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Summary Of Fish Habitat/Water Quality Since The Silver Fire Of 1987

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EXECUTIVE SUMMARY

The Silver Fire of 1987 burned almost 100,000 acres within the Siskiyou National Forest. Since the fire, much work has been done to monitor the effects of fire and salvage logging within the burned area. Over half of the burned area was in the Kalmiopsis Wilderness which was left untouched subsequent to the fire. The remaining 42,350 acres were designated as the Silver Fire Recovery Project area. Monitoring began when the Record of Decision for the Final Environmental Impact Statement was issued by the Forest Supervisor in the summer of 1988.

Because of the emphasis on ecosystem management, monitoring was performed on a wide variety of elements, from fish habitat surveys to road construction to recreational use. This monitoring effort will provide important information on how well improved management practices are performing. The intent of this summary is to compile existing monitoring results to address the following question:

What are the effects of salvage logging and road construction on water quality/ anadromous fish habitat in the area of the Silver Fire of 1987?

From a review of the monitoring data that has been collected to date, it appears that the watersheds are recovering well from such a significant disturbance event. Actual effects from the fire and salvage logging have been significantly less than the predictions of the FEIS. The lack of adverse effects is attributed to, protection of riparian areas, improved road construction practices, and minimizing disturbance through the use of helicopter logging. Vegetation regrowth in the burned and salvaged areas has been very strong. Based on stream surveys, it appears that fish habitat and fish populations were not affected by the fire or salvage logging. The anadromous fish species of concern which spawn in the Silver and Indigo Creeks are the steelhead trout and the Chinook salmon.

The winter of 1995 produced the first storm of significant magnitude since the fire occurred. Additional monitoring data after this storm will be instrumental in bringing closure to some elements regarding effects of the fire and management activities. During the summer and fall of 1995, monitoring of roads, small stream channels, current fish habitat surveys, and landslide inventory from air photo interpretation will provide this needed information. Twelve miles of road were constructed for the salvage operation and are currently being monitored. After a cursory look at the conditions after the storm, it appears that management activities have not caused any adverse effects.

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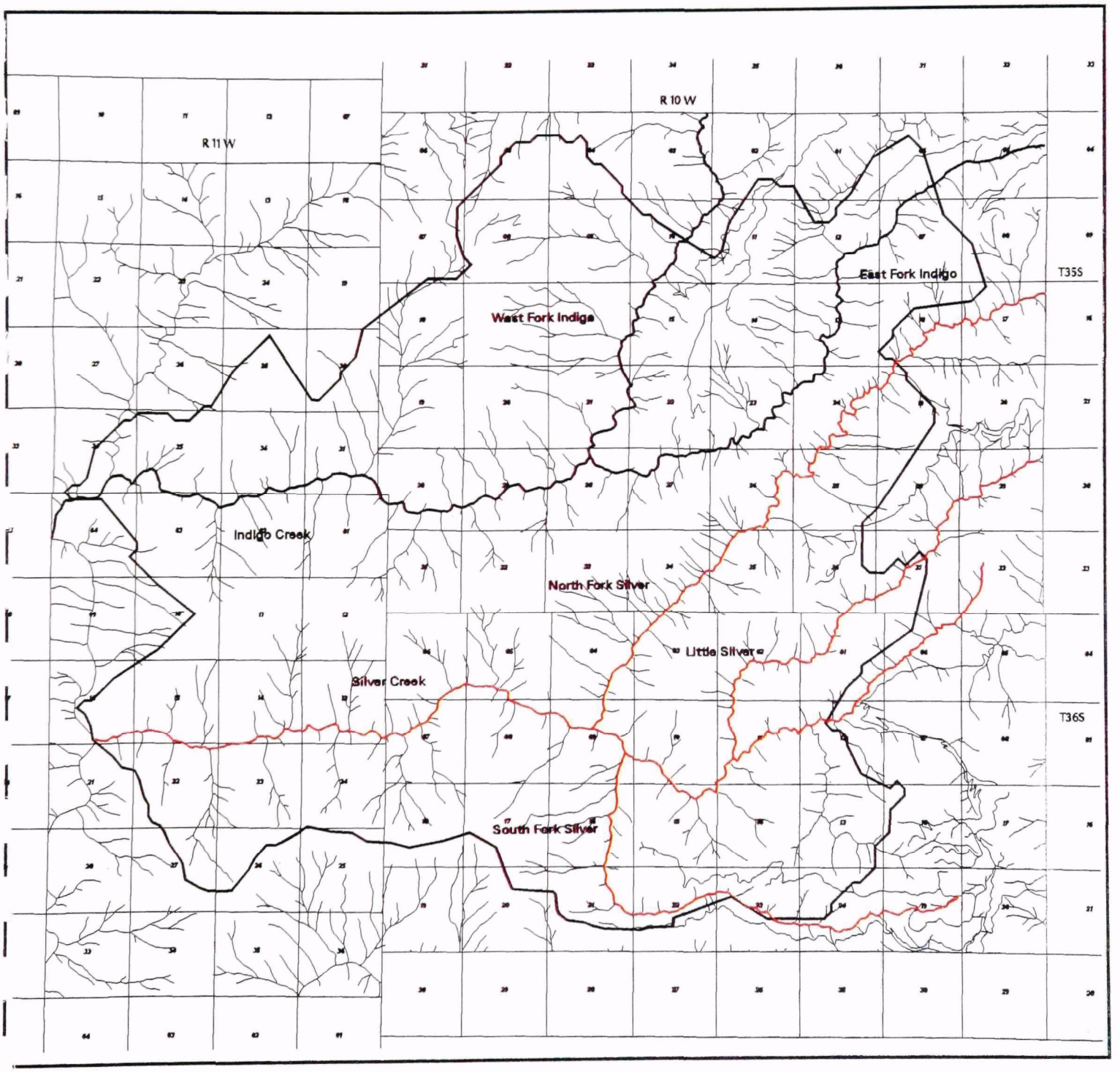
Silver Fire Recovery Project
Location and Area Map



PROJECT OBJECTIVES

The purpose of this report is to summarize existing monitoring data on the effects the 1987 wild fire and subsequent salvage operations had on water quality and fish habitat. This report will also look at the original monitoring objectives to see if they have been achieved, how well do actual conditions correlate with predictions of effects in the EIS and recommend additional monitoring and data analysis.

In addition to the existing data, it is essential that new monitoring data be collected. During the winter of 1995, there was the first large storm event within the project area since the fire. Monitoring after such an event is instrumental in understanding the effects of the fire and salvage logging. Planned monitoring includes: small and intermittent stream cross-sections including a stream shade survey, a landslide inventory for the current state of the watersheds, a fish habitat survey on some of the fish bearing streams, and a road inventory to complete original monitoring and assess current condition.

WILD FIRE AND TIMBER SALVAGE BACKGROUND

On August 30, 1987, lightning ignited, the Silver Fire. The fire burned until November, covering over 96,240 acres in the Siskiyou National Forest in southwestern Oregon. Approximately 42,350 acres were designated as the Silver Fire Recovery Project (SFRP). The Kalmiopsis Wilderness Area was left to recover naturally. Before the fire was completely controlled, work began on the Silver project.

The recovery project was located in the Silver Creek and Indigo Creek drainages which are just north of the Kalmiopsis Wilderness. Figure 1 shows the area and the location of the recovery project. Approximately 50% of the Silver Creek drainage burned; 24,200 acres out of 51,000 acres. And approximately 37% of the Indigo Creek drainage burned; 18,150 acres out of 49,400 acres. Both of these watersheds are tributaries to the lower Wild and Scenic Illinois River.

History of Fire

The following information regarding the history of fire was presented in the Silver Creek Watershed Analysis, April 1995, Ver. 1.0. This section applies to both the Silver and Indigo Creek watersheds that were affected by the 1987 wild fire.

Southwestern Oregon and the Siskiyou National Forest have a long history of major wildfires. In the warm-temperate, dry-summer, 'Mediterranean' climate of the Siskiyou Mountains, the forests are easily set afire; and fires of widely varying intensities have been frequent. Fires in 1987 were the third worst on record. The Silver Fire burned 96,240 acres.

Atzet, Wheeler, and Gripp (1988) described the settlement period of 1820-1910 as a period when fire was forced on the land by trappers, miners, ranchers, and settlers to eliminate vegetation, drive game, enhance forage and clear land. Fire suppression programs begun around 1910 have created a relatively fire-free condition except for the area that burned with the 1987 Silver Fire.

Fire frequency for prehistoric or pre-settlement times is a better reflection of the natural role of fire in the ecosystem than data from more recent times due to the large amount of burning during the settlement era. A 30 year average fire cycle for the Mixed Conifer forest type was determined by Agee (1991). Atzet and Wheeler (1982) determined fire cycles of 20 years for inland plant associations with cycle length increasing to 60 years or more for coastal areas. Natural fire cycle for Silver Creek and Indigo watershed is between 30 and 50 years.

The potential for future large fire occurrence is high to extreme. This is a result of the vegetation, steep slopes, and abundance of south aspects and lack of road access to help contain fires in large portions of the area. Roads that are within the watershed can also add to the likelihood of fire by introducing humans starts. There are portions of the Silver Fire area that contain heavy fuel loadings and have a high potential of burning again. Within the project area, 12 percent of the total burned at high intensity, 33 percent burned at medium intensity, and 54 percent burned at low intensity.

Environmental Impact Statement for Management Alternatives of the Fire Area

Soon after the fire was out, work began on preparing the Environmental Impact Statement (EIS). An interdisciplinary team convened to identify the issues, collect and interpret field data, develop a range of alternatives, refine mitigation measures, and estimate the environmental impacts of each alternative. Several major issues were at stake: rapid timber recovery of fire-killed trees, protection of water quality and fisheries, maintenance of site productivity, mitigation of the impact to wildlife habitat, reforestation, road construction in a largely roadless area, recreation experience and visual concerns, and the economics involved in each of these areas.

The EIS, as required by the National Environmental Protection Act of 1969, described the area and proposed several management alternatives. In the EIS all aspects of the affected environment were considered and the best management alternatives were presented. The selected alternative included significant attention to the water quality and fish habitat issues. It also included a moderate level of salvage logging and road construction.

Fire Salvage Activity

Commercial sized trees killed by the fire had an estimated 262 Million Board Feet (MBF) of timber. Of this total, approximately 95 MBF (36 percent) was actually salvage logged. Most of the logging was done using helicopters with a small percentage skyline logged.

To accommodate the salvage harvest, there were initially 20 miles of road proposed for construction. However, due to Congressional action, 8 miles of road were eliminated from the proposed plan, reducing the total mileage to12. Because of this change and the increased market price of timber at the time, it became economically feasible to fly logs more than twice the usual distance calculated for helicopter logging. This adjustment had considerable effect by reducing the amount of disturbance in the project area associated with road construction and skyline harvest. Salvage logging was done in areas of high or medium intensity burn where drainage hillslopes were in low to moderate risk of landslides.

Rapid recovery of the fire-killed timber was an important social and economic issue subsequent to the fire. The total amount of timber which was removed by salvage logging was approximately 5,700 acres, or 13 percent of the total 42,350 acres included in the Silver Fire Recovery Project Area.

The designated salvage logging areas and their acreage are as follows:

- Sugar Mountain: 626 acres total, 78% helicopter logged
- Lazy: 906 acres total, 95% helicopter logged
- North Face: two sales 236 acres total, helicopter logged only
- Hat Trick: 415 acres total, helicopter logged only
- Black Hat: 582 acres total, 60% helicopter logged
- Half Bald: 692 acres total, 96% helicopter logged

- Old Glory: 74 acres total, (Percentage of acreage that was helicopter logged is unknown for the rest of this list.)
- Silver Hog: 1484 acres total
- Blue Indigo: 232 acres total
- Hardscrabble: 243 acres total
- Deep Purple: 327 acres total

Emergency Burn Restoration

Immediately after the fire, emergency burn restoration was performed. Rehabilitation measures were designed to prevent offsite degradation of water quality and fisheries, to minimize soil erosion and productivity losses, and to prevent offsite damage to life and property. Treatments included aerial and hand sowing of grass and legume seed, fertilization, construction of check dams, construction of straw bale erosion barriers, spreading of straw mulch, planting shrubs and tree seedlings, and contour log structures (Gross et al., 1989).

The benefits of these treatments are unknown at this time. There is current controversy regarding the benefits of grass-seeding. It appears that grass and legume competition to conifers, herb, fungi, and shrubs is often severe in the first couple of years. Amaranthus (1993) reported that sugar pine seedlings in grass seeded plots experienced reduced root-tip and mycorrhiza formation, low levels of soil moisture to meet evapotranspirational demand, high levels of mortality, and reduced growth. In the monitoring which followed the Silver Fire, Amaranthus (1989) noted that grass seeding significantly reduced the presence of a particular shrub that hosts important nitrogen-fixing bacteria capable of increasing site nitrogen. Because high nitrogen losses can accompany intense fire, natural mechanisms that return nitrogen to the soil are important to long-term productivity.

MONITORING OF FIRE EFFECTS

Background

The Silver Fire Recovery Project has been closely coordinated with both the Environmental Protection Agency (EPA) and Department of Environmental Quality (DEQ). EPA and DEQ support of the project weighed heavily on the monitoring and communication between the agencies. The selected alternative included a comprehensive monitoring plan. Total ecosystem management was the approach taken in the plan. As a result, subsequent monitoring has produced a lot of data covering many aspects.

Since the fire of 1987, several government documents have been published that guide monitoring within the project area. These are listed as follows:

- **Record of Decision for the SFRP** - July 1988. The Forest Supervisor, Ron McCormick, identified reasons for the selected alternative as modified for the Final EIS. The desired alternative included the monitoring plan to be implemented.
- **Siskiyou Forest Plan**, May 1989. This document redirected the overall management goals to be achieved throughout the forest.
- **Eligibility Studies for both Silver Creek and Indigo Creek** and their tributaries used for determining whether or not these streams can be designated as National Wild and Scenic rivers.
- Record of Decision, the President's **Northwest Forest Plan** - April 13, 1994. This document presents the Aquatic Ecosystem Management guidelines and Aquatic conservation Strategy.

The documents listed above reflect the policy changes toward an "ecosystem" approach. The Silver Project is considered a pioneer in its objectives.

The approach toward monitoring was comprehensive. In 1988 and 1989, funding was directed to the Galice Ranger District specifically to accomplish Silver monitoring. It became an important focus of District resource specialists. A monitoring summary report was produced in each of those years. Monitoring covered many aspects, but there was little cohesion between the individual projects and in the documents which presented monitoring results.

By 1991, monitoring activities were significantly reduced from the 1989 level. This was do to two reasons: Short term implementation monitoring, to determine if project activities went as planned, was completed; funds for long term monitoring had been significantly cut and personnel priorities were shifted to other activities. In 1990 and 1991 the results of monitoring were briefly summarized on one page in a newspaper circulated to the public. The collaborative effort between the EPA and Forest Service to produce this report, was a joint exercise to summarize what had been collected for water quality and fish habitat monitoring. Therefore, this report will focus on the aquatic section of the Silver monitoring plan.

The monitoring was divided into individual projects based on discipline. The individual monitoring projects were grouped according to how their specific objectives achieved the overall monitoring goals and included, implementation, effectiveness and validation monitoring. The monitoring objectives were divided into the following groups:

Group 1 - Monitoring to insure that implementation is consistent with the law or by prior agreement with an outside agency (*implementation monitoring*).
Group 2 - Monitoring to insure that mitigation measures for reduction of potential adverse resource impacts are implemented (***implementation monitoring***).
Group 3 - Monitoring that will provide information to help make future management decisions (*effectiveness monitoring*).
Group 4 - Monitoring to add to the general data base (inventory) (*effectiveness monitoring*).
Group 5 - Research (*validation monitoring*).

These groups describe the priority order given to each individual monitoring project. In this report the overall monitoring group will be identified, but the monitoring activities will not be described in the order of the groups listed above.

This report will address the monitoring of sediment delivery, stream buffers, stream shade, and channel morphology. Following the discussion on upland and channel response, fish habitat will be evaluated.

Precipitation/Climate

Typically this area is characterized as Mediterranean with cool wet winters and warm dry summers. In the mountainous region of the fire area, the winters bring rain, snow and often rain on snow events. These rain on snow events can accelerate runoff and infiltration by the combination of melting snow with the precipitation. Saturation, resulting from heavy winter precipitation, can trigger landslides and slumps. Higher turbidity and peak flows also occur during the winter.

Within the context of observing watershed health, comparing precipitation records prior to and since the fire is necessary to understanding hydrologic effects. From 1987 to 1994 this area was been considered by many to be in a drought state. Average annual precipitation was below normal and there had not been a winter storm of significant magnitude. The 1995 season was the first year that annual rain fall were normal over the fire area. During the winter of 1995, there was a storm that ranged

from a 5 to 25 year return frequency in intensity in southern Oregon. The fact that there was an increase in the amount of precipitation and a storm of significance in 1995 was a strong reason to continue monitoring following that winter season. Comparing 1995's monitoring results with the results collected from the years directly after the fire will help in making conclusions regarding the overall health and recovery of the area.

Summary of Monitoring Activities

Table 1 presents a summary of the monitoring activities, the years that data was collected, and the number of sites or type of monitoring performed.

Landslide Monitoring

The geology of the area is dominated by the Dothan (also called Franciscan) sandstone of Jurassic Age with numerous igneous intrusions of diorite in the headwater of the Silver Creek drainage. The Dothan formation is characterized as a medium grained, well-indurated graywacke, with alternating mudstone layers. These rocks tend to weather to coarser soil textures than many soils common to other rock types of the Coast Range.

In 1988 and 1989, landslide monitoring was performed by Joe Cornell, geologist (now retired). The objective of the monitoring was to determine changes in slope failure rate due to the wildfire and/or management. The inventory was done using helicopter flights, aerial photos, and ground traverse.

Several conclusions from the monitoring were made. A historic landslide inventory was used to characterize the rate and volumes under natural conditions without management activities. It was determined that major episodes of mass wasting coincide with high precipitation winters. Another conclusion was that stream bank failure usually involves only 100 to 300 cubic yards.

