Fish Creek

Watershed Restoration

Monitoring Plan

"Monitoring is the measure of success of any restoration."
J. Kershner

August 15, 2001

U.S.D.A. Forest Service Region 6
Mt. Hood National Forest
Clackamas River Ranger District

Prepared by Tracii L. Hickman

Table of Contents

A Restoration Monitoring Procedure

1. define participants;
2. establish clear goals and objectives
3. design monitoring to detect change to (a) distinguish treatment effects from other variations, and (b) take replicate samples over space and time;
4. prioritize monitoring activities;
5. implement field prescriptions and techniques;
6. analyze data and report results; and
7. adapt goals and objectives to new information.

From: Kershner, J.L. (1997)

Table 1. Summary Table of Monitoring Activities.

Slope Processes

- Slope Stability
- Hydrologic Function

Restoration Goal	Restoration Activity	Monitoring Task	Frequency	Measure of Effectiveness	Who Completes Monitoring	Data Storage
Slope Stability						
Reduce the ratio of landslides associated with young plantations	Thin plantations 10-40 years old (mean age 20 years)	Inventory landslides	After a 10 year or greater storm event	Reduce ratio of landslides from plantations (12.2 per square mile) compared to unmanaged land (2.0 per square mile)	Forest geotech engineer and District engineering	
Reduce the ratio of landslides associated with unneeded roads and needed roads	Decommission roads Storm proof roads	Inventory landslides	After a 10 year or greater storm event	Reduce rate of landslides from roads (currently one every two miles)	Forest geotech engineer and District engineering	
Increase slope stability	Plant landslide tracks	Stocking survey	2001 or by 5th year after plant	50% survival of planted stock & 125 tpa overall	silviculture	
Hydrologic Function						
Increase precipitation infiltration, and decrease concentration of runoff and channel network expansion	Decommission old roads Storm proof roads	Monitor peak flows at U.S.G.S. gaging station.	Instantaneous	Reduced slope of the rising and falling hydrograph curve	U.S.G.S. Hydrology	
Decrease magnitude of rain-on-snow events	Thin plantations to accelerate stand development	Monitor peak flows at U.S.G.S. gaging station.	Instantaneous	Lower peak on rain-on-snow hydrograph curve for similar size events	U.S.G.S. Hydrology	

Riparian Area Function

- Large wood and large sediment recruitment and movement
- Riparian Areas Processes - Shading, Community Diversity, Nutrient Contribution, Floodplain Function

Restoration Goal	Restoration Activity	Monitoring Task	Frequency	Measure of Effectiveness	Who Completes Monitoring	Data Storage
Riparian Area Function						
Accelerate restoration of riparian areas to mature stand conditions	Plant riparian areas	Stocking survey	2001 or by 5th year after plant	50% survival and 125 tpa of all tree species.	Silviculture	
	Thin riparian areas	Implementation survey	1998 & 1999	Stands meet design criteria for developing future LWD recruitment.	Silviculture	
Restore movement of large wood and large sediment into stream channels	Reconstruct road/stream crossings	Inventory restored stream crossings	After a 10 year or greater storm event	Photo points at restored stream crossings document passage	Geotech & Engineering	
		Large wood survey	Every five years beginning in 2000	Large wood survey documents introduction of upslope wood & sediment	PNW	
Riparian Area Processes						
Restore floodplain function	Decommission roads in riparian areas	Stream surveys	Every 2 years	Increase in side channel and off-channel habitat	PNW	
Reduce summer stream temperatures	Plant riparian areas Thin riparian areas	Temperature probe monitoring	Every 2 years beginning in 2000	Decrease in peak 7 day average stream temperature to meet State standard 64°F	U.S.G.S. Hydrology	

Instream Conditions and Fish Populations

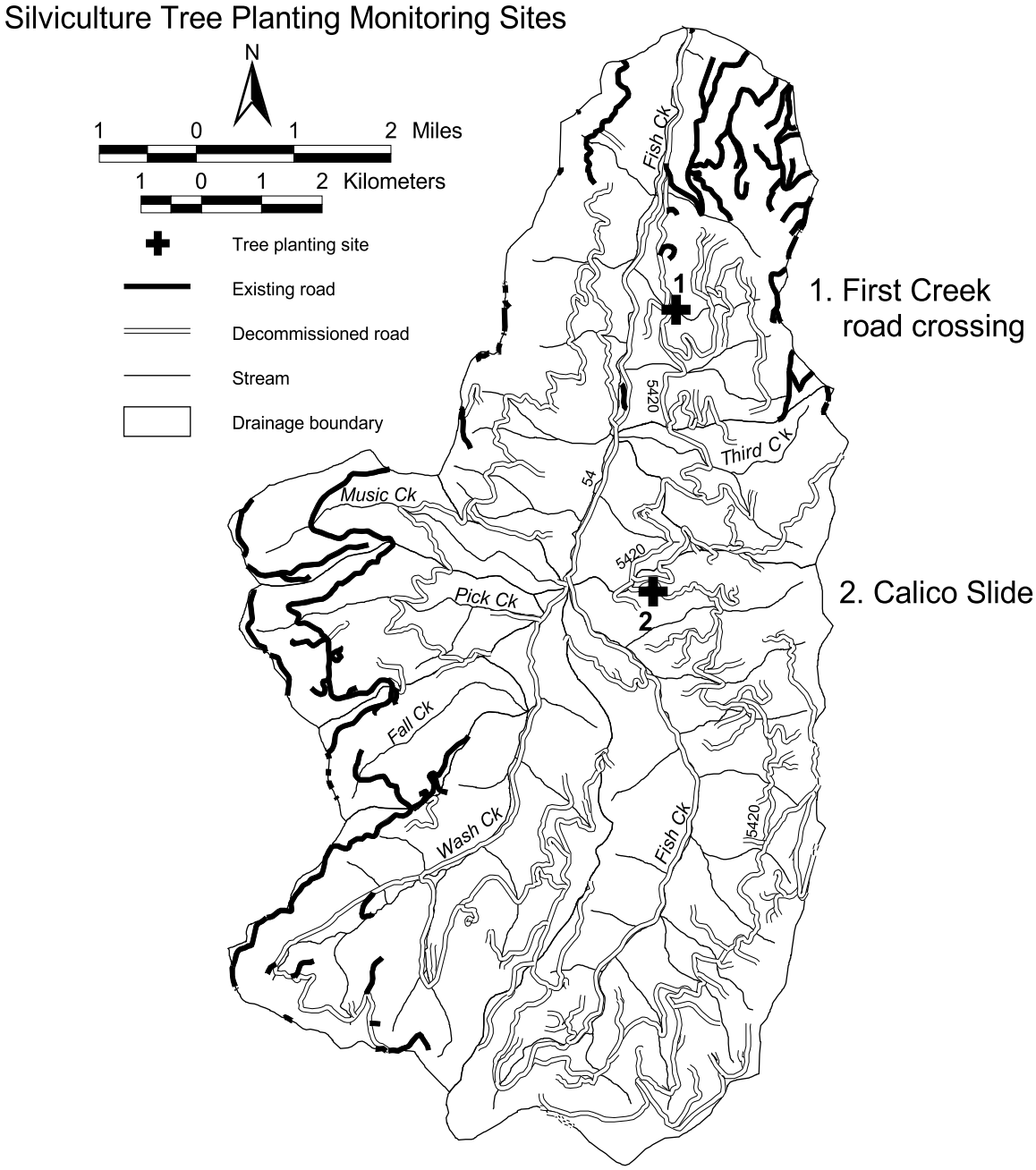
Restoration Goal	Restoration Activity	Monitoring Task	Frequency	Measure of Effectiveness	Who Completes Monitoring	Data Storage
Fish Habitat						
Restore lower Fish Creek to pre-flood conditions (see Shively et al. 1996)	Import wood and rebuild habitat structure	Stream habitat survey	Every 2 years	Percentage of available pool habitat increases towards Forest Plan standard	PNW	
Aggrade stream bed	Plant riparian areas, allow large wood to accumulate in stream channel	Channel cross sections	After a 10 year or greater storm event	Elevation gain	Fisheries	
Fish Populations						
Maintain or increase contribution of Fish Creek salmonids to Upper Clackamas watershed fish populations	Restore instream habitat conditions	Smolt trap survey	Every year	Fish Creek smolt numbers are maintained or increase in proportion to upper Clackamas River basin populations	PNW	
	Reduce magnitude and duration of rain-on-snow storm impacts	Monitor peak flows at U.S.G.S. gauging station.	Instantaneous	Lower peak on rain-on-snow hydrograph curve for similar size events	U.S.G.S. Hydrology	

