Grand Canyon National Park
Fire Effects Monitoring Program Annual Report
2001 Calendar Year

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Executive Summary

This Fire Effects Monitoring Program Annual Report summarizes the Fire Effects Monitoring Program activities from January 1, 2001 to December 31, 2001. The following report justifies the existing plot network, details annual accomplishments, outlines plans for the future, and provides a data summary for information collected to date.

There have been no significant changes to the monitoring protocols in the past year, but some may occur in the near future as all monitoring type descriptions and monitoring objectives are revisited. The schedule for plot installations in 2002 is as rigorous as 2001 and is possible only with the full-time commitment of the Fire Effects staff. Such a schedule is necessary to continue to make up for deficiencies in plot installations over the past seven years. With little prescribed fire activity planned for 2002, this is the perfect opportunity for numerous plot installations.

Data analysis is not significantly different from previous years, and minimum sample size has been calculated with pre-burn data only. Utilizing these parameters, and lumping together spring and fall burning, we can theoretically assess 6 of our 11 variables with statistical confidence at this time.

As a program review has been lacking for several years and significant changes may be on the horizon, it is recommended that the Regional Fire Ecologist conduct a full program review in the 2002 calendar year to ensure this program is on track.

INTRODUCTION

The 2001 field season marked the second time all goals were accomplished in the 13-year history of the Fire Effects program at Grand Canyon, resulting in 76 total FMH plot visits. Our success occurred despite the crew facing the heaviest workload on record at this park. Additionally, we hosted three people from the Rocky Mountain National Park Fire Effects Crew in June in lieu of a formal RX-80 class. After attending training on Normalized Burn Ratio (NBR) and Composite Burn Index (CBI) techniques for assessing fire severity, 54 CBI plots were installed within the Outlet Wildfire of 2000.

For the 2001 field season, we had planned on 26 YR0X remeasurements and completed 26, and planned 31 installs but completed 32. We had planned 18 immediate Post-burn visits in conjunction with scheduled prescribed fires and completed 18. However, due to a staffing shortage in prescribed fire overhead and unrevised burn plans, no prescribed burns occurred. The 18 immediate Post-burn reads we did accomplish were from plots burned in the Swamp Ridge Fire Use Complex on the North Rim. Of the 32 plot installs, seven were on the South Rim and 25 were on the North Rim. Ten were in two new monitoring types (GRIN & GRED) designed to monitor shrub and tree encroachment on North Rim meadows, as well as response to potential prescribed fires. The three PIEN, or subalpine mixed-conifer, monitoring type installs were the first pre-burn installs in this vegetation class since 1994. These 76 fire effects plot visits eclipsed the previous busiest year (1999) by 22 visits.

In addition to meeting plot installation and remeasurement objectives, Fire Effects Crewmembers assisted with operations on the 11,000+ acre Swamp Ridge Fire Use Complex between July and October. The Tower and Vista Fires of this Complex burned within two of the areas of highest plot concentrations on the North Rim, causing the 18 unscheduled immediate Post-burn reads on plots burned in the Complex. Data from these plots will also allow substantial analysis of post-burn effects from the Complex. Combined with planned installs and re-reads, the Swamp Ridge Complex plots provided an excellent opportunity for Monitors, Fire Use Modules, other fire detailers, and several Grand Canyon employees (25 people in total) to assist us with our work, advance fire taskbooks, and witness first-hand what Fire Effects entails.

Crewmembers also took part in diverse extracurricular activities, including a detail with the Bandelier Fire Effects Crew, an out-of-park detail with the Saguaro Fire Use Module, in-park details with the Yellowstone and Zion Fire Use Modules, helitack work, and assisting fire dispatch.

Additional plot installations are planned for 2002, but we hope that we will finally have made up our deficit from previous years after next season's work.

GOALS

The Fire Effects Monitoring Program exists in order to meet goals and objectives set forth in the General Management Plan, NPS Strategic Plan, and GRCA Strategic Plan. Grand Canyon National Park's General Management Plan (1995) states, "The natural role of fire within park ecosystems will be restored within the constraints specified in the park's Fire Management Plan." It also states, "...surveys will be required for the management of natural resources [including] effects of fire exclusion and prescribed fire on park wildlife and the representative vegetation communities." Long-term goals for preserving park resources are identified in the NPS Strategic Plan (1997) and the Grand Canyon Strategic Plan (1997). The GRCA Fire Effects Monitoring Program operates under Goal Category I: Preserve Park Resources, GPRA Long-term objective Ia1: 10% of targeted disturbed park lands, as of 1997, are restored, and 20% of priority targeted disturbances are contained.

The primary aim of the Fire Effects Monitoring Program is to provide information to fire and resource managers, which allows them to affirm that prescribed fire objectives are being met or to identify and correct deficiencies. Through the Fire Effects Monitoring Program at Grand Canyon National Park, data have been collected on pinyon-juniper woodlands, ponderosa pine associations, subalpine conifer forests, and North Rim meadows.

Specific goals and objectives regarding the Fire Effects Monitoring Program can be found in the Fire Monitoring Plan, an appendix to the Fire Management Plan. This document is reviewed annually and updated as needed.

STAFFING

Grand Canyon converted the GS-9 Fire Effects Specialist to a GS-9/11 Fire Ecologist and the term GS-6 Fire Effects Crew Leader to a subject-to-furlough GS-6/7 Lead Fire Effects Monitor, hiring new people in both positions. Despite turnover at both of these positions, consistency and quality assurance were maintained since both incoming employees had previously worked within the Grand Canyon Fire Effects program. While the Fire Ecologist position remained unfilled until September, 2001, the Lead Monitor managed all field and most office operations. During this time, it became apparent that the Lead Monitor is in a better position to perform supervisory functions for the crew. Efforts to achieve official supervisory status for the Lead Monitor are now underway.

Four GS-0404-05 seasonals were hired to work on the Fire Effects Crew for the expected season. However, regular crewmembers reached the end of their season while the Swamp Ridge Complex was still growing and efforts to complete CBI plot installations for the 2000 Outlet Fire continued. To help complete the 18 unexpected immediate Post-burn reads and CBI plots, additional personnel were brought on for a pay period or two. Table 10 reflects all Fire Effects related positions and the number of pay periods worked, including overtime and hazard pay hours. Table 11 shows distribution of major duties among field personnel to indicate that Fire Effects Crewmembers do not just function as plot monitors at Grand Canyon, but also aid in wildland engine coverage, helibase operations, wildfire suppression, Level 1 fire monitoring, fire reconnaissance, and other activities. Every regular Fire Effects Crewmember went on at least one fire or fire effects detail—in-park or out-of-park—during the 2001 season.

TABLE 1. Fire Effects Crewmembers for 2001 calendar year.

Monitor	Account #	Starting Date	Ending Date	# Pay Periods	OT Hrs	Hazard Hrs
Tonja Opperman, GS-9/11	Base funded: 251	01/01/01	05/04/01	9		
Kara Leonard, GS-9/11	Base funded: 251 (H11)	09/24/01	12/31/01	7	0	0
Li Brannfors, GS-6/7	Fuels Overhead funded: 252 (H12)	05/06/01	12/29/01	17	531	282.5
Lisa Hahn, GS-5	Fire FX Base: 252 (H12)	04/20/01	11/29/01	16	379.75	186
Kristina Ross, GS-5	Fuels Overhead funded: 252 (H12)	04/20/01	11/07/01	14.5	283.25	179.5
Laura Rasmussen, GS-5	Fire FX Base: 252 (H12)	04/23/01	10/31/01	14	174.4	31.5
James Roberts, GS-5	Fire FX Base: 252 (H12)	04/23/01	10/15/01	12.5	338.75	215
Li Brannfors, GS-5	Fire FX Base: 252 (H12)	01/01/01	05/05/01	9	35	8
Emily Cammack, GS-5/02	Fire FX Base: 252 (H12)	11/26/01	12/20/01	2	0	0
Cindy Bell, GS/4	Fire FX Base: 252 (H12)	10/22/01	10/30/01	1	16	23

TABLE 2. Base-hour crew activities by percent and category. Highlighted areas are where crewmembers spent majority of base-hour time.

Monitor	FMH Field	FMH Office	CBI Plots	Wildfire And Helibase Ops.	Rx Fire Ops	Non-FMH Training	Fuel Samp-ling	Air Quality	Teaching and Supervi-sion	Meetings And Confer-ences	Holidays And Leave
Li Brannfors, GS-6/7	25	46	4	11	0	8	2	2	1	0	2
Lisa Hahn, GS-5	34	42	2	11	0	8	2	1	0	0	1
Kristina Ross, GS-5	38	34	0	7	0	8	0	0	0	0	13
Laura Rasmussen, GS-5	42	41	0	1	0	9	1	0	0	0	6
James Roberts, GS-5	35	36	0	14	0	5	2	0	0	1	4
Li Brannfors, GS-5	3	74	0	1	1	4	0	0	2	6	9
Emily Cammack, GS-5/02	0	100	0	0	0	0	0	0	0	0	0
Cindy Bell, GS-4	38	63		0	0	0	0	0	0	0	0

MONITORING TYPES AT GRAND CANYON

Every vegetation type at Grand Canyon National Park where prescribed fire is used requires the Fire Ecologist to develop a document called the FMH-4 Monitoring Type Description sheet. This document provides a physical and biological description, desired future condition, burn prescription, and burn objectives. Grand Canyon's prescribed fire program places great importance on these documents, as they guide every burn plan.

FMH-4 Monitoring Type Description Sheets are completed for PIED, PIPO, PIPN, and PIAB. The PIEN FMH-4 was written in 1993 but needs revision after input from the Natural Resources Branch staff. The GRIN & GRED FMH-4s have not been written but initial data gathered this year and next will allow the monitoring types to be better defined.

GREAT BASIN CONIFER WOODLAND (PIED)

This monitoring type has been discontinued. No new data were collected and no installations are scheduled. Many plots installed in the PIED monitoring type were installed when the program was still very new in the National Park Service. Written protocols did not exist, there was little crew training, and there was not a year-round staff to maintain data records. Consequently, there are many errors in the data. For example, fuel transects were read at different lengths on different plots, and diameters of multiple-stemmed junipers were read in a variety of ways. *Caution should be used when interpreting any of the PIED data now.*

SOUTH RIM PONDEROSA PINE (PIPO)

A total of 16 visits were made to PIPO plots during the 2001 field season, including 7 new installs in the Long Jim I, II, III, and Horsethief burn units. With a lack of fires on the South Rim, no plots within this monitoring type burned. A total of 29 plots exist as of December 2001, and all but the 2001 new installs plus one other have burned. Five more plots will likely be installed in 2002 in the Long Jim I, II, III, & Horsethief burn units. The Fire Effects Crew will need to remain up-to-date on plans to burn South Rim units so as not to miss an opportunity to collect data.

Because Grand Canyon National Park's prescribed fire program relies on opportunistic burning to take advantage of all burning opportunities, not all plots are burned in *either* spring or fall as suggested under the standard fire effects monitoring protocols. In order to have the capability to tease out effects of seasonal burning, we decided to install more plots in the South Rim Ponderosa Pine monitoring type. After the plots are burned there may be enough plots in spring to analyze them separately from the plots burned in fall. Presently all plots are being analyzed independent of burn season, and minimum plot numbers are being calculated accordingly.

NORTH RIM PONDEROSA PINE (PIPN)

Twenty-four plot visits occurred in North Rim Ponderosa Pine, including 10 new installs and 11 immediate Post-burn reads, almost all of which were in the Walla Valley burn unit. This flurry of activity allowed us to meet minimum plot numbers for PIPN and gather substantial pre-burn data for the Walla Valley area, which subsequently burned in the Tower Fire Use Fire. Plots are now located in Walhalla, Outlet, Walla Valley, Northwest III, Northwest I, and Roost burn units. Twenty-two plots have now been installed, 20 of which have burned.

With little North Rim ponderosa left to burn in a first-entry cycle, we may install a few more plots in this monitoring type before our window of unburned opportunity closes. If these installations occur, they will be randomized over the unburned portions of Walhalla, Walla Valley, and Outlet burn units.

PONDEROSA PINE WITH WHITE FIR ENCROACHMENT (PIAB)

Fourteen plots were visited in the PIAB monitoring type during 2001. Two installs were made, and additional new ones are not scheduled since minimum plot numbers have been achieved for both primary and secondary monitoring variables (see Table 3). Seven plots burned in the Vista Fire Use Fire, giving us valuable data to assess effects of yet another fire use incident on the North Rim. Twenty-four plots have now been installed, and 19 have burned.

Thought should be given to expanding the plot network in the future since 4 PIAB plots burned in the Outlet Wildfire, rendering any post-burn data from those four incomparable with data from plots burned within prescription.

ROCKY MOUNTAIN SUBALPINE CONIFER (PIEN)

Three additional PIEN plots were installed during the 2001 field season, giving us 7 total plots with pre-burn data and 12 total installed (5 were installed following the Outlet Fire and thus have no pre-burn data). Only 2 of the 7 plots with pre-burn data have burned. We plan to install at least 3 more plots in 2002 to allow us to perform initial minimum plot calculations. As previously mentioned, the FMH-4 Monitoring Type Description is out of date, but our pool of data from plots as the PIEN monitoring type expands should give us a good start on further defining this type. Although the forest description is known, the specific objectives for the area remain loosely defined with the exception of fuel load reduction. Consultation with the Natural Resources Branch staff is desired before finalizing the FMH-4 Monitoring Type Description objectives over the coming years.

NORTH RIM MEADOWS (Interior and Edge) (GRIN & GRED)

We established two new monitoring types in 2001: North Rim Meadows Interior & Edge. The purpose of these is threefold. First, fire managers have been making mention of possibly burning The Basin meadow area in the near future; therefore, it behooves us to establish monitoring in advance. Second, the grassland/meadow vegetation type of the North Rim has not been represented in our Fire Effects program until now. Finally, even if the meadow areas don't burn, the plots could serve as a useful, standardized tool to monitor encroachment of tree and shrub species out from the forest edge.

With all of these points in mind, we installed 5 brush plots in the interior meadow areas (GRIN) and 5 modified forest plots on various portions of the forest-meadow edge (GRED). Brush plot protocols were used on the GRIN plots to capture future occurrence of shrubs, although none exist now on the plots. All 10 plots were within the geographical area of The Basin, but future installations may expand to other meadows on the North Rim. Five more plots within each monitoring type are scheduled to be installed next year if time permits.

MISCELLANEOUS (XXXX)

This is not a monitoring type at all, but is the folder label given to all plots that no longer have a place in Grand Canyon National Park's Fire Effects Monitoring network. They have been removed because they are located on ecotone boundaries that do not fit easily into any of the monitoring types established, or subsequent visits have found the plots to meet one or more of our established rejection criteria. This isn't to say that the data are not important, but to include them in the network significantly increases the necessary sample size needed to evaluate primary monitoring variables. Plot stakes remain in the ground, and the plot data remains in the Fire Effects Office to be used if it is ever needed.

MINIMUM PLOT CALCULATIONS AND PLOT INSTALL PRIORITIES

Minimum plot calculations are shown in Table 3 for each monitoring type and each monitoring variable in that type. Although we will burn in the spring and fall without differentiating between different monitoring types, we only plan to install as many plots as needed by pre-burn minimum plot calculations. Very cursory analysis thus far has not indicated a great deal of variability between spring and fall burn effects, and we have been able to meet minimum plot numbers despite lumping plots from different burning seasons together. Following is a justification for minimum plots and installs in each monitoring type.

- For PIED, all plots needed are installed and there are no plans to continue with this monitoring type as it monitored fuel reduction efforts around Grand Canyon Village as a result of hand piling and jackpot burning methods.

- For PIPO it is necessary to monitor overstory ponderosa pine with the most confidence we can reasonably achieve. Monitoring at 90% confidence with R=20 is achievable now for overstory ponderosa as 22 plots are required and we have installed 29. Total fuel load monitoring is also valid at 90%/R20 as only 9 plots are required. Although we want to monitor poles, there is so much variability that we cannot monitor them with any significance. As we add plots to the network, we will continue to calculate minimum plot size for monitoring ponderosa poles. In 2002, more plots will be randomly located in the Long Jim I, II, III, or Horsethief units. Although we may not technically need more PIPO installations to meet minimum sampling goals, we will take the opportunity to gather new data for fire managers and install more plots in the few remaining unburned units. To capture effects of spring burning, plots must be installed the previous year.

- In the PIPN monitoring type, overstory ponderosa is also the most important monitoring variable. It is reasonable to monitor overstory at 90%/R20 in this type, for the 10 installations in 2001 have given us a total of 22 plots, when we only need 9 (see Table 3). Additionally, we can monitor total fuel load at 90%/R20 with calculations showing 17 plots required. Although we would like to monitor ponderosa poles with statistical significance, it is not possible when 90 plots are needed. We will monitor ponderosa poles at the highest level possible with 22 plots plus future installations. Further installs are not necessary, but could be beneficial. With the small amount of remaining unburned ponderosa scheduled for treatment soon, we may choose to install a few more PIPN plots in these areas as time permits. To capture fire effects for spring burns, plots must be installed the previous year.

- The PIAB monitoring type now has 24 installed plots, more than the required 20 for monitoring overstory density at 90%/R20. New minimum plot calculations show that we can now monitor total fuel loading at 90%/R20 with only 12 plots, but white fir poles remain just out of reach at 80%/R20 with 27 plots required. More plots would be needed to monitor ABCO poles to our desired level of significance. However, monitoring the tertiary variable significantly is not possible with the other monitoring types, so pursuing additional installations for PIAB to capture poles is not a high priority. Further installs may be planned to make up for the four PIAB plots which burned in the Outlet Wildfire, but with four extra plots beyond required minimum sample size for overstory already in existence, we may decide no additional plots are necessary. Any 2002 installs will be a low priority.

- Minimum plot calculations for PIEN are not shown, since there are only 7 plots with pre-burn data. Three more plots must be installed for a more precise indication of the number of plots needed. We have planned to install at least 3 of these plots in the 2002 field season. Then, the PIEN monitoring type only needs the FMH-4 monitoring type protocols to be updated to begin focused analysis.

- Both meadow/grassland monitoring types (GRIN=grasslands, interior; GRED=grasslands, edge) do not have minimum plot calculations at this time since no monitoring objectives have been established. Five plots have been installed in the GRIN type, and five in the GRED type. Five further installations in each type are scheduled in 2002. These plots must be read/installed in August or early September every year. Data gathered next year will help us to establish official FMH-4 monitoring type descriptions.

- The XXXX type does not need to have minimum plot calculations, as it is a repository for plots that currently do not fit in any monitoring type. It is included in Table 3 only for consistency.

TABLE 3. Results of minimum plot calculations by monitoring type and monitoring type variable. All calculations are based on pre-burn data until additional data are available to do post-burn calculations. *NOTE: Calculations outlined in heavy double lines meet minimum plot requirements for 80% confidence interval and R-value of 20.*

	Primary Monitoring Type Variable	Secondary Monitoring Type Variable	Tertiary Monitoring Type Variable
FPIED1D02	**Total Fuel Load** 80%/20=6 90%/20=11 *n=15 Pre*	**Overstory** 80%/20=15 JUOS, 7 PIED 90%/20=27 JUOS, 12 PIED *n=15 Pre*	n/a
FPIPO1D09	**PIPO Overstory** 80%/20=13 90%/20=22 *n=29 Pre*	**Total Fuel Load** 80%/20=5 90%/20=9 *n=29 Pre*	**PIPO Poles** 80%/20=104 90%/20=175 *n=27 Pre*
FPIPN1D09	**PIPO Overstory** 80%/20=6 90%/20=9 *n=22 Pre*	**Total Fuel Load** 80%/20=10 90%/20=17 *n=22 Pre*	**PIPO Poles** 80%/20=90 90%/20=152 *n=22 Pre*
FPIAB1D09	**PIPO Overstory** 80%/20=12 90%/20=20 *n=24 Pre*	**Total Fuel Load** 80%/20=7 90%/20=12 *n=24 Pre*	**ABCO Poles** 80%/20=27 90%/20=46 *n=24 Pre*
FPIEN1D10	**Total Fuel Load** n/a (n=7)	**Overstory** n/a (n=7)	n/a
BGRIN1D01	n/a (n=5)	n/a (n=5)	n/a (n=5)
FGRED1D08	n/a (n=5)	n/a (n=5)	n/a (n=5)
FXXXX	n/a (n=12)	n/a (n=12)	n/a (n=12)

GRAND CANYON'S PLOT NETWORK

EXISTING PLOTS AND 2001 ACCOMPLISHMENTS

There are 126 plots currently installed in the network (Table 4), twelve of which are in the FXXXX category and will no longer be monitored on the standard FMH schedule, and two of which are installed on the Shoshone unit and used as "practice" plots. Thirty-two plots were installed this year, 7 on the South Rim and 25 on the North Rim. Twenty-six visits were made to re-read previously burned plots (Year 1, Year 2, and Year 5 post-burn) and 18 visits were made to immediate Post-burn plots. This makes for a total of 76 plot visits in 2001, the heaviest workload ever at Grand Canyon.

TABLE 4. Number of plots installed by monitoring type in 2001 and previously.

Monitoring Type Code	Monitoring Type Name	Rim	Number of Plots Installed in 2001	Total Number of Plots Installed
FPIED1D02	Great Basin Conifer Woodland	S	0	17[1]
FPIPO1D09	South Rim Ponderosa Pine Forest	S	7	29
FPIPN1D09	North Rim Ponderosa Pine Forest	N	10	22
FPIAB1D09	North Rim Ponderosa Pine with White Fir Encroachment	N	2	24
FPIEN1D10	Rocky Mountain Subalpine Conifer Forest	N	3	12[2]
BGRIN1D01	North Rim Meadows--interior	N	5	5[3]
FGRED1D08	North Rim Meadows--edge	N	5	5[4]
FXXXX	Plots on either rim that do not fit in any current monitoring type[5]	S & N	n/a	12

[1] Two of these 17 plots were installed on the Shoshone Burn Unit after a blowout in pinyon-juniper to monitor post-burn fire effects and to provide "practice" plots for the crew to read every year. One is installed in unburned pinyon-juniper and the other next to it in burned pinyon-juniper.

[2] Five plots were installed in 2000 after the Outlet Wildland Fire, immediately post-burn. "Pre-burn" data in the FMH database was crafted from the post-burn data in order to fool the database and avoid error messages; however, real Pre-burn data do not exist for these plots. For minimum plot calculations, we realistically only have 7 PIEN plots.

[3] This is a grass fuel model but is coded as brush in order to allow brush species to be entered in the database if they are encountered during post-burn visits.

[4] In order to monitor shrub and tree encroachment at the edge of the grassland we use modified forest plot protocols. This is coded as a "forest" model because half of each plot within this monitoring type is physically within a forested environment.

[5] These plots were originally installed in the early years of fire effects monitoring at Grand Canyon. Subsequent revision and interpretation of monitoring type protocols has led to the rejection of these plots.

PLOT REMEASUREMENTS FOR 2001 AND BEYOND

Forty-four plots were re-measured in 2001 and 56 such visits are planned for 2002 (Table 5). Workload is expected to lessen through 2004, then pick back up again in 2005 & 2006 (Table 6). In 2002, 56 plot visits are planned, along with 28 installs (Table 7) for a total of 84 plot visits. More installs may occur in 2003. *It is expected that the crew will spend the first two months on the South Rim, and most of the remainder of the season on the North Rim in 2002.*

TABLE 5. Plot re-measurements by plot type for 2002 and 2001.

	Total Plots to Remeasure 2002				Total Plots Remeasurement 2001			
Plot Type	G	B	F	Total	G	B	F	Total
YR0X Visits POST Visits	0	0	49 (7 P)	49 (7 P)	0	0	26 (18 P)	26 (18 P)
Total Visits	0	0	56	56	0	0	44	44

P = Immediate Post-burn Remeasurements

TABLE 6. Five-year projected number of plot re-measurements by year

	Number of Plots					
Year	2002	2003	2004	2005	2006	2007**
YR0X Visits POST Visits	49 (7 P)	38 (12 P)	20 (13 P)	48 (17 P)	52 (10 P)	35
Total Visits	56	50	33	65	62	35**

**These projections do not predict plots burned after 2006. Plots will undoubtedly be burned during this time but plans are not finalized.

TABLE 7. Projected plot installation.

Plots to be Installed 2002				Projected Total BY 12/02			
G	B	F	Total	G	B	F	Total
0	5	23	28	0	10	132	142

POST-BURN PLOT VISIT SUMMARY

Eighteen plots burned this year at Grand Canyon: 11 on the Walla Valley burn unit due to the Tower Fire Use Fire, and 7 on the Walhalla burn unit due to the Vista Fire Use Fire-- all on the North Rim (Table 8). All were burned for the first time.

Table 9 shows how many of the total plots in the network have been visited at post-burn intervals. Of the 114 active plots in the network, 79 have immediate Post-burn data, and 11 have had immediate Post-burn data gathered again, after a second burn. Although 92 first or second-entry immediate Post-burn visits should have been made, two immediate Post-burn visits were missed in the past, making the total number of visits only 90. Under a perfect fire effects monitoring schedule, the Total columns in Tables 8 and 9 would show the same number.

TABLE 8. Number of burned plots.

