ASSESSMENT OF STREAMFLOW AND WATER QUALITY FOLLOWING CLEARCUTTING OF STAND 1-10-1 ON THE U. OF I. EXPERIMENTAL FOREST

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INTRODUCTION

Harvesting forest lands has been a common practice in the United States for many years. With the introduction of the concept of "multiple use" management however, an increase in the concern for harvesting impacts on other resources has evolved. One such concern focuses on the effects timber harvesting has on water yield and water quality. Several harvesting techniques are presently practiced by foresters, but of extreme interest to forest hydrologists is the practice of tractor logging clearcuts, and the potential impacts on water yield and water quality.

One might assume that water yield and quality would be only minimally altered by a clearcut, if altered at all. On the contrary, tractor logged clearcuts as small as 3.5 acres in southwestern Oregon showed average streamflow increases of 14 percent during the first year following harvest (Harr 1979a). In addition, Rothacher (1973) and Harris (1973,1977) have shown that significant increases in size of flows occur when timber harvesting is accompanied by soil disturbance (Harr 1979b). Typically, as streamflow increases, the capacity of that stream to carry sediments also increases (Brown 1976). This in turn can impact such water quality parameters as turbidity and specific conductivity.

This study was designed to monitor streamflow from a clearcut located on the University of Idaho, College of Forestry, Wildlife and Range Sciences (FWR) Experimental Forest. Being a tractor logged clearcut typical of the harvesting regime on the Experimental Forest, there was much interest in determining the changes in water yield and water quality in the clearcut watershed. To the author's knowledge, there have not been any studies similar to this proposal conducted on the Experimental Forest. Thus, it is believed that this is a timely study well in need of being conducted.

The specific objectives of the study were three-fold:

1. Determine the changes in water yield from a tractor logged clearcut.
2. Determine suspended sediment loads and subsequent sediment flux in the drainages flowing from the clearcut.
3. Determine the changes in the water quality parameters, turbidity and specific conductivity, resulting from tractor logging a clearcut.

Study Area Characteristics

Characteristics of the study area include a mean elevation of approximately 3200 feet above mean sea level with slopes ranging from 15 to 55 percent, with northly and easterly aspects. The climate of this study area is typical of the northern Rocky Mountain province, with a slight maritime influence from the Pacific Coast. Cool, wet winters and warm, damp summers typify the study area, with average daytime temperatures of 36°F during winter months (November-April), and 59°F during milder months (May-October) (NOAA 1981). Annual precipitation near the area averaged 25 inches over the 23-year period from 1957-1979, with a maximum average snowpack depth of 53 inches. The 1982 water year (October 1981-October 1982) was an average year with approximately 29 inches of precipitation recorded and a maximum snowpack depth of 48 inches (NOAA 1977, 1977-1982, 1981-1982, and SCS 1921-1979, 1982).

Records show the dominant overstory in the general study area to consist of _Abies grandis Lindl_., _Thuja plicata Don_., _Pseudotsuga menziesii Mirb_. and small amounts of _Larix occidentalis Nutt_., with an understory of primarily *Pachistima myrsinities Raf*., *Physocarpus malvaceus Kintze* and *Holodiscus discolor Maxim* (Lohse 1979). This vegetation is underlain by a Vassar silt loam soil, composed of a granitic parent material capped with loess soil and Mount Mazama ash. (See Figure 1.) The Vassar soil tends to drain fairly rapidly, and is also moderately erodable (Soil Conservation Service 1981).

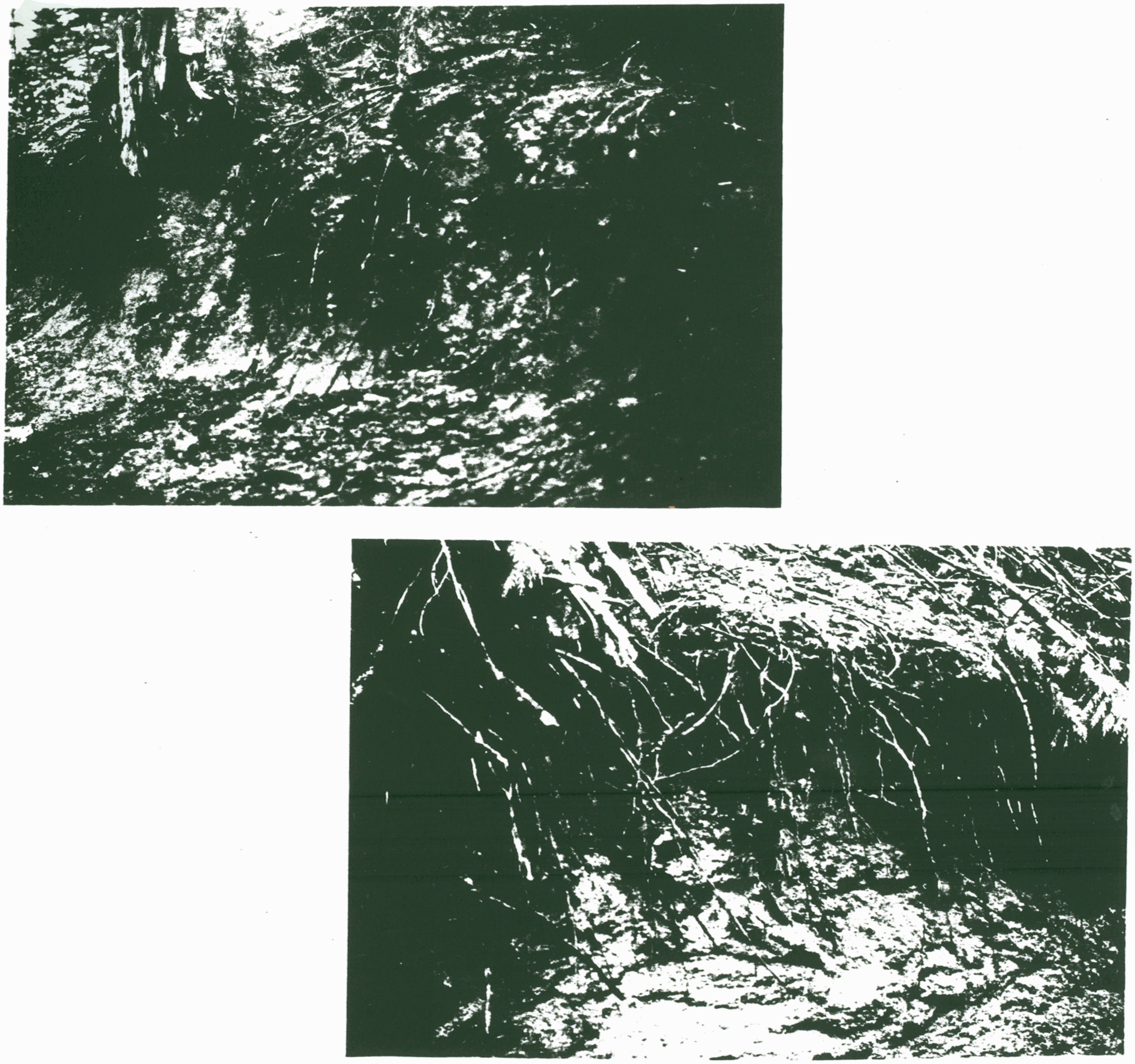

Figure 1--Vassar silt loam soil found in the study area.