Table 1
Summary of Monitoring Activities and Years Collected

Monitoring Activities:	Sites	Years Collected:
Sediment Loading: Landslide Inventory	air photo interpretation	1988-1989
Infiltration Rates	24 sites	1988-1989
Slope Erosion: Erosion Pins	4 sites	1988-1990
Roads and Landings: Erosion Pins	4 roads	1988-1992
Road BMPs: Field Review	field review	1988-1989
Stream Management Unit Width	24 units	1989
Cable Logging Layout	25 units in 8 timber sales	1989
Channel Changes: Cross-Sections Class III and IV	4 streams, 3 sets each	1988-1989
Channel Changes: Cross-Sections Class I and II	3 critical reaches	1988-1990
Peak Stream Flows	3 sites	1988-1989
Low Stream Flows	5 to 11 sites	1988-1993
Fish Habitat: Stream Surveys	1 to 33 miles	1988-1993
Fish Population: Electrofishing	3 sites	1988-1989
Stream Water Temperature	11 sites	1988-1993
Water Quality: Turbidity	auto. sampled 4 to 6 sites	1988-1989

Riparian areas that burned, suffered only underburn of brush. Only a few small fire-related landslides had occurred in the Silver project area through fall, 1994. In 1989 a natural landslide blocked the creek upstream of the fire area, forming a landslide dam and small lake. This landslide dam was reviewed by John Costa, USGS, and a report was written on that site. The dam was breached the following

winter in 1990, which trigger some slide activity.

Surface ravel along the inner gorges notably increased following the fire, but no calculations were made. Sediment delivery appears to be less than the modeled predictions in the Silver EIS. Had the precipitation and streamflow been average or above, landslide activity may have been different

During the summer of 1995 a helicopter reconnaissance flight was flown over the fire area with the purpose of looking for changes in the landscape that might have occurred since the last aerial photos were flown in 1992 and the recent storm event. Cindy Ricks, the Siskiyou National Forest Resource Geologist, and Elizabeth Kormeier, the EPA/NNEMS intern participated in the reconnaissance flight. There is photo/slide documentation of the flight available at the Galice Ranger District office in Grants Pass, OR.

From the helicopter flight, the following general observations were noted. Vegetation regrowth in the burned and salvaged areas has been very strong. Erosion from preexisting landslides was apparent. It appears that the main stream sections of both Silver Creek and Indigo Creek were not burned during the fire. The riparian areas look intact. Some of the riparian areas on the small intermittent streams had been burned but were not salvaged logged.

On some slopes where both fire and harvesting had occurred, the presence of rock debris chutes was noted. These are natural topographic depressions that when left exposed to precipitation are the first to collect material such as woody debris and the first to erode because water will travel down slope in these chutes. On other slopes where large woody material was left, the wood has fallen into these debris chutes and is slowly being transported down the hill with the help of gravity.

A natural slide that appears to be new this year occurred approximately 1/4 mile upstream from the mouth of Silver Creek (Figure 2). With the help of aerial photos taken in 1995, the amount of material which slid into Silver Creek can be estimated. It also appeared that there was a very shallow, new slide in a burned and harvested area on the south side, north-facing slope of Indigo Creek approximately one mile upstream from the mouth (Figure 3). As a very rough estimate, it appeared to be approximately 400 feet long and possibly between 6 and 10 feet deep; this would need to be verified using air photos from the flight that is scheduled for this fall.

The aerial photos taken in 1995 will be used to perform a landslide inventory that will be compared to the previous landslide inventory. By comparing the historic inventory to the post fire, it can be determined if the rates and volumes of landslides increased as the result of the fire and salvage logging.

Roads and Landings

Two monitoring projects were performed with the intention of evaluating road construction in the Silver Fire Recovery Project area. Roads and landings were monitored during 1988 and 1989 with the goal of verifying that the design, location and operation met the soil and water objectives. The hypothesis of the monitoring was that the Best Management Practices (BMP) for stream crossings, road construction, and landing construction would be implemented. The methods which were used by Paula Fong, a Siskiyou Forest soil scientist, were observation, fill slope measurements, and stream morphology measurements above and below new road drainage crossings to detect changes. The locations of this monitoring was in 4 places, 3 newly constructed road, and 1 road that was formerly in existence that was extended for salvage logging.

According to the summary of the 1989 Monitoring Report, of the 4 roads evaluated, only 2 showed noticeable movement. There was no fill movement on the new construction extensions of Bald Mountain Road and the original Bald Mountain. Road. The Black Hat and Sugar Mountain timber sale road systems showed measurable fill slope movement. Total precipitation did not account for differences in fill response. A more erosive fill material type and steeper gradient was associated with greater fill movement.

Barriers installed at the completion of road construction to minimize vehicle use were effective at protecting road drainage. Excessive vehicle use can cause road rutting, which results in channelizing water down the road surface. Quite often this water will end up draining on a fill slope which can cause erosion or fill failure. None of the fill slope showed signs of erosion.

It appears that the new road construction has not significantly contributed sediment to the stream systems. The new roads appear to have been well constructed, although some problems with drainage have been encountered with plugged culverts.

During the summer of 1995 a general survey of the new roads that were constructed for salvage logging, was performed. Preliminary results revealed, roads and road drainage do not appear to increased erosion or sediment delivery to streams. Aside from plugged drainages, no significant gullying has been found below culverts.

However, some of the landings are beginning to show signs of slumping and cracking. This is most likely caused by either natural decay of organic material that was incorporated in the fill or insufficient compaction at the time of construction, or a combination of both these factors. If these areas are allowed to continue to move, there is a likelihood that they could fail in the future delivering fill material downslope.

Figure 2: New Slide Into Silver Creek (Winter 1995)

New slide into Silver Creek,
close to confluence with the Illinois River.

Figure 3: Shallow Slide In Mainstem of Silver Creek (Winter 1995)

Shallow slide in burned and harvested area,
on north slope of mainstem Silver Creek.

Riparian Areas

The riparian areas are the sensitive zones along stream banks which integrate the land ecology with that of the stream. Preserving these areas from salvage logging has been a landmark for this project.

Stream Buffer Areas

The width of Stream Buffer areas, known as Stream Management Unit (SMU), were monitored to insure that mitigation measures for reduction of potential adverse resource impacts were met. The objective of this monitoring was to insure that the buffer widths, that had been prescribed for each of the streams, ranging from the small and intermittent to the larger fish bearing streams, had been accurately field located and adhered to during logging operations. The fish bearing stream of North Silver was given a 600 foot width buffer. The smaller fish bearing streams were given a 200 foot or greater width buffer. The perennial and intermittent streams were given buffer widths ranging from 25 to 200 feet depending on the size of the stream. Monitoring for the protection of riparian areas was done in the Bald Mountain and Chinaman Hat regions, as well as Indigo Creek. Results of the monitoring summary, report the project objectives and prescriptions were met during layout and harvest.

Cable Logging Compliance with Riparian Area Prescriptions

Cable Logging Layout monitoring was designed to monitor protection of riparian areas during timber harvest. Objectives of this monitoring included documenting if cable logging operations complied with riparian area prescriptions and related contract provisions. The objectives also included documenting corrective actions when not in compliance. Methods to monitor the harvests included weekly and/or daily inspections and subsequent completion of inspection reports. Of the total 5,700 acres which were salvaged, approximately 1,400 acres or 24 percent were cable logged. Results of the 1989 monitoring summary indicate that the operators performed high quality work with few violations. The occasional corrective action included stream clean out when material was impeding flow. It also included leaving trees when they provided benefit to the stream or their removal would damage stream channel or riparian vegetation.

Protection of these riparian areas during salvage logging operations was highly effective in meeting objectives where shade and protection against erosion and sedimentation are needed to maintain a healthy riparian ecosystem. From helicopter observation during the summer of 1995, it appears that the stream buffer areas are still functioning well and that they were very effective in maintaining stream bank integrity as well as reducing sediment delivery to the stream. A picture taken during the helicopter flights shows the preservation of the riparian buffers (see Figure 4 & 5).

Figure 4: Riparian Buffers on Bald Mountain

Riparian Buffers on Bald Mountain and Chinaman Hat (below).

Figure 5: Riparian Buffers on Chinaman Hat

Low Flows and Peak Flows

Low flow and peak flow monitoring was performed with the objective of determining the change in low flow volumes associated with fire during the critical July/August peak stream temperature periods through time. Flow data were also used to determine post-fire change in the infiltration rate.

Increases in flow were predicted in the Environmental Impact Statement prepared for the Silver Fire Recovery Project area. The hypothesis for the monitoring was that there is a potential for summer stream flows to increase if vegetation is either burned or removed during timber harvest. The flows were expected to increase for two reasons. First, because of the loss of evapotranspiring vegetation, groundwater levels would remain higher contributing to higher base flows in the streams. Second, because of the loss of so many trees, the accumulation of snow in the winter would be greater than pre-fire. This would cause an increase in runoff or infiltration which would increase stream flow. According to the hydrologic technician, who directed riparian area layout, the riparian areas had to be remarked as the perennial streams extended further upslope after the fire than they had historically (Howard Jubas, personal comm. 1995).

The methods used to detect peak flows were crest stage and staff plates. Unfortunately this monitoring was unsuccessful for the most part. For the low flows, measurements were taken by the hydrologist technician manually during the summer. Selected locations in both Silver and Indigo drainages were monitored for low flow. Peak flows were monitored in 1989 and low flows have been monitored from 1988 to 1993. Low flow measurements also exist between 1958 and 1967.

Figures 6 and 7 shows the low stream flow in Indigo and Silver Creeks with the amount of annual precipitation. The annual precipitation was estimated. Four NOAA stations were averaged with weighting placed on their elevations and distances from the project area.

In examining the graphs of annual inches of precipitation and the summer low flow measurements for Indigo and Silver Creeks. Indigo and Silver Creek have very similar patterns in stream flow. They appear to correlate very well. However, precipitation does not appear to have a good correlation. Low flows did not follow the pattern of increasing in wetter years and decreasing in dryer years.

Annual precipitation estimates are missing several months of data for 1993 and 1994. These values do not reflect the actual precipitation. Unfortunately, more accurate estimates for annual precipitation are not available.

In an attempt to understand the effects of fire on flow, correlations were made between the low flow measurements from the burned watersheds and unburned watersheds. The Illinois River at the Kerby gauging station and Sucker Creek were selected because of their comparable low flows.

Silver and Indigo Creeks correlate well with Sucker Creek from 1958 to 1967, values between 0.48 and 0.61. However, these creeks do not correlate with Sucker Creek after 1987. This could indicate some effect of fire on stream flow. However, when comparing the Illinois River at Kerby with Silver and Indigo Creeks, the flow measurements do not correlate very well between 1958 and 1967, but do correlate extremely well after 1987, especially on Silver Creek with a correlation value of 0.83. This would indicate that the fire didn't appear to have any effect on stream flow. Without more information and a more detailed look into the flow characteristics and the

precipitation patterns, it is impossible to make conclusions regarding the effects of fire and harvesting on streamflow.

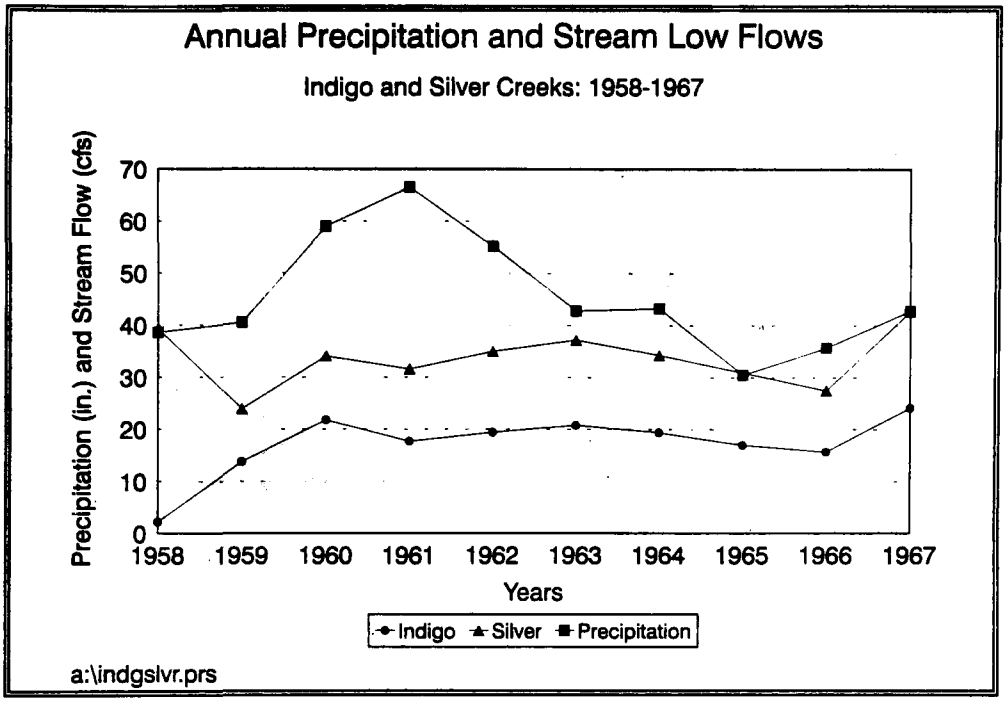


Figure 6: Annual Precipitation and Stream Low Flows (1958-1967)

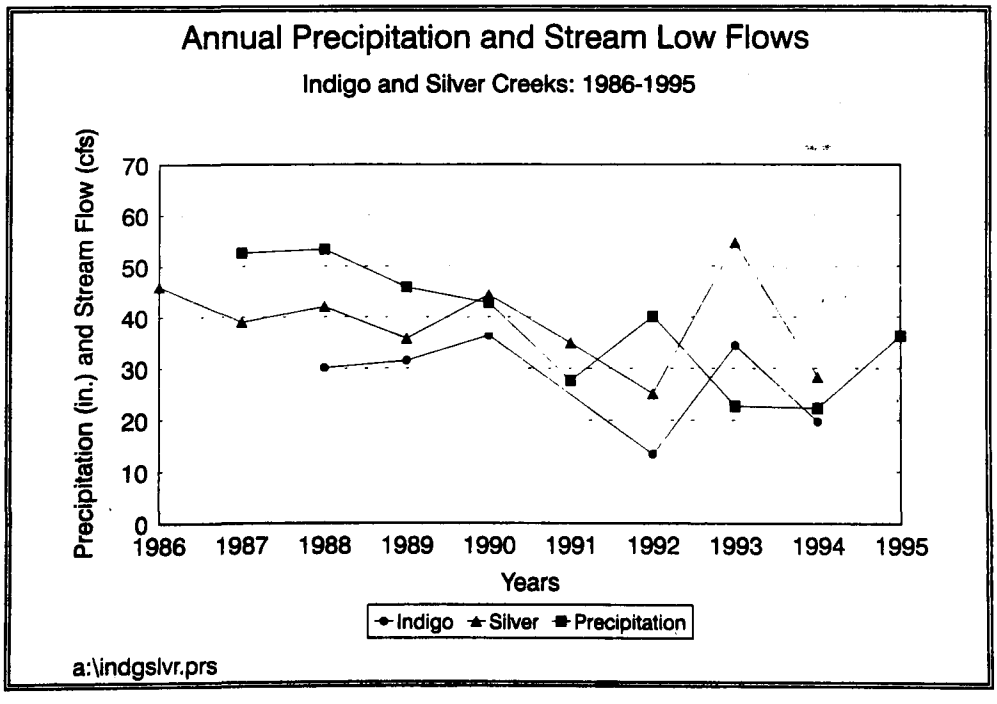


Figure 7: Annual Precipitation and Stream Low Flows (1986-1995)

Unfortunately, same day measurements were not available for Sucker Creek and Illinois River at Kerby, only monthly averages. Monthly averages were compiled for August and September, and depending on the day the measurement was taken for Silver or Indigo Creek, the corresponding monthly average was used.

Stream Morphology

Stream channel monitoring took place during 1988 and 1989 with the goal of detecting stream morphology changes due to increased sediment from the fire, timber harvest and road construction. This monitoring was performed under Group 3, or monitoring that will provide information to help make future management decisions. The hypothesis of the monitoring was that stream bank erosion and sediment deposition in the streambed will increase. In the FEIS, it is stated that, "vegetative recovery within the watershed and the high natural sediment transport rates are expected to return stream sediment loading to pre-fire conditions in about twenty years" (SFRP FEIS, p. IV-76). The methods which were used for this monitoring were cross-sections using the sag tape method, stream channel inventories, channel gradients, photos, stream side area fire evaluation, R-1 Stream Reach Inventory, and Channel Stability Evaluation.

The monitoring locations were intended to be 6 headwater streams, but because of access, unavailable personnel, and funding difficulties, only 3 headwater streams along the east-facing slope of Bald Mountain in the South Fork Silver drainage were monitored. The burn intensity of the streams varied. Riparian areas were left intact on these streams and some of the upslope areas were salvaged logged. The streams that were monitored coincided with the stream shade/stream temperature monitoring on two headwater streams. The other headwater stream was monitored for channel morphology and not shade/stream temperature.

The channel cross-sections were analyzed graphically as well as mathematically. Stream channel cross-sections were analyzed for the change in area between the same cross-sections measured in two consecutive years. The three streams analyzed were labeled streams B, C, and D. Graphs of the actual cross-sections are presented in Appendix B.

Cross section area is a useful tool in evaluating total area change from one year to the next, but it is not sufficient to understand fully what is happening within the stream channel. Is there aggradation or degradation occurring? It is possible that a significant change in shape could occur with virtually no change in area. To get a better sense of channel change, in addition to area, the Gini coefficient was determine to detect change in channel shape and width to depth ratio to determine if the channel was becoming more deep or wider. A computer program has been developed by Paul Schinke, hydrology assistant, to analyze cross-sections and arrive at these various indices.

The cross-sections taken in 1988 and 1989 have been analyzed, but significant changes in cross-section shape have not occurred. In such a short time period with a mild winter in between, changes were not expected. These measurements, however, were beneficial in establishing a baseline that future measurement can be compared to. The cross sections were remeasured in 1995 and the results will be published in a subsequent monitoring report on collected 1995 data.

In the larger mainstem of Indigo and Silver Creeks, stream morphology was monitored at fish bearing critical reaches between 1988 and 1990. The main hypothesis of the monitoring

was that stream power in critical reaches will be sufficient to transport bedload sediment from the fire and management activities though the critical reaches on Silver and Indigo Creeks. To monitor changes in stream morphology, equi-spaced cross-sections were surveyed in pools and glides. In addition, particle size distributions of bed material and channel gradients were surveyed. The surveyed units represent 50% of each critical reach length. Stream shade was also monitored using a solar pathfinder. An additional reach was added to the monitoring program in 1989. As of now, there are no significant volume changes; however, there have been minor shifts in the location of sediment. Large volumes of fine sediment appeared to be the result of local source areas, not fluvial transport of fire or management related sediment. The monitoring data supports the prediction that stream power is sufficient to prevent accumulation.

