1997 Year-End Report

Fire Effects Monitoring Program

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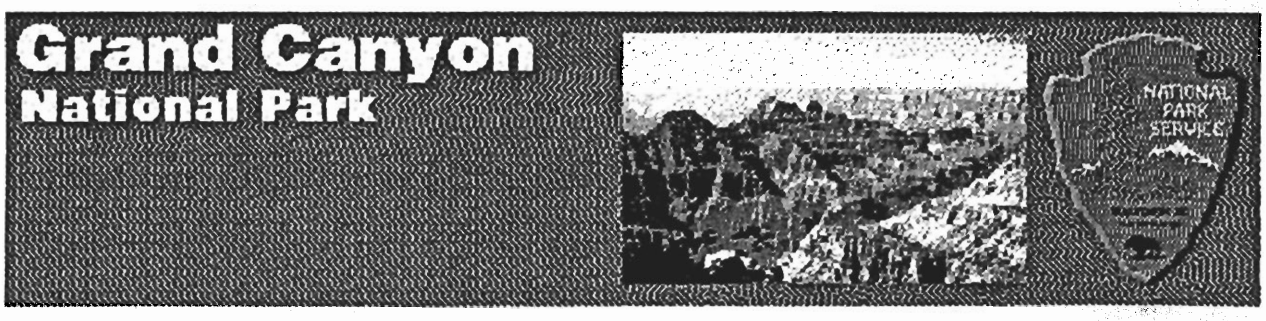

GRAND CANYON NATIONAL PARK
Fire Effects Monitoring Program
1997 Year-end Report

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Introduction

The purpose of this report is to provide details about the Fire Effects Program at Grand Canyon National Park by documenting program accomplishments and changes. This information allows others to evaluate the program, and gives the new field crew a starting point for the next field season. For the first time in many years the program is undergoing extensive revisions, including increased emphasis on crew training, new protocols for field procedures and for filing data, revised monitoring type descriptions, and the development of new monitoring types. In addition, professional resource managers at the Grand Canyon Science Center are part of the revision process.

In 1997 Grand Canyon consisted of a fire effects staff of three biological technicians and made 37 plot visits. The crew also helped prepare burn units, monitored fuel moistures, monitored air quality, served as prescribed fire monitors, and served on several wildfire assignments. Opportunities were taken to participate in formal and informal training.

Monitoring Type Descriptions

There are four monitoring types at Grand Canyon—two on the North Rim and two on the South Rim. All are forest types and there are no control plots:

PIPO1—South Rim Ponderosa Pine Forest
PIED1—South Rim Great Basin Conifer Woodland
PIPN1—North Rim Ponderosa Pine Forest
PIEN1—North Rim Rocky Mountain Subalpine Conifer

An additional 15 plots were established on the North Rim during a fire history study completed by Northern Arizona University. Five plots in each of three ecotones were established according to FMH protocols, with the notion to incorporate these plots into the FMH program. There were no monitoring type description sheets written for these plots, but they were divided into Lower, Middle, and Upper ecotones by the researchers. These plots have not been included in the current monitoring program yet, but a preliminary analysis suggests most can be incorporated into a restructured North Rim monitoring scheme. All of these plots have been monitored as they are burned, but some plots may be eventually discontinued. They are located on the Walhalla Plateau and near The Basin, labeled as follows:

PIPN2, Plots 1-5 for Lower Ecotone plots (Walhalla Plateau)
PIPN3, Plots 1-5 for Middle Ecotone plots (Walhalla Plateau)
PIPN4, Plots 1-5 for Upper Ecotone plots (The Basin)

Plot Network Information

Grand Canyon's Fire Effects Program is undergoing a major overhaul during 1997 and 1998, therefore plot network information may change considerably before the 1998 field season. For example, some plots still included in the network that are not scheduled to burn in the next five years should be re-installed in burn units which are scheduled, and plots with over half of the postburn data missing should be re-installed. Also, the North Rim plots will be restructured to include the NAU plots. Information provided in the following series of tables reflects the current plot network and will be updated promptly as the network changes.

Of the 74 plots installed at Grand Canyon, 59 are in the original four monitoring types, while fifteen are in temporarily named PIPNx types until they can be incorporated into new or existing types. There were 37 plots visited this year, including 12 immediate post burn reads. Plot visits are expected to increase by 32% next year to monitor previously installed plots. The need for additional plot installations will not be known until the plots are restructured to reflects changes in burning priorities.

Most FMH plots on the South Rim have burned. One plot in the PIPO1 type was burned but all post burn files except year five are missing, and a plot in PIED1 was not burned with the other plots in the burn unit due to fire behavior and/or ignition techniques. Only minimal plot installations are necessary in the South Rim types to provide a planned safety margin. The North Rim, however, has few burned plots. There will be a need to install a significant number of additional plots on the North Rim if burning emphasis returns to the north boundary where the PIEN1 monitoring type is located. There are three plots installed in this type, but because these units are not scheduled to burn there will be no further installations in this type at this time.

TABLE 1. Plot installation by monitoring type and year.

	PIPO1	PIED1	PIEN1	PIPN1	PIPN2	PIPN3	PIPN4	TOTAL
1989		1						1
1990	1							1
1991	1	5						6
1992	8	2		3				13
1993	4	5	1	16				26
1994	1	2	2					5
1995								0
1996	2				5	5	5	17
1997	5							5
TOTAL	22	15	3	19	5	5	5	74

TABLE 2. Minimum plot re-reads by monitoring type for 1997 and projections through 2003 for established plots only. Additional plots may be established in new monitoring types which will increase installations, pre-reads and immediate postburn reads in the future.

Reread Year	PIPO1	PIED1	PIEN1	PIPN1	PIPN2	PIPN3	PIPN4	Total
1997	7 (6P)	5	0	8(3 P)	0	0	0(3P)	15(12P)
1998	12 (1P)	7 (1P)	0	5 (2P)	0 (4P)	0 (5P)	3	27(13P)
1999	10	3	0	5	4 (1P)	5	3	31 (1P)
2000	2	1	0	2	1	0	2	20 (4P)
2001	0	0	0	2	1	0	2	5
2002	11	5	0	9	0	0	5	30
2003	4	7	0	2	4	5	0	22

(xP) = Number of Immediate Postburn Rereads in addition to other postburn visits.

TABLE 3. Projected plot installation and resulting 1998 totals. Projected plot totals reflect the number of *plots available for analysis* in each monitoring type and *do not include previously installed plots that cannot be used* either because they are not scheduled or because too much information is missing from the file. Some monitoring types are still undergoing changes, therefore additional plot calculations are not yet available.

	PIPO1	PIED1	PIEN1	NewPIPN1	NewPIPN2	New P-J*	Total
1998 Installations	2	2	0	5?	5?	10?	24?
Projected Totals	22	15	3	22	15	10	87

*It has not been decided whether this plot will be installed in 1998 or later.

TABLE 4. Number of plots that have burned.

	PIPO1	PIED1	PIEN1	PIPN1	PIPN2	PIPN3	PIPN4	Total
Plots burned in 1997	6	0	0	3	0	0	3	12
Plots burned to date	19	13	0	9	0	0	3	44

TABLE 5. 1997 postburn plot summary.

	PIPO1	PIED1	PIEN1	PIPN1	PIPN2	PIPN3	PIPN4	**Total**
Immediate Post	6	0	0	3	0	0	3	12
YR01	1	0	0	0	0	0	0	1
YR02	1	0	0	1	0	0	0	2
YR05	5	5	0	2	0	0	0	12
TOTAL	13	5	0	6	0	0	3	27*

*Additional plot visits were made to re-read preburn information for plots scheduled to burn within two years, for a total of 37 plot visits.

TABLE 6. Results of minimum plot calculations by monitoring type and monitoring type variable. The goal for minimum plots in each monitoring type is calculated using the value in bold type and adding three more plots for insurance.

	Primary Monitoring Variable		Secondary Monitoring Variable	
	80% R=20	80% R=25	80% R=20	80% R=25
FPIED1D02 (n=15)	**10**	6	12	8
FPIPO1D09 (n=21)	**19**	12	16	10
FPIEN1D10 (n=3)	*	*	*	*
FPIPN1D09 (n=19)	**22**	14	19	12
FPIPN2D09 (n=5)	*	*	*	*
FPIPN3D09 (n=5)	*	*	*	*
FPIPN4D09 (n=5)	*	*	*	*

*Not enough installed plots to calculate this value.

TABLE 7. Plots classified by burn unit and monitoring type.

Burn Unit	PIPO1	PIED1	PIEN1	PIPN1	PIPN2	PIPN3	PIPN4	TOTAL
Entrance	1, 7	1, 3, 4, 5, 12						7
Picnic	4,5,11,12	2, 7						6
Topeka	3	6, 8						3
Quarry	6, 10	9, 10, 11						5
Atchison I	9	13, 14, 15						4
Atchison II	13, 14							2
Santa Fe	2							1
Village	8							1
Hance	15							1
Watson IV	17, 20, 21, 22, 23, 24							6
Lonetree	19							1
Nankoweap			1					1
South Bear			2, 4					2
NW I				1, 2				2
NW III				9, 12				2
NW V				11, 14, 19				3
Tiyo I				3, 7, 8, 18			2, 4, 5	7
Tiyo II				13, 16			1, 3	4
Widforss				4, 17				2
Vista I & II					2			1
Vista IV				5, 6, 10, 15				4
Walhalla					1, 3, 4, 5	1, 2, 3, 4, 5		9
Total	22	15	3	19	5	5	5	74

Data Analysis

Initial Data Interpretation and Actions Taken

Grand Canyon's first priority is to correct database errors that have accumulated over the past six years. First, however, hard copies of data files must be complete and well-organized. The fire effects staff generated a list of problems identified up to this point, including possible solutions (Appendix A). Corrections to the database are critical before any worthwhile analyses can be completed. As portions of the database are corrected, analyses will determine whether prescribed burns meet objectives.

An important question for the fire effects staff is to understand how Grand Canyon's prescribed fire activities may be affecting overstory tree densities. Contemporary fire researchers studying ponderosa pine and fire believe that prescribed burns are responsible for killing an unacceptable number of overstory ponderosa trees. The overstory data for the PIPN1 and PIPO1 monitoring types were checked for errors in October and November 1997 and then analyzed. The full report appears in Appendix B. Essentially, there are not enough postburn data in the ponderosa pine types to make definitive conclusions, but the trends so far do not indicate that prescribed fires are significantly affecting live overstory densities. The action to be taken at this time is to continue installing, monitoring, and burning plots in these monitoring types so that this information is more conclusive in five years or less. The overstory analysis is being shared with the Grand Canyon Science Center professional resources staff.

Additional Analyses Needed

As sections of the database are corrected (target completion date is October 1, 1998), analyses will continue. Priorities in PIPN1 and PIPO1 are overstory density, followed by fuel reduction and pole mortality. For PIED1 the emphasis is on total fuel reduction. PIEN1 is being discontinued as a monitoring type until burning in this forest type is again a priority. Futiure North Rim monitoring types with ponderosa pine as a major overstory species will concentrate on overstory density, and an additional monitoring type in pinyon-juniper on the South Rim will focus on the same variable.

As the data are analyzed, trends will be shared with the Grand Canyon Science Center staff and others. Research proposals will be written for trends requiring further study.

Program Information

Staff Participants

During the 1997 field season there was one lead GS-7 fire effects biological technician, one seasonal GS-5 biological technician, and one volunteer dedicated to the Fire Effects Program. Fortunately, seasonals from the Branch and volunteers were available to help with plot visits.

TABLE 8. Number of pay periods in field season devoted to fire effects.

Monitor	Starting Date	Ending Date	Pay Periods devoted to Fire Effects	**Total # of Pay Periods**
Tonja Opperman	6/1/97	12/1/97	11	13
Andy Thorstenson	5/12/97	11/7/97	11	13
Chris Moore	5/26/97	9/26/97	8	9

Changes in Protocol

A number of changes have taken place in the way FMH plots are monitored. Most changes are not specifically related to the type of data collected, but are meant to ensure that data are collected consistently over time and are stored and backed-up properly. The following list includes changes that have taken place during the 1997 monitoring season as well as those changes that are being finalized before the 1998 season.

1. Seedling maps are no longer created for each plot visit because the information is not essential to monitoring goals.
2. To increase monitoring consistency from visit to visit, protocols for Photography were written and will be taught to crew members at the beginning of the 1998 field season in a FMH Shortcourse tailored to GRCA monitors (see Appendix C).
3. There has been a problem with plant identification procedures, including failure to take a proper plant press into the field for gathering specimens, and in having those specimens properly identified and catalogued. A consistent procedure will be in place for 1998 in which crew members collecting specimens will be held accountable for obtaining a proper identification of the plant in conjunction with the park botanist, and will submit samples to the park's herbarium for inclusion in the plant collection.
4. On 100-foot transects in the PIED1 and PIPO1 monitoring types, duff and litter will be taken every 10 feet rather than every 5 feet to spread data points across the entire fuel sampling plane.

5. Data sheets are undergoing revisions to be specific to Grand Canyon's protocols and minimize inconsistencies with data collection techniques and information records.
6. A new system will soon be in place for keeping all hard copies of plot data. Each plot will have a three-ring binder with tabs for each plot visit clearly marked.
7. Currently there is no backup for slides that have been taken since 1989. Beginning with the 1997 season, photographs, slides, and photos on disk were acquired for each plot. Photos for each visit will be included in the 3-ring binders with the data sheets from that visit; slides will be kept in a fire-proof safe as a backup; and computer disks will be kept in yet another building. When funds are available, all past slides will be converted into photos for inclusion in the 3-ring binders. This allows crewmembers and others to easily look at photo documentation and will allow photos to be available for field reference.
8. More photos need to be taken of reference stakes to aid future crews in locating plots. This will become a standard procedure in 1998 for all new plot installations and will be done during visits to existing plots.
9. Good maps of all plot locations have not been made. All existing and future plots will be marked on a quadrangle and these maps will be stored in the map case in the fire effects office. A large wall map will also be made to show all FMH plots and burn units.
10. A range pole in the center of each photo will become standard procedure to provide a focus point and a scale in photos. A reasonably priced collapsible/telescoping pole is needed.