The clearcut that is being evaluated in this study is number 1-10-1, located northeast of Moscow, Idaho at T40N, R3W, Section 7 on the Flat Creek Unit of the College of FWR Experimental Forest. (See Appendix A) Two intermittent streams flow easterly through this 17 acre clearcut; one at the northern end, and a smaller, less significant (in terms of its contribution to the streamflow) at the southern end. These two drainages converge approximately 185 feet below the clearcut in a moderately dense stand of cedar, and 300 feet further downstream this stream empties into the south fork of Brown's Meadow Creek. (See Appendix B) The area extending from the eastern edge of clearcut unit 1-10-1 to the south fork of Brown's Meadow Creek encompasses a _Thuja plicata Don._, _Abies grandis Lindl_. stand of approximately 80 percent density, along with a large amount of windfall and downed woody material. This stand possibly acts as a "buffer strip", catching and absorbing overland flow before it reaches the south fork of Brown's Meadow Creek or any of the small streams mentioned above. This "buffer strip" will be discussed further in the "conclusions" of this report.

The undisturbed, control watershed immediately adjacent to clearcut unit 1-10-1 is vegetatively and topographically similar to the clearcut unit. It has two intermittent streams flowing easterly through the area, as does the clearcut unit, but this control watershed is approximately three times larger in size than clearcut unit 1-10-1. In addition, this control watershed has not been disturbed in recent years by timber harvesting. In the 1930's this watershed was selectively logged for _Pinus monticola Dougl_., as were most of the lands in the surrounding area. This harvesting, however, was not considered in this study.

PROCEDURES

Sampling Design

Following a field and aerial photo reconnaissance of clearcut unit 1-10-1 and the surrounding area, six sample stations were chosen for data collection. Unfortunately no previous streamflow data is available for clearcut unit 1-10-1, and therefore no comparisons can be made as to the change in streamflow and sediment flux before and after harvesting this unit. However, a comparison can be made with the streamflow and sediment flux from the immediately adjacent undisturbed watershed. In addition, comparisons of turbidity and specific conductivity can also be made between these two areas. Thus, of the six sample stations chosen, two were located immediately below the clearcut, two within the "buffer strip", and two in the undisturbed watershed adjacent to the southern end of the clearcut. (See Appendix C)

Field Analysis

Data collection began in early February of 1982 and continued once a week until the cessation of snowmelt runoff. In addition to collecting water samples at each station, water temperature was recorded as were flow width and depth. Velocity measurements were taken at most stations using a pygmymeter, however, occassionally low flows prevented readings from being taken.

Lab Analysis

Lab analysis involved calculating discharge (cfs) for each station by multiplying the width (feet), depth (feet), and velocity (feet/second) measured at each station. In addition, water samples collected in the field were used to measure turbidity, specific conductivity, and suspended sediment concentrations for each station. Turbidity was measured with a Hach Model 2100 A Turbidimeter, and specific conductivity with a Simpson YSI Model 33 S-C-T Meter. Suspended sediment concentration was determined by filtering each sample through a 0.45u millipore filter and then oven drying each at 300°F for approximately 8.0 hours. The sample was then weighed and the weight of the filter was subtracted from the total weight. The residual was defined as the suspended sediment concentration. These concentrations were adjusted to represent mg/l units.

Data Analysis

All measurements taken were summarized in a tabular form for ease of viewing. (See Appendix D) This summarized data was then used to compare specific parameters of the watershed in clearcut unit 1-10-1 and the adjacent, undisturbed watershed. Comparisons included hydrographs and sediment flux graphs for each watershed during the snowmelt runoff period. In addition, summary tables were developed to specifically compare turbidity and specific conductivity in the clearcut watershed and in the undisturbed watershed. Finally, the technique of least squares linear regression was used with the data from both watersheds in an attempt to develop models for future prediction of discharge, suspended sediment concentration, and sediment flux.

RESULTS AND DISCUSSION

The hydrographs developed depict the harvested watershed A and the undisturbed watershed D following the same general pattern of discharge. (See Figure 2A.) They each began the season at a very high rate, which probably indicates that snowmelt was at a peak when sampling began. The hydrographs then declined rapidly and fluctuated for the remainder of the runoff season. These fluctuations were due in part to the fluctuating air temperatures and resulting effects on the snowpack melt, and to the sporadic and often very intense spring rains.

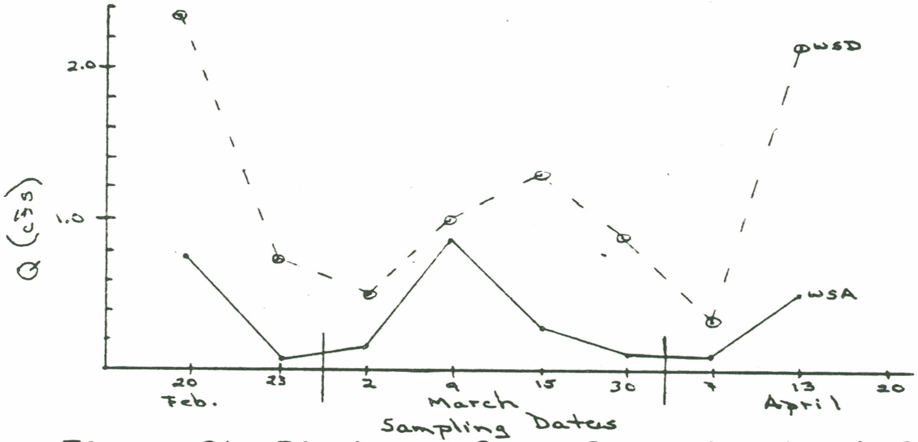

Figure 2A--Discharge from clearcut watershed A and undisturbed watershed D during snowmelt runoff season.

From the sediment flux data presented, it appears that the harvested watershed A initially had a higher flux level than the undisturbed watershed D, but as the runoff season progressed the flux at watershed A dropped below the level of watershed D. (See Figure 2B.)

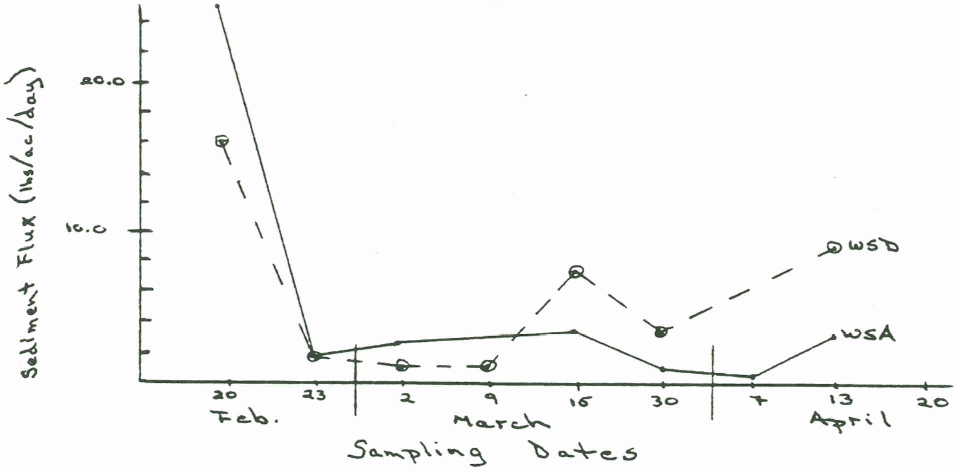

Figure 2B--Daily suspended sediment flux from clearcut watershed A and undisturbed watershed D during snowmelt runoff season.