Fish Habitat

Fish habitat monitoring was included in monitoring Group 1, or monitoring to insure that implementation is consistent with the law or by prior agreement with an outside agency. The first objective of the fish habitat monitoring was to document changes in steelhead and chinook habitat due to fire and management activities. The second objective was to document changes in summer steelhead populations. The third objective was to compare predicted habitat capability with observed monitored values. The hypothesis was that the steelhead and Chinook population and habitat will change as predicted in the Smolt Habitat Capability Index model. The methods used were electrofishing during 1988 and 1989 to detect changes in summer steelhead population, and the Hankin and Reeves Stream Survey Method to document the changes in habitat. In addition aquatic macro-invertebrate sampling was performed. Over 750 photo points were taken in 1988 and 1989 to provide record of the present day stream and stream side conditions. The stream survey results are summarized below.

Based on the Smolt Habitat Capability Index model used in the FEIS, steelhead smolt populations were expected to decrease by 23 percent from pre-fire levels. The Chinook smolt populations were expected to decrease by 4 percent from pre-fire levels. However, population tracking is difficult when the fish of concern are anadromous, which migrate over long distances and are effected by many factors, both natural and human caused.

Stream Surveys

The stream survey includes the following parameters: fish standing crop (electrofish selected location or use mask and snorkel), habitat typing (pool: riffle: glide: cascade), volume and area of each habitat unit, large woody debris, substrate composition (visual estimate), spawning gravel locations and quality, barriers to fish migration, photos, and water temperature.

Results of the 1989 monitoring summary indicated there was a significant increase in pre-smolt steelhead between 1988 and 1989. Many factors can influence the populations of biological species which have natural fluctuations from year to year. No significant difference was noted in aquatic stream habitat between the two years as indicated by benthic macro-invertebrate sampling. Fish habitat and populations appear healthy in Silver and Indigo Creeks following fire and management activities. Numerous factors may account for this such as extremely mild winter between 1987 and 1988 which kept sediment increases to a minimum. As of the time of monitoring, harvest activity and roads have not caused watershed impacts that would lead to significant changes in stream conditions. Increases in large woody material in the fire area may have had a beneficial impact on fisheries.

Stream surveys have been done every year since 1988; however, the streams that were surveyed each year were different. The list of streams surveyed did not remain constant from year to year. The streams that were surveyed in the SFRP area and their respective ratings were as follows:

- Silver Creek: 9+ (surveyed 1988-1991)
- North Fork Silver Creek: 8 (surveyed 1988-1990)
- Little Silver Creek: 7+ (surveyed 1988-1989, and 1991)
- South Fork Silver Creek: 4 (surveyed 1988-1989)
- Indigo Creek: 9 (surveyed 1988-1990)
- East Fork Indigo Creek: 8 (surveyed 1988-1990, and 1992)
- West Fork Indigo Creek: 8 (surveyed 1988-1992)

These survey ratings give an indicator of stream habitat and salmonid fish production capability. Streams were rated on a scale of 1-10 with 1 indicating the poorest capability and 10 indicating the highest. The higher ratings were characteristic of streams which have good to excellent habitat for anadromous fish migration. Waterfalls are considered barriers to migration. South Fork Silver Creek received a lower rating because of its steep gradient, frequent debris jams causing passage difficulty, low fish counts, and primarily resident trout. During all years that surveying was done, the ratings did not change.

The species of fish which are particularly susceptible to habitat changes are the anadromous species of salmonids. Anadromous fish are the fall-Chinook salmon, steelhead trout, and the sea-run cutthroat trout. Resident fish that have been observed are the rainbow and cutthroat trout. Non-game species are sculpins and redside shiners. The redside shiners are indicators for higher temperatures. These fish can withstand the higher temperatures, whereas the anadromous species cannot.

Silver and Indigo creeks are major tributaries to the Illinois River. This river feeds into the Rogue River. The Rogue River fishery is world famous for its anadromous salmonids. Indigo Creek contributes approximately 13.9 miles of anadromous fish habitat and spawning ground. Silver Creek contributes approximately 20.2 miles of anadromous fish habitat and spawning ground.

Table 2
Silver and Indigo Fish Bearing Stream Miles

Creek	Stream Miles
Mainstem Silver	12.9
North Fork Silver	5.0
South Fork Silver	0.25
Little Silver	0.95
Todd Creek	1.1
Mainstem Indigo	8.1
West Fork Indigo	3.4
East Fork Indigo	2.4

Overall fish populations have been high since the fire of 1987; however, this statement is based on the quality of fish habitat and observation during the stream surveys. Because the endangered fish of concern are the anadromous species, and migration is inherent to these species, population estimates and figures are difficult to achieve.

It is the wild stocks of fish that are at the forefront of concern. The wild stocks have a greater diversity within the genetic pool. Maintaining and protecting these fish is a very high priority.

The Oregon Department of Fish and Wildlife (ODFW) has a list of Sensitive Species and Stocks of Concern. Two of the species on the list occur in mainstem Silver. They are the Fall Chinook Salmon and the Illinois River Winter Steelhead. The American Fisheries Society (AFS) also has a list of Sensitive Species and Stocks of Concern with these same fish listed. The National Marine Fisheries Service may review these species for potential listing under the federal Endangered Species Act. The Chinook does not occur on the mainstem Indigo.

Water temperature is a critical limiting factor for the survival of salmonids, especially during the warm summer months. For fish survival, temperature ranges from 45 to 59 degrees Fahrenheit are optimal, 59-69 degrees F are less than optimal, from 69 to 75 degrees F growth ceases, and above 75 degrees F there is mortality (p.III-91, Siskiyou National Forest Plan, Final Environmental Impact Statement). Temperature will be more thoroughly discussed in a subsequent section. Temperatures in the Illinois River have been somewhat higher than optimal, thus making a stressful environment for rearing salmonids. The problems in the Illinois River are compounded by the presence of a competitor species, the redside shiner. The redside shiner is capable of survival in higher average temperature streams than the salmon or the trout. Increased water temperatures due to changes in riparian vegetation from management activities could reduce salmonid abundance or production (Reeves et al., 1987).

As for the findings from the stream surveys, qualitatively Silver Creek has excellent fish habitat. However, there is opportunity for structural and non-structural improvements in and along the channel. During peak temperature periods the lower reaches of Silver Creek are creating a stressful environment. Temperature measurements during peak temperature periods in the upper reaches are cooler and provide excellent water quality for resident trout.

Table 3 presents a synopsis of the stream surveys and the year that these surveys were performed.

Table 3
Stream Survey Results

Stream	Years	Stream Habitat Summary
Silver Mainstem	1988-1991	Good to excellent for anadromous fish migration up to mile 12.7, site of the 1989 landslide. Good resident habitat above the landslide barrier. Fewer pools and less cover than lower reaches.
North Fork Silver Creek	1988-1990	Good condition. A steeper gradient, large boulder segment in the confluence area could limit fish passage during low flow periods. Waterfalls at approx. 5 stream miles from mouth.
Little Silver Creek	1988-1989, 1991	Anadromous fish passage ends at waterfalls, 1.0 miles up. Resident habitat abundant above falls. Important salmonid habitat for the Illinois River. Winter steelhead, no Coho or Chinook. Average stream temp. while surveying is 52 degrees F.
South Fork Silver Creek	1988-1989	Steep gradient, frequent debris jams causing passage difficulty, low fish counts, thought to be primarily resident trout. Low flow is 3.6 cfs at mouth. Winter steelhead use the lower 0.25 miles of stream. Rainbow and cutthroat were found for another 6 miles upstream.
Indigo Creek	1988-1990	Important tributary for fish production. Minimal management keeps pristine conditions. 45 ft. of wetted channel width near mouth. Increase in fish numbers in 1990 possibly due to an increase in summer flow, an increase in the macro-invertebrate community due to additional nutrients entering the stream occurring from the 1987 Silver Fire.
East Fork Indigo Creek	1988-1990, 1992	Lower reaches have excellent fish habitat. Middle: 3 subsurface areas between Breezy and Chief Creeks, in stream sediment, low amounts of wood. Upper: 5 subsurface areas above Chief Creek, past timber harvest, low flows, minimal pool habitat.
West Fork Indigo Creek	1988-1991	Anadromous fish habitat was excellent up to a natural landslide (created West Indigo Lake) at stream mile 6.8. However, 3 areas of summer subsurface flow exist. Winter steelhead and possibly sea-run cutthroat. No Coho or Chinook salmon present. Abundance of sediment in the systems from natural landslides. West Indigo Creek has a lower amount of pool and glide habitat, and grater amounts of riffle habitat than most of the other systems in the Silver Fire area. An increase in sediment would likely increase the amount of riffle habitat and decrease pool and glide habitat. Substrate size in riffles would likely become more uniform, which in turn would decrease the quality of the riffles used by the smaller size salmonids.

All of these summaries were compiled from the Stream Survey Reports, years 1988 through 1993, for the Galice Ranger District, Siskiyou National Forest.

Large wood recruitment has increased as a result of the fire. Increased recruitment and delivery to channels has been identified in the stream inventory monitoring, from aerial reconnaissance of the area, and from the recent low level aerial photos. Increases in the large wood recruitment process is probably one of the major benefits of the fire for improving channel condition, fish habitat, and site productivity. Large woody debris is abundant in the stream channels at this time. During the helicopter reconnaissance flight, large accumulations of wood from the fire-killed trees eight years ago were present in the North Fork Silver Creek, Little Silver Creek, and West Fork Indigo Creek.

Substantial amounts of large wood are present in the tributaries delivered to the stream from the burn areas. Large wood accumulation were seen in North Fork Silver Creek and West Fork Indigo Creek (Figure 8 & 9). Large wood was also seen in the mainstem Indigo Creek. It appears that more wood has accumulated in the steeply sloped, burned, smaller tributary drainages rather than the lower mainstem of these creeks. This maybe attributed to the larger mainstem channel and greater associated stream power which has the capacity to move the wood more quickly.

Figure 8: Large Wood Pile in North Fork Silver Creek

North Fork Silver Creek

Figure 9: Large Wood Pile in West Fork Indigo

West Indigo Creek

Water quality/Compliance

Water quality refers to the physical and chemical parameters which enable the biosystem of the stream to function. Parameters such as temperature and turbidity are important for health of the macro-invertebrate community, the plants, and the fish, both resident and anadromous. These parameters, because of their importance, are regulated by the federal and state governments.

Stream Shade and Temperature

Fire effects, which in areas burned riparian vegetation, were expected to increase stream temperature as the result of the loss of stream shade in the watershed. Standing burned trees in the riparian area still provide some stream shade. If these trees were salvaged logged, stream temperature was expected to increase further. However, with selection of alternative I-Modified and implementation of stream buffer zones to preserve the riparian area, stream temperature was expected to show no increase because of salvage logging.

Increases in stream temperatures have been shown to cause the following: increased fish mortality, increased fish metabolism which increases fish oxygen demand, increased diatom diversity (such as blue-green algae), and increased pathogenic bacteria which links back to fish mortality. The Oregon Water Quality Standards for temperature pertinent to the Silver Fire area is [OAR 340-41-365(2)(b)].

Stream temperature monitoring was done as part of monitoring Group 1, monitoring to insure that implementation is consistent with the law or by prior agreement with an outside agency. Stream shade was included in Group 3, monitoring that will provide information to help make future management decisions. The objectives of this monitoring were to validate the water temperature predictions made in the original model used in the Environmental Impact Statement. The selected alternative included the prediction that temperatures would not increase as the result of salvage logging. The hypothesis of the monitoring was that the buffer zone prescriptions will maintain stream shade and water temperatures at post-fire levels.

In October 1988, Mike Amaranthus, Howard Jubas, and David Arthur presented a scientific paper at the Symposium on Fire and Watershed Management entitled "Stream Shading, Summer Streamflow and Maximum Water Temperature Following Intense Wildfire in Headwater Streams". This paper reflected stream shade monitoring that was done after the fire. The streams analyzed were labeled streams A, B, and C. Two of the three headwater streams that were measured are the same streams that were analyzed for changes in channel morphology, streams B and C. The focus of the paper was to compare the upstream temperature with the downstream temperature as they flowed through heavily burned areas. Stream shade had been reduced from pre-fire levels of approximately 90% or greater to less than 30% post-fire. Flow measurements were observed as well, and it was concluded that the higher the rate of flow, the less of a temperature increase will occur.

The methods employed for this monitoring program were to establish a transect for the solar pathfinder measurements and mark the location with rebar. Streamflow measurements were made in each of the streams using a USGS (United States Geological Survey) calibrated flume. The streamflow measurements were taken on July 25. Streamflow varied from 0.035 cfs to 0.076 cfs. The reach lengths varied from 4920 feet to 7710 feet. Stream temperatures were taken using calibrated minimum/maximum thermometers at the above and below portions of the selected reach. The thermometers recorded temperatures from June 15 to

September 15. Temperature increases along the three streams ranged from 6 degrees Fahrenheit to 18 degrees F. The maximum stream temperatures themselves ranged from 55 degrees F to 73 degrees F.

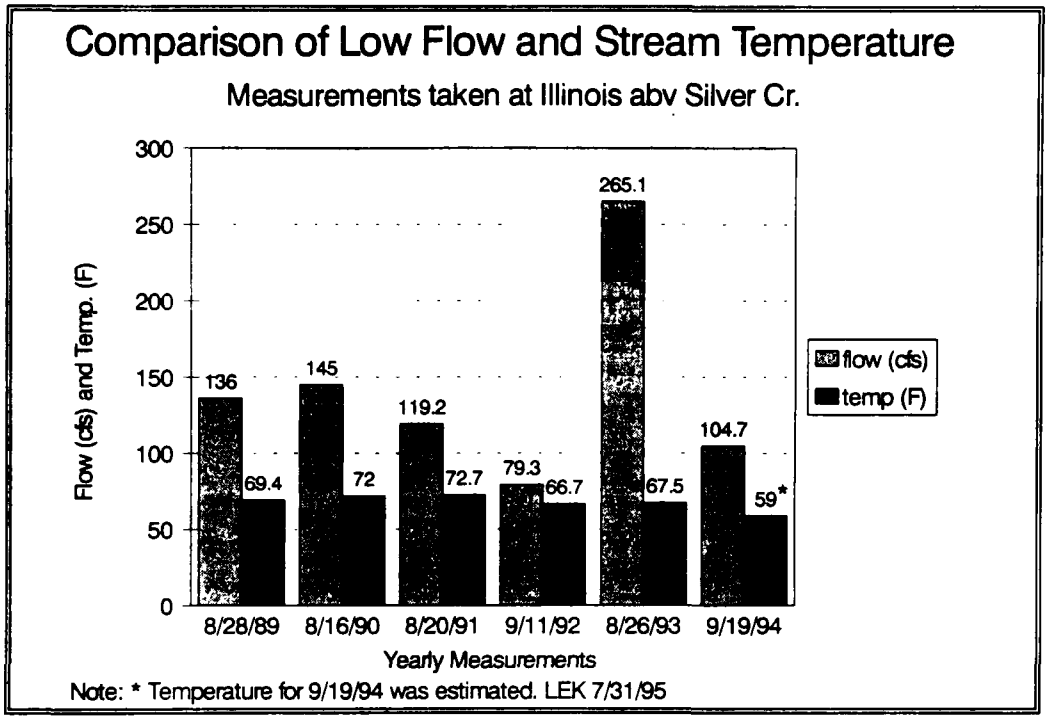


Figure 10: Comparison of Low Flow and Stream Temperature At Illinois River

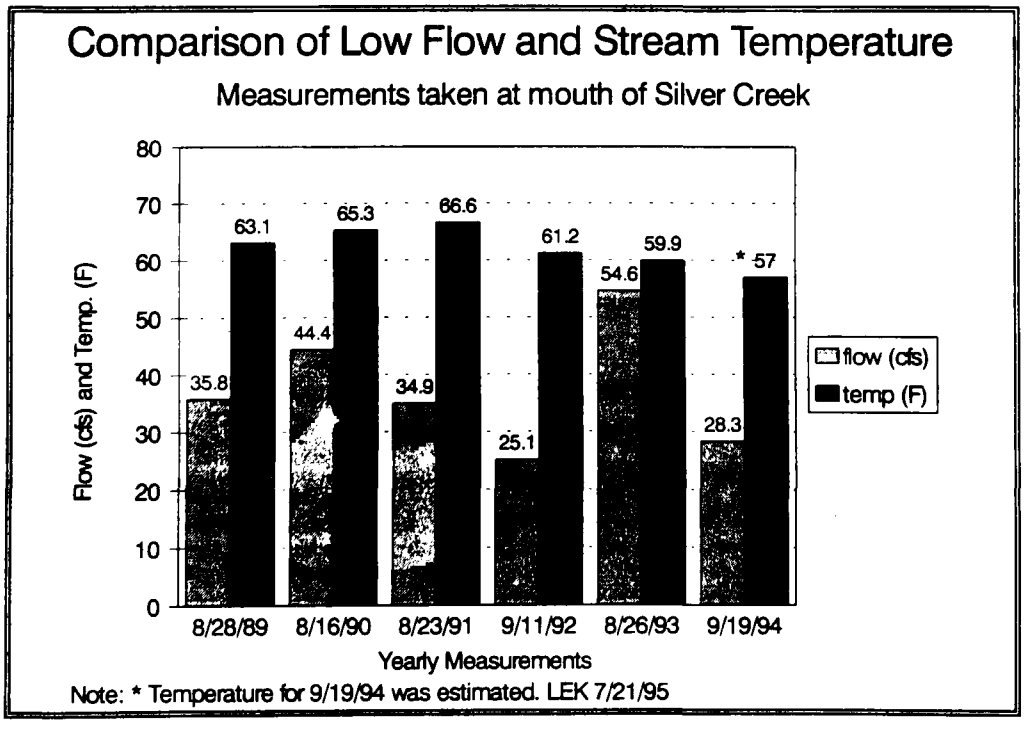


Figure 11: Comparison of Low Flow and Stream Measurement At Silver Creek

Because these are headwater streams, stream flow is extremely low. The length of the reaches where temperature was measured at the top and bottom range from over three quarters of a mile to almost a mile and a half. Because a "control" stream, one that had not burned or been subject to salvage logging, was not used for comparison, the significance of the temperature increases cannot be concluded. The monitoring did show that dead trees do provide stream shade.