	Total Plots Burned 2001				Total Plots Burned to Date			
Plot Type	G	B	F	Total	G	B	F	Total
Initial Burn Reburn	0	0	18 (0 R)	18 (0 R)	0	0	81 (11 R)	81 (11 R)
Total Burned	0	0	18	18	0	0	92	92

R = Second-entry reads (reburns)

TABLE 9. Post-burn plot summary (visits to date).

	G	B	F	Total
Immediate Post-burn	X	X	79 (+11R)	90*
Immediate Non-fire	X	X	X	X
1 Year post-burn	X	X	72	72**
2 Year post-burn	X	X	54	54
5 Year post-burn	X	X	30	30
10 Year post-burn	X	X	0	0

*Immediate Post-burn read missing on two plots, in 1996 & 1998
**1 Year post-burn read missing on two plots, in 1993
R = Second-entry reads (reburns)

WHERE THE PLOTS ARE LOCATED

The plots in the network are randomized across 24 different burn units (Table 10). Maps showing where plots are located in burn units are available in the Fire Effects Office.

Table 10. Transects/plots classified by burn unit and monitoring type.

	Boundary	Entrance	Hance	Horsethief	Imperial	Lone Tree	Long Jim I	Long Jim II	Long Jim III	Nankoweap	NW I	NW III	Outlet	Picnic	Quarry	Shoshone	Roost	Thompson	Topeka	Village	Vista IV	Walhalla	Walla Valley	Watson IV
PIED		01 03 04 05 12												02 07	09 10 11	16* 17*			06 08 13 14 15					
PIPO		01 07	15	18 27		19	29 30	25 28	26 31					04 05 11 12	06 10				02 03 09 13 14	08				17 20 21 22 24
PIPN											01 02		05 09 12									03 04 07 10 14	06 18 08 19 13 20 15 21 16 22 17	
PIAB												06 07 25	02 22 08 23 10 11 12				27				03 04 05 09	13 18 14 19 15 20 16 26 17		
PIEN	02 04 12				05 06 07 09					01 03							10 11	08						
GRIN													04				01 02 03 05							
GRED													02				01 03 04 05							

* PIED 16 & 17 are named SHOS 1 & 2 in the GRCA database, but are read under PIED protocols.

THE 10-YEAR BURN PLAN

At this time it is estimated that up to 7,277 acres may be burned in calendar year 2002 in Watson I-III, Hance, Outlet, and Walhalla units. We may install a few new plots on Walhalla in the North Rim Ponderosa Pine monitoring type next year since this will likely be be our last chance to do so within that unit. Planning installations far in advance is necessary because, first, it takes time to install plots over extensive areas, and, second, if an opportunity to install a plot is missed, there may be no unburned areas remaining for future installs in these monitoring types. We have made our best guess at how the 10-Year Burn Plan will affect plot workloads, and it is reflected in the previous tables of this report.

The shift to landscape-level burning continues, and names for previously delineated small burn units are absorbed into larger units. This can make it difficult to track which plots are in which burn units. It is especially difficult when new burn boundaries are created and combined with poor plot location or burn unit mapping. Now that we have most plots located by GPS, we will be more confident about exactly where plots are located; however, when only portions of large units are burned, *it is necessary to accurately map burn edges in order to know if a plot is burned or not.* In this case, the Fire Ecologist or Lead Fire Effects Monitor should request this information from the Burn Boss or Fuels Specialist.

PROGRAM INFORMATION

2001 CHANGES IN PROTOCOL

Calculating Minimum Plots

At Grand Canyon National Park units are burned in both spring and fall for a single monitoring type. For example, South Rim Ponderosa Pine may be burned in spring and fall as conditions warrant. Research from northern Arizona supports burning ponderosa pine in both seasons. It is not possible to install plots and label them "spring" or "fall". Rather, we will install plots, burn them, and then analyze the information to see differences between spring and fall burning with regard to burn objectives. We had previously planned on installing double the amount of required minimum plots to allow for dual-season analysis. However, as we have begun to approach those doubled numbers, analysis is not showing as much variability as anticipated. Initial post-burn condition minimum plot calculations have shown we are still meeting or are close to meeting the required number of plots even when plots from spring and fall burning are lumped together. Additionally, fire managers can provide no guarantee that a second-entry burn will occur in the same season as the first-entry burn; thus, individual plots cannot always be analyzed as either spring- or fall-burned. We will continue to base plot installation goals for 2002 on the previously established minimum plot numbers since they are attainable, but further installs in our main monitoring types will curtail sharply after that. Henceforth, minimum plot numbers used in this report will be based solely on pre-burn calculations for consistency.

Randomization over Large Areas

Grand Canyon National Park is moving more burning to landscape scales of 500-3000 acres in one operational period. We have concerns regarding the way plots are distributed over the landscape using the standard FMH protocols. We realize that it is not realistic to install a significant number of plots in each burn unit because this would necessitate hundreds of plots. However, randomizing 10 initial plot locations over the 22,000 acres (as is the case in North Rim Ponderosa Pine) that will burn in five years means we have zero, one, or two plots per burn unit and in five years, 100% of the 22,000 acres will be burned and there is nowhere for new installs if they are needed. This is not effective adaptive management. We will try to randomize initial plots in the *first* portion of the area to be burned, and then we will have ample unburned areas to install additional plots in future years. In order to ensure plot information filters back to the Prescribed Fire Manager, *we will randomize these new plots in areas that are scheduled to burn in the next one-three years rather than the next five years* as the FMH protocols suggest.

FUTURE CHANGES IN PROTOCOL

No major changes are planned for 2002. A heavy workload again awaits us, with the vast majority of work on the North Rim. The crew may be brought on earlier to accommodate this busy schedule, and some sort of housing on the North Rim will be pursued. A STEP employee may be hired for a shorter season and duty stationed solely on the North Rim.

CONTROL PLOTS

Because ponderosa pine is in the spotlight at Grand Canyon National Park, we may opt to use control plots in the near future for monitoring types with ponderosa pine. It will be difficult to install them so that they are not at risk of being burned during a prescribed fire. We are entertaining the idea of re-reading some of the Covington plots that have already been installed on the North and South Rims in ponderosa pine. The park has agreed to protect these plots from fire. Fire Management, Resource Management, and others need to discuss the need for control plots, options for installing them, and the advantages/disadvantages.

EQUIPMENT INFORMATION

Most day-to-day fire effects equipment is in the Fire Effects Office at #1 Shuttle Bus Road. Two large black and gray plastic bins are used to haul items in the vehicles during the field season. Items like flagging, clipboards, cruiser vests, camping supplies, and other miscellaneous field items for the Fire Effects Crew are stored in the fire cache, upstairs, in a gray cabinet. Rebar is stored outside the Fire Effects Office in a wooden box painted to complement the exterior of the building.

While on the North Rim this year, our office space consisted of an apartment which remained vacant when one of the permanent fire positions on the North Rim went unfilled. We shared this apartment with the Prescribed Fire Technicians. Although temporary, this was a vast improvement over a tent or cramming into the North Rim helibase outbuilding, as we did for the first pay period or two this year. When the new Fire & Emergency Services building is constructed within the next 1-2 years, there will finally be a permanent

Fire Effects office on the North Rim similar in size to our South Rim office. This is not a luxury, but a necessity since our workload and field operations are heavily weighted toward the North Rim.

INNOVATIONS

Considering the daunting amount of work on the North Rim this year, we tried a new approach and moved all essential office supplies over with us, including two computers. We completed most of the data entry and checking, and plant pressing and mounting on the North Rim. This was made possible by having work and storage space in the form of a vacant apartment shared with Prescribed Fire in 2001. Although crowded at times, having dedicated office space was a great boon and necessary in light of the massive amount of North Rim field work. With a Fire Effects office on the North Rim, we are able to maximize our time by keeping up with data entry, error checking, plus plant identification and pressing on-site rather than travelling back to the South Rim to do so. Had we waited until the end of the season or spent more time each week travelling to and from the South Rim to do all office work, it is doubtful we would have been able to meet our goals. One crewmember stayed on until Nov. 29 and an additional one was temporarily hired for a month to assist with all of the office work created by the vast amount of field work.

We received a new crew-cab 4WD truck with a camper shell that suits our needs for summer plot work, holds all of our equipment, and comfortably transports 6 souls. This year we also utilized the Fire Ecologist's S-10 pickup during the field season when the crew needed to split up. This seems more cost-effective than renting a summer vehicle from GSA for intermittent use, and caused minimal conflict with no Fire Ecologist for most of the field season.

Our "plot board" continues to be invaluable. Crewmembers do a good job keeping information updated. It guides daily field and office activities while providing one place to track plot visits and plot data for the season. However, with increasing work on the North Rim and complete transfer of necessary office supplies to the North Rim during the field season, the dry-erase plot board was left behind on the South Rim this year. A transportable alternate would help us track our progress no matter what rim we are on.

The crew was duty-stationed on the South Rim once again but had to camp out on the North Rim. When North Rim work only involved a couple pay periods, this situation was agreeable. However, we were exclusively on the North Rim for field and office work from mid-June until November 15, creating a camping trip of 5 months in length. Luckily, the apartment office had a kitchen and bathroom for us to use, but with 5 people sharing one facility, it became crowded quite often. Since the workload is going to remain centered on the North Rim for the foreseeable future, we must endeavor to find some temporary housing for the crew over there or consider duty-stationing the crew on the North Rim.

Our Excel Plot Status worksheet continued to allow accurate tracking of all past and projected future plot activity. It shows every year since the inception of the program in 1989 plus 10 years of future projections (currently to 2012) across the top and all plots down the left side. PRE, POST, YR01, YR02, etc. are entered in the appropriate cells and formulas tally annual reads and cumulative plot installs at the bottom. It helps in tracking our accomplishments and filling out tables for the annual report. Additionally, we add "flags" to some cells if, for example, a POST visit was missed for the plot in a previous year, making plot network inconsistencies immediately recognizable. Improvements for 2001 included a new matrix which can track total distances hiked and driven for each plot and the season as a whole.

All plot locations continue to be tracked in an updated ArcView GIS database, allowing maps to be produced with ArcView for each plot in the monitoring network. Due to the massive input of time required to produce individual maps for each plot, as well as the only moderate amount of use these maps receive, we will begin changing to group maps showing as many plots as possible on 8.5 x 11" paper at an approximate scale of 1:24,000. New plot installations were randomized exclusively with ArcView. Consultation with the new Fire GIS Specialist allowed advanced refinement of potential plot installation areas. Using available GIS coverages, we can now eliminate areas that meet rejection criteria like proximity to roads, ecotone boundaries, and evidence of fire within the last 10 years before we even get out in the field. We also have queried the vegetation coverage to find out which vegetation types contain plots which match our existing monitoring types. Our randomization zones can then be narrowed down to only the areas with the highest probability of successful plot installation, decreasing time previously spent ground truthing plots which truly had been randomly located across the landscape.

In March 1999 an unplanned 15-acre "blowout" occurred in a pinyon-juniper area on the Shoshone prescribed fire unit during ignition. We decided to install a plot in the burned area and another directly adjacent plot in the unburned area to track herbaceous recovery while providing a "practice" area for the Fire Effects Crew. The area is only a few miles from the office off the paved Yaki Pt. road. Each spring after the crew starts for the season, we all go out to these plots and complete at least the read in the heavily burned plot. This gives the crew a chance to learn the protocols, understand all the forms, and ask questions about the program without the pressure of doing it perfectly the first time. Although we believe RX80 Plot Monitoring Techniques is a good course for Fire Effects Monitors, it is usually not offered before our field season starts. Using our practice plots helps the entire crew understand Grand Canyon's protocols right away and is directly reflected in the data quality of "real" early-season plot reads.

NEED FOR REGIONAL PROGRAM REVIEW

There is a need for the Fire Ecologist to devote more time to literature review in order to make recommendations on burning strategies. With the current workload, there is simply not the staff available to free the Fire Ecologist position for keeping up with numerous ecology issues, which has the potential to hinder progress in the prescribed fire program.

In order to bring the adaptive management concept full-circle, it is necessary for the Fire and Science Center staff to meet with the Regional Fire Ecologist to identify trigger points for action. We have specific prescribed fire vegetation objectives, but we have not identified what, exactly, will be done if the objective is not reached.

Fire Effects crewmembers have always shared in the suppression workload at GRCA, and this has been supported by the Fire Ecologist and Fire Use Manager because it allows crewmembers to experience variety in their day-to-day work, learn new skills, observe fires on the landscape, and make extra money in overtime. However, this arrangement was unbalanced because it took more away from the overall Fire Effects program than was provided to the Fire Effects staff. Table 11 shows the difference between the amount of plot installations planned and accomplished for every year since the program was established at GRCA. The trend was always negative, which reflected poorly on the Fire Effects program, and the park's prescribed fire program as a whole. But in 2001 installation goals finally were achieved, which can be attributed to Fire Effects staff getting the *opportunity* but rarely being *required* to assist with initial attack or nation-wide suppression efforts; consequently, not only were plot installation goals met, but new records for annual Fire Effects accomplishments were set. We hope that Fire Effects personnel will continue to have the opportunity to assist other aspects of the fire program, as long as doing so will not adversely impact Fire Effects goals. This seemingly can be achieved by asking the Fire Ecologist or Lead Monitor which crewmembers can be available for non-Fire Effects duties, and allowing the supervisors to make that decision on a case-by-case basis. In some cases, using Fire Effects Monitors for non-monitoring purposes may be unavoidable, but the consequences must be weighed carefully. If this doesn't work, Fire Effects staff should no longer be utilized for suppression activities. If data validity and comprehensiveness are to be maintained within the prescribed fire program, the collection, quality control, and archiving of such data need to be given an appropriate level of priority in the fire organization.

Table 11. Planned GRCA plot installations vs. actual plot installations by year.

Year	Planned Installs	Actual Installs	Difference
1994	13	4	-9
1995	12	1	-11
1996	9	3	-6
1997	2	5	+3
1998	24	4	-20
1999	21	7	-14
2000	56	5	-51
2001	31	32	+1

For all the reasons listed above, a Regional Program Review should be scheduled for 2002. It may be appropriate to meet with both Fire and Resource Management staff during this meeting.

DATA ANALYSIS AND DISCUSSION

INTRODUCTION

This section provides feedback to the prescribed fire staff on how well objectives are met. Some analyses cannot be completed with the current analysis software. Herbaceous data were analyzed in the 1999 Report to provide some preliminary results, and have not been updated as we received no feedback on their usefulness.

The graphical information presented in this report allows resource managers to more accurately determine whether prescribed fire is meeting objectives. Keep in mind that the objectives set in the FMH-4 Monitoring Type Descriptions are based on the best available science, and they can be revised as new information becomes available. All resource managers are invited and encouraged to contribute information that will aid in this process.

STATISTICAL REVIEW

Reporting Variability with SD and CI

It is appropriate to report sample means with a measure of variability to explain how confident we are in our estimates. Otherwise, people tend to interpret the sample means as if they were the true population means. Unfortunately, we can't assume that our sample mean will be the same as the true population mean – that depends on how many samples we take, and how much variability there is in whatever we're measuring. So, we need a way to measure how well our sample mean estimates what's really out there (the true population mean). For this report, we chose to do this using the Standard Deviation of the Mean (SD) and Confidence Intervals (CI). SD represents the variability in the actual data we collected. For those variables where we do not have the minimum sample size, we chose SD to represent variability. For variables where minimum sample size has been achieved, we used CI to express the confidence in our estimate of the true mean.

Interpreting Bar Charts

All bar charts in this analysis compare data from the same plots only through time. The Pre-burn reads for which there were no later reads were not included in the analysis. This ensures that sample size (n) is the same for both means (columns), but may be small. The size of the error bars may change over time as the measured data becomes more or less variable. Fuels charts show a break down of fuel size classes with an error bar for the *total* fuel load only. Statistically significant changes cannot be evaluated without more powerful statistical software—remember, averages represent only what was measured in the confines of individual plots if minimum sample size is not met.

Interpreting Scatter plots

The scatter plots show the actual values for each plot visit, the amount of data collected to date, and trends in each plot. A diamond shape that is "moving down" represents a decrease in values over time, a diamond shape "moving up" represents an increase, and a "bull's eye" indicates no change. If there is only one large white diamond, it indicates the plot has not burned. If a plot has burned twice, second-entry reads are indicated by circles.

OUTLET WILDFIRE MONITORING

Five plots (all PIEN) were installed in the Outlet Wildfire burned area after the 2000 burn. The plot locations were randomized within high-intensity burn areas only. Plots were established to monitor recovery in these areas, although pre-burn data for the plots do not exist. Additionally, 2 PIEN plots and 4 PIAB plots that were previously installed and unburned, were burned in this wildland fire. They will likely not be used in further data analysis for these monitoring types, but may be used in monitoring the effects of the wildfire. Caution should be used when analyzing pre-burn data from these plots, because a great deal of time had elapsed between the Pre-burn visit when trees were tagged, and the immediate Post-burn visit, and there are data inconsistencies. For example, trees tagged as poles in 1993 were overstory trees in 2000. It is expected that all these plots will be monitored on the standard FMH schedule. Preliminary data analysis and will be explored in future years.

Fifty-four Composite Burn Index (CBI) plots were also installed within the Outlet Wildfire to monitor fire severity. Data from these 30 meter circular plots were correlated with Normalized Burn Ratio (NBR) satellite imagery to match detectable change with burn severity. A resulting matrix of burn severity was created by the Fire GIS Specialist to show severity for the entire Outlet Fire at 30 meter pixel resolution.

PIPO RESULTS AND DISCUSSION

<u>OVERSTORY DENSITY</u>

Objective 1: Achieve and maintain an overstory *Pinus ponderosa* density (greater than or equal to 16" dbh) of 19-25 trees per acre (47-62 trees/ha) as stated in the Desired Future Condition, measured at 5 years post-burn.

Results: <u>Figure 1</u> shows that there is little change in large *Pinus ponderosa* overstory tree density across the entire plot network after 5 years of monitoring. Only 5 out of 19 plots with Year 5 data show any discernible deviation from pre-burn data. <u>Figure 2</u> suggests pre-burn densities are already lower than the low end of desired future tree conditions, and there is little change in the mean tree density from Pre-burn to Year 5.

Was objective met? Yes and no. Prescribed fires have not induced much, if any, mortality in this size class of *Pinus ponderosa*. This is good since limiting overstory ponderosa mortality is of great import. However, pre-burn densities were already lower than the desired future condition range, and a huge recruitment of trees into the overstory class can't be expected within a 5 year time span. So we neither are within the desired range now, nor were we before we began to burn. Additional Year 5 data will be available next year to further assess this variable with greater confidence.

<u>OVERSTORY SCORCH</u>

Objective 2: Limit average crown scorch on overstory *Pinus ponderosa* (greater than or equal to 16" dbh) to 30%, measured immediately Post-burn.

Results: At this time we cannot complete analysis for this variable. The database program (fmh.exe) does not allow assessment for scorch on trees of our unique size class. They can be compiled by hand at a future date. <u>Figure 3</u> shows the data we *can* extract from the database—mean scorch per plot on all live ponderosas greater or equal to 6 inches (15 cm) dbh. This graph indicates only 4 of 19 plots had a mean scorch of greater than 30% after the first entry burn and only 2 of 16 plots had a mean scorch of greater than 30% after the second burn. Since this includes all trees from 6-16 inches (15-40 cm), it is likely that if they are taken out of the analysis, the mean scorch heights will be lower for trees greater than 16" (40 cm) dbh. <u>Figure 4</u> shows minimum, mean, and maximum scorch heights for the first and second-entry burns.

Was objective met? Unknown, but likely met. The trend with numerous plots is very favorable.

FUEL LOADING

Objective 3: Maintain an average total fuel load of 0.2 to 9.3 tons/acre (0.5 to 23 tons/ha) as stated in the Desired Future Condition, measured immediately Post-burn.

Results: Figure 5 shows total fuel load by plot for the entire plot network. Notice that many pre-burn data points are missing due to faulty data collection methods of the past. At this time, there are 8 plots with comparable pre-burn and post-burn data. Figure 6 is the total mean fuel load for comparable plots, showing that the mean fuel load is just within the Desired Future Condition limit. Most of the fuel reduction was in litter and duff.

Was objective met? Yes. Minimum pre-burn sample size at 80%/R20 is 5 plots, and despite inconsistent data collection in the past, we still have 8 plots with which to do analysis. More data will be needed to assess results with 90% confidence, but for now the objective of fuel load reduction to 0.2-9.3 tons/acre is being met. Small error bars give credence to this conclusion.

POLE DENSITY

Objective 4: Reduce *Pinus ponderosa* poles with dbh of 1-6 inches (2.5-15cm) to average 0-200 trees/acre (0-494 trees/ha), measured 2 years post-burn.

Results: Figure 7 shows the plot data across the network; note the high variation in pole densities from 0 to nearly 1800 poles/hectare. Figure 8 shows that mean *Pinus ponderosa* pole densities monitored through post-burn Year 2 decreased from 430 to 350 trees per hectare, but the error bars are large.

Was objective met? Unknown with such high variability in the data, but trend is favorable. Due to the large number of required minimum pre-burn plots, it is not realistic that we will be able to assess this objective to our desired level of statistical confidence.

SNAG DENSITY

Objective: Track snag densities over time.

Results: Figure 9 shows that small snag densities have increased on 7 plots, decreased on 4 plots, and remain unchanged on others from Pre-burn through second-entry post-burn Year 2 monitoring. Values range from 0-100 small snags/ha. Large snags show less variability (Figure 10) but the zero values on most plots confound the data, making error bars wide (Figure 11). Figure 11 represents means for the 2 size classes from pre-burn through Year 5. Relatively little change has occurred in the larger trees, but snags have nearly tripled in the 6-15.9" size class.

Was objective met? There is no objective for a certain number of snags at this time. Consultation with the Grand Canyon National Park wildlife biologist is needed to define an objective.

SEEDLING DENSITY

Objective: Track seedling densities over time.

Results: Figure 12 shows *Pinus ponderosa* seedling densities generally decreasing. This may help lessen the pole density problem in future decades. Figure 13 illustrates variation in *Quercus gambelii* seedlings due to resprouting after fire. In plots where QUGA did not exist before burning, there is little change, but in plots where QUGA did exist, there are both increases and decreases in QUGA density.

Was objective met? There is no objective for seedling densities at this time. This information is provided for general knowledge, so that other resource management staff at Grand Canyon know the trends that are occurring.