Considerations for Additional Protocol Changes

Other items have been brought to the attention of the fire effects staff which may also necessitate changes in protocol, but they have not been explored sufficiently at this time to warrant a change.

1. The Grand Canyon botanist has expressed a concern that FMH plots do not capture the herbaceous variability. However, the focus of the monitoring program is not on herbaceous plants, and she does not believe fire activities are impacting any sensitive herbaceous populations. More discussion between the botanist, and the prescribed fire staff is necessary before a decision can be made. Alternative methods will be evaluated if necessary.

2. Depending on cost, the fire effects office may have a custom write-on/wipe-off board to help keep track of plot schedules throughout the season. Figure 1 is a draft of how this board will be organized.
3. There is some doubt as to why Grand Canyon collects 50-meter herbaceous transect information during immediate postburn plot visits. It is unclear at this time why this is standard procedure and will be reevaluated before 1998 through consultation with the prescribed fire staff, the park botanist, the Intermountain Region Fire Effects Specialist, and the Fire Monitoring Program Specialist.

Changes in Protocol following a Program Review

Although the Grand Canyon program has been reviewed in the past, there is no information on the recommendations from that review or if they were instituted. Obviously, another program review is required. Another program review is welcomed late in the 1998 field season. This would give the fire effects crew time to institute long-needed, necessary changes and organize all monitoring information in the new office.

Equipment Information

All fire monitoring equipment is currently stored in two cabinets located at Fire Support. One cabinet is in the fire effects office for smaller, more delicate, or more expensive equipment such as compasses, clinometers, extra measuring tapes, tatums, tree tags, flagging, the GPS unit, the camera, and plant pressing materials. Another larger cabinet is in the Saw Cache where the full field backpack is stored. Rebar is located just outside of the Saw Cache on the ground. Film is stored in the refrigerator at Fire Support. All blank forms, past data sheets, and photos are stored in a single file cabinet in the fire effects office. A backup copy of data sheets that cannot be entered in the computer (e.g. tree maps) are stored in the Prescribed Fire Manager's office with a current backup copy of the FMH database. However, the fire effects office is supposed to move before the 1998 field season begins. With the additional space in the new office, all equipment

Figure 1. Draft for custom organizational fire effects board.

Plot ID	Type of Visit	Burn Unit	Date Read	Copy Made	Entry Complete	Film Sent	Photos Catalogued			Database Back-up	Burned
							slides	prints	photos		

before the 1998 field season begins. With the additional space in the new office, all equipment cabinets and file cabinets will likely be in one place and there will be new locations for data back-ups. A complete list of equipment vendors and contact information is provided in Appendix D.

Status Of Five-Year Burn Plan

The Grand Canyon's five year burn plan has not changed since it was reported in July 1997 (Table 9). During the 1997 season, the Watson IV burn was completed along with portions of

TABLE 9. Five year burn plan as of Summer 1997

Fiscal Year	Project	Acres	Season
1997	Village Fuel Break	80	Winter
	Hospital	80	Fall
	Watson IV	535	Fall
	Lonetree	800	Summer
	Widforss	1035	Fall
1998	N. Rim Mechanical	120	Fall
	Tiyo I	800	Fall
	Walhalla	1500	Spring
	Vista III	435	Summer
	Topeka	824	Spring
	Santa Fe	275	Spring
	Atchison I & II	840	Spring
1999	N. Rim Mechanical	200	98-99
	Vista I & II	435	Fall
	Walhalla	1500+	Spring
	Kibbey	355	Summer
	Pasture	4200	Spring
	Tusayan	800	Spring
	Watson I	635	Spring
	Entrance	---	---
	Quarry	840	Spring
2000	N. Rim Developed Area	100	99-2000
	Tiyo II	610	Fall
	NW I, II, III	2000	Fall
	Tiyo I	800	Fall/Sum
	Widforss	1035	Fall/Sum
	CC Hill	80	Summer
	Shoshone	1110	Spring

	Grandview	570	Spring
	S. Rim Mechanical	200	Fall
2001	NW IV	300	Fall
	Outlet/Dragon	7435	Fall
	Kibbey	355	Summer
	Vista I, II, III	871	Summer
	Watson III	635	Spring
	Picnic	200	Spring
	Horsethief	4960	Spring
	S. Rim Mechanical	200	2000-01

Tiyo I and Widforss. Due to changes in priority for prescribed burning on the North Rim, some plots are no longer in burn units scheduled for the next five years. Three of three plots are no longer scheduled in the PIEN1 type, and seven of nineteen are no longer scheduled in the PIPN1 type. Taking these changes into account, the FMH monitoring network is being redesigned to have all installed and additional plots burned by 2000. Plots installed in future monitoring types (possibly a new pinyon-juniper type) may have a later burn deadline.

Until the PIEN1 Monitoring Type again becomes a priority for burning on the North Rim, there will be no further plots installed in this type. Plots which are already established will not be removed, but will not be visited until they are scheduled for burning. Plot files for the PIEN1 plots will be kept indefinitely to ensure these plots are available to future monitors.

Monitoring Type Information

The previous monitoring type descriptions were re-written this year to help alleviate some confusion about what is an acceptable plot and what is not. Such confusion in the past has resulted in plot installations which probably should have been rejected. Including these plots in the monitoring type serves to increase the variation and requires even more plots to capture that variation. The new monitoring type descriptions are included in Appendix E.

North Rim Types

Changes will result in the North Rim monitoring types as plots are restructured to reflect plots and the fact that 7 of these plots are located in units not scheduled to burn in the next 5 years, this monitoring type will be restructured based on overstory species composition and geography. An attempt will be made to include as many plots as is reasonable from a pooling of the current PIPN1 plots and the NAU plots to create two new types—a Ponderosa/White Fir Association, and a Ponderosa/Mixed Conifer Association. There are a total of 34 PIPNx plots installed on the North Rim but only 27 are scheduled to be burned in the next 5 years. Of these 27, they can be divided into two new associations with 17 plots in the Ponderosa/White Fir Association and 10 plots in the Ponderosa/Mixed Conifer Association. At this time, analysis of these new plot groupings is not complete enough to determine minimum plot calculations, but will be completed before the 1998 field season.

South Rim Types

In time, Grand Canyon will likely establish an additional pinyon-juniper monitoring type on the South Rim. Although there is already a pinyon-juniper type established, the primary goal in this type is a reduction of understory growth and total fuel load. However, these forests historically burned via stand-replacement crown fires. Most of the prescribed burn units managed with these goals are located within a close proximity of the South Rim Village developed area, prohibiting use of prescribed crown fires. As the prescribed fire staff at Grand Canyon explores possibilities of utilizing crown fires in pinyon-juniper forests on the southwestern plateau of the park, a new monitoring type description will be written and additional FMH plots will be installed.

Conclusion

Crew members of the Grand Canyon Fire Effects Program were able to successfully monitor all FMH plots this season with help from volunteers and other fire crew members, but a larger crew will be necessary next year in order to have time for correcting problems in the database and completing necessary analyses. There are also more plots scheduled for monitoring during 1998 and a strong possibility for more plot installations.

Extensive revisions to the Fire Effects Program will change the way data are collected and stored to ensure these data are reliable in the future. This kind of program overhaul will take time to develop and implement but is critical to the credibility of the FMH program. Unfortunately, not all information requested for this report is available because of these program revisions. For example, providing graphical representations of data that have errors is not worthwhile, and projections of future plot installations cannot be accurately predicted until the monitoring types are restructured over the coming months. All interested parties will be kept informed of Grand Canyon's progress in revamping the monitoring program and workload estimates will be revised accordingly.

Appendix A: Identified Problems and Solutions in GRCA FMH Database

The Fire Monitoring Handbook (FMH) database at Grand Canyon requires corrections before it can be analyzed with sufficient accuracy. In many cases, the reason the database was not maintained properly stems from a lack of personnel dedicated to the task. Reorganization of the prescribed fire staff at the Canyon will eliminate many of these past problems by providing continuity and guidance for the future monitoring program. Following is a list of problems identified to date and potential solutions.

Target date for completing the clean-up of the entire database is October 1, 1998. By this time, most field problems with tree tags, plot directions, and plot layout should also be corrected as plots are visited during the 1998 season.

FMH Problems	FMH Solutions
1. Brown's transect lengths are not the same for all plots in a monitoring type; some are 50' and some are 100'.	1. Begin reading all plots correctly next year; fix misread data by deleting or multiplying existing data by a correction factor.
2. Fifteen FMH plots established in conjunction with NAU were numbered differently in the database, the files, and the field; no FMH-4s exist for these plots.	2. Label files to reflect database labels. Change plot tags next year when visiting North Rim; decide whether any of these plots are acceptable for use in current monitoring types, or if additional N.Rim types should be established; decide to disregard plots which do not fit in current or foreseen forest monitoring types.
3. No fire history information is written on FMH-5s for any plots.	3. No solution at present. The fire history database does not make this information easy to obtain; fire locations are entered as points with acreage, but there are no maps of fire occurrences.
4. Not every plot file has a detailed plot location description.	4. Photocopies of topographic maps will be put in each file with plot location clearly marked; written descriptions will be revised to clearly match maps; all plots will be located on a set of FMH topographic maps to remain in map case for reference.
5. Unknown plant species and lack of follow-up in having them identified and entered in database.	5. Make known to all field personnel an established procedure to get plants properly collected and identified; hold persons accountable for follow-up.

6. Numbers on overstory and pole tags are the same, resulting in confusion when pole trees grow into the overstory.	6. Future plots will have overstory trees numbered 1-100 and pole trees 101-999; poles growing into overstory can just have the "P" crossed off the tag. More care will be taken with established plots to ensure that new overstory trees are immediately tagged with new numbers that do not conflict with any other overstory or pole tag on the plot; such tag changes will be documented in the hardcopy for each plot.
7. Tags are not readily updated or replaced; pole trees grown into the overstory may still have P-tags for many years; trees in non-pole quadrants which have grown into the overstory may be overlooked during re-reads because they did not have original tags.	7. Field crews will carry extra blank tags, nails, and a stamp kit in the field on every plot visit to make tag changes, additions, and replacements; crews will be advised to measure all trees in non-pole quadrants to ensure capture of new overstory trees.
8. Tags are not always placed on trees at dbh, resulting in measuring errors.	8. Re-nail all tags at proper height as plots are revisited; take care to nail future trees at correct height; inform crews that dbh measurements must be made at the nail for consistency.
9. Postburn information missing for some plots because FMH crew season had already ended when postburn read was due.	9. Permanent or term positions will help to eliminate this problem in addition to greater communication between field personnel and supervisory staff.
10. Some data sheets and photos are missing entirely.	10. No solution at present.
11. Fire behavior information missing for some burned plots.	11. Check all other, non-FMH burn files for such information; disregard plots with no fire behavior information until they are reburned.
12. Plots not burned in accordance with established burn prescriptions, resulting in highly variable fire effects data which is difficult to analyze with accuracy. Igniters sometimes intentionally put a lot of fuel on FMH plots to "get them to burn."	12. Decide to either follow established prescriptions for burning in future, or stratify monitoring types to reflect different burning seasons (this would result in many plot installations); inform ignition crews at briefing of how to approach lighting an FMH plot.
13. The 50-meter transects may not be sampling grass species sufficiently.	13. Revise protocols to capture grasses; solicit help from GRCA Botanist.
14. A few plots are not square, resulting in failure to read last 2 or 3 points on a 50-meter transect.	14. Make plots square as they are revisited in 1998.
15. Misidentification of tree species from year to year.	15. Develop a quick-reference guide for N.Rim trees; identify and correct discrepancies; revisit plots in 1998 to confirm correct species identification.
16. Brush species tagged and counted as poles.	16. Identify such individuals and make necessary corrections in field, on all datasheets, and in database program.

17. Non-brush species counted as brush.	17. Because there are so few brush species, make a reference list with i.d. characteristics for use in the field; or revise brush data sheet with all possible codes listed at bottom.
18. Failure to obtain comparable photo documentation from year to year.	18. Take previous photos into field for easy match; establish protocols for camera position; promptly re-take unacceptable photos.
19. Plots not read at same phenological stage each year.	19. Begin to read plots on a schedule based on ecosystem dryness; plots which will dry out first will be read first. Reference photos before going into the field to see which plants were flowering during the last visit.
20. Possible problems with data entry, though they have not yet been identified. When data sheets are difficult to read, people sometimes "guess" or can accidentally insert the wrong name/number.	20. Check all hard copies for possible errors and identify; fix such errors in database as soon as possible. This is a major project that will take many months to sort through.

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APPENDIX B

Grand Canyon National Park
Fire Effects Program

Ponderosa Pine Overstory Mortality Analysis

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December 16, 1997

Introduction

The National Fire Monitoring Handbook (FMH) protocols designed by the National Park Service have been performed at Grand Canyon National Park since 1989 when a pilot program was started. Since then, 59 plots have been installed in four monitoring types on the North and South Rims. The four monitoring types are: Rocky Mountain Subalpine conifer Forest (PIEN1), North Rim Ponderosa Pine (PIPN1), South Rim Ponderosa Pine (PIPO1), and South Rim Pinyon-Juniper (PIED1).

This report focuses on the question, "How have prescribed fires affected live overstory ponderosa pine tree densities?" Only live overstory ponderosa pines in PIPN1 and PIPO1 were evaluated. This analysis does not include information about any ponderosa pines that may occur in other monitoring types, nor does it include pole-size ponderosa pines or species other than ponderosa pine that occur in PIPN1 or PIPO1.

It is important for users of this information to be aware that the FMH program was designed as a monitoring tool for evaluating the effects of prescribed fire and it is not research. This type of monitoring is meant to identify trends which can then be investigated through further study. There have also been inconsistencies with some aspects of data collection, further complicating any analyses. The Grand Canyon Fire Effects staff is correcting the data anomalies which can be corrected and have instituted changes to prevent future data uncertainties.

Methods

Plots for each monitoring type are randomly located throughout units scheduled to burn within five years. Each plot is 50x20 meters with overstory sampled in the entire 1000m^2 area. All overstory trees are tagged with numbers during installation. Overstory trees are defined as trees with a diameter at breast height (dbh) greater than or equal to 15.1 centimeters and do not have to be dominant in the canopy to be qualified as overstory trees.