This lower flux level of watershed A could be due to the much higher discharge rate found in watershed D, a rate to be expected considering that the area of watershed D is approximately three times larger than that of watershed A. A higher discharge rate generally implies that more sediment will be flushed through the system resulting in a higher flux level, as was seen in this comparison.

One other factor from the sediment flux data to be discussed is the higher sediment flux level of watershed A (compared to watershed D) at the beginning of the runoff season. This could be indicating that when a watershed is disturbed, the initial amount of sediment being flushed through the system can be quite high as a result of that disturbance. As the runoff season progresses, however, the watershed can gradually adjust to the increased amount of sediments and distribute them throughout the system. Also, quite often one finds that the fine sediments flush through the system immediately following a disturbance, with the larger, heavier sediments being left behind. Later in the runoff season as discharge rates decline, these larger sediments are too heavy to be moved through the system and thus a lower sediment flux measurement is recorded. In addition, in this study area the "buffer strip" of vegetation between the clearcut and the south fork of Brown's Meadow Creek could have served as a catchment basin for much of the sediment flowing down from the clearcut. As the sediments reached the buffer strip, they could have been trapped by understory vegetation, slash or even tree stumps, and thus further movement of these sediments would be halted. This buffer strip, the initial flushing of fine sediments, the ability of the watershed to gradually distribute sediments, and/or the decrease in discharge could be the reason (s) for the sediment flux level in watershed A declining as the runoff season progressed.

The turbidity and specific conductivity measurements both reflect a general trend of watershed A showing higher values than the undistrubed watershed D. (See Table 1.) These trends indicate that as a watershed becomes disturbed, water quality parameters such as turbidity and specific conductivity can be increased.

Table 1--Turbidity and specific conductivity from clearcut watershed A and undisturbed watershed D during snowmelt runoff season.

Turbidity (NTU at 21°C)			Specific conductivity Umhos at 21°C		
Date	Watershed A	Watershed D	Date	Watershed A	Watershed D
2/20	15.0	8.7	2/20	31	28
2/23	16.0	5.5	2/23	32	30
3/2	17.0	9.8	3/2	32	29
3/9	12.0	9.4	3/9	30	29
3/15	6.4	5.5	3/15	32	29
3/30	6.6	4.8	3/30	31	30
4/7	5.4	6.2	4/7	32	30
4/13	6.0	5.6	4/13	31	30
4/20	5.4	7.5	4/20	38	31

The attempts to develop prediction equations by the least squares linear regression technique were not quite as successful as was hoped. (See Table 2.) However, the coefficients of determination (r^2) for the discharge and sediment flux equations were of high enough values to be couraging. It is believed that with at least one more season of data, e equations would be more accurate and the coefficients higher.

Table 2--Least squares linear regression equations developed with discharge and suspended sediment data from watersheds A and D.

Equation	Coefficient of determination(r^2)
$Q_{wsa} = 0.02646 + 0.30751(Q_{wsd})$	0.491
$S_{wsa} = 39.168 + 0.551(SS_{wsd})$	0.054
${}_{wsa} = -2.727 + 1.427(SF_{wsd})$	0.759

Q = discharge (cfs)

SS = suspended sediment (mg/l)

SF = sediment flux (lbs/acre/day)

wsa = clearcut watershed A

wsd = undisturbed watershed D

The limitation of only one season's data appears to be a major blem throughout this project. Due to the typically short runoff period he study area, only eight data points were obtained for use in data ysis. It is very hard to characterize any parameter, be it of water or seedling growth, on the basis of such few data points. Thus oped that at least one more season of data will be collected to up on the data obtained this season.

<u>ion</u>

summary, it appears that tractor logging clearcut unit 1-10-1 duce some changes in water quality. Water yield was impractical are between watershed A and the undisturbed watershed D due to the partial sampling scheme that was used. However, the water quality parameters measured were comparable and revealed some interesting results. Sediment flux in watershed A was initially higher than in watershed D, and turbidity and specific conductivity each followed a general trend of being higher in watershed A. The linear regression equations developed were not as successful as was hoped, but it is believed that they could be useful in the future with additional data.

Generally it is felt that much was learned from this project, and even though a large amount of data could not be collected, this project provided useful and interesting base data from which to build upon. In addition, this study provided the author with an opportunity to gain insight into research techniques and methodology, and to appreciate the time committment necessary for research work.

It is sincerely hoped that this study will be continued or a similar study developed so as to obtain more information that will be useful to land managers.

