

PILOT MANAGEMENT STUDY: LOGGING SILTATION EFFECTS
ON FOUR STREAM INVERTEBRATE POPULATIONS
IN THE LOWELL RANGER DISTRICT

by

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A THESIS

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Approved: _____

Dr. Paul Engelking

Stream invertebrates' sensitivity to siltation that follows logging activities might be useful in ongoing environmental monitoring. Determining that usefulness requires isolation of individual parameters that influence invertebrates, surveying of populations under a range of conditions, integration of the survey procedures into the mainstream of resource monitoring, and comparison of the results to those available through other stream indicators. This paper addresses the first three of these issues with an outline for a survey comparing four invertebrate populations, *order trichoptera*, *order plecoptera*, *order ephemeroptera*, and *family gerridae*, *order hemiptera* (caddisfly, stonefly, mayfly, and water strider), to stream sediment, within a series of controls, and to the history of a dozen stream subbasins, in the Lowell Ranger District. The study would take an estimated \$712 and 670 hours.

ACKNOWLEDGEMENTS

This project coalesced over a year and a half, under influences from several sources. Three seasons of spotted owl monitoring in the Willamette National Forest, Lowell Ranger District--including the development of a monitoring process that became the protocol for all of Region 6 (Oregon and Washington)--opened the portal of resource monitoring. Professional identification with fresh water fish ecosystems constrained the focus to that medium, and the chemistry department stipulated a project with hands-on, scientific study and a mathematical character.

After at least two hundred hours of work (and with no end in sight) a magnificent suggestion from Dr. Engelking turned the project into a management study: a consideration of the costs and advantages of the particular stream analysis process being used.

Many people have guided or assisted this project along the way, and to them I credit my continued vigor in its development. In the Forest Service, this list includes Suzanne Rock, Rick Scott, Scott Peets, Rick Cope, Jon Belcher, Jack Curtis, and Ellen Sayre. Others in the wider community include Lane Community College scientist, Stan Swank; Oregon Department of Fish and Wildlife Salmon

Trout Enhancement Program biologist, Dawn Kori; Colorado State University Earth Resources scientist, Lee MacDonald (coordinating with the Region 10 Environmental Protection Agency); and the editor of Flyfishing magazine, Marty Sherman.

At the University of Oregon, Lloyd Dolby supplied healthy irony and topic ideas, Dennis Todd offered literature and an early vote of confidence, and LeRoy Klemm and Cheyney Ryan accepted advisory roles on the thesis committee.

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CHAPTER 1: OVERVIEW

Goals of the Study

Several ideas motivate this project. First, its subject addresses a relevant aspect of human responsibility: the management of the living realm that surrounds society. Second, it has a chance of both integrating into and clarifying other research in the resource field. Finally, it could generate useful results.

The context of this study is fully pertinent. Since people both depend on and disrupt ecosystems, they must maintain them. Very few could claim to know the details of what is necessary to sustain life--all the microorganisms involved in respiration, digestion, or growth, for example. While dependent on this inherited equilibrium, no real choice exists to cast off the better parts; and for proteins, fish are certainly among the best. Even as the elements of human well-being are a matter of conjecture, the balances of other natural systems are even less charted; and while industry and sheer numbers encroach further and further over the land, maintenance requirements of the living system will increasingly become a human issue. Fresh water fisheries are no exception.

Fish populations, and their habitat areas, are dwindling in Oregon.¹ The stream macroinvertebrates (here insects) of the current study are a relevant link in the lives of fish, being a major food source. The study would explore one part

of that chain: the effect of soil sediments on several populations of local stream invertebrates, particularly sediments that follow timber harvest activities.

One aspect of the project, the searching of historical documentation for insights into current conditions, is not a frequent tool in the literature of water quality studies. It may be that historical information has traditionally been in forms that were difficult to translate for water quality purposes. Further, documentation sufficient to one use may have large gaps when applied to another, making original research inevitable.

These weaknesses may be changing. Large resource managers (eg. state and federal agencies) are entering a time when data about thousands of square miles--on soils, satellite topography, vegetation, wildlife, streams, roads, timber stands, and other resources--are kept functionally in computer systems that have the capability of overlaying, calculating relationships, and predicting events of interest: road construction on a steep slope of unstable soil next to a prime trout stream can be expected to effect local tourism, and this affect can now be anticipated as well at a computer screen as along a favorite fishing reach. Millions of dollars are being invested to develop such systems, even as they are invested in the systems of medicine and other sciences.

A study such as the one proposed here both tests the capabilities of these new tools in assisting resource analysis and tenders the imagination of technical developers towards long-term, responsible custody of the resources. It's a reality check.

To be functional within the mainstream of water studies, the survey must be both technically compatible and practical. Compatibility results from studying the equipment and techniques of professionals and leading edge researchers, reading their work, and asking questions about any parameters they use that are tricky to duplicate or difficult to compare from one study to another.

For example, if one researcher surveyed stream insect populations in the riffles of coastal streams to a depth of ten centimeters, the results might have little useful comparison to another's survey of insects to a depth of two inches in slow moving valley waters. The more differences in format, the less likely two studies will be worth attempting to compare. At the least, projects should use standard units, readily available equipment, and common terminology. At best, resource monitoring would have balanced continuity in people and purposes, so that the field could develop responsibly.

The tools and techniques in the current survey have been compared, in part, to ones used by researchers in the Region 10 Environmental Protection Agency (Alaska, Idaho, Oregon, Washington); the Lowell Ranger District, Region 6-Pacific Northwest Experimental Station, and Region 5 (Intermountain) macroinvertebrate handbooks of the US Forest Service; and the Oregon Department of Fish and Wildlife, Salmon Trout Enhancement Program. Equipment and plans are not foreign to these other systems.