Preburn data are gathered within two years of the prescribed burn, and for overstory, consist of species, dbh, crown class, and damage codes. Prescribed burns are usually conducted in late summer, fall, and spring. Postburn data are collected within six weeks of the prescribed burn and include mortality, crown scorch, and char height for all overstory trees. The information gathered during the preburn visit is collected again at one year postburn, two years postburn, and five years postburn. It may also be collected at 10 years postburn if the plot is not burned again. When a plot is re-burned, the monitoring cycle begins again with an immediate postburn plot visit. None of these plots have burned more than once.

In addition to the 59 installed plots, 15 plots were installed in 1996 to assist with a research study on the North Rim for a total of 74 plots in the entire monitoring system. As of yet, these 15 additional plots are not included in any specific monitoring type, but have been monitored as they are burned. Although many are dominated by ponderosa pine, because they have not been associated with a monitoring type, they are excluded from this analysis.

Summary of Data Analysis

The Preburn densities for North Rim Ponderosa Pine (PIPN1) and South Rim Ponderosa Pine (PIPO1) are highly variable, and only a few plots have been monitored for YR05 data (2 plots on the North Rim and 5 on the South Rim). The best estimate available for understanding postburn overstory mortality is the YR02 data which contains more samples on both North and South Rims. However, the YR02 data are not evenly distributed in either monitoring type, making statistical evaluations questionable. Supporting data for this analysis is in Appendix A.

South Rim Ponderosa Pine

There was a decrease in overstory ponderosa pine stems in the PIPO1 monitoring type from Preburn to YR02 of 2.6%, amounting to about one tree per hectare per year. On the ten plots with YR02 data, the mean overstory ponderosa pine stems per hectare is187 and the median is 150. Due to outliers in the dataset, the median is probably a more true representation of actual stem densities. This sample size is the largest of any analysis in this report, however, it is still not significant enough to come to definitive conclusions. A study by Harrington (1993) suggests that 60% of mortality in ponderosa pine due to fire injury occurs by the end of the first year postburn, and 90% by the end of the fourth year. If this is so, it is not expected that a great loss in overstory stems will occur between now and YR05 on these plots.

The YR05 plots show a small increase (4.4%) in overstory ponderosa pine stem densities since they were burned because what were previously pole-size trees have grown into the overstory size class. After five years postburn, these five plots have a mean stem density of 144 overstory ponderosa trees per hectare and a median stem density of 130. Again, the sample size is not statistically significant.

North Rim Ponderosa Pine

The decrease in overstory ponderosa pine stems per hectare in five PIPN1 plots from Preburn to YR02 was 10%, amounting to approximately one tree per hectare per year. The current mean for YR02 plots is 244 overstory ponderosa stems per hectare, with a median of 210. Due to outliers in the dataset, the medians are probably a more true representation of actual stand densities. Harrington's research, again, suggests there will not be a great loss of overstory stems between YR02 and YR05.

After five years postburn, there was a 22% decrease in overstory ponderosa pine stem densities in the two PIPN1 plots. These plots, located in the Northwest I burn, are the two most dense plots in this monitoring type and appear as strong outliers in the Preburn data, therefore they are not representative of the PIPN1 stands normally encountered on the North Rim. In addition, two plots do not constitute a statistically significant sample size.

It is uncertain whether the mortality seen on these two plots is due to fire or other factors. Dense stands of ponderosa pine are likely experiencing environmental density-dependent stresses as well as the density-independent stress of fire. Preburn data show that these two plots had an average dbh of 35.2 cm, but a YR05 dbh of 36.8 cm. This suggests that the overstory mortality occurred in the smaller portions of the overstory size classes. In any case, the mean overstory ponderosa pine stems per hectare for these two plots is still very high at 365 overstory ponderosa stems per hectare. This figure does not include pole densities and can be misleading since overstory trees are defined by a diameter limit and not by crown class.

Conclusion

Information gathered from the FMH monitoring program suggests that prescribed fire activities are not greatly affecting overstory ponderosa pine densities on the North Rim or the South Rim ponderosa pine plots. Figures 1 and 2 in Appendix A illustrate this point well as none of the columns show a great difference in trees per hectare from Preburn through Postburn plot visits.

This dataset has a lot of variation and very few data points, making statistical inferences difficult. None of this information can be extrapolated to make bold inferences about how prescribed fire may actually be affecting live overstory ponderosa pines in Grand Canyon National Park. This information can only be used to understand what is happening within the boundaries of individual plots until there are enough to make a statistically significant sample for identifying real trends. Efforts to burn more plots are continuing in order to obtain significant results.

Literature cited

Harrington, M.G. 1993. Predicting *Pinus ponderosa* mortality from dormant season and growing season fire injury. Int. J. Wildland Fire 3(2): 65-72.

APPENDIX A: SUPPORTING DATA

Data Descriptions

This section describes data for the North Rim Ponderosa Pine (PIPN1) and South Rim Ponderosa Pine (PIPO1) monitoring types. There are two essential elements used to describe data. One is the *typical value* and the other is the *spread.*

Typical values are shown in Table 1. Note the range of values in the columns for mean, maximum, and minimum. Also note the difference in the number of plots available for different analyses.

Table 1. Typical values for live overstory ponderosa pine densities in PIPN1 and PIPO1.

	Mean	Median	Standard Deviation	Maximum	Minimum	Number of Plots (n)
PIPN1 Preburn	160	130	119	550	60	19
PIPN1 YR01	264	210	193	540	90	5
PIPN1 YR02	244	210	166	480	90	5
PIPN1 YR05	365	365	64	410	320	2
PIPO1 Preburn	197	170	122	560	60	22
PIPO1 YR01	181	155	135	530	60	12
PIPO1 YR02	176	150	121	500	60	13
PIPO1 YR05	144	130	93	290	60	5

Figures 1 and 2 show live stems per hectare for each plot in each monitoring type. These are the data points used to calculate the values in Table 1. It is easy to determine at a glance which plots have been burned and which have only been installed at this point. Each column represents actual stem counts in each plot. Note the variation in Preburn stem densities.

The second descriptor of data is the spread. Box-and-Whisker plots illustrate the spread of the data for each monitoring type (Figures 3 through 10). These graphs allow comparison of the medians between groups of data (e.g. Preburn, YR01, YR02, YR05). It is best to compare some stem densities by medians rather than means when outliers exist in the dataset, because outliers do not heavily influence the median, as they do the mean.

A box-and-whiskers plot shows the data in quartiles. Middle quartiles are represented by the two halves of the floating column and the first and fourth quartiles are represented by the extended lines called whiskers. Plots that do not fall within the box or the whiskers are considered outliers and are represented by dots. An evenly distributed dataset is illustrated with equal lengths for all four quartiles. Scales on all graphs are the same to aid in comparisons between graphs. There are four box-and-whiskers plots for each monitoring type to show differences in the spread when comparisons are made using different plots.

North Rim Ponderosa Pine (PIPN1) Data Spread

Figure 3 includes all plots and shows that the data for PIPN1 are skewed toward higher stem densities. This comparison of medians suggests that the density of live ponderosas is increasing over time. Actually, it is not, but appears this way because the only two plots represented in the YR05 column are the two plots identified as outliers in the Preburn column (PIPN1 Plots 1 and 2).

Figure 4 shows the data distribution when Plot 1 and Plot 2 are excluded. This dataset is more evenly distributed overall, but there is still skewness to the right and an outlier at a higher density. Again, this graph does not compare the same exact plots over time and does not give an accurate description of how stem densities may be changing.

Figure 5 compares the exact same plots in each column from Preburn to YR02. Again, the data are skewed towards higher densities, but there are no outliers in this dataset. This figure implies that there has been relatively little change in ponderosa pine densities from Preburn to YR02.

Figure 6 compares medians from the exact same plots from Preburn to YR05, but there are only two plots with Post YR05 data in this monitoring type. In addition, these two plots were the outliers in the Figure 3 Preburn column and are therefore not representative of the types of densities normally encountered on the North Rim. The distributions are even and there are no outliers.

South Rim Ponderosa Pine (PIPO1) Data Spread

Figure 7 compares medians for all plots in the PIPO1 monitoring type, showing outliers at higher stem densities and some skewness to the right. As in Figure 3, the noticeable decrease in stem density over time is not a true decrease because there are 22 plots for the Preburn sample and only 5 plots for the YR05 sample.

Figure 8 excludes the outliers found in Figure 7 (PIPO1 Plot 15). Although the data are still skewed toward higher stem densities, the distributions are more normal and there are no outliers. The median is not fairly compared between groups in this graph since the same plots are not compared over time.

Figure 9 compares ten plots from Preburn through YR02. This is the highest comparable sample size available in the FMH database for ponderosa pine on either the North or South Rims at this time and therefore is the best representation available for determining trends in live stem densities. Plot 15 is an outlier in the Preburn data, but otherwise the data are distributed evenly and there is little change in the median live stem density over time.

Figure 10 compares five plots from Preburn through YR05, excluding a YR01 comparison because PIPO1 Plot 8 was never read at YR01. This allows five plots to be compared fairly from Preburn to YR05. Although densities are skewed toward higher stem densities, there are no outliers and little change in the median density over time.

Reasons for Data Inconsistencies

Few of the Box-and-Whisker plots illustrate evenly distributed data. Many statistical inferences depend on data that does not have outliers and is not skewed. In all cases, the skewness and outliers exist at higher densities than the median. Reasons why this has occurred may be attributed to:

1. Vague monitoring type descriptions result in high variability of installed plots,

2. Poor interpretation of monitoring type descriptions results in installation of plots which do not meet criteria,

3. Inconsistent sampling techniques, especially failure to record pole trees that have recently grown into the overstory size class, and

4. Attempting to draw conclusions from a post burn sample size which is simply too small to capture the natural variability of the stands.

Data Analysis

Keep in mind that the following graphs can only be as accurate as the data from which they were made, and these data have inconsistencies. Although an effort has been made to check all overstory data used in this analysis to ensure its validity, some problems may not surface until a later stage.

The following graphs in this report compare means, not medians. Means are highly sensitive to outliers, of which there are many (refer to the box-and-whisker plots). To ensure a fair comparison, these graphs compare only those plots that have been consistently read over time. Plots were excluded if they had not burned or if a post burn read was missing. Medians are comparable in the box-and-whisker plots.

The standard error bars on the columns show confidence levels at 80%, a sufficient level for our purposes. This interval means if ten samples were taken and the mean was calculated for each, that mean would fall within this interval eight out of ten times. Two of every ten times the sample mean would be wrong. In other words, 20% of the means calculated in these graphs probably fall outside of this interval in the true population of live overstory ponderosa pines in Grand Canyon. Smaller confidence intervals indicate our guesses will be more accurate based on the variability of the data. All confidence intervals were calculated using a t-distribution because of the small sample sizes.

North Rim Ponderosa Pine (PIPN1) Analysis

Figure 11 compares five plots which have been monitored from Preburn to YR02. The mean stems per hectare of live overstory ponderosa pines falls slightly over time. However, because of the small sample size (n=5) and the variation in the data, the confidence interval is very wide. Essentially, there is little certainty that these figures represent what is happening to ponderosa pine populations two years after burning.

Figure 12 compares the two plots in the PIPN1 monitoring type that have been post burn read after five years. The mean of these two plots decreases over time, but again, there is a considerably small sample size and a wide confidence interval. The confidence interval decreases over time as the difference between plot densities decreases. Although overstory stems are decreasing over time, the plots represented in this graph are the two outliers from Figure 3 and are not representative of the densities monitored in the PIPN1 monitoring type. These plots are probably not representative of the average stand density of ponderosa pine on the North Rim, but that is difficult to say until the PIPN1 database includes more plots.

South Rim Ponderosa Pine (PIPO1) Analysis

Figure 13 compares the ten plots that have been monitored from Preburn through YR02. There is a slight decrease in the mean stem density over time, amounting to one tree per hectare each year. The confidence interval is considerably smaller than PIPN1 graphs which included only a few plots (+/-50, as compared to +/-250). However, the distribution of this data had notable skewness toward higher stem densities, influencing the means in this graph. This graph represents the largest comparable sample size available for ponderosa pine but is still not statistically significant.

Figure 14 compares five plots that have been monitored from Preburn to YR05, except YR01. YR01 data are excluded from this graph because one of the plots with YR05 data does not have YR01 data, and for a fair comparison, the YR01 data must be excluded. The confidence intervals, again, are smaller than for the PIPN1 type due to less variability in the data points. There is a small increase in live overstory density, but this cannot be assumed to be true for the entire population of live overstory ponderosa pine since this is not a statistically valid sample.

Table 2 is a summary of the mortality illustrated in the above graphs. Calculated percentages for each year are based on the mean stems per hectare for each monitoring type. The values range from –4.4% in plots where stems have grown into the overstory size class since the plots were burned, to 22.0% which averages overstory losses in the two most dense plots of either North or South Rim ponderosa pine monitoring types.

Table 2. Percent change in live overstory ponderosa pine stems.

	PIPN1 YR02 Plots n=5	PIPN1 YR05 Plots n=2	PIPO1 YR02 Plots n=10	PIPO1 YR05 Plots n=5
Preburn to YR01	2.2%	1.0%	1.0%	0%
YR01 to YR02	7.4%	10.8%	1.6%	-2.9%*
YR02 to YR05	n/a	9.7%	n/a	-1.5%
Total Decrease in Stems/Hectare	9.6%	22.0%	2.6%	-4.4%

*Change from Preburn to YR02, not YR01 to YR02.

