forestry report

CANADIAN FORESTRY SERVICE • NORTHERN FOREST RESEARCH CENTRE

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HYDROLOGY

WATER

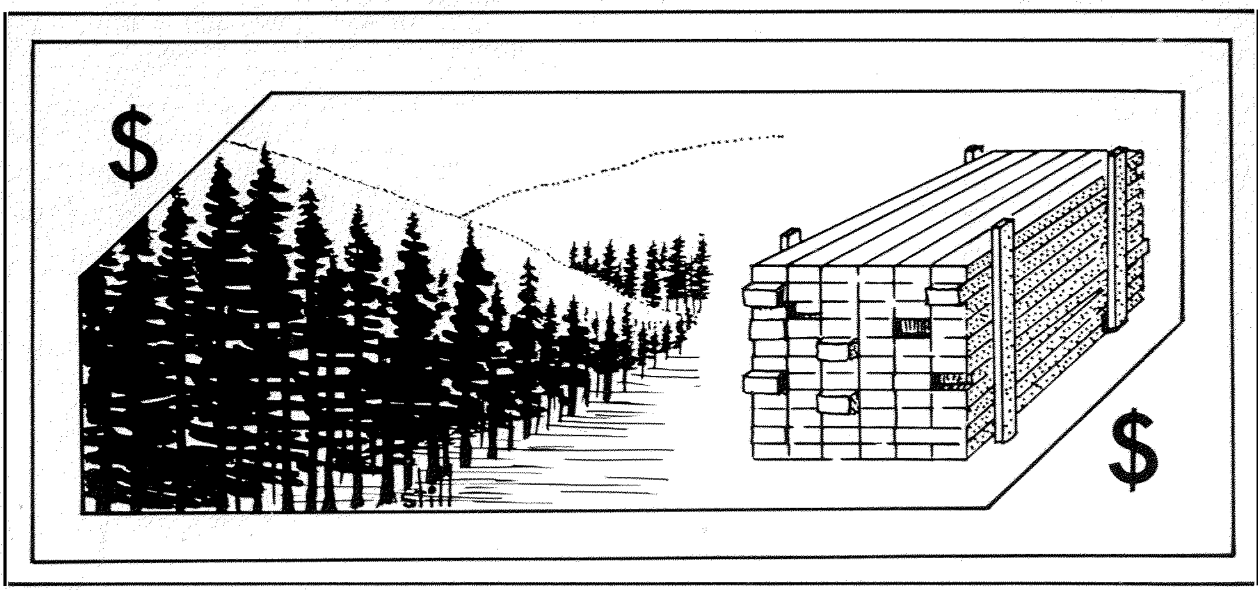
A Forest Product

-Wanted or Not-

We usually get too much water during spring snow melt runoff. This roadway along the Fraser River in Northeastern British Columbia is perhaps poorly located. It is flooded at roughly 20 - 25 year intervals. This is the 'normal' condition. Extensive forest clearing over much of the headwaters will likely increase the flooding frequency.

Timber products - their harvesting, manufacture and utilization - are 'normal' and important components of Canada's economy. More water and sediment are likely resultants of present day harvesting practices. Can we harvest timber and not produce more water or dirt? Probably. Can we do it as cheaply as now? Not likely!

Saskatchewan River Watershed Protection Worth More Than 3 Million Dollars A Year



It costs money to manage land. Our money. How much should we spend to manage land for water? The easy solution is to charge for the product. No pay – no water. Impossible! No matter how intensively or extensively we manage a watershed, water will continue to run off and be delivered to the user.