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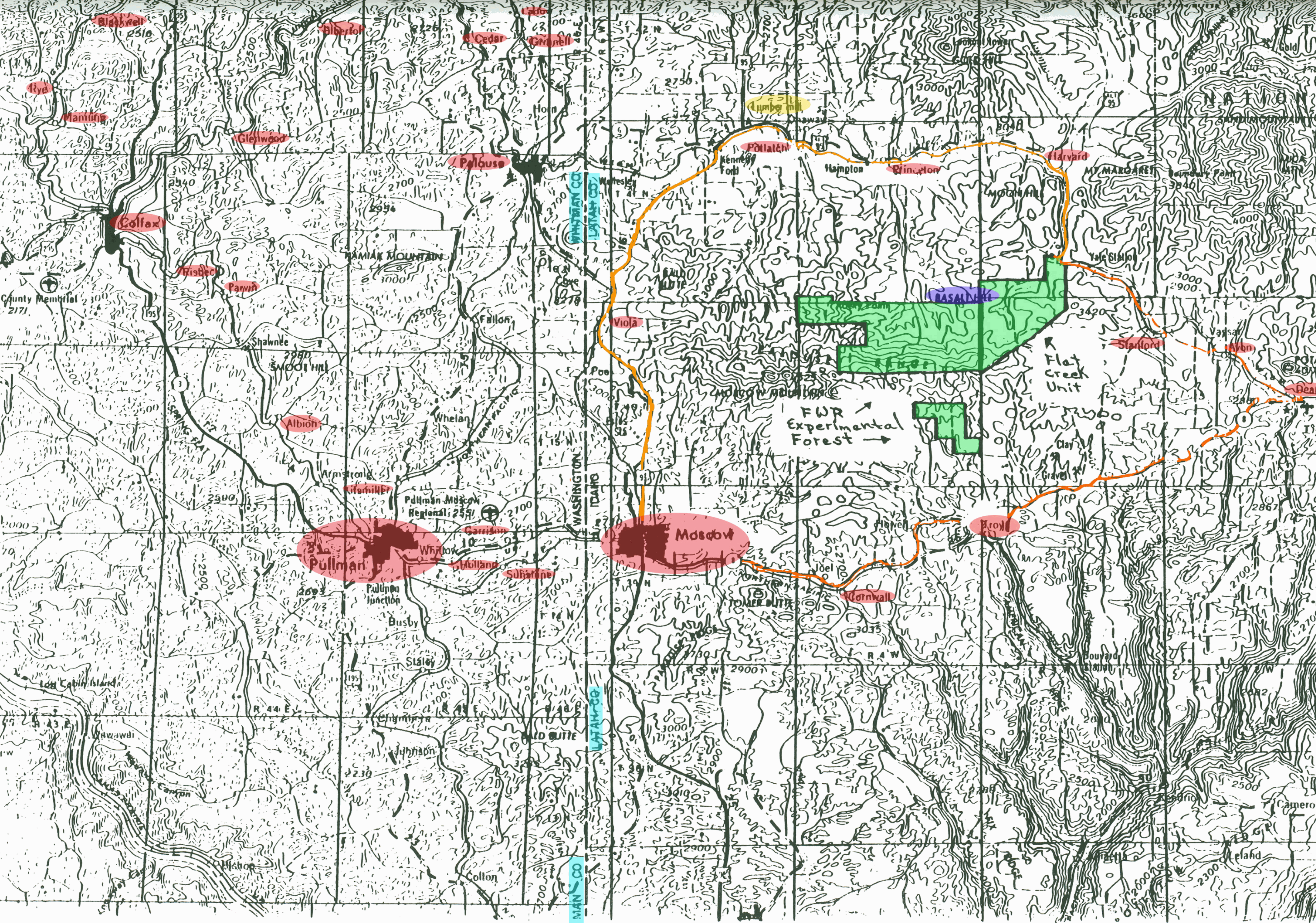
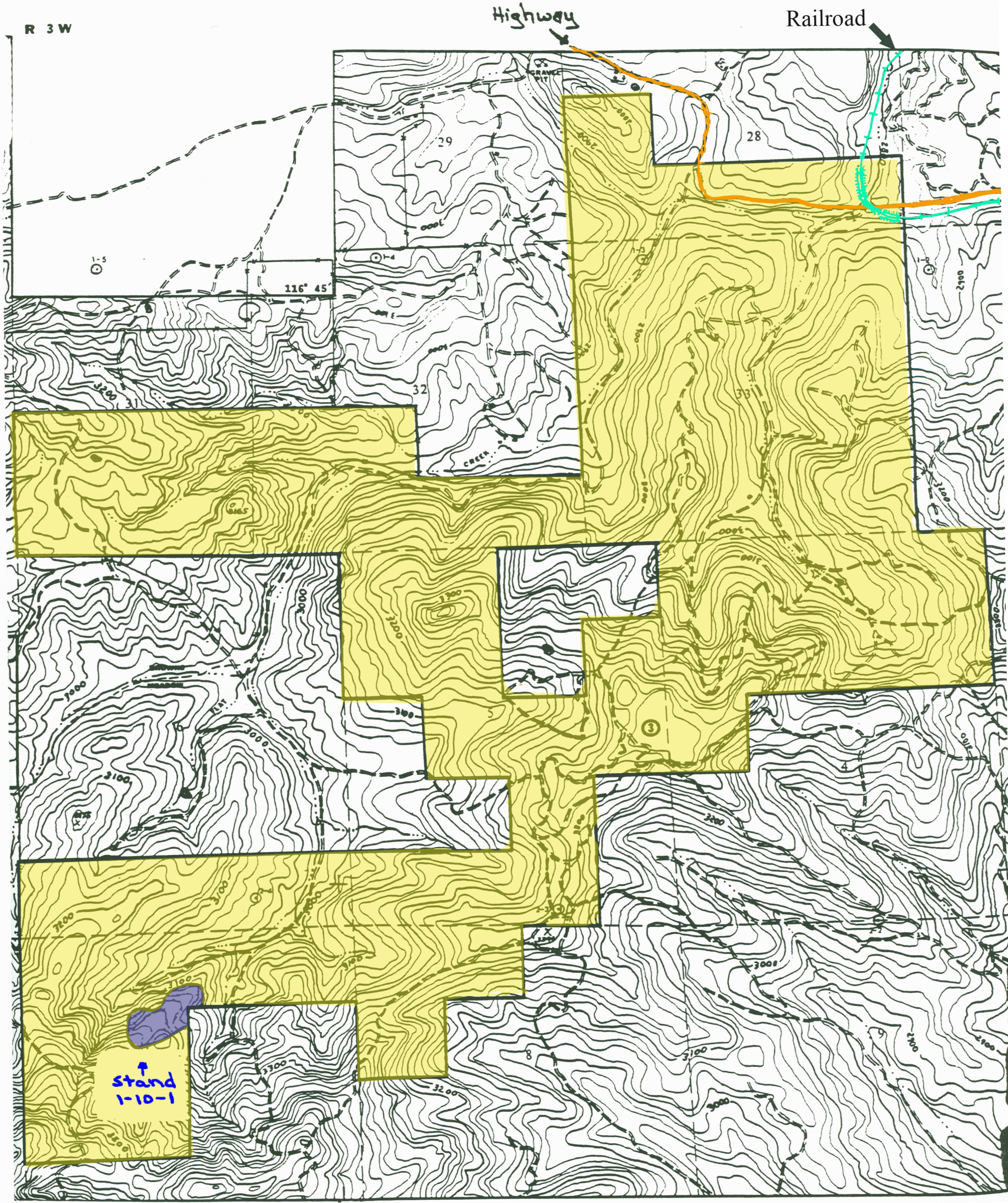
APPENDIX A