Figure 1. Live 16" DBH and larger *Pinus ponderosa* Densities, by plot
December 2001

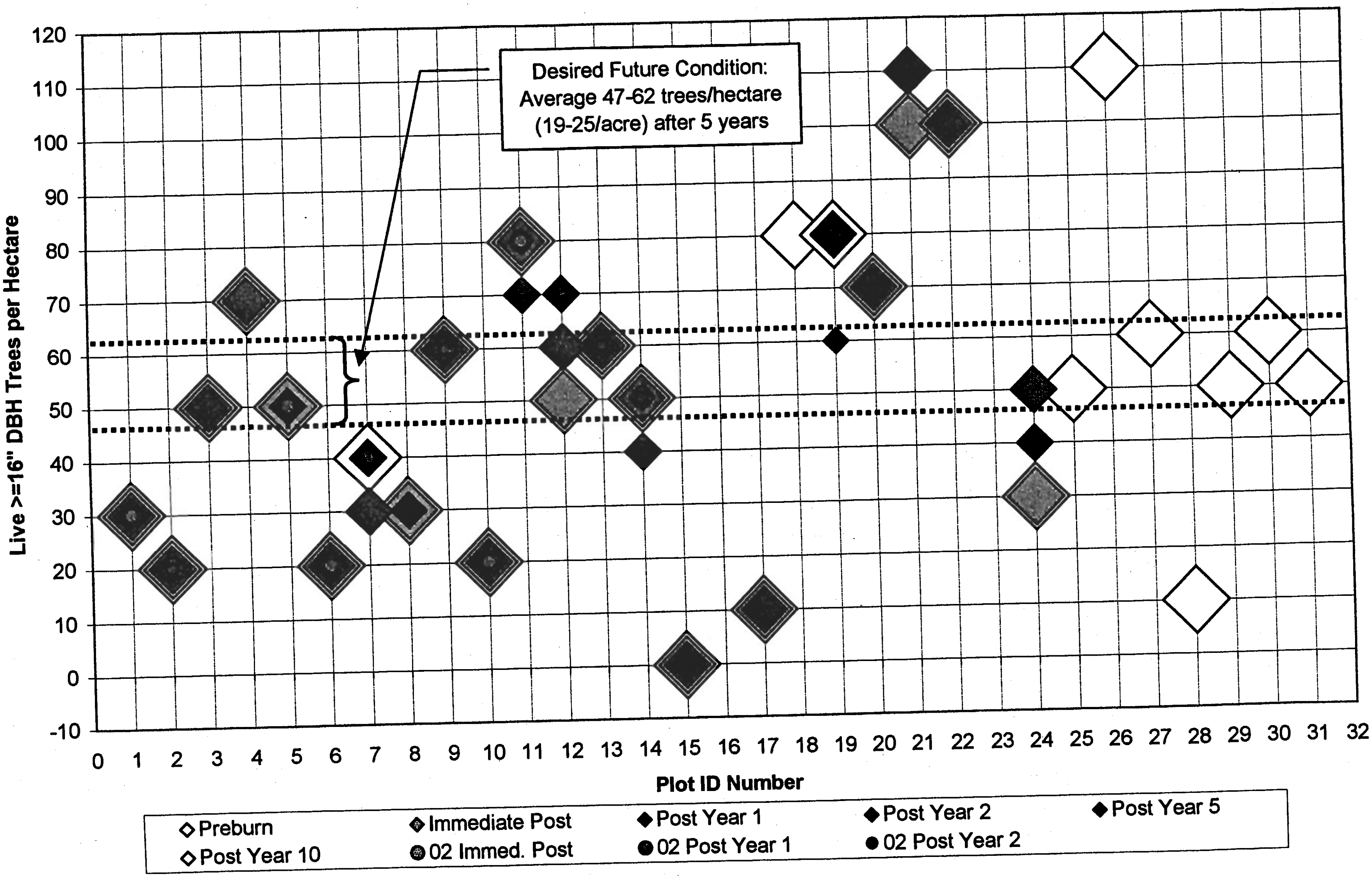
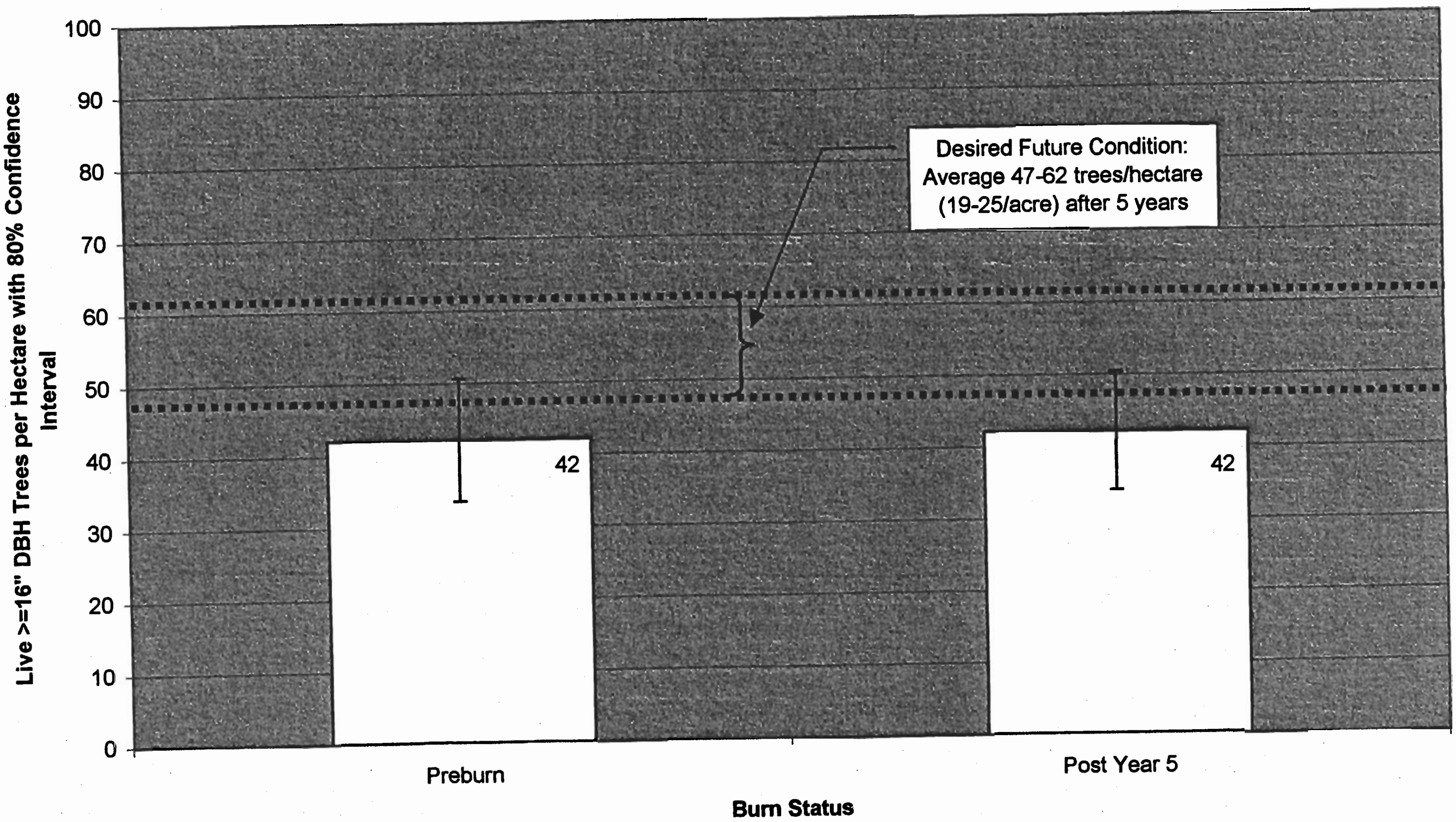


Figure 2. Mean Density of Live 16" DBH and larger *Pinus ponderosa*
December 2001
n = 14 plots, *required minimum pre plots = 13*



South Rim Ponderosa Pine (PIPO)

Figure 3. Post-burn Crown Scorch Percent on Live *Pinus Ponderosa* Overstory Trees, by plot
December 2001

↑ Here includes all trees ≥ 6" dbh.

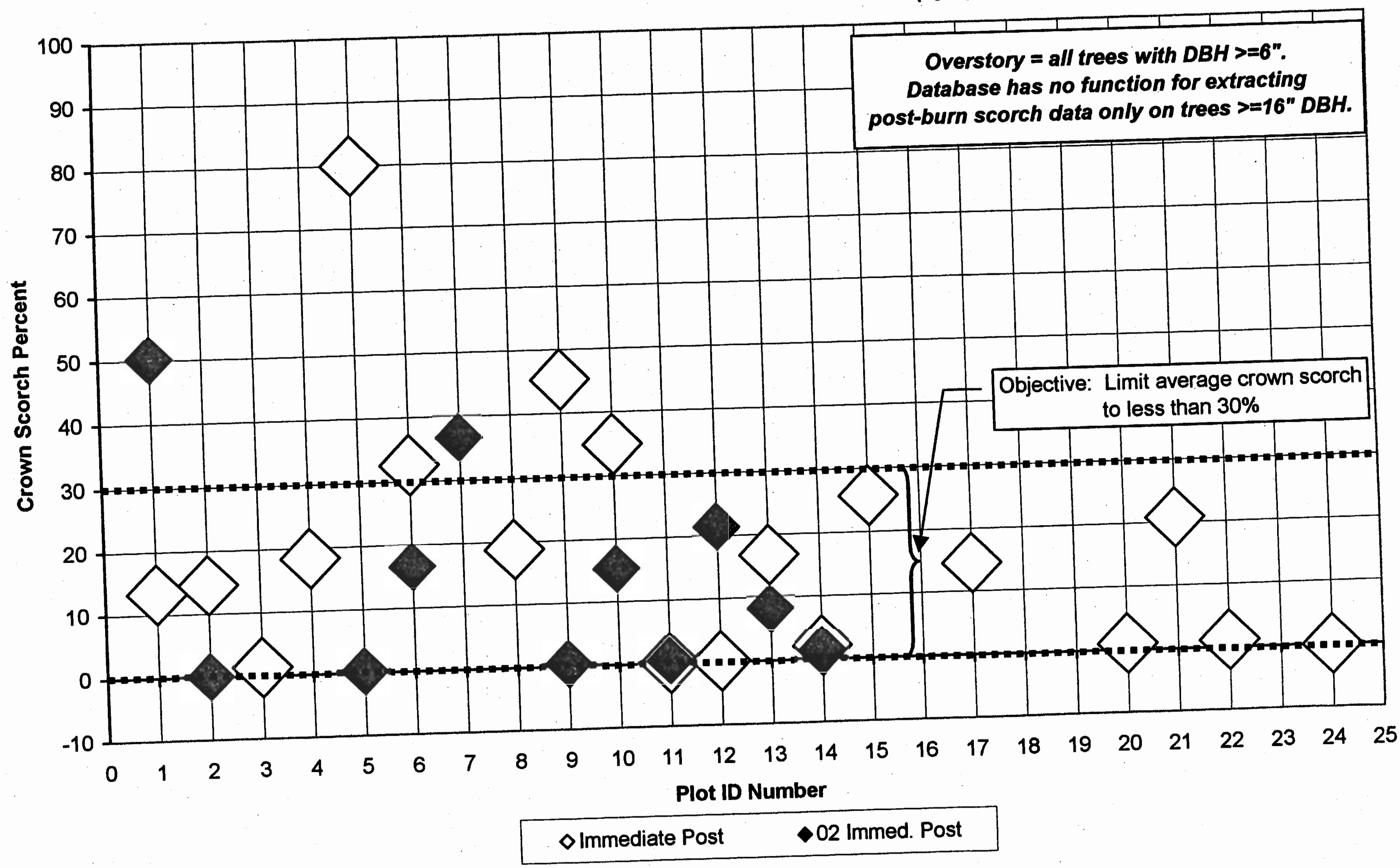


Figure 4. Post-burn Crown Scorch Percent on Live *Pinus ponderosa* Overstory Trees
December 2001

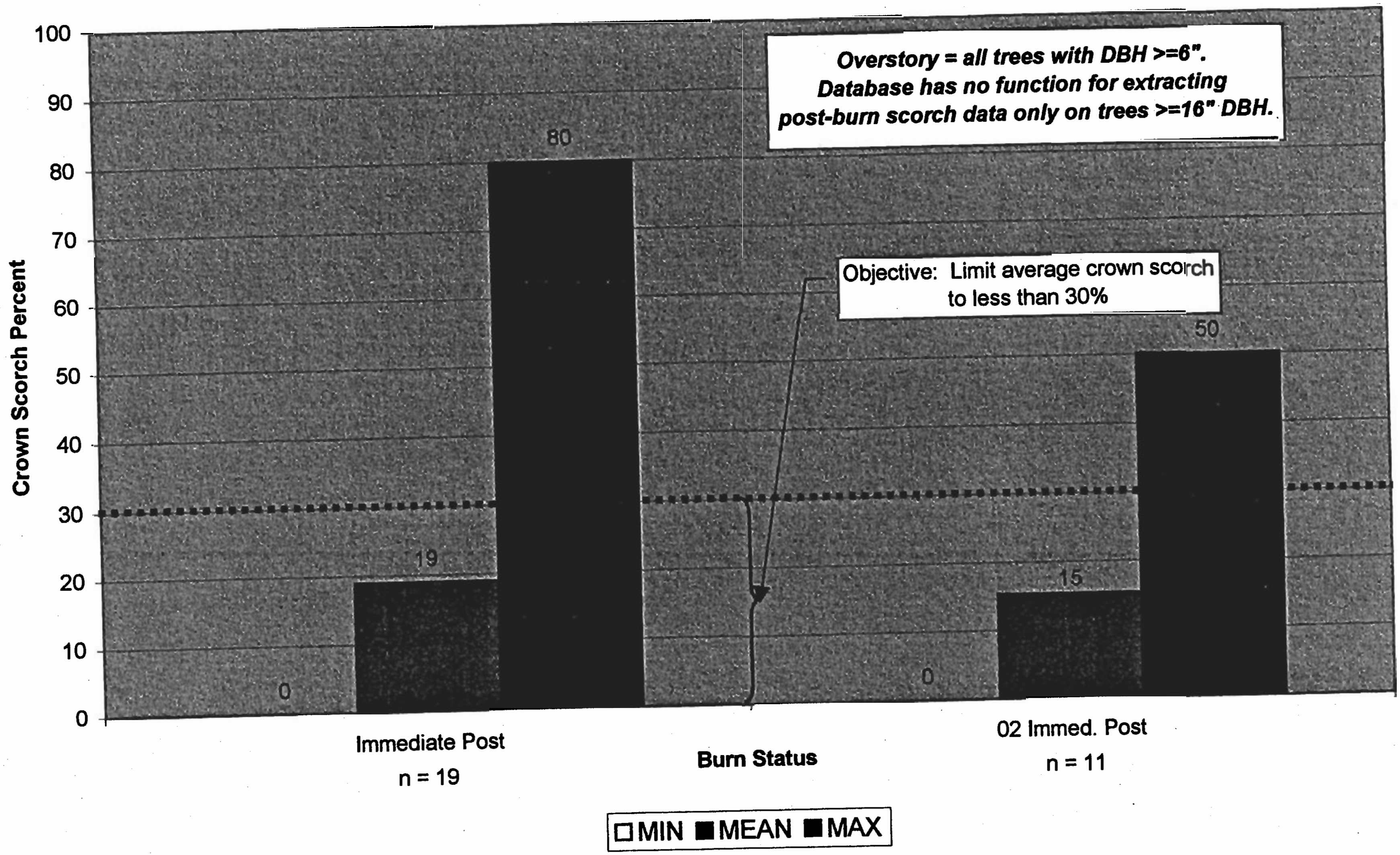


Figure 5. Total Fuel Load by Plot
December 2001
100-foot fuel transects

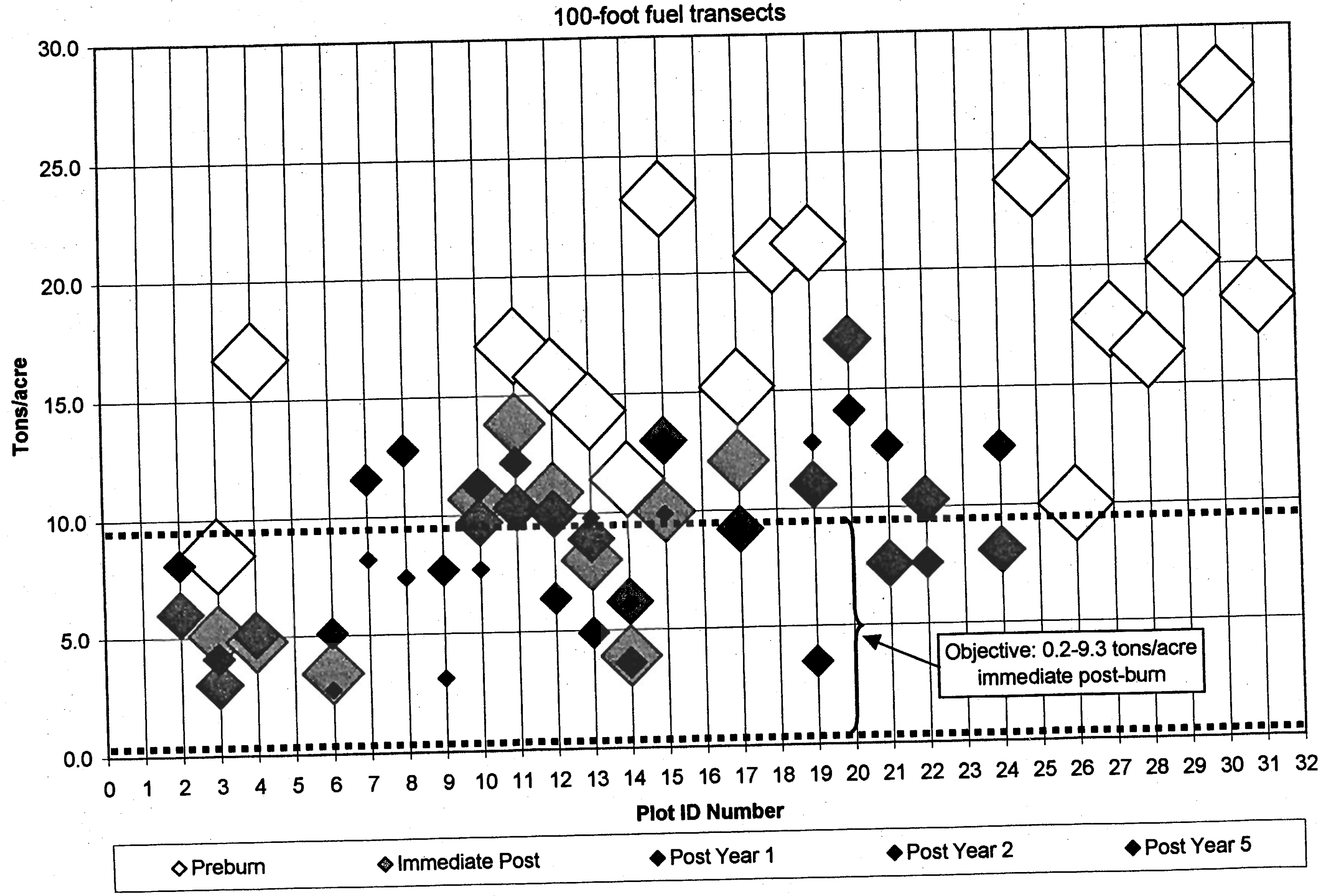
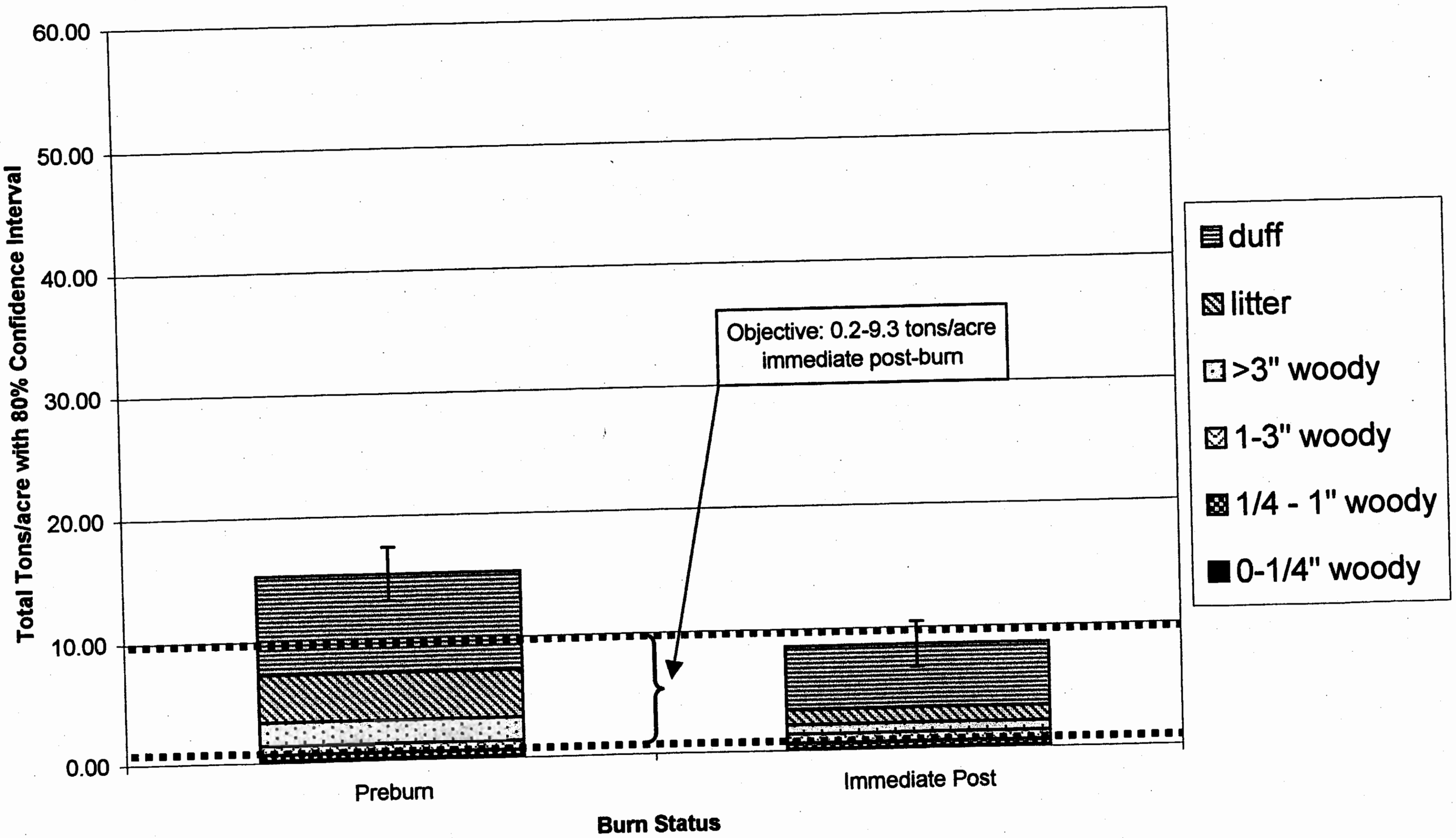


Figure 6. Total Mean Fuel Load
December 2001
100-foot fuel transects
n=8, *required minimum pre plots = 5*



(1-6" dbh)

Figure 7. ***Pinus ponderosa*** **Pole Densities, by plot.**
December 2001

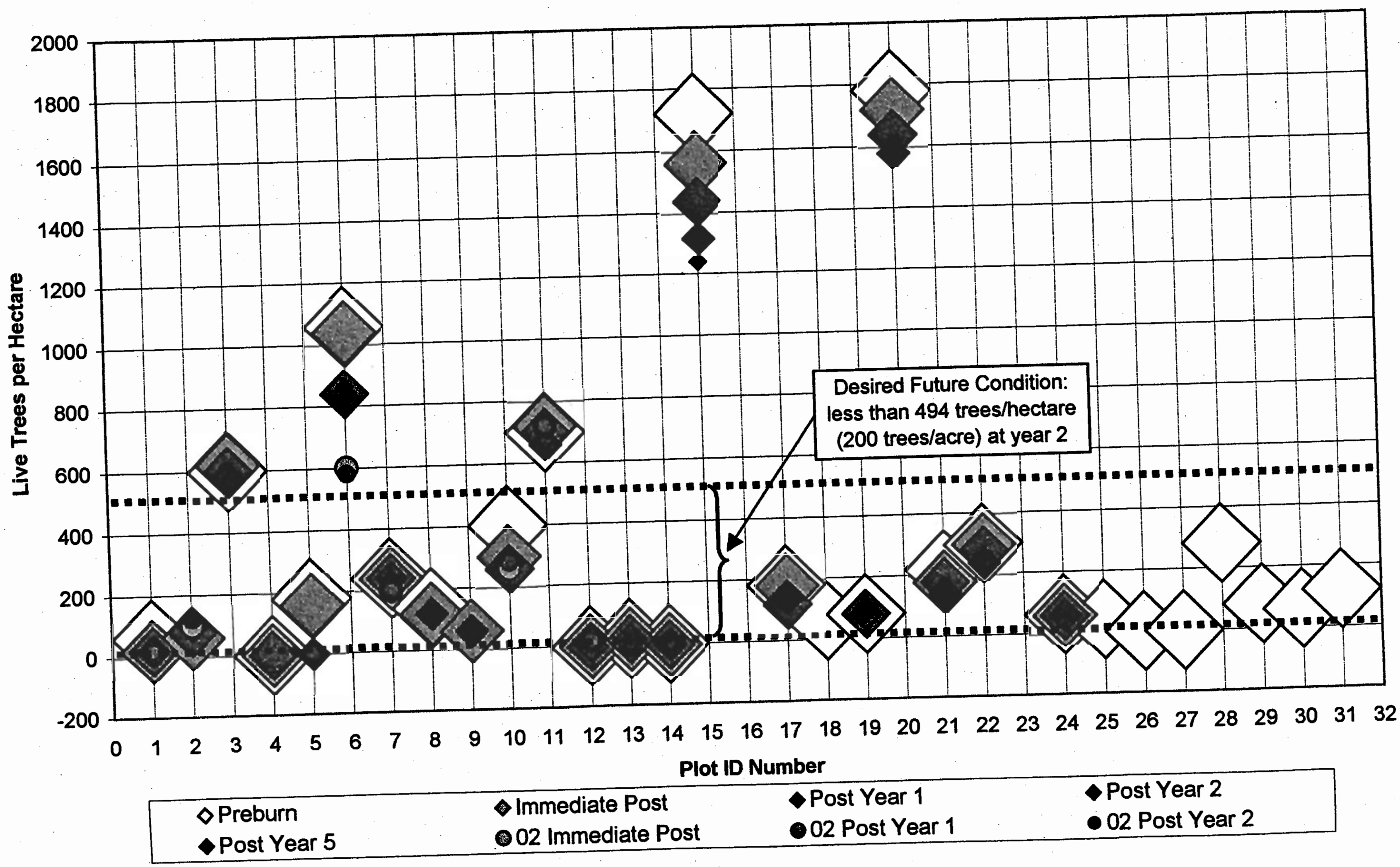


Figure 8. Mean *Pinus ponderosa* Pole Density
December 2001
n = 18 plots, *required minimum pre plots = 104*