Summer stream temperatures have been measured using Ryan tempmentors since 1988 at the mouth of Silver Creek and on the Illinois River above and below the mouth of Silver. Ryan thermographs measure the daily highs and the daily lows. These data can be referenced at the Galice Ranger District office in Grants Pass, OR via Howard Jubas, the hydrology technician. Temperatures have varied due to natural variation in streamflow, air temperature and other factors, but have not measurably increased as the result of the fire. Please see Figures 10 and 11 which are bar graphs for the Illinois River above Silver Creek and Silver Creek at the mouth.

The two figures compare low flow with same day temperature for Silver Creek at the mouth and the Illinois River above Silver Creek. Temperatures for Silver Creek at the mouth, corresponding to the days when low flow measurements were taken, range between approximately 57 degrees Fahrenheit and 66.6 degrees F. The Illinois River low flow temperature range from approximately 59 degrees F to 72.7 degrees F.

Fish bearing stream temperatures do not appear to have increased as a result of loss of stream shade in the headwater streams. Review of the monitoring data indicates that less than 5 percent of the headwater streams burned in this manner and that post-fire maximum water temperatures have not appreciably increased at the mouth of large downstream tributaries draining the fire area. One surprising conclusion that can be drawn from examining these graphs is that years that had lower flows do not correspond to higher temperatures. The flow data and the temperature readings do not appear to be related in any way.

Figures 12 and 13 present the seven day highs which more accurately represent the sustained peak temperature that the stream carries. Figure 12 depicts the seven day average around the peak temperature for South Fork Silver Creek, Silver Creek upstream or above the mouth of South Fork, and Silver Creek at the mouth. The maximum temperature that Silver Creek at the mouth has sustained is 71.7 degrees F. South Fork Silver Creek is contributing cooler temperature water to Silver Creek. Figure 13 depicts Indigo Creek at the mouth, Silver Creek at the mouth and the Illinois River above Silver Creek. It is clear that Indigo and Silver Creek both contribute cooler temperature water to the Illinois River.

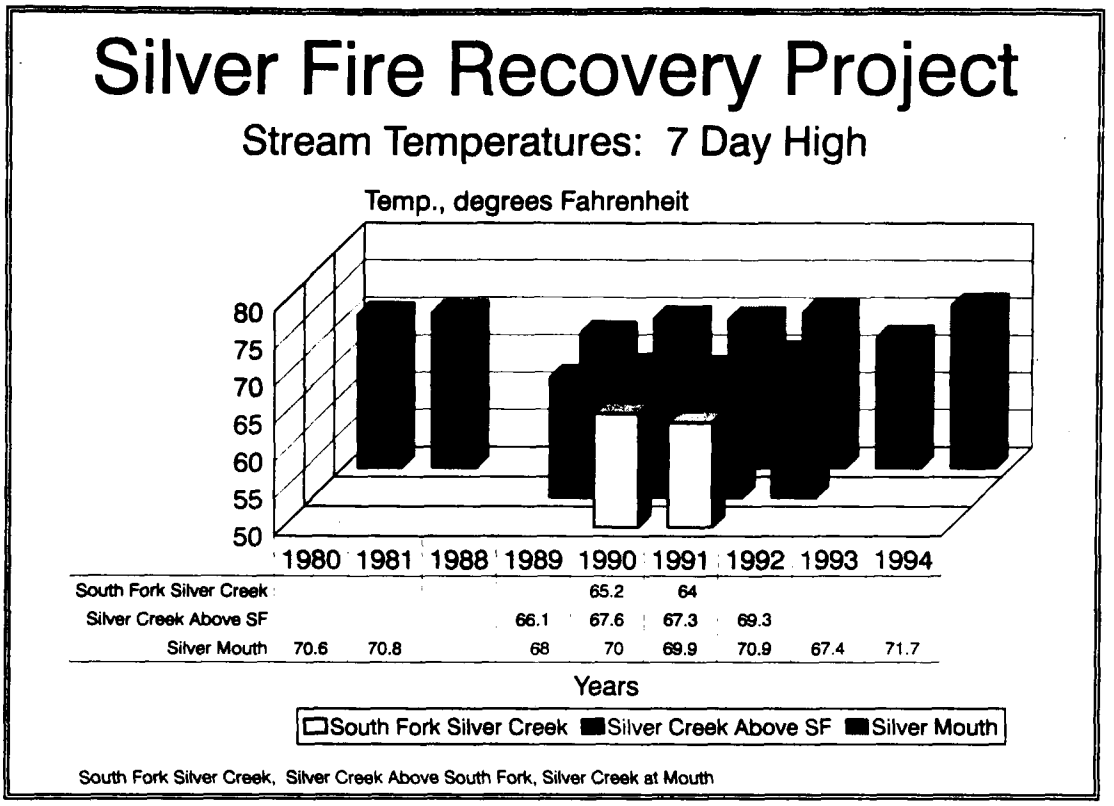


Figure 12: Stream Temperatures: 7 Day High (Figure 1)

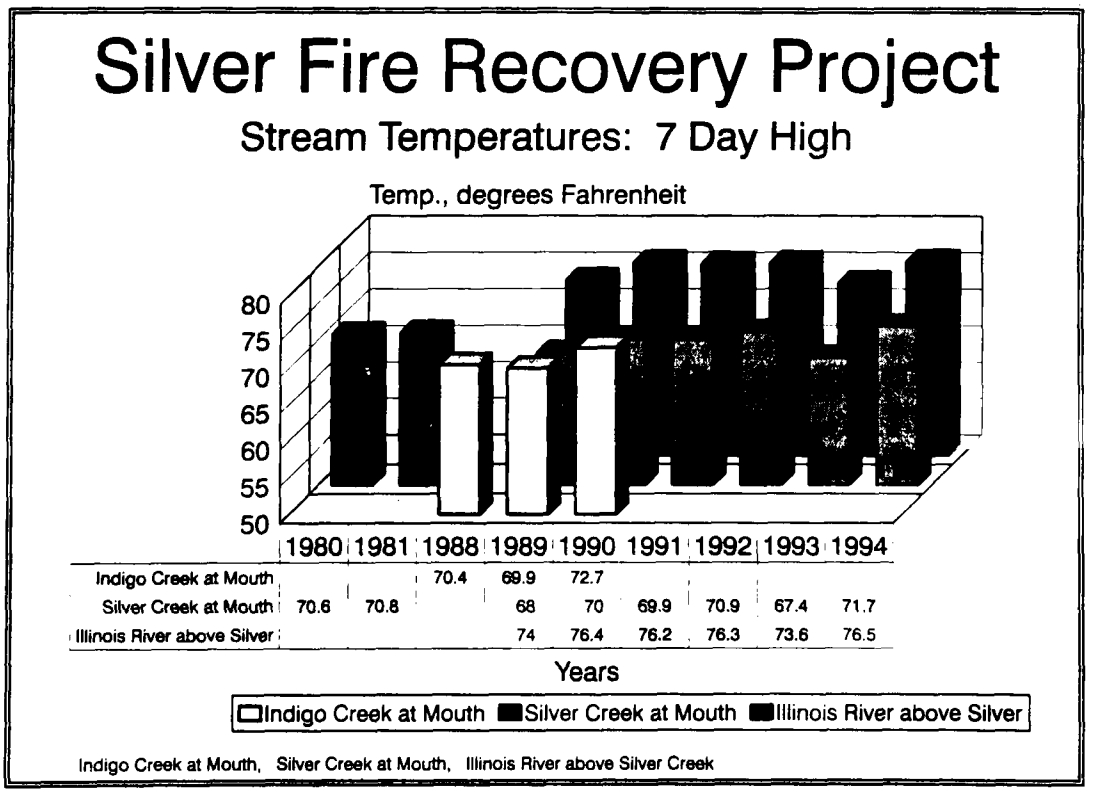


Figure 13: Stream Temperature: 7 Day High (Figure 2)

Turbidity

Turbidity refers to the amount of light that is scattered or absorbed by a fluid; thus, turbidity is an optical property of the fluid. Turbidity is usually due to the presence of suspended particles of silt and clay, but other materials such as finely divided organic matter, colored organic compounds, plankton, and microorganisms can contribute to the turbidity of a water sample (EPA Monitoring Guidelines, p.102).

Surveillance monitoring of non-point source pollution or turbidity monitoring was included in Group 1, or monitoring to insure that implementation is consistent with the law or by prior agreement with an outside agency. The objectives of the monitoring were two-fold: to determine the sources of pollution when in-stream turbidity measurements indicate excessive turbidity, and to determine the amount of turbidity during periodic runoff events. The hypothesis was that the best management practices which were implemented, such as the riparian buffers, will be effective in controlling non-point source pollution and excessive turbidity will be wildfire related.

High turbidity levels adversely affect the feeding and growth of salmonids and other fish species. A recent review concluded that the ability of salmonids to find and capture food is impaired at turbidities in the range of 25-70 NTU. NTU refers to nephelometric turbidity units, a unit measured by a photoelectric turbidimeter. Other studies indicate that growth is reduced and gill tissue is damaged after 5-10 days of exposure to water with a turbidity of 25 NTU. At 50 NTU some species of salmonids are displaced (EPA Monitoring Guidelines, p.103).

The Oregon Water Quality Standards for turbidity (OAR 340-41-365) state, no more than a 10 percent cumulative increase in natural stream turbidities shall be allowed, as measured to a control point immediately upstream of the turbidity causing activity. Since the increases must include cumulative increases, it is important to review turbidity conditions and management activities upstream of the Silver Burn area.

Potential sources of turbidity in the headwaters of Silver and Indigo Creeks include disturbed soils associated with timber harvest and roads. Sloughing of soils on some cut banks may be occurring in over steepened areas. Raveling of fills on roads with sidecast construction may be continuing in a few areas. Some timber harvest units contain ephemeral streams that were not sufficiently protected during earlier harvest practices, which may exhibit erosion. While these may be potential sources of turbidity and sediment, no problems resulting from these areas are known (SFRP FEIS, p. III-35).

The prediction from the SFRP Final Environmental Impact Statement is that the Silver Fire is expected to increase the potential for turbidity in Silver and Indigo Creeks. The predicted increase in turbidities and sedimentation are 54 to 335 percent above the pre-fire levels including the modeled effects of previous harvest activities. The greatest potential sources of turbidity increases within the project area are in stream side inner gorge areas. Fine sediments within the channels of burned small and intermittent stream banks are also potential sources of turbidity. There are no pre-fire levels, though, to compare with current levels.

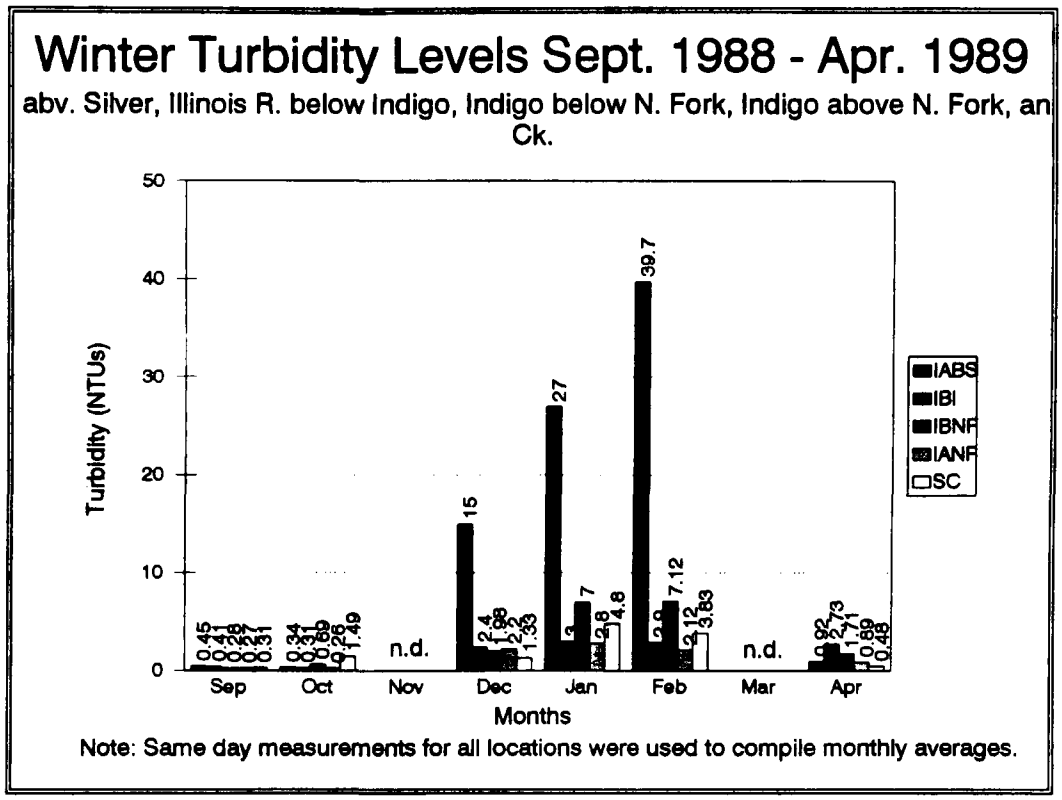


Figure 14: Winter Turbidity Levels (Sept. 1988 - Apr. 1989)

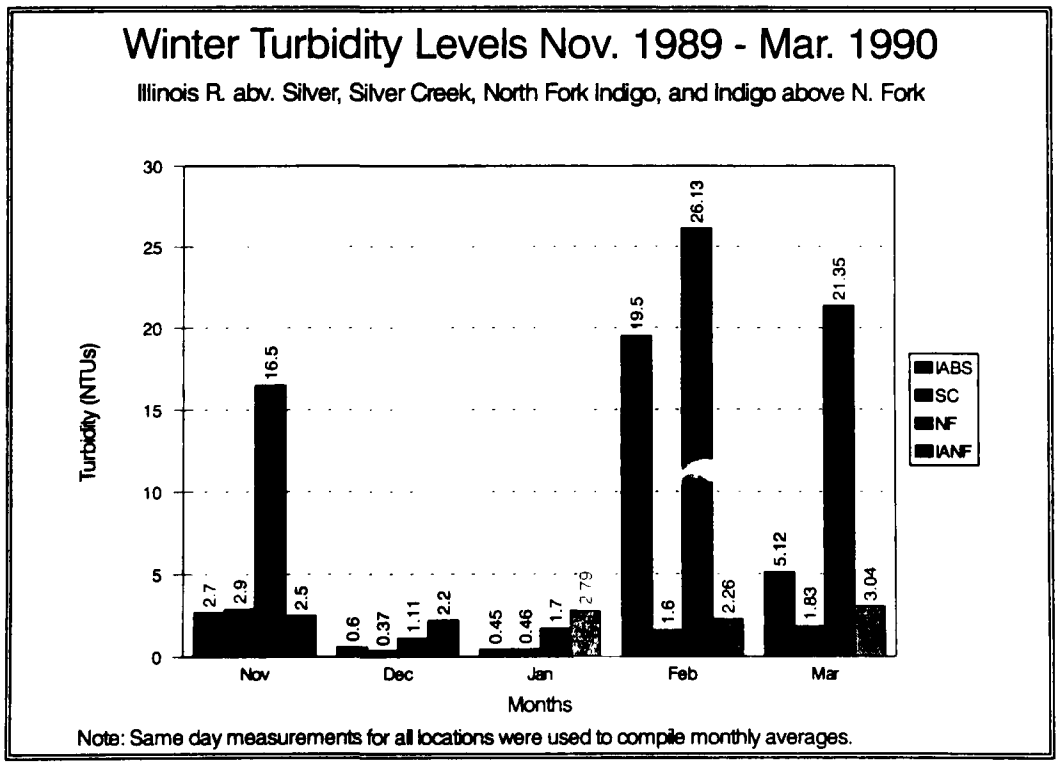


Figure 15: Winter Turbidity Levels (Nov. 1989 - Mar. 1990)

ISCO samplers were used as turbidimeters and placed in several locations during the winter months of 1988-89 and 1989-90. Bar graphs, Figures 14 and 15, show the monthly averages of data points. Turbidity does not appear to be a significant area of concern. Occasional heavy precipitation events significantly increases the turbidity, which is normally expected. Overall turbidity is low, and is not affecting Beneficial uses. Determining sources of turbidity when monitoring is done at the mouth of various streams and tributaries is virtually impossible. There is no way to separate fire related turbidity increases, natural turbidity increases, or management related turbidity increases.

CONCLUSIONS

The project area encompassed 42,350 acres. Out of this total, approximately 5,700 acres were logged for fire-killed timber, or 13 percent. Within the project area, 9 percent of the total burned at high intensity, 32 percent burned at medium intensity, and 59 percent burned at low intensity.

Comparing the monitoring results with the prediction of effects in the FEIS show that the actual effects are significantly less the predicted effects in all of the monitoring areas. Vegetation regrowth in the burned and salvaged areas has been very strong. The lack of adverse effects from salvage logging is attributed to, protection of the riparian areas, improved road construction practices, and minimizing disturbance through the use of helicopter logging.

Surface ravel along the inner gorges increased following the fire. It appears that the new road construction has not significantly contributed sediment to the stream system. However, some of the landings are beginning to show signs of slumping and cracking. If these areas are allowed to continue to move, there is a likelihood that they could fail in the future.

Riparian area layout and protection has been a landmark for this project. Results of implementation monitoring show that riparian prescriptions were met during layout and harvest. Protection of riparian areas during salvage logging operations was highly effective in meeting objectives where shade and protection against erosion and sediment are needed to maintain a healthly riparian ecosystem. Helicopter observations during the summer of 1995 show that the stream buffer areas are still functioning well and that they were very effective in maintaining stream bank integrity and reducing sediment delivery to the stream. Monitoring results showed that the salvage operators performed high quality work in protecting riparian areas.

Stream flows were predicted to increase in the FEIS as the result of the loss of evapotranspiring vegetation and the accumulation of snow in the burned areas. Results of the monitoring effort indicate that the fire didn't appear to have any effect on stream flow in the fish bearing streams. It was noted that perennial streams did extend further upslope in burned areas than they historically had.

There have been no noticeable effects in increases in turbidity or sediment. The FEIS predicted that vegetative recovery and the high natural sediment transport rates will return the stream sediment loading to pre-fire conditions in about twenty years. Stream channel cross sections show some shifting of sediment storage areas but no overall increase or decrease in aggradation or degradation. The main hypothesis of the monitoring was that stream power in critical reaches will be sufficient to transport bedload sediment from the fire and management activities through

Silver and Indigo Creeks. The monitoring data supports this prediction. The cross sections were remeasured in 1995 following a significant storm and the results will be published in a subsequent report.

It appears that fish habitat and fish population were not detrimentally affected by the fire of timber salvage operations. These conclusions are based on the fish habitat surveys. Results of 1989 monitoring indicated there was a significant increase in pre-smolt steelhead between 1988 and 1989. Based on the model used in the FEIS, steelhead smolt populations were expected to decrease by 23 percent from pre-fire levels. Fish habitat and populations appear healthy in Silver and Indigo Creeks following fire and management activities. At this point in time, fire-killed wood is making its way to the stream channels. Although not thoroughly examined, the benefit to the fish habitat will most likely be significant.

In the headwater streams that were burned, stream shade had been reduced by as much as 60 percent. The objective of stream temperature monitoring was to validate predicitions that stream temperature will not increase over post fire levels as the result of salvage logging. Temperatures have varied by year due to natural factors such as air temperature and flow. The stream temperature in fish bearing streams did not increase as the result of the fire. In the headwater stream where salvage logging occurred, there was no additional loss of stream shade. One surprising conclusion that can be drawn from the monitoring data is that years that had lower flows do not correspond to higher temperatures or years of higher flows to lower temperatures. Stream flow and temperature do not appear to have a correlation.

The effects of salvage logging are still being monitored. After a look at the preliminary results from this monitoring it appears that the watershed is in good condition because of improved harvest and road construction techniques that are not contributing sediment to the stream system. The road monitoring/erosion pin study will be extremely helpful in understanding fill movement and its rate of movement over time which is expected to be very low.

The results of the intermittent stream cross-sections which were performed in the summer of 1995 will be helpful to understand how the watershed responded to a significant storm. The baseline data which was collected in 1988 and again in 1989 showed virtually no difference; thus, no significant stream bank erosion or sediment deposition in the streambed has been observed.

It appears that the disturbance created by fire resulting in the abundance of new growth, the addition of large woody material and nutrients to the stream were all beneficial to the ecosystem. However, the watersheds appear to still be recovering.

One of the biggest areas where monitoring has made a difference in management is in the mere presence of data. More site specific relationships are known, so that better recommendations to management can be made. Thus, more substantiated decisions will be made on other projects in the Silver Creek area or in geoclimatically similar watersheds.

FUTURE MONITORING

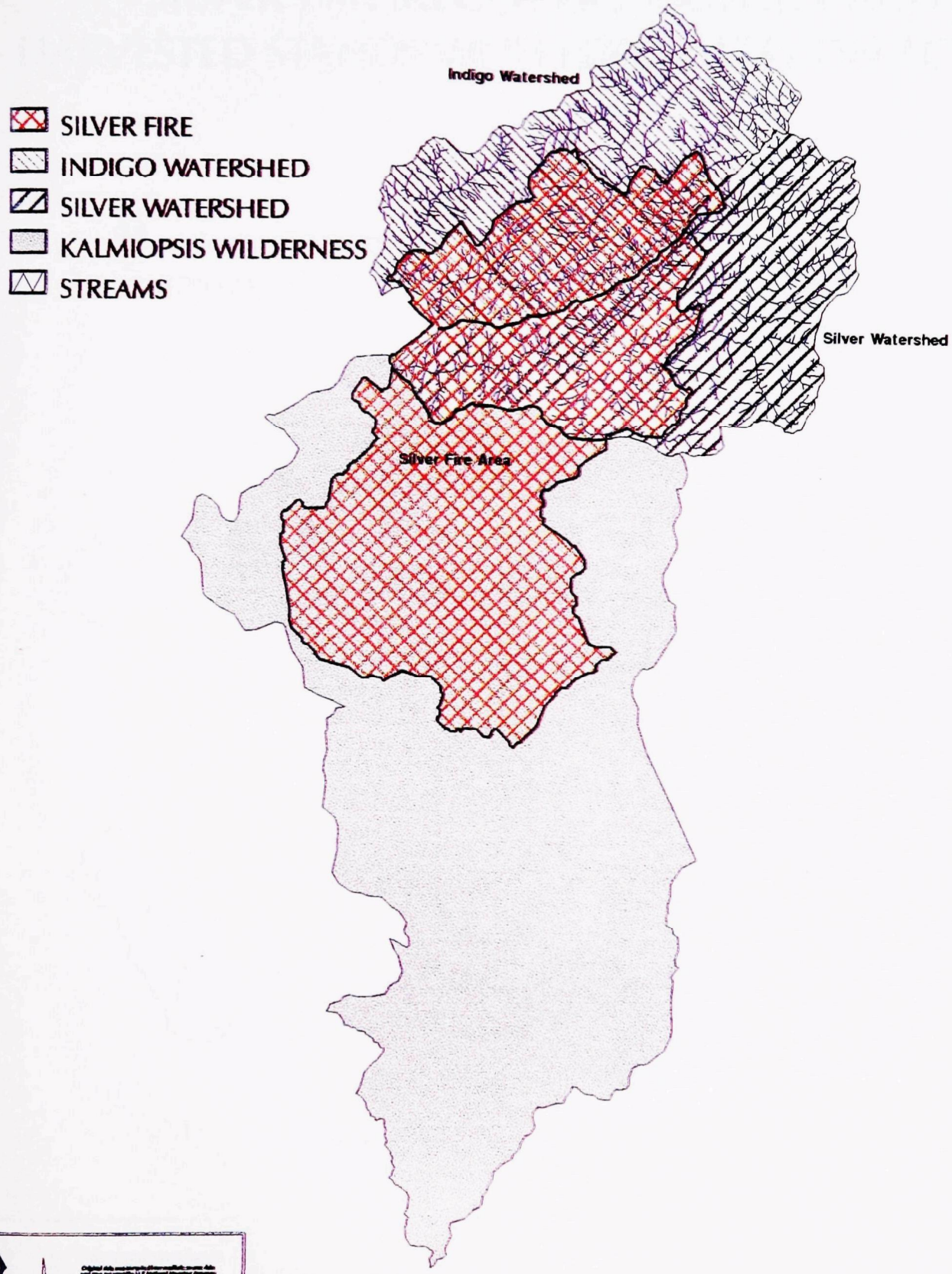
In the near future, it will be meaningful to quantify the landslides and estimate the sediment delivery to streams using the air photos taken during fall of 1995. Duplicating the previous monitoring efforts for small and intermittent stream cross-sections on the east-facing slope of Bald Mountain, as well as duplicating the stream shade monitoring will be of tremendous value for comparing current

conditions to the baseline conditions. For future management decisions, knowing and having the ability to quantify the differences will be invaluable.

The road inventory which is currently in process will need to be analyzed. Conclusions regarding the roads and landings and their effect on sediment delivery to the stream can be finalized. Another recommendation is to perform a stream survey with the intent of surveying those areas where large woody material has collected in the stream.

APPENDIX A

ENTIRE SILVER FIRE AREA



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SILVER FIRE RECOVERY PROJECT AREA
HARVESTED STANDS WITH REFORESTATION ACTIVITY

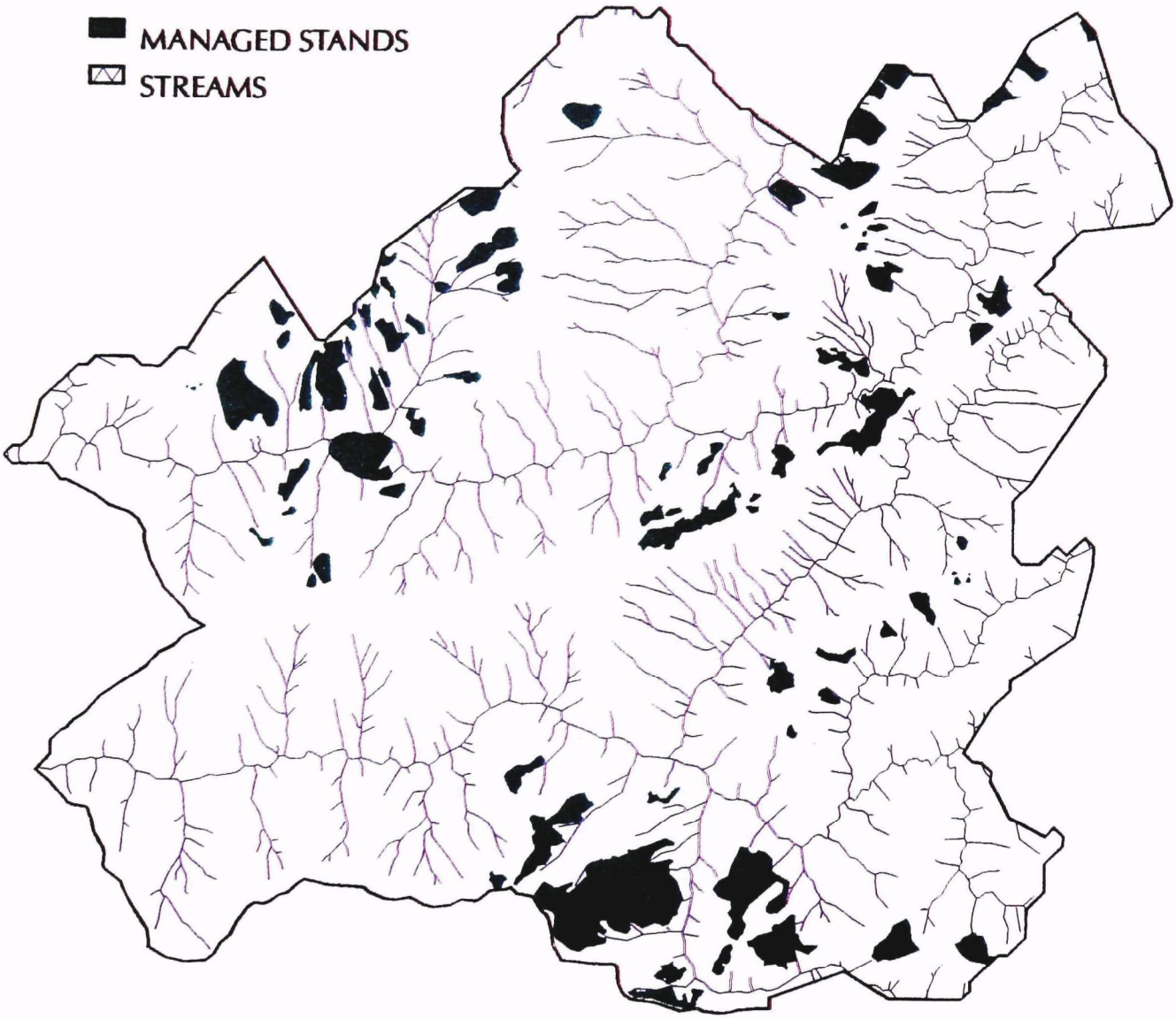

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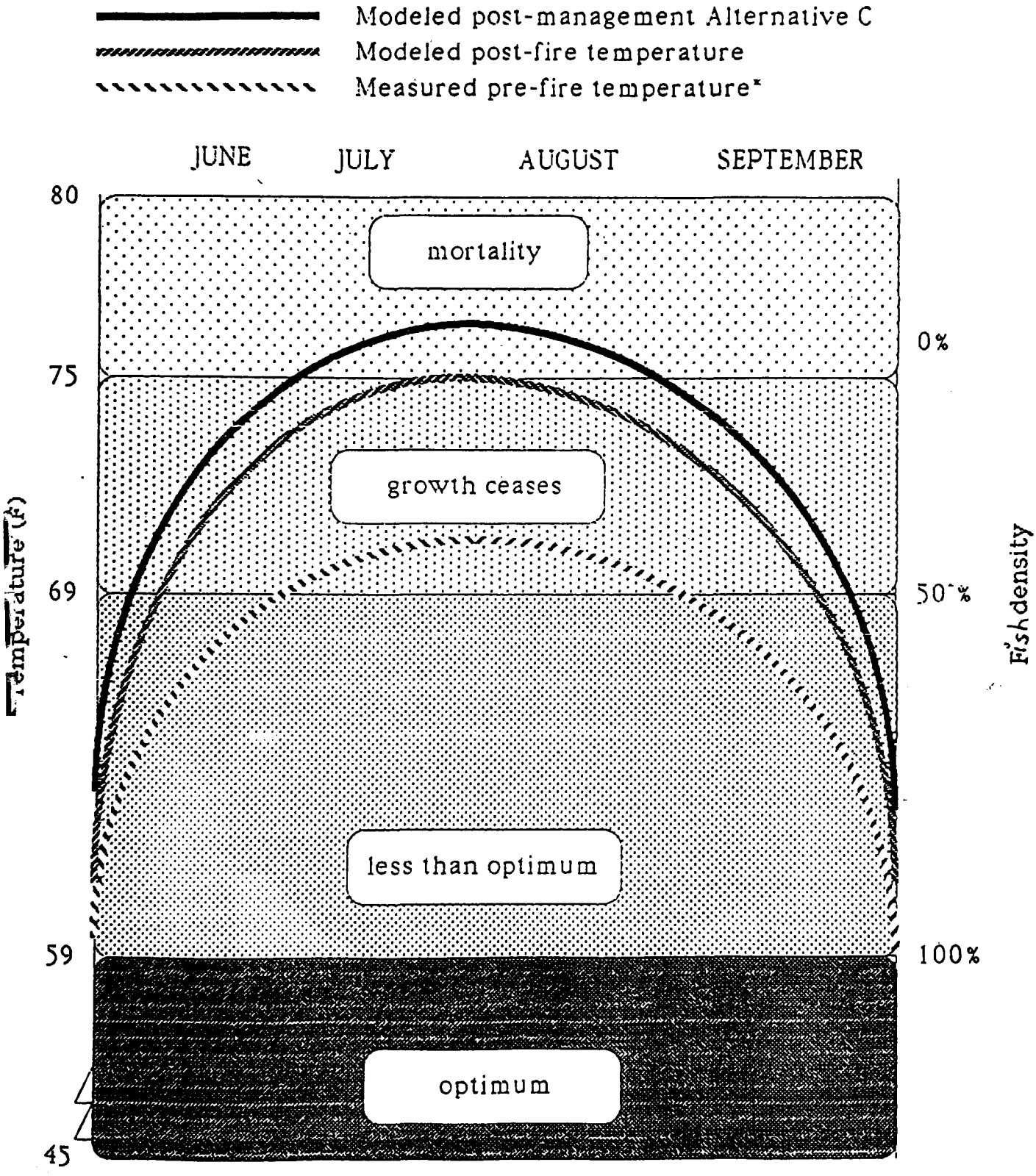
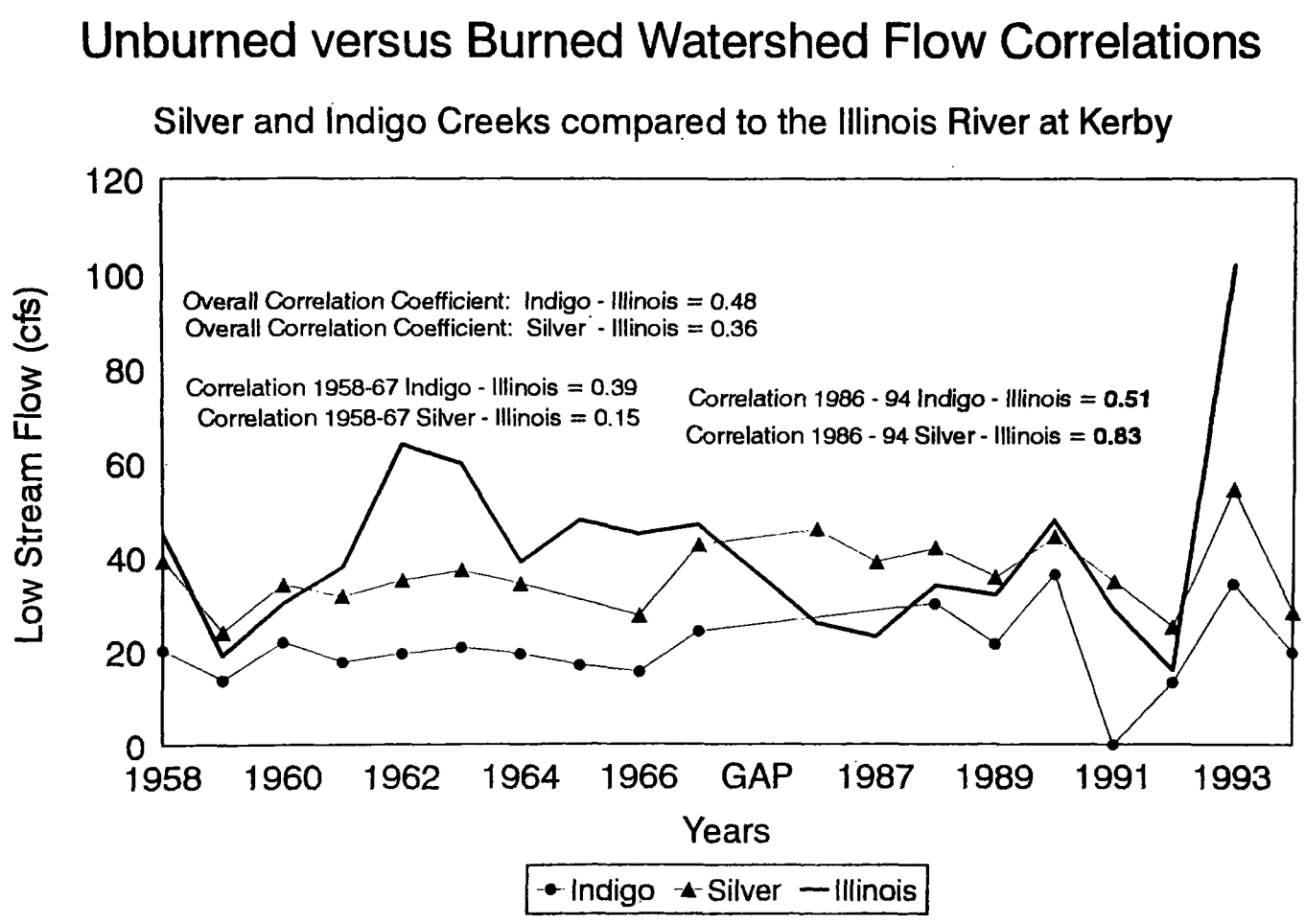
Figure 11 Johnson/Amaranthus

Stream Temperatures for Indigo Creek-Siskiyou National Forest



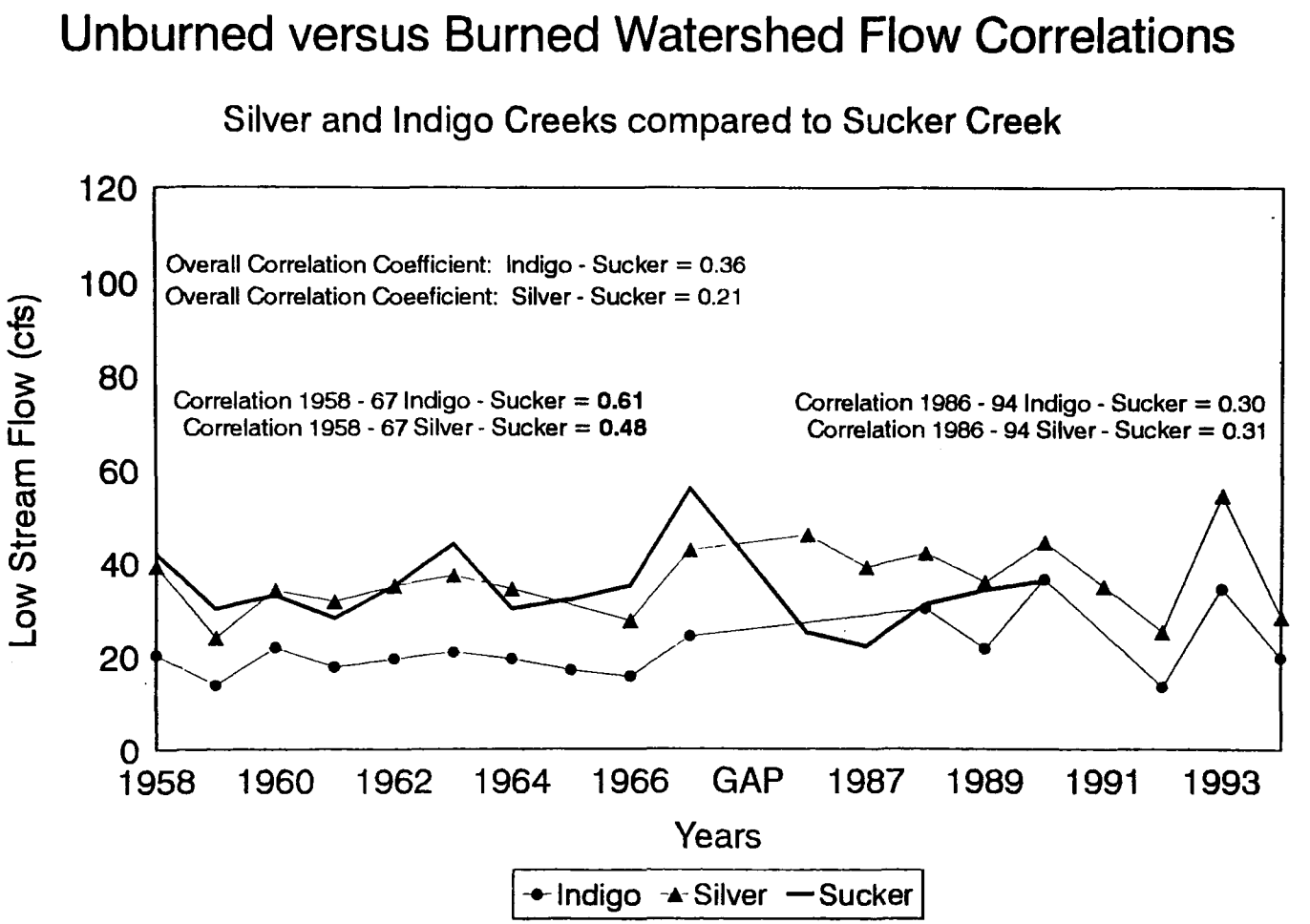
* Stream temperatures are caluclated as the mean of high and low values during each 24 hr period

Figure 13a



Indigo and Silver Creeks (burned) compared to Illinois River at Kerby (unburned), 1958 - 1994. Average monthly flow in Aug. or Sept. in the Illinois River plotted next to single day low flow measurements in Indigo and Silver Creeks.

Figure 13b



Indigo and Silver Creeks (burned) compared to Sucker Creek (unburned), 1958 - 1994. Averaged monthly flow in Aug. or Sept. in Sucker Ck. plotted next to single day low flow measurements in Indigo and Silver Creeks.

Figure 13c

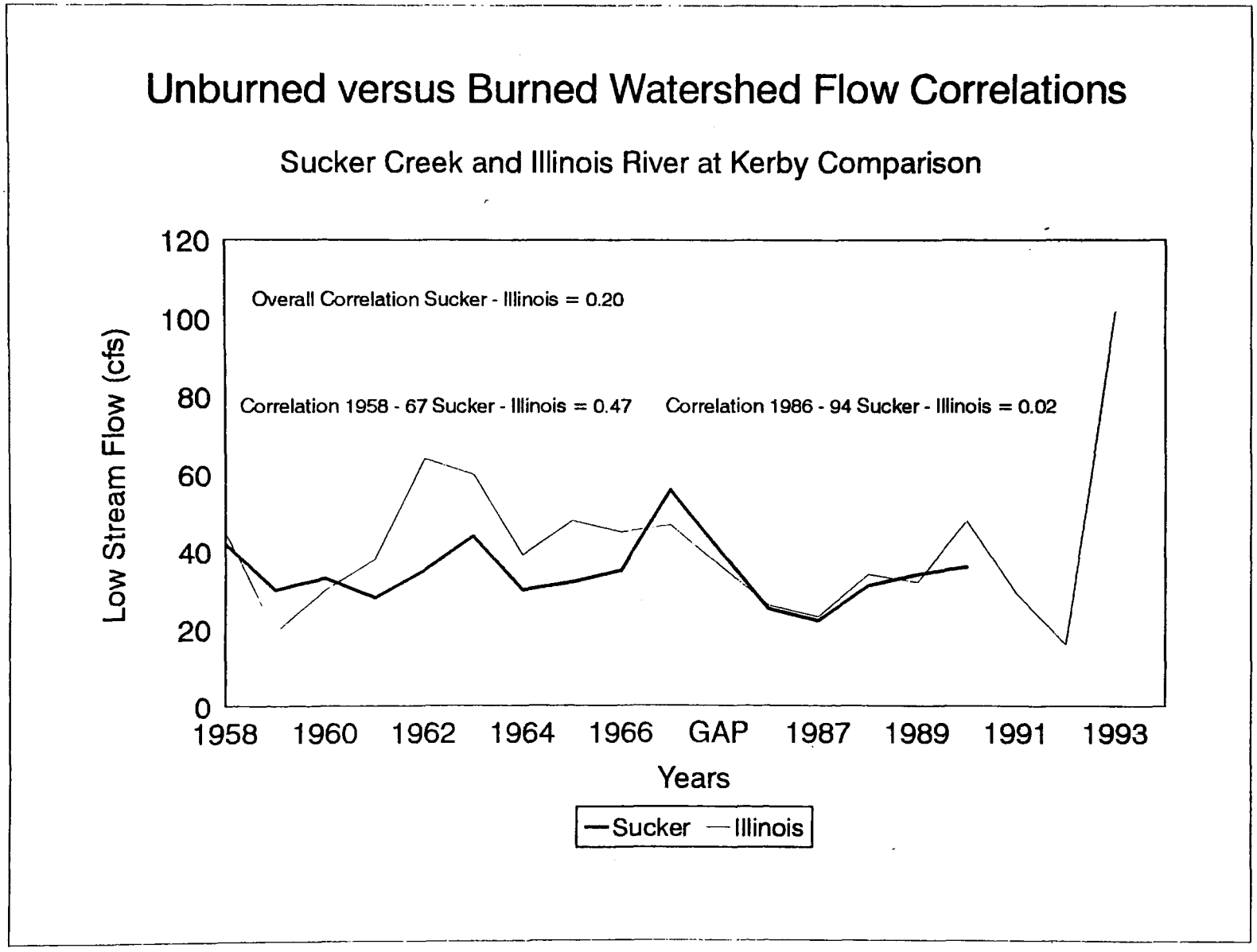
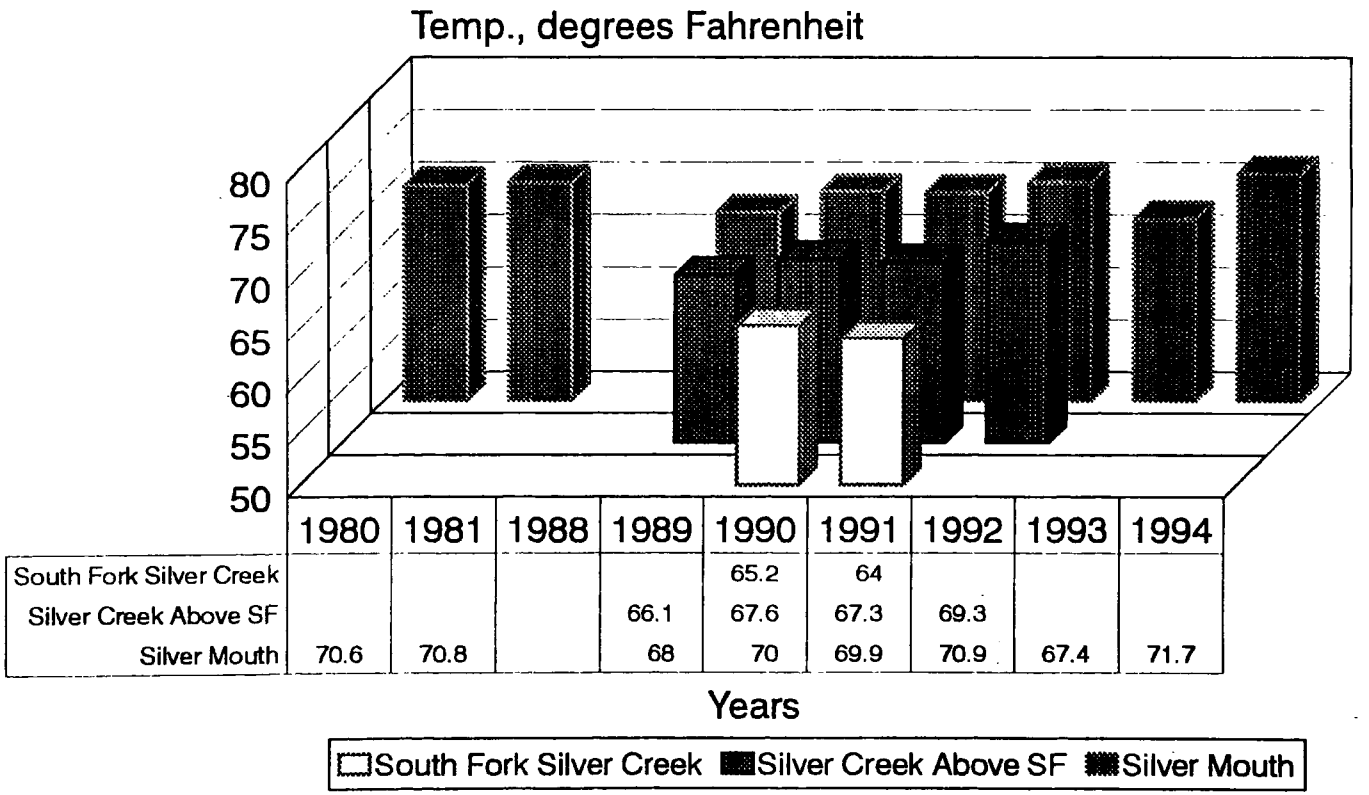

Unburned versus Burned Watershed Flow Correlations
Sucker Creek and Illinois River at Kerby Comparison
Overall Correlation Sucker - Illinois = 0.20
Correlation 1958 - 67 Sucker - Illinois = 0.47
Correlation 1986 - 94 Sucker - Illinois = 0.02
Low Stream Flow (cfs)
120
100
80
60
40
20
0
1958
1960
1962
1964
1966
GAP
1987
1989
1991
1993
Years
Sucker
Illinois

Figure 15a

Silver Fire Recovery Project

Stream Temperatures: 7 Day High



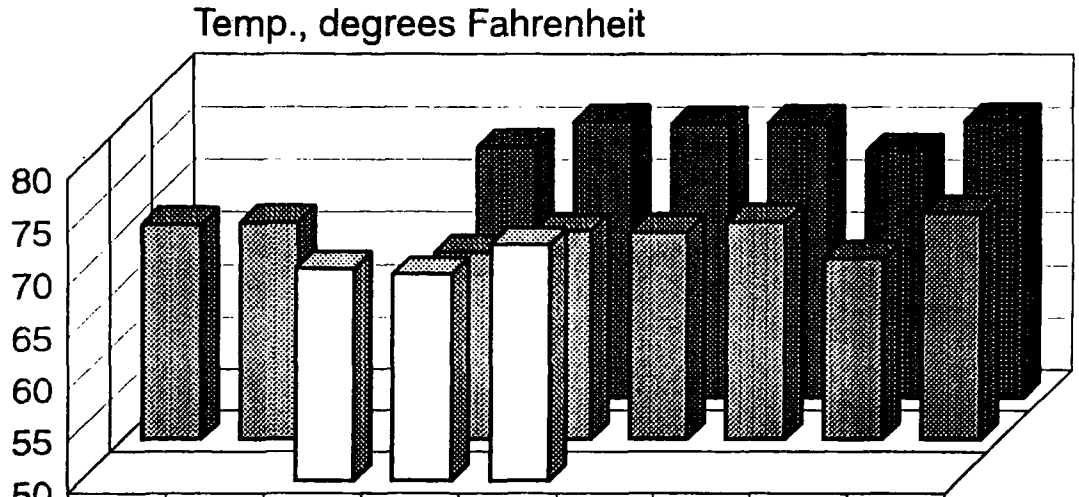
	1980	1981	1988	1989	1990	1991	1992	1993	1994
South Fork Silver Creek					65.2	64			
Silver Creek Above SF				66.1	67.6	67.3	69.3		
Silver Mouth	70.6	70.8		68	70	69.9	70.9	67.4	71.7

South Fork Silver Creek, Silver Creek Above South Fork, Silver Creek at Mouth

Figure 15b

Silver Fire Recovery Project

Stream Temperatures: 7 Day High



	1980	1981	1988	1989	1990	1991	1992	1993	1994
Indigo Creek at Mouth			70.4	69.9	72.7				
Silver Creek at Mouth	70.6	70.8		68	70	69.9	70.9	67.4	71.7
Illinois River above Silver				74	76.4	76.2	76.3	73.6	76.5

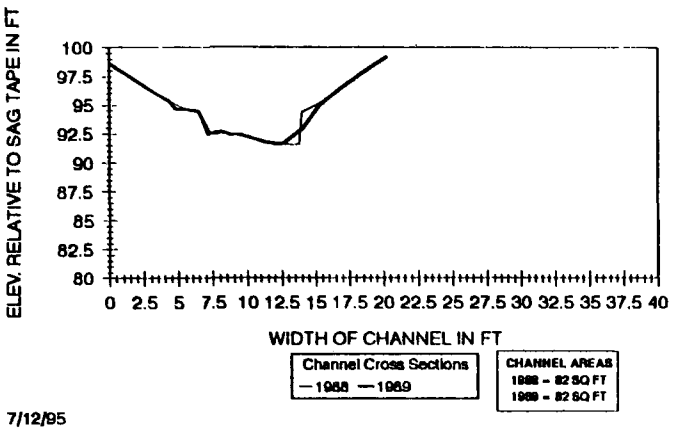
Years

Indigo Creek at Mouth Silver Creek at Mouth Illinois River above Silver

Indigo Creek at Mouth, Silver Creek at Mouth, Illinois River above Silver Creek

BALD MTN B1A

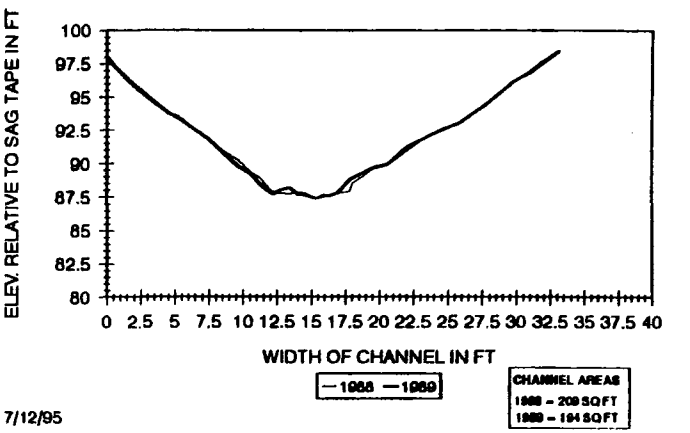
1988-89 COMPARISON



7/12/95

BALD MTN B1B

1988-89 COMPARISON



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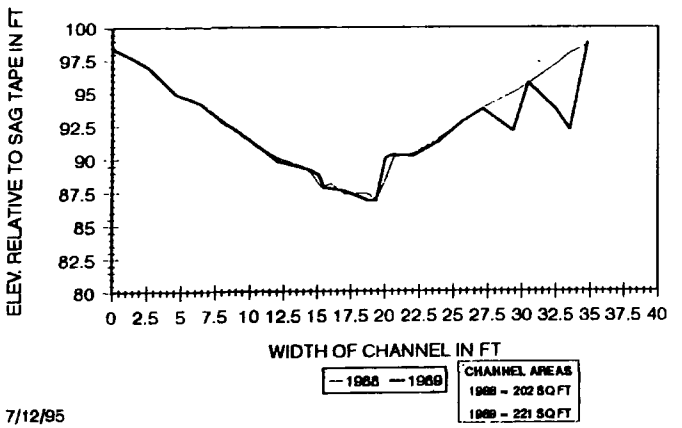
BALD MTN B1C

1988-89 COMPARISON



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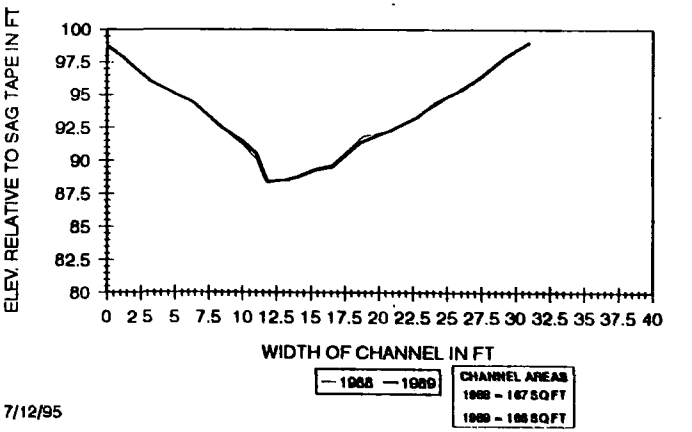
BALD MTN B1D