LOCATION OF STAND 1-10-1

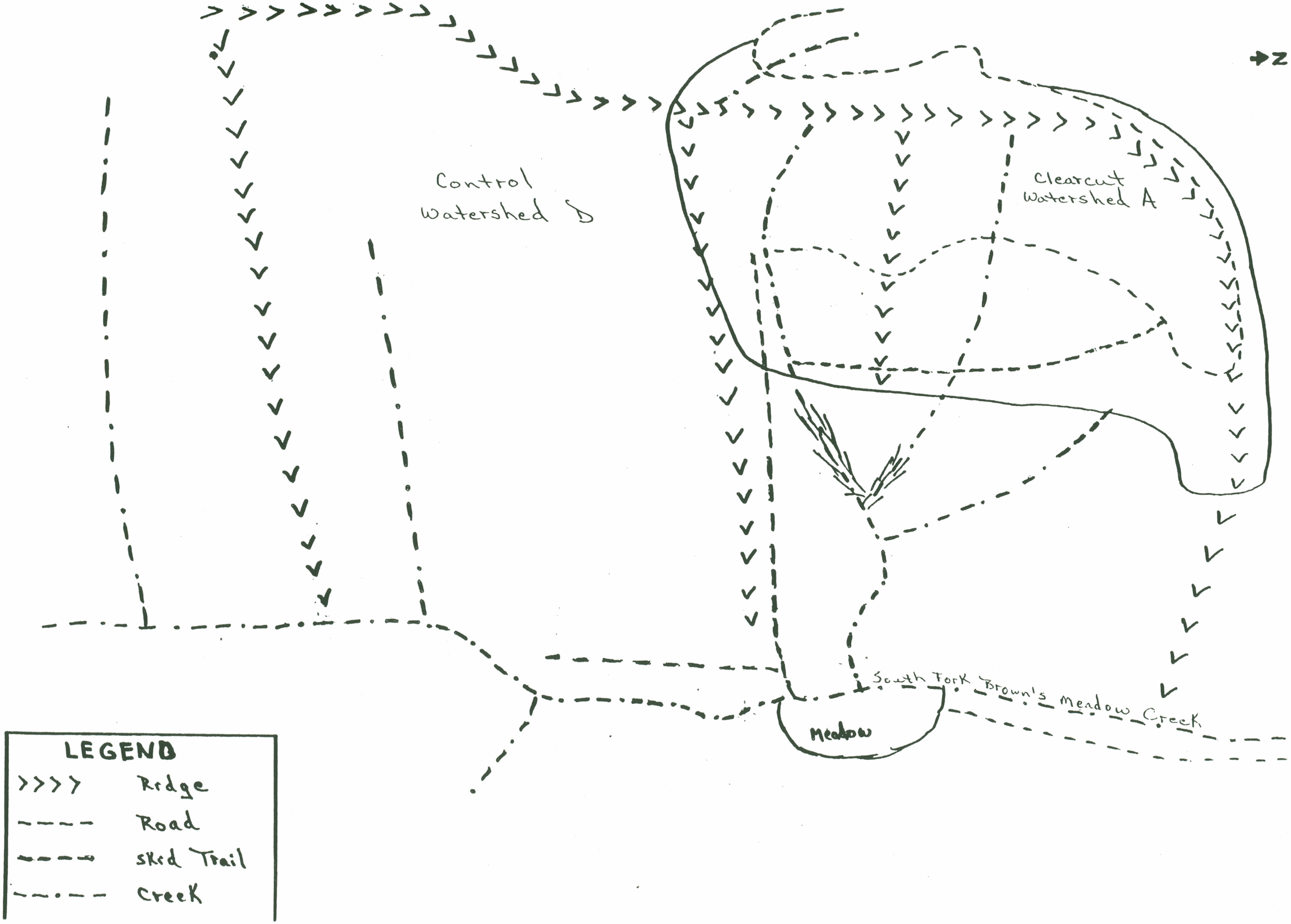

Blackwell
Elberton
Cedar
Grinnell
Rye
Manning
Glenwood
Palouse
Colfax
Risbeck
Parvin
County Memorial 2171
Kamiak Mountain
Fallon
Shawnee
Smoot Hill
Albion
Whelan
Armstrong
Kitzmiller
Pullman-Moscow Regional 2551
Pullman
Pullman Junction
Garrison
Whitlow
Holland
Sunshine
Busby
Staley
Log Cabin Island
Johnson
Colton
Bald Butte
Lumber mill
Onaway
Potlatch
Kennedy Ford
Hampton
Princeton
Harvard
Moon Hill
Mt Margaret
WHITMAN CO
LATAH CO
WASHINGTON
IDAHO
Viola
Moscow Mountain
Basalt Hill
Flat Creek Unit
FWR Experimental Forest
Yale Station
Stanford
Vassar
Avon
Deary
Clay
Gravel
Moscow
Joel
Cornwall
Tomer Butte
Troy
Howell
Bovill
Kendrick
Leland
Cameron
Juliaetta
Gold
Sand Mountain

Flat Creek Unit - U. of I. Experimental Forest



APPENDIX B

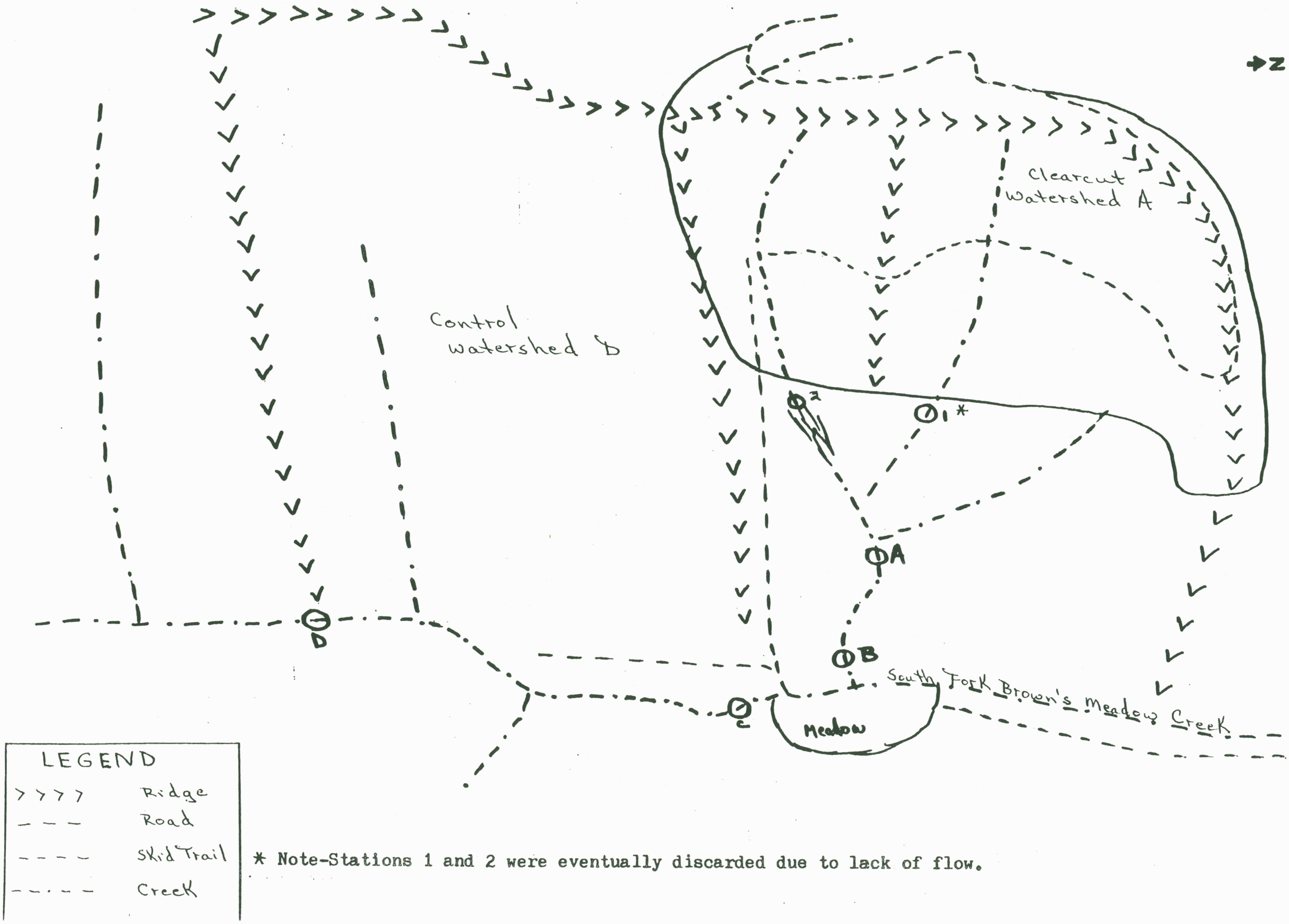
STREAM DRAINAGE LOCATIONS
IN STAND 1-10-1


Control Watershed D
Clearcut Watershed A
→Z
South Fork Brown's Meadow Creek
Meadow
LEGEND
>>>> Ridge
Road
skid Trail
creek