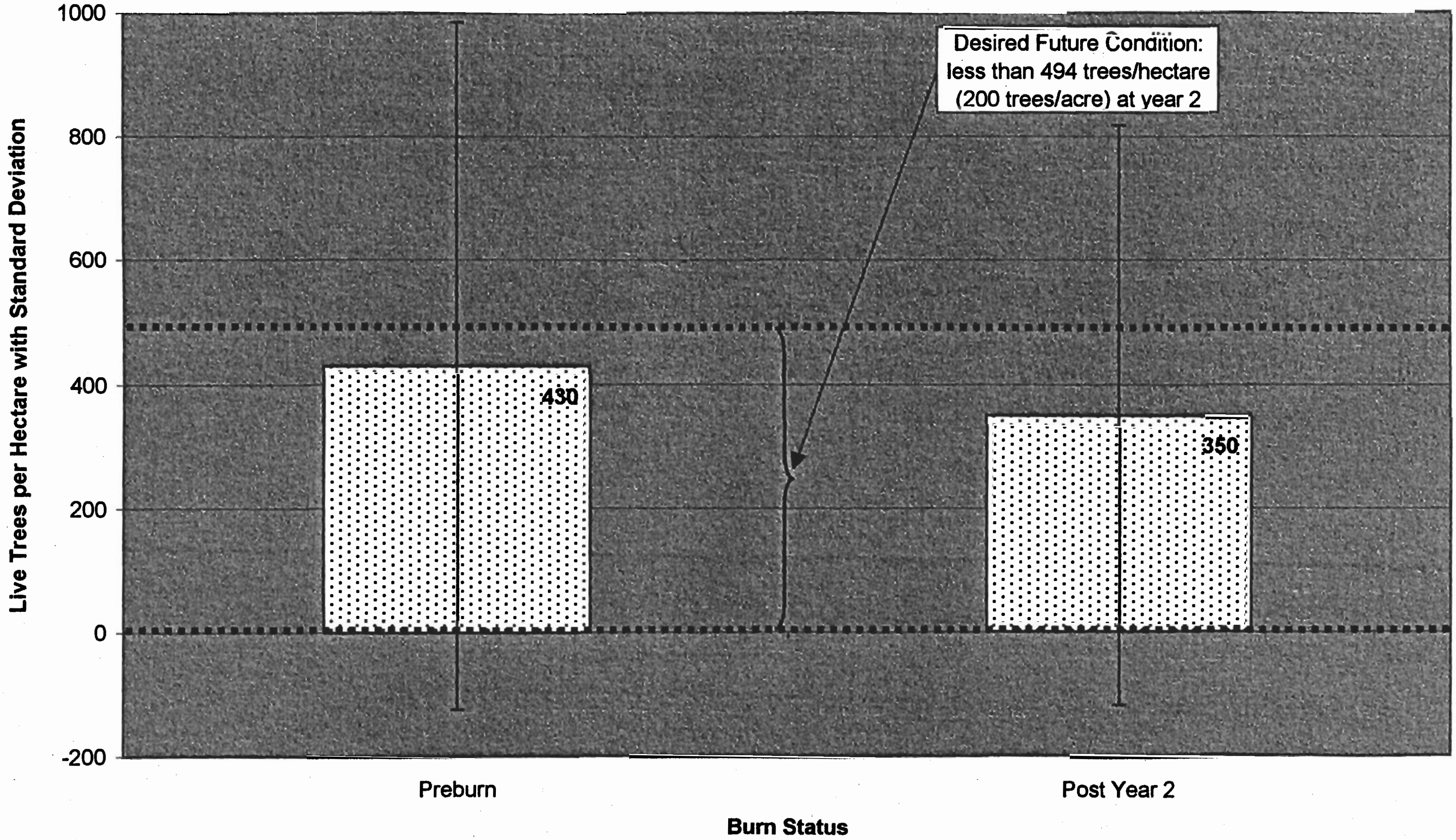


Figure 9. 6 - 15.9" DBH Snag Densities, by plot
December 2001

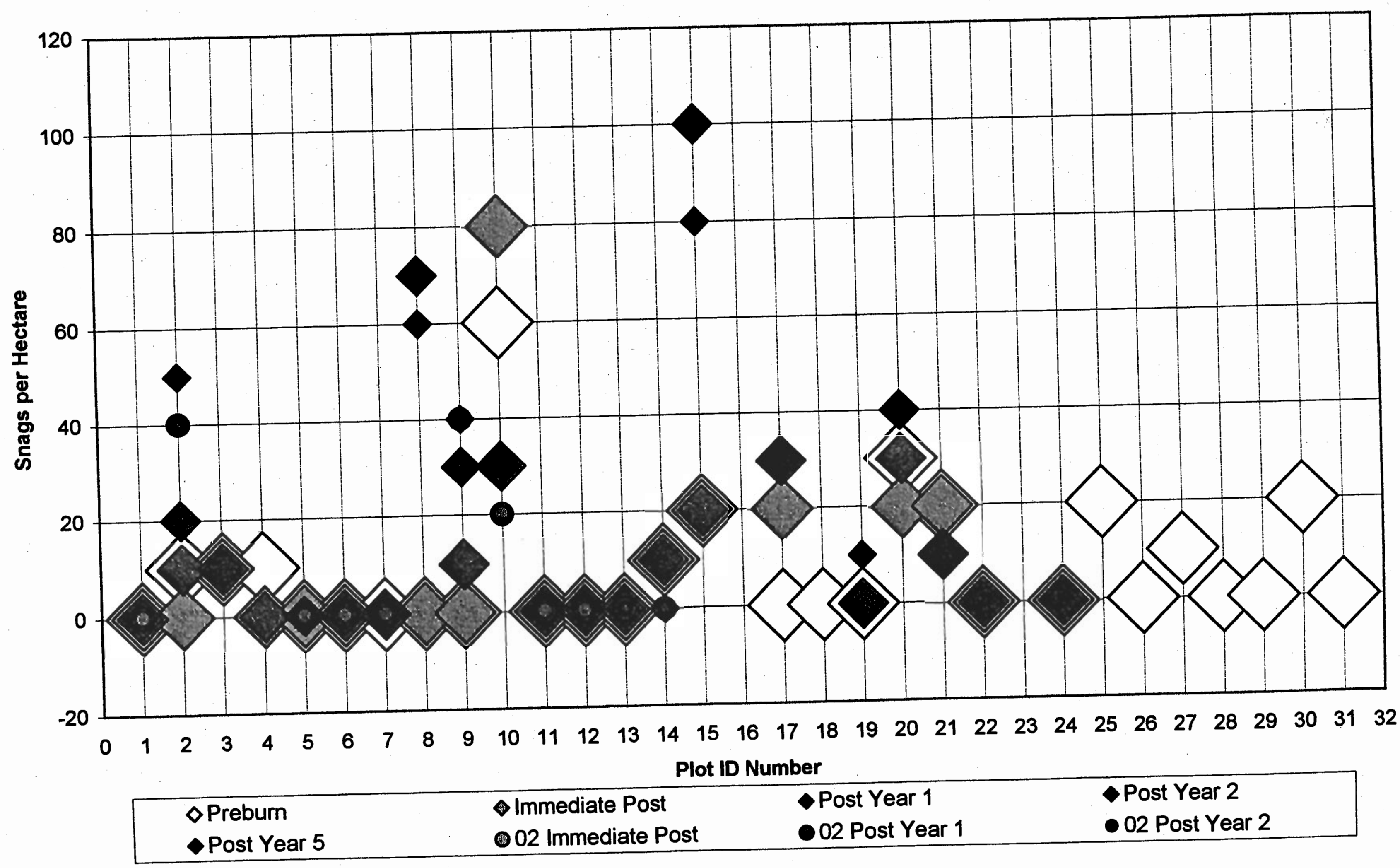
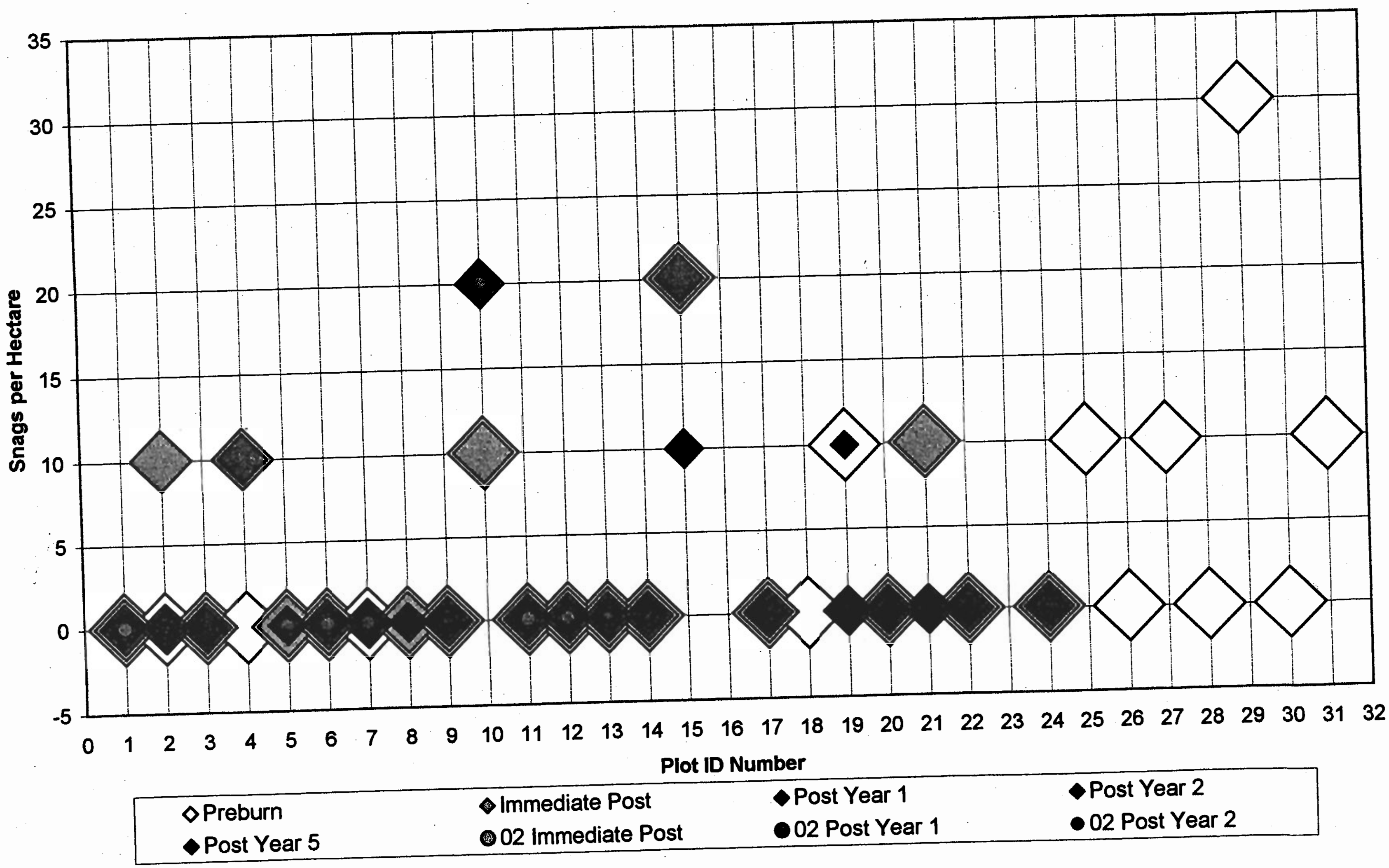


Figure 10. 16" DBH and larger Snag Densities, by plot
December 2001



South Rim Ponderosa Pine (PIPO)

Figure 11. Mean Snag Density, by size class
December 2001
n = 14 plots; *required minimum pre plots = 310 (>=16"), 94 (6-15.9")*

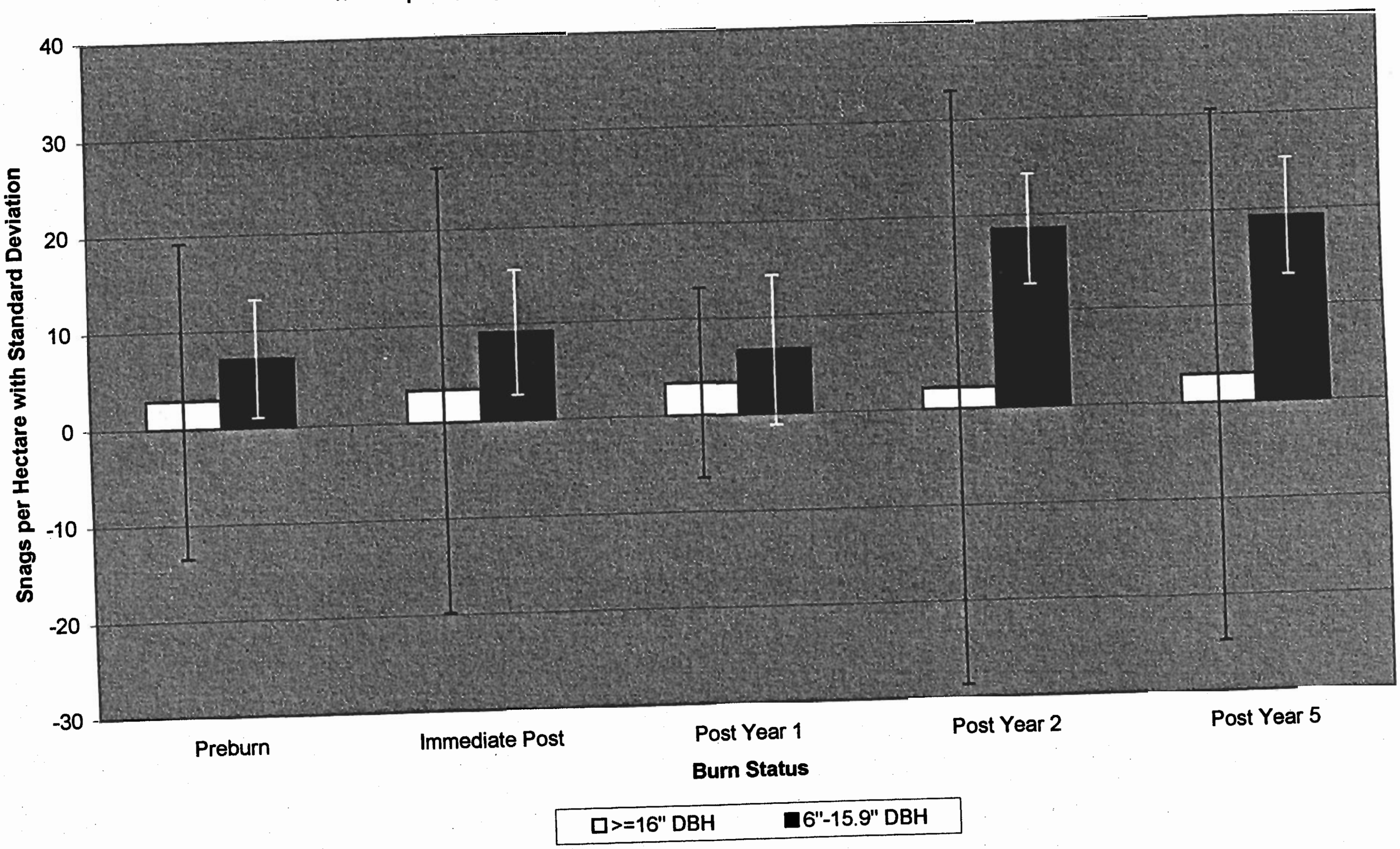


Figure 12. ***Pinus ponderosa*** **Seedling Densities, by plot**
December 2001

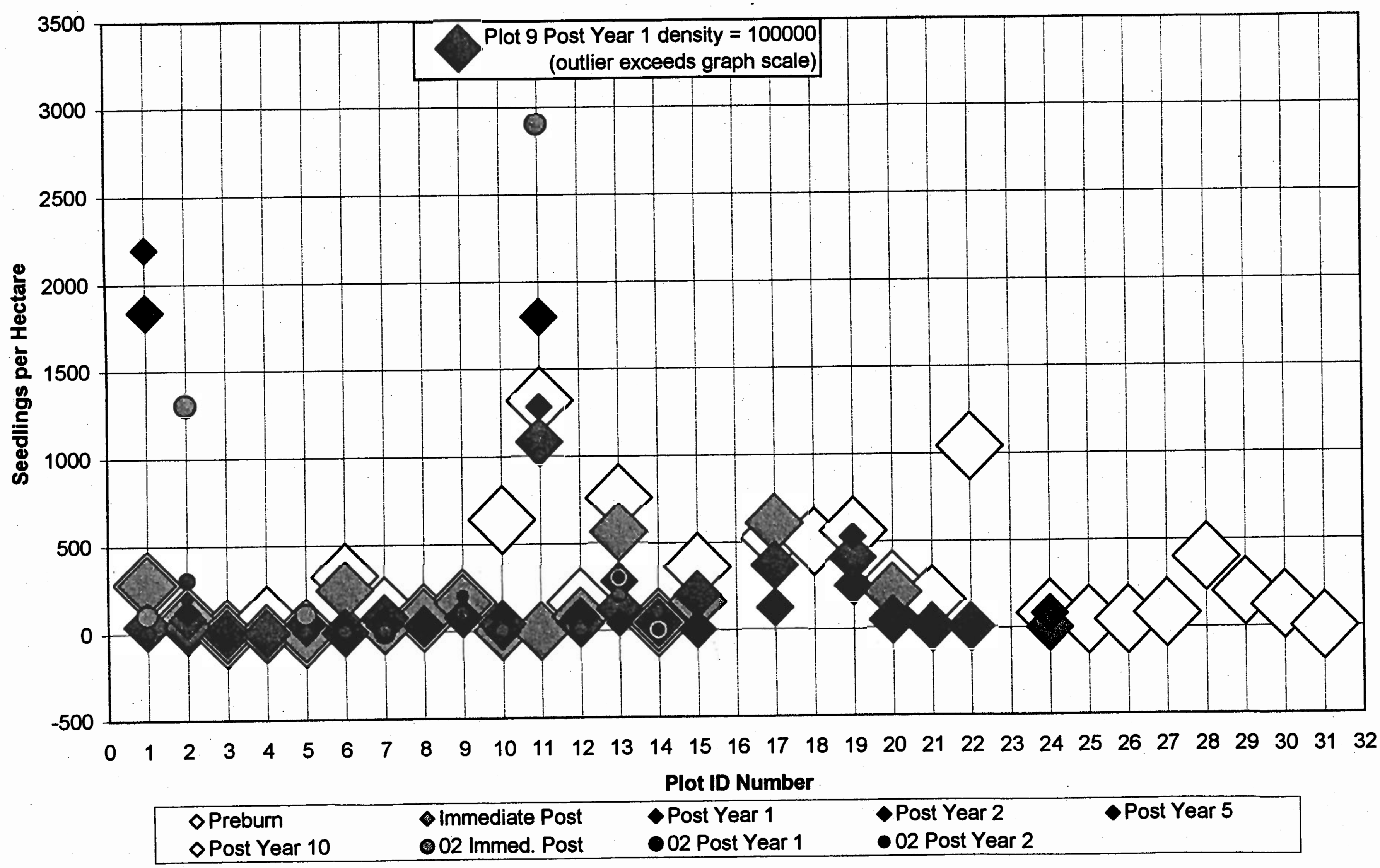
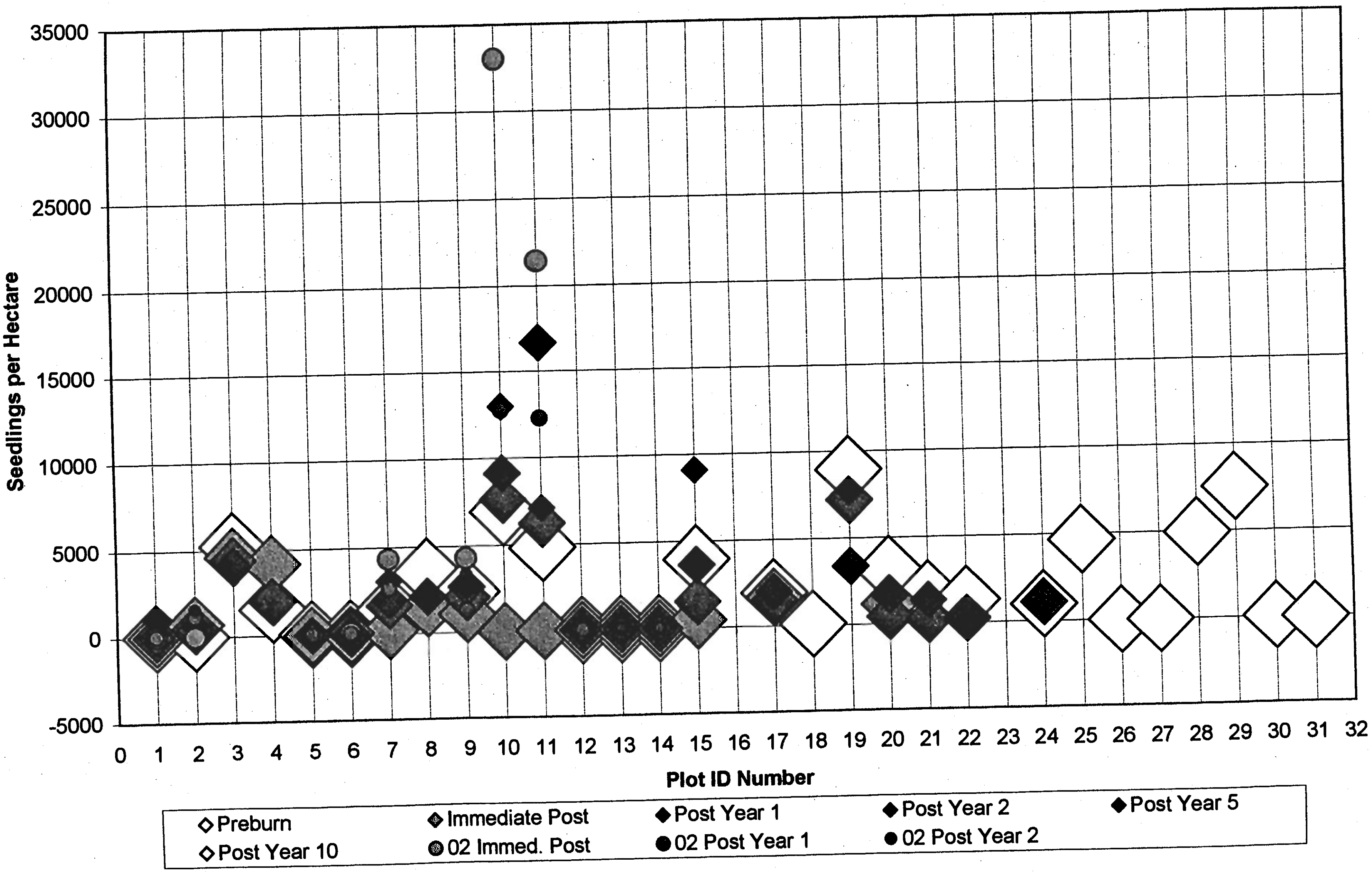


Figure 13. *Quercus gambelii* Seedling Densities, by plot
December 2001



PIPN RESULTS AND DISCUSSION

<u>OVERSTORY DENSITY</u>

Objective 1: Achieve and maintain an overstory *Pinus ponderosa* density (greater than or equal to 16" dbh) of 40-56 trees per acre (99-136 trees/ha) as stated in the Desired Future Condition, measured at 5 years post-burn.

Results: <u>Figure 14</u> illustrates a very slight decrease in large *Pinus ponderosa* across the entire plot network. There are only 2 plots with Year 5 data—both showing a change in density between 2 and 5 years post-burn. One shows a positive change, and one a negative change. These 2 plots--PIPN 1 and 2--were both burned in the Northwest III prescribed burn in 1993. The entire body of post-burn data includes 3 plots with a declining trend, 2 with an increasing trend, and 15 are unchanged. There is no bar graph for this variable because there are only 2 plots with Year 5 data.

Was objective met? It is unknown at this time, since there are not enough Year 5 data.

<u>OVERSTORY SCORCH</u>

Objective 2: Limit average crown scorch on overstory *Pinus ponderosa* (greater than or equal to 16" dbh) to 30%, measured immediately Post-burn.

Results: At this time we cannot complete analysis for this variable. The database program (fmh.exe) does not allow assessment for scorch on trees of our unique size class. They can be compiled by hand at a future date. <u>Figure 15</u> shows the data we *can* extract from the database—mean scorch per plot on all live ponderosas greater or equal to 6 inches (15 cm) dbh. This graph indicates only 4 of 20 plots had a mean scorch of greater than 30% after the first-entry burn. Since this includes all trees from 6-16 inches (15-40 cm), it is likely that if they are taken out of the analysis, the mean scorch heights will be lower for trees greater than 16" (40 cm) dbh. <u>Figure 16</u> shows minimum, mean, and maximum scorch heights for the first-entry burn.

Was objective met? Unknown, but likely met. With data from 20 plots, the trend is quite favorable.

<u>FUEL LOADING</u>

Objective 3: Maintain an average total fuel load of 0.2 to 9.3 tons/acre (0.5 to 23 tons/ha) as stated in the Desired Future Condition, measured immediately Post-burn.

Results: <u>Figure 17</u> shows a lot of change on individual plots, with fuel loads almost always decreasing. <u>Figure 18</u> shows that duff, litter, and 1000-hour fuels (>3" woody) are decreased the most after the first-entry burn. It is understood that it will likely take more than one treatment to reduce fuel loads to desired conditions. A burn prescription that would reduce fuel loads to desirable levels the first time might be too hot for overstory ponderosa pine.

Was objective met? Not yet. We have the required number of minimum pre-burn plots, but although total mean fuel load was cut in half on average, it is still higher than the desired future condition. It seems as though a second-entry burn will be required to meet our objectives, or objectives need to be re-assessed.

POLE DENSITY

Objective 4: Reduce *Pinus ponderosa* poles with dbh of 1-6 inches (2.5-15cm) to average 0-200 trees/acre (0-494 trees/ha), measured 2 years post-burn.