Figure 1. Live Overstory Ponderosa Pine Change Over Time by Plot PIPN1 Monitoring Type

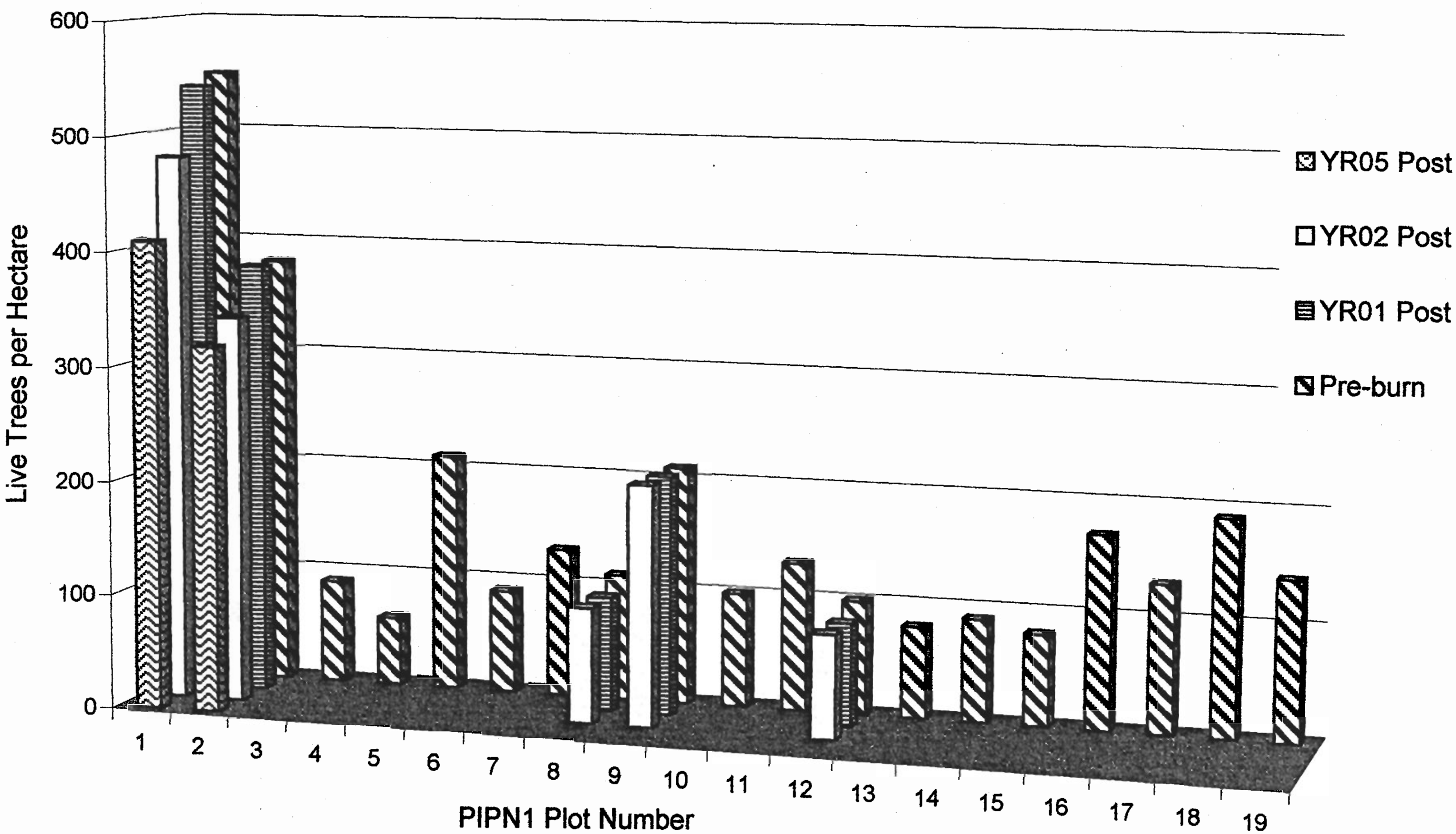


Figure 2. Live Overstory Ponderosa Change Over Time by Plot
PIPO1 Monitoring Type

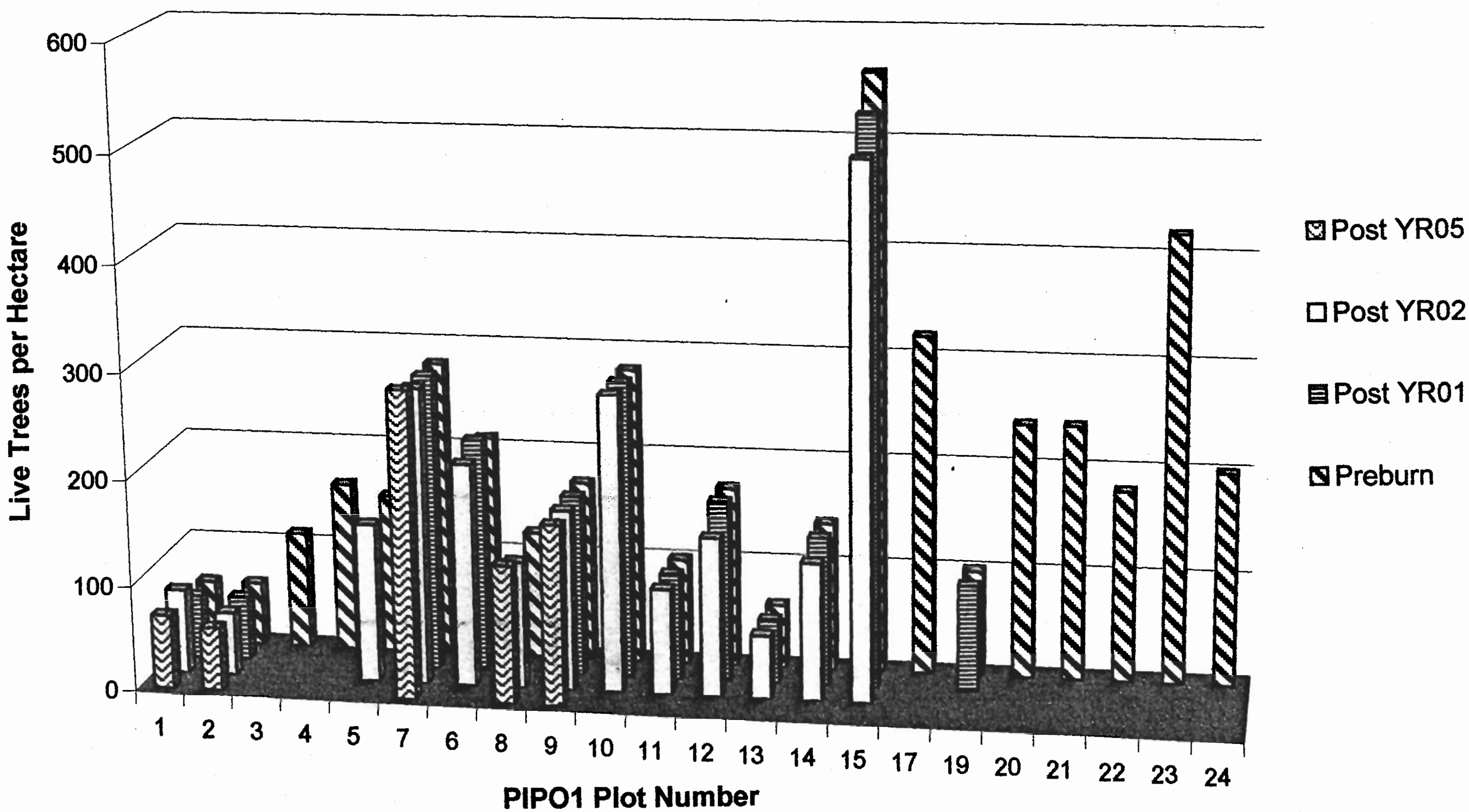


Figure 3. PIPN1 Data Distribution Including All Plots

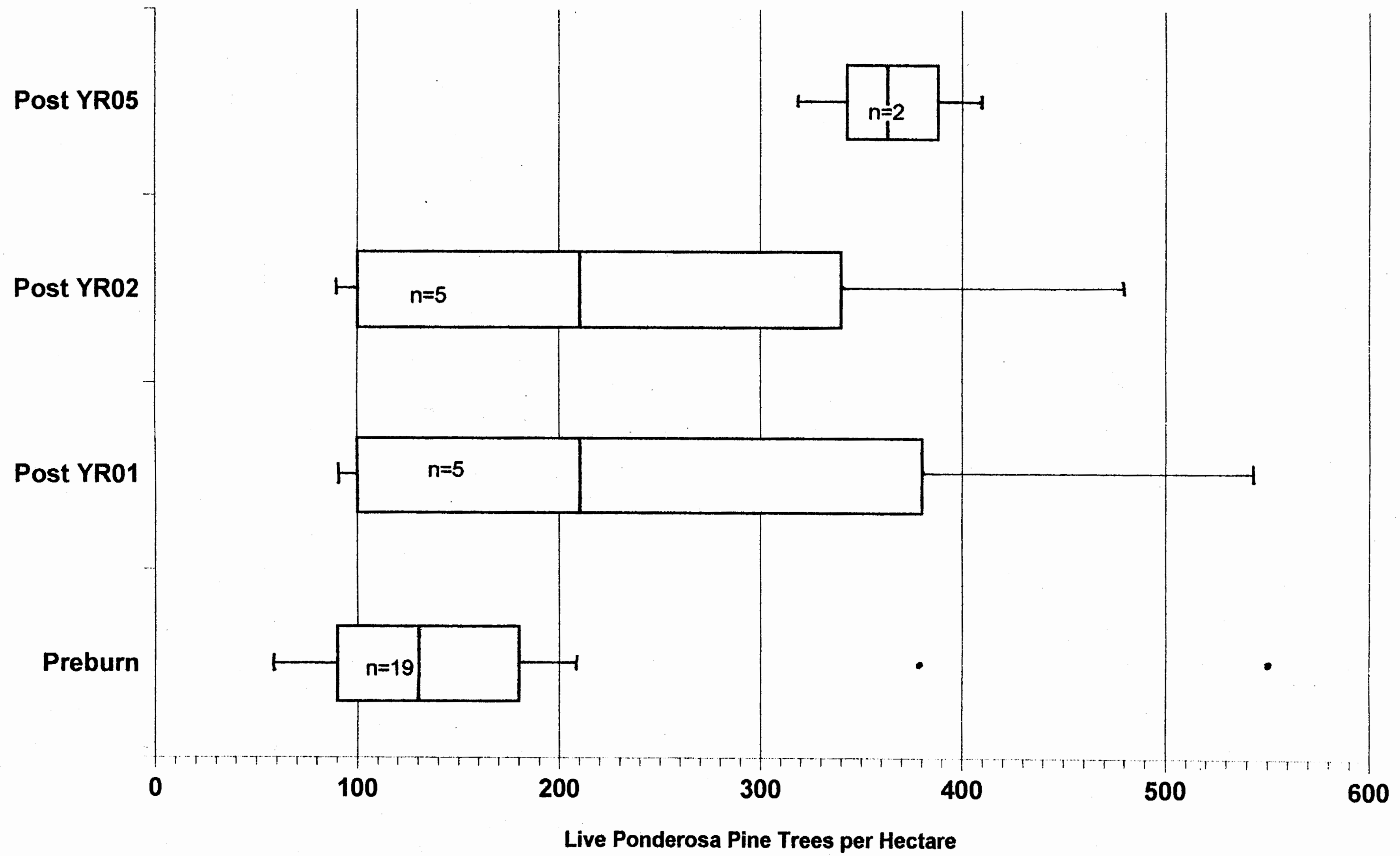


Figure 4. PIPN1 Data Distribution Excluding Outliers

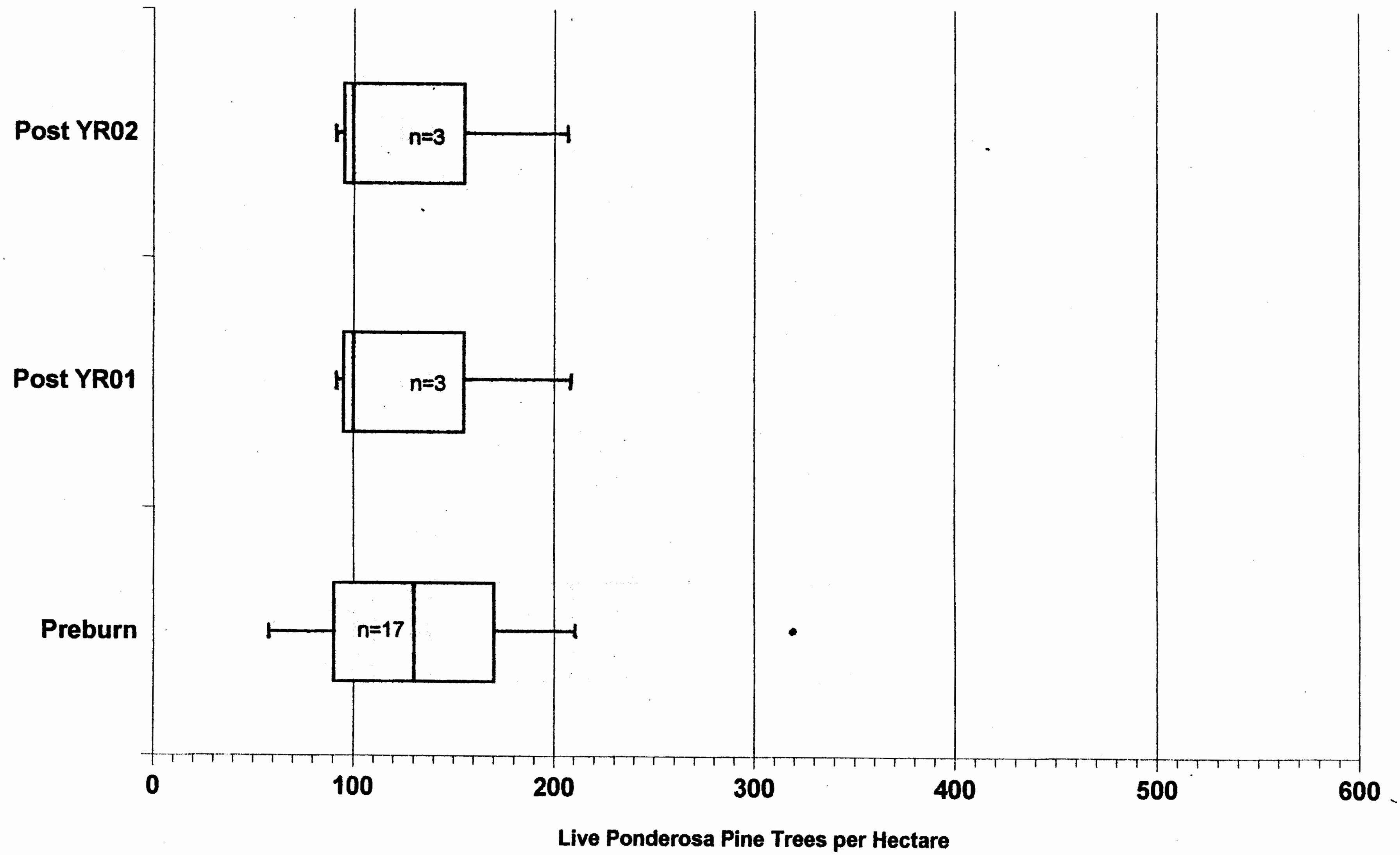


Figure 5. PIPN1 Data Distribution Including Comparable Plots from Preburn to YR02

