Because of differences in habitat characteristics between the wheeled vehicle and airboat - track vehicle test sites, it was impossible to make any realistic comparisons of impact recovery between airboats or track vehicles and any of the individual types of wheeled vehicles. However, the following analyses do compare recovery from airboat and track vehicle impacts with that from the wheeled vehicles as a group.

## Complete Recovery of Lanes

The clearest statement about recovery of an experimental test lane could be made when we knew exactly where the lane was and still could not find any trace of it. Using this criterion, we analyzed the 1978-79 and 1985 data (Appendix A) separately for the one pass, medium impact, and heavy impact levels.

### One Pass Impacts

Among the one pass lanes, only the airboat impacts had completely disappeared between when they were made in fall 1978 and the first sampling period in late winter 1979 (Figure 1). None of the track vehicle one pass lanes had disappeared within this same period. The only wheeled vehicle habitat where all of the one pass lanes were still visible in late winter 1979 was the small cypress, although almost all of them were still visible at this time in the marl marsh and pine plots. Of the habitats where wheeled vehicles were tested, the sand marsh showed the highest percentage of completely recovered one pass lanes.

In addition to the airboat one pass lanes, at the end of one full year following the creation of the experimental lanes, the sand marsh, pine, and track vehicle peat marsh one pass lanes had disappeared. All of the track vehicle marl marsh one pass lanes were still visible. Approximately 40 to 50 percent of the small cypress and wheeled vehicle marl marsh one pass lanes had completely recovered by this time.

By fall 1985 all one pass lanes, except for one in the small cypress, had disappeared.

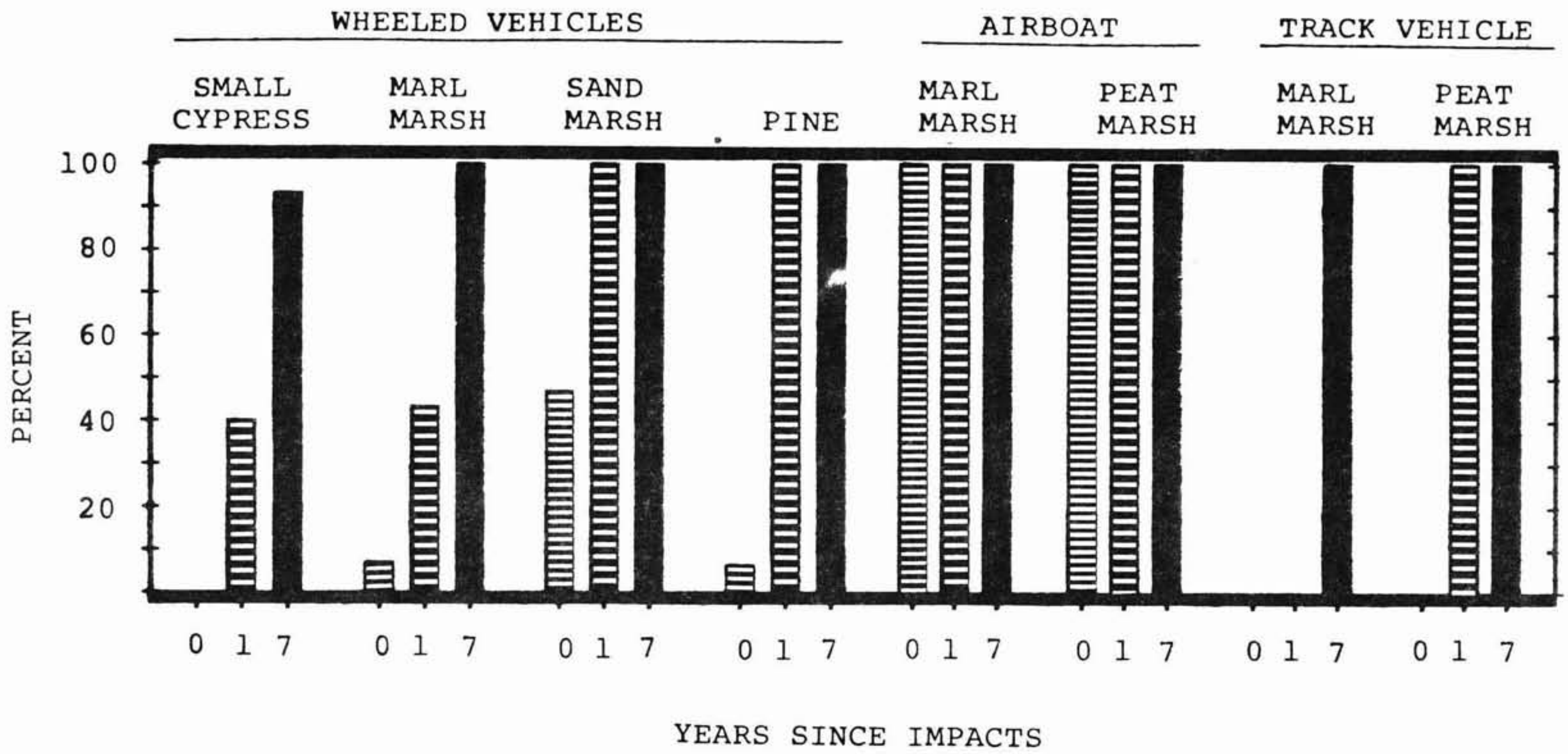



Figure 1. Percent of experimental one pass lanes that had recovered (i.e. no longer visible).

### Medium Impacts

Among the medium impact lanes, the airboat marl marsh lanes had disappeared by late winter 1979, but all others were visible (Figure 2).

In fall 1979 all of the track vehicle marl and peat marsh and the wheeled vehicle marl marsh lanes were still visible. Only 20 percent of the small cypress lanes had disappeared within one year, but in sand marsh, pine, and airboat peat marsh habitats between 40 and 70 percent of the lanes had completely recovered within this period.

By fall 1985 all of the medium impact lanes in the airboat and track vehicle habitats had disappeared, while a few lanes were still visible in most of the wheeled vehicle habitats. The sand marsh data indicated that all lanes in this habitat had disappeared. However, one of the sand marsh replicate plots had been completely and another partially destroyed since 1979, and it is possible that a few of the lanes in the destroyed plots might have been found in 1985. This possibility is enhanced by the fact that the plot which was destroyed was originally the most impacted and the one which remained was the least impacted of the sand marsh sites.

### Heavy Impacts

Few of the heavy impact lanes in any habitat had disappeared during this study, even by fall 1985 (Figure 3). It seems clear that once severe soil disturbance occurs, it takes a very long time for those tracks to disappear. These impacts are most likely to be a major management problem in the small cypress and marl marsh habitats where heavy impacts were created with a variety of vehicle types, some with a relatively small number of passes. The problem of heavy impacts in pine, sand marsh, and peat marsh habitats appears to be less significant, since we found it difficult to create severe soil disturbance in several of their replicate plots or a fairly large number of passes was required to create them. However, ruts can obviously be created in these habitats with sufficiently frequent use as evidenced by the existence of old trails in these habitats.

### Interpretation of Complete Recovery

Airboat lanes recovered more quickly than those produced by any other vehicle type. This is because during normal operation airboats are not in contact with the ground, and frequently are in water deep enough so that the vegetation is merely bent over and shortly thereafter pops back up again, particularly in one pass lanes. In the medium impact tests the number of runs was sufficient to severely batter the vegetation and eliminate the associated litter in the peat marsh. These impacts were visible for over a year following the creation of the impacts. In the marl marsh habitat the vegetation was sparse and short enough that the airboats were unable to produce any lasting impacts. We never were able to produce severe soil disturbance with an airboat. Nevertheless, existing airboat old trails do show evidence of ruts. This is probably