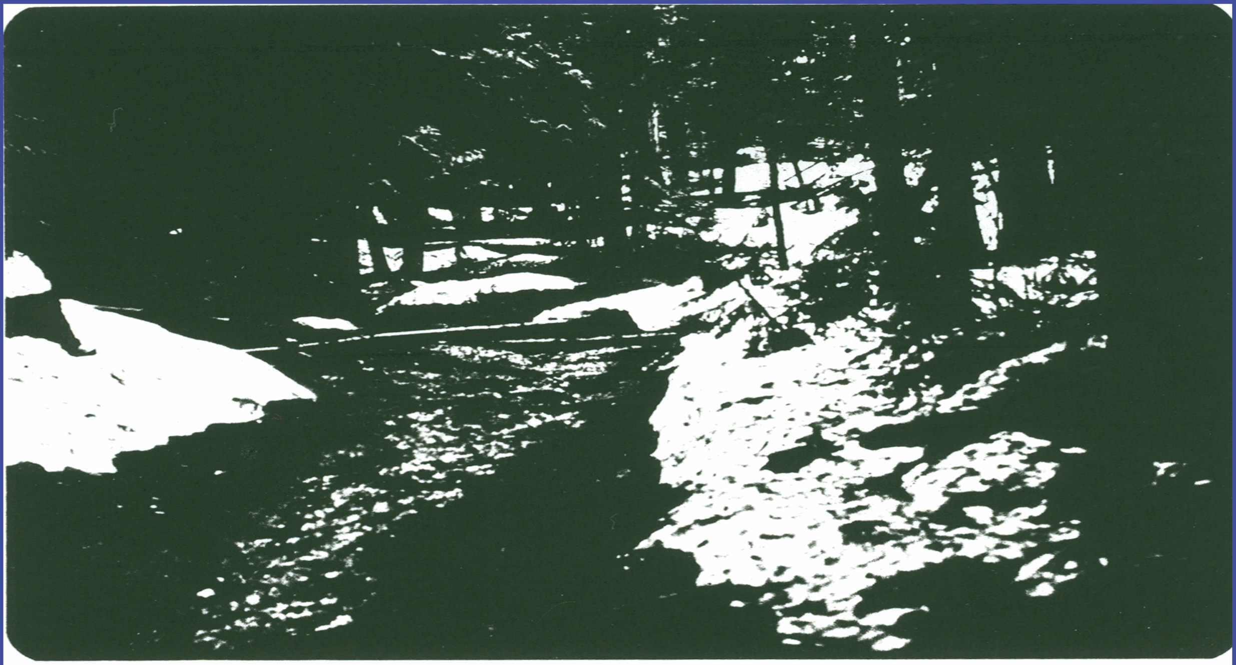
APPENDIX C

SAMPLE STATION LOCATIONS
IN STAND 1-10-1

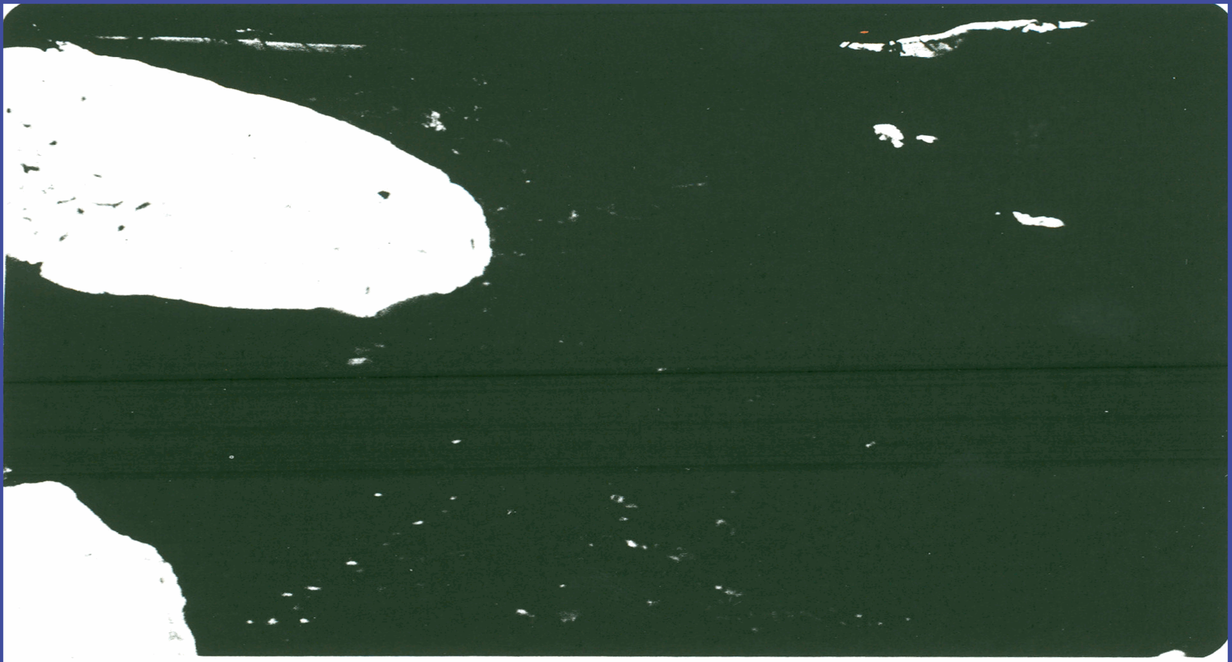
SAMPLE STATION LOCATIONS IN STAND 1-10-1



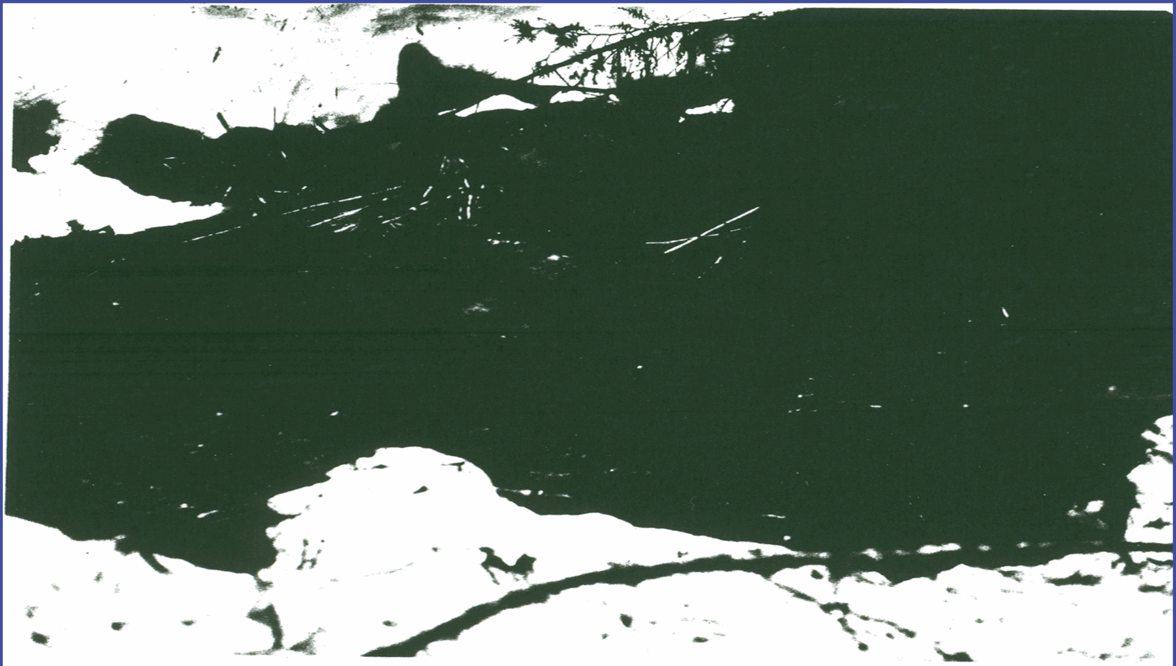
* Note-Stations 1 and 2 were eventually discarded due to lack of flow.