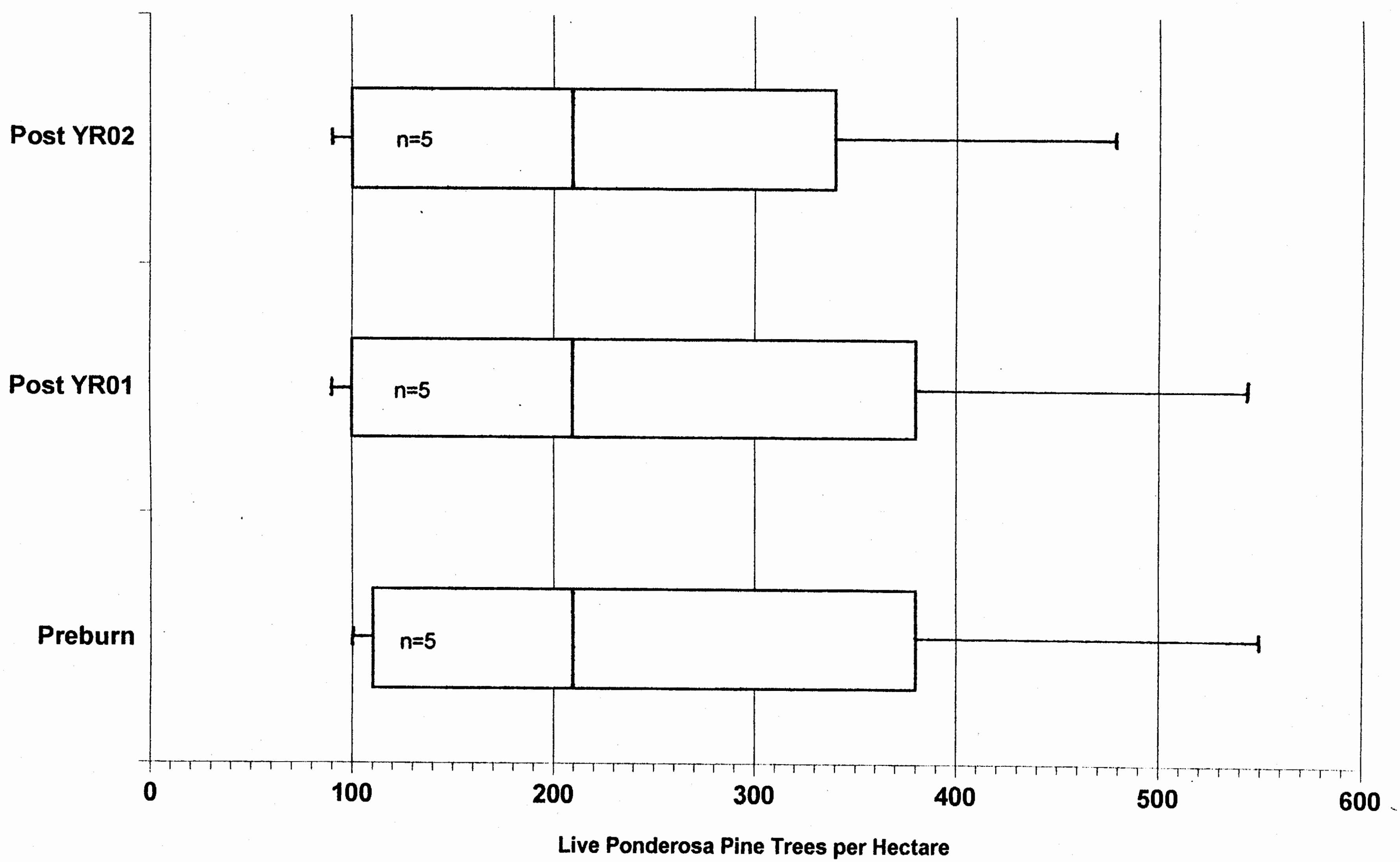


Figure 6. PIPN1 Data Distribution Including Comparable Plots from Preburn to YR05