Other concerns:

- Effectiveness of different road obliteration treatments
- Human use and impacts on water quality (pioneered roads and/or impacts to restored stream crossings)
- Potential introduction of noxious weeds
- Maintain long-term PNW data set
- Offsite tree stock used for many plantations on the old 5420 road

All restoration activities listed in table 1 are mapped in a Geographic Information System (GIS). Map 1 shows the locations of tree planting monitoring sites and locations of all decommissioned roads, including their old road number. Additional maps are found in Appendix B. Associated with each map are databases, such as photo points, site surveys, and additional notes or records.

Map 1. Location map of tree planting monitoring sites and location of decommissioned roads.



Introduction

The Fish Creek Watershed

Fish Creek is a 30,000-acre watershed on the Mt. Hood National Forest (the Forest). In 1994, Fish Creek watershed analysis identified it as the most geologically unstable watershed on the Forest. The watershed is the site of a long-term aquatic research project conducted by the Forest Service Pacific Northwest Research Station in Corvallis, Oregon. The Northwest Forest Plan identifies Fish Creek as a Tier One, key watershed. The goal of key watersheds is to maintain and recover habitat for anadromous salmonids at risk for extinction (USFS 1994).

A series of storm events, culminating in a 100-year plus storm event, struck Fish Creek during the winters of 1995-97. Impacts from the flood in the geologically sensitive watershed, coupled with management activities such as road building and timber harvest, were widespread. Landslides destroyed roads and turned over streambeds. Large wood and boulders changed the course of Fish Creek. Vegetation in riparian areas was cleared away and replaced by expanses of cobblestones. The number and severity of landslides, combined with other impacts from the storms, triggered a review of management goals in the Fish Creek watershed.

Disturbance Ecology and Restoration

Natural ecosystems are generally resilient, but this resilience can be compromised by human alterations to the system. These human induced disruptions can modify the frequency and magnitude of natural disturbances and alter the species composition, habitat features, and resilience of an ecosystem.

The goal of the Fish Creek restoration and recovery program is to protect and restore hill slope and fluvial processes that both conserve the ecosystem and create and maintain habitats for fish and wildlife. It is natural disturbances, such as landslides and floods for aquatic organisms, and wind and fire for terrestrial animals, that create habitat diversity.

Fish Creek has been under observation and study for many years. The Pacific Northwest Research Station has been evaluating instream fish habitat restoration and fish populations since the early 1980's. A comprehensive, watershed-wide evaluation of physical, ecological and social processes were reported in the Fish Creek watershed analysis in 1994. After the floods, factors affecting landslide incidence were analyzed to determine where and why landslides occurred (DeRoo et al. 1998). Changes in the stream channel and habitat conditions were also evaluated (Shively et al. 1996). Fish Creek publications and other relevant documents are listed in Appendix A.

Some key findings are listed below:

- Following the floods, the highest density of landslides on the Mt. Hood National Forests was in Fish Creek.
- In Fish Creek, the highest landslide incidence was in young (less than 20 years old), replanted harvest units.
- Older roads (constructed before 1968) had twice the rate of landslides than roads constructed after 1968.
- Mid-slope and valley bottom roads acted as traps of coarse sediment and large wood, altering the distribution of sediment and wood during landslides.
- Timber harvest in zero order stream channels and riparian areas reduced the availability of large wood for transport to larger stream channels.
- Following the floods, streams in Fish Creek had high temperature regimes similar to urban streams in the lower Clackamas River.
- Following the floods, pool frequency was greater, but there was less overall pool habitat available in Fish Creek.

An interdisciplinary team was formed to evaluate this information and propose management alternatives for the Fish Creek watershed. A scientific review panel provided feedback to the interdisciplinary team to insure a full range of management alternatives. The Mt. Hood National Forest Land Management Plan (1990) and the Northwest Forest Plan (1993) provided the basis for all management alternatives.

Following analysis of post-flood studies, restoration projects in the Fish Creek watershed were identified. Watershed restoration projects targeted hill slope areas and riparian areas. The projects were comprehensive, integrated, and were located from hilltop to stream bottom. Hill slope projects include road obliterations, storm proofing roads, and road/stream crossing restoration, and silvicultural treatments in plantations and landslide areas. Riparian area projects include road obliterations, storm proofing roads, road/stream crossing restoration, riparian silvicultural treatments such as tree planting and tree thinning, erosion control, and instream fish habitat restoration and side channel reconstruction. In effect, the entire watershed was treated. For example, 106.5 miles of road, or 73% of the road system, were decommissioned. The remaining 35.5 miles of road were repaired, or storm-proofed.

Monitoring

By curbing human activities that can modify natural disturbances, such as timber harvest and road building, coupled with restoration projects, it is expected the ecosystem will regain its resilience. Future natural disturbances will contribute toward maintaining habitat diversity and ecosystem health. Monitoring, a piece of the adaptive management cycle, will allow a measure of how the watershed is recovering temporally and spatially with respect to landslide tracts, riparian areas and upslope harvest units, temperature in streams, stability of landslide and old road beds, reconstructed stream crossings, and fish

populations. From monitoring data the resilience of the watershed after another large disturbance, such as the 1995-96 floods, can be evaluated.

Restoration Projects

Many steps were taken before Fish Creek restoration projects were implemented on the ground. As described above, baseline data collection was extensive (see Appendix A). Once results of initial post-flood studies were completed, a scientific panel of watershed restoration specialists was assembled. The scientific panel reviewed findings of field studies, identified data gaps and suggested options for restoration. An interdisciplinary team was assembled at the Clackamas River Ranger District to write an environmental analysis as required by the Natural Environmental Policy Act.

The interdisciplinary team described issues around watershed restoration in the Fish Creek watershed, presented alternatives for restoration and described the effects of the different alternatives. Public opinion and ideas were important in the development of the Fish Creek restoration plan. There were many avenues for involvement including an open house, several mailings with information about the project and field trips. After the decision notice was signed contractors implemented restoration projects.