Results: Figure 19 shows that *Pinus ponderosa* pole tree densities are generally within or near the range of Desired Future Conditions, with the notable exception of plot 5. Figure 20 shows mean densities to be decreasing, although error bars are wide.

Was objective achieved? Unknown. Minimum sample size has not been achieved for this variable, but the trend is toward a decrease in pole densities. Due to the large number of required minimum pre-burn plots, it is not realistic that we will be able to assess this objective to our desired level of statistical confidence.

SNAG DENSITY

Objective: Track snag densities over time.

Results: Figure 21 shows small snag density changes across the plot network. Response to fire ranges from the dramatic increase on plot 1 to the noticeable decrease on plot 3, although overall change is slight. Figure 22 illustrates decreases in large snag densities on 3 plots, increases on 1, and no changes on 16 between pre-burn conditions and the most recent post-burn data. Plots 1 and 2 were both burned in the Northwest III prescribed burn in 1993. There is no bar graph because there are only 2 plots with Year 5 data.

Was objective met? There is no objective for a certain number of snags at this time. Consultation with the Grand Canyon National Park wildlife biologist is needed to define an objective. The trend is toward little overall change.

SEEDLING DENSITY

Objective: Track seedling densities over time.

Results: Figure 23 shows *Abies concolor* seedling densities across the monitoring network. Many plots have zero values, and one plot shows a large increase while another shows a large decrease. Figure 24 shows *Pinus ponderosa* seedlings densities on all plots, most all of which show negative trends where seedlings existed before the fire. This decrease may help mitigate future increases in pole densities. Figure 25 shows many zero values for *Populus tremuloides* seedlings, and some slight increases on some plots and decreases on others.

Was objective met? There is no objective for seedling densities at this time. This information is provided for general knowledge, so that other resource management staff at Grand Canyon can see the trends that are occurring.

Figure 14. Live 16" DBH and larger *Pinus ponderosa* Densities, by plot
December 2001

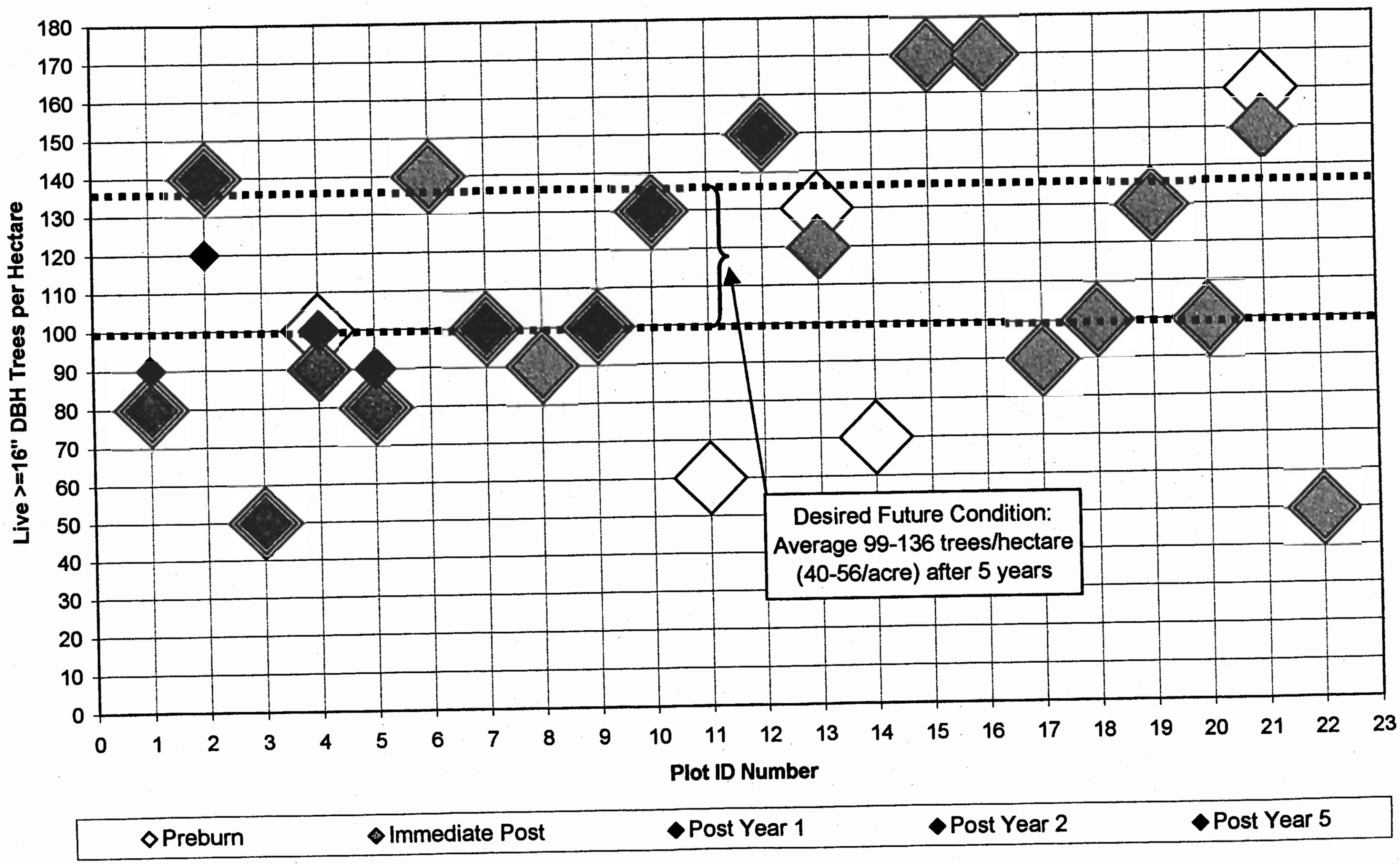
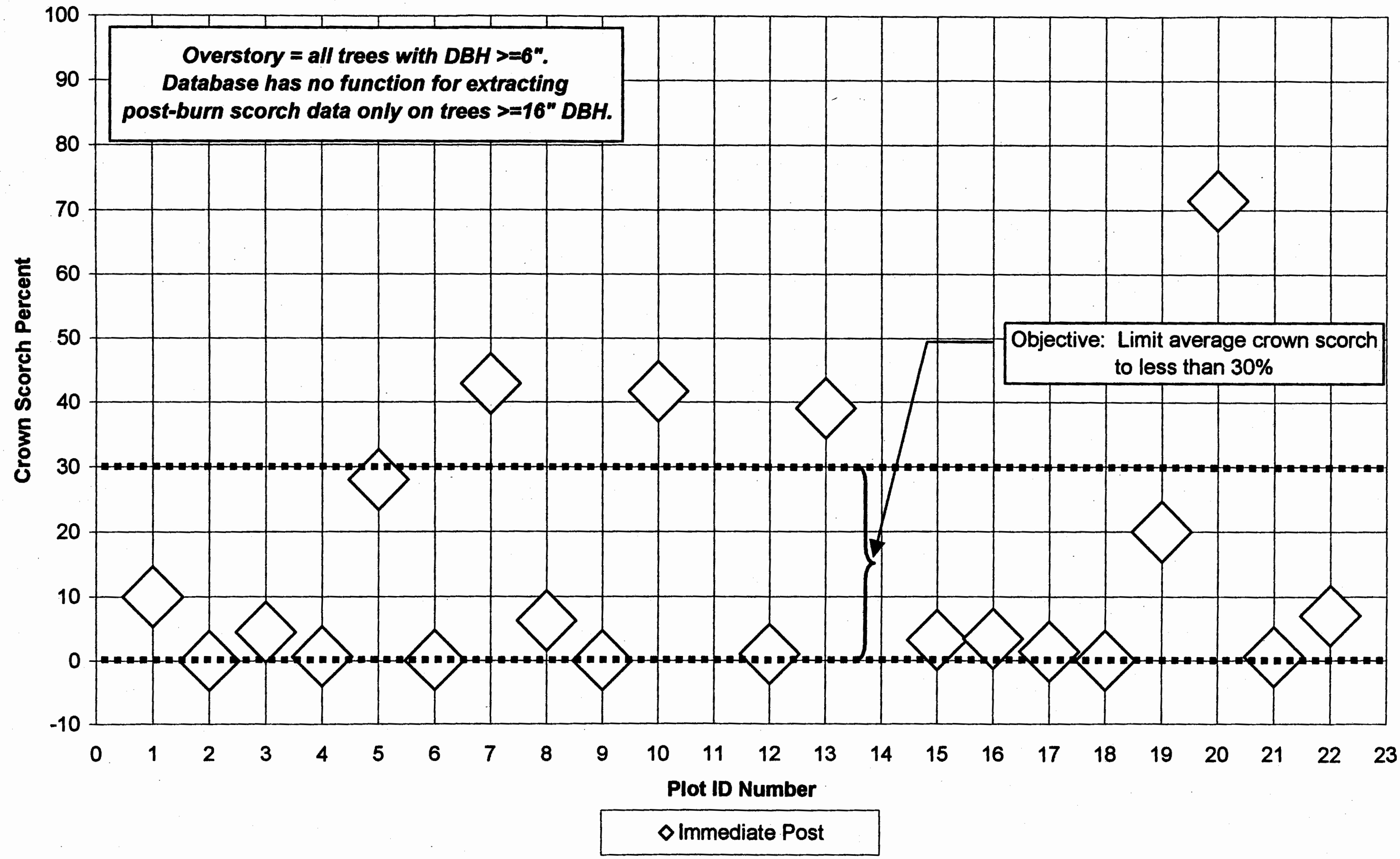


Figure 15. Post-burn Crown Scorch Percent on Live *Pinus Ponderosa* Overstory Trees, by plot
December 2001



North Rim Ponderosa Pine (PIPN)

Figure 16. Post-burn Crown Scorch Percent on Live *Pinus ponderosa* Overstory Trees
December 2001
n = 20

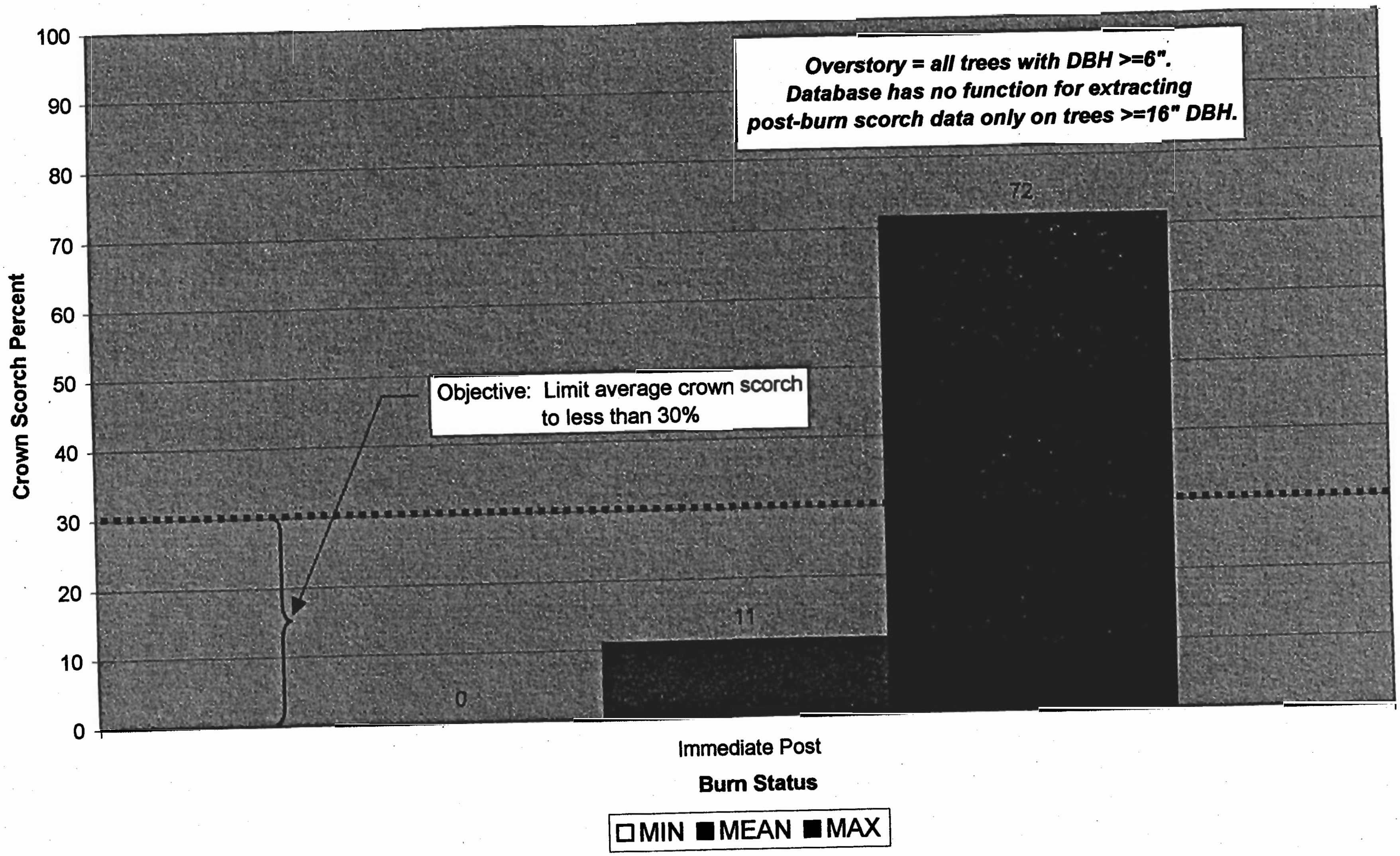
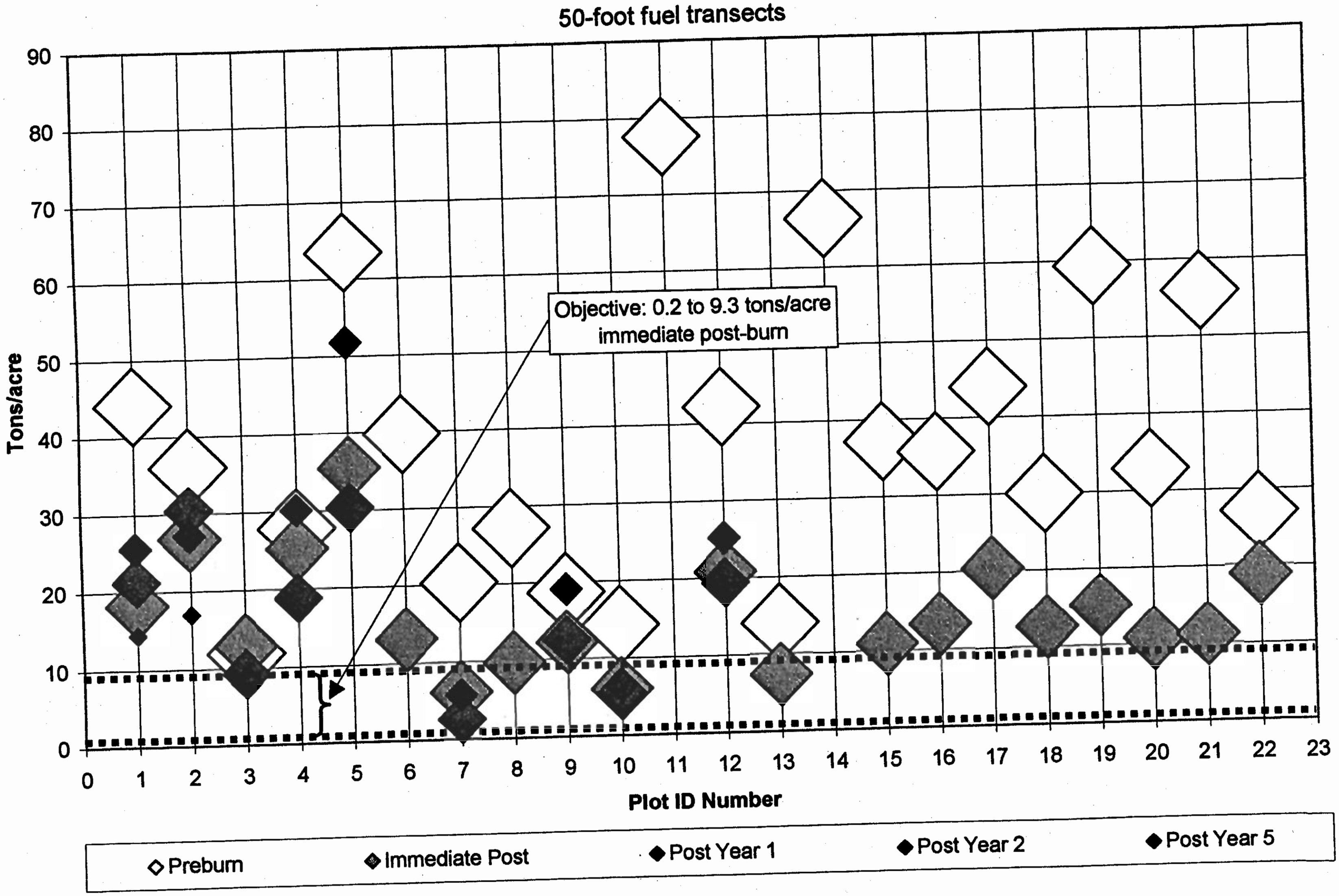


Figure 17. Total Fuel Load, by plot
December 2001
50-foot fuel transects



North Rim Ponderosa Pine (PIPN)

Figure 18. Total Mean Fuel Load
December 2001
50-foot fuels transects
n=20, *required minimum pre plots = 10*

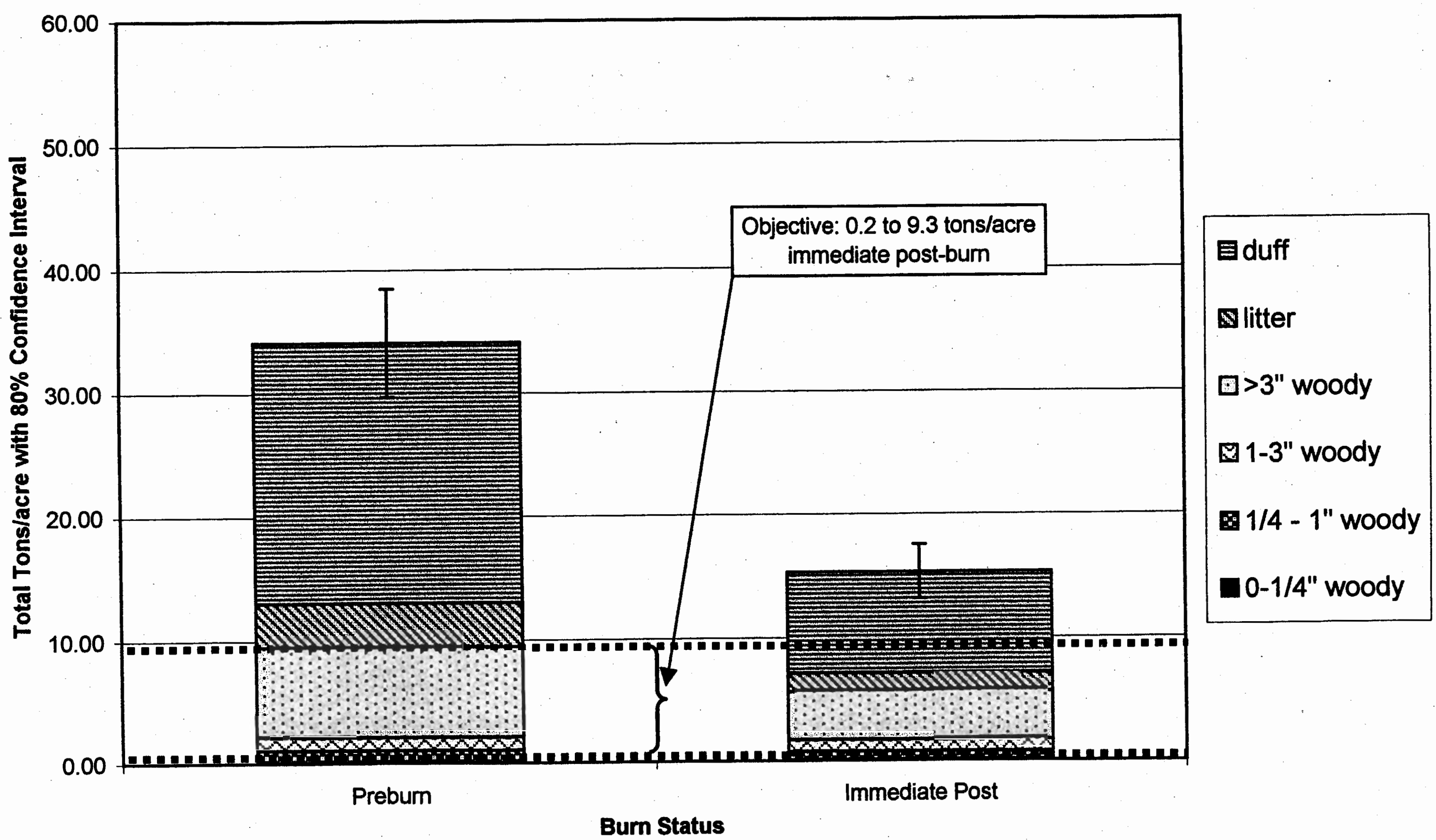


Figure 19. ***Pinus ponderosa*** **Pole Densities, by plot**
December 2001

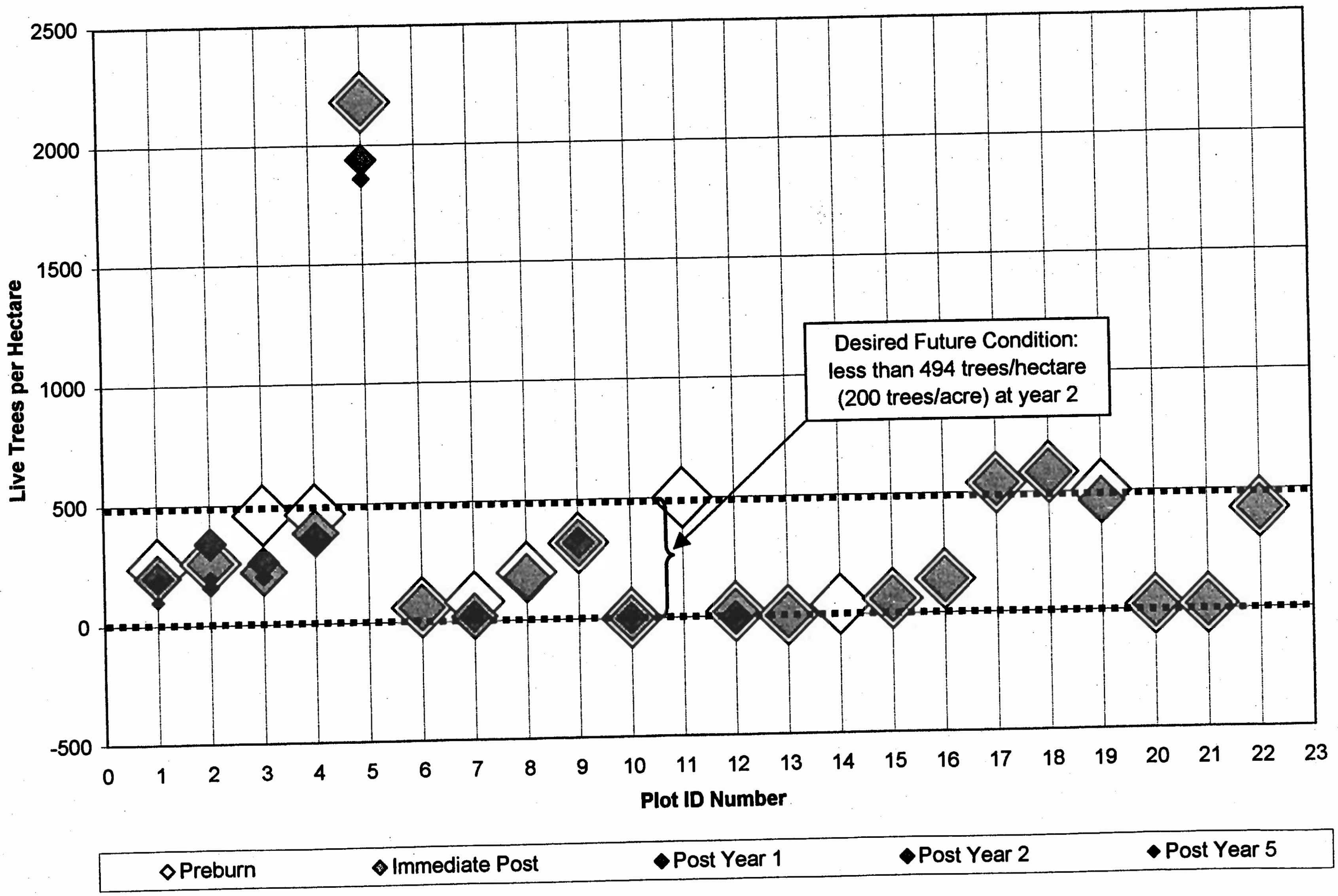


Figure 20. Mean *Pinus ponderosa* Pole Density
December 2001
n = 9 plots, *required minimum pre plots = 90*