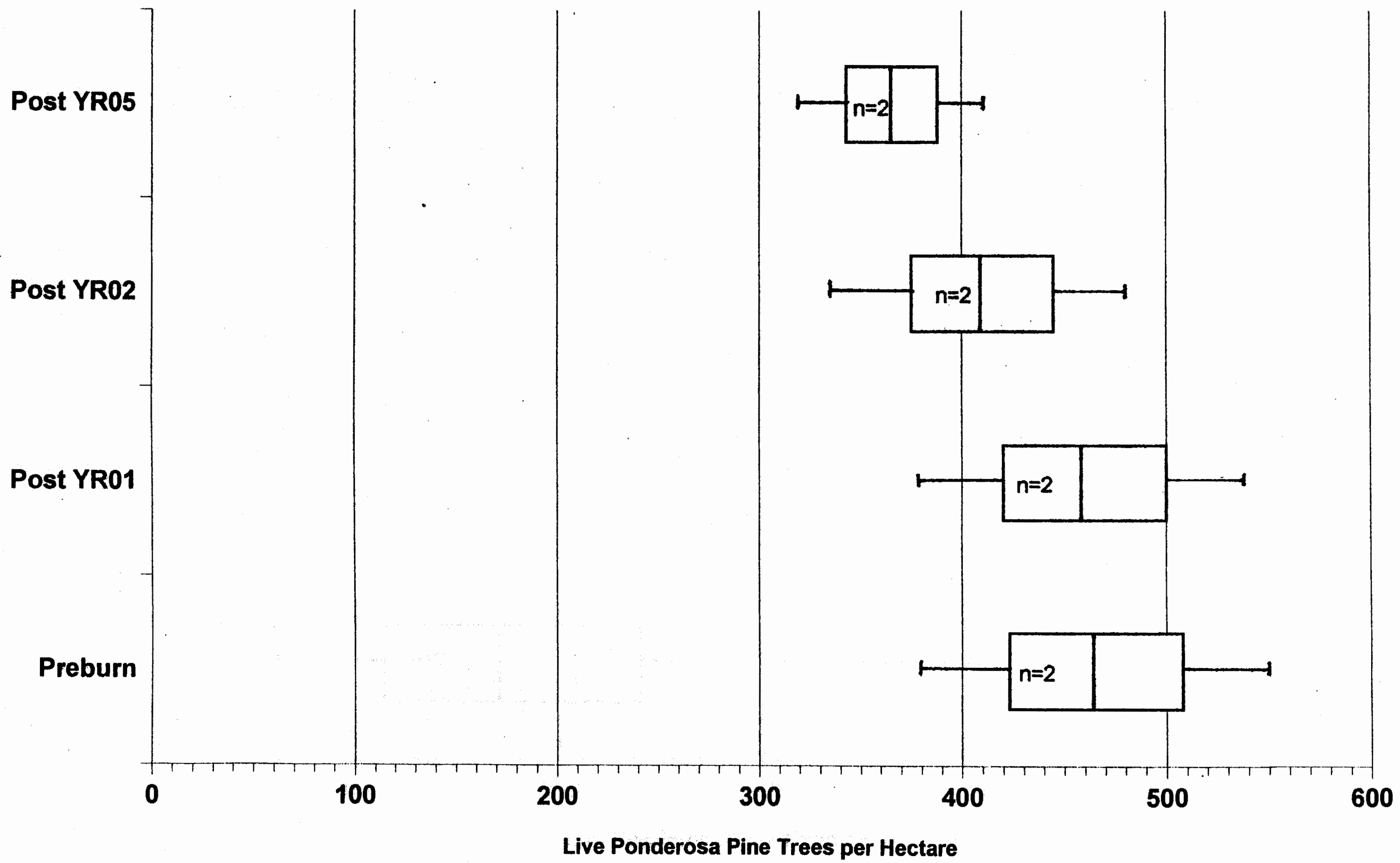


Figure 7. PIPO1 Data Distribution Including All Plots

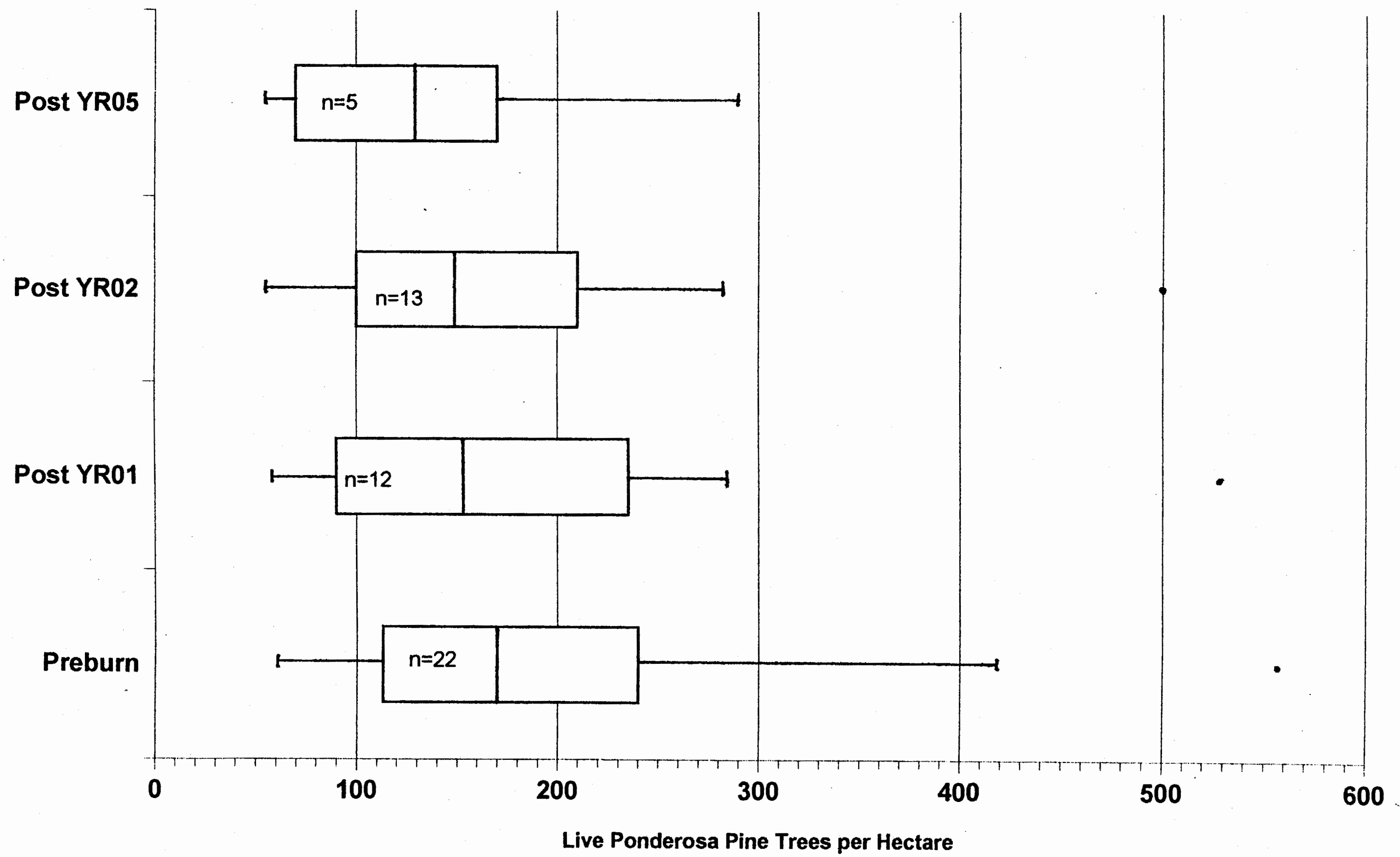


Figure 8. PIPO1 Data Distribution Excluding Outliers

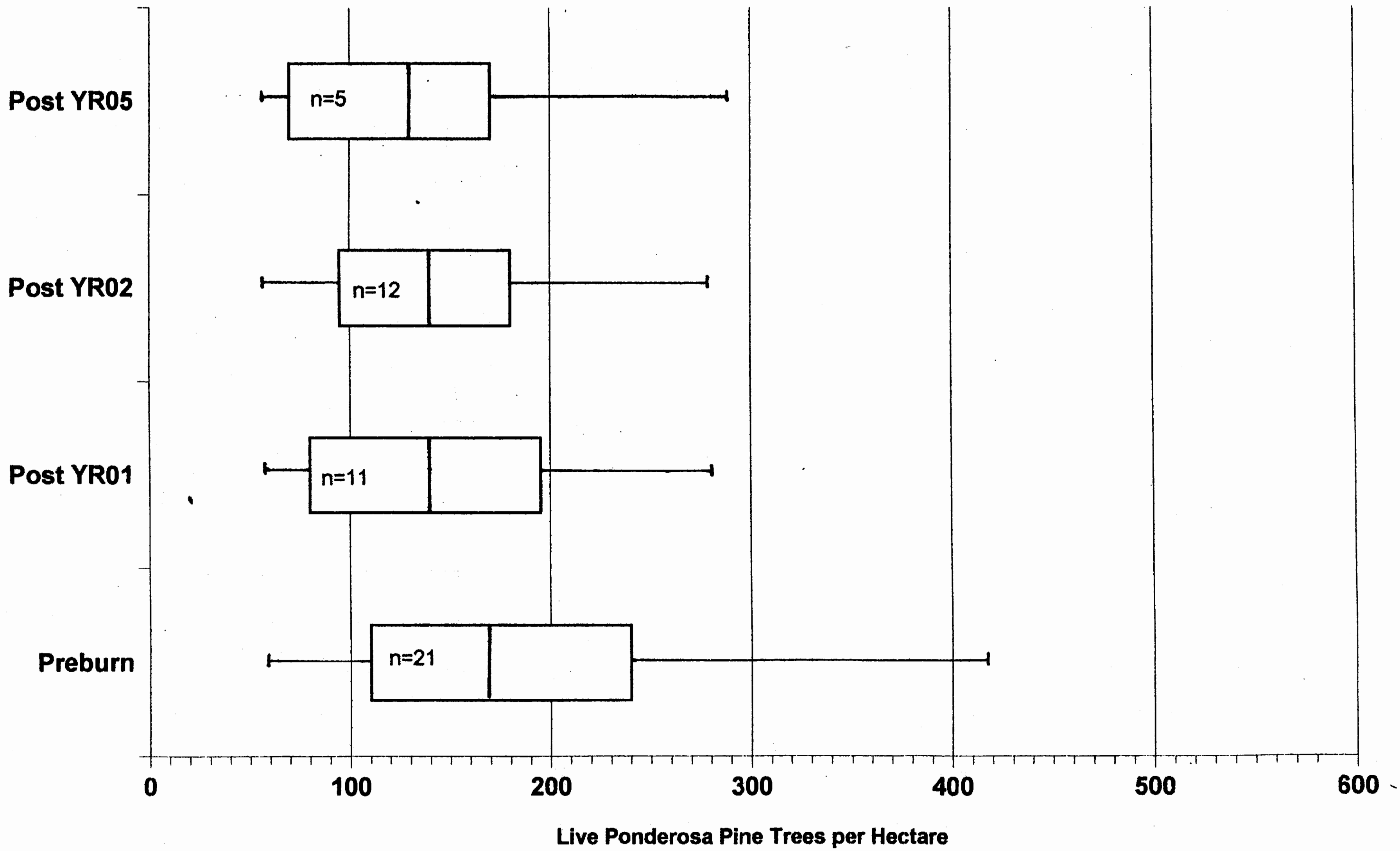


Figure 9. PIPO1 Data Distribution for Comparable Plots from Preburn to YR02

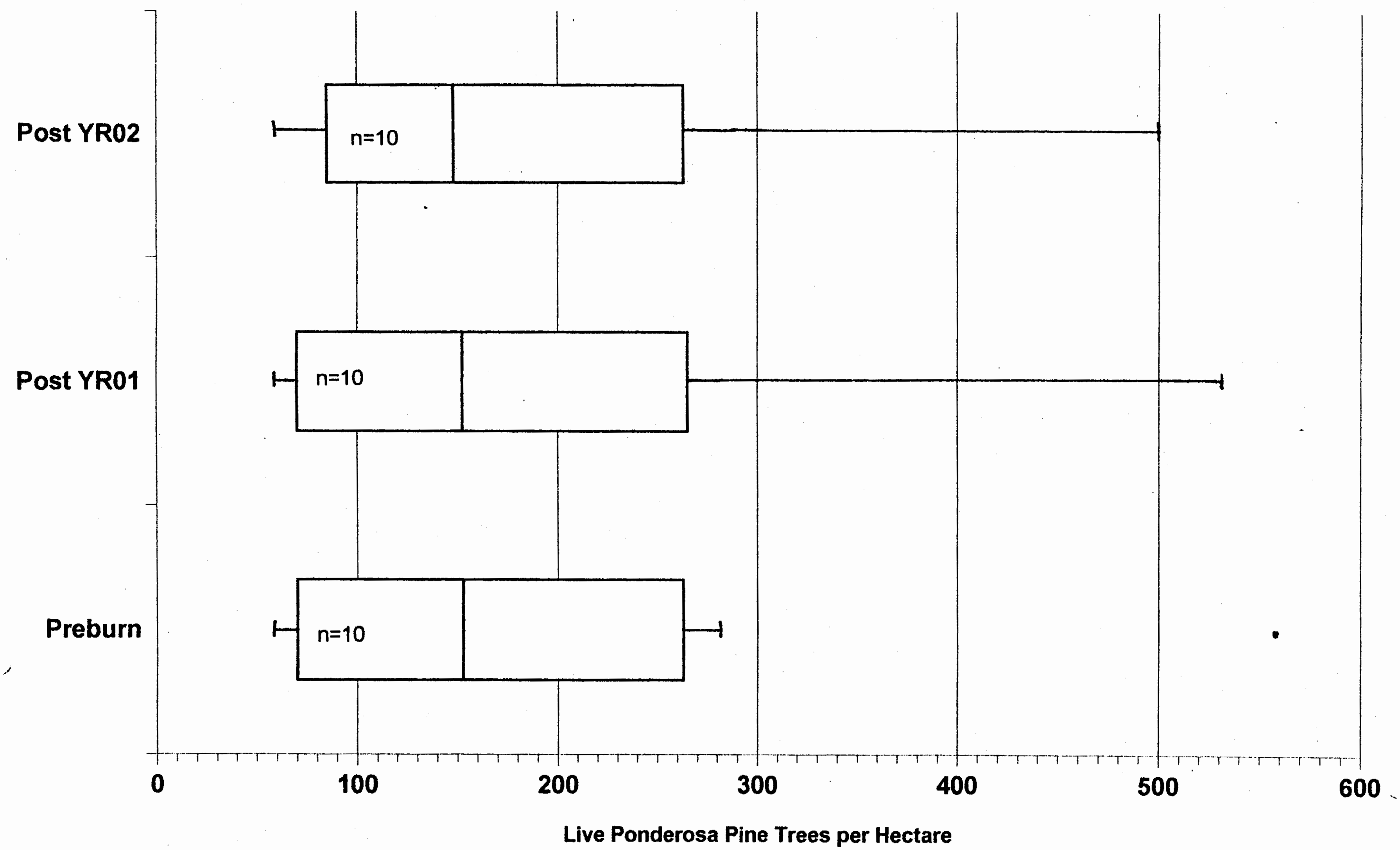


Figure 10. PIPO1 Data Distribution Including Comparable Plots from Preburn to YR05

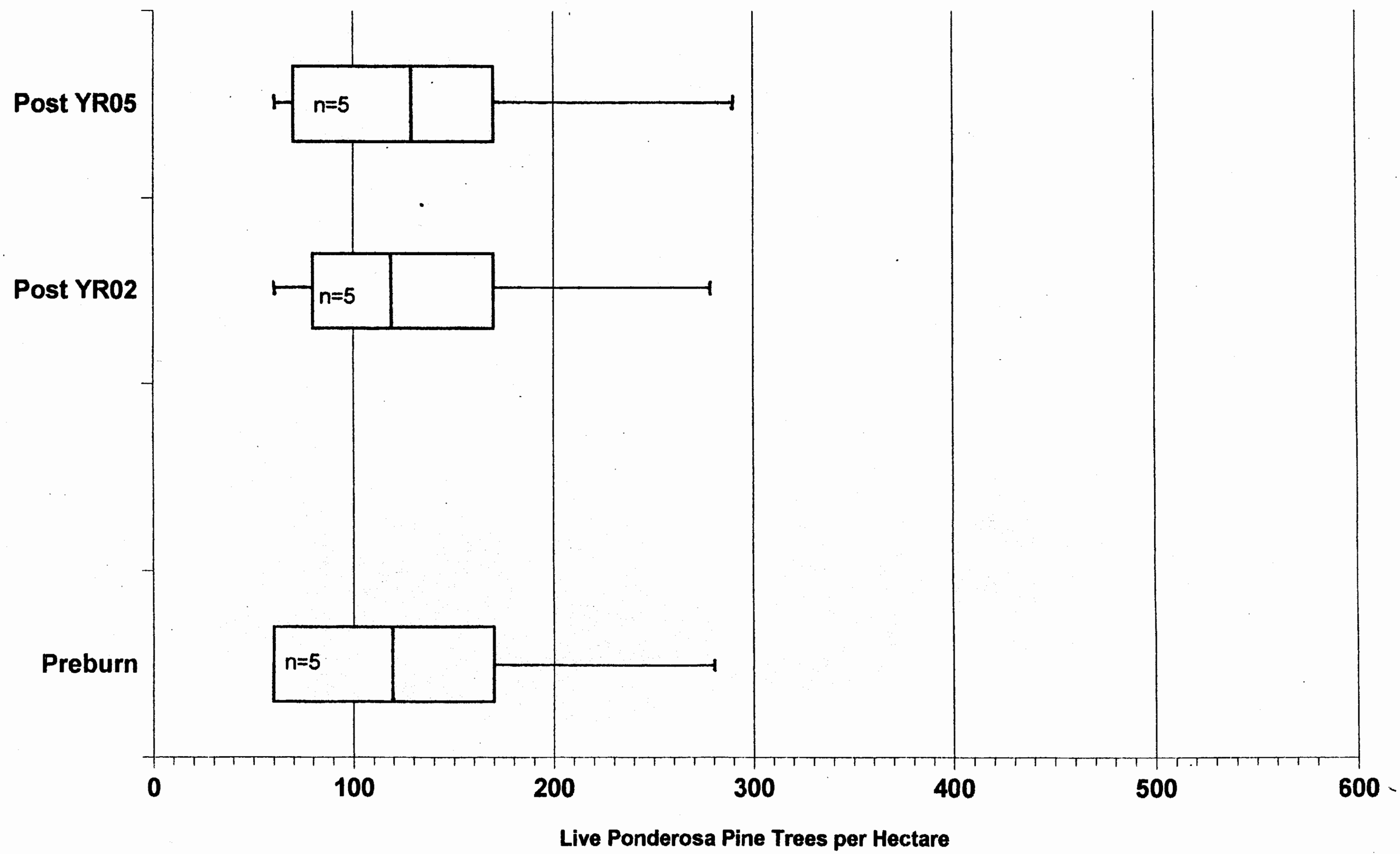


Figure 11. Changes in Live Tree Density from Preburn to YR02
PIPN1 Monitoring Type

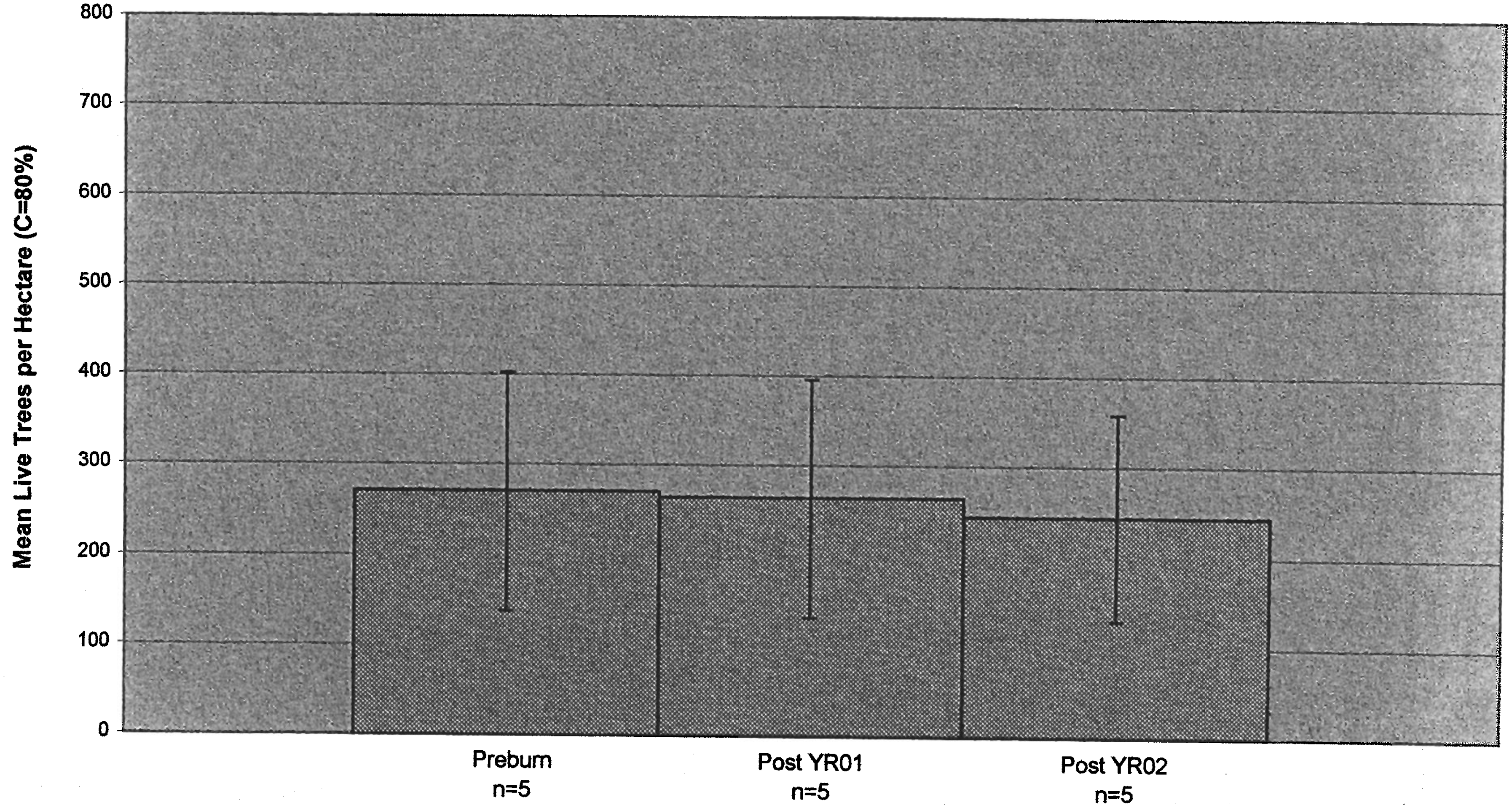


Figure 12. Changes in Live Tree Density from Preburn to YR05
PIPN1 Monitoring Type