Invertebrate surveying is a fairly new field, so mass-produced equipment is not available. Instead, the standards of this study--collection screen, sample

frame, unit choices--are simple, cheap, and reproducible. Similarly, controls such as water temperature, depth, stream gradient, and substrate² are measurable without much training or complex equipment. These choices give practical transferability to other studies.

One final goal of the study is to secure results. It may be possible to confirm or refute the presence of measurable effects of particular timber harvest activities on invertebrate populations. This would contribute a small byte of definition to the vast nebulae of resource management considerations. In particular, this study (ideally) will show whether invertebrate populations are reduced during heavy sedimentation or following documented soil disturbances in this region, and indicate how time and distance effect that reduction. It may also show to what extent stream sediment levels reflect the disturbances as time passes.³

Also, useful qualification of the individual parameters of measurement and control may result, indicating which are more or less valuable, and for what types of information. For example, the tree canopy overhanging the streams might turn out to wield a large influence on populations, where gradient measurements (within some range of common values) might prove insignificant. The amount of investment into each type of measurement could then be weighed against the value of its results. This information could save time in future monitoring. To some extent, this information has already been learned by individual technicians,

and estimates are available in the literature. This study would specify the measurements to a given location and its ecosystem.

With the goals of relevance, serviceability, and positive results, this study should at least prove useful to the researcher in deepening the experience of the medium and clarification of the field of study.

Range Limits

Two limits apply to the range of this study: a restriction of ecological diversity in the subject area and a limit to the usefulness of the applied results. The diversity is restricted so there is enough similarity between study units to form a basis of comparison on the particular issues of interest. The application of the results will be limited by the clarity (certainty) of the relationships uncovered.

The indigenous variety of life forms found within stream systems can lead to variations in the results of population surveys that have nothing to do with people's influences. To isolate population effects specific to logging, the survey area is restricted to two basins near to one another (Fall Creek and Winberry Creek, on map, subsequent page). This assumes that evolved populations will have had enough interchange to have similar available genetic pools, and that soil, elevation, and climatic differences are minimized.

Beyond these inherent parallels, the basins were also chosen for their consistency in human influence. Both have been left to go "wild" since the regular burning of the undergrowth was ceased with the removal of the aboriginals. Both basins have also suffered a steady advance of road cuts and "checkerboard" clear

cut logging, followed by burning, planting, and fertilization. The subbasins⁴ of the study ideally will reflect a range of severity of ecosystem disruption, from fairly untouched to heavily roaded and logged.

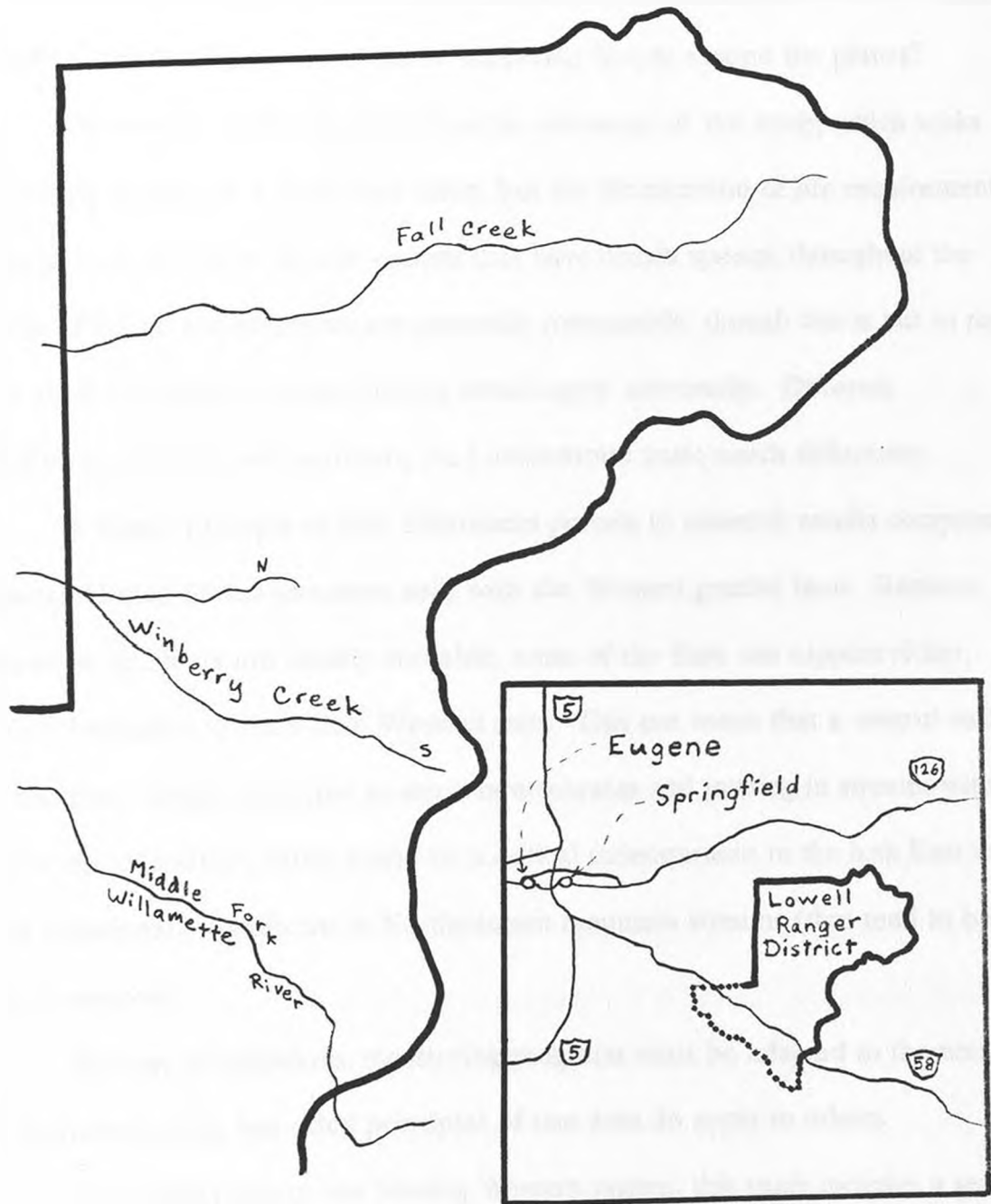


Figure 1. Lowell District and Project Streams

If the geographical and ecological range of study is so tightly limited, how far can the results apply? Will they be confined to the same streams, to Western Oregon Cascade slopes, to mountain temperate forests around the planet?

The answer to this question is in the character of the study, which seeks not simply a chart of a local food chain, but the illumination of life requirement principles of particular insects--insects that have cousin species throughout the world. Physical requirements are generally comparable, though this is not to say that all of the specific measurements would apply universally. Different conditions (climate, soil nutrients, etc.) concentrate basic needs differently.

A classic example of how differences pertain to research results compares Eastern United States limestone soils with the Western granite base. Because limestone nutrients are readily available, areas of the East can support richer, denser biological systems than Western soils. This can mean that a control such as dissolved oxygen, essential to some invertebrates and missing in streams with active decomposition, often would be a critical measurement in the lush East and only occasionally significant in Northwestern mountain streams (that tend to be rich in oxygen).

Because of variations, monitoring programs must be adapted to the norms of individual areas, but often principles of one area do apply to others.

For comparison to one leading Western system, this study includes a series of measurements found to be consistently important in Rocky Mountain region streams. If these parameters were found to hold true here in the Cascades as

well, it could be a valuable extension to the theory and tools of stream monitoring.

At the other end of the spectrum, if none of the ideas panned out conclusively, there would still be some value in the clarification of individual study and control parameters which could be regrouped for later uses. At the least, people at the Ranger District would know which of the measurements were interesting or particularly sensitive for streams in their area.

The clearer the results, the wider range of application they have. At this point, it is a matter of conjecture how definite the results of this project would be, but the usefulness of the study is enhanced as much as possible by strictly limiting the environmental range and coordinating with standards already in use in other areas.

Outline of the Study

Briefly, the idea of the study is to compare a number of similar streams that have undergone differing degrees of soil disturbance to see how insect populations vary with the harvest activities. Four basic types of measurements are involved: stream insect populations, the amount of sediment (soil) suspended in the water, the documented extent of disruptive activity (logging and road building), and controls. The data will be compared by computer, using a series of simple least-squares regressions (described in the Trial Fits section of Chapter 2).

For this paper, the project divides according to what is done and what is not yet done, the former being of definite time and expense, and the latter being only estimated.

Work Done

The work already completed includes research, design, and testing of most key measurement concepts, coordination with other people involved in the project's success, and the building and gathering of equipment, maps, and field forms for accurate data collection. So far, at least 200 hours and \$150 have been invested towards these ends (listed, page 30.)

Yet to Do

The next section of this paper shows in detail the proposed tasks and estimates of the time and money it would take to complete them. Here follows a short summary of these tasks, for overview.

Choice of particular creeks to be included in the study will undergo revision. The "office" issue involves the quality of historic records available for different areas and by different methods.

Sulfate measurement follow-up work needs to be done on the processing of hazardous waste (barium chloride).

In-field elimination of possible streams will be done based on the difficulty of access and their reasonable fit to structural control parameters.

Subunit choice will be refined to maximize insect sampling similarity between streams. Simultaneous invertebrate samples will be taken on all streams (within a week or less of fairly consistent weather).

Simultaneous water samples will be taken from all streams and analyzed at the Rigdon District water lab.

Historic computer data at the Forest Service will be analyzed for acres of harvest and miles of road building within each subbasin.

Evaluation of all of these data by linear regression comparisons will be done.

Finally, the findings will be reported. Parameters that were especially useful will be identified for testing on other streams.

Chapter 1 Notes

1. According to Dave McTeague, editor of NW Steelheader magazine, "A recent report from the American Fisheries Society lists 214 stocks of Northwest anadromous fish as being threatened and in danger of extinction (McTeague 5)."
2. *Gradient* is the steepness of the stream. *Substrate* is jargon for the physical medium under observation, in this case gravel, sand, logs, boulders, etc., which line the stream beds.
3. MacDonald (1989) has developed a theoretical model for sediment (and water) yield into streams as a function of time after clear cutting, based on a number of actual studies.
4. A *basin* is the combined area of all the land that feeds rainfall into a major creek or river. *Subbasins* are the smaller watershed areas that run into individual feeder creeks of the main stem.

CHAPTER 2: DETAILS

Stream Choice

Parameters and Purposes

The ecological significance of stream choice--pursuing genetic, geologic, and climactic similarity--has already been acknowledged. Beyond this concern, two other issues will affect the preliminary choice. First, the historical data on line at the Lowell Ranger District is limited to the study areas of other particular projects. The district has been developing databases for decades, but the current entry into the computer system has only begun in recent years. The areas now available include Winberry Creek and a large upper section of Fall Creek, but not lower Fall Creek, so study streams will mainly be limited to these developed areas.

The second issue is how many streams it will take to assure a good probability of useful results. A rigorous procedure for this decision would include preliminary samples and comparisons of all significant parameters to obtain estimated uncertainties. Instead, this paper (somewhat arbitrarily) offers time and cost estimates for a study of twelve streams, including at least one fully unharvested stream as a control.

Equipment and Processes

For the computer aspect of the study, information about which streams are on line is most directly obtained by asking the district planners who have been working with it.

Time and Cost Estimate

Fifteen minutes comparing maps in the planning department would precisely specify the streams available on computer; another hour of analysis would decide which were the right size (five to eight square kilometers--two to three square miles) and had road access.

Hazardous Waste Disposal

Parameter and Purpose

For measuring sulfate, the available test kit uses barium chloride, a hazardous material (according to the test kit's Material Safety Data Sheet). The sulfate parameter is integral to the invertebrate analysis process used by the Intermountain Region of the Forest Service (Winget and Mangum) which this study will attempt to parallel, so researching a responsible route of disposal is inherent in the project.

Equipment and Processes

Inquiries to date have uncovered several possible routes of processing if the substance proves significantly toxic, including reuse by the manufacturer, and disposal with a hazardous waste broker, a treatment, storage, and disposal facility, or the University (Environmental Health and Safety Office, for information).

Each of these options should be assessed for practical and ethical merit. If the product can reasonably be used and processed, proper handling gear should be purchased, including disposable gloves and transport containers, and a transfer plan established.

Time and Cost Estimate

Half an hour of phone calls on a business day should produce the list of options, costing perhaps \$3.00. (The only hazardous waste landfill in the area is Arlington, East of Portland, and the supplying company is in Colorado.) Another half hour of shopping would likely complete the equipment, for under \$5.00. Delivery (up to 300 miles) at the end of the project might take six hours and \$70, plus fees.

Visit for Access and Controls

Parameters and Purpose

Some relevant parameters can only be assessed by a stream side visit. These involve the ability to reach a good sampling area and the verification of similar structures on every stream. For access, unless a suitable sampling site can be reached with a hike taking less than about eight minutes, inclusion of the stream is not appropriate. There are enough subbasins in the research area not to require too much time outlay.

Other deciding factors are in the specific structure of the stream. These are not simple to categorize, but many useful characteristics have been identified.¹ Pertinent to the fish (and likely to be pertinent to the invertebrates)

are the tree cover or canopy, and the stream substrate, gradient, pH, and temperature. Additional controls to be measured include aspect (direction of slope), sulfate levels and stream width and depth.

Equipment and Process

Mostly simple tools are needed for the measurement of controls:

- compass for stream and canopy aspect
- clinometer for gradient and canopy angle
- thermometer
- meter stick or ruler
- pH meter (also available at laboratory during sediment analysis)
- sulfate kit

At the stream, various measurements and classifications will be documented on a regular form (Appendix A) that will allow for easy translation onto computer.

When all of the streams have been chosen and assessed, the control variables will be listed in computer spreadsheet format² for later comparison with other parameters. Also, the resulting data will be organized to generate a biotic condition index, as used in Forest Service Intermountain Region (see Appendix B for development).

Time and Cost Estimate

Previous control visits took about three quarters of an hour per creek, including drive time. Adding to this the sulfate measurement, they might take one hour per creek to a total of twelve hours, or one and a half days. Vehicle expense at \$.25 per mile comes to \$42.00. (This assumes twelve creeks, with 20 miles to reach the area and 2 additional miles each creek, one way.) The sulfate/barium chloride disposal might be \$15.00. Initial construction of a

spreadsheet for these controls would probably take an hour. Data entry for the twelve streams might take another two hours, for a total of fourteen hours. The biotic condition index analysis will take another half hour per stream.

Invertebrate Surveys

Parameters and Purpose

Four insect populations are counted, *order trichoptera* (Caddisfly), *order plecoptera* (Stonefly), *order ephemeroptera* (Mayfly), and *family gerridae*, *order hemiptera* (water strider). These insects are common in the area, fairly easy to identify, and apparently somewhat sensitive to logging activities.³ In order to optimize comparisons between streams, a qualitative system will be used to choose subunits. To control the life-stages and environment of the sample insects, surveys of all streams will take place within the same week of fairly even weather, temperatures will be read at the time of sampling, and precipitation records for immediately preceding days and weeks will be obtained from the National Weather Bureau at the Mahlon Sweet airport.

Equipment and Processes

The sampling requires a net for collecting insects from the stream (U.S. Department of Agriculture). It is placed immediately downstream from a subunit frame and should be constructed wide or funnelled to insure capture of the mass of insects released from the stream bed. Rocks and dirt within the subunit frame are disturbed to an approximate depth of two inches (5 cm), and insects and debris are collected and rinsed. From there, all insects large enough to identify

are documented on field forms. (Additionally, adult *gerridea* visible upon approach to the stream may be counted and added to each sample number.)

Before this formal sampling begins, six small samples (approximately 10 cm square, each) should be made in the unit area to locate the greatest population density. These six samples would be taken from the downstream ends of the various microenvironments observed on site. Formal samples will then be placed just above the two most highly populated checks.

The invertebrate sampling circuit will be completed twice to increase measuring consistency. Then the results will be added to the growing data spreadsheet.

Time and Cost Estimate

The trial samples already done, with no drive time or additional measurements included, averaged one hour per subunit. The initial testing to locate best habitats will take at least another hour per stream. Adding in drive time, temperature reading, and duplicate samples on each stream, total time for each circuit (of two) will be around forty hours. Work with the forms and spreadsheet will add perhaps five hours. For ten outings and 24 creek visits, driving cost reaches \$124. An additional investment will be required for quantitative sampling in the style of the Biological Condition Index (which uses professional invertebrate identification). This estimate (for 36 samples) is \$180.

Sediment and Lab Measurements

Parameters and Purpose

Suspended sediment, measured by a laboratory vacuum filtration process, is the third cornerstone of this study (with invertebrates, controls, and historical analysis being the others). Other possible laboratory measurements (for controls) are dissolved oxygen, alkalinity, and pH. Since dissolved oxygen is plentiful in these streams except during warm weather when there is an excess of decomposing plant material (eg. slash after logging), this measurement is only occasionally relevant (MacDonald, Smart, and Wissmar 80). This unimportance especially applies where no-harvest stream buffer strips have become standard practice. Alkalinity (referring to carbonates, not to just any alkali) and pH, on the other hand, are often relevant to invertebrate health and so would be valuable controls (Winget and Mangum 8, U.S. Department of Agriculture 6). Beyond this, the alkalinity is a critical component of the biotic condition index comparison (Appendix B).

Equipment and Processes

Drawing of water samples and the chemical analyses need to be done on the same day (Curtis), or better yet, chemical measurements on the stream are preferable to transporting samples to the lab. The sediment measurement can wait a few days, if necessary, but a single field trip for collection and analysis is most cost-effective. Rigdon and Oakridge Ranger Districts have meters for pH and alkalinity. Rigdon also has the vacuum filtration system for sediment analysis.

To measure suspended sediment, a series of filters are numbered, presoaked with distilled water, dried in an oven, and weighed before use (in milligrams). Then they are soaked a second time in distilled water, and a measured sample of stream water is drawn through each one. The filters are again oven dried, then the weight of the sediment is calculated as the difference in the before and after filter weights compared to the volume of water in the sample:

$$\text{suspended solids density (mg/liter)} = \frac{[\text{difference in filter weights (mg)} \times 1000]}{\text{volume (ml)}}$$

Since sediment levels can fluctuate considerably over time, this "grab" sampling should be done at least two more days (preferably not successive) to stabilize the character reading of individual streams. Additionally, a backdrop of the sediment measurements from other projects (eg. the Warner Creek Fire monitoring program in Oakridge) would frame this study's sediment levels in relation to the general levels of the Forest. Large areas fluctuate roughly together in the wake of precipitation, and these ongoing projects have machinery set to automatically "grab" samples at a regular interval.

Time and Cost Estimate

The three sampling cycles will take about one full day (eight hours) each. Entering this data (into the spreadsheet) will take about four hours. Collecting and entering data of other studies will take another day. The driving will cost

about \$111, (includes mileage to Oakridge). Purchased filters will cost another \$12 (at \$25 per box of 100).

Data Overlays

Parameters and Purpose

The hypothesis of this study is that direct effects of harvest activities on sediment levels and invertebrate populations are predictable based on logging records. To test the relations, several quantities will be determined from the records of each stream system. Harvested units will be tracked by acres, constructed roads, by length. These figures will be generated for whole subbasins and for areas within certain smaller distances of the streams.

Equipment and Processes

Lowell District's Geographic Information System (GIS)⁴ has the capacity to overlay two data sets (eg. a stream subbasin and a timber sale containing several units) and use the resulting new boundaries to generate the number of overlapping acres. It can also circumscribe (or *buffer*) a stream at any chosen radius and generate acres of interest within that new boundary. New road miles are also available.

This study will use the GIS to analyze roads and cuts for each whole subbasin, and for the buffers at 200 feet and at 50 feet from the stream.⁵ The Winberry Creek data are within an area of current harvest planning and are ready to work with, but the Fall Creek data are within a spotted owl Habitat Conservation Area that is closed to new clear cut timber sales. These data have

been archived (to create workspace) and will have to be restored before the overlaying can begin.

Time Estimate (Belcher)

The usual rule of thumb for the length of data processing is to guess the needed time, double it, and increase to the next order of magnitude. Thus, what seems to be an hour's job actually takes two days, a week's job takes two months, etc. The list on the following page uses a somewhat less somber estimate, merely doubling the first guess.

<u>Task</u>	<u>Winberry Creek</u>	<u>Upper Fall Creek</u>
Unit by subbasin	Report: 4 hrs	Restore: 8 hrs Report: 4 hrs
200 foot buffer around streams	Build: 8 hrs Report: 4 hrs	Build: 8 hrs Report: 4 hrs
50 foot buffer around streams	Build: 8 hrs Report: 4 hrs	Build: 8 hrs Report: 4 hrs
Put roads into 200 foot buffer	Build: 2 hrs Report: 4 hrs	Build: 2 hrs Report: 4 hrs
Put roads into 50 foot buffer	Build: 2 hrs Report: 4 hrs	Build: 2 hrs Report: 4 hrs
TOTAL:	40 hrs	48 hrs

Table 1. GIS Time Estimates

Data entry of the results into the working spreadsheet will take about half an hour. The foregoing analysis assumes only a single time standard (perhaps the last three years of activity). A new report form devised to isolate time intervals will take about four hours. Adaptation of the different buffered areas within that framework will only take about ten minutes each.

The time estimate for developing the "veg" layer (timber stand age, from harvested units, by year), for the lower Fall Creek area where it has not yet been done, is three months. Hand-analysis for the control stream in that area will take about five hours.⁶

Trial Fits

Parameters and Purpose

Each parameter will generate a list of values: one value per stream. (Where several subunits are used, the values will be averaged.) Any two lists can then be paired, point for point, to see how they are related. List comparison is the essential form of information available through this study. (For example, stream basins with many miles of roads built in the last few years will probably have high levels of suspended sediment in the water. Those with few roads will have less.)