Projects are listed below and grouped into two main categories, hill slope and riparian area. The groupings reflect the natural processes the projects attempt to restore such as hydrologic function, and large wood and sediment delivery.

1) Hill Slope Restoration Projects

- Obliteration of 106.5 miles of road, including removal of pavement and gravel, scarification of road surface, recontouring as needed, and application of erosion control materials.
- Restore about 70 road/stream crossings, including pulling back side slopes, removing culverts, adding large wood to side slopes and in-channel, and application of erosion control materials.
- Thin 1,431 acres of young trees, and
- Plant landslides where feasible.

2) Riparian Area and Stream Channel Restoration Projects

- Thin 2,056 acres of young trees,
- Restore and plant road/stream crossings,
- Reconnect historic side-channels with mainstem Fish Creek,
- Restore fish habitat, and
- Storm proof 35.5 miles of road.

Participants

The Clackamas River Ranger District has the lead on most projects. Resource areas involved are: engineering, fisheries, botany, silviculture, recreation, and geographic information systems (GIS). The Pacific Northwest Research Station (PNW) in Corvallis, Oregon has been monitoring fish habitat and fish populations in the watershed since the early 1980's. Over the years their monitoring has adapted and changed based on their findings. They will continue the research project, although modified from earlier efforts because of the changes in the watershed. The Forest geologist is the lead on landslide inventories, slope stability evaluations and road obliteration effectiveness. The Forest hydrologist has oversight of 303(d) water quality restoration and the U.S.G.S. gauging station.

Goals

There are three goals of the monitoring program.

1. *Document and evaluate changes from intensive, watershed-wide restoration.* A major goal of Fish Creek restoration is returning processes, such as frequency and size of landslides and large wood recruitment, to a level more closely resembling a disturbance regime prior to human disruption of the ecosystem. For example, roads appear to be the dominant factor interrupting the natural cycle of landslides. Obliteration of roads and restoration of stream crossings should result in changes in the magnitude and impact of natural disturbances.

2. *Determine when Fish Creek has met recovery goals of the 303(d) listing.* Fish Creek was listed as a water quality impaired stream in 1998. The state of Oregon Department of Environmental Quality (DEQ) has determined Fish Creek will be removed from the 303(d) list when rolling seven day average high of stream temperatures meet the state standard of 64° F. Fish habitat was also a concern, and physical parameters reported by Shively (1996) were a template for restoration projects.

3. *Maintain the integrity of the long-term PNW research data set.* The Forest has a long-term partnership with the Pacific Northwest Research Station. Though not an explicit restoration monitoring item, the description of fish habitat and fish population estimates for Fish Creek is a data set unique in its duration and completeness. A goal of the Forest and PNW is to maintain the data sets for future trend analysis.

Monitoring Plan

This document is based on an interdisciplinary review and agreement of priorities of monitoring activities in Fish Creek. This document is an overview study plans of the various restoration projects and their corresponding monitoring plans. For example, the

fisheries department at the Clackamas River Ranger District is monitoring temperature recovery. Study plans and field protocols for activities are found in that department. This document gives an overview of the activities and location of additional information.

A series of restoration activities have been undertaken in the Fish Creek watershed. They are broadly grouped into the following categories:

- Restoration of hill slope processes through road obliterations, road storm proofing, hill slope silvicultural treatments and road/stream crossing restoration.

- Restoration of riparian processes through silvicultural treatments, and road/stream crossing restoration.

- Fish habitat and fish population restoration through instream habitat restoration.

Table 2 outlines the restoration work completed since the floods in the mid-1990's.

Table 2. Summary of Post-flood Restoration Projects Completed in Fish Creek

Road Activities	
Road Decommissioned Category	**Miles Decommissioned**
Level III, IV, and V	50.6
Level I and II	45.9
Level I and II closed naturally	**10.0**
Total System Miles Closed	**106.5**
Major Pipes Removed	**114**
Minor Pipes Removed	**1,050**
Stream Crossings Restored (estimate)	**60-80**
Erosion Control (all hand placed)	
Seeding and Fertilizing	435 acres
Mulching with Annual Rye Grass Straw	114 acres
Erosion Control Mat	718 square yards
Silviculture Activities	
Thinning	
Hillslopes	1,431 acres
Riparian Areas	2,056 acres
Total Acres Thinned	**3,487 acres**
Landslides Planted	**50 acres**
Restored Road/Stream Crossings and Decommissioned Riparian Roads Planted	**3 acres**
Instream Activities	
Miles of Stream Treated	**2**
Number of Side Channels Restored	**1**

Time Frame

Restoration and recovery of the Fish Creek watershed will be gauged over years and decades. For example, integral to the recovery and restoration of hill slope processes is establishment of mature coniferous vegetation to provide root strength and slope stability. Mature conifers must be present to future large wood for fish habitat. Monitoring to delineate this change requires the same long-term time frame.

Data Storage

All data is stored on compact discs located at the Clackamas River Ranger Station as part of GIS. The map located on page 4 and the maps located in Appendix B are products of the Geographic Information System. Each resource area also maintains their own data set.

Summary of Monitoring

Outlined below is the corresponding monitoring of restoration activities. The landscape-level process is identified, followed by goals, restoration activities, monitoring tasks, the measure of effectiveness, the frequency of monitoring, and who will complete the task.

Restoration of Hill Slope Processes

Processes:

- Landslides
- Large wood recruitment
- Sediment delivery
- Movement and storage of water

Goals:

- Reduce the ratio of landslides associated with unneeded roads and needed roads.
- Accelerate hydrologic function of plantations.
- Restore hydrologic function where roads have interfered with drainage.
- Allow passage of large wood and sediment into stream channels.
- Evaluate effectiveness of different types of road obliteration treatments.
- Reduce peak flows during large storm events.
- Reduce the ratio of landslides associated with young plantations.

Restoration Activity

- Obliterate roads.
- Storm proof roads.
- Thin plantations 10-40 years old (mean age 20 years).
- Plant landslide tracks.
- Reconstruct road/stream crossings.

Frequency

- Landslides and road inventories repeated following a 10-year or greater storm event.

- Instantaneous peak flow monitoring at gauging station.
- Photo points at road/stream crossings repeated following a 10-year or greater storm event.
- Photo points along mainstem Fish Creek repeated following a 10-year or greater storm event, and every other year along mainstem Fish Creek between 2000 – 2010.
- Landslide planting inventory in 2001.

Monitoring Tasks:

- Inventory landslides following a ten-year or greater storm event.
- Monitor peak flows at the U.S.G.S. gauging station.
- Inventory restored sites (road obliterations and road/stream crossings).
- Inventory public access, pioneered roads and areas of human use.
- Inventory road obliterations for effectiveness of treatment.
- Inventory planted landslide tracks for effectiveness and to evaluate vegetation cover contributed by all tree species.

Measure of Effectiveness:

- Reduction in ratio of landslides from roads.
- Road obliteration techniques meet objectives for restoration.
- Reduction in ratio of landslides from young plantations.
- Ground disturbance at stream crossings from human use is not causing a reduction in water quality.
- 50% survival of planted trees and minimum stocking of 125 trees per acre.