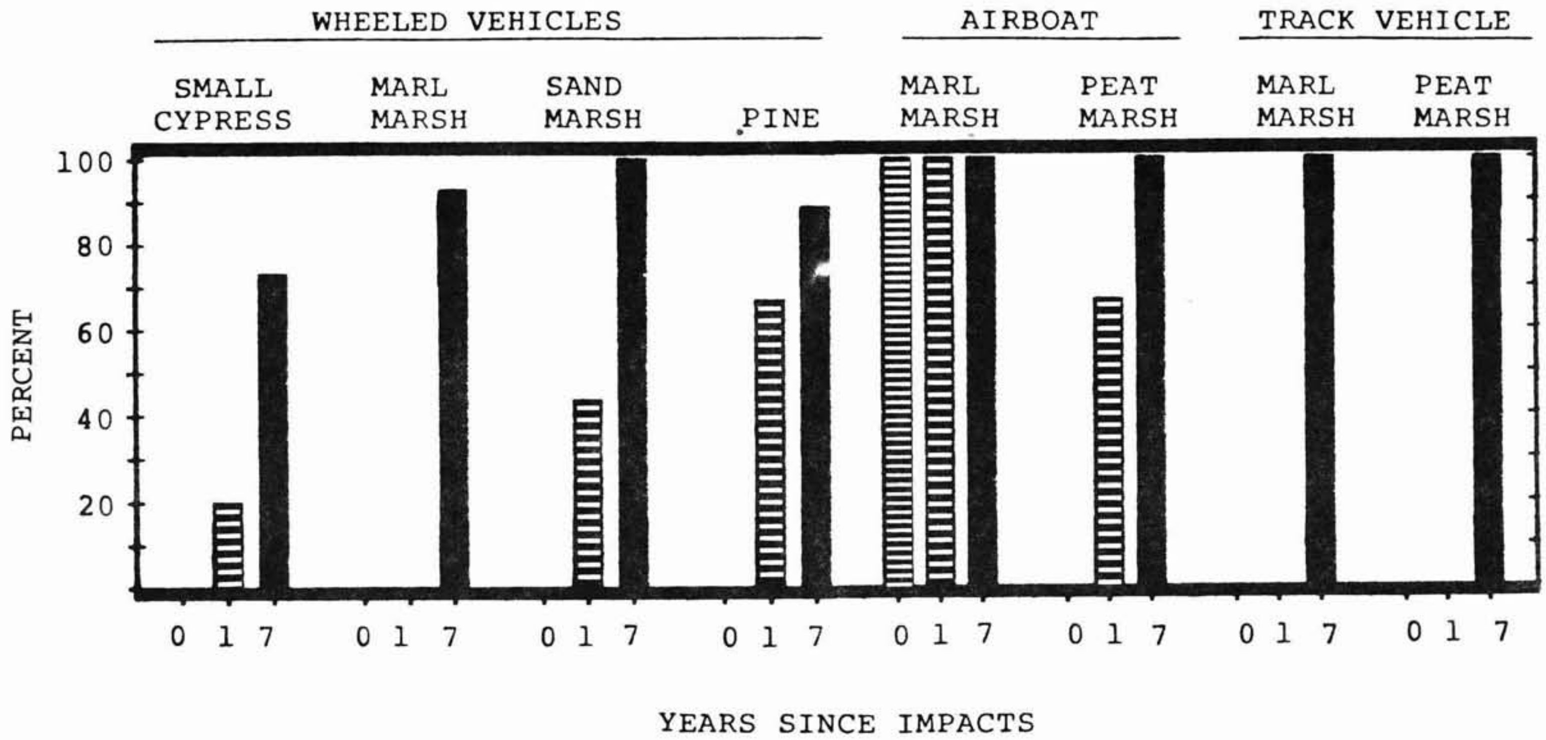
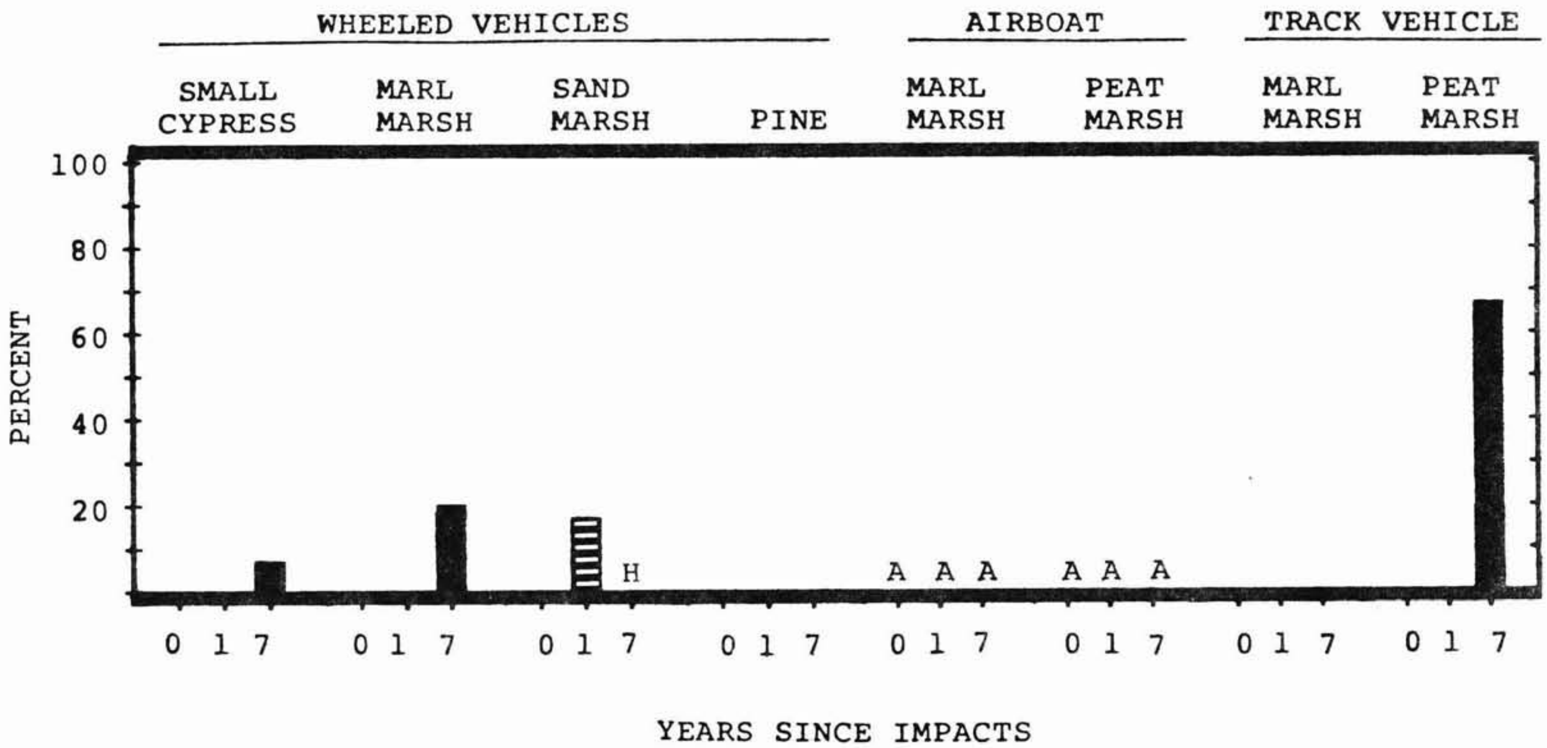



Figure 2. Percent of experimental medium impact lanes that had recovered (i.e. no longer visible).




A Airboats could not achieve heavy impacts in these habitats.
H Plot one was destroyed by heavy grazing and we were never able to produce heavy impacts in plots two and three.

Figure 3. Percent of experimental heavy impact lanes that had recovered (i.e. no longer visible).

associated with vehicles operating at times of the year when water levels were considerably shallower than they were when we conducted our test runs.

The other vehicles all ran directly on the ground surface. As a vehicle passed along a lane, vegetation in the wheel tracks was generally bent over and pushed onto or, where water levels were above or near the ground surface, into the surface soils. As a result, the vegetation was normally at least bruised and the brittle litter broken up as a vehicle ran over it. Within a short time after a one pass or medium impact lane was created, it tended to appear as a pair of relatively "green" paths through the plot due to recovery and regrowth of vegetation and the absence of the brownish litter. In the heavy impact lanes the disturbed soil generally supported a much reduced plant community, at least during the first year following the creation of the impacts. In the fall 1985 sampling period, some of these lanes were difficult to see, not because of recovery within them, but because vegetation rooted adjacent to the lanes had overgrown them. However, others were still obvious due to water being present only in the lane ruts or differences in amount, height, or taxonomic composition of vegetation in and adjacent to the lanes.

## Statistically Recovered Lanes

While disappearance of an experimental ORV lane represented the clearest case of recovery, another way of looking at it is on the basis of when lane parameters had statistically recovered (i.e. were not significantly different from control values) in a replicate plot (Appendix C). Thus, the trail may still be visible, but some environmental parameters may not be significantly different from conditions on an adjacent undisturbed site. This allowed us to make an assessment of which aspects of the environment were and remained more impacted by an ORV track. However, even if a parameter is not significantly different from the controls, it is possible that there were real differences which our techniques simply were not sensitive enough to identify. One place this situation may have occurred was with our increasing the lane sample size from three in 1979 to six in 1985. This change increased our ability to detect real differences between lane and control plots. Despite this increased ability to detect impacted lanes in 1985, the percentage of statistically recovered lanes had increased substantially since 1979 (Figures 4-6).

### Late Winter 1979

The ranges in the percentage of lanes that were statistically recovered in late winter 1979 varied from 0 to 100 percent among the live vegetation parameters in the one pass (Figure 4) and medium impact (Figure 5) lanes. All soil parameter percentages indicated at least 75 percent recovery in these same lanes.

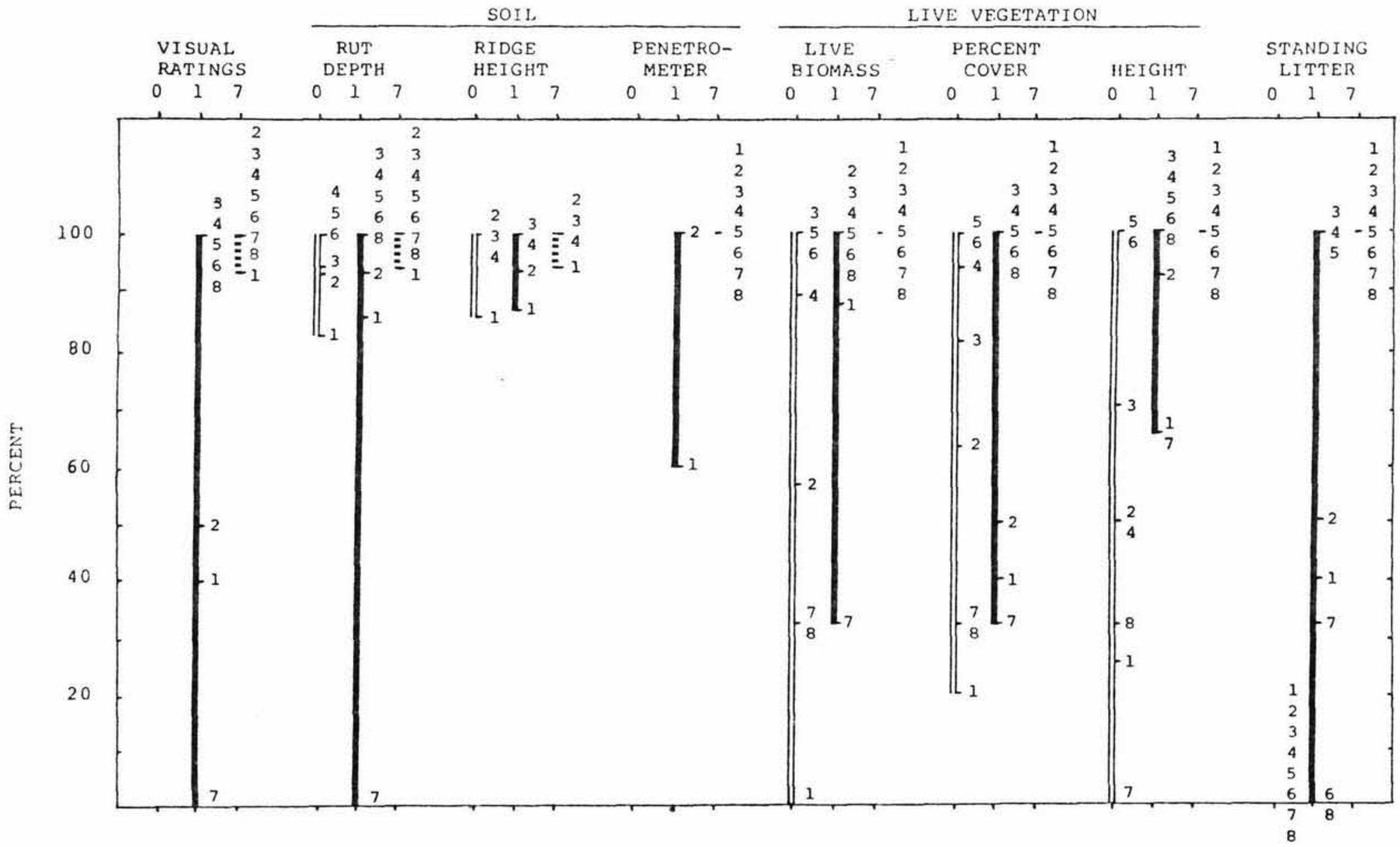



Figure 4. Percentages of one pass experimental lanes in the different habitats that had recovered (i.e. were not significantly different from the controls) at Ø, 1, and 7 years after the lanes were created. Vertical bars indicate ranges of percentages of all habitats for which data are available for each sampling period. Dashes identify the percentage for each habitat. See Table 1 for a key to the numbers used to identify each habitat.