Where the relations are linear, i.e., the two parameter values rise and fall together by a simple numerical factor, the method of *linear regression*, or *least squares fitting* gives a precise estimate of the proportionality (Young, 101), which can be seen as the slope on an x-y graph. The Lotus spreadsheet comes with a regression program that analyzes simple lists of numbers in this manner (see note 2.)

Even when the relation of two parameters is not linear, they may rise and fall together in some form, and this can be seen by graphically plotting all pairs of data points. This study will first plot relations, then run regressions on any that appear to warrant the effort.

Equipment and Processes

Lotus programs are on line in the University of Oregon physical chemistry lab and at the Forest Service, as well as on many private computers. They

include a graphing program that allows the user to view plots on the screen with little difficulty. These computers generally have an attached printing capacity and can store all spreadsheets with their calculations on portable disks for use at other locations. Data evaluation within the program is methodical, and easy, after a little training.

Time and Cost Estimate

Labeling and indexing the spreadsheet for easy access will take an hour. Study of the dozen control lists for idiosyncracies that could disrupt standard measurements will take half an hour.

Preliminary graph viewing will take three minutes each, including the time to save graphs and note the general relation. Every significant control variation that needs its numbers to be included in a graph will take an extra few seconds. With sediment levels and four different invertebrates to be compared to three levels each of roads and clear cuts (sixty graphs or more), this process will take at least three hours.

Preliminary least squares fits are similarly swift, taking perhaps two minutes each, but more complicated regressions can also be done, using two or more lists compared to one other. This would be useful, for example, in the case of buffered streams. Clear cut acres within a buffer could be subtracted from the total acres to generate a list of acres outside the buffer. Then the areas within and without the given radius could be fitted at the same time to the level of

sediment (or an invertebrate population) to see how the effects change with distance.

Other compound fits will include both roads and clear cuts, and different buffer levels of roads and cuts. Each rearrangement and regression will take about four minutes--fifteen of them an hour. An additional hour will be spent comparing the various lists to the biotic condition index. If various year intervals are included in the historical lists, the analysis time will increase exponentially. They should be constrained to two periods at most.

Because this work is strenuous on the nerves, long stints require intermittent slack time, and fatigue generates error that is time consuming to correct. This is mainly what doubles every estimate. When evaluation and production of good quality, labeled graphs and regressions are added to the process, the time estimate increases to two hundred hours (for strong correlations) or twenty hours (for no correlations).

Purchasing a new computer system to handle this project would cost about \$1500.

Follow-up

Parameters and Purpose

When the data have been gathered and analyzed, they will be distilled into a form accessible to other people interested in the study. The report will include observations about the value of the individual parameters and of the comparison to the Region 5 biotic condition index process. It might also discuss parameters

not included that could be affecting the results, and review the available literature and ways to use these parameters in future surveys. (Other possible influences include nitrogen fertilizer application, the blasting and soil disturbance of trail-building and heavy recreational use, quarry excavation, forest fires, and geologic soil stability differences.)

A second follow-up task is to test the prediction value of any strong correlations that appear in the data. If the study shows that one invertebrate population is consistently effected by some one parameter, measurement of that parameter in new study streams would be used to predict the state of the population, then the prediction tested with invertebrate surveying to verify the correlation.

Equipment and Processes

The only additional equipment needed for the follow-up is a word processor, which is likely to be available on any computer equipped to handle the data analysis.

Time and Cost Estimate

Organizing the results into a coherent order, complete with labeling on the graphs, presentation of the working assumptions and principles, and assertion of the relative importance of the findings, will take a good week (forty hours). Searching the literature (and District documents) for information on other influences will take another thirty hours. Testing correlations on new streams might take approximately ten hours per stream, depending on what was included.

Travel and gear are estimated at \$15.00 for four streams, if only controls and invertebrate samples are taken.

Chapter 2 Notes

1. These measurement parameters are the subject of several of the references, including MacDonald, 1989, U.S. Department of Agriculture, and Winget and Mangum.

2. A computer spreadsheet is a form developed over the years specifically for computation of numbers in lists. Spreadsheets are almost universally used for large scale inventories, money management, and other business applications, as well as in the analysis of scientific data. This study will use the IBM-based Lotus 1-2-3 spreadsheet.

3. Stan Swank, phone conversation.

4. The GIS is now being adopted in many branches of government to allow coordination between them.

5. 50 and 200 foot buffers are commonly used in planning Forest Service riparian (waterway) ecological maintenance. The State Forest Practice Rules require of riparian buffers that they "not average less than twenty five (25) feet or average more than one hundred (100) feet (Oregon Department of Forestry)."

6. The process described in this section (computerized) was originally planned to be done all by hand. The control stream, an unharvested area on the lower section of Fall Creek, will still have to be done by hand, since it is outside the area currently available on the Geographic Information System. Manually, it involves researching through timber sale files for all roads built and units harvested within the watershed(s) of interest, mapping that information, and planimetrying the acres (and road lengths) that fall within particular ranges. The results will be similar to those achieved by the computerized process. Searching the files is mostly done. Mapping the units and roads will take about two and a half hours per subbasin, and planimetry will take another two.

CHAPTER 3: CONCLUSIONS

Time and Cost Summary

The tables following list time and expense estimates for the work already done on this study and for the work left to do to complete it. Most of the estimates are probably good within a factor of three.

Table 2. Estimated Investment To Date

	<u>\$</u>	<u>Time/hr</u>
I. RESEARCH, DESIGN AND TESTING		
Inquiries, Follow-ups on Topic	\$ 5	35
Literature Search		40
Learn Sediment Filtration	\$ 7.50	7
Research the Parameters	\$ 25	70
Research and Order Sulfate Test Kit	\$ 35	1.5
Layout Visits: \$.75 and .75 hrs per creek, full day (8 cr)	\$ 6	6
Embeddedness Surveys ¹ \$.75 and 1.5 hrs per creek (5 cr)	\$ 3.75	7.5
Invertebrate Surveys (\$.75) 1 hr per creek, 2 local trial runs		2
Subtotal	\$ 74.75	167

(continued, next page)

II. COORDINATE WITH RESOURCES

Letter to Ranger		.25
Letter to RDMA (department heads)		.5
Coordinate Lab, Bottles	\$ 5	5
Overlay Time Analysis (Belcher)		.5
Subtotal	\$ 5	6.25

III. BUILD EQUIPMENT, MAPS, AND FORMS

Study Roads.. and Choose Creeks		2
Build 1"/mi Analysis Map		2
Build Individual 4"/mi Stream		3
Basin Maps		
Sale Inventory		10
Design Random Number Chart		.5
Make Route and Dispatch		.5
Schedules		
Build, Measure and Plan Subunit		.5
Frame (for random sample)		
Collect Waders, Net, and		7
Thermometer	\$ 70	
Gather and Study Bug Charts		5
(identification material)		
Build net (screen)		2
Subtotal	\$70	32.5
TOTAL	\$149.75	205.75h

Table 3. Estimated Investment
Needed to Complete the Study

	\$	<u>Time/hr</u>
I. Stream Choice		1.25
II. Hazardous Waste Disposal Route	\$ 78	7
III. Visit for Access and Controls	\$ 42	20
IV. Invertebrate Surveys	\$304	85
V. Sediment and Lab Measurements	\$123	36
VI. GIS Data Overlays	(Huge)*	105
VII. Trial Fits	(\$1500)	100
VIII. Follow-up	\$ 15	110
TOTAL	\$562	464 hrs

*Parenthetical amounts are for equipment, already installed.

Merit and Damage Summary, Recommendations

Merit

What makes this study pertinent is the failure of affected native ecosystems to support the indigenous strains of fish. If the causes of the failure can be documented, managers will have more leverage to create and enforce regenerative policies than if the situation stays in the realm of common sense.

The key facet of the study is the invertebrate populations as indicators of stream condition. If they prove to be predictably sensitive, to flow level, sediment, vegetation, or other parameters, then the cumbersome monitoring process may be streamlined somewhat. If the biotic condition index used in Region 5 proves to apply equally here in the Cascades, it will be a major step towards standardizing the invertebrate monitoring field, partly by virtue of publicity.

Faults and difficulties of the project include the inherent nonlinearity in most biological states, i.e., populations tend to plateau at particular levels of health and number, rather than dispersing evenly through a steady scale (Winget and Magnum, 3). Also, the question of bank stability has not been thoroughly addressed: the only unharvested watersheds in the area have been avoided due to especially unstable soils, which will almost undoubtedly skew the standard. On the nearby McKenzie District, the French Pete drainage is a set-aside wilderness that could possibly serve as a control stream. It is far enough away (by water) that the genetics--and so the life cycles--of the invertebrates could be enough

different, again, to skew the results. Inclusion of both controls might provide good information, for the same reasons.

In the long run, this study is merely a snapshot of the stream, another beginning, towards knowing its aerobic environment. There is and will be no single ideal model for proving aquatic health, no matter how much everybody wants one (MacDonald, 1991). To establish dependable parameters will require repeated measurements over many years.

Damage

The summary estimate of cash outlay for this job is \$712: \$150 already spent and another \$562 go. The time cost is categorically higher: 206 hours spent and 464 hours to go, for a total of 670 hours. (At my current, fairly low level Forest Service wage rate, that comes to over \$5,000.)

A second burden is to be found in the expanding of the work load for the few District people that are competent to run the GIS historical computer analysis, requiring at least enough time to train someone else in the specifics necessary for this study. These people already have a steady backlog of desired project analysis for the various District departments, especially since the system is just coming on line for the first time. Years of paperwork and other data are being "crunched" to fit their new channels.

The third physical difficulty is the production of toxic material (in the sulfate analysis). If final research parameters are expected to be sustained over years, hazardous waste is in no way a trivial issue, though the quantities may be

trivial compared to common industry. Again, the information obtainable through the chemical use needs to be considered for its necessity, for alternatives, for clean routes of reprocessing, and for the extent of its toxicity.

Recommendations

Without broad experience in project design and choice, I cannot know for sure how pertinent this study is, given the time involved, but I have an indefinite idea of how it compares to other priorities in research and resource monitoring. The budget for one year of legally mandated spotted owl calling on the Lowell District (taken out of timber receipts) is on the order of sixty to seventy thousand dollars. I assume this is comparable from one district to the next. General fisheries budgets, though perhaps not as fully mandated, are on a similar scale--for work in stream rehabilitation, fish incubation, original surveys, and other projects. Because of the size of these budgets and the relevance of this study, I imagine that it is on par with at least some of the other ongoing work.

I would recommend that the Lowell District (or Willamette Forest) do or sponsor the study, and that the money come from retribution dollars, a response to growing public outcry about the declining stability of fish runs, that are dollars that have begun to show up in the growing fisheries budgets of the last few years. I think the people of the Forest Service, as managers of millions of acres of public land, have a responsibility to determine what parameters are the most valuable for tracking the health of the streams, and to establish an extended process for maintaining that health.

More broadly, I recommend that the Forest Service continue to rebuild fisheries habitats, preventing further degradation, and to aggressively mitigate the worst faults of the last few generations' management processes (being, first, the destabilized state of mountain slopes--with active clean-up of known land slides, intermittent air monitoring in heavy slide seasons, when possible, a quick-response process of blocking slides from reaching streams, and a long-term, conservative road management program; second, the lack of access over dams--mitigated with ladders; and third, the overexposure of the soil that leaches it of nutrients, porosity, microorganisms, and ground water--with refoitation of the watersheds, especially along stream beds.)