Who Completes

- Road and landslide inventories, photo points and public use monitoring by Forest geotechnical engineer and District engineering group.
- U.S.G.S. gauging station oversight at headquarters by Forest hydrologist.
- Stocking inventories by silviculture.

Restoration of Riparian Processes

Process:

- Large wood recruitment and movement
- Sediment recruitment and movement
- Riparian area diversity
- Riparian area shading
- Floodplain function

Goals:

- Accelerate tree growth for future large wood recruitment.
- Increase stream shade and decrease peak seven-day rolling average stream temperatures.
- Restore riparian areas, including species diversity, and connectivity with the main channel.

Restoration Activity

- Riparian silvicultural treatments
- Road/stream crossing restoration
- Road obliterations adjacent to Fish Creek
- Reconnect sidechannels and overflow channels to Fish Creek mainstem

Monitoring Tasks:

- Stocking surveys of planted stock and evaluate vegetation cover of all tree species on stream crossing restoration sites along Road 54 and 5420
- Photo points.
- Sample summer temperatures at sixteen sites throughout Fish Creek watershed (see map 1, page six).

Frequency:

- Stocking survey and evaluation in 2001.
- Temperature monitoring every two years (2000, 2002 etc.).

Measure of Effectiveness:

- 50% survival of planted stock and minimum 125 trees per acre of all tree species.
- Peak seven-day rolling average stream temperatures meet state standards of 64° F.
- Disturbed riparian areas are restored to a mature vegetation community.

- Floodplain connectivity is restored and the stream reclaims overflow channels isolated by road construction.

Who Completes:

- Stocking surveys completed by silviculture.
- Temperature probe monitoring completed by fisheries.

Fish Habitat and Fish Population Restoration, PNW Habitat Data Set

Processes:

- Riparian area function
- Formation and maintenance of instream habitat

Goals:

- Restore fish habitat conditions in lower Fish Creek to pre-flood conditions are described in Shively et al. 1996.
- Maintain or increase contribution of Fish Creek salmonids to Upper Clackamas watershed fish populations.
- Maintain PNW research data sets.
- Document channel changes in key reaches of Fish Creek.

Restoration Activity

- Riparian area silvicultural treatments
- Instream fish habitat restoration
- Restoration of road/stream crossings

Monitoring Tasks:

- Basin-wide stream surveys (Fish Creek and Roaring River).
- Basin-wide wood surveys Fish Creek and Roaring River).
- Longitudinal profile (Fish Creek).
- Channel cross sections (Fish Creek–key reaches).
- Instream photo points (Fish Creek and Roaring River).
- Smolt trapping.
- Compilation of habitat parameters from unroaded watersheds within the Clackamas River watershed.

Measure of Effectiveness:

- Fish habitat composition approaches that of unroaded basins.
- Fish Creek smolt numbers are maintained or increase in contribution to upper Clackamas River basin populations (i.e. as percentage of dam index).

Frequency:

- Fish Creek basin surveys of fish habitat and wood completed every two years (2000, 2002 etc.) or following a > than 10-year storm event.
- Roaring River basin surveys of fish habitat and wood completed every six years (2002, 2008 etc.) or following a > than 10-year storm event.
- Channel cross-sections and longitudinal profile analysis redone in key reaches after a 10-year or greater storm event.
- Basin longitudinal profile analysis redone every 10 years.
- Instream photo points in Fish Creek and Roaring River retaken every ten years.
- Smolt trap annually.
- Intensive large wood survey repeated every five years (under review).

Who Completes:

- Basin surveys to be completed by PNW with assistance from Clackamas River Ranger District.
- Smolt trapping to be completed by PNW with assistance from Clackamas River Ranger District.
- Channel cross-sections, longitudinal profile analysis, and photopoints to be completed by Clackamas River Ranger District.

Incomplete Tasks

There has been no formal update of the Fish Creek watershed analysis since the floods of the mid-1990's, subsequent studies, and implementation of the watershed restoration project. Updates of key resource information, such as miles of road per square mile, number of road/stream crossings removed and number remaining, miles of fish habitat restoration and miles of road removed from riparian areas have not been completed.

Concerns

The invasion of noxious weeds is an ongoing concern across the Ranger District. There will be ongoing monitoring of documented (known noxious week species in the watershed) by botany and/or personnel trained in noxious week identification. Expansion of noxious weeds will also be monitored. A goal is to eventually control noxious weed sites through manual, biological, and/or chemical methods.

Offsite tree stock was used for many of the plantations along the old 5420 road. The Forest-level annual aerial insects and disease detection flight will be used to monitor thinning crowns and when disease and pests start entering offsite stands.

Other Monitoring

During the summer of 2001 a turbidity monitoring sensor was installed at the U.S.G.S. gaging station on Fish Creek. The goal of the turbidity monitoring is to determine the relative contribution of Fish Creek fine sediments compared to two similar stations, one at Carter Bridge, 0.5 miles downstream of Fish Creek on the mainstem Clackamas River, and another on the mainstem Clackamas River below River Mill dam. A secondary goal is to evaluate trends in turbidity levels following the watershed restoration in Fish Creek.

Information Analysis, Storage and Reporting

Each individual resource area is responsible for information analysis and reporting.

PNW reports findings from smolt trapping and the habitat survey in the annual publication "Fisheries Partnerships in Action".

Digital information, such as digital photos and GIS maps, can be found with the Fish Creek librarian Bob Bergamini at the Clackamas River Ranger District. A reference shelf of Fish Creek publications, photos and information is found in the fisheries department.

The Forest geologist maintains the database of landslides, landslide origin and photo points of road decommissioning work.

PNW archives and maintains fish habitat, large wood inventory and smolt trap data sets.

An overview of monitoring tasks and the corresponding time interval for data collection is presented in table 3.

An interdisciplinary reporting of findings will follow a 10-year or greater storm event. The year 2010 is also targeted for an interdisciplinary reporting of findings.

Table 3. Monitoring Timeline

Frequency		Task	Begin Year	Contact
Instantaneous	➔	Gauging Station (temperature and turbidity)	Ongoing	HQ I.Steinblums
Every Year	➔	Smolt Trapping	2000	PNW B.Strobel
Every Other Year	➔	Temperature Probes	2000	Fisheries B.Bergamini
	➔	Fish Habitat Surveys	2000	PNW B.Hansen
	➔	Mainstem Photopoints (until 2010)	2000	Fisheries B.Bergamini
Every 5 Years	➔	Large Wood Surveys	2005	PNW B.Hansen
Every 6 Years	➔	Fish Habitat Surveys Roaring River	2002	PNW B.Hansen
Following a Greater than 10 Year Flood Event	➔	Landslide and Road Obliteration Surveys		HQ T.DeRoo
	➔	Stream Crossing Photo Points		HQ T.DeRoo
	➔	Stream Surveys, LWD		PNW B. Hansen
	➔	Channel Cross Sections		Fisheries B.Bergamini
Every 10 Years	➔	Channel cross-sections	2007	Fisheries B.Bergamini
Other	➔	Fish habitat survey in 2001 due to low water year	2001	PNW B.Hansen
	➔	Landslide Revegetation, Riparian Area Stocking Survey	2001	T. Rottman Silviculture
2010	➔	Interdisciplinary report of monitoring findings	2010	All

Appendix A

References and Other Useful Documents

Baker, C., 1999. Comparison of summer stream temperatures in the Clackamas Sub-basin using cluster analysis. on file at Clackamas River Ranger District, Mt. Hood National Forest.