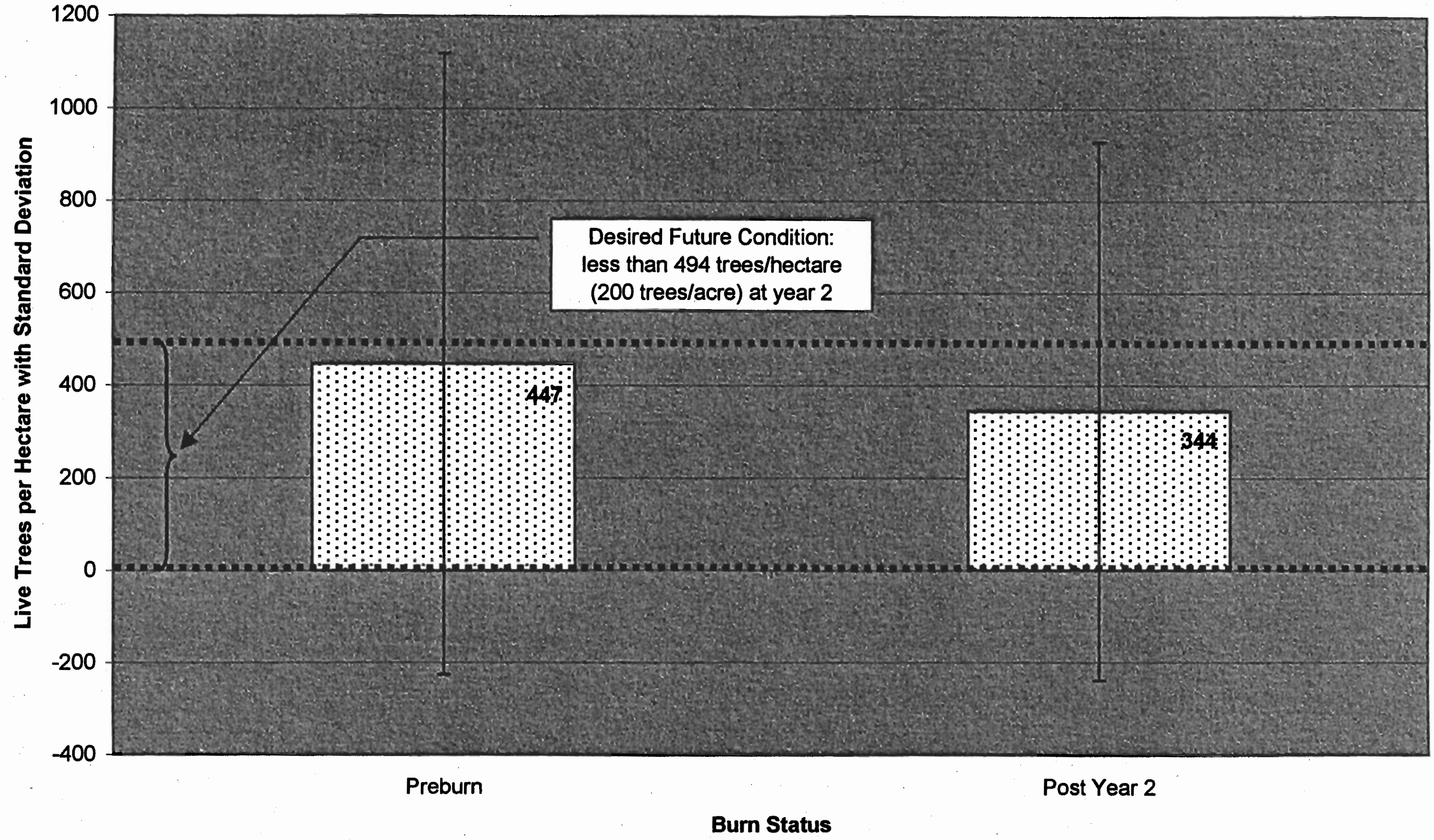


Figure 21. 6 - 15.9" DBH Snag Densities, by plot
December 2001

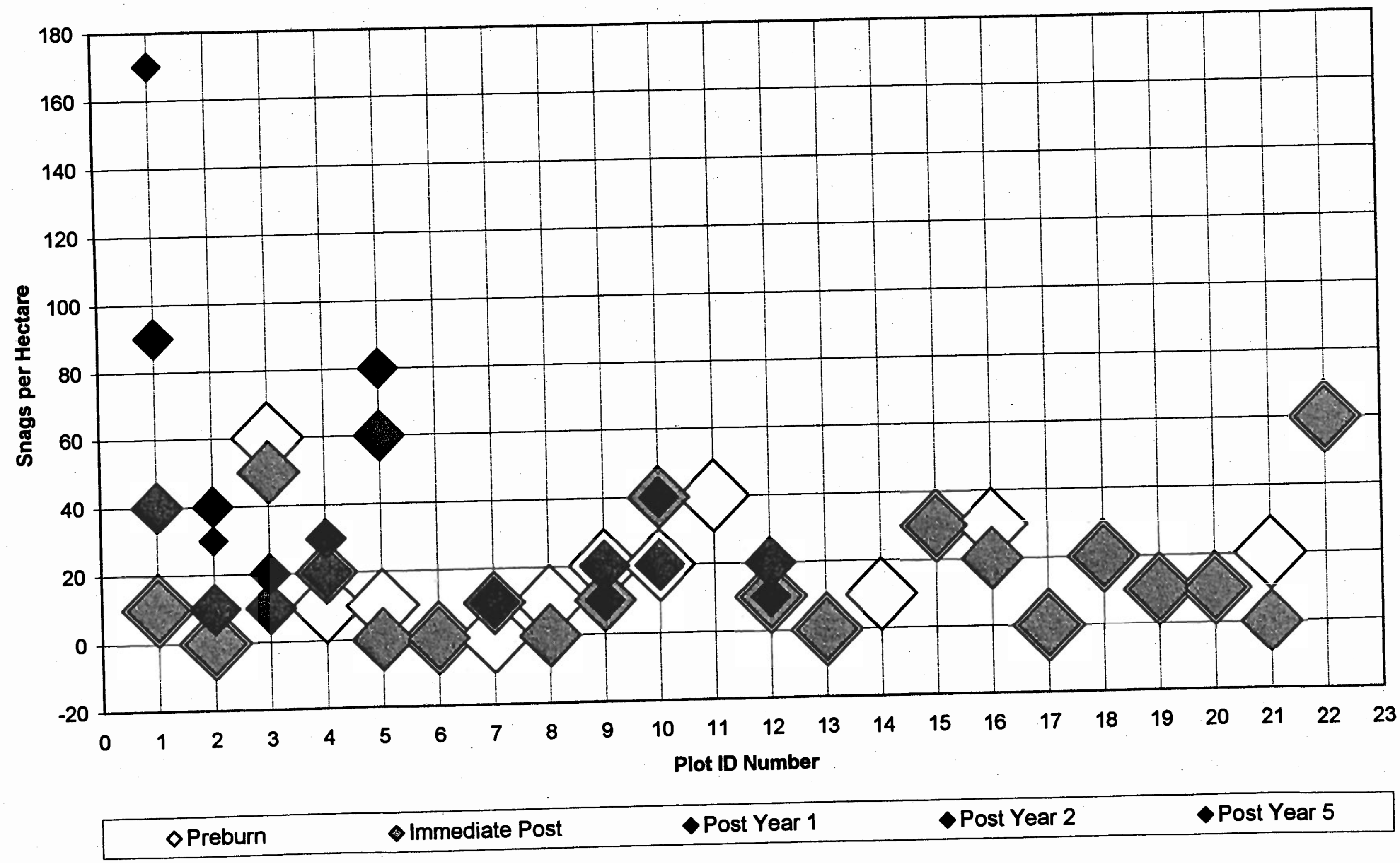


Figure 22. 16" DBH and larger Snag Densities, by plot
December 2001

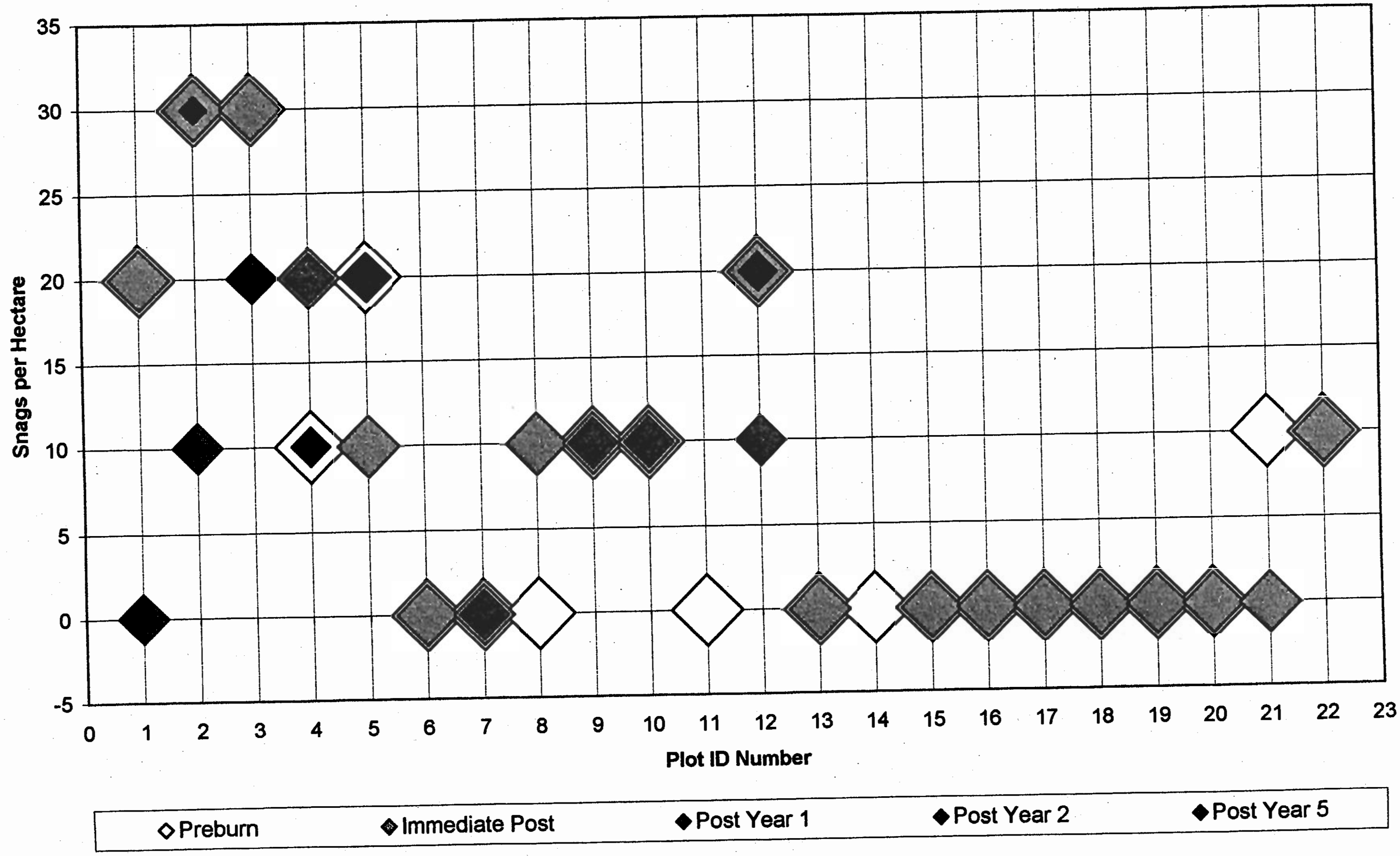


Figure 23. *Abies concolor* Seedling Densities, by plot
December 2001

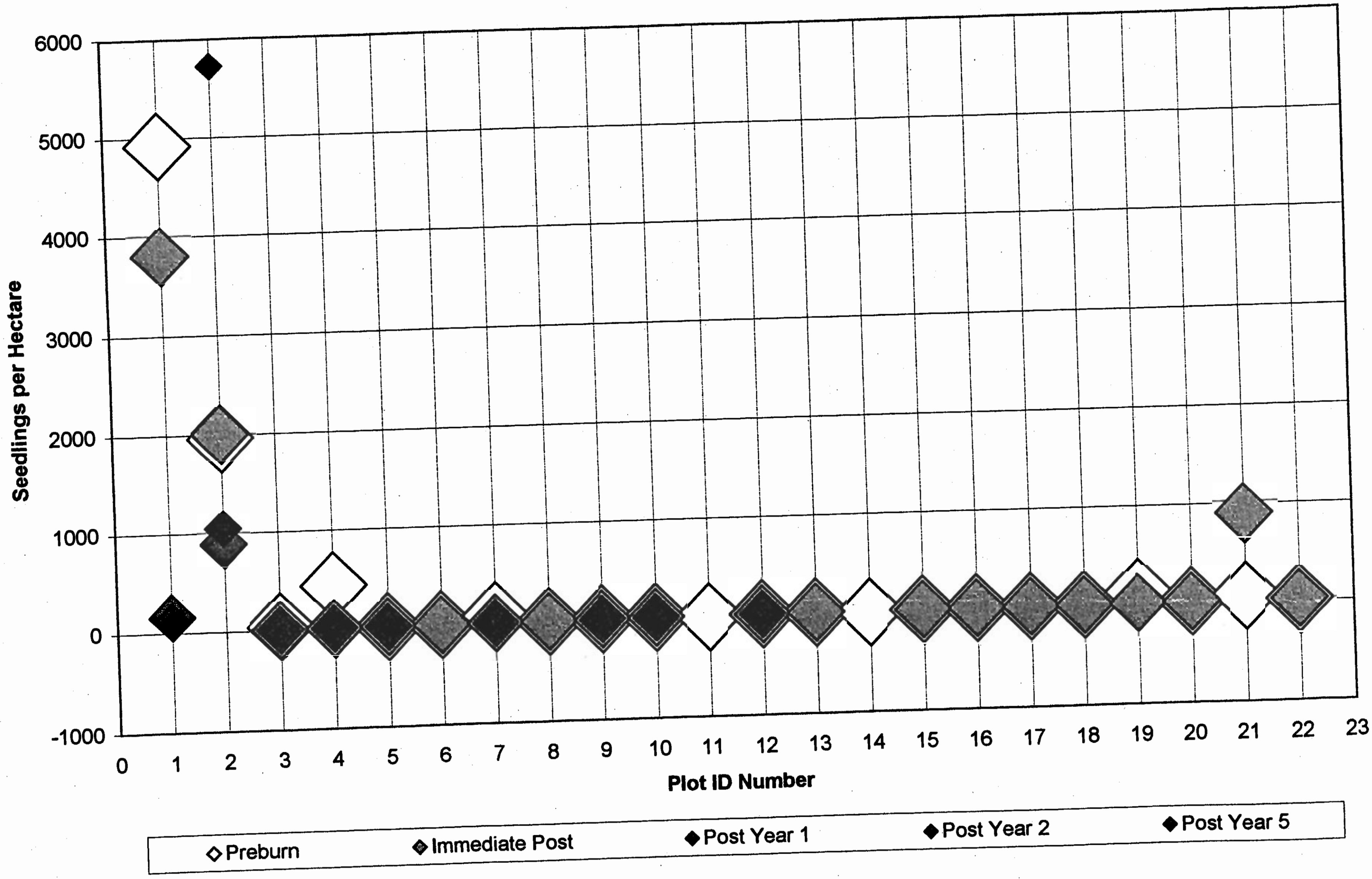


Figure 24. ***Pinus ponderosa*** **Seedling Densities, by plot**
December 2001

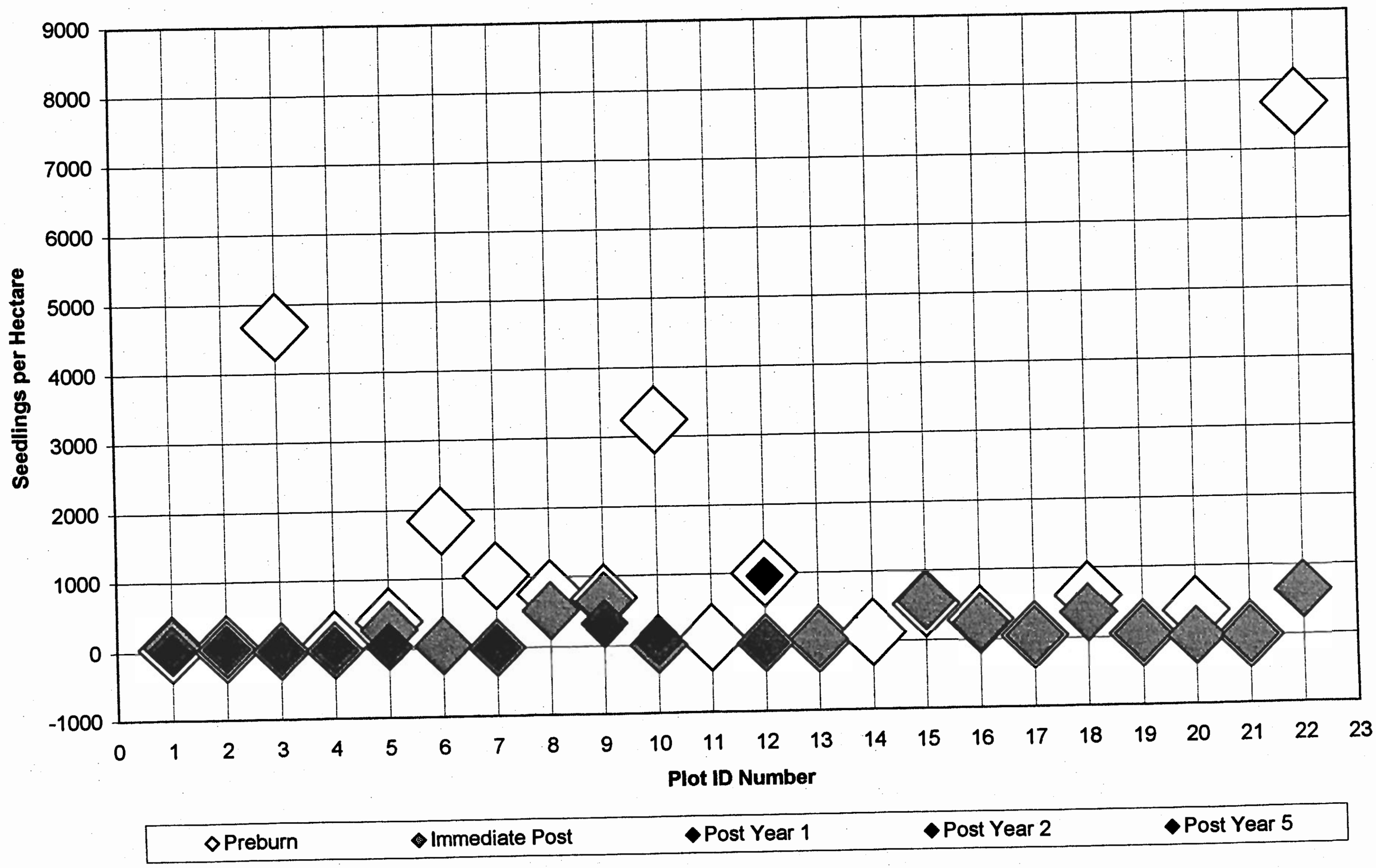
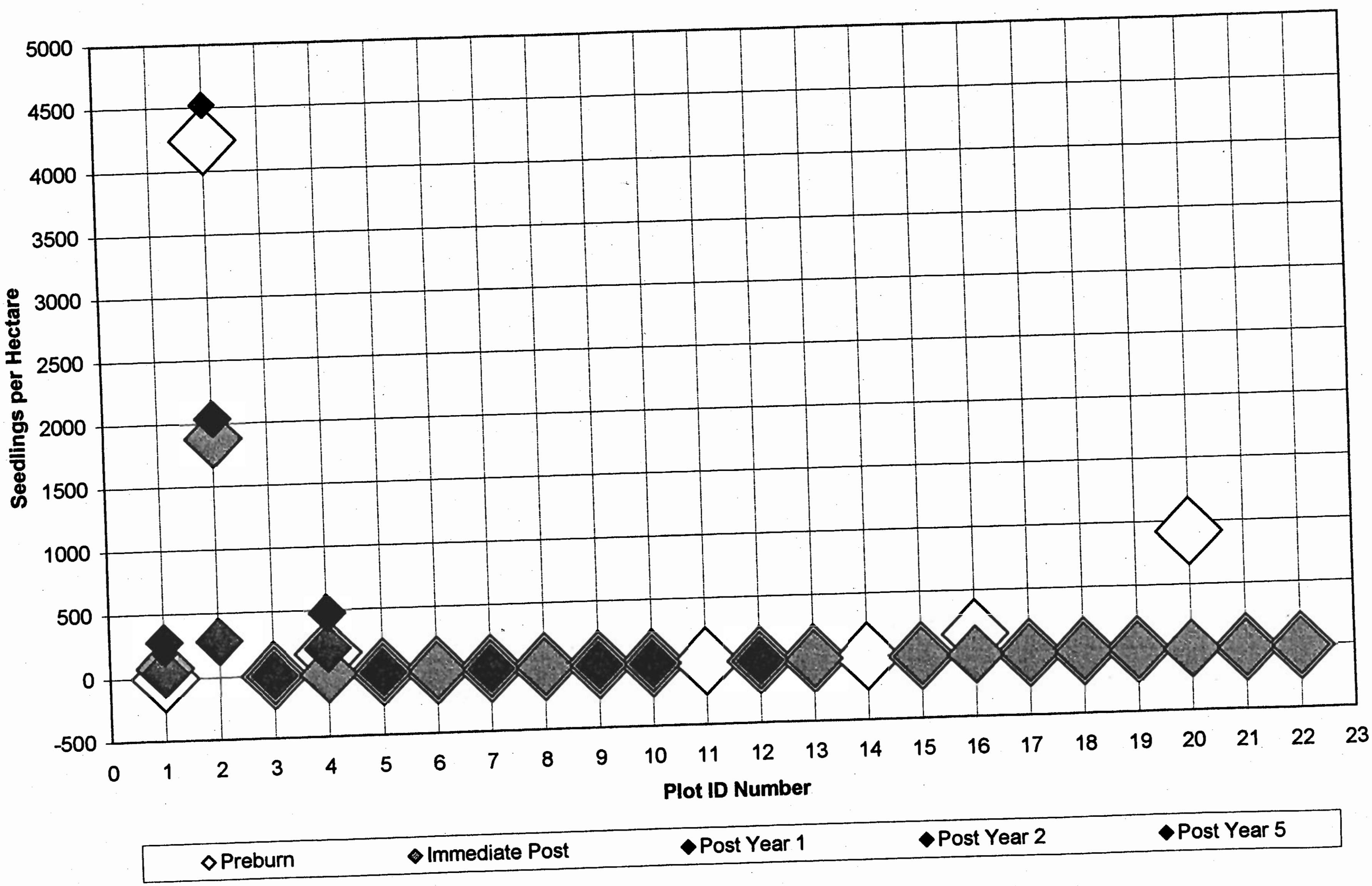


Figure 25. ***Populus tremuloides*** **Seedling Densities, by plot**
December 2001



PIAB RESULTS AND DISCUSSION

<u>OVERSTORY DENSITY</u>
Objective 1: Achieve and maintain an overstory *Pinus ponderosa* density (greater than or equal to 16" dbh) of 47-62 trees/hectare as stated in the Desired Future Condition, measured at 5 years post-burn. Note: *Pinus ponderosa* comprises less than 50% of overstory with remaining percentage occupied by mostly *Abies concolor* and *Populus tremuloides*.

Results: <u>Figure 26</u> shows *Pinus ponderosa* live overstory densities for all plots. Most plots show little change over time, with densities decreasing on plots 7, 8, and 10, and increasing on plots 12 and 18.

Was objective met? It is unknown whether or not this objective was met since there are not enough Year 5 data. However, the trend of existing data is favorable.

<u>OVERSTORY SCORCH</u>
Objective 2: Limit average crown scorch on overstory *Pinus ponderosa* (greater than or equal to 16" dbh) to 30%, measured immediately Post-burn.

Results: At this time we cannot complete analysis for this variable. The database program (fmh.exe) does not allow assessment for scorch on trees of our unique size class. They can be compiled by hand at a future date. <u>Figure 27</u> shows the data we *can* extract from the database—mean scorch per plot on all live ponderosas greater or equal to 6 inches (15 cm) dbh. This graph indicates only 1 plot had a mean scorch greater than 30% after a first-entry burn. Since this includes all trees from 6-16 inches (15-40 cm), it is likely that if they are taken out of the analysis, the mean scorch heights will be lower for trees greater than 16" (40 cm) dbh. <u>Figure 28</u> shows minimum, mean, and maximum scorch heights after the first- and second-entry burns.

Was objective met? Unknown, but likely met.

<u>FUEL LOADING</u>
Objective 3: Maintain an average total fuel load of 0.2 to 20 tons/acre, as defined in the Desired Future Condition, measured immediately Post-burn.

Results: <u>Figure 29</u> shows the range of pre-burn fuel loads that exist in this monitoring type. Most plots show a decrease in total fuel load. <u>Figure 30</u> shows total mean fuel load pre-burn and post-burn. Most of the change is in duff, litter, and large woody fuels. Minimum plot requirements are met for this variable; therefore, confidence intervals are shown on the graph.

Was objective met? Not yet, although error bars indicate we may be in the desired range and trends are favorable. It is generally understood that more than one treatment is necessary to decrease fuel loading to desirable levels without achieving high mortality of overstory ponderosas.

POLE DENSITY

Objective 4: Reduce *Abies concolor* poles with dbh of 1-6 inches (2.5-15 cm) to average 0-100 trees/acre (0-247 trees/ha), measured 2 years post-burn.

Results: Figure 31 illustrates the range of *Abies concolor* pole densities—approaching 1800 per hectare on one plot while zero on others. Figure 32 shows mean *Abies concolor* pole densities decreased from 309 to 166 trees/ha on 7 plots, but error bars are wide.

Was objective met? Unknown because minimum sample size is not achieved, but trends are favorable. Unlike the other main monitoring types, pole variability is less in PIAB. We have installed 24 plots and only 27 are required, so assessing this variable with confidence may be attainable in the future with more installs or as more plots burn.

SNAG DENSITY

Objective: Track snag densities over time.

Results: Figure 33 shows that small snag densities increase slightly more than decrease over time after fire. Large snag densities in Figure 34 do not fluctuate greatly, and decrease very slightly with time.

Was objective met? There is no objective for a certain number of snags at this time. Consultation with the Grand Canyon National Park wildlife biologist is needed to define an objective.

SEEDLING DENSITY

Objective: Track seedling densities over time.

Results: Figure 35 shows *Abies concolor* seedling densities across the monitoring network—trends by plot vary, with a general decrease post-burn. Figure 36 indicates there are few plots with any *Pinus ponderosa* seedlings at all, and there are both increases and decreases on those that have burned. Figure 37 shows *Populus tremuloides* seedlings also do not seem to have a definitive trend.

Was objective met? There is no objective for seedling densities at this time. This information is provided for general knowledge, so that other resource management staff at Grand Canyon are aware of the trends.

Figure 26. Live 16" DBH and larger *Pinus ponderosa* density, by plot
December 2001

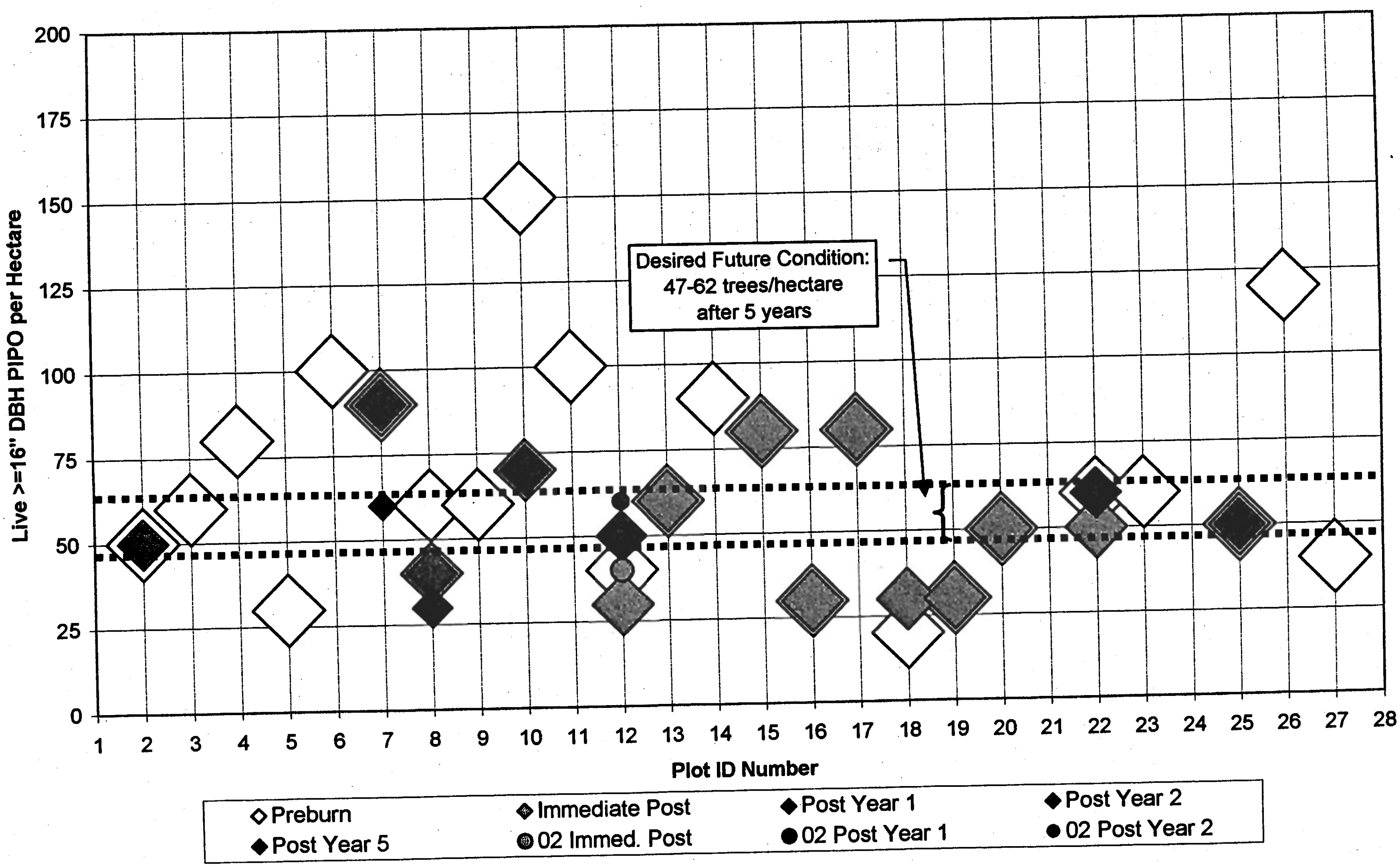


Figure 27. Post-burn Crown Scorch Percent on Live *Pinus Ponderosa* Overstory Trees, by plot
December 2001

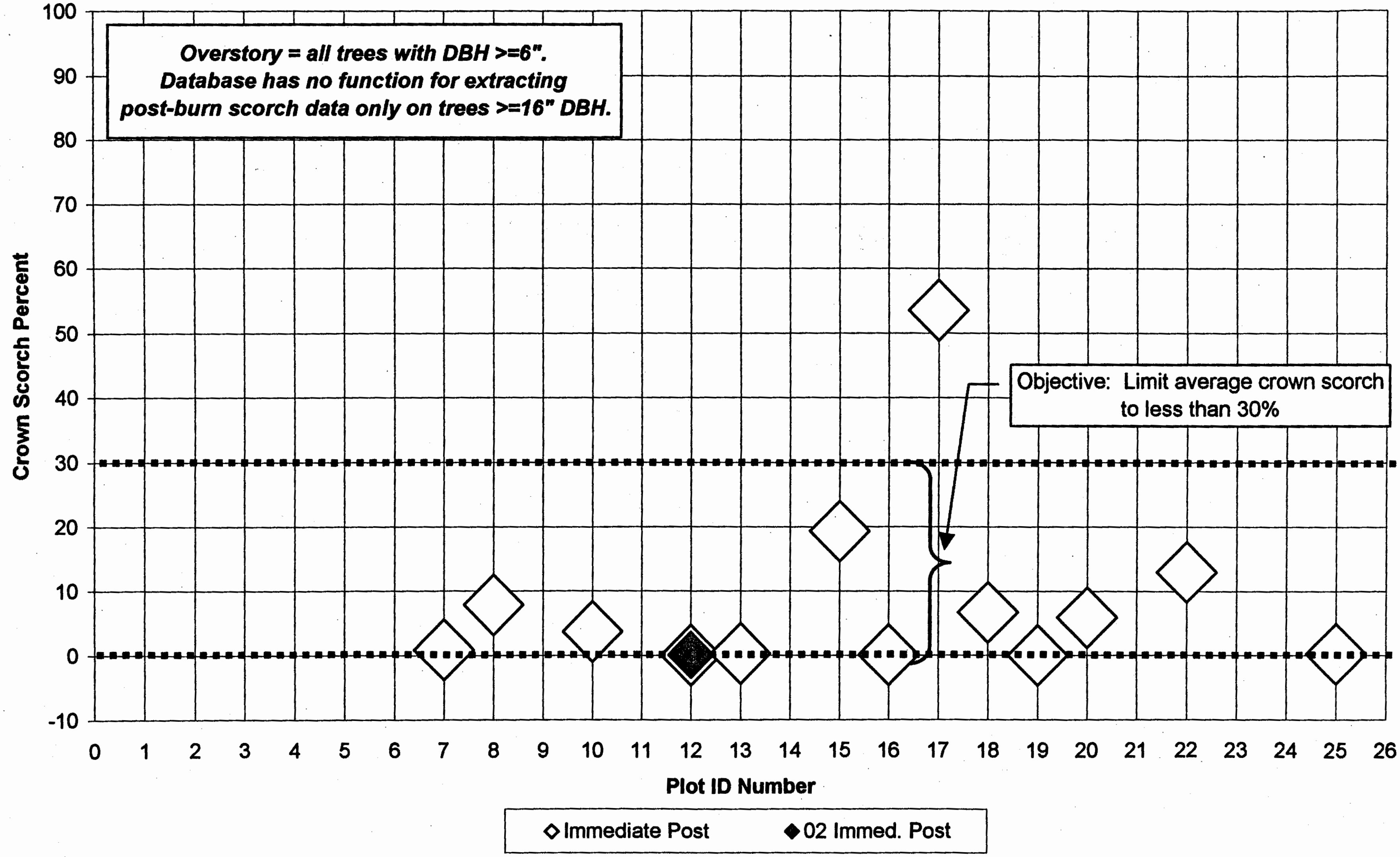


Figure 28. Post-burn Crown Scorch Percent on Live *Pinus ponderosa* Overstory Trees
December 2001

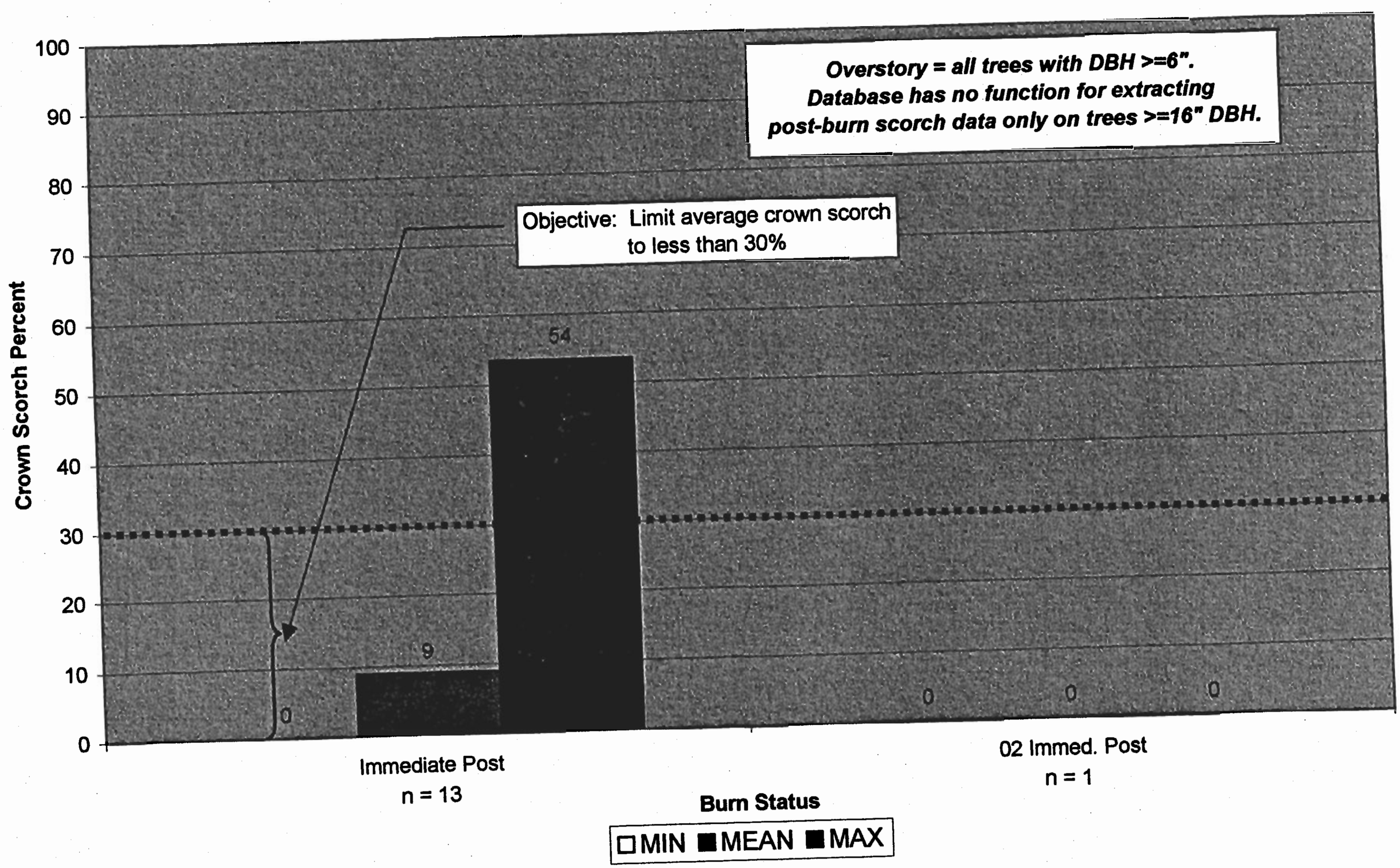
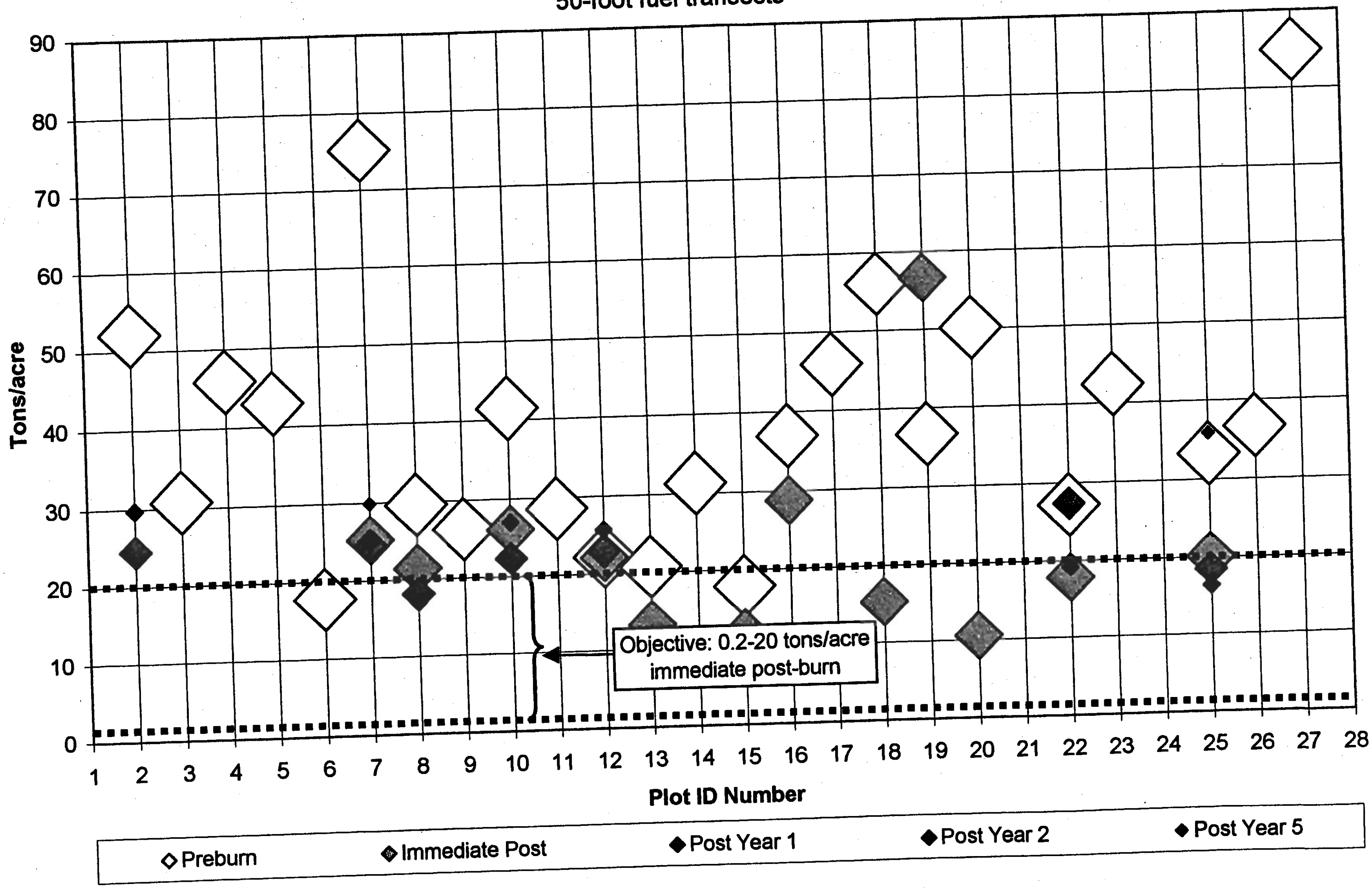


Figure 29. Total Fuel Load, by plot
December 2001
50-foot fuel transects



North Rim Ponderosa Pine with White Fir Encroachment (PIAB)

Figure 30. Total Mean Fuel Load
December 2001
50-foot fuels transects
n=13, *required minimum pre plots = 7*

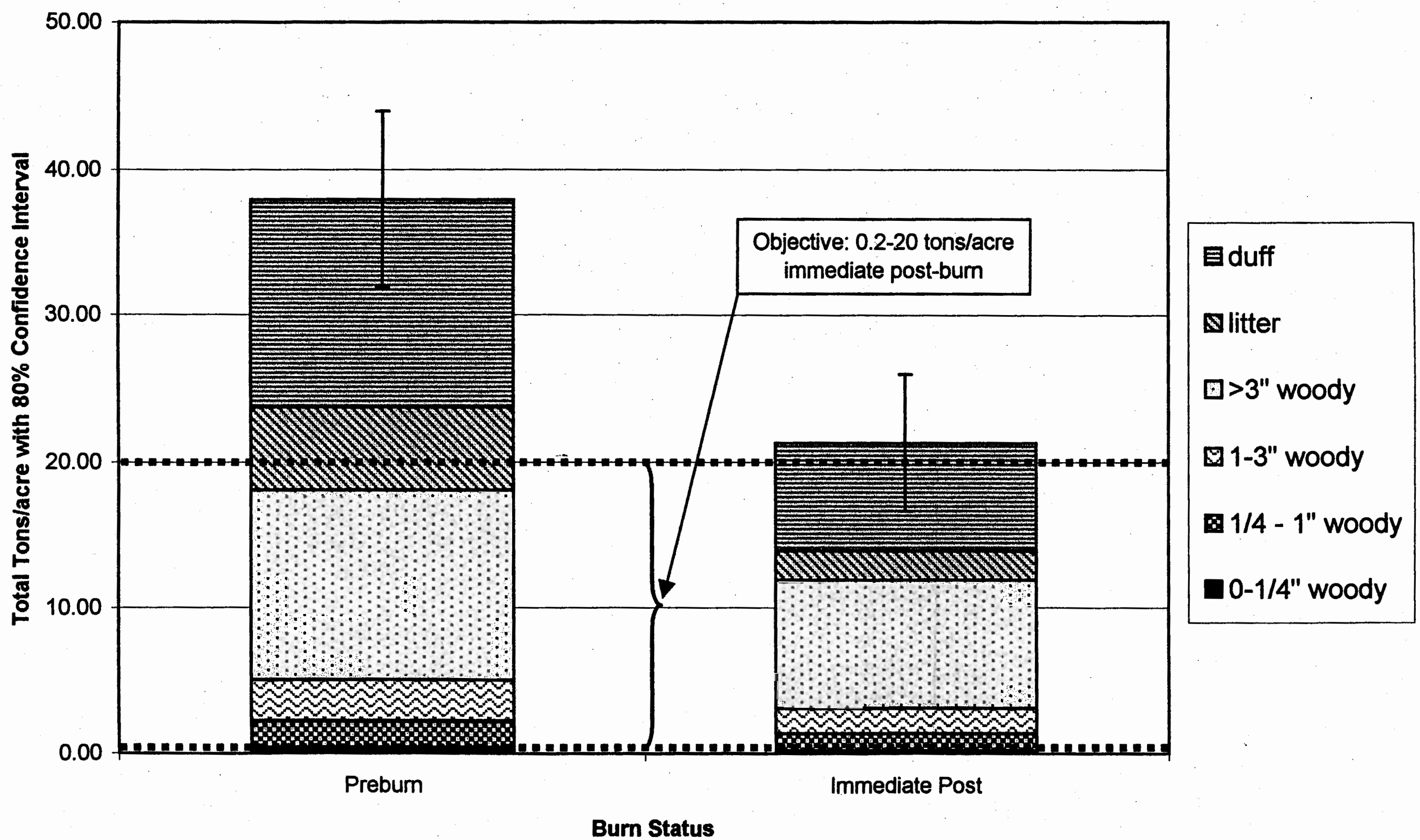


Figure 31. ***Abies concolor*** **Pole Densities, by plot**
December 2001

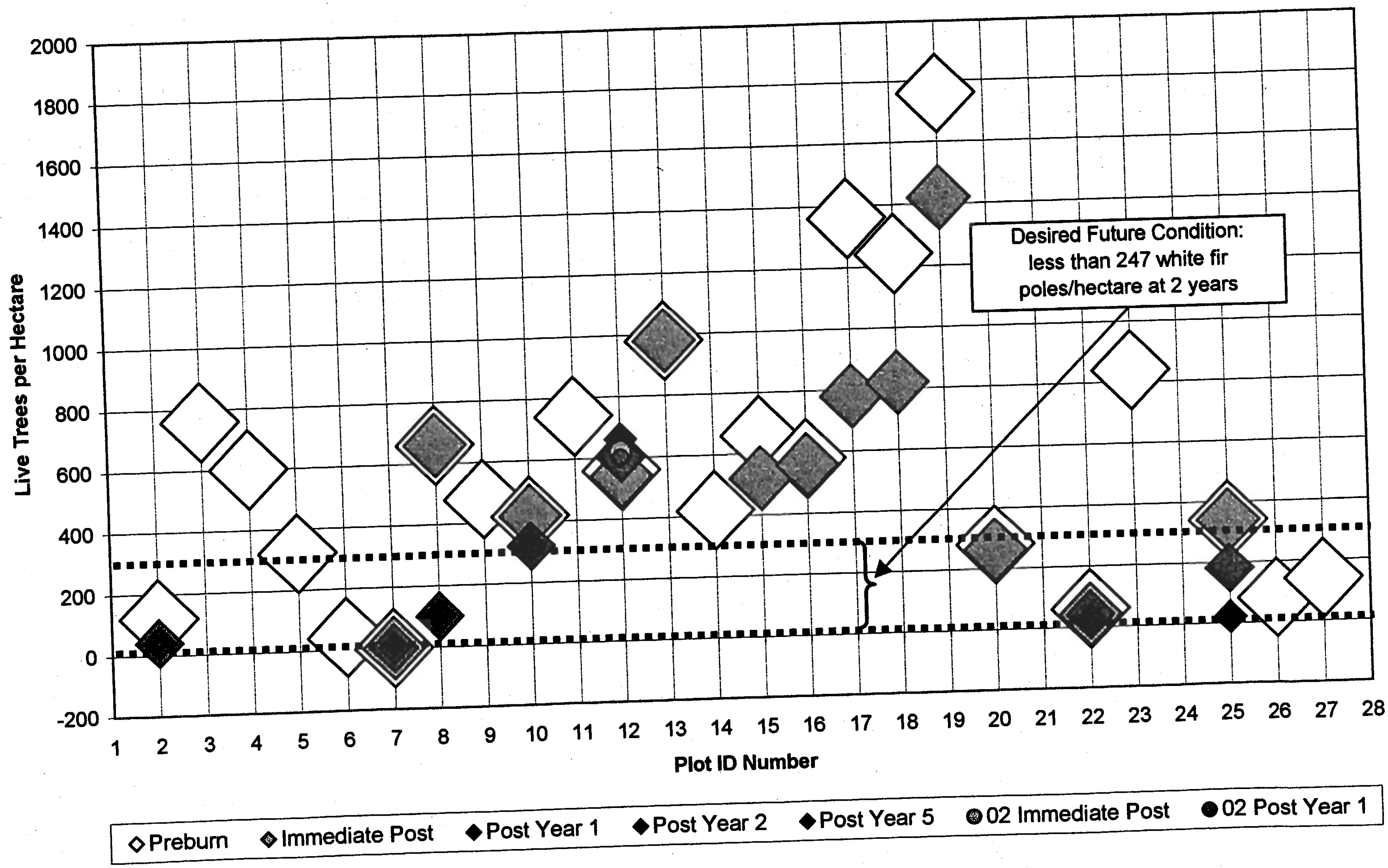


Figure 32. Mean *Abies concolor* Pole Density
December 2001
n = 7, *required minimum pre plots = 27*