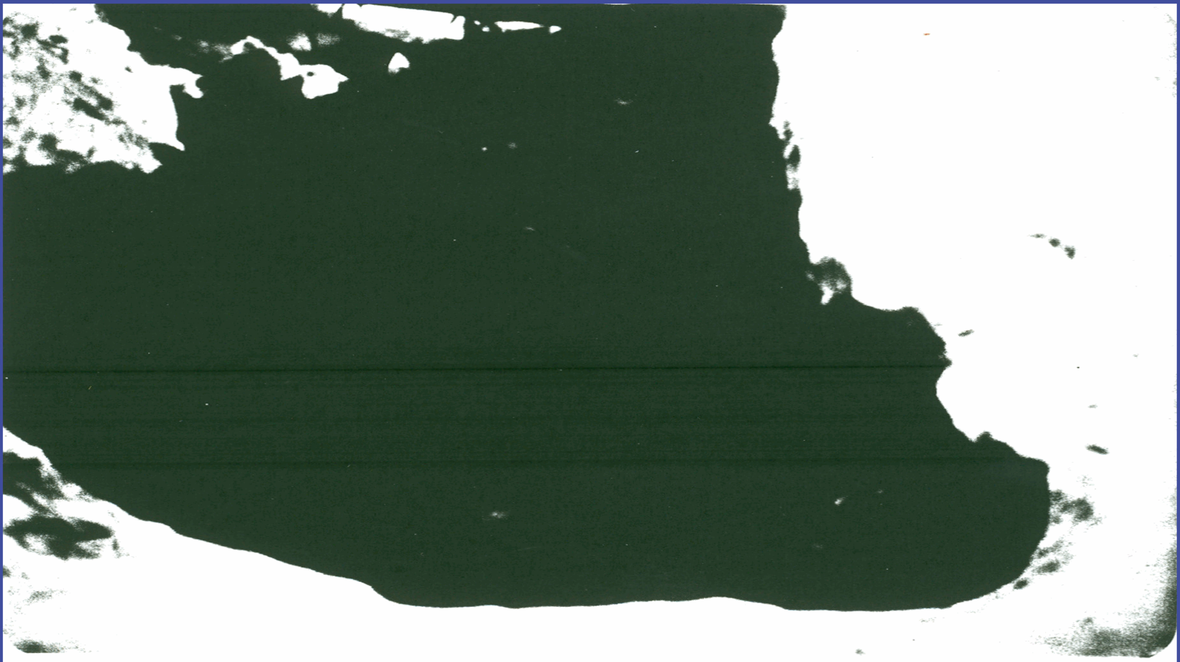
Sample Station A



Sample Station B



Sample Station C



Sample Station D

APPENDIX D

DATA

Date	Station	Filter #	Filter wt. (g)	Filter & sed. wt. (g)	Sediment wt. (g)	Volume filtered (ml)	Inorg. & org. susp. sed (mg/l)
2/20/82	A	14	.0886	.1542	.0656	661	99.2
2/20/82	B	18	.0880	.1169	.0289	688	42.0
2/20/82	C	24	.0902	.0988	.0086	775	11.1
2/20/82	D	27	.0889	.1250	.0361	685	52.7
2/23/82	A	15	.0883	.1469	.0586	595	98.5
2/23/82	B	16	.0877	.1024	.0147	342	43.0
2/23/82	C	11	.0867	.1205	.0338	755	44.8
2/23/82	D	12	.0861	.1043	.0182	842	21.6
3/2/82	A	9	.0861	.1145	.0284	631	45.0
3/2/82	B	22	.0890	.1000	.0110	518	21.2
3/2/82	C	10	.0869	.1134	.0265	869	30.5
3/2/82	D	13	.0870	.0967	.0097	829	11.7
3/2/82	1	20	.0880	.0920	.0040	442	9.0
3/9/82	A	23	.0884	.0949	.0065	708	9.2
3/9/82	B	21	.0882	.0915	.0033	550	6.0
3/9/82	C	25	.0883	.0920	.0037	460	8.0
3/9/82	D	19	.0876	.0908	.0032	445	7.2