Contract No. DTFH70-99-C-00018. June 1999. OR FS ERFO 96-11(5) Fish Creek Area Roads. U. S. Department of Transportation Federal Highway Administration Vancouver, WA.

DeRoo, T.G., Doug Smith and Doug Anderson. 1998. p. 379-390. Factors Affecting Landslide Incidence after Large Storm Events during the Winter of 1995-1996 in the Upper Clackamas River Drainages, Oregon Cascades. S. Burns, Ph.D., editor, in Environmental, Groundwater and Engineering Geology: Applications from Oregon. Star Publishing Company, Belmont, CA.

Fish Creek Restoration Environmental Analysis. 1998. on file at Clackamas River Ranger District, Mt. Hood National Forest.

Fish Creek Water Quality Restoration Plan. 2000. draft on file at Clackamas River Ranger District, Mt. Hood National Forest.

Fish Creek Watershed Analysis. 1994. Mt. Hood National Forest. Estacada, Oregon.

Fisheries Partnerships in Action, Clackamas River Subbasin, Oregon, 1998. Accomplishments Report for the Clackamas River Fisheries Working Group.

Henderson, R. 1996. Fish Creek and Roaring River Sampling 1996 V*star and Riffle Stability Index. on file at Clackamas River Ranger District, Mt. Hood National Forest.

Hickman, T.L. 1999. Fish Creek – Adaptive Watershed Management in the 21st Century. Mt. Hood National Forest. Estacada, Oregon.

Kershner, J.L. 1997. Monitoring and Adaptive Management. Pages 116-131 in J. E. Williams, C.A. Wood, and M.P. Dombeck, editors. Watershed Restoration: principles and practices. American Fisheries Society, Bethesda, Maryland.

Koonce, G. 1998. Assessment of Flood Effects on Fish Habitat and Channel Condition with Recommendations for Rehabilitation in the Fish Creek Subbasin of the Clackamas River Drainage. David Evans and Associates, Inc.; Inter-Fluve, Inc.

Reeves, G.H., and six coauthors. 1997. Fish Habitat Restoration in the Pacific Northwest: Fish Creek of Oregon. Pages 335-359 in J. E. Williams, C.A. Wood, and M.P. Dombeck, editors. Watershed Restoration: principles and practices. American Fisheries Society, Bethesda, Maryland.

Shively, D.R., and four coauthors. Changes in Channel Characteristics and Fish Habitat in Fish Creek and Roaring River, Two Principal Tributaries to the Clackamas River: Comparisons Between the 1964 and 1996 Flood Events. T. Laenan, editor, Proceedings of the Second Annual Pacific Northwest Water Issues Conference, "The Flood of '96..." October 1996. Portland, OR.

U.S. Forest Service and U.S. Bureau of Land Management. 1994. Record of decision for amendment to Forest Service and Bureau of Land Management planning document within the range of the northern spotted owl. Portland, Oregon.

U.S. Forest Service. 1990. Land and Resource Management Plan. Mt. Hood National Forest. Sandy, Oregon