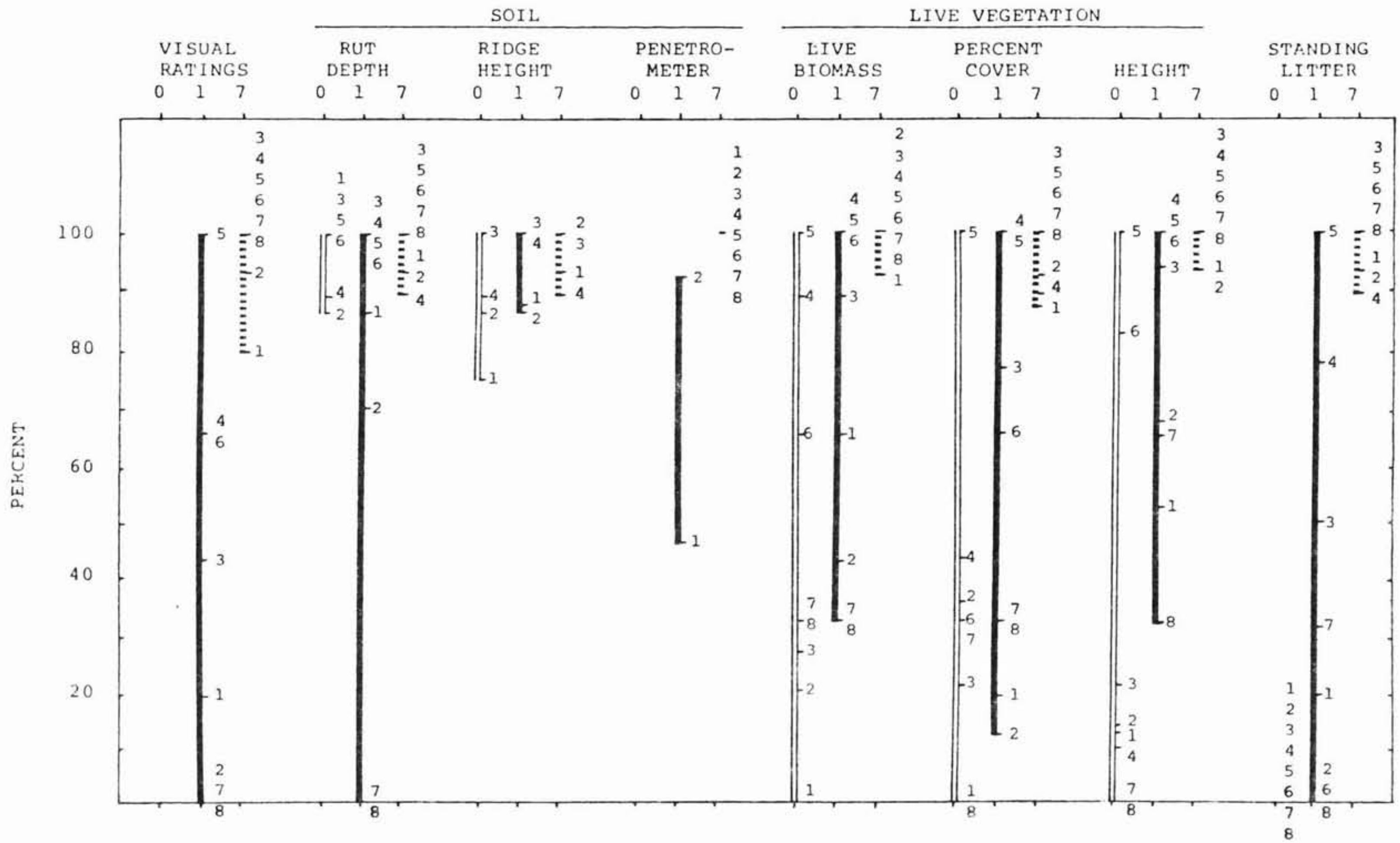



Figure 5. Percentages of medium impact experimental lanes in the different habitats that had recovered (i.e. were not significantly different from the controls) at Ø, 1, and 7 years after the lanes were created. Vertical bars indicate ranges of percentages of all habitats for which data are available for each sampling period. Dashes identify the percentage for each habitat. See Table 1 for a key to the numbers used to identify each habitat.

In the heavy impact lanes the only parameter that ranged up to 100 percent recovery at this time was ridge height, and most parameters were below 35 percent (Figure 6).

Standing litter had consistently shown no recovery in all habitats and at all impact levels because this brittle material had all been knocked down and broken up during the test runs (Figures 4-6). No data were available on visual ratings in late winter 1979.

Fall 1979

In the one pass and medium impact lanes, soil parameters had shown little or no additional recovery at the end of the first year after the impacts had been created (Figures 4-5). Visual ratings and standing litter ranged from 0 to 100 percent. All of the live vegetation parameters in these lanes still showed a wide range of percent recovery, but none of them had less than 14 percent of the lanes recovered in any habitat.

In the heavy impact lanes, for the rut depth, standing litter, and live vegetation parameters recovery ranged from 0 to 100 percent, while for the visual ratings it was less than 20 percent (Figure 6). Penetrometer measurements of compressive strength indicated little recovery for this parameter in the heavy impact lanes of the two habitats where it was evaluated.

Fall 1985

By fall 1985, the live vegetation, standing litter, and soil compressive strength (penetrometer) parameters had completely recovered in all one pass lanes (Figure 4). Among the visual rating and remaining soil parameters, only one lane in the small cypress was all that had not recovered.

Among the medium impact lanes, at least 80 percent of the lanes in all habitats for all parameters had recovered (Figure 5). The small cypress, wheeled vehicle marl marsh, and pine were the only habitats which had not recovered completely.

Percentages of recovered heavy impact lanes in the various habitats varied from 0 to 100 percent for the different parameters (Figure 6). Live biomass and vegetation height were the parameters which showed the greatest recovery. Wheeled vehicle marl marsh had not completely recovered for any parameter, while small cypress and pine had recovered completely in only two of eight parameters. The lack of recovery suggested for the pine habitat was somewhat misleading since only two of the nine attempts at creating a heavy impact there were even successful. Also, rut depth, percent cover, and standing litter in both pine heavy impact lanes were statistically recovered in fall 1979, but neither was statistically recovered in fall 1985. This discrepancy was solely a function of the increased sample size in 1985. Appendix Tables A 10, A 29, and A 39 clearly show that at least some recovery has occurred for these parameters between 1979 and 1985.

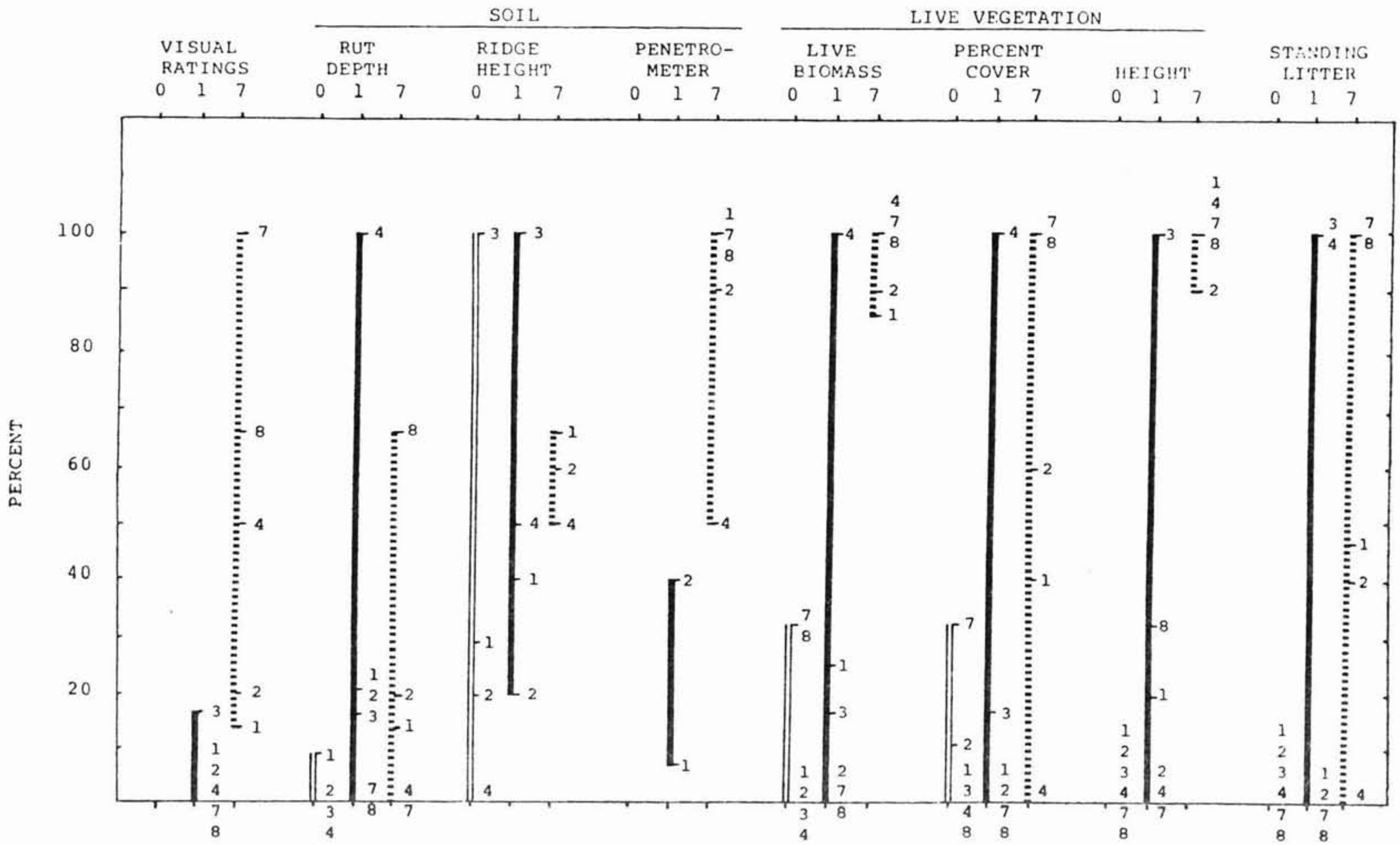



Figure 6. Percentages of heavy impact experimental lanes in the different habitats that had recovered (i.e. were not significantly different from the controls) at Ø, 1, and 7 years after the lanes were created. Vertical bars indicate ranges of percentages of all habitats for which data are available for each sampling period. Dashes identify the percentage for each habitat. See Table 1 for a key to the numbers used to identify each habitat.

Interpretation of Statistical Recovery

In contrast to the visual rating, live vegetation, and standing litter parameters, rut depth and ridge height generally showed little recovery over the seven years since the impacts were initially evaluated. At the one pass and medium impact levels, while only a few lanes in some habitats were significantly impacted initially, some of these had not yet completely recovered. In the heavy impact lanes, where severe soil disturbance had occurred, fewer than 70 percent of the lanes had recovered in terms of rut depth and ridge height even after seven years.

We ranked all of the habitats on the basis of which had shown the smallest percentage of lanes which had statistically recovered for each parameter at each impact level during each sampling period to determine which habitats were exhibiting the least recovery for all of these combinations (Table 3). We then ranked the second lowest and the third lowest. This approach allowed a relatively objective analysis of which habitats were exhibiting the slowest recovery from the impacts made in 1978. As in the previous analyses, the small cypress had recovered least and the marl marshes the next least. The airboat habitats had by far the highest ranking because this vehicle type produced the fewest initial impacts and recovered most quickly from those it did make.

These same habitat ranking patterns were exhibited in the individual 0, 1, and 7 year data summaries, with the exception of the track vehicle lanes (Table 4). During the 0 and 1 year sampling period, recovery of the track vehicle marl and peat marsh lanes was comparable to the poor recovery seen in the small cypress and marl marsh wheeled vehicle lanes. However, after 7 years almost all of the track vehicle lanes had statistically recovered.

## Analysis of Taxonomic Differences

The difficulty involved in identifying many of the immature plants encountered in the plots forced us to discuss them in terms of taxa, rather than species or genera. Also, not being trained botanists, none of the authors would stoutly defend all of our identifications, although some of the more distinctive forms are accurately identified. More importantly, by identifying the various taxa at a consistent level of taxonomic detail within each replicate plot, we were able to make statements about differences in taxonomic composition between the test lanes and adjacent undisturbed habitats that are relevant to recovery from ORV impacts. We have made no attempt to compare the 1985 taxonomic analysis with that done in 1979. The personnel involved in making taxonomic decisions were completely different at these times, and the relative ability and effort put into this aspect of the study were also different, so that comparisons are more likely to be misleading than helpful. However, the personnel and methodologies were consistent within each sampling period.

Table 3. Total number of lowest, second lowest, and third lowest ranked habitats according to their degree of recovery (i.e. smallest percentage of lanes not significantly different from controls) for each parameter during each sampling period at each impact level based on their relative position along the vertical bars in Figures 4-6.

| | Wheeled Vehicle | | | | Airboat | | Track Vehicle | |
|---|---|---|---|---|---|---|---|---|
| Ranking | Small Cypress | Marl Marsh | Sand Marsh | Pine | Marl Marsh | Peat Marsh | Marl Marsh | Peat Marsh |
| (1) Lowest | 26 | 15 | 3 | 14 | 0 | 2 | 17 | 14 |
| (2) Second Lowest | 18 | 19 | 5 | 3 | 0 | 0 | 4 | 3 |
| (3) Third Lowest | 7 | 9 | 3 | 3 | 0 | 1 | 5 | 3 |
| (4) Total | 53 | 43 | 11 | 20 | 0 | 3 | 26 | 20 |
| (5) Total Number of Possible Comparisons * | 56 | 56 | 45 | 53 | 28 | 28 | 41 | 41 |
| (6) Percent (4)/(5) | 95 | 77 | 24 | 38 | 0 | 11 | 63 | 49 |

* Where all of the habitats were neither 0% recovered (year 0) nor 100% recovered (year 7) for a particular parameter during a particular year at a particular level of impact.

Table 4. Total number (by sampling period) of the three lowest ranked habitats according to their degree of recovery (i.e. smallest percentage of lanes not significantly different from controls) for each parameter at each impact level based on their relative position along the vertical bars in Figures 4-6. This table is similar to Table 3 except (1) numbers of the three lowest ranked habitats are summed and (2) these numbers and the percentage each is of their total possible occurrences are shown by individual sampling period.

| | Wheeled Vehicle | | | | Airboat | | Track Vehicle | |
|---|---|---|---|---|---|---|---|---|
| Year | Small Cypress | Marl Marsh | Sand Marsh | Pine | Marl Marsh | Peat Marsh | Marl Marsh | Peat Marsh |
| 0 Years | | | | | | | | |
| Number of Occurrences | 13 | 10 | 6 | 7 | 0 | 1 | 7 | 7 |
| Percent of Possible Occurrences* | 93 | 71 | 43 | 50 | 0 | 10 | 88 | 88 |
| 1 Year | | | | | | | | |
| Number of Occurrences | 24 | 20 | 5 | 3 | 0 | 2 | 18 | 13 |
| Percent of Possible Occurrences* | 100 | 83 | 24 | 14 | 0 | 17 | 100 | 72 |
| 7 Years | | | | | | | | |
| Number of Occurrences | 16 | 13 | 0 | 10 | 0 | 0 | 1 | 0 |
| Percent of Possible Occurrences* | 89 | 72 | 0 | 56 | 0 | 0 | 7 | 0 |

* Where all of the habitats were neither 0% recovered (year 0) nor 100% recovered (year 7) for a particular parameter at a particular level of impact.

The analyses of total number of taxa per sample plot in fall 1985 indicated significant differences between lanes and controls in only a few heavy impact lanes in small cypress and wheeled vehicle marl marsh habitats (Appendix Table C 41). In all these cases there were fewer taxa in the lanes.

We subsequently analyzed each taxon individually in each habitat replicate to see if it occurred more frequently in either control or lane plots and how many times it was listed as being common or abundant within individual control or lane plots. Tables 5-8 list those taxa which were of more than sporadic occurrence and which we feel had been consistently identified at a replicate site.

In the small cypress both Dichromena and Rhynchospora were distinctly more frequent in the control samples at one or more replicate plots, while Bacopa, Eleocharis, two forms of Panicum, and Utricularia were more frequently found in the lanes (Table 5). The occurrence of Bacopa and Utricularia in the lanes is not surprising since the ruts provide a wetter habitat more suitable to these genera. We are unable to explain why the other species were more common in either the lane or control plots. However, it was interesting that Dichromena and Rhynchospora were also more frequent in the old trail control plots, as were Bacopa and Eleocharis in the old trails themselves.

The only taxon which was more frequent in one or the other of the wheeled vehicle marl marsh plots was Centella, and it was found more often in the test lanes (Table 6).

Pluchea and yet another form of Panicum were more frequent in the pine control plots, while Hypericum, Ludwigia, and Xyris were more frequent in the lanes, (Table 7). Ludwigia was also found more often in the large cypress old trails.

In the track vehicle peat marsh sites (Table 8), the only taxon which was more frequent in one or the other of the plots was Cladium, and it was more frequent in the controls. Cladium does not appear to tolerate severe soil disturbance as it was also distinctly more frequent in the control plots at the old trail small cypress, marl marsh, and pine sites. Taxa at the track vehicle marl marsh sites were similarly distributed in both the lane and control sample plots.

## RESULTS AND DISCUSSION - OLD TRAILS

Most of the old trails study sites established in 1979 were still visible from the air in February 1985 and on the ground in fall 1985. Airboat old trail plots in marl and peat marsh habitats were established at the beginning of the study in 1979, but airboats continued to use them and they were dropped from our study shortly thereafter. Two of the sand marsh sites had been heavily used between 1979 and 1985, and as a result were not included in the 1985 sampling. One of the hammock old trails

Table 5. Number of sample plots in which each taxon was present during fall 1985 in the unrecovered lanes and associated controls at the small cypress experimental test sites.

| Taxon | Plot No | Control | 1 Pass Tractor | Medium ATC | Medium Light | Heavy ATC | Heavy Light | Heavy Chain | Heavy Tractor | Heavy Heavy |
|---|---|---|---|---|---|---|---|---|---|---|
| Aristida | 1 | 1 | 2 | S | 0 | 1 | 1 | 0 | 0 | 1 |
| | 2 | 0 | S | 1 | S | 0 | 0 | S | 0 | 0 |
| | 3 | 0 | S | 0 | S | 0 | 0 | 0 | 0 | 0 |
| Bacopa | 1 | 0 | 0 | S | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | S | 0 | S | 0 | 2 | S | 0 | 1 |
| | 3 | 0 | S | 0 | S | 1 | 2 | 1 | 1 | 2 |
| Centella | 1 | 2 | 0 | S | 3 | 1 | 1 | 0 | 2 | 3 |
| | 2 | 1 | S | 4 | S | 2 | 0 | S | 0 | 0 |
| | 3 | 1 | S | 0 | S | 0 | 1 | 0 | 0 | 0 |
| Cladium | 1 | 5 | 5 | S | 2 | 1 | 3 | 5 | 3 | 1 |
| | 2 | 4 | S | 5 | S | 3 | 6 | S | 6 | 6 |
| | 3 | 3 | S | 3 | S | 3 | 4 | 4 | 1 | 3 |
| Dichromena | 1 | 5 | 2 | S | 2 | 3 | 3 | 0 | 0 | 1 |
| | 2 | 1 | S | 2 | S | 3 | 0 | S | 0 | 0 |
| | 3 | 0 | S | 0 | S | 0 | 0 | 0 | 0 | 0 |
| Eleocharis | 1 | 0 | 2 | S | 0 | 3 | 0 | 1 | 0 | 2 |
| | 2 | 0 | S | 2 | S | 3 | 1 | S | 0 | 1 |
| | 3 | 0 | S | 0 | S | 0 | 0 | 0 | 0 | 0 |
| Hymenocallis | 1 | 1 | 0 | S | 0 | 1 | 0 | 0 | 3 | 1 |
| | 2 | 0 | S | 0 | S | 0 | 0 | S | 0 | 0 |
| | 3 | 0 | S | 0 | S | 0 | 0 | 0 | 0 | 0 |
| Ipomoea | 1 | 2 | 1 | S | 0 | 1 | 1 | 0 | 0 | 4 |
| | 2 | 1 | S | 2 | S | 2 | 0 | S | 0 | 0 |
| | 3 | 0 | S | 0 | S | 0 | 2 | 1 | 0 | 0 |

Table 5. Continued.

| Taxon | Plot No | Control | 1 Pass Tractor | Medium ATC | Medium Light | Heavy ATC | Heavy Light | Heavy Chain | Heavy Tractor | Heavy Heavy |
|---|---|---|---|---|---|---|---|---|---|---|
| Muhlenbergia | 1 | 2 | 3 | S | 2 | 2 | 3 | 4 | 1 | 1 |
| | 2 | 5+ | S | 4 | S | Ø | 5+ | S | 3 | 6 |
| | 3 | 5+ | S | 6+ | S | 4 | 4 | 5+ | 5 | 4 |
| Panicum 1 | 1 | Ø | 2 | S | 1 | 3 | Ø | Ø | 1 | 1 |
| | 2 | Ø | S | 1 | S | 1 | Ø | S | Ø | Ø |
| | 3 | Ø | S | Ø | S | Ø | Ø | Ø | Ø | Ø |
| Panicum 2 | 1 | 6+ | 5 | S | 6 | 5+ | 3 | 6 | 5 | 5 |
| | 2 | 2 | S | 4 | S | 6+ | Ø | S | 4 | Ø |
| | 3 | Ø | S | Ø | S | Ø | Ø | Ø | Ø | Ø |
| Rhynchospora | 1 | 5 | 3 | S | 5 | 4 | 4 | 2 | 2 | 1 |
| | 2 | 6 | S | 5 | S | 4 | Ø | S | 3 | Ø |
| | 3 | Ø | S | 1 | S | Ø | Ø | 2 | Ø | Ø |
| Sagittaria | 1 | Ø | Ø | S | Ø | Ø | Ø | Ø | Ø | Ø |
| | 2 | 2 | S | 3 | S | 3 | Ø | S | 2 | Ø |
| | 3 | Ø | S | Ø | S | Ø | Ø | Ø | 1 | Ø |
| Taxodium | 1 | Ø | Ø | S | Ø | Ø | Ø | Ø | Ø | Ø |
| | 2 | 2 | S | 1 | S | Ø | 2 | S | 1 | 2 |
| | 3 | 1 | S | Ø | S | Ø | Ø | 2 | Ø | 1 |
| Utricularia | 1 | Ø | 1 | S | Ø | Ø | 2 | 2 | 1 | 2 |
| | 2 | 2 | S | Ø | S | 1 | 5 | S | 2 | 3 |
| | 3 | 1 | S | 6 | S | 5 | 6 | 4 | 4 | 5 |

S No data available
\+ Common or abundant in at least half of the six lane or control plots

Table 6. Number of sample plots in which each taxon was present during fall 1985 in the unrecovered lanes and associated controls at the wheeled vehicle marl marsh experimental test sites.

| Taxon | Plot No | Control | Medium Light | Heavy | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | ATC | Light | Chain | Tractor | Heavy |
| <u>Centella</u> | 2 | Ø | S | S | 3 | 2 | 3 | S |
| | 3 | 3 | 5 | 6 | 2 | 3 | 2 | 5+ |
| <u>Cladium</u> | 2 | 4 | S | S | 6 | 5 | 4 | S |
| | 3 | 5+ | 6+ | 6+ | 5 | 6+ | 5 | 4+ |
| <u>Ludwigia</u> | 2 | 4 | S | S | Ø | 2 | 4 | S |
| | 3 | 1 | 3 | 2 | Ø | Ø | 1 | 1 |
| <u>Muhlenbergia</u> | 2 | 6+ | S | S | 5 | 3 | 6 | S |
| | 3 | 6 | 5 | 4 | 5 | 3 | 4 | 5 |
| <u>Panicum</u> 2 | 2 | Ø | S | S | Ø | Ø | Ø | S |
| | 3 | 2 | 2 | Ø | Ø | Ø | 2 | 2 |
| <u>Rhynchospora</u> | 2 | 6 | S | S | 5 | 5 | 1 | S |
| | 3 | 5 | 5 | 5 | 1 | 2 | 1 | 6+ |

S No data available
\+ Common or abundant in at least half of the six lane or control plots

Table 7. Number of sample plots in which each taxon was present during fall 1985 in the unrecovered lanes and associated controls at the pine experimental test site.

| Taxon | Plot No | Control | Medium Smooth | Heavy ATC | Heavy Smooth | Heavy Chain |
|---|---|---|---|---|---|---|
| *Centella* | 3 | 2 | 5 | 3 | 5 | 2 |
| *Cladium* | 3 | 3 | 2 | 4 | 3 | 3 |
| *Cuscuta* | 3 | 4 | 4 | 5 | 4 | 3 |
| *Flaveria* | 3 | 2 | Ø | 5 | 2 | 2 |
| *Hypericum* 1 | 3 | 2 | 2 | 2 | 4 | 4 |
| *Hypericum* 2 | 3 | 2 | 2 | Ø | 3 | 1 |
| *Ludwigia* | 3 | 2 | 1 | 2 | 4 | 4+ |
| *Muhlenbergia* | 3 | 2 | 4 | 5 | 3 | 2 |
| *Panicum* 1 | 3 | 3 | 2 | 4 | 3 | Ø |
| *Panicum* 3. | 3 | 4 | 2 | 1 | 2 | 2 |
| *Pluchea* | 3 | 3 | 3 | 2 | 1 | 1 |
| *Rhynchospora* | 3 | 1 | Ø | 3 | 1 | 4 |
| *Xyris* | 3 | Ø | 1 | 3 | 1 | 4 |

* Common or abundant in at least half of the six lane or control plots

Table 8. Number of sample plots in which each taxon was present during fall 1985 in the unrecovered lanes and associated controls at the airboat-track vehicle marl marsh and peat marsh experimental test sites.

| | | Marl Marsh | | Peat Marsh | |
|---|---|---|---|---|---|
| Taxon | Plot No | Control | Heavy Track Vehicle | Control | Heavy Track Vehicle |
| Bacopa | 1 | 2 | 4 | S | S |
| | 2 | 4 | 4 | 1 | Ø |
| | 3 | 3 | 4 | S | S |
| Cladium | 1 | 5 | 5 | S | S |
| | 2 | 6+ | 6+ | 5+ | 1 |
| | 3 | 6+ | 6 | S | S |
| Eleocharis | 1 | 6 | 6 | S | S |
| | 2 | 5 | 4+ | Ø | Ø |
| | 3 | 6 | 6+ | S | S |
| Hymenocallis | 1 | Ø | Ø | S | S |
| | 2 | 2 | 1 | Ø | Ø |
| | 3 | 1 | 1 | S | S |
| Proserpinaca | 1 | Ø | Ø | S | S |
| | 2 | Ø | Ø | 2 | Ø |
| | 3 | Ø | Ø | S | S |
| Utricularia | 1 | 3 | 3 | S | S |
| | 2 | Ø | Ø | 2 | Ø |
| | 3 | 1 | 3 | S | S |

S No data available
\+ Common or abundant in at least half of the six lane or control plots

was originally located in a dense stand of shrubby growth on the edge of a hammock. We were able to relocate the position of the plot on the ground, but the dense regrowth which had occurred since 1979 made it impossible to find the trail. This was the only old trail which we considered to have recovered on the basis no longer being visible.

As we discussed in our earlier report (Duever et al. 1981), the characteristics of old trails in hardwood hammocks were so different from those in adjacent undisturbed habitat that we developed a separate sampling strategy for them to supplement our regular measurements. These trails were typically open to the sky so that understory growth was frequently quite dense in the trail as opposed to the adjacent forest floor which was in deep shade. We felt that recovery of this habitat would be evidenced more by regrowth of the woody taxa which characterize the hammock than by development of a dense herbaceous understory. Thus in this habitat, we also counted numbers of the various taxa of woody plants growing in 1 by 5 m plots in the trail and adjacent habitat. The results of these supplementary samples are included below in the discussion of taxonomic characteristics of the old trail sites. All of the hammocks studied were on irregular rocky surfaces where ruts occurred only in scattered depressions. One old trail, where we had been able to measure rut depths in 1979, had since recovered and ruts were no longer visible. However, at another site we were able to measure rut depths in 1985, where ruts had not previously been noted (Table D 2). Except for the one hammock old trail which was no longer visible, the visual ratings for the hammock sites were still significantly different from the adjacent control plots in 1985 (Table D 1).

## Statistically Recovered Trails

Little recovery for most parameters in most habitats was found in 1985 when we evaluated it on the basis of whether individual trail parameters had statistically recovered (i.e. were not significantly different from control values). Visual ratings indicated recovery in only one pine plot in 1985, so it appears that these trails will be visually apparent for many years (Table 9). Rut depths also showed recovery in only one habitat, the sand marsh plots in 1979. However, in 1985 we were able to measure significantly different rut depths in the one remaining sand marsh plot which had not been destroyed. This suggests that ruts were present in all of the sand marsh sites in 1979, but were not detected by the methods we were using then. Also we did not report the presence of ridges in 1979 in any habitat, but in 1985 found ridges which were significantly different from controls at two of three marl marsh sites. Among the live vegetation and standing litter parameters, with the exception of the pine sites, no habitat had more than two trails recovered. All of the pine old trails had recovered in terms of biomass, vegetation height, and number of plant taxa, and in two of the three trails percent cover and standing litter had also recovered.

When the data in Table 9 were combined for all habitats, the visual rating, live vegetation, and standing litter parameters indicated a

Table 9. Number of replicate old trail plots where the trail parameter values had statistically recovered (i.e. were not significantly different from the control values) at Ø, 1, and 7 years after abandonment (Appendix D).

| | Large Cypress | | | Small Cypress | | | Marl Marsh | | | Sand Marsh | | | Pine | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ø | 1 | 7 | Ø | 1 | 7 | Ø | 1 | 7 | Ø | 1 | 7 | Ø | 1 | 7 |
| Visual Rating | Ø | Ø | Ø | Ø | Ø | Ø | Ø | Ø | Ø | Ø | Ø | Ø | Ø | Ø | 1 |
| Soils | | | | | | | | | | | | | | | |
| Rut Depths | Ø | Ø | Ø | Ø | Ø | Ø | Ø | Ø | Ø | 3 | 3 | Ø | Ø | Ø | Ø |
| Ridge Heights | S | S | 3 | S | S | 3 | S | S | 1 | S | S | 1 | S | S | 3 |
| Live Vegetation | | | | | | | | | | | | | | | |
| Biomass | 3 | 1 | 1 | Ø | Ø | 2 | Ø | Ø | 2 | 1 | Ø | 1 | 2 | 1 | 3 |
| Percent Cover | 3 | 1 | Ø | Ø | Ø | 1 | Ø | Ø | 1 | Ø | Ø | 1 | 1 | Ø | 2 |
| Height | 3 | 2 | 3 | Ø | 1 | 2 | Ø | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 3 |
| Number of Taxa | S | S | 2 | S | S | 1 | S | S | 2 | S | S | 1 | S | S | 3 |
| Standing Litter | S | 3 | 2 | S | 1 | 2 | S | Ø | 1 | S | 1 | 1 | S | 1 | 2 |
| Sample Size | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 3 |

S No data available

greater percentage of statistically recovered trails in 1985 than in 1979 (Figure 7). Rut depth recovery had occurred in 20% of the trails in 1979, but in 0% of the trails in 1985 because two of the sand marsh sites had been destroyed, and the methods used in 1985 clearly showed the presence of ruts in the remaining sand marsh site.

When the data in Table 9 were combined for all parameters (except number of taxa, for which we only have data in 1985, and ridge height), most habitats also indicated that more trails had recovered in 1985 compared to 1979 (Figure 8). The only exception was the large cypress, where the data indicated recovery has been declining since the first measurements were taken in late winter 1979. This pattern was most evidenced by the biomass and percent cover data (Table 9). The reasons for this were similar to those described above for the hammock sites. A dense growth of herbaceous vegetation has developed in the trails which are more open to the sky than is the adjacent deeply shaded forest. Deeper water in the trail also contributed to the development of a very different community from that which exists in the adjacent forest. Although several of the other habitats also have a woody overstory, their undisturbed canopies are relatively open and the resultant trail - control comparisons were much more appropriate than they were in either the hammock or large cypress sites.

Thus, while there has been recovery for some parameters in some old trails, they all have a number of years to go before they could be considered to be statistically, much less completely, recovered.

## Percent Recovery of Trails

In order to obtain a better idea of how quickly recovery was progressing for each parameter in each habitat, we calculated their percent recovery in each replicate plot for individual sampling periods (Appendix D), and summarized them as ranges by habitat (Table 10). For visual rating and rut depth, percent recovery was calculated as the difference between the initial average values measured in March 1979 and the October 1979 and October 1985 average values, respectively, divided by the initial March 1979 values. For the other parameters, percent recovery was calculated by dividing each average trail parameter value by each respective control parameter value. The control value would represent 100% recovery.

Maximum percent recovery for visual ratings in 1985 were all less than 70 percent and minimum values ranged from 19 to 38 percent of our original measurements made during late winter 1979 (Table 10). Over the same period, maximum percent recovery of rut depths were from 56 to 96 percent, but minimum percent recovery was only between -4 and 38 percent.

As discussed above, the data for the large cypress old trails were not really comparable to those from the adjacent control plots. The extremely high percent recovery for all of the large cypress vegetation parameters, except standing litter, clearly indicate the large amount of

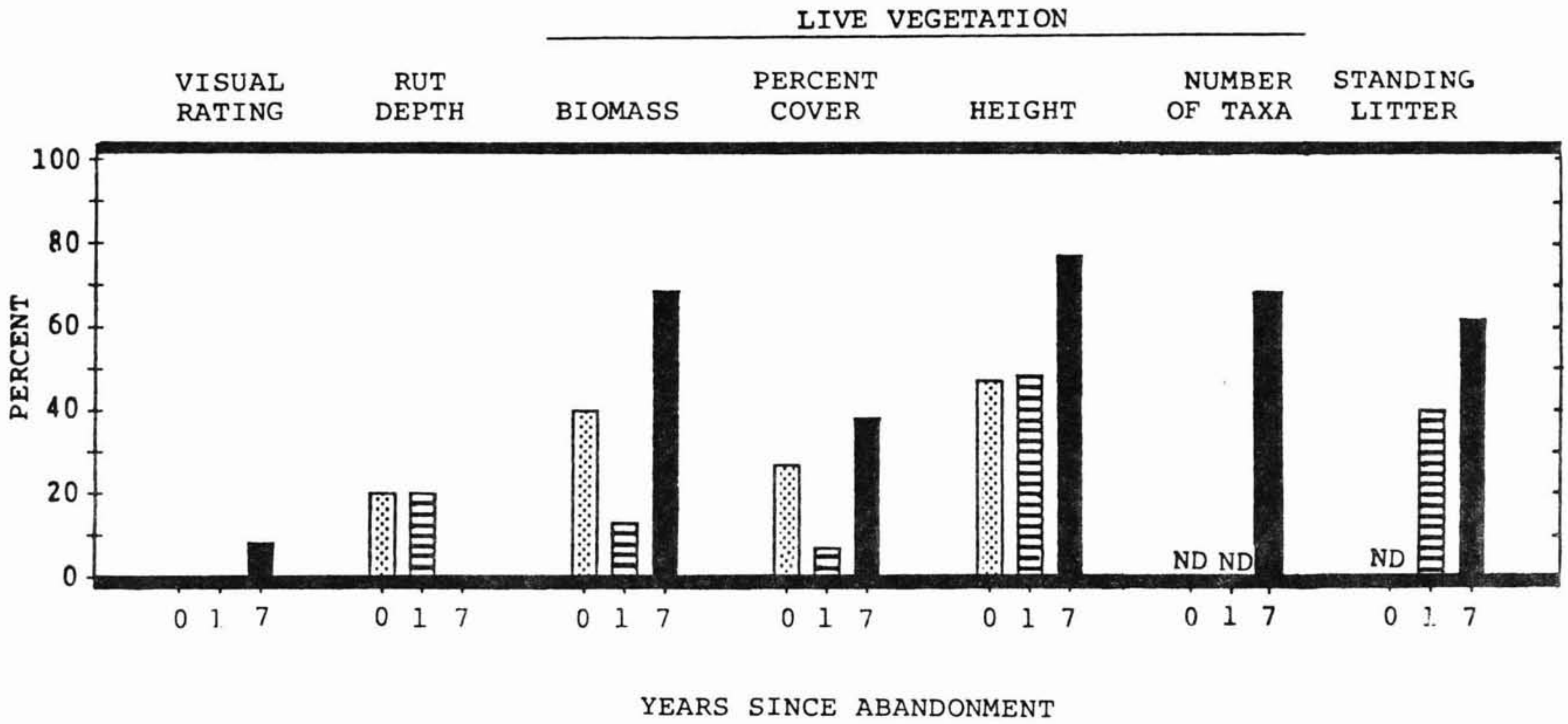



Figure 7. Percents of old trail parameters showing recovery (i.e. not statistically different from controls) for all habitats combined.

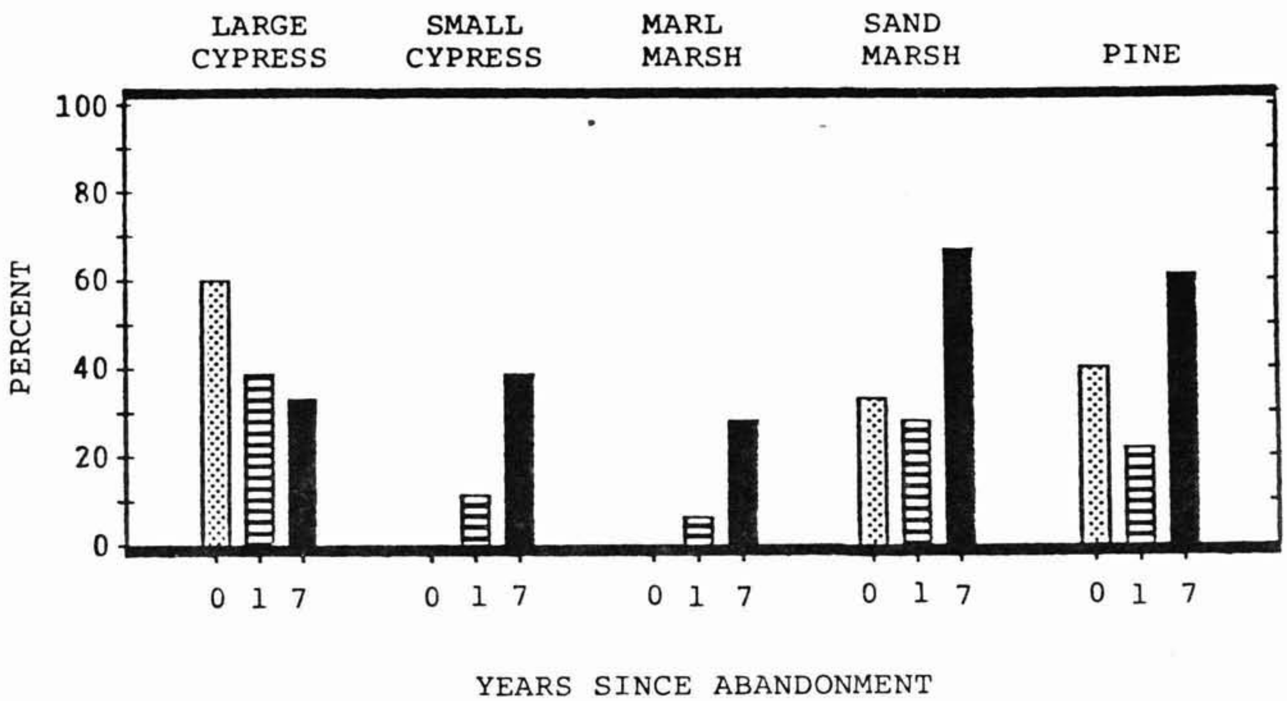



Figure 8. Percents of old trails recovered (i.e. not significantly different from controls) for all parameters combined.