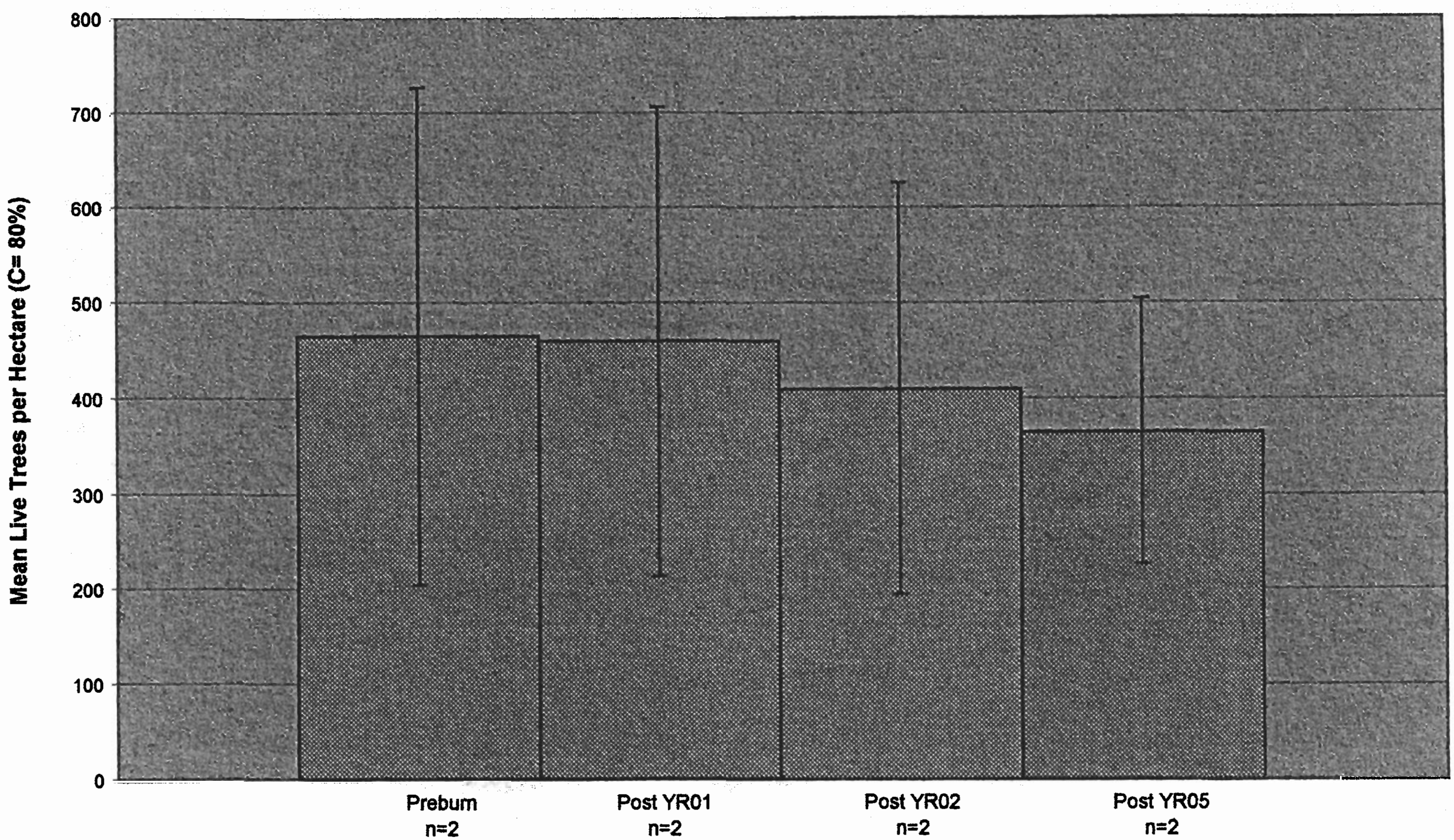


Figure 13. Changes in Live Tree Density from Preburn to YR02
PIPO1 Monitoring Type

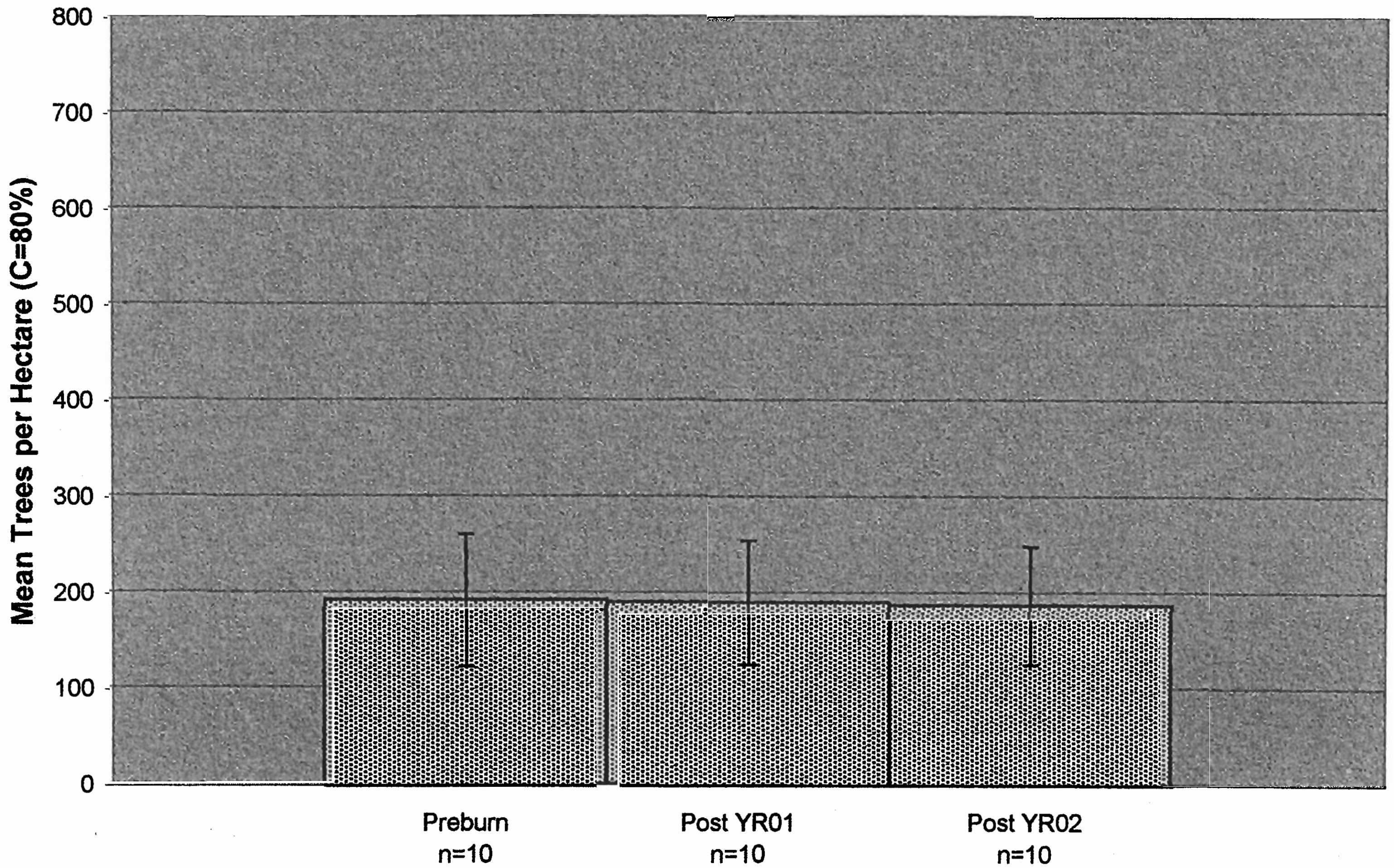
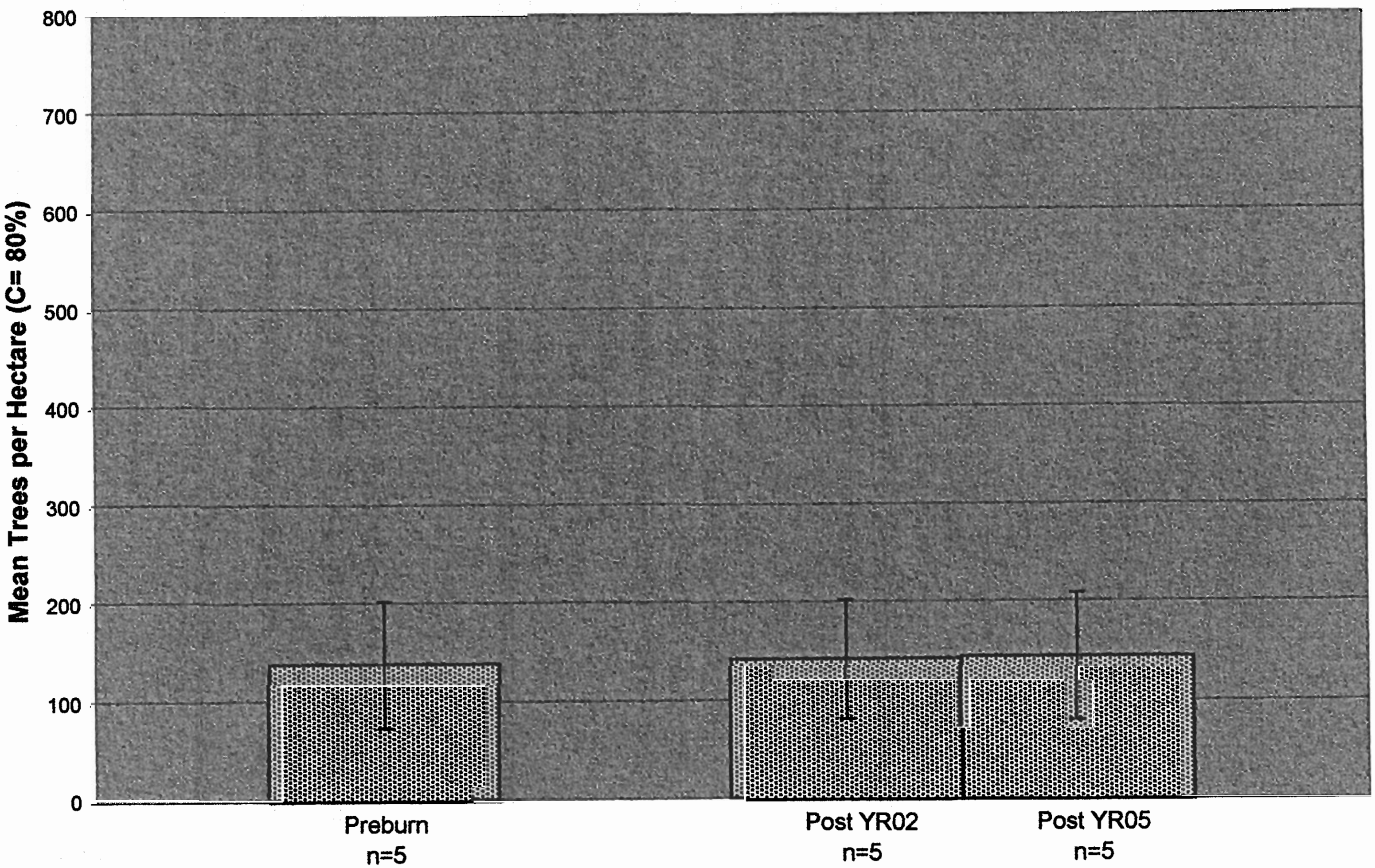


Figure 14. Changes in Live Tree Density from Preburn to YR05
PIPO1 Monitoring Type



Appendix C: Draft for GRCA FMH "Shortcourse"

DRAFT
Grand Canyon National Park
Fire Effects
FMH Short Course

Andy Thorstenson 15 October 1997

Tentative Date: May 1998

SCHEDULE

Day 1

- Introduction/Overview to the Prescribed Fire and Fire Effects Programs at Grand Canyon
- Explain local Monitoring Types, vegetation, and fuel conditions
  - FMH-4 Monitoring Type Description Form
  - Plot protocols for varying vegetation types
  - Prescriptions for Rx Fires to be accomplished this year
- Issue field equipment to all new staff (compass, clinometer, hand lens, etc.)
- Monitoring FMH plots : see the Forest Methods section of the FM Handbook
- FMH forms used to record field observations completely, legibly and correctly
- Location of FMH information, materials, and equipment
- FMH hardcopy filing system, protocols, and backup methods
- Visit to a recently burned FMH plot to visually assess the effects of fire
- Undertake a very brief compass skills orientation, and practice pacing and chaining

Day 2

- Organize paperwork, equipment, and information required to read a plot
- Install a practice plot from a point on a map; use GRCA protocols spiced with liberal readings from the FMH handbook
- Shamefully brief introduction to plant families, dichotomous keys, common plants frequently encountered in Grand Canyon
- Discussion of important vegetative characteristics to look for to aid in recognizing various plants
- How to collect and preserve specimens when necessary
- Review photographic protocols and standards; emphasize the long-term importance of these photos

- Write a detailed FMH-5 route description with appropriate UTM, Lat/Long, TRS, slope, aspect, fire history, plot visit history, etc.
- Assure all headings, diameters, heights, ages, locations, tags are in order both in the paperwork and on the plot
- Focus on consistency in implementation to assure long-term validity of data collection

Day 3

- Introduction to computer data entry for FMH using practice plot data from previous day
- General exploratory of the analysis functions on FMH; fuel loading, overstory mortality, vegetation change over time, etc.
- Review post-field standards to assure accurate and complete data
  - Revise, amend, or rewrite route descriptions for FMH-5
  - Update topos and hand-drawn maps
  - Add slope, fire history, site visit data, etc to FMH-5A
  - Update Field Copy folder with most current maps and data
  - Identify any unknowns from the vegetative transects, label collected samples, send samples to Nancy Brian or the Study Collection
  - Collect all completed paperwork in an appropriately labeled file, where it is then ready for data entry
  - File completed FMH-26 in appropriate file so that slide sorting will be easy.
  - File completed rolls of film in an envelope ready for processing

MATERIALS NEEDED

- Fire Monitoring Handbooks (at least 1 for every 2 participants)
- One complete set of FMH-4s for everyone
- Complete burn plan for an upcoming prescribed unit
- Complete FMH pack and equipment
- 7.5 minute topo maps for determining lat/long, utm, etc.
- Grand Canyon map of all prescribed fire burn units and all FMH plots in the Park
- Compass and clinometer for every participant
- Plant identification reference materials