Appendix B

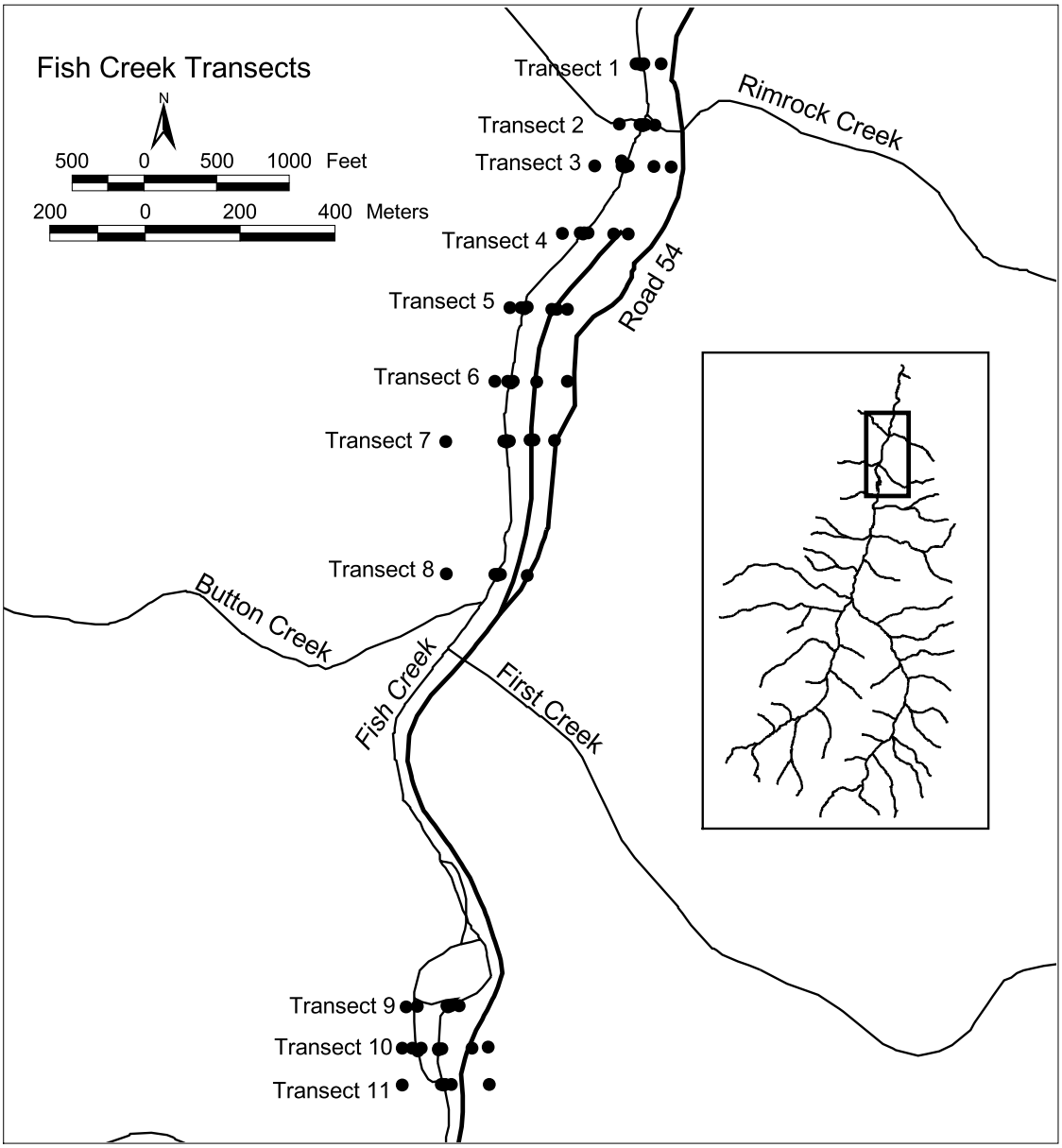
Fish Creek Monitoring Maps

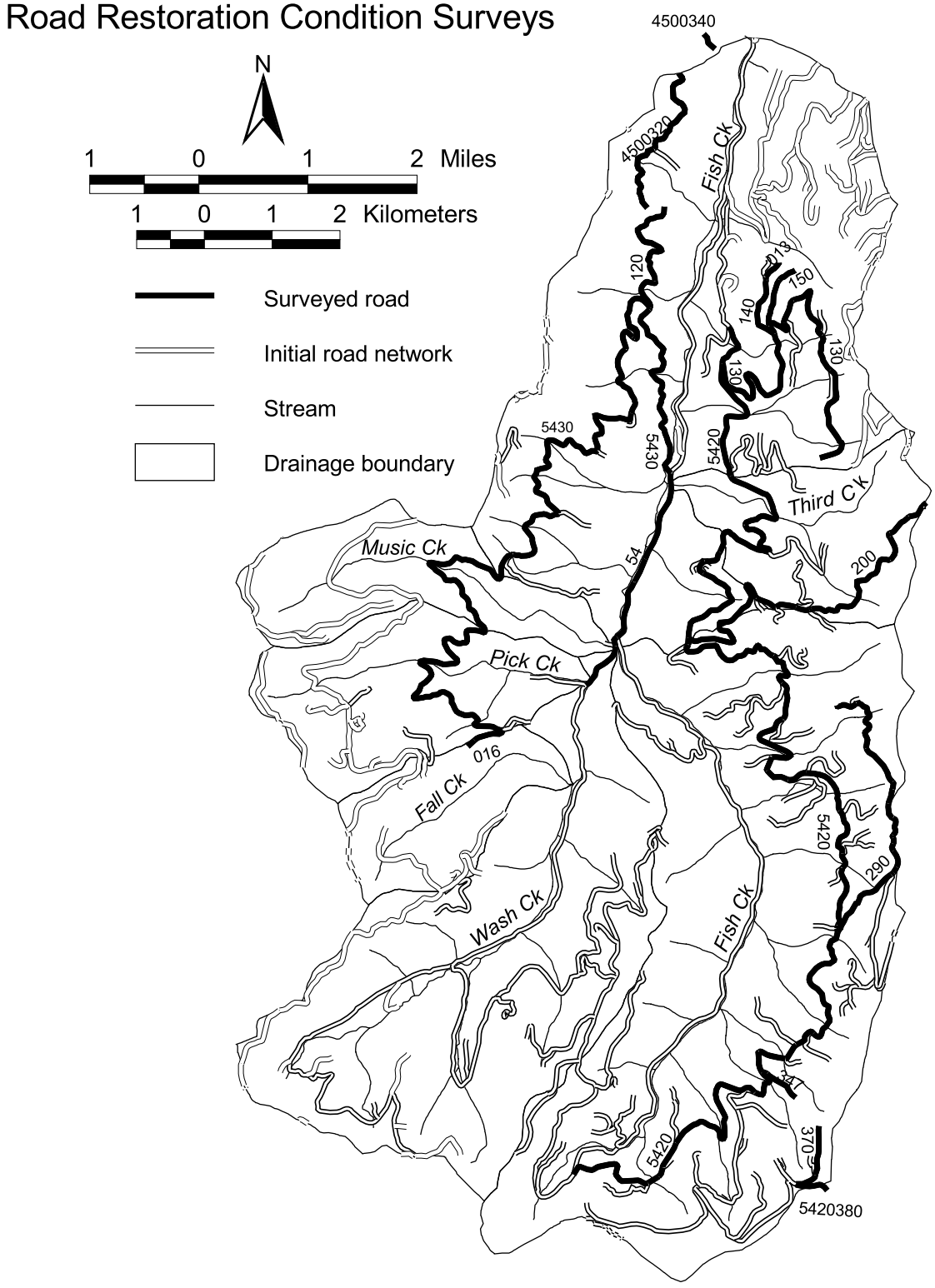
All maps are stored in GIS compact discs, located at the Clackamas River Ranger District