Table 10. Minimum and maximum percent recovery for replicate old trail plots in each habitat at 0, 1, and 7 years after abandonment (See Appendix D for the individual percentages). The control value would represent 100% recovery.

| Habitat | Visual Rating | Rut Depths | Live Vegetation: Biomass | Live Vegetation: Percent Cover | Live Vegetation: Height | Live Vegetation: Number of Taxa | Standing Litter | Number of Plots |
|---|---|---|---|---|---|---|---|---|
| Large Cypress | | | | | | | | |
| 0 | S | S | 0 | 0 | 0 | S | S | 3 |
| 1 | 0-3 | -8-11 | 0-1 | 0-10 | 0-43 | S | 0 | 3 |
| 7 | 38-63 | 27-56 | 37-995 | 252-978 | 40-200 | 100-200 | 3-27 | 3 |
| Small Cypress | | | | | | | | |
| 0 | S | S | 0 | 0 | 0 | S | S | 3 |
| 1 | 8-18 | 0-16 | 1-21 | 1-30 | 20-96 | S | 0-21 | 3 |
| 7 | 25-38 | 38-66 | 44-74 | 11-48 | 49-109 | 37-62 | 9-27 | 3 |
| Marl Marsh | | | | | | | | |
| 0 | S | S | 0 | 0 | 0 | S | S | 3 |
| 1 | 3-33 | 13-22 | 1-27 | 0-43 | 0-47 | S | 0 | 3 |
| 7 | 25-45 | -4-96 | 57-90 | 23-96 | 89-162 | 64-133 | 36-69 | 3 |
| Sand Marsh | | | | | | | | |
| 0 | S | S | 0-3 | 0-9 | 0-9 | S | S | 3 |
| 1 | -20-45 | S | 5-26 | 4-28 | 25-85 | S | 0-9 | 3 |
| 7 | 28 | P | 96 | 121 | 80 | 118 | 46 | 1 |
| Pine | | | | | | | | |
| 0 | S | S | 1-5 | 1-23 | 6-13 | S | S | 3 |
| 1 | 6-20 | -18-36 | 3-12 | 5-15 | 55-58 | S | 0-34 | 3 |
| 7 | 19-68 | 20-58 | 81-141 | 28-62 | 100-139 | 63-80 | 34-92 | 3 |

S No data available
P Ruts found in 1985, but recorded as 0 during 1979 field work

understory vegetation in at least some of the old trails as compared to that found in the nearby undisturbed forest.

During 1985, with few exceptions the maximum percent recovery for most of the live vegetation and standing litter parameters in most of the remaining habitats (other than large cypress) fluctuated within ± 41 percent of the control values (100%). With the exception of percent cover and standing litter, most of their minimum percent recoveries were within ± 63 percent of the control values (100%). Minimum percent recovery for percent cover and standing litter for these same sites both ranged from 9 to 46 percent of the control values (100%). Thus, while some parameters have essentially recovered in some trails in the seven years since abandonment, in all of the habitats at least one trail is less than 40 percent recovered in terms of visual rating, rut depth, percent cover, and/or standing litter.

## Analysis of Taxonomic Differences

As in the experimental lane sites, we analyzed each taxon in each habitat replicate to see if it occurred more frequently in either control or trail plots and how many times it was listed as being common or abundant within individual control or lane plots. Tables 11-16 list those taxa which were of more than sporadic occurrence and which we feel had been consistently identified at all replicate sites of each habitat.

Seven taxa were identified as being distinctly more frequent in the small cypress old trail control plots (Table 11). These included Cladium, Dichromena, Ipomoea, Muhlenbergia, one form of Panicum, Rhynchospora, and Taxodium, while Bacopa and Eleocharis were the only taxa more frequently found in the old trails themselves. As mentioned above in the discussion of the experimental lanes, Bacopa, Dichromena, Eleocharis, and Rhynchospora were also similarly distributed in those small cypress plots. In addition to being more frequent in the control plots, Muhlenbergia was listed as being common or abundant in at least half of the control plots at two of the three sites.

Cladium was the only taxon which was found more often in control plots at the marl marsh sites, while Eragrostis was the only species found more commonly in the trail plots at these sites (Table 12).

At the large cypress sites, Blechnum and Hyptis were found more often in the control plots, while Bacopa, Diodia, and Ludwigia were more frequent in the old trails (Table 13). Bacopa and Ludwigia were also listed as being common or abundant in at least half of the trail plots at all three sites. Although cypress seedlings were not present in any of the old trail plots, they were absent from the control plots as well.

Six taxa were more frequent in the old trail pine control plots (Table 14). These included Aristida, Cladium, Cuscuta, Dichromena, Muhlenbergia, and a form of Panicum, while Eragrostis and an unidentified forb were more frequent in the old trails.

Table 11. Number of sample plots in which each taxon was present during 1985 at the small cypress old trail sites.

| Taxon | Site 1 | | Site 2 | | Site 3 | |
|---|---|---|---|---|---|---|
| | control | trail | control | trail | control | trail |
| Bacopa | 1 | 4 | 1 | 5 | Ø | 6 |
| Cladium | 4 | Ø | 2 | Ø | 6 | Ø |
| Dichromena | 4 | Ø | 2 | Ø | Ø | Ø |
| Diodia | 1 | Ø | 1 | 2 | Ø | Ø |
| Eleocharis | Ø | Ø | Ø | 2 | 1 | 6+ |
| Eragrostis | 1 | 2 | 2 | 2 | 1 | Ø |
| Flaveria | Ø | Ø | Ø | Ø | 4 | Ø |
| Ipomoea | 2 | Ø | 2 | Ø | 1 | Ø |
| Muhlenbergia | 5+ | Ø | 5+ | Ø | 6 | Ø |
| Panicum 2 | 5+ | 1 | 1 | Ø | 5 | Ø |
| Rhynchospora | 5 | Ø | 6+ | 3 | 3 | 1 |
| Taxodium | 5 | Ø | 4 | Ø | Ø | Ø |

\+ Common or abundant in at least half of the six trail or control plots

Table 12. Number of sample plots in which each taxon was present during 1985 at the marl marsh old trail sites.

| Taxon | Site 1 | | Site 2 | | Site 3 | |
|---|---|---|---|---|---|---|
| | control | trail | control | trail | control | trail |
| Centella | 1 | 4 | 2 | 1 | Ø | Ø |
| Cladium | 4+ | 2 | 4 | 4 | 4 | Ø |
| Dichromena | 1 | 2 | 3 | Ø | Ø | 1 |
| Diodia | 1 | 2 | 1 | Ø | 3 | Ø |
| Eragrostis | Ø | 1 | Ø | Ø | Ø | 5+ |
| Muhlenbergia | 6+ | 6+ | 2 | 4 | 6+ | 6 |
| Rhynchospora | 2 | 4 | 5+ | 2 | 1 | 3 |
| Sedge 1 | 1 | 2 | 1 | Ø | 1 | 1 |

+ Common or abundant in at least half of the six trail or control plots

Table 13. Number of sample plots in which each taxon was present during 1985 at the large cypress old trail sites.

| Taxon | Site 1 | | Site 2 | | Site 3 | |
|---|---|---|---|---|---|---|
| | control | trail | control | trail | control | trail |
| Bacopa | 2 | 6+ | 1 | 3+ | 1 | 5+ |
| Blechnum | Ø | Ø | 2 | Ø | 3 | Ø |
| Diodia | 1 | 2 | 3+ | 3 | 1 | 5 |
| Hyptis | 1 | Ø | Ø | Ø | 2 | Ø |
| Ludwigia | 4 | 5+ | 1 | 5+ | 3 | 6+ |
| Proserpinaca | 2 | 5+ | 3 | 1 | 3 | 5 |
| Sagittaria | 2 | Ø | 1 | Ø | Ø | 2 |

+ Common or abundant in at least half of the six trail or control plots

Table 14. Number of sample plots in which each taxon was present during 1985 at the pine old trail sites.

| Taxon | Site 1 | | Site 2 | | Site 3 | |
|---|---|---|---|---|---|---|
| | control | trail | control | trail | control | trail |
| *Andropogon* | 1 | Ø | 1 | 1 | 4 | 4 |
| *Aristida* | 1 | Ø | 1 | 1 | 4+ | 2 |
| *Centella* | 1 | Ø | 1 | 1 | 4 | 4 |
| *Cladium* | 4+ | Ø | 4 | 1 | 2 | Ø |
| *Cuscuta* | 4 | 2 | 2 | Ø | 2 | Ø |
| *Dichromena* | 3 | Ø | 1 | Ø | 2 | 3 |
| *Eragrostis* | Ø | 1 | Ø | 3 | 1 | 5 |
| Forb | Ø | 3 | 1 | 2 | Ø | Ø |
| *Ludwigia* | Ø | 3 | Ø | Ø | 1 | 1 |
| *Muhlenbergia* | 6+ | 3 | 2 | 3 | 4 | 2 |
| *Panicum* 1 | 5 | 2 | 4+ | Ø | Ø | Ø |
| *Panicum* 2 | 4+ | 4 | Ø | Ø | 1 | 1 |
| *Pinus* | 1 | 1 | Ø | 1 | 2 | 2 |
| *Rhynchospora* | 2 | 3 | 4 | 2 | 6+ | 5 |

+ Common or abundant in at least half of the six trail or control plots

In the one sand marsh old trail which had not been destroyed, Spartina was the only taxon which was more frequent in the control plots and Eragrostis the only taxon more frequent in the old trails (Table 15). The replacement of Spartina by Eragrostis was one of the primary reasons the trail was visible in the field.