Appendix D: Current Equipment Vendors

Insight (For computer equipment/supplies/programs)
6820 S. Harl Ave
Tempe AZ 85283
1-800-467-4448 (ask for Marguerite Lara at x5961)

Forestry Suppliers (Field equipment)
P.O. box 8397
Jackson MS 39284-8397
1-800-647-5368

Century Photo Products (3-ring binders and clear photo/slide holders for storage)
P.O. Box 2393
Brea, CA 92822
1-800-767-0777

HomeCo Ace Home Center (rebar—can be cut to specifications (1/2" x 18") and delivered to GRCA)
1763 E. Butler Avenue
Flagstaff AZ 86001
1-800-628-0582

National Weather Service (pilot balloons)
Phone: 301-713-1829

International Association of Wildland Fire (IAWF) (Reference books on fire/ecology)
P.O. Box 328
Fairfield WA 99012-0328

Ben Meadows Co. (Field equipment)
P.O. Box 80549
Atlanta GA 30366
1-800-241-6401

National Band and Tag Co. (Brass tags Style #115 w/hole at 3/16", pre-numbered and blank)
721 York St/P.O. Box 430
Newport KY 41072-0430
(606) 261-TAGS

Trimble Navigation (GPS information)
2203 Timberloch Place
Suite 250
The Woodlands TX 77380

National Wildfire Coordinating Group Catalog (NWCG) (Fire-related materials, equipment and books)
ATTN: Great Basin Cache Supply Office
3833 South Development Ave
Boise ID 83705

Patricia Ledley Bookseller (Reference books and field guides)
One Bean Road/P.O. Box 90
Buckfield ME 04220
(207) 336-2778
http://ww.ledlie.com

Xerox (For rolls of copier paper for large map copies at Engineering)
1851 E. First St, Ste 552
Santa Ana, CA 92705
1-800-822-2200

Seattle Filmworks (photo, slide, and photo-on-disk developing)
1260 16th Ave W.
Seattle WA 98119
1-800-FILMWORKS
Customer #: 29733369

Kodak (ordering film in bulk)
U.S. Customer Support—Government
1187 Ridge Road West
Rochester NY 14650-3009
1-800-828-6203

Grand Canyon National Park Lost and Found (extra cameras for monitor's fire packs)

Appendix E. Revised FMH-4 Monitoring Type Descriptions

FMH-4 **MONITORING TYPE DESCRIPTION SHEET** Park: **GRCA**

Monitoring Type Code: F P I E D1D02 **Date Described:** 08/13/97

Monitoring Type Name: Great Basin Conifer Woodland

Preparer(s): Kerr/Opperman

Burn Prescription: Units will be burned during the monsoon season or from September until May or until green-up using head, flanking, and backing fires as needed to meet burn objectives. RH 20-50%; dry bulb 50-90°F; mid-flame winds 0-7 G15 mph; average flame length 1-6 feet; average rate of spread 1-28 chs/hour 10-hour TLFM 6-12%; 1000-hour TLFM 9-20%; live fuel moisture 60-120%.

Burn Objectives: Reduce total fuel loading by at least 60 % immediate post-burn so as not to exceed 20 tons/acre; limit overstory mortality of pinyon pine to 20% within 5 years post-burn.

Monitoring Variables: Total fuel loading; overstory tree density.

Monitoring Objectives: Sample size sufficient to be 80% confident total fuel load figures are within 20% of the population mean; 80% confident overstory tree density figures are within 20% of the population mean.

Physical Description: 6,400-7,000 feet on the south rim; 0-20% slope of all aspects; soils are shallow and loamy with a gravelly consistency, derived from Kaibab limestone.

Biological Description: 90% of overstory stems are pinyon pine and/or Utah juniper; ponderosa pine is an occasional overstory tree; absolute canopy cover is 20-60%; understory is sparse, composed of herbaceous plants (bluegrass, paintbrush, blue grama, locoweed, lupine, and squirreltail) and shrubs (mormon tea, banana yucca, snakeweed, serviceberry, cliffrose, apache plume, and rabbitbrush); combined cover for brush and herbs is <50%.

Rejection Criteria: Large rock outcroppings or barren areas >20% of the plot; areas with anomalous vegetation, boundary fences; areas within 30 meters of roads, utility corridors, human-created trails, human-created clearings, or slash piles; areas within 10 meters of significant historic or prehistoric sites or transitional ecotones; areas burned within the past 10 years; areas with more than 3 overstory ponderosa pine trees or >10% ponderosa pine cover; areas with >75% cover of either pinyon pine or Utah juniper.

FMH-4

PIED1 Plot Protocols

GENERAL PROTOCOLS		YES (√)	NO (√)		YES (√)	NO (√)
Preburn	Control Plots/Opt		√	Herb Height/Rec	√	
	Herbaceous Density/Opt		√	Abbreviated Tags	√	
	OP/Origin Buried		√	Crown Intercept/Opt		√
	Voucher Specimens/Rec	√		Herb. Fuel Load/Opt		√
	Stereo Photography/Opt		√	Brush Individuals/Rec	√	
	Belt Transect Width = 2 x 50 meters			Stakes Installed: All		
	Herbaceous Data Collected at: Q4-Q1 · Q3-Q2					
Burn Postburn	Duff Moisture/Rec		√	Flame Zone Depth/Rec	√	
	Herbaceous Data/ Opt	√		Herb. Fuel Load/Opt		√
	100 Pt. Burn Severity/Opt	√				

FOREST PLOT PROTOCOLS		YES (√)	NO (√)		YES (√)	NO (√)
Overstory	Area sampled	50 x 20 m		Quarters Sampled	Q1,Q2,Q3,Q4	
	Tree Damage/Rec	√		Crown Position/Rec	√	
	Dead Tree Damage/Opt		√	Dead Crown Position/Opt	√	
Pole-size	Area Sampled	25 X 20 m		Quarters Sampled	Q1 & Q2	
	Height/Rec	√		Poles Tagged/Rec	√	
Seedling	Area Sampled	25 X 10 m		Quarters Sampled	Q1	
	Height/Rec	√		Seedlings Mapped/Opt		√
Fuel Load	Sampling Plane Length	100 feet		Fuel Continuity/Opt		√
	Aerial Fuel Load/Opt		√			
Postburn	Char Height/Rec	√		Mortality/Rec	√	

Rec = Recommended   Opt = Optional

FMH-4 **MONITORING TYPE DESCRIPTION SHEET** Park: **GRCA**

Monitoring Type Code: F P I P N1D09 **Date Described**: 08/13/97

Monitoring Type Name: North Rim Ponderosa Pine Forest

Preparer(s): Kerr/Opperman

Burn Prescription: Units will be burned during monsoon season, or from September until May or until green-up with head, flanking, and backing fires to meet burn objectives. RH 15-60%; dry bulb 40-80°F; mid-flame winds 0-7 G15 mph; average flame length 0-4 feet; average rate of spread 0-14 chs/hour; 10-hour TLFM 5-12%; 1000-hour TLFM 11-30%; live fuel moisture 60-120%.

Burn Objectives: Reduce total fuel loading by 40-80% immediately post-burn; thin white fir > 6" dbh by 60% within 2 years post-burn; limit overstory ponderosa pine scorch to <30 feet; limit overstory ponderosa pine mortality to 20% within 2 years post-burn.

Monitoring Variables: Total fuel loading, overstory tree density.

Monitoring Objectives: Sample size sufficient to be 80% confident total fuel load figures are within 20% of the population mean; 80% confident overstory tree density figures are within 20% of the population mean.

Physical Description: 6,900 to 8,900 feet elevation on the North Rim; slopes range from 0% to >60%, including all aspects; soils are moderately shallow on ridgetops and silty loams in drainage bottoms, all are derived from Kaibab limestone parent material.

Biological Description: Total canopy cover is at least 25% ponderosa pine; white fir, trembling aspen, and Douglas-fir may be present with occasional Engelmann spruce; absolute canopy cover >50%; understory composed of scattered conifer and deciduous poles, seedlings, and shrubs (*Juniperus communis, Robinia neomexicana, Ribes viscosissimum*, and *Symphoricarpos* spp.).

Rejection Criteria: Large rock outcroppings or barren areas >20% of the plot; areas with anomalous vegetation, boundary fences; areas within 30 meters of roads, utility corridors, human-created trails, human-created clearings, or slash piles; areas within 10 meters of significant historic or prehistoric sites or transitional ecotones; areas burned in the last 10 years; areas with >50% overstory cover of trembling aspen.

FMH-4

PIPN1 Plot Protocols

GENERAL PROTOCOLS		YES (√)	NO (√)		YES (√)	NO (√)
Preburn	Control Plots/Opt		√	Herb Height/Rec	√	
	Herbaceous Density/Opt		√	Abbreviated Tags	√	
	OP/Origin Buried		√	Crown Intercept/Opt		√
	Voucher Specimens/Rec	√		Herb. Fuel Load/Opt		√
	Stereo Photography/Opt		√	Brush Individuals/Rec	√	
	Belt Transect Width = 2 x 50 meters			Stakes Installed: All		
	Herbaceous Data Collected at: Q4-Q1 · Q3-Q2					
Burn Postburn	Duff Moisture/Rec		√	Flame Zone Depth/Rec	√	
	Herbaceous Data/ Opt	√		Herb. Fuel Load/Opt		√
	100 Pt. Burn Severity/Opt	√				

FOREST PLOT PROTOCOLS		YES (√)	NO (√)		YES (√)	NO (√)
Overstory	Area sampled	50 x 20 m		Quarters Sampled	Q1,Q2,Q3,Q4	
	Tree Damage/Rec	√		Crown Position/Rec	√	
	Dead Tree Damage/Opt		√	Dead Crown Position/Opt	√	
Pole-size	Area Sampled	25 X 20 m		Quarters Sampled	Q1 & Q2	
	Height/Rec	√		Poles Tagged/Rec	√	
Seedling	Area Sampled	25 X 10 m		Quarters Sampled	Q1	
	Height/Rec	√		Seedlings Mapped/Opt	√	
Fuel Load	Sampling Plane Length	50 feet		Fuel Continuity/Opt		√
	Aerial Fuel Load/Opt		√			
Postburn	Char Height/Rec	√		Mortality/Rec	√	

Rec = Recommended Opt = Optional

FMH-4 **MONITORING TYPE DESCRIPTION SHEET** Park: **GRCA**

Monitoring Type Code: F P I P O1D09 **Date Described**: 08/13/97

Monitoring Type Name: South Rim Ponderosa Pine Forest

Preparer(s): Kerr/Opperman

Burn Prescription: Units will be burned during monsoon season, or from September until May or until green-up with head, flanking, and backing fires as needed to meet burn objectives. RH 15-60%; dry bulb 40-80°F; mid-flame winds 0-7 G15 mph; 10-hour TLFM 5-12%; live fuel moisture 60-120%; average flame length 0.5-4 feet; average rate of spread 1-14 chs/hour; 1000-hour TLFM 11-30%.

Burn Objectives: Reduce total fuel loading by 40-80 % immediately post-burn; reduce ponderosa pine <3" dbh by 50% within 2 years post-burn; limit overstory crown scorch to <30'; limit overstory mortality to <20% within 5 years post-burn.

Monitoring Variables: Fuel loading, overstory tree density.

Monitoring Objectives: Sample size sufficient to be 80% confident total fuel load figures are within 20% of the population mean; 80% confident overstory tree density figures are within 20% of the population mean.

Physical Description: 6,000 to 7,500 feet elevation on the South Rim on level to rolling terrain, including all aspects; soils are moderately shallow with a silty loam texture, all are derived from Kaibab limestone parent material; occasional barren rock outcrops.

Biological Description: Total overstory stems are 50-100% ponderosa pine; pinyon pine, Utah juniper, and Gambel oak may be present; absolute canopy cover is 20-60%; understory composed of shrubs (big sagebrush, squawbush, rabbitbrush, and cliffrose) and herbaceous (bluegrass, blue grama, lupine, snowberry, gooseberry and various grasses and sedges).

Rejection Criteria: Large rock outcroppings or areas >20% of the plot with <10% ground cover; areas with anomalous vegetation, boundary fences; areas within 30 meters of roads, utility corridors, human-created trails, human-created clearings, or slash piles; areas burned within past 10 years; areas within 10 meters of significant historic or prehistoric sites or transitional ecotones.

PIPO1 Plot Protocols

GENERAL PROTOCOLS		YES (√)	NO (√)		YES (√)	NO (√)
Preburn	Control Plots/Opt		√	Herb Height/Rec	√	
	Herbaceous Density/Opt		√	Abbreviated Tags	√	
	OP/Origin Buried		√	Crown Intercept/Opt		√
	Voucher Specimens/Rec	√		Herb. Fuel Load/Opt		√
	Stereo Photography/Opt		√	Brush Individuals/Rec	√	
	Belt Transect Width = 2 x 50 meters			Stakes Installed: All		
	Herbaceous Data Collected at: Q4-Q1 · Q3-Q2					
Burn Postburn	Duff Moisture/Rec		√	Flame Zone Depth/Rec	√	
	Herbaceous Data/ Opt	√		Herb. Fuel Load/Opt		√
	100 Pt. Burn Severity/Opt	√				

FOREST PLOT PROTOCOLS		YES (√)	NO (√)		YES (√)	NO (√)
Overstory	Area sampled	50 x 20 m		Quarters Sampled	Q1,Q2,Q3,Q4	
	Tree Damage/Rec	√		Crown Position/Rec	√	
	Dead Tree Damage/Opt		√	Dead Crown Position/Opt	√	
Pole-size	Area Sampled	25 X 20 m		Quarters Sampled	Q1 & Q2	
	Height/Rec	√		Poles Tagged/Rec	√	
Seedling	Area Sampled	25 X 10 m		Quarters Sampled	Q1	
	Height/Rec	√		Seedlings Mapped/Opt		√
Fuel Load	Sampling Plane Length	50 feet		Fuel Continuity/Opt		√
	Aerial Fuel Load/Opt		√			
Postburn	Char Height/Rec	√		Mortality/Rec	√	

Rec = Recommended   Opt = Optional