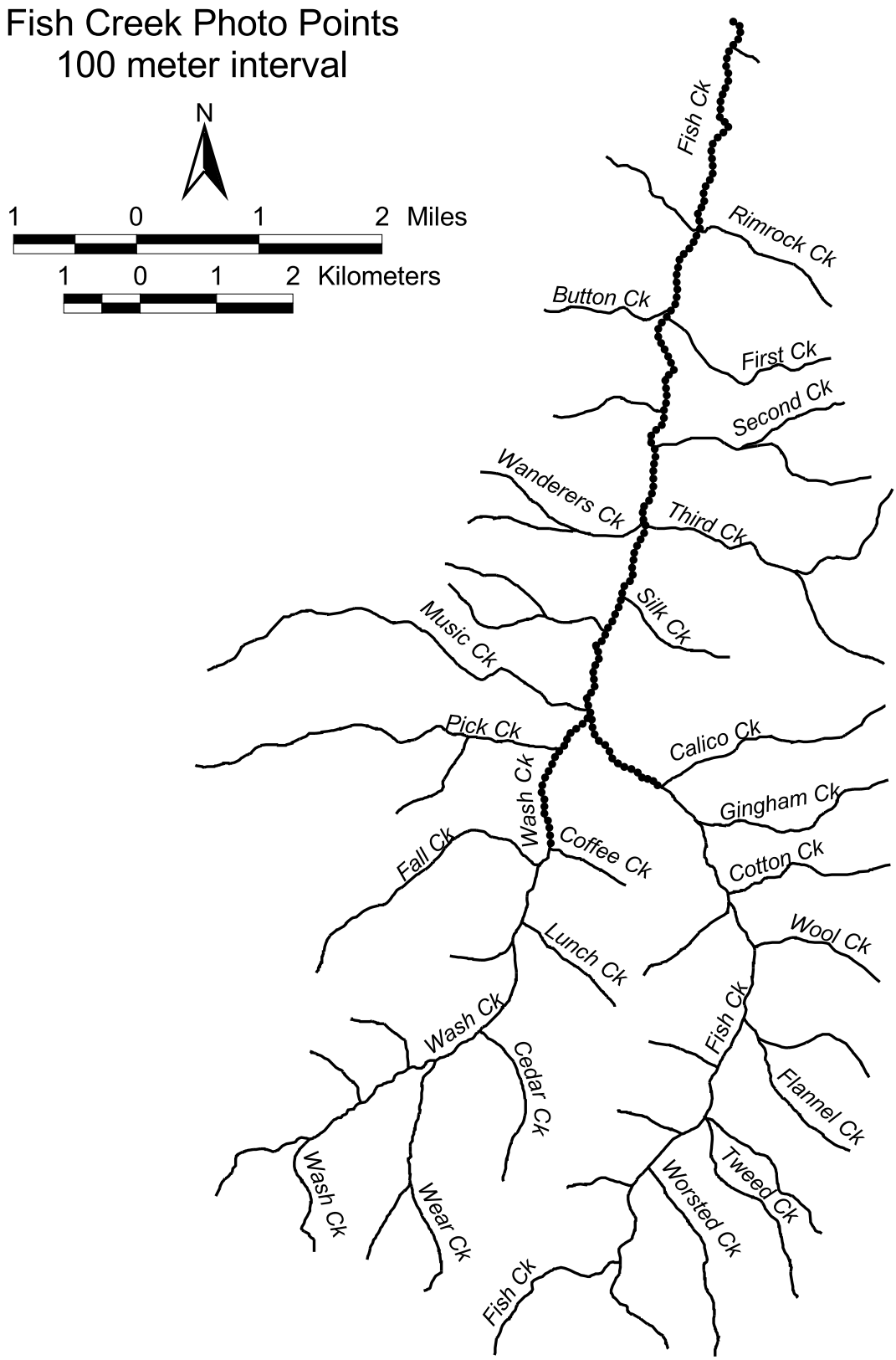
Fish Creek Stream Transects

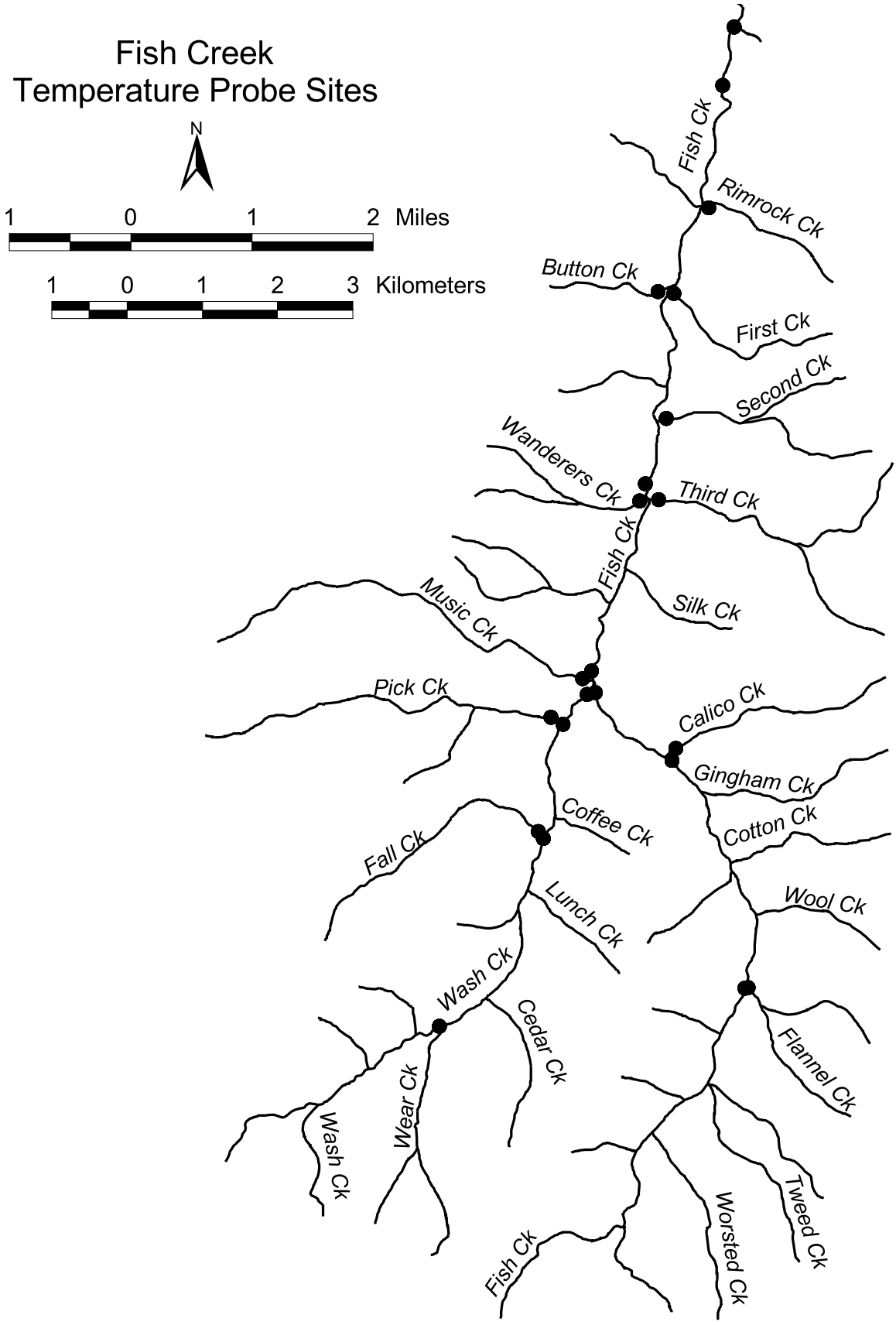
Transect data for years 1996 and 1999

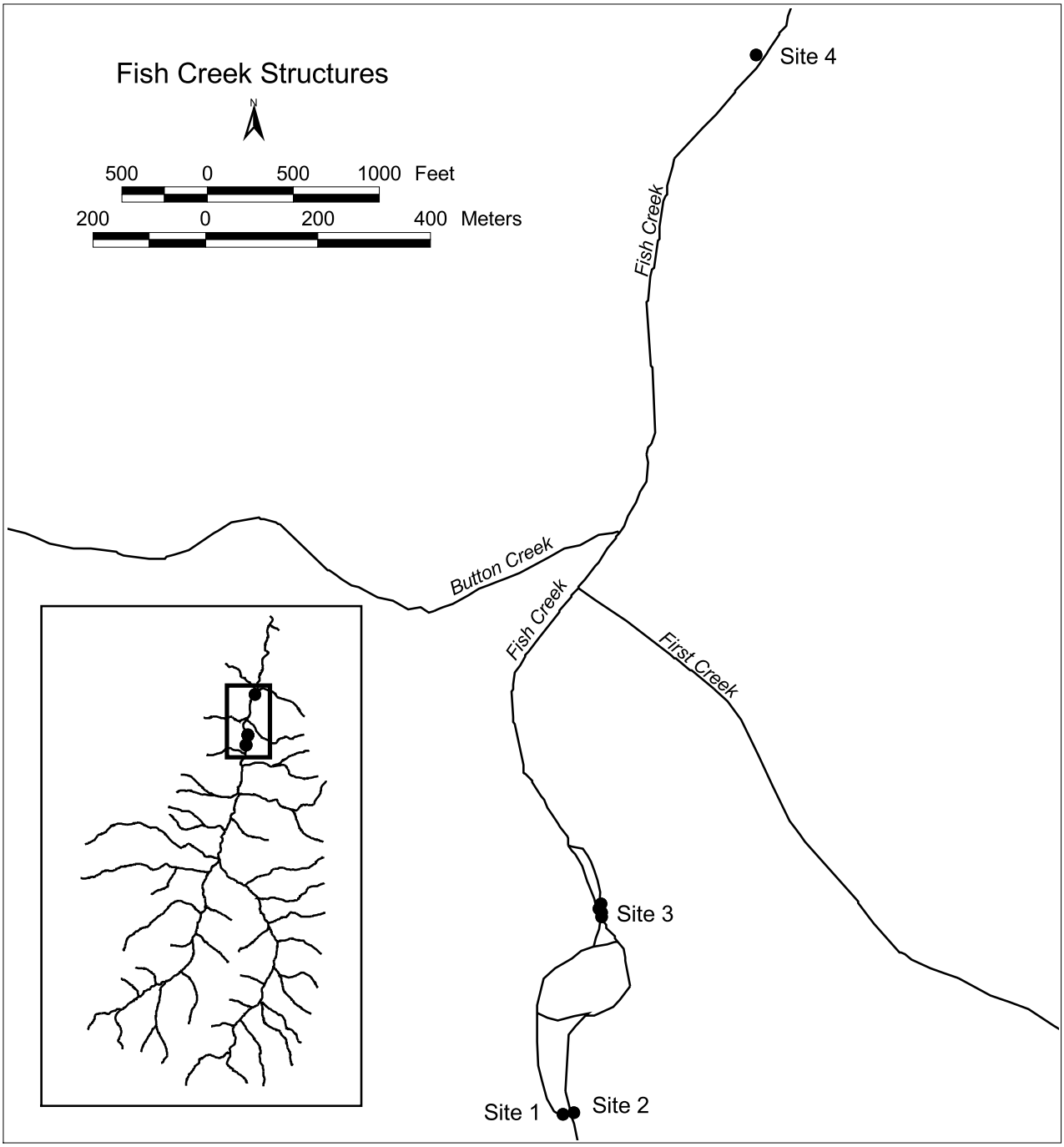
Photo points at each transect

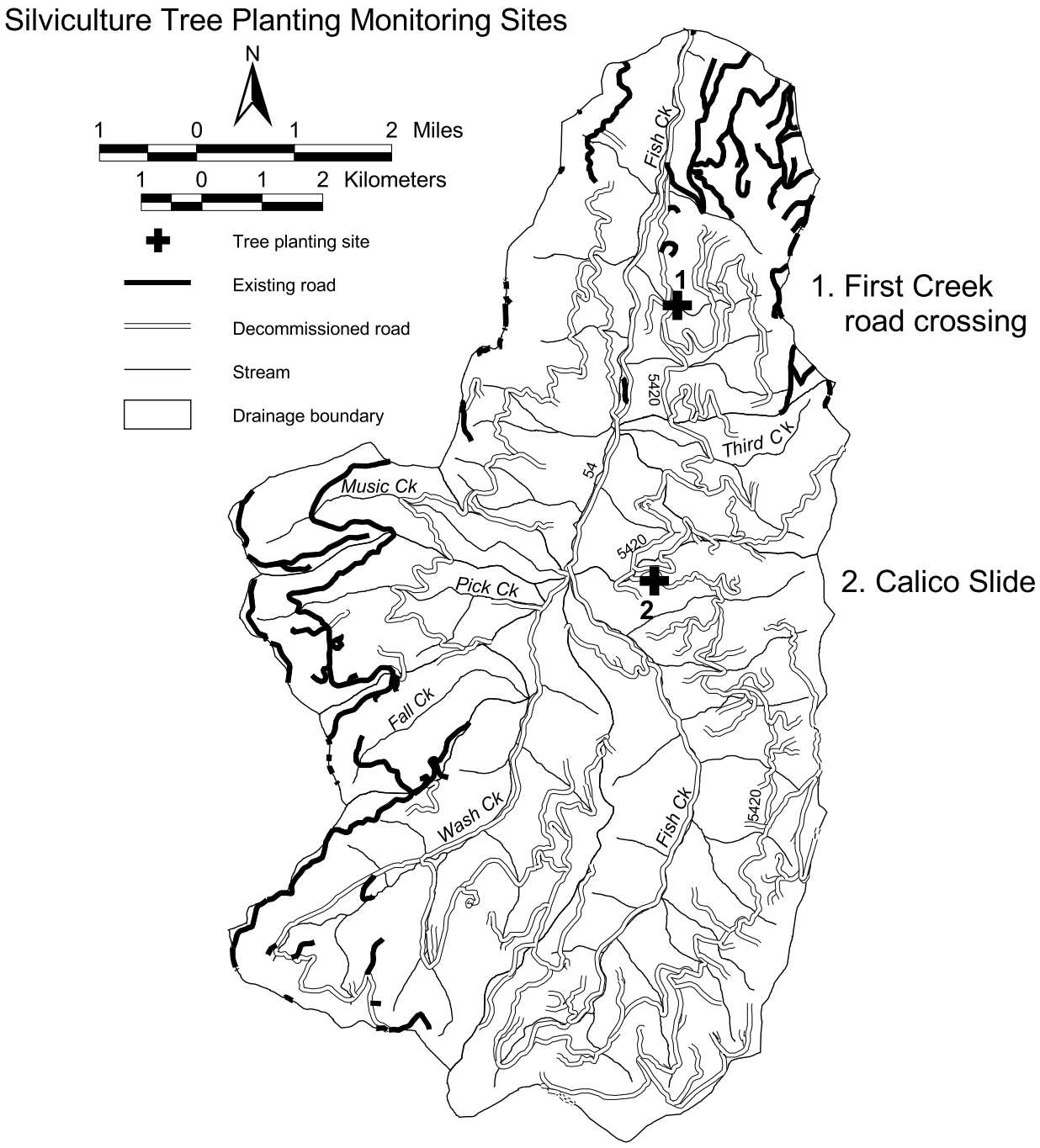



Road Restoration Condition Surveys
N
1 0 1 2 Miles
1 0 1 2 Kilometers
Surveyed road
Initial road network
Stream
Drainage boundary
4500340
4500320
Fish Ck
120
013
150
140
130
130
5430
5430
5420
Third Ck
Music Ck
54
200
Pick Ck
016
Fall Ck
5420
290
Wash Ck
Fish Ck
370
5420
5420380


Fish Creek Photo Points
100 meter interval
N
1 0 1 2 Miles
1 0 1 2 Kilometers
Fish Ck
Rimrock Ck
Button Ck
First Ck
Second Ck
Wanderers Ck
Third Ck
Silk Ck
Music Ck
Pick Ck
Calico Ck
Wash Ck
Gingham Ck
Fall Ck
Coffee Ck
Cotton Ck
Wool Ck
Lunch Ck
Wash Ck
Fish Ck