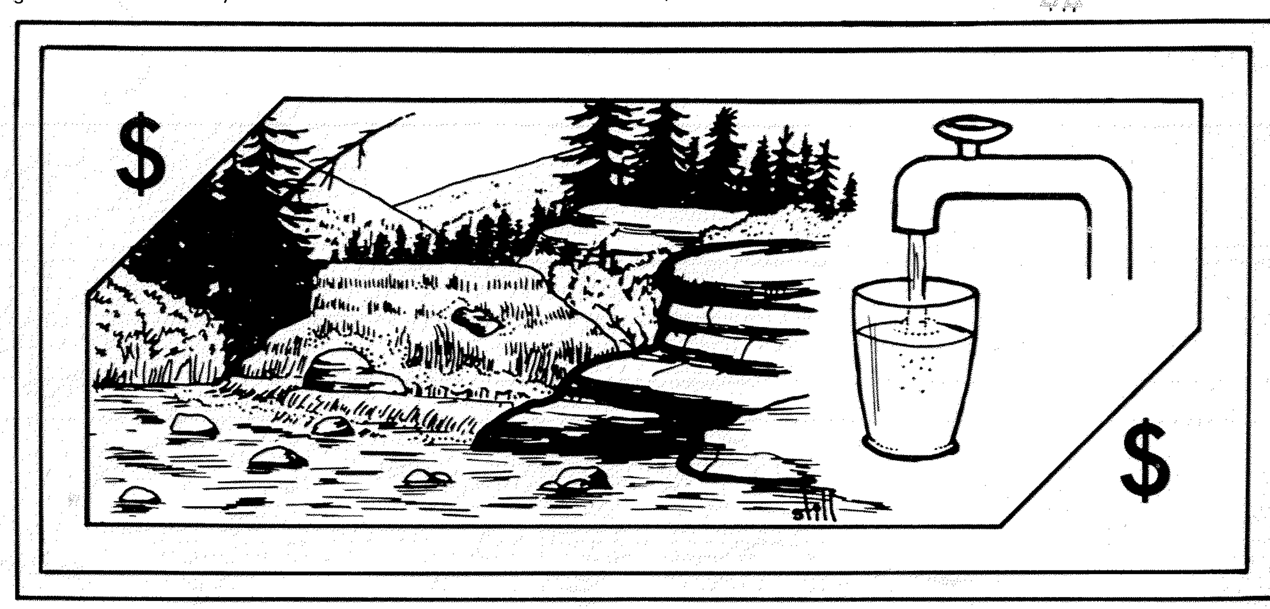
The user expects his supply of water to be timely and clean. A pattern of downstream use evolves around normally expectable flows. The normal flow can be changed through management. In fact we can't maintain the status quo without some management.

Managing to maintain the status quo is very much like managing to sustain an allowable annual cut. We charge stumpage to manage timber land: Why not a similar charge to manage watersheds?

This analogy was used to determine how much should be spent in managing the Saskatchewan River headwater. The ratio of initial stumpage dues to final lumber selling price at the mill is 0.10. This ratio applied to the price paid by Saskatchewan River water users for domestic and industrial consumption yields a 1970 'stumpage value' for water of $3,560,914.00. These dollars apportioned to the watershed areas supplying the water are:

Forest Reserve 43.6% or $1,551,855.00
Green zone outside of Forest Reserve - 4.6% or $163,802.00
National Parks 41.9% or $1,490,596.00
Plains 9.9% or $354,160.00

This timber-water analogy provides a rational means of allocating money to manage a watershed simply for water. This figure is also a minimum value: that is, water for other than domestic or industrial use in cities has not been evaluated. Certainly there is a cost to maintain water based recreation, aesthetics and transportation. These uses have user value too. And it costs to meet these uses. The knotty problem of obtaining money to meet any of these costs is probably best left to the legislatures of benefiting provinces — Alberta, Saskatchewan, and Manitoba. However, the 1970 cost of management of the forest reserve in Alberta, $1,087,735.00 would be more than met by the value determined above.



Chinooks May Influence Forest Management

Where and when can snow accumulations be manipulated to create desirable hydrologic regimes? Where sufficient snow and trees co-exist. Chinook winds create local climate abnormalities. The Alberta foothills area would be blanketed deeply in snow throughout each winter were it not for Chinooks. These warm winds originate on the west side of the continental divide. Where they penetrate the east slopes area, they often force snow-free conditions.

The major river valleys are most influenced. Lethbridge, Calgary, Rocky Mountain House, Hinton are cities that receive frequent and intense warming during the winter. This warming creates a desirable environment for people, but makes the snow manager's job difficult. We don't really know what happens to the snow - do Chinooks cause evaporation, melt or both?

Are Chinooks present elsewhere; Probably. Edmonton, Red Deer, Grande Prairie - all experience warming - but less so than the cities mentioned above. There are probably several intensities of Chinooks. Those wholly confined to valleys would be the lowest. Those spreading uniformly along the entire foothills, the highest.

One thing for certain - some Chinooks don't spread out of the valleys. The accompanying photographs show snow removal from the Bow river valley - but not from an adjacent area to the south.

Getting back to the original question, sufficient snow often does not exist in March to form any runoff - because of Chinooks. Where and how often this occurs is an important question in managing the East Slopes or any forested watershed. Areas with frequent snow loss do not have the same potential for snow pack manipulation as those with less frequent Chinooks.

If water were in extreme short supply then efforts to create more through forest manipulation might be justified in areas where the chance of success was 50% or greater. On the other hand, the present and near foreseeable demand for water would most likely require success odds better than 75%.

Thus, the purpose for studying the aereal extent of Chinook influence is to quantify, with predictable odds, the chances of having a snow pack to contribute to spring runoff. The final output from the study will be a series of maps of the East Slopes - including the Northern portion - with isolines of equal evaporation potential at several probability levels. These maps will be useable by forest managers and land use planners to determine whether or not snow management practices need to be considered.

May June Streamflow Can Be Reliably Predicted From Snow Course Data

Most of the water flowing in the rivers of the prairies during spring and summer was stored in a 'snow reservoir' during the preceding winter. Forecasting this flow is an important function of water management agencies and is also a means of testing our understanding of the hydrologic system of an area.

The May 1 - June 30 streamflow in Marmot Creek can be forecast with a fair degree of precision using only the snow water equivalent measured in late March at one snow course on the experimental watershed. For example, if the snowpack at the snow course is measured at 4.8 inches snow water equivalent in late March, the forecast May - June runoff from Cabin Creek sub-basin is 326.2 acre-feet (the standard error of estimate being 14.2 acre-feet, or 4.3% of the mean May - June flow).

RO = 176.34 + 31.22 (SC)

RO = May - June runoff from Cabin Creek

SC = March snow water equivalent snow course number 1.

The inclusion of other related variables, such as rainfall and evaporation during snow melt, might improve the model.

To obtain the water equivalent of the snowpack a sample is removed as a core in the snow tube and the tube with its sample is weighed with the spring balance.

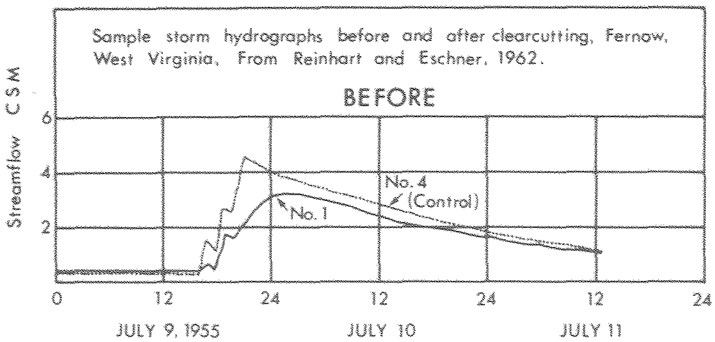
Timber Harvest Increases Streamflow, Some Type Examples

Annual runoff as a percentage of annual precipitation.

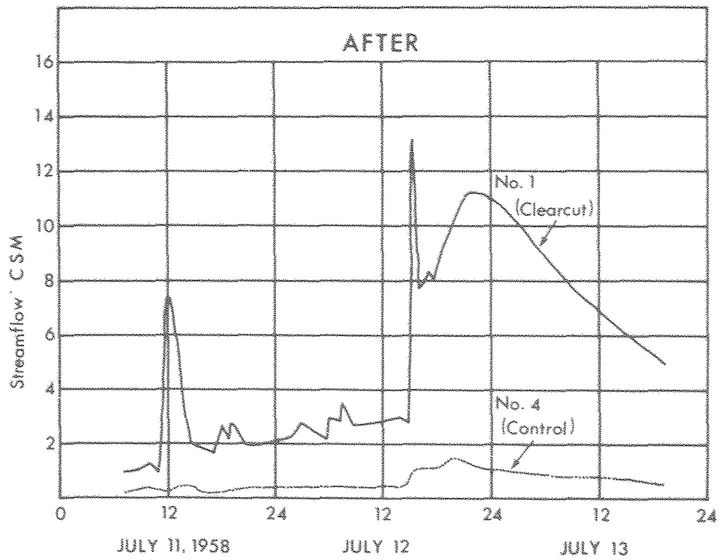
Watershed			Not Harvested	Harvested
1	Coweeta 13 (1940)	North Carolina, U.S.A.	43%	64%
2	Coweeta 13 (1962)	North Carolina, U.S.A.	43%	64%
3	Coweeta 3	North Carolina, U.S.A.	33%	40%
4	Coweeta 22	North Carolina, U.S.A.	62%	71%
5	Fernow 1	West Virginia, U.S.A.	38%	47%
6	Fernow 2	West Virginia, U.S.A.	44%	48%
7	Fernow 7	West Virginia, U.S.A.	54%	60%
8	Wagon Wheel Gap	Colorado, U.S.A.	29%	36%
9	Fool Creek	Colorado, U.S.A.	37%	48%
10	Kamakia	East Africa	28%	51%
11	Kenya	East Africa	22%	27%
		$\bar{X}$	39.36	50.54

Annual Flows

Harvesting increases total annual water yield. This table gives the first year results of clear or partial clearcutting on ten watersheds, one of which has been clear cut twice. The difference in percent of precipitation yielded is significant at the 90% probability level.

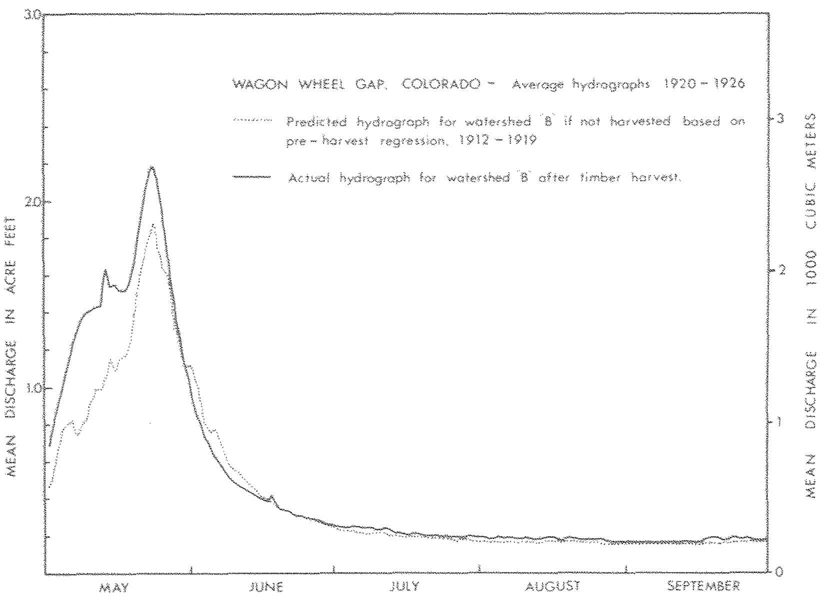


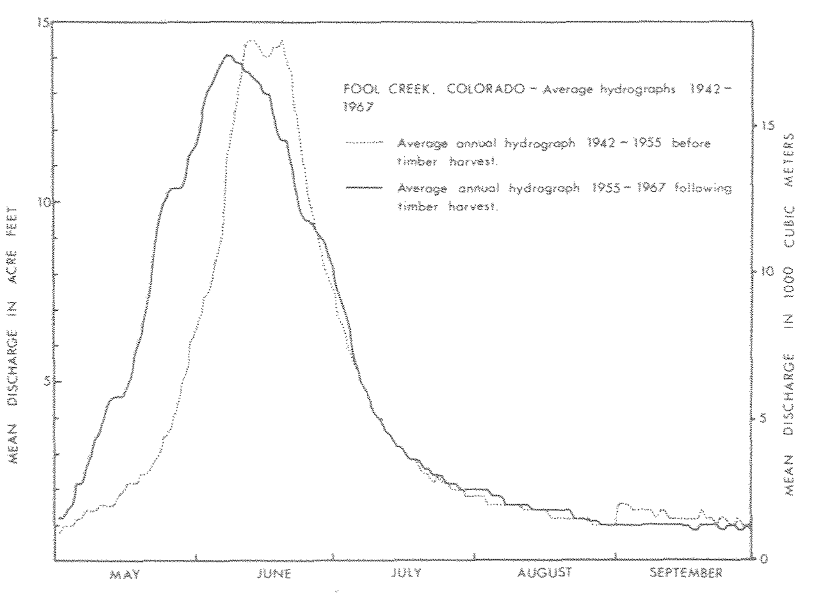
Sample storm hydrographs before and after clearcutting, Fernow, West Virginia. From Reinhart and Eschner, 1962.



Storm Flows

Clearcutting increases peak magnitude and streamflow volume from intense rain storms. This effect diminishes quite rapidly with time as regrowth occurs.





Snowmelt Runoff

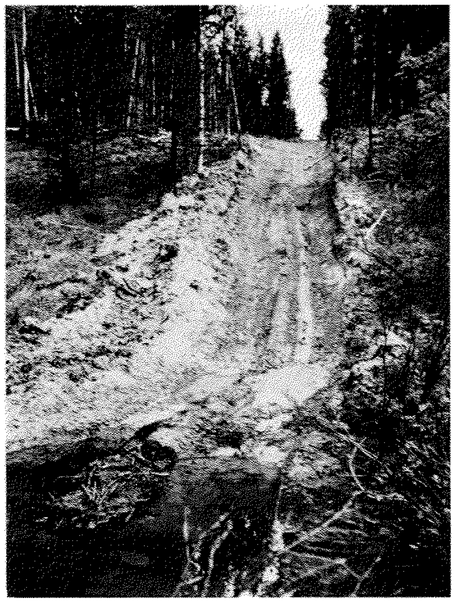
In this example, clearcutting a 246 acre Douglas Fir - Aspen watershed caused an increase in snow melt runoff volume. There was also an increase in the magnitude of the peak flow.

Patch cutting a 714 acre Spruce-fir-Lodgepole pine watershed caused an even greater increase in snow melt runoff volume than clearcutting. The peak was unaffected in magnitude, but occured earlier. Sixteen years of regrowth has not materially altered the amount of increase.

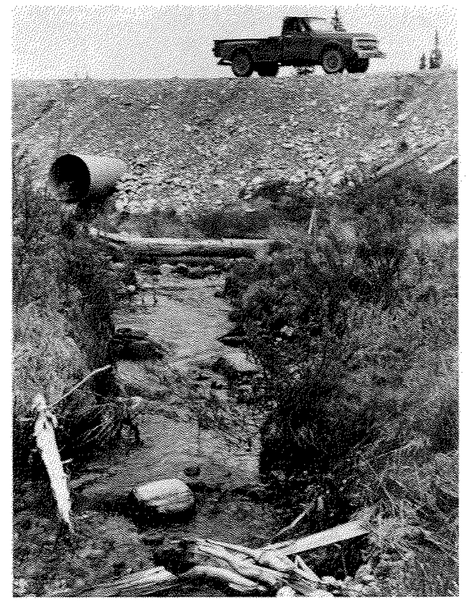
Seismic Trails and Logging Roads Produce Little Sediment During Non Storm Conditions

Preliminary results from a sediment sampling program in small headwater streams in the Hinton-Edson area, Alberta show that during non-storm periods, sediment discharges from seismic trail-stream and road-stream intersections were small and not significantly different. Average sediment discharge from roads was 20 pounds per day, slightly higher than the average 14 pounds per day from seismic trails.

Sediment discharge ranged from 0.41 to 90.0 pounds per day, while streamflow averaged 0.20 to 13 cubic feet per second. Sediment discharges from roads and seismic trails were obtained by taking the difference in sediment discharges between samples taken upstream and downstream from a sediment source.



Seismic trail-stream intersection showing severe soil disturbance and sediment deposition at bottom of slope. Most serious sedimentation occurs during periods of high rainfall and streamflow, and during or shortly after road construction when soils are easily eroded and before plant cover can provide protection.

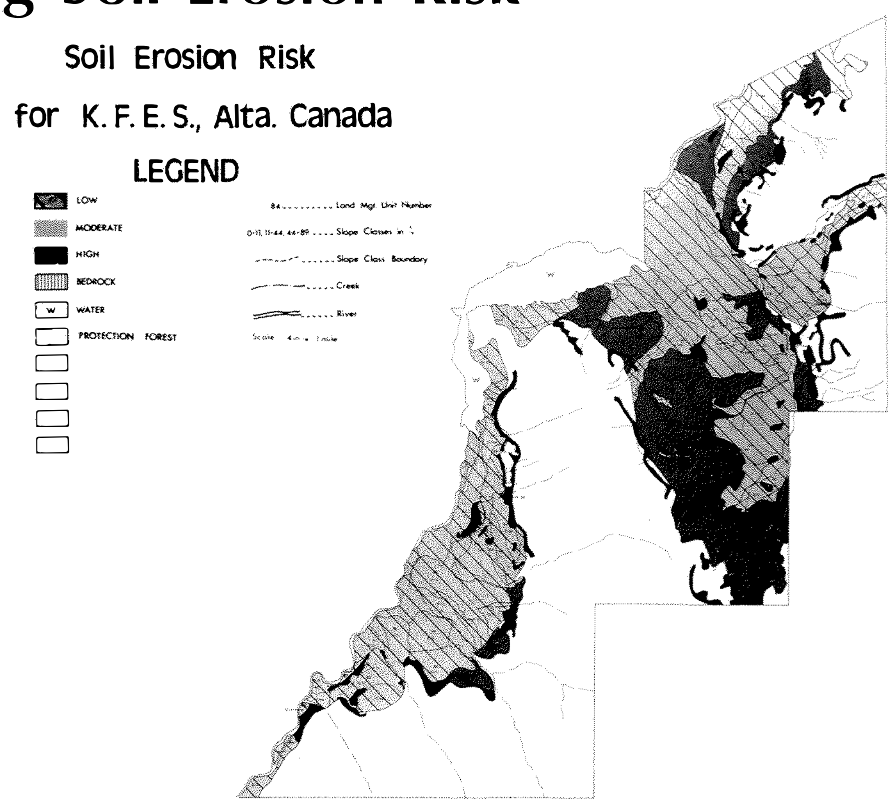


Road-stream intersection showing eroding fill section, a major sediment source. Roads, seismic trails and other surface disturbances which intersect natural drainage channels are the chief sources of sediment in the forest.

Rating Soil Erosion Risk

A soil erosion risk rating map has been prepared for the Kananaskis Forest Experiment Station. The purpose of the map is to identify relative risks of soil erosion for land use planning and management. Erosion risks are defined as high, moderate and low. Areas of high erosion risk are characterized by steep slopes and soils developed from glacial till deposits containing high percentages of silt and clay. Areas of low erosion risk are characterized by gentle slopes and soils developed from surficial deposits containing large amounts of gravel.

Erosion risks were determined by identification of surficial deposits with aerial photographs and the correlation of their physical characteristics with slope steepness. This method is based on the assumption that soil erodibility is determined by the physical characteristics of surficial deposits or parent material from which soils develop, and slope steepness.



Harvesting Effects on Snowpack Detec able on Marmot Experimental Watershed

How does timber removal affect snow accumulation and distribution? We expect that additional snow will accumulate in cut over areas and that the edges of the residual stand will act as 'snow traps'. These effects jointly modify streamflow after harvest. The question is how much does a particular harvesting pattern influence streamflow through its effect on the snowpack?

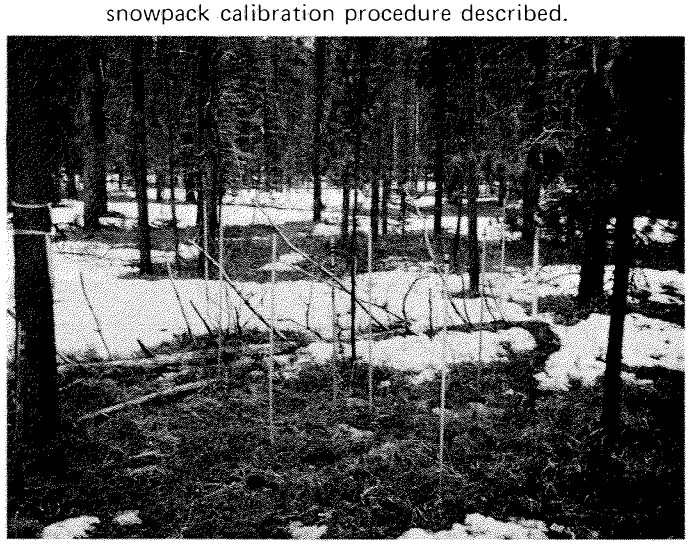
We anticipate a partial answer to this question from the Marmot Creek experimental watershed. Areas to be harvested on cabin creek sub-basin have been marked out 'on the ground'. For the past four years, we have been conducting intensive snow measurement campaigns in both these to be harvested areas (treated) and the adjacent watersheds which are not to be harvested (control). As a result of this effort, we can now detect any changes that may occur in the average snow accumulation over the to-be logged areas greater than 0.14 inches of snow water equivalent. Similarly for any individual point that may lie close to an edge after harvest, changes 0.31 inch or greater can be detected. The effect of harvest is determined by subtracting the snowwater equivalent predicted without harvest from that observed upon harvesting.

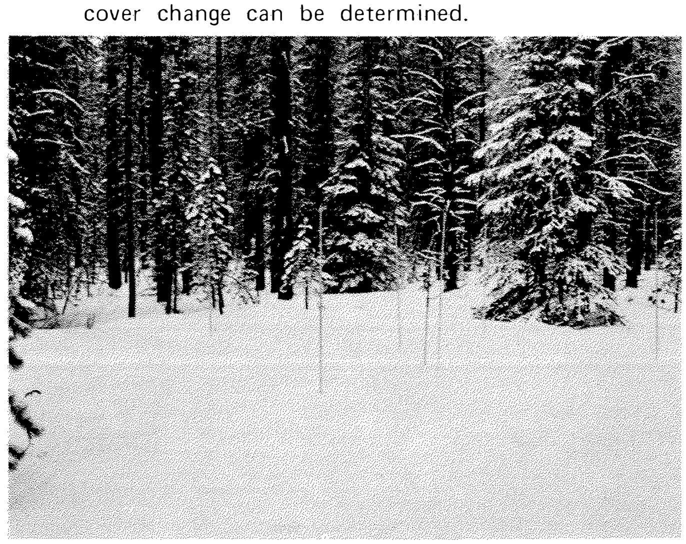
4 Early in the melt season, snow has disappeared from north edges of forest openings (photo 4) due to back

5 radiation from the trees. Late in the season, snow still remains on south edges that are shaded (photo 5).

6 The pattern of bare areas in the forest in spring results from differential accumulation and melt caused by the distribution of stems and canopy of the trees. Changes in the pattern due to cover manipulation (e.g., by logging) can be detected statistically by the snowpack calibration procedure described.

7 More snow accumulates in small forest openings than in the forest. The increase includes that due to change in the forest cover as well as a chance or random error component. With the snowpack calibration procedure the amount attributable to the forest-cover change can be determined.





The Impact of Timber Harvesting on Water Yield

A co-operative study has been initiated by member agencies of the Alberta Watershed Research Program, to obtain a measure of the degree to which existing logging on large tracts of forest land has affected the water yield and flow regime of streams draining these areas. The Atmospheric Environment Service, the Canadian Forestry Service and Water Management Services of the Department of the Environment, together with the Alberta Forest Service and Northwestern Pulp and Power Co. Ltd., are actively engaged in this research.

The basic idea is to determine the average water yield of several logged and undisturbed watersheds for the same time interval. A simple statistical comparison of these values is then made to determine if they are significantly different.

The first objective of this study is to make comparisons at a time when the difference in streamflow from the two types should be most pronounced i.e. during snow melt runoff in May and June.

Watershed research to meet this objective is being conducted on Northwestern Pulp and Power Company's lease area, near Hinton and Edson in western Alberta. The experimental design requires that data be obtained from at least six logged and six undisturbed watersheds. In 1972 one undisturbed and seven harvested watersheds were instrumented with stream guages. Streamflow data from two additional harvested watersheds will be 'hand' collected. The streamflow data from the one undisturbed and from five previously instrumented experimental watersheds will be used for the 'undisturbed' comparison. The first test of this multiple watershed experiment will be with data from 1973 May - June runoff.

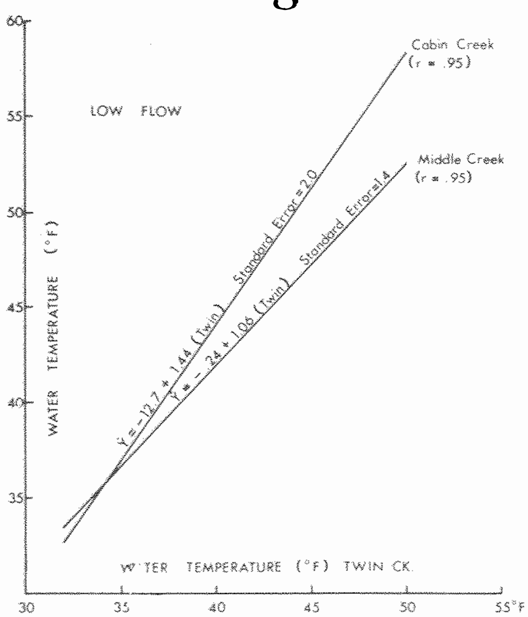
Fox Creek watershed: one of several logged watersheds currently being gauged.

Gauged watersheds on Northwestern Pulp and Power Company's Lease.

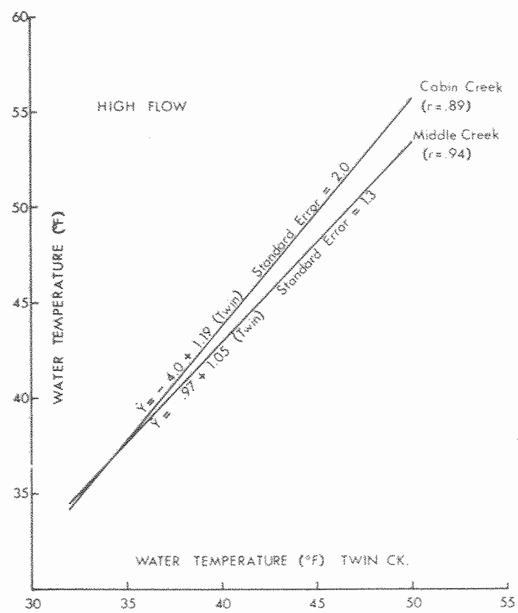
Watershed	Drainage System	Area Miles^2	Proportion Cut (%)	Perimeter of Cut (Miles)	Edge/Area Ratio (Miles^{-1})	Dominant Vegetation
1 ATH 1304	Oldman	6.32	61	36.0	9.3	SW
2 ATH 1307	Fish	4.47	72	16.1	5.0	SW
3 ATH 1604	Oldman	7.61	47	21.7	6.1	PLSW
4 BER 0303	Fox	7.01	36	34.5	13.7	PL
5 BER 0304	Fox	4.74	53	42.3	16.8	PLSW
6 BER 0306	Cabin	4.85	0	0.0	0.0	PLSW
7 MCL 0901	Anderson	4.14	32	19.1	14.5	PL
8 MCL 0902	Quigley	6.49	27	32.1	18.3	PLSW
9 MAR 0301	Pine	10.29	35	60.2	16.5	PL
10 MAR 0710	Edson	2.69	32	14.1	16.4	PLSW

ATH = Athabasca Working Circle (W.C.), BER = Berland W.C., MCL = McLeod W.C., MAR = Marlboro W.C., SW = White spruce, PL = Lodgepole pine.

Harvesting Effect on Stream Temperature Detectable



Stream temperature is important to fish that live in mountain streams. In timber harvesting, shelter strips of sufficient width are often left along the stream banks to provide shading. This helps to reduce the fluctuations in water temperatures. Some change is still inevitable because openings in the forest canopy expose both water and soil to solar radiation. A calibration of Marmot Experimental basin streams to detect water temperature changes after harvest has been completed.



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