The other factor critical to fisheries is ocean security. It is in the interests of anyone involved in the maintenance of the resource to take an interest and voice in the health of the sea cycle. Eventually, when the resource has been rebuilt to some fraction of its inherent richness, the financing of monitoring and maintenance can come out of fisheries receipts.

Chapter 3 Notes

1. *Embeddedness* describes several different measurements of the depth of fine gravel, silt, and sand around the larger rocks in a stream bed, in reference to the depth of the free water in among the rocks. Vertical rock measurements are made above and below the sediment surface after removing the rock in position.

I studied these parameters with a series of samples taken from streams in the study area. For subunits, I looked for sections of cobble and gravel at the water's edge that were at least sixteen feet (5 meters) long. Within these areas, subunits were chosen at random.

The resulting numbers varied more within the individual streams than between the averages from one stream to the next. In other words, I was not measuring a stable characteristic that would compare effectively between streams, so the results were not useful--as I was collecting them.

To pursue this further, I would stand back from the stream to conceptualize sediment flow patterns, then choose subunits from the same area of a given hydrologic structure, rather than randomizing them throughout sections of roughly defined cobble bars that line streams. For example, at high water, rock and soil appear to move in waves under the fluctuating currents. As flows ebb, these waves are deposited in legible forms which might be used as the basic study structure. Subunits could then be chosen from a single part of the deposit, and so be comparable from stream to stream. It might also be useful to choose subunits of similarly sized rock, rather than allowing much of the sample sometimes to be near a single boulder, as was the case in previous trials.

Another way to resolve excess variation might be to swamp the measurement with data, i.e. to use multiple large samples or numerous subunits averaged together in order to overcome inherent "noise."

Because either of these compensations would require more time than I had, I decided to drop the measurement from the study, even though it could be useful for stream sediment characterization if it worked.

Trial embeddedness samples took about an hour and a half for two small subunits (using a coat hanger bent square for area, at 22 cm each side). This included driving and hiking time on a circuit of several streams. To fine out the process to measurements that could compare effectively would take an estimated five days (40 hours), if it could be done. It would entail a rough classification of alluvial forms, trial samples around some common structure to determine its consistency, and comparison within and between streams. From there, the sampling time would be roughly comparable to previous trials, for a total of 24 hours for 12 streams (at four streams per outing): after practice. . . a grand total of 64 hours.

APPENDICESAppendix A: The Field Forms

STREAM VISIT FORM

rbr 1/92

Date _____ Stream: _____ #: _____

Visit Type: controls sediment invert. other

Observers: _____ Elev.: _____

Precip.0: 1: 2: 3: 4: 5: wk: mo: _____

INITIAL MEASUREMENTS

Aspect: _____ Gradient: _____ Water T: _____ CC: _____

<Canopy angle> _____ % Closure: _____ % Canopy: _____

Substrate Type (rate in order of dominance 1-6, 1 = most dominant; if not present, do not rate):

Boulder _____, Rubble + Boulder _____, Rubble _____,

Gravel + Rubble _____ Gravel _____, Sand - Silt _____.

Bank slopes L: _____ R: _____ Max. Depth _____

LWD _____ <Width> _____

SUSPENDED SEDIMENT

Sample Label: _____

pH: _____ Alkalinity: _____

Sediment: _____



INVERTEBRATE VISIT

Subunit ID: _____

T: _____ P: _____

E: _____ G: _____

Comments: _____



CODES FOR STREAM VISIT FORMS (rbr 10/91)

Precipitation: get figures from airport weather, build spread sheet for quick tally, and fill in as appropriate.

CC = cloud cover, S scattered, C clear, O overcast, F fog,
R rain.

Aspect is measured in 360° from true North.

Bank gradient: R,L, face downstream.

Percent Canopy is an estimate of cover for the whole unit, based on [(average angle, E->W->W, of canopy peak)/90°] X percent closure in leafed-out stage, viewed from center of stream unit.

Maximum Depth refers to main current stream, not isolated pools.

LWD asks for a description of the large woody debris in the stream.

Invertebrates: T *Trichoptera* = caddisfly, P *Plecoptera* = stonefly, E *Ephemeroptera* = mayfly, G *Gerridae* = water strider.

Boulder > 12", Rubble 3" - 12", Gravel 1/8" - 2.99", Sand/silt < 1/8".

Appendix B: USFS Intermountain Region Invertebrate Surveys

(Winget and Magnum)

The biotic condition index (BCI) is a tool developed under contract by Robert N. Winget, Brigham Young University, and Fred A. Mangum, Uinta National Forest, both in Provo, Utah. The index culminates a series of measurements found to be significant to stream macroinvertebrates in that area. The publication, Biotic Condition Index: Integrated Biological, Physical, and Chemical Stream Parameters for Management, develops the rationale, method, and use of BCI. It also shows the general result of a large-scale study done using the method, which appears valuable.

In the study, four stream parameters, substrate, sulfate, alkalinity, and gradient are overlaid to achieve a "Predicted Community Tolerance Quotient" (CTQp). The next step is to compare that quotient with the "Actual Community Tolerance Quotient" (CTQa). This requires a particular type of invertebrate surveying different from the central, simple one presented in the current paper, and in order to effectively compare to the BCI, the current study must sample the same four parameters and hire professional analysis of all invertebrates. It should not be necessary to do this for all streams in the survey area if results are swiftly clear. Also, it is hoped that a less intensive invertebrate sampling procedure might prove as useful as the comprehensive one.

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