Cedar Ck
Flannel Ck
Wash Ck
Wear Ck
Tweed Ck
Worsted Ck
Fish Ck


Fish Creek
Temperature Probe Sites
N
1 0 1 2 Miles
1 0 1 2 3 Kilometers
Fish Ck
Rimrock Ck
Button Ck
First Ck
Second Ck
Wanderers Ck
Third Ck
Fish Ck
Silk Ck
Music Ck
Pick Ck
Calico Ck
Gingham Ck
Coffee Ck
Cotton Ck
Fall Ck
Lunch Ck
Wool Ck
Wash Ck
Cedar Ck
Flannel Ck
Wash Ck
Wear Ck
Tweed Ck
Worsted Ck
Fish Ck


Fish Creek Structures
N
500 0 500 1000 Feet
200 0 200 400 Meters
Site 4
Fish Creek
Button Creek
Fish Creek
First Creek
Site 3
Site 1
Site 2


Silviculture Tree Planting Monitoring Sites
N
1 0 1 2 Miles
1 0 1 2 Kilometers
Tree planting site
Existing road
Decommissioned road
Stream
Drainage boundary
Fish Ck
1
1. First Creek road crossing
5420
Third Ck
54
Music Ck
5420
Pick Ck
2
2. Calico Slide
Fall Ck
Wash Ck
Fish Ck
5420