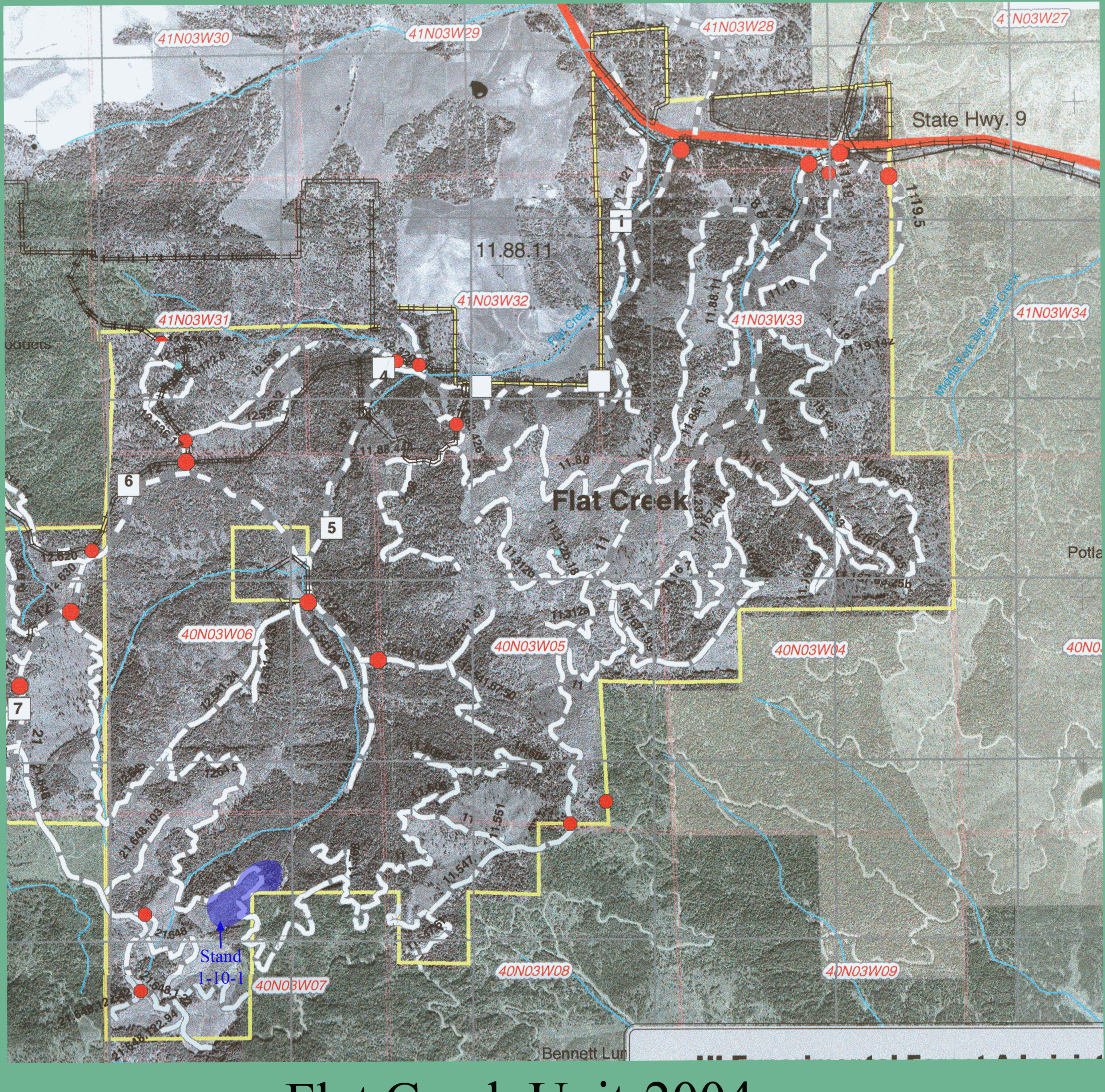
Date	station	Temp. when sampled °C	Date when turbidity done	Date when specific conductivity done	10 NTU standard Turbidity NTU at 21°C	Specific conductivity at 21°C µmhos	Discharge cfs
2/20/82	A	—	3/30/82	4/1/82	15.0	31	.78
2/20/82	B	—	3/30/82	4/1/82	8.2	31	—
2/20/82	C	—	3/30/82	4/1/82	4.0	29	—
2/20/82	D	—	3/30/82	4/1/82	8.7	28	2.32
2/23/82	A	2	3/30/82	4/1/82	16.0	32	.07
2/23/82	B	2	3/30/82	4/1/82	14.0	31	—
2/23/82	C	3	3/30/82	4/1/82	6.8	29	—
2/23/82	D	3	3/30/82	4/1/82	5.5	30	.67
3/2/82	A	2	3/30/82	4/1/82	17.0	32	.19
3/2/82	B	3	3/30/82	4/1/82	4.5	32	—
3/2/82	C	3	3/30/82	4/1/82	7.2	30	—
3/2/82	D	3	3/30/82	4/1/82	9.8	29	.51
3/2/82	1	3	3/30/82	4/1/82	10.0	35	—
3/9/82	A	—	3/30/82	4/1/82	12.0	30	.88
3/9/82	B	—	3/30/82	4/1/82	8.7	31	—
3/9/82	C	—	3/30/82	4/1/82	6.5	30	—
3/9/82	D	—	3/30/82	4/1/82	9.4	29	1.05

Date	Station	Filter #	Filter wt. (g)	Filter & sed. wt. (g)	Sediment wt. (g)	Volume filtered (mℓ)	Inorg. & org. susp. sed. (mg/ℓ)
3/9/82	1	26	.0896	.0923	.0027	318	8.5
3/15/82	A	38	.0905	.1191	.0286	720	39.7
3/15/82	B	17	.0881	.1418	.0537	458	117.2
3/15/82	C	7	.0874	.1314	.0440	938	46.9
3/15/82	D	5	.0901	.1209	.0308	778	39.6
3/30/82	A	3	.0863	.1096	.0233	688	33.9
3/30/82	B	8	.0856	.0947	.0091	412	22.1
3/30/82	C	6	.0888	.1161	.0273	852	32.0
3/30/82	D	4	.0865	.1087	.0222	705	31.5
4/7/82	A	33	.0896	.0961	.0065	737	8.8
4/7/82	B	28	.0884	.1164	.0280	911	30.7
4/7/82	C	31	.0902	.1080	.0178	729	24.4
4/7/82	D	32	.0902	.1424	.0522	849	61.5
4/13/82	A	1	.0864	.1042	.0178	770	23.1
4/13/82	B	30	.0896	.1596	.0700	828	84.5
4/13/82	D	29	.0904	.1168	.0264	818	32.3
4/13/82	1	37	.0898	.1051	.0153	778	19.7

Date	Station	Temp. when sampled °C	Date when turbidity done	Date when specific conductivity done	100 & 10 NTU standards Turbidity NTU at 21°C	Specific conductivity at 21°C umhos	Discharge cfs
3/9/82	1	—	3/30/82	4/1/82	9.1	38	—
3/15/82	A	2	4/20/82	4/20/82	6.4	32	.33
3/15/82	B	2	3/30/82	4/1/82	13.0	31	—
3/15/82	C	3	4/20/82	4/20/82	7.2	29	—
3/15/82	D	3	4/20/82	4/20/82	5.5	29	1.28
3/30/82	A	3	4/20/82	4/20/82	6.6	31	.12
3/30/82	B	3	4/20/82	4/20/82	4.7	33	—
3/30/82	C	3	4/20/82	4/20/82	5.1	29	—
3/30/82	D	3	4/20/82	4/20/82	4.8	30	.91
4/7/82	A	4	4/20/82	4/20/82	5.4	32	.11
4/7/82	B	4	4/20/82	4/20/82	5.7	34	—
4/7/82	C	4	4/20/82	4/20/82	3.3	31	—
4/7/82	D	4	4/20/82	4/20/82	6.2	30	.34
4/13/82	A	3	4/20/82	4/20/82	6.0	31	.57
4/13/82	B	3	4/20/82	4/20/82	8.3	30	—
4/13/82	D	3	4/20/82	4/20/82	5.6	30	2.15
4/13/82	1	3	4/20/82	4/20/82	13.0	40	—
4/13/82	2	3	4/20/82	4/20/82	9.2	35	—

Date	Station	Filter #	Filter wt. (g)	Filter & sed. wt. (g)	Sed. wt. (g)	Volume filtered (ml)	Inorg. & organic susp. sed. (mg/l)
4/13/82	2	2	.0859	.1077	.0218	794	27.4
4/20/82	A	34	.0899	.1136	.0237	588	40.3
4/20/82	B	35	.0896	.1023	.0127	559	22.7
4/20/82	C	36	.0898	.1222	.0324	872	37.2
4/20/82	D	39	.0886	.1330	.0444	800	55.5

Date	station	Temp. when sampled °C	Date when turbidity done	Date when specific conductivity done	10 NTU standard Turbidity NTU at 23°C	specific conductivity at 23°C µmhos	Discharge cfs
4/20/82	A		4/28/82	4/28/82	5.4	38	Unavailable
4/20/82	B		4/28/82	4/28/82	3.7	34	
4/20/82	C		4/28/82	4/28/82	4.9	32	
4/20/82	D		4/28/82	4/28/82	7.5	31	



Flat Creek Unit-2004 map

Location of Complete Research:

Author & Title: Gillette, Amy

Assessment of Streamflow and Water Quality Following Clearcutting of Stand 1-10-1 on the U. of I. Experimental Forest

University of Idaho Library:

Call Number- Not found in Library's data base

College of Natural Resources:

Department- Forest Resources-
University of Idaho Experimental Forest

Other Sources: