forestry report

CANADIAN FORESTRY SERVICE NORTHERN FOREST RESEARCH CENTRE

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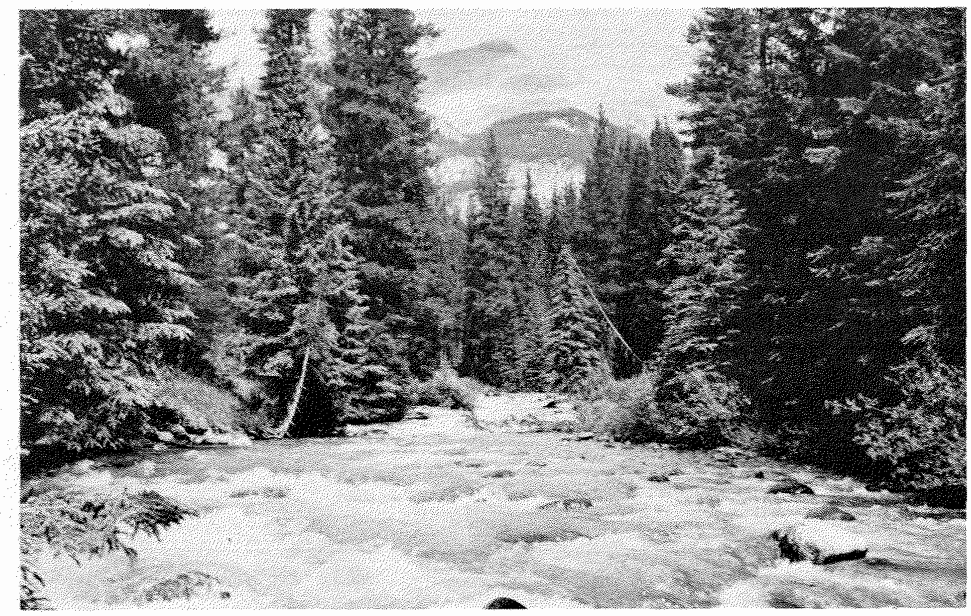


IN THIS ISSUE . . .
WATERSHEDS:

WATERSHEDS: SUPPLIERS OF OUR MOST PRECIOUS RESOURCE

Water is a forest product. Foresters will naturally think of timber as the main forest crop but there are others, water being one of them. When we stop to think that the Eastern Slopes of the Rockies supply the greatest percentage of water to the Prairie River systems, we realize how important watershed management can be. Water will always flow from forested land but we now know that good watershed management can regulate, to a degree, the water-crop, avoiding floods and low water periods. Today's flow is the result of yesterday's management – tomorrow's flow is our responsibility.

The rate of flow plotted on a graph over time constitutes a hydrograph, the annual hydrograph is the total product for a year.

"When" water is required is as important as "how much". By arranging trees in various groupings and patterns, we can shift the time that water is delivered to a stream within limited bounds. Purposeful forest land management that alters the hydrograph in a predictable and desirable manner is watershed management.

Watershed management is a relatively new field of forest land management. The term watershed management is often used to mean watershed protection and/or watershed preservation. Watershed protection usually means erosion control and often involves the application of both hydrologic and engineering principles. Watershed preservation is the setting aside of vital water yielding areas that cannot be exploited without undue erosion damage, or are reserved for purposeful hydrograph alternation through timber extraction at some future time, that is, a passive rather than an active management role. True purposeful watershed management is not now practiced anywhere in Canada.

The tools of the watershed manager are timber stands and silvicultural systems. The only difference between the timber manager and the watershed manager are his product priorities. The timber manager uses silvicultural research results to create healthy, productive forest stands for tomorrow's wood harvest. The watershed manager uses forest hydrology research results to create forests that modify tomorrow's runoff. The two "managements" may be identical but quite likely will not.

Watershed management is not forest hydrology, just as timber management is not silviculture. Forest hydrology is the study of principles and relationships between forest stands and water production. These principles, when applied, produce predictable hydrograph modification.

To summarize, all forest land is watershed. Watershed management is the purposeful application of forest hydrology principles to forest land management to affect an alteration in the time rate of flow of water. Watershed protection is the application of hydrologic principles and engineering measures to control erosion. Watershed preservation entails reserving of an area from use and its protection from fire, insect or disease outbreak.

In the following pages you will find examples of watershed protection research and development, forest hydrology research, and an application of derived knowledge to one watershed management situation.

EROSION AND SEDIMENTATION FROM FOREST ROADS AND LOGGING CAN BE REDUCED

Approximately 2,500 miles of forest roads per year were constructed in Alberta between 1963 - 1970. Total road mileage for the seven year period is 17,500 miles.

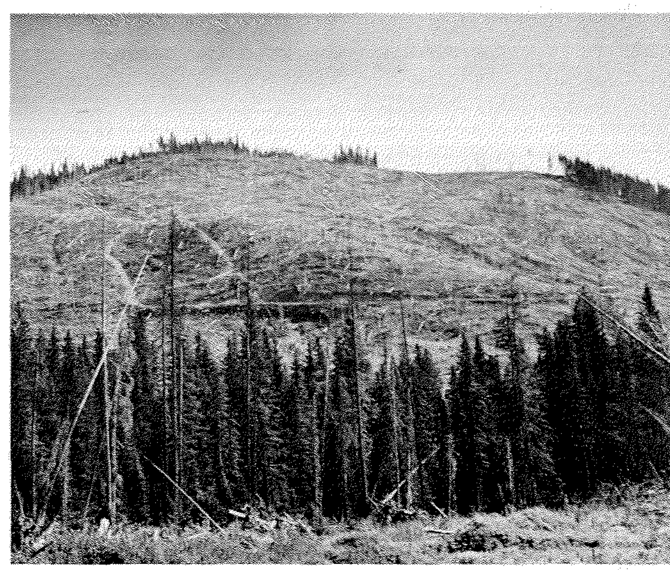
Erosion under natural conditions is usually a slow, gradual process of wearing away the land surface. However when natural conditions are disturbed, such as vegetation removed by fire, grazing, logging or forest roads, erosion can become accelerated and very destructive. Erosion is defined here as the forces of falling raindrops, flowing water and gravity acting together to break soils into fine particles, which are easily suspended, transported and deposited by water. Sedimentation is defined as the discharge and deposition of water borne soil particles into stream channels.

Most serious erosion and sedimentation in forest lands are caused by forest roads and logging. Damage occurs during or shortly after road construction and logging when soils are disturbed and exposed, and before plant cover can provide protection. The main causes of damage are poor practices in road construction and logging. Examples are: logging on steep slopes, skidding straight up and down slopes, skidding long distances, accumulation of logging debris in stream channels, roads that disrupt or change natural drainage channels, roads with steep gradients and roads with inadequate drainage facilities to divert concentrated runoff from road surfaces.

The effects of erosion and sedimentation on the forest environment can be described in these terms: Site deterioration occurs from the loss of surface soils and subsequent difficulty in re-establishing plant cover on the site. Water quality loss is caused by increased suspended sediment in streams, increased water temperatures and nutrient content, and reduced levels of dissolved oxygen in stream waters. Furthermore, these factors acting together or singly can adversely affect fish populations and fish habitats. Aesthetic and recreational values of a landscape are reduced by the existence of unattractive logged areas, eroded roadways and silt laden streams.

The causes and effects of erosion in forested lands can be reduced in most cases by careful planning and execution of road construction and logging operations. **Probably the most important element in reducing damage is the provision of on-the-spot supervision of operations by experienced personnel.** Equipment operators most often are not aware of, or motivated towards preventing the problems of erosion and sedimentation. The following discussion and photographs illustrate examples of poor road construction and logging practices that could have been avoided.

Shows lack of planning in skidroad layout.



Similar terrain and logging method, but much less disturbance from skidroads.

Skidroads should be carefully planned on steep slopes to avoid excessive disturbance. A haphazard system of skidroads may occupy 20% of a logged area, but a well planned system need occupy only 10%.

Skidding straight up and down slopes should be avoided. Steep gradients and disturbed soils result in serious erosion.

Steep gradients can be avoided by locating skidroads along the contour or running them diagonally across the slope.

Ground skidding of logs for long distances should be avoided, because road surfaces are kept in a highly disturbed state, subject to easy soil movement and the formation of gullies. Maximum skidding distances of one-quarter to one-half mile should be used, beyond which logs should be truck hauled from the forest.

Extreme accumulation of felled trees and logging debris in a stream channel. Debris should not be allowed in stream channels because it has a direct, adverse effect on water quality and during high water flows aids in scouring and erosion of the stream channel.

Skidroads and truckroads should be located away from stream channels to prevent unnecessary sedimentation. The skidroad is too close to the small tributary and does not have a bridge or culvert for crossing the main stream. Furthermore the skidroad gradient is too great and no provisions have been made to prevent sediment discharge into the main stream.

Forest roads and skidroads should have drainage facilities adequate to divert concentrated runoff from their surfaces. Construction of cross drains to divert water from the road would have prevented the formation of gullies.

Cross drains should extend across the full width of a road bed so that water drains downhill from the toe of the cut bank to the shoulder. The cross drain in the photograph is not correct as it attempts to direct water in an uphill direction causing it to collect in the roadside ditch.

Culverts should be installed at all stream channels that intersect a roadway. The culvert in the photograph is incorrect, having organic material in the fill and not enough fill to adequately cover the culvert. Depth of fill material to cover a culvert should be equal to the diameter of the culvert or a minimum of 12 inches. Organic material, like the trees in the photograph, should not be included in fill material as extreme settling and wash outs can very easily occur.

OIL IN THE SWAN HILLS

In 1957 it was headline news . . . OIL IN THE SWAN HILLS. Before many months had gone by the oilfield was 300 square miles of roads, seismic lines, pipelines and powerlines serving 900 wellsites. Twelve to 18% of some townships were bared of protective vegetative cover.

The damage was obvious. A combination of highly erosive soils, steep topography, high precipitation and poor engineering practices resulted in the most extensive and severe erosion and sedimentation problems of any forested area in Alberta. Sporadic oil spills, sometimes made directly into streams, intensified the pollution problem and caused serious damage to the valuable sport fishery of the Swan River.

An immediate four phase program was started:

1. An inventory of existing watershed damage and condition in the Swan Hills oilfield.
2. Measurements of precipitation, erosion and runoff.
3. Suspended sediment sampling in streams.
4. Rehabilitation trials, demonstrations and plot studies.

In 1969, from May to October, the most erosive plot indicated sediment movement equivalent to 65 tons per acre: the least erosive plot, 27 tons per acre. Rainfall, 1967-1970, ranged between 12.5 and 14.0 inches. Runoff averaged 40 per cent of precipitation on all plots, but was as high as 87 per cent during intense rain storms. These plots give a conservative estimate of total sediment produced from disturbed lands in the Swan Hills oilfield at 500,000 tons per year.

Rehabilitation Studies

Check dams and contour trenching were tried as methods of runoff control. These were not successful unless complemented by a protective vegetative cover.

Seeding trials on unprepared seedbeds were generally unsuccessful. High mortality and down-slope movement of seed were common unless ideal surface and moisture conditions prevailed. Raking or harrowing seed into the seedbed increased success by 50 per cent. Late fall seeding responded significantly to surface preparation and, at this time of year, post-harrowing was judged to be unnecessary. Deeper, more uniform seedbeds were prepared for cereal grain companion crops by the use of flexible drag harrows. On compacted soils bulldozer mounted teeth were used to till the surface to a depth of 12-14 inches. This method resulted in an ideal seedbed and greatly reduced surface erosion.

Based on the trials, grass species were rated in the following order of priority: timothy, creeping red fescue, Kentucky bluegrass, crested wheatgrass, pubescent wheatgrass, and bromegrass. The two most suitable legumes tested were rambler alfalfa and red clover. Grass legume mixtures were seeded at an optimum rate of 40 lbs. per acre. Fertilizer applications of 200-250 lbs. per acre of 16-20-0-14, ammonium nitrate - phosphate - sulphate compounds, applied with the seed gave the best results.

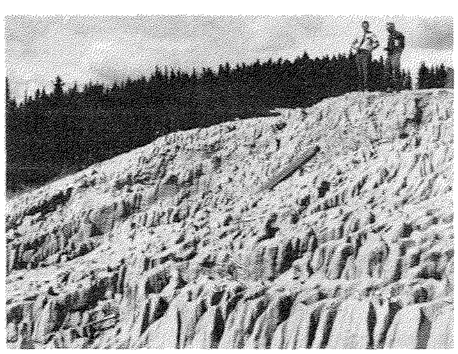
Legumes survived poorly on dry, well-drained slopes unless protected by a nurse crop. A nurse crop of barley provided a high degree of erosion prevention that was later enhanced by the protective dead straw mulch.

Turfiber, straw/asphalt, sawdust/asphalt, jute mesh, straw/plastic netting and brush mulches improved growing conditions and stabilized slopes while vegetation was becoming established. Turfiber process, in which seed, asphalt emulsion, fertilizer and mulch are applied with a truck-mounted hydroseeder, was adaptable to large scale operations where access was available. Brush mulch had a distinct advantage in that material was readily available and could be easily and economically applied with construction machinery.

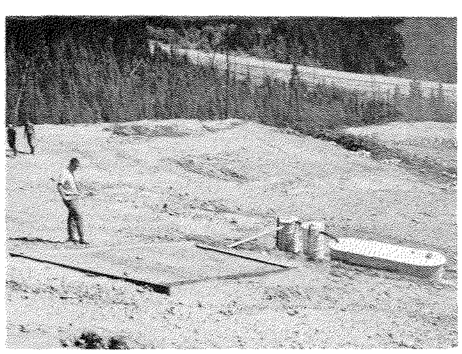
The result — successful rehabilitation. Large sums of money are being expended annually by both industry and government in a joint drive towards eventual restoration of this sensitive watershed.

Look like worms? They're not! They're roads and oil well sites in the Swan Hills.

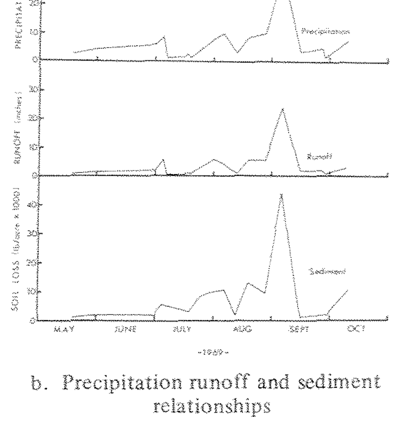
A problem well site.



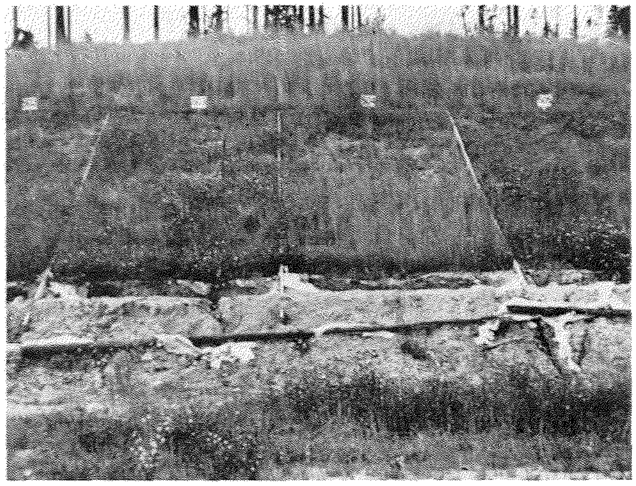
The results of denudation!



How much runoff and sediment? A precipitation gauge network and runoff plots supplied the answer.
a. Runoff plot.



b. Precipitation runoff and sediment relationships



Nurse crop trial plots.

Successful rehabilitation to prevent erosion.

FOREST HYDROLOGY

Snow Accumulation

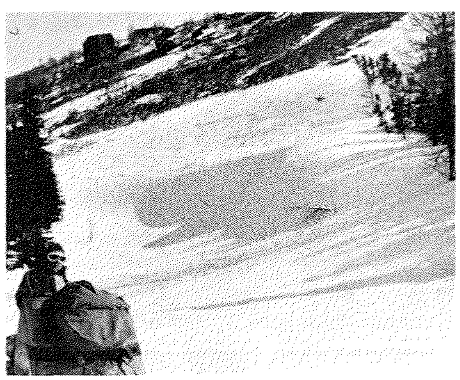
A reservoir is a device for storing water. The winter snowpack of Alberta's Forest Reserve is the reservoir for the spring and late season stream flow to the Prairie Provinces. The snowpack is a particularly useful reservoir because its size is altered by forest management.

Snow accumulates wherever wind velocity decreases, whether in hollows or in the lee of a forest edge.

Snow drifts form behind any barrier. The size of a drift is governed by wind speed and by barrier height - porosity. The effect of any given barrier can be noted 2 to 10 times the height of the barrier, down wind.

. . . And Melt

Deeply drifted snow has less surface area per unit volume than an evenly distributed snowpack. The energy available to melt snow, warming by wind or the sun's rays, is relatively evenly supplied to the earth surface. Therefore, the lower the ratio of surface area to volume, the slower the melt rate. This principle is clearly demonstrated by this photo sequence.



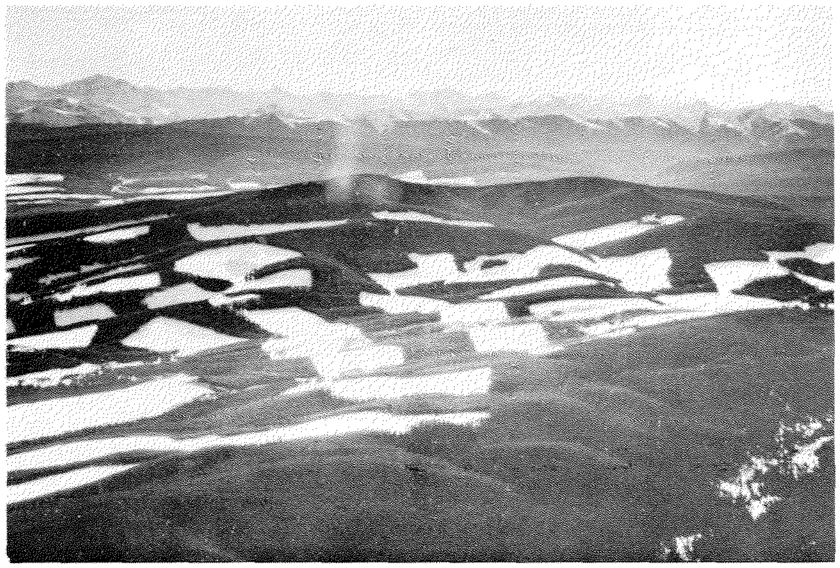
a. Wind and sun have begun to take their toll of the snowpack both in the drift and surrounding it.

b. An appreciable snow volume still remains in the drift after that surrounding has completely disappeared.

c. By mid summer a small snowfield still persists from the drift.

These photos illustrate the effectiveness of the alpine vegetation in creating drifts for late season snow fields, and subsequent runoff.

Each acre of such snow yields about 150,000 gallons of water per week for each foot of depth. The usefulness of such snow accumulation is not restricted to the alpine. Similar delayed and prolonged melt seasons can be achieved in the commercial forest at lower elevations.



Forest edges, however they are created, induce some drifting. Patch work harvesting patterns such as these on the Northwestern Pulp and Power Company's lease area near Hinton, Alberta are particularly useful for "creating" differential snow accumulation. At this elevation however, prolonged melt seasons are difficult to attain unless the size and orientation of the clear cut blocks are carefully arranged to take maximum advantage of wind and shading.

WATERSHED MANAGEMENT

Poplar forests and associated grasslands are valuable for game and livestock. Through shelter and food, poplar rangelands provide rearing ground for waterfowl and wildlife.

Because of the interspersed open spaces, gentle topography, easy access from centers of populations, and abundance of game poplars also receive high recreational use.

In southwestern Alberta about 8% of the area is converted from rangeland to forest through encroachment of poplar trees every 10 years. The sequence is from grass to willows to aspen. This represents a gradual loss in the ability of such ranges to support livestock. (Measurements indicate a decrease in grass production from 1200 lb./acre on fescue prairie to 400 lb./acre under the aspen groves.)

Many ranchers have taken upon themselves the task of clearing aspen and willow, either to check this encroachment or to create more rangeland.

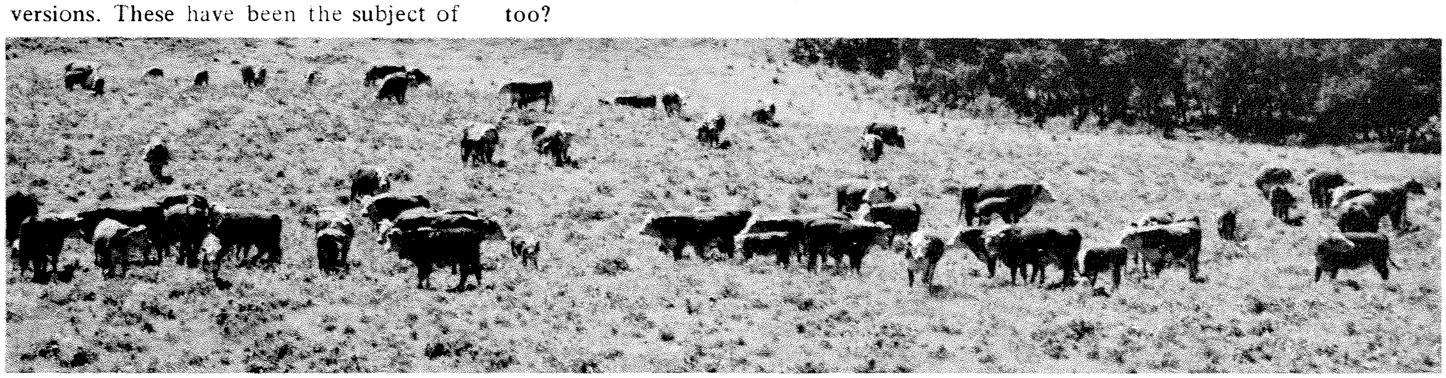
There are hydrological consequences from such clearing and vegetation conversions. These have been the subject of studies in Streeter Basin, an experimental watershed in the Porcupine Hills of southwestern Alberta which was established in 1963 to determine the hydrologic effects of poplar clearing.

We know we can increase grass areas by clearing willows and aspen, and reseeding. A study of such clearing in southwestern Alberta indicates that the present practice of totally clearing aspen and replacing it with grass does not serve the best interests of range or watershed management. When totally cleared, snow that would otherwise accumulate in aspen stands gets blown away or drifted into gullies and depressions. Such snow becomes direct runoff on melting. Lack of snow accumulations on ridges causes reduced recharge of local groundwater flow systems. Thus, springs that are both game and livestock water supply dry up earlier than they would have had normal recharge been allowed. Snow also disappears from large open areas two or three weeks before it does within small openings among the trees.

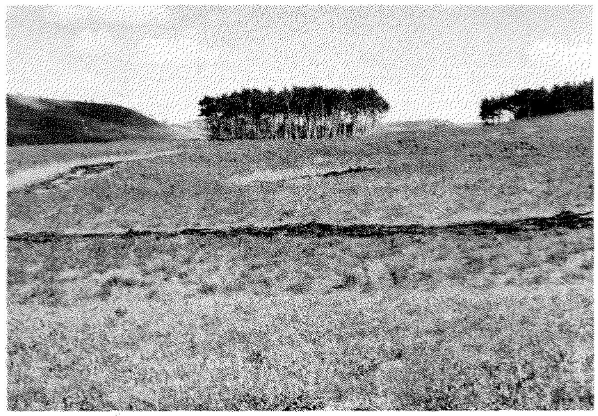
Can we have both more grass and water too?

The research in Streeter Basin indicates that the interests of range and watershed management could be better served by creating narrow strips or small block openings among the trees near ridge tops, which are the main recharge areas for locally discharging springs. This can be combined with aspen removal in a large proportion of the area in the valley bottom. Cut-over areas can be seeded or converted to grass. The treed strips along ridges hold snow and allow infiltration of melt water. Streambank vegetation may be left uncut if needed to provide shade to reduce any increase in stream water temperature.

Clearings done in this way can help to sustain the flow from perennial springs which are livestock water supply. Numerous watering sources and strip clearings cause better cattle distribution and better range use than a single watering source in the valley bottom.

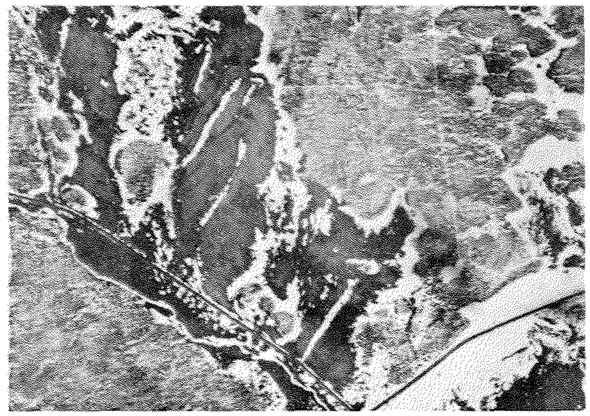


Aspen grasslands of Alberta are habitat for deer, elk and moose and are also used to graze domestic cattle.

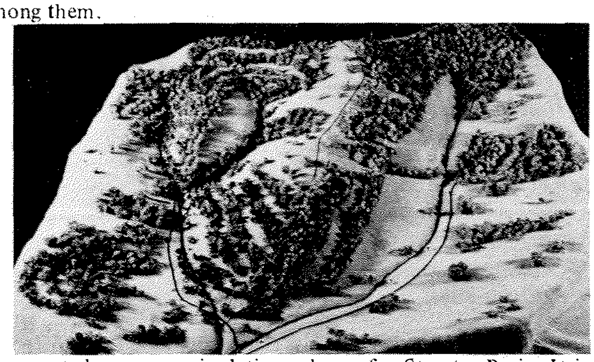


Aspen removal increases grass production. It also increases the amount of snow that is lost via wind action. Ridge tops are areas of groundwater recharge, and the removal of trees here reduces drifting, causing a shallow, non-persistent snow pack.

Numerous local groundwater discharge areas such as this spring occur throughout Streeter Basin. Elsewhere in the Porcupine Hills, springs similar to these don't flow all summer after the vegetation on their recharge source areas have been removed.



An aerial view in the spring. Although snow falls more or less uniformly throughout Streeter Basin, wind action causes locally heavy accumulations under the trees. In the spring of the year, snow clears from the open areas two to three weeks earlier than it does either under the trees or from small clearings interspersed among them.



A suggested aspen manipulation scheme for Streeter Basin. It is designed to accumulate and hold snow on the upper slopes. Approximately one-half of the previously treed area has been cleared. The expected benefits are:

1. Prolonged groundwater discharge from local springs.
2. Better distribution of grazing livestock and game animals.
3. Increased forage production on the cleared portion.

WATERSHED NEWS

Marmot Treatment Starts

The long anticipated commercial harvest test in Marmot watershed basin commenced in earnest this year. Roads have been installed on Cabin Creek sub basin to allow removal of 700,000 cubic feet out of a total of 1.4 million cubic feet of timber. Approximately fifty percent of the timbered area will be harvested.

The treatment plan is for road construction in 1971 with two years to ascertain if these cause any undue sediment. Actual harvest will commence in 1973 or 1974 dependent upon the outcome of the road-sediment evaluation.

The harvest is not commercial in the strictest sense. Existing Department of Lands and Forest guidelines have been modified to allow harvesting within the 6500 feet elevation protection forest, as well as within the stream bank residuals. However no roads or skid trails may be constructed on slopes over 40% or within the immediate vicinity of the stream channel.

The test will be evaluated both during the road phase and through the completion of harvest for any change in water yield, quality or regime. The anticipated result of the test is to demonstrate that high altitude spruce-fir forests can be carefully harvested without loss of the watershed value.

Probable hydrological effects of clearcutting, large blocks in Alberta Reviewed

Clearcutting coniferous forests or the creation of large openings in these forests generally result in a measurable increase in one or more of the following: snow accumulation, snowmelt rate, and water yield. The increase in water yield, and the delivery time depend on both the percent of watershed cut and the pattern of cut. Clearcutting results in increased erosion and sedimentation rates, but these increases can be attributed more to road and skid trail construction than to the fact that an opening is created. Other side effects produced by clearcutting include: increased flood hazard, changes in water temperature, depletion of the water's dissolved oxygen, and changes in groundwater levels. Carefully planned and controlled clearcutting could be compatible with good watershed management provided roads and skid trails are not constructed on steep slopes.

Consideration must be given to present and future water requirements when planing clearcut sizes and cutting patterns. Steps should be taken to evaluate the effects on water yield, quality and regime of any harvesting or silvicultural system before it is applied to large areas in Alberta.

Symposium on the role of snow and ice in hydrology scheduled for Banff, September 6 - 20, 1972.

This symposium should be of particular interest to foresters who are concerned with multiple use management. Subject topics range from highly theoretical - i.e. physics and chemistry of snowfall and snow distribution, to practical - modification of snowfall, snow cover and ice cover. Further details can be obtained from:

Dr. I. C. Brown
Canadian National Committee for the IHD
No. 8 Building, 870 Carling Avenue
Ottawa, Ontario.

WANT MORE INFORMATION?

Recent publications of the forest hydrology research section (available from the indicated author).

Golding, D.L.

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Rothwell, R.L.

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Singh, T.

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3. A principal components regression model for predicting infiltration. American Geophysical Union, National Fall Meeting, Transactions, Vol. 51(11): 755. 1970.
4. A calibration procedure with data from a mountain watershed. American Society of Range Management, 24th Annual Meeting, Reno, Nevada, February 14-18, 1971.
5. A minimum entrophy rotation of principal components for obtaining simple structure in a hydrologic data matrix. American Geophysical Union, National Fall Meeting, December 6-9, 1971.

Swanson, R.H.

1. Local snow distribution is not a function of local topography under continuous tree cover. New Zealand Journal of Hydrology Vol. 9, No. 2, 1970. pp. 292-298.
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3. Sampling for direct transpiration estimates. New Zealand Journal of Hydrology Vol. 9, No. 2, 1970. pp. 72-77.
4. A Thermal flow meter for estimating the rate of xylem sap ascent in trees. In: Proceedings: Flow - Its measurement and control in Science and Industry. R.B. Dowdell, ed. (In press, 1971).
5. Velocity distribution pattern in ascending xylem sap during transpiration. In Proceedings: Flow - Its measurement and control in Science and Industry. R.B. Dowdell, ed. (In press, 1971).

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1. Guidelines For Stream Protection In Logging Operations. R.L. Lantz. Oregon State Game Commission, Box 3503, Portland, Oregon 97208. August, 1971. 29 pp. illustrated.
2. Management Practice on the Bitterroot National Forest. A Task Force Analysis May 1969 - April 1970. U.S. Forest Service, Region 1, Missoula, Montana 59801. 1971. 100 pp. illus.

CONTRIBUTORS

R.H. Swanson

(Watershed: Suppliers of our most precious resource, watershed News)
Mr. Swanson is Project Coordinator for Forest Hydrology Research in the Northern Forest Research Centre. He is also Research Coordinator for the interagency Alberta Watershed Research Program. He joined the C.F.S. in 1968.

D.L. Golding

(Snow accumulation – and melt)
Dr. Golding joined the C.F.S. in 1966 to study the interactions between the forest floor and runoff, and the forest canopy as it affects snow accumulation and melt.

T. Singh

(Aspen clearing – watershed conditions)
Dr. Singh joined the C.F.S. in 1966 to study the value of aspen in watershed manipulation.

R.L. Rothwell

(Erosion and sedimentation)
Mr. Rothwell joined the C.F.S. in 1966 to study erosion and sedimentation problems in the East Slopes.

G.R. Hillman

(Probable hydrological effects of clearcutting)
Mr. Hillman joined the C.F.S. in 1967 to study plant community – soil water movement interaction.

E.C. Wyldman

(Oil in the Swan Hills)
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