1988-89 COMPARISON



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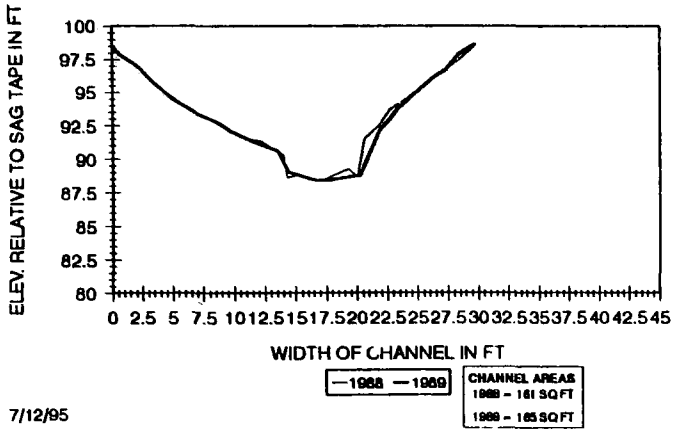
BALD MTN B2D

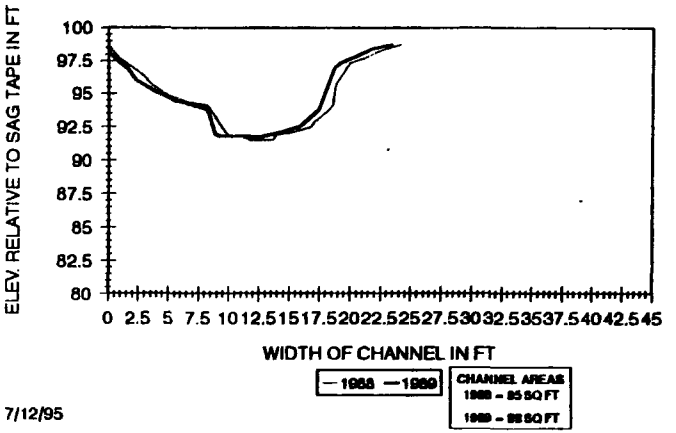
1988-89 COMPARISON



7/12/95

BALD MTN B2E

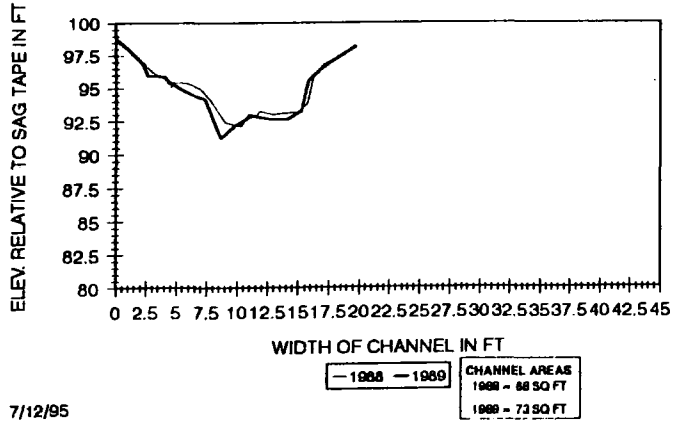
1988-89 COMPARISON



7/12/95

BALD MTN B3A

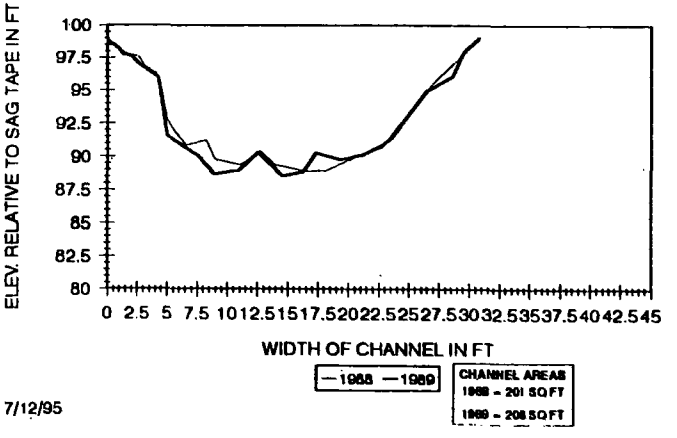
1988-89 COMPARISON



7/12/95

BALD MTN B3B

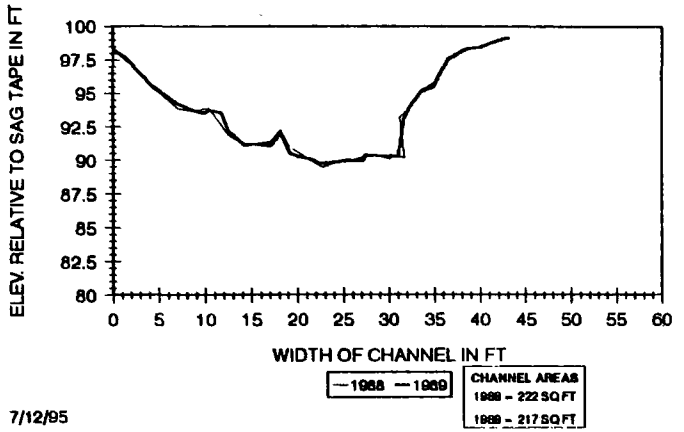
1988-89 COMPARISON



7/12/95

BALD MTN B4B

1988-89 COMPARISON



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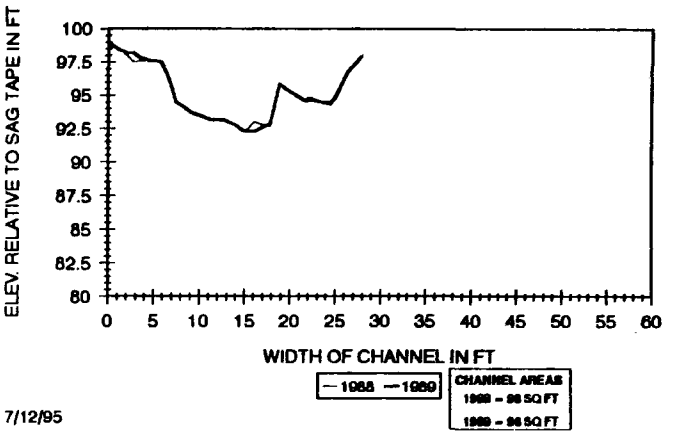
BALD MTN B4C

1988-89 COMPARISON



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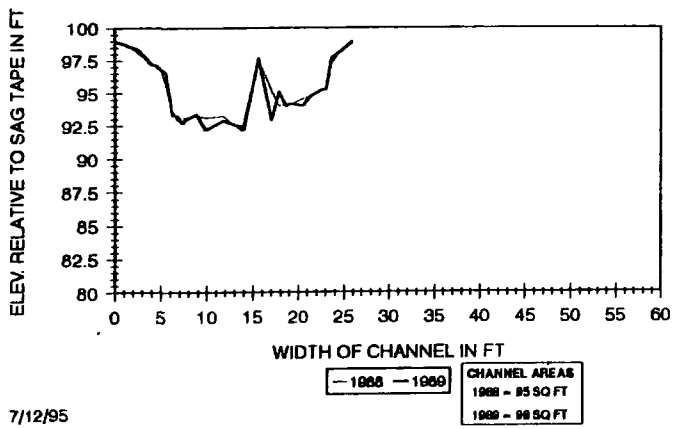
BALD MTN B4D

1988-89 COMPARISON



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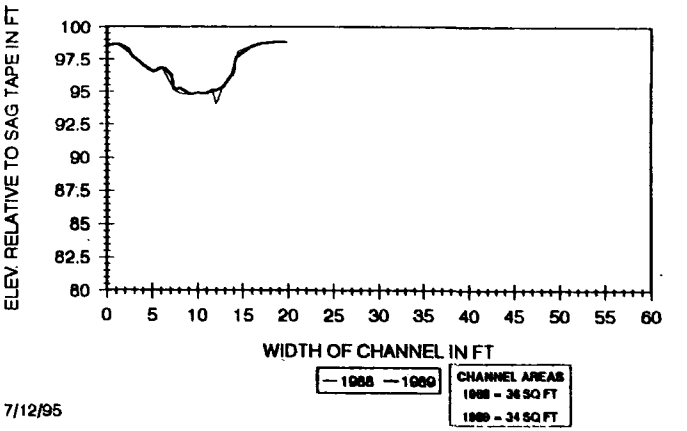
BALD MTN B4E

1988-89 COMPARISON



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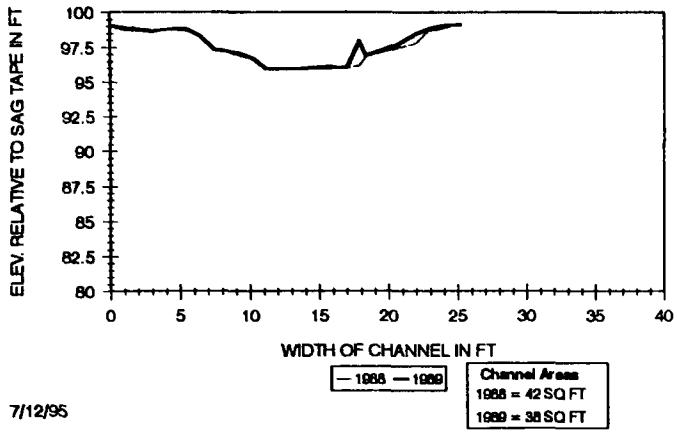
BALD MTN C1E

1988-89 COMPARISON



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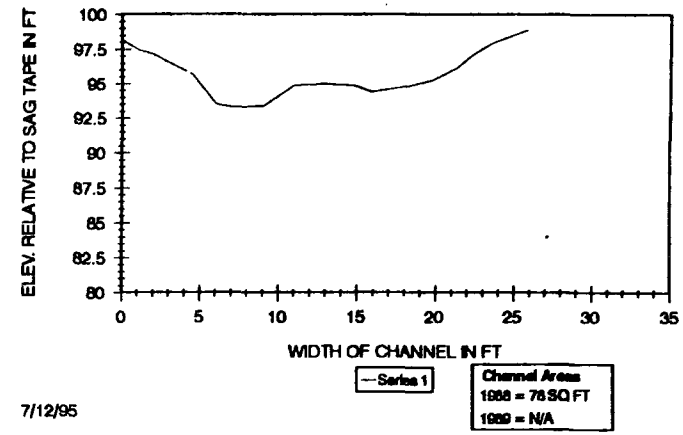
BALD MTN C2A

1988-89 COMPARISON



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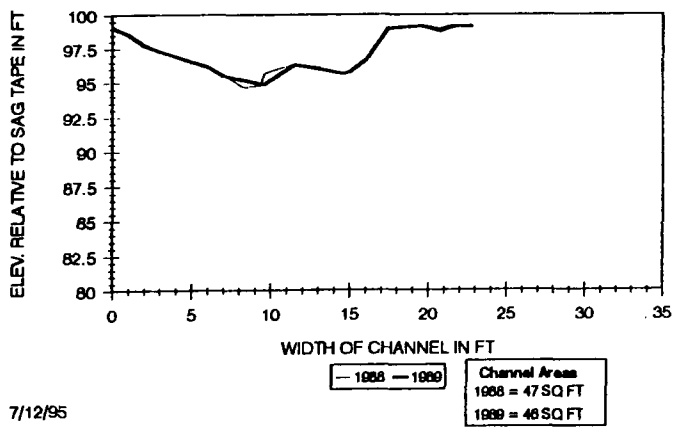
BALD MTN C2B

1988-89 COMPARISON



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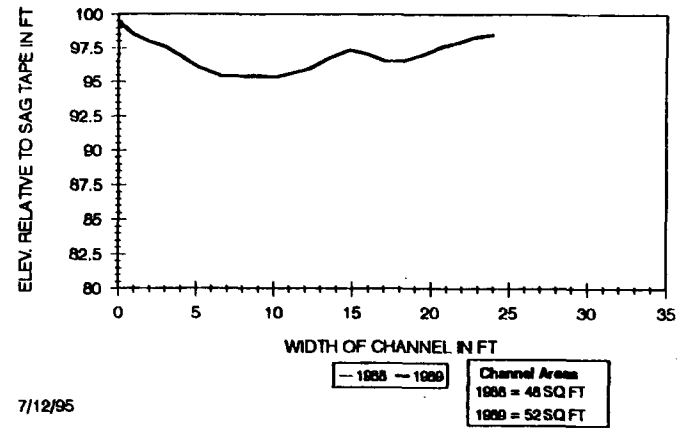
1988-89 COMPARISON



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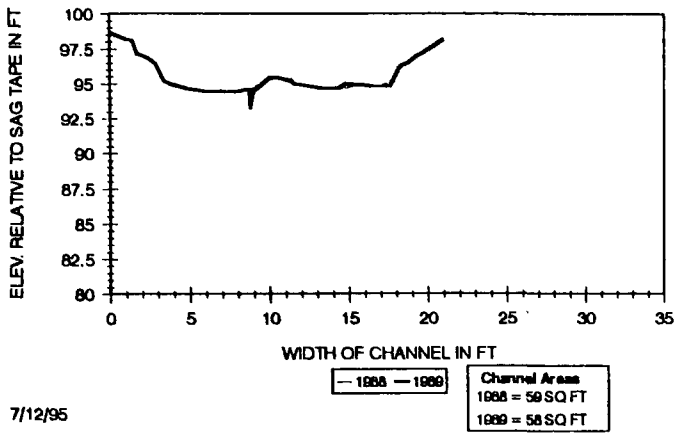
1988-89 COMPARISON



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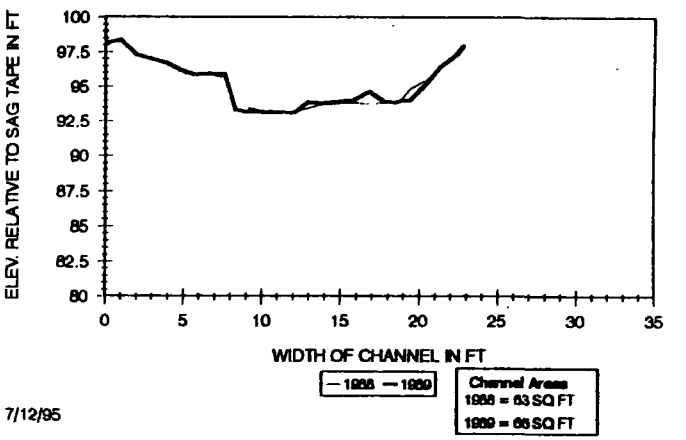
1988-89 COMPARISON



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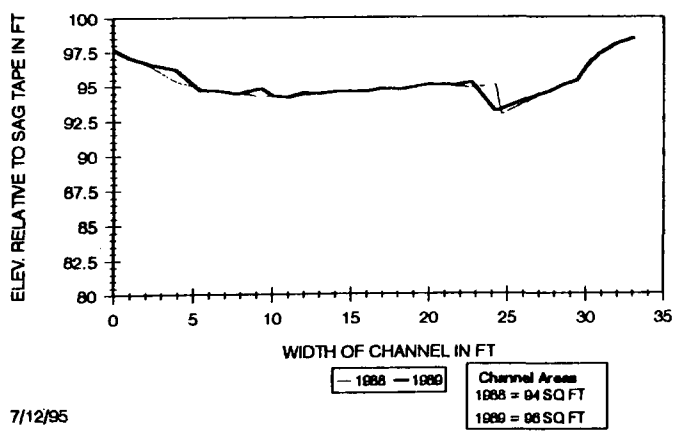
1988-89 COMPARISON



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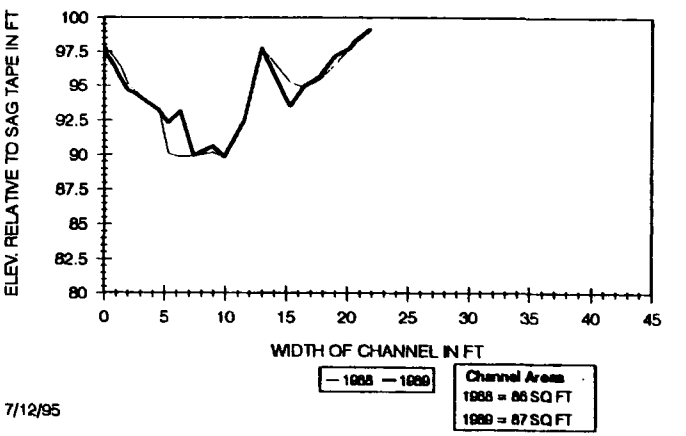
1988-89 COMPARISON



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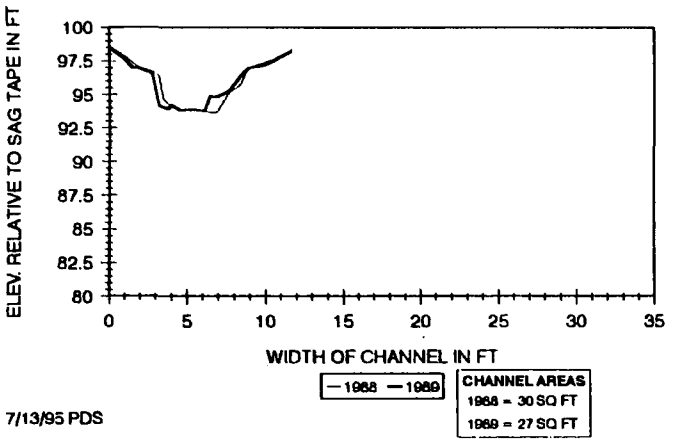
BALD MTN D2A

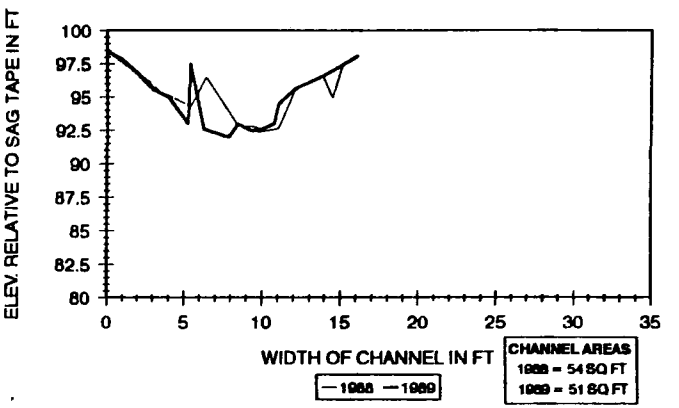
1988-89 COMPARISON



7/13/95 PDS

BALD MTN D2B

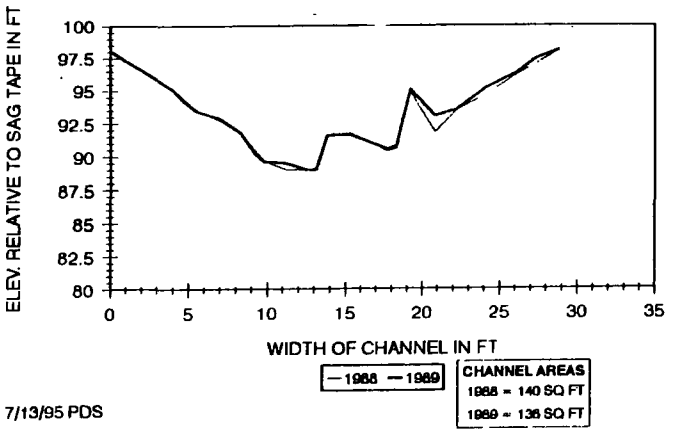
1988-89 COMPARISON



7/13/95 PDS (LINE 18 RECORD OF DISTANCE=33 APPEARS TO BE AN ERROR)

BALD MTN D2C

1988-89 COMPARISON



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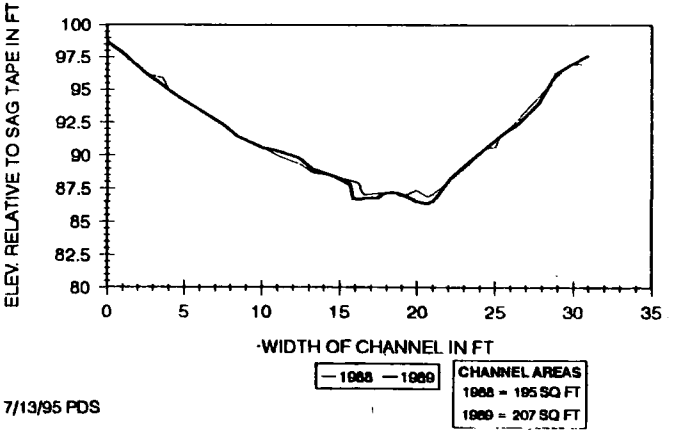
BALD MTN D2D

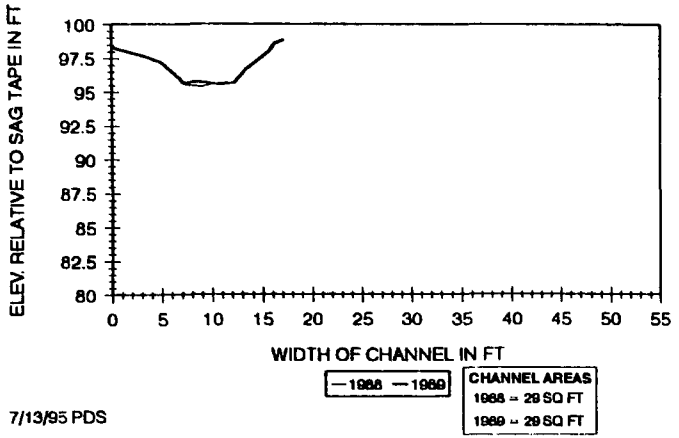
1988-89 COMPARISON



7/13/95 PDS

BALD MTN D3D

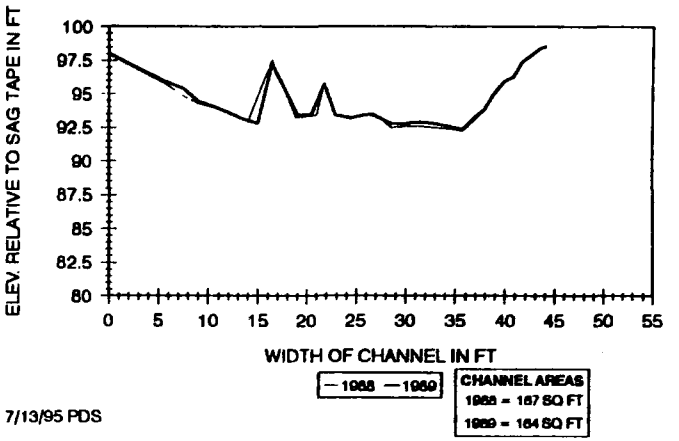
1988-89 COMPARISON



7/13/95 PDS

BALD MTN D3E

1988-89 COMPARISON



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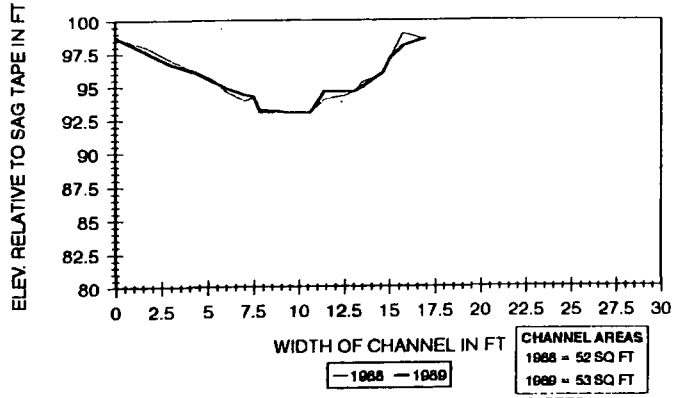
BALD MTN D4A

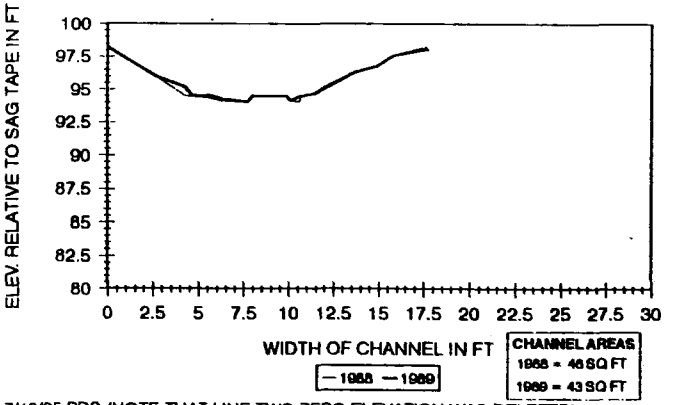
1988-89 COMPARISON



7/13/95 PDS (NOTE THAT LINE TWO ZERO ELEVATION WAS DELETED)

BALD MTN D4B

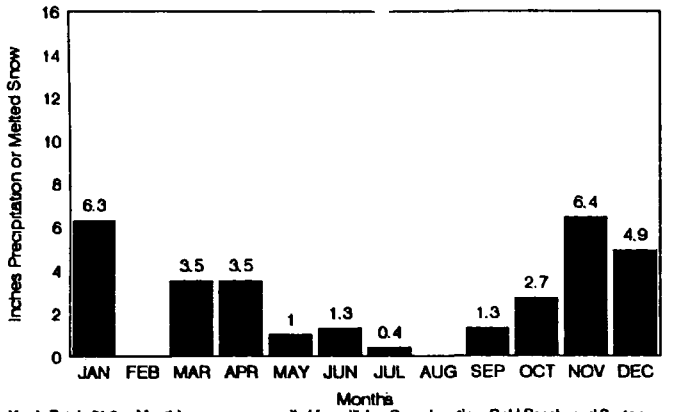
1988-89 COMPARISON



7/13/95 PDS (NOTE THAT LINE TWO ZERO ELEVATION WAS DELETED)

Silver Fire Recovery Area

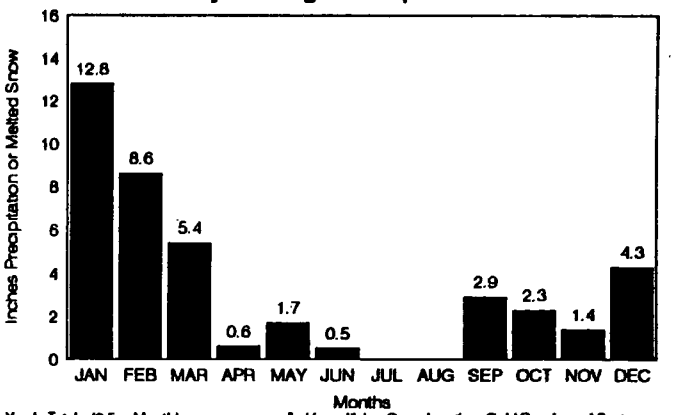
1958 Monthly Average Precipitation Estimate



Yearly Total: 31.3 Monthly averages compiled from Illahe, Cave Junction, Gold Beach, and Sexton Summit NOAA stations

Silver Fire Recovery Area

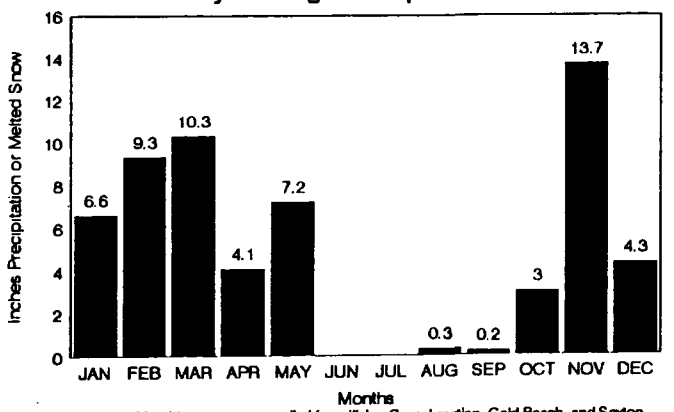
1959 Monthly Average Precipitation Estimate



Yearly Total: 40.5 Monthly averages compiled from Illahe, Cave Junction, Gold Beach, and Sexton Summit NOAA stations

Silver Fire Recovery Area

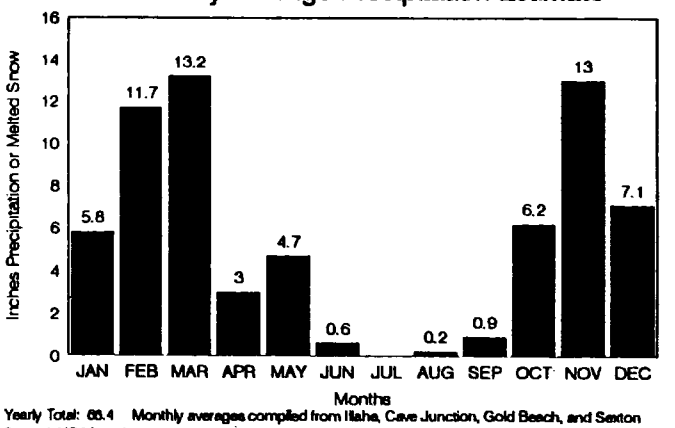
1960 Monthly Average Precipitation Estimate



Yearly Total: 59.0 Monthly averages compiled from Illahe, Cave Junction, Gold Beach, and Sexton Summit NOAA stations

Silver Fire Recovery Area

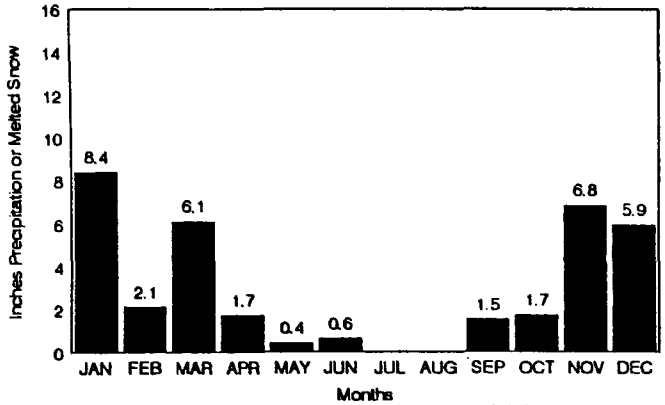
1961 Monthly Average Precipitation Estimate



Yearly Total: 66.4 Monthly averages compiled from Illahe, Cave Junction, Gold Beach, and Sexton Summit NOAA stations

Silver Fire Recovery Area

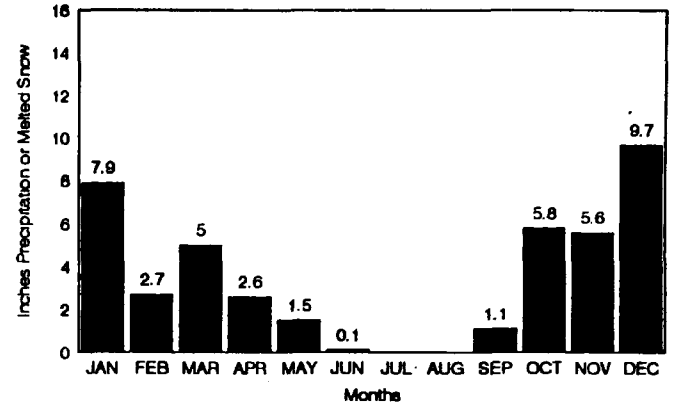
1966 Monthly Average Precipitation Estimate



Yearly Total: 35.2 Monthly averages compiled from Illahe, Cave Junction, Gold Beach, and Sexton Summit NOAA stations

Silver Fire Recovery Area

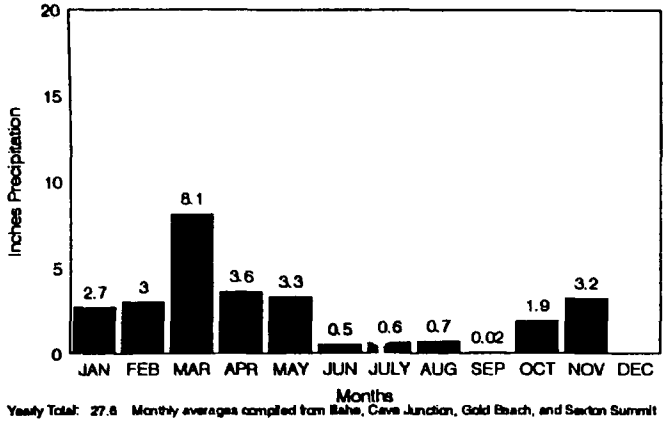
1967 Monthly Average Precipitation Estimate



Yearly Total: 42.0 Monthly averages compiled from Illahe, Cave Junction, Gold Beach, and Sexton Summit NOAA stations

Silver Fire Recovery Area

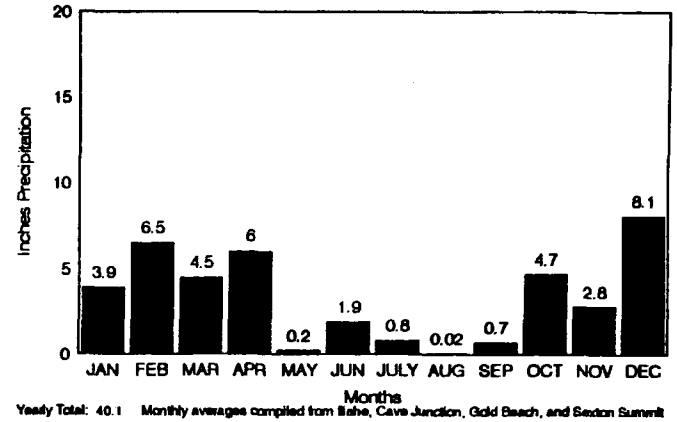
1991 Monthly Average Precipitation Estimate



Yearly Total: 27.8 Monthly averages compiled from Illahe, Cave Junction, Gold Beach, and Sexton Summit NOAA stations

Silver Fire Recovery Area

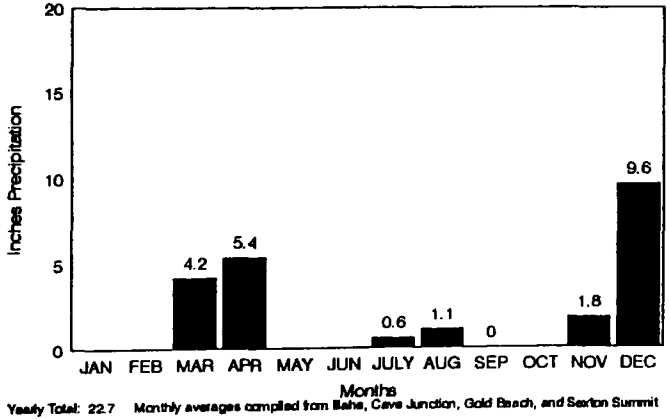
1992 Monthly Average Precipitation Estimate



Yearly Total: 40.1 Monthly averages compiled from Illahe, Cave Junction, Gold Beach, and Sexton Summit NOAA stations

Silver Fire Recovery Area

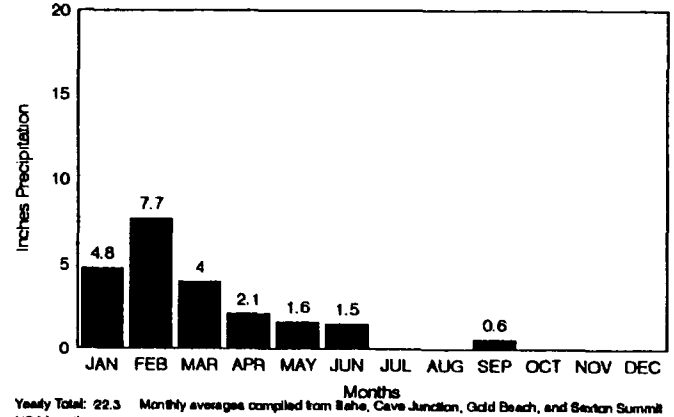
1993 Monthly Average Precipitation Estimate



Yearly Total: 22.7 Monthly averages compiled from Illahe, Cave Junction, Gold Beach, and Sexton Summit NOAA stations

Silver Fire Recovery Area

1994 Monthly Average Precipitation Estimate



Yearly Total: 22.3 Monthly averages compiled from Illahe, Cave Junction, Gold Beach, and Sexton Summit NOAA stations

APPENDIX B

References

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