In the hammock sites, Myrsine, Toxicodendron, and Psychotria were more common in the undisturbed hammock plots as was Baccharis in the old trails (Table 16).

In general, there were a number of differences between taxa occurring in old trail or control plots. A few taxa clearly prefer the deeper water and/or less shaded conditions of some of the trails (Bacopa, Diodia, Eleocharis) or the greater shade of some of the control sites (Blechnum). Cladium was more frequent in the control plots of the old trail small cypress, marl marsh, and pine habitats and the experimental lane peat marsh. It appears to be strongly selected against by disturbance. Alternately, at the three driest sites Eragrostis occurred more commonly in the trails, suggesting that it is more successful and persistent on previously disturbed sites. However, with most of the taxa it is difficult to say for certain what the primary reasons were for their distribution at the old trail sites seven years after abandonment.

## CONCLUSIONS

The purpose of this study was to evaluate the long term recovery of ORV impacts. To this end we measured a variety of parameters in experimentally created lanes and abandoned old trails at sites which had been recovering for seven years. In terms of some biological processes seven years is a long time. However, in terms of soil processes and growth of forest trees, it is a very short period. Thus, the recovery which has occurred during this period could be described as good for certain impact levels and environmental parameters, but poor for others.

### Experimental Lanes

As described in our 1981 report, the crux of creating significant ORV impacts is soil disturbance. Soil disturbance increases as a site gets wetter, either along a moisture gradient or at different times of the year. If water levels are at or above the soil surface, impacts are much greater than if they are well below ground. So habitats or portions of a habitat which are wet more of the time are more likely to be impacted and will take longer to recover. They also tend to have substrate and vegetative characteristics which make them more susceptible to impacts.

The other major management consideration relating to ORV impacts is the length of time required for recovery. Anything over one year becomes a cumulative impact, since that is the interval between heavy use periods.

Table 15. Number of sample plots in which each taxon was present during 1985 at the sand marsh old trail site.

| Taxon | Site 2 | |
|---|---|---|
| | control | trail |
| *Eragrostis* | 2 | 6+ |
| *Muhlenbergia* | 4+ | 3 |
| *Rhynchospora* | 6+ | 6+ |
| *Spartina* | 4+ | Ø |

+ Common or abundant in at least half of the six trail or control plots

Table 16. Number of sample plots in which each taxon was present during 1985 at the hammock old trail sites.

| Taxon | Site 2 | | Site 3 | |
|---|---|---|---|---|
| | control | trail | control | trail |
| *Baccharis* | 2 | 3 | 1 | 3 |
| *Myrsine* | 4 | 1 | 5 | 1 |
| *Panicum* 1 | 1 | 1 | 2 | Ø |
| *Parthenocissus* | 2 | 1 | Ø | 1 |
| *Psychotria* | 2 | Ø | 3 | Ø |
| *Toxicodendron* | 4 | 1 | 1 | Ø |

If one criterion (A) for recovery was the disappearance within one year of any track produced by a single pass in any habitat where a vehicle type normally operates, then clearly the only vehicles which meet criterion A are the ATC and airboat. All of the swamp buggies also meet criterion A in the sand marsh and pine habitats, and the track vehicle in the peat marsh. As the allowable number of passes, and therefore the level of impact, increases to the point where the vegetation is severely damaged but the lane still disappears within one year (criterion B), the airboat is still acceptable in the marl marsh but not in the peat marsh habitats. The ATC also still meets criterion (B), but now only in the sand marsh and pine habitats. Thus, these are the only types of vehicles which could still be allowed in the preserve and the only habitats they could operate in, if tracks which completely disappear within one year (criteria A or B) were considered the only acceptable levels of impact.

Another possible criterion (C) for an acceptable level of recovery would be to allow the tracks to be visible for more than one year, as long as any remaining impacts were not statistically significant. Examination of the Tables in Appendix C indicates that if the visual rating parameter were considered on this basis, then not surprisingly, we obtain essentially the same grouping of allowable vehicles and habitats as by criteria A or B.

If criterion C is applied to the presence of significant ruts and ridges one year after the impacts were made, then most of the wheeled vehicles could make one pass through all habitats. The exceptions would be the tractor buggy which would not be allowed in either small cypress or marl marsh habitats and the heavy buggy which would not be allowed in the small cypress. The ATC could operate in any habitat at any level of activity on the basis of criterion C as applied to rut and ridge impacts.

If criterion C were applied to vegetation impacts, we again find that on the basis of biomass, most of the wheeled vehicles could make one pass in any habitat. Again the tractor buggy is an exception, but now it would only be excluded from the small cypress. On the basis of height, one pass impacts would be acceptable from most wheeled vehicles in all habitats except the small cypress. The tractor buggy would be excluded from the marl marsh as well. Height impacts would also be acceptable at medium impact levels for all vehicles in the sand marsh and pine. Standing litter did not statistically recover at any sites and percent cover at only a few where the trail was still visible one year after they were made. Thus, if percent cover or standing litter were the basis for criterion C, the allowable vehicles and the habitats they could use would be the same as for the complete disappearance of trails (criteria A or B).

The results of our 1985 sampling showed that virtually all of the one pass lanes had completely disappeared. This was also the case with most of the medium impact lanes. The small cypress was the only habitat where a number of medium impact lanes were still visible, but only a few of these had not statistically recovered for most parameters. Where we were able to create heavy impacts, very few had disappeared, and a large percentage of lanes in a number of habitats had not statistically recovered for many of the parameters. Thus, these data clearly indicate that once a vehicle has severely disturbed the soil, recovery of that track takes a very long time. It also follows that the types of vehicles (ATC, airboat) with which we had the hardest time creating heavy impacts would be the ones least likely to impact the soil. And the habitats (sand marsh, pine) where we had the hardest time creating heavy impacts would be the areas most resistant to ORV impacts.

## Old Trails

The 1985 old trail data indicated that there had been substantial recovery since 1979 for a variety of parameters. However, many parameters in many lanes still had a long way to go before they would be statistically recovered, much less the trail no longer visible. In particular, there were very few lanes which had statistically recovered in terms of visual rating and rut depth. At only one site had the trail completely disappeared. The pine was the habitat showing the most recovery, with the distinct exception of the visual rating and rut depth parameters.

## General Comments

One question that kept coming up in the course of our data analyses was, why are there visibly rutted trails through habitats where we were unable to create "heavy impacts"? Besides those trails not originally created by ORV's, we are aware of several reasons for this discrepancy. Airboat trails are more easily rutted during periods when water levels are closer to the ground surface than when they are high, as was the situation when we created our experimental lanes. For the other vehicles which always run in contact with the ground surface, the most likely explanation involves the temporal distribution of impacts. Most Big Cypress National Preserve ORV trails are impacted over a two month period each year, which is associated with the November - December hunting season. However, our experimental impacts were created within a few hours. The difference in the temporal distribution of our experimental impacts and those normally created in the Big Cypress National Preserve could result in significantly different affects on vegetation recovery. Vegetation which is impacted by a passing vehicle is frequently not killed outright, and will resprout and continue to grow. However, if after resprouting it is again impacted, its ability to resprout and grow is further diminished. Subsequent repeated impacts on these plants will eventually kill them, whereas the same total number of passes in a few hours may only be comparable to a single pass as far as recovery is concerned. Once the plant has been killed its ability to bind the soil will also be diminished, and further passes will then begin to create a rutted trail, whereas an equal or greater number of passes over a short period of time might not even begin to create a rut.

While standing litter may seem to be a relatively minor aspect of BCNP habitats, we were particularly interested in this component of the system because it is the major source of fuel controlling the spread of natural fires. All South Florida ecosystems exist as a function of a specific fire regime. Prior to man's recent efforts to reshape the South Florida landscape, the major types of plant and animal communities were distributed primarily according to the influences of each site's hydrologic characteristics, which in turn influenced the frequency and severity of fires. During the past 100 years, man's activities have altered many of the factors which control the occurrence and spread of fires in South Florida. ORV trails represent one of these factors, since they have created extensive networks of trails which can function as firebreaks in otherwise undisturbed habitats. These trails may be swathes of bare ground, which are rutted and therefore frequently wetter than the surrounding habitat. However, less impacted trails where the vegetation is merely bent over and the brittle standing litter eliminated are a much more widespread type of ORV trail. These latter trails may not affect the spread of hot, fast moving fires, but they may sufficiently impede slow backing fires, so that certain areas may over the long run burn less frequently than they should, and ultimately change the character of portions of the Big Cypress National Preserve. Standing litter was one of the parameters which showed the slowest recovery from ORV impacts, and this combined with its importance to the maintenance of a natural fire regime within the Big Cypress National Preserve, must be kept in mind when management decisions are being made about the use of ORV's in this area.

It must be kept in mind that the parameters which we monitored relate primarily to the aesthetic, soil, and understory plant community characteristics of the study sites. Within the time frame available to us for this study, it was necessary to concentrate on components of the system which we could reasonably expect to see changes in within a relatively short time. We were aware that woody components of the forested Big Cypress Swamp communities are much slower growing than the herbaceous components, and that we would not be able to quantitatively measure their long term recovery from impacts. However, despite the lack of quantitative data, it can safely be said that 50 to 300 year old trees which have been killed in the course of ORV use or trail construction cannot be expected to recover by regrowth in less than 50 to 300 years.

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Appendices A-F (141 pages) to this report are available for inspection at:

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