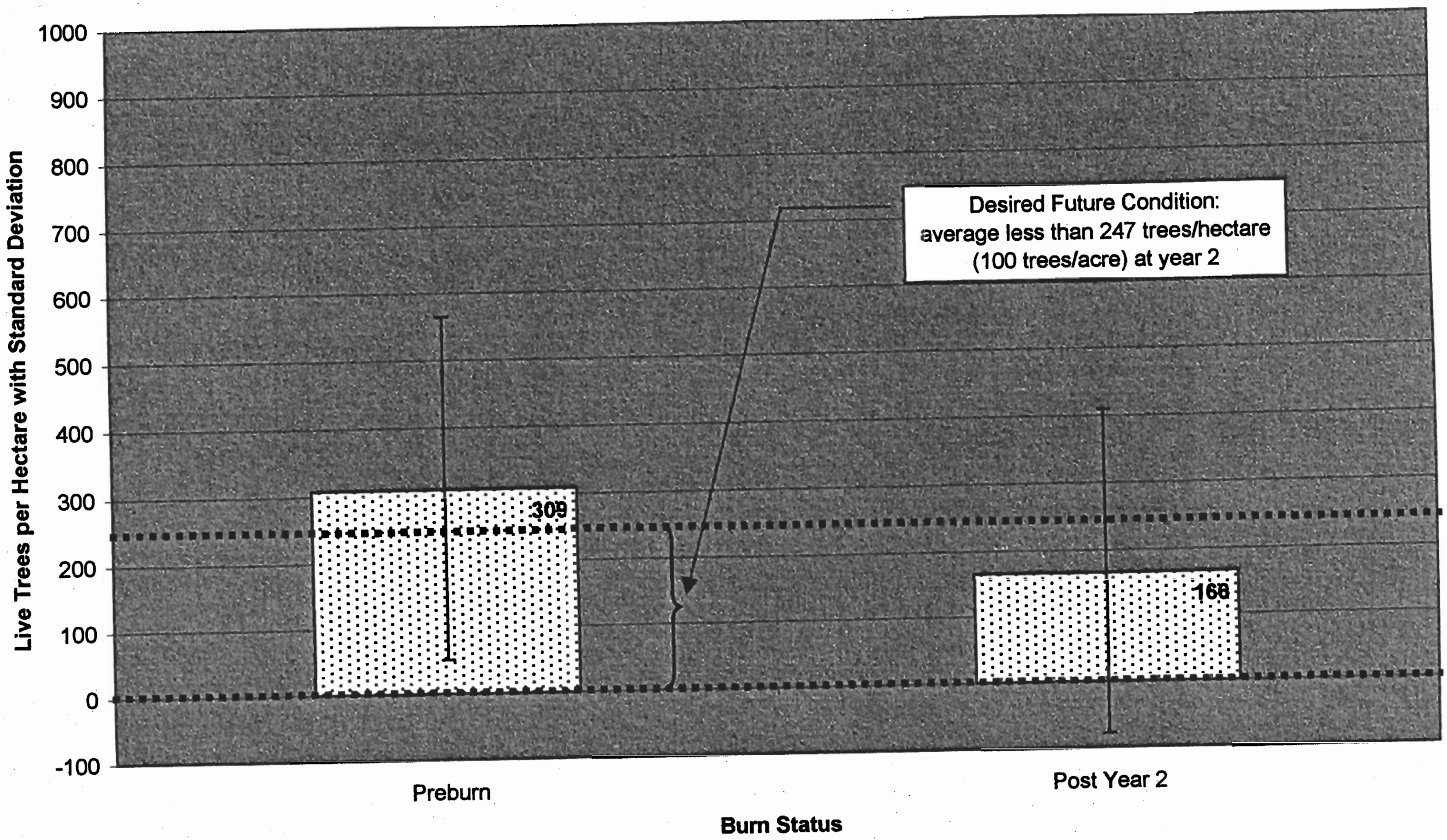


Figure 33. 6 - 15.9" DBH Snag Densities, by plot
December 2001

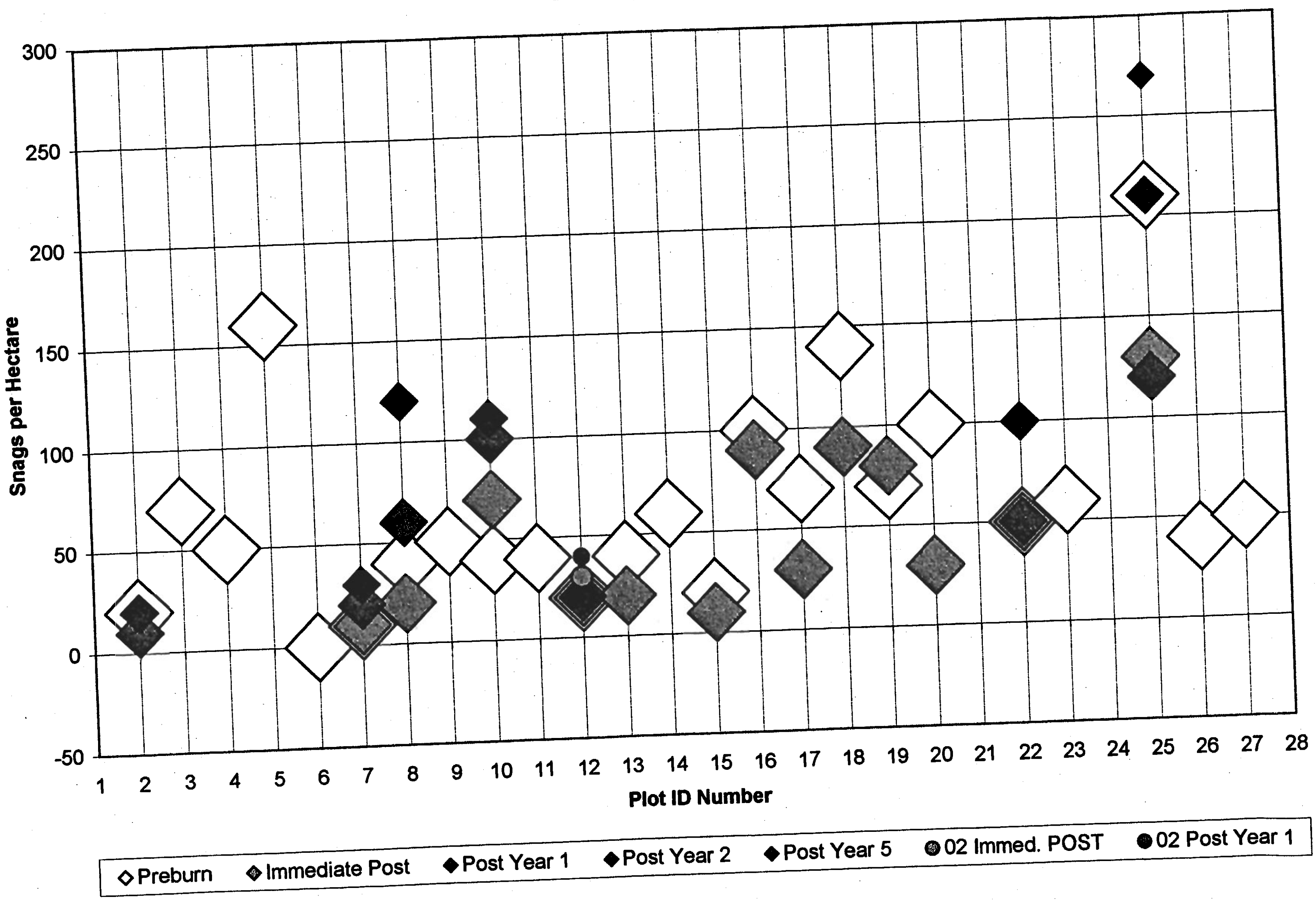


Figure 34. 16" DBH and larger Snag Densities, by plot
December 2001

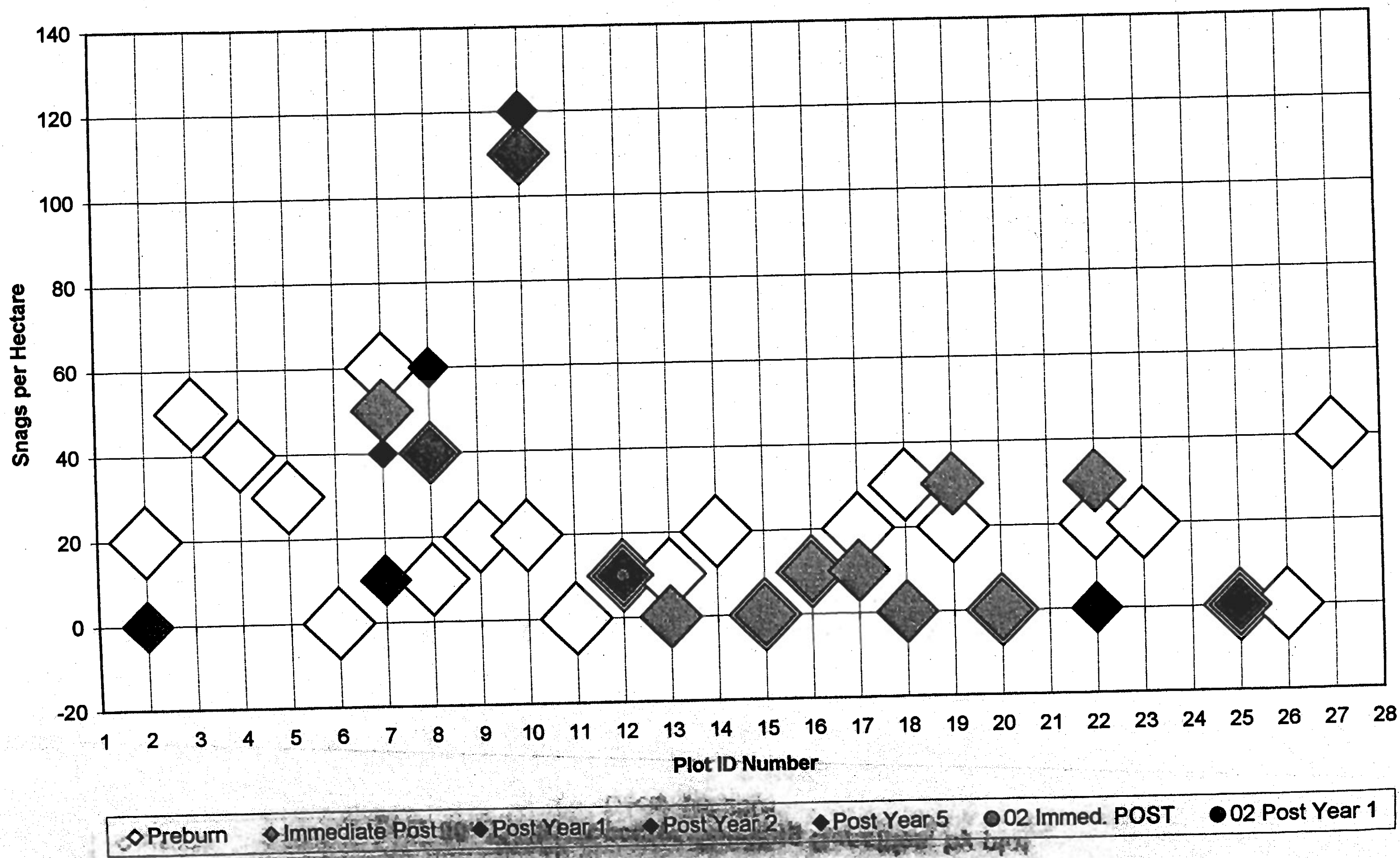


Figure 35. ***Abies concolor*** **Seedling Densities, by plot**
December 2001

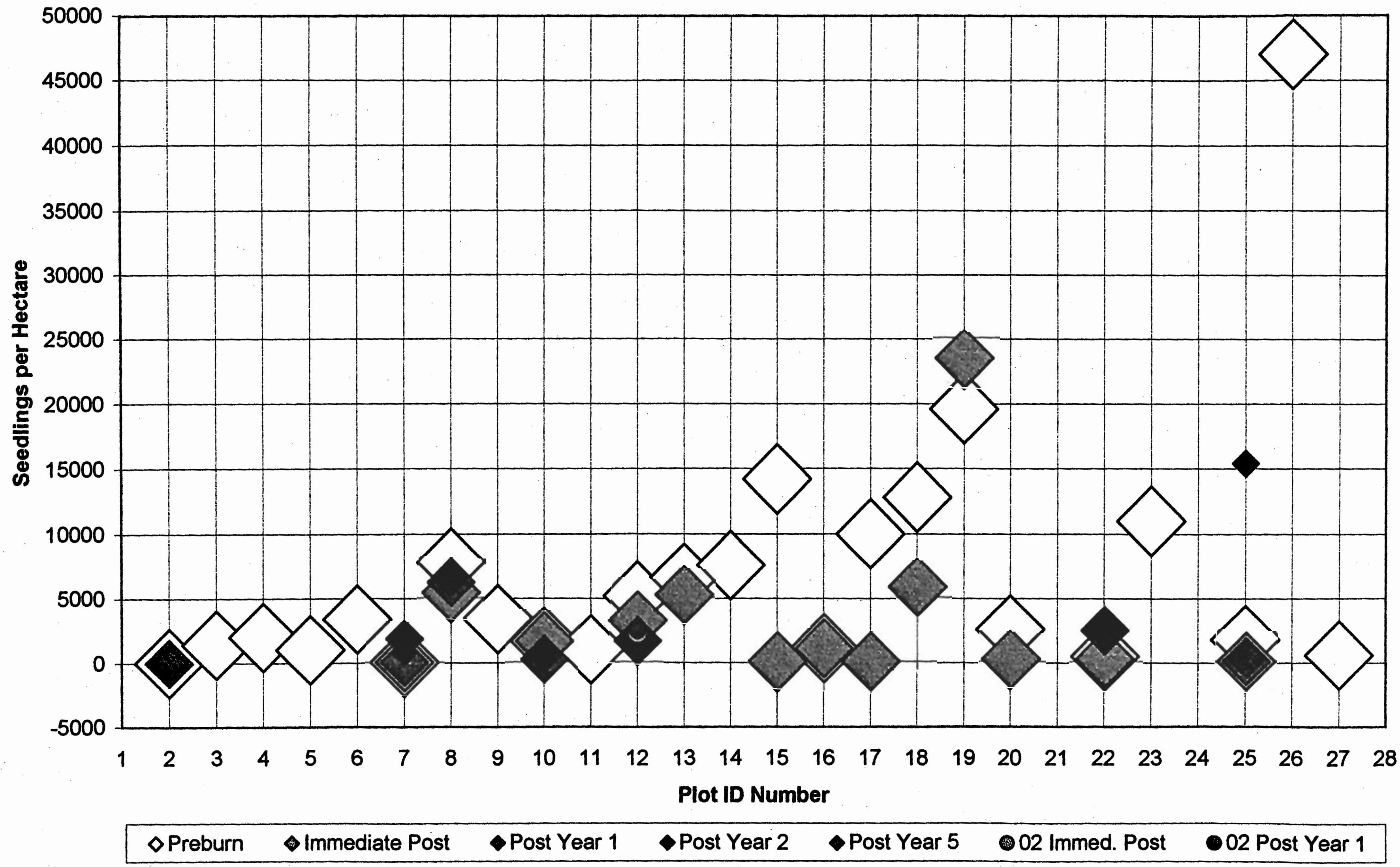


Figure 36. ***Pinus ponderosa*** **Seedling Densities, by plot**
December 2001

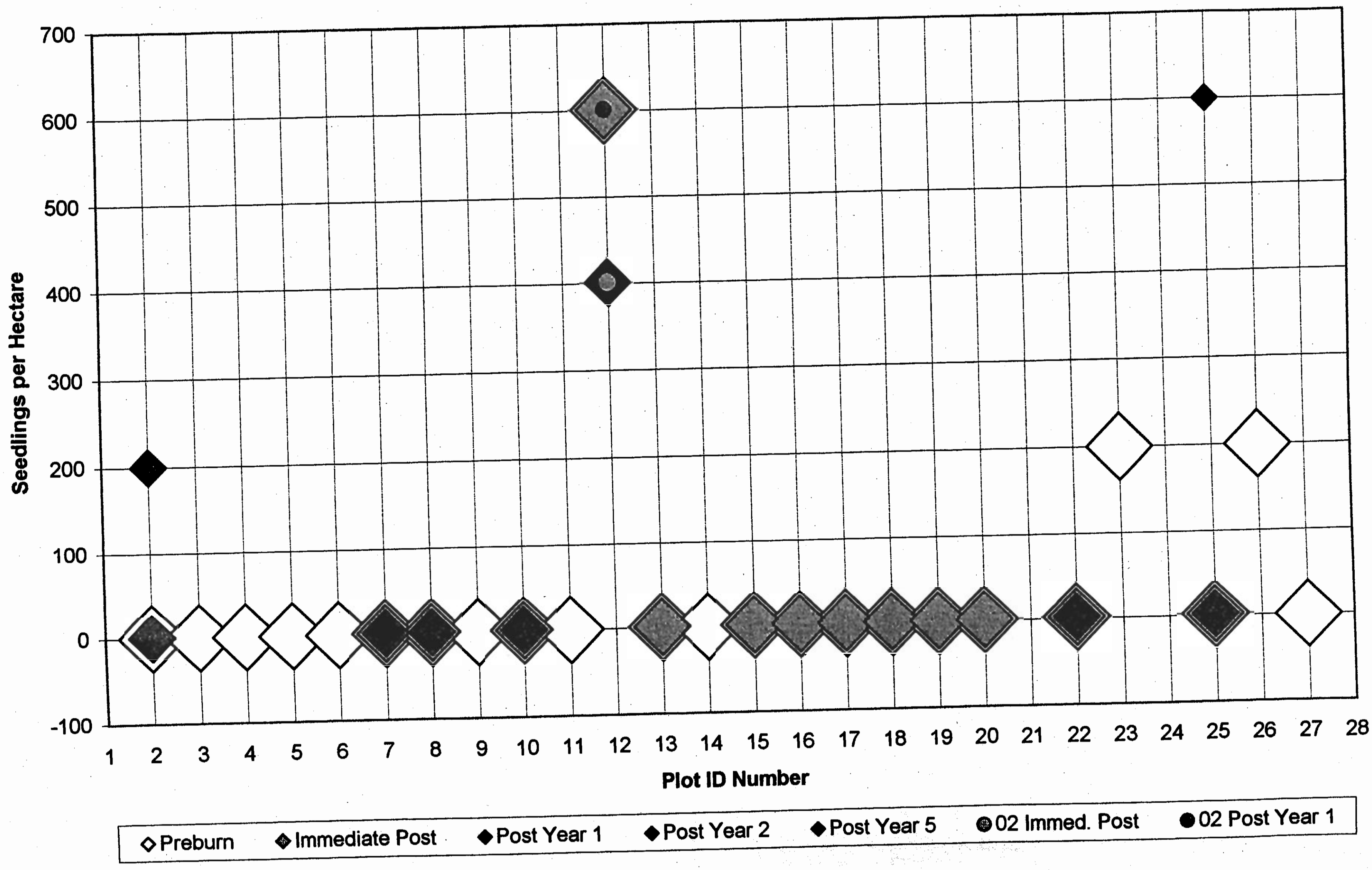
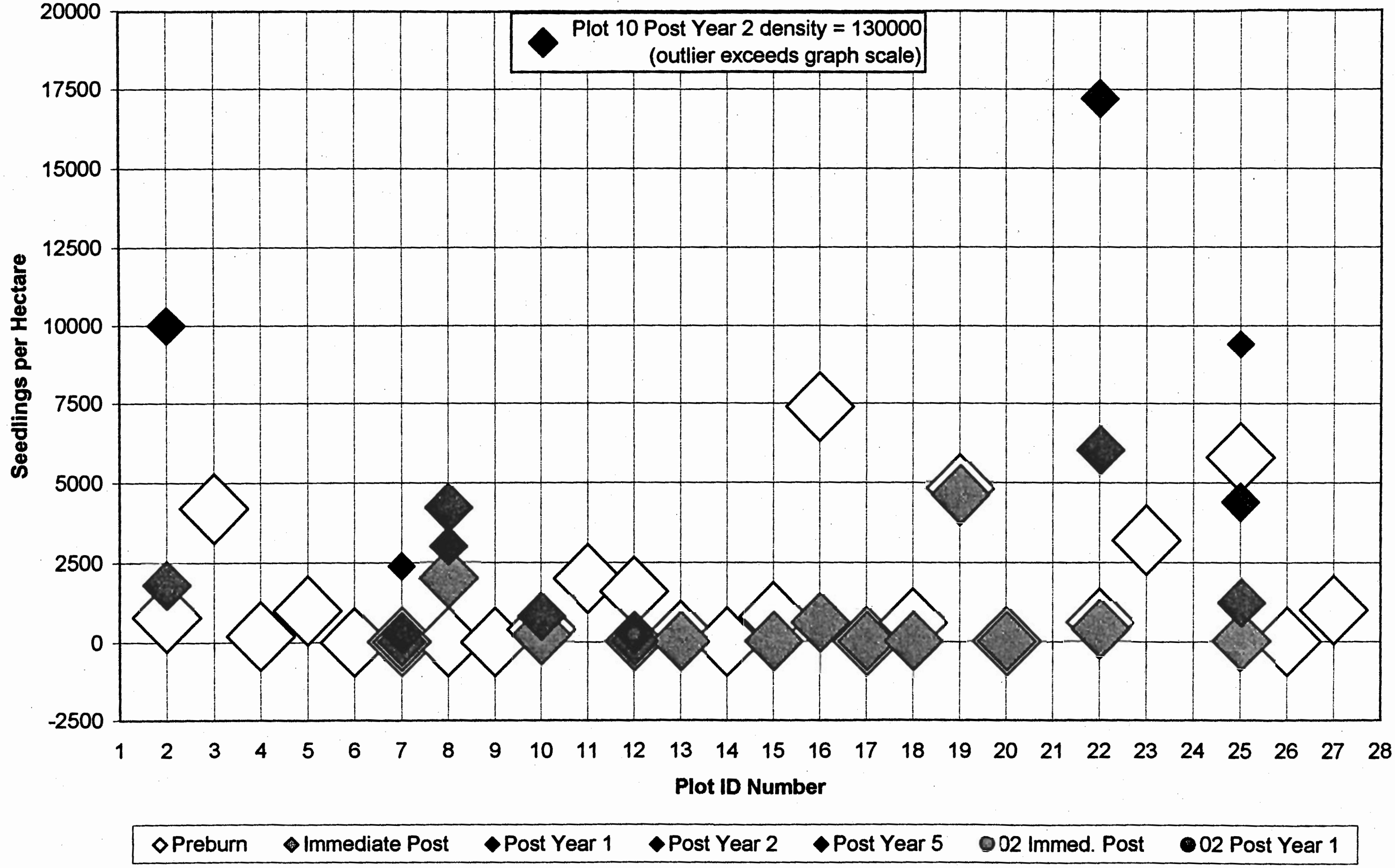


Figure 37. ***Populus tremuloides*** **Seedling Densities, by plot**
December 2001



SUMMARY OF RESULTS

Table 12 shows results for all variables that have specific monitoring objectives identified in FMH-4s. After over 13 years of fire monitoring, six variables can finally be assessed with our minimum level of statistical confidence, but only three objectives can accurately measured. This does not mean the plots have not been installed. In most cases, the minimum pre-burn number of plots is there, but the plots may not have burned, or they may have been burned only recently. Therefore, data to assess overstory at five years post-burn are not collected yet. Although we have only met one of our stated burn objectives (total fuel load for PIPO), we are headed in the right direction on fuel loading for both PIPN and PIAB. Another entry in the burn cycle will hopefully reduce fuels to desired levels. With several more years of Year 5 data, overstory densities may be available in the near future. Further installs in PIEN next year will show whether we're on target with that monitoring type. Monitoring pole densities with any confidence seems to be prohibitive for all types except PIAB, so trend analysis may be all we are ever able to show for that variable.

This table illustrates the problems that result from not installing plots on schedule, as well as turnover in management staff resulting in changing burn priorities. If more plots had been installed in past years, five-year data would be available today to assess overstory. Similarly, if we had burned the units on schedule based on the previous Long-Range Project Plan, we would have post-burn data on many more plots. Several plots installed this year and last do not now look like they will be burned within three years and will have to be re-read. The effects of delaying plot installs or burns are not immediately apparent. It may be years after the burn when the data suddenly become important to justify the prescribed fire program, only to find that they are not available for five more years. If prescribed burning becomes a controversial issue in the future, we do not have the local data to support this program. This is a serious issue that should be addressed by the GRCA Fire Management staff, the Science Center staff, and the Regional Fire Ecologist.

Table 12. Summary of Results for variables with specific objectives.

Monitoring Type	Variable	Minimum Samples Achieved? Y/N	Objective Achieved? Y/N/Unknown
PIPO	Overstory (PIPO)	Y	Unknown
	Fuel Load	Y	Y
	Poles (PIPO)	N	Unknown
PIPN	Overstory (PIPO)	Y	Unknown
	Fuel Load	Y	N
	Poles (PIPO)	N	Unknown
PIAB	Overstory (PIPO)	Y	Unknown
	Fuel Load	Y	N
	Poles (ABCO)	N	Unknown
PIEN	Overstory (mixed)	N	Unknown
	Fuel Load	N	Unknown