ALPINE ECOLOGY UNIT, WASTE POINT

Summary of Research Results in Catchment Hydrology, 1955-61.

The general scope of catchment investigations in the Snowy Mountains Area is as follows:-

1. Condition and trend of plant communities and soils in relation to land use.

2. Hydrological properties of plant communities and soils in relation to quality, rēgime and amount of water yield.

3. Catchment management techniques to achieve the most desirable soil and plant conditions with respect to 2.

The following progress has been made:

1. Condition and Trend of Soils and Plant Communities

Knowledge of the condition and trend of soils and vegetation in relation to the natural environment and to various land use practices is essential for sustained productivity. This information for the Snowy Mountains area, during the period of summer grazing up to 1958 has already been made known (see references).

Since the removal of grazing above 4,500 feet in 1958, changes in the plant cover have been measured on permanent transects, quadrats and on grazing trials. A variety of methods has been used, depending on local conditions, including line intercept and quadrat analyses, stereoscopic photography, plant yield, and changes in livestock weight. The transect, quadrat and photographic measurements show a trend towards revegetation of bare and eroded areas, and increased yield from formerly grazed plots, with consequent increased infiltration of soil moisture and reduced soil loss. Most of the field data remain to be analysed; however, for one snowgrass (*Poa caespitosa*) area at Rennix Gap (5,000 ft.) for which analyses have been completed the following results have been obtained:

(i) Considering the snowgrass communities as a whole, there has been a significant increase in the amount of snowgrass, from 37% cover in 1955 to 51% in 1960. Shrubs have increased slightly, and bare ground and inter-tussock communities have decreased.

(ii) Considering further the inter-tussock areas, which comprise about 35% of the pasture and are the most sensitive to change, the following significant improvement was also measured (Table 1).

Table 1. - Comparison of Inter-tussock Areas at Rennix Gap during and after grazing.

Type of Cover	1955 (During grazing)	1960 (3 years after grazing
Bare Ground	41%	21%
Minor Herbs	38%	46%
Litter	21%	33%

Additional permanent reference areas have also been established to follow long-term changes on natural vegetation. It is still too early (four years) for worthwhile data to have emerged.

2. Catchment Hydrology

The three important hydrological characteristics of soils and vegetation in relation to water supply catchments are the quality (i.e. sediment, etc.), regime (seasonal distribution) and amount of water yield.

These characteristics have been examined since 1956 on a variety of climax and disclimax communities above 4,000 ft, with the aim of ascertaining the most suitable types of plant cover. Specific problems which have been investigated include infiltration and percolation, soil loss, evapotranspiration, accumulation and persistence of snow, interception of rain, cloud and fog, and hydrological characteristics of *Sphagnum* bogs.

(a) Surface Run-Off and Soil Loss (See References)

Surface run-off and soil loss from 60 50-sq.ft. plots in forest, snowgum-snowgrass, and alpine herbfield areas at Kosciusko were measured for three years. The results were evaluated in terms of successional status, slope, percentage ground cover, amount of ground cover of different kinds (herbs and herbaceous litter, woody and sclerophyll litter, shrubs), presence or absence of trees, and soil moisture, surface compaction, and soil frost effects.

Maximum infiltration and minimum soil loss were found to acquire a dense ground cover of herbs at the rate of about 0.2 lbs per square foot (dried at 180°F for 48 hours). More than double this amount of woody and sclerophyll litter, or of shrubs, were necessary to give equivalent protection. Improved pastures which were grazed provided inadequate cover (0.05 lbs per sq. ft.). Run-off and soil loss were proportionately much greater from heavy rains falling on relatively dry surface soil, than from the total rainfall.

It was concluded that considerable improvement in catchment performance would result from practices which encouraged succession from the widespread depleted (partly bare) and regrowth conditions (shrubs) towards more natural forest, snowgum-snowgrass, and alpine herbfield vegetation. The comparative value of these cover conditions is summarised in Tables 2, 3 and 4.

<u>Table 2.</u> - <u>Run-off and Soil Loss Characteristics of Forest Plots.</u>

Type	Run-off (%)		Soil Loss (lb/50 sq. ft.)	
	Total Rains 1956-58	1 in/30 min Rain	Total rains	1 in/30 min Rain
Natural	0.30 ± 0.08	2.97 ± 1.09	Nil	Nil
Regrowth	1.69* ± 0.53	20.71* ± 6.83	0.04* ± 0.01	Tr.
Depleted	3.66* ± 1.47	39.02* ± 13.61	0.54* ± 0.18	0.02 ± 0.01

* Significantly different from "Natural".

<u>Table 3.</u> - <u>Run-off and Soil Loss Characteristics of Snowgum-Snowgrass plots.</u>

Type	Run-off (%)		Soil Loss (lb/50 sq.ft.)	
	Total Rains 1956-58	1 in/30 min Rain	Total Rains	1 in/30 min Rain
Natural	0.56 ± 0.22	7.37 ± 4.12	Nil	Nil
Regrowth	0.56 ± 0.24	8.54 ± 3.67	0.01* ± 0.00	0.004 ± 0.004
Depleted	3.30* ± 0.98	30.75* ± 8.83	4.70* ± 2.20	2.74* ± 1.37
Short Pasture	1.60* ± 0.43	16.49 ± 2.62	Nil	Nil

*Significantly different from "Natural".

Table 4. - Run-off and Soil Loss Characteristics of Alpine Herbfield Plots.

Type	Run-off (%)	Soil Loss (lb/50 sq.ft.)
Snowgrass-snow daisy	3.55 ± 1.78	0.004 ± 0.004
Depleted	8.08* ± 0.82	58.60* ± 24.36

* Significantly different from natural snowgrass-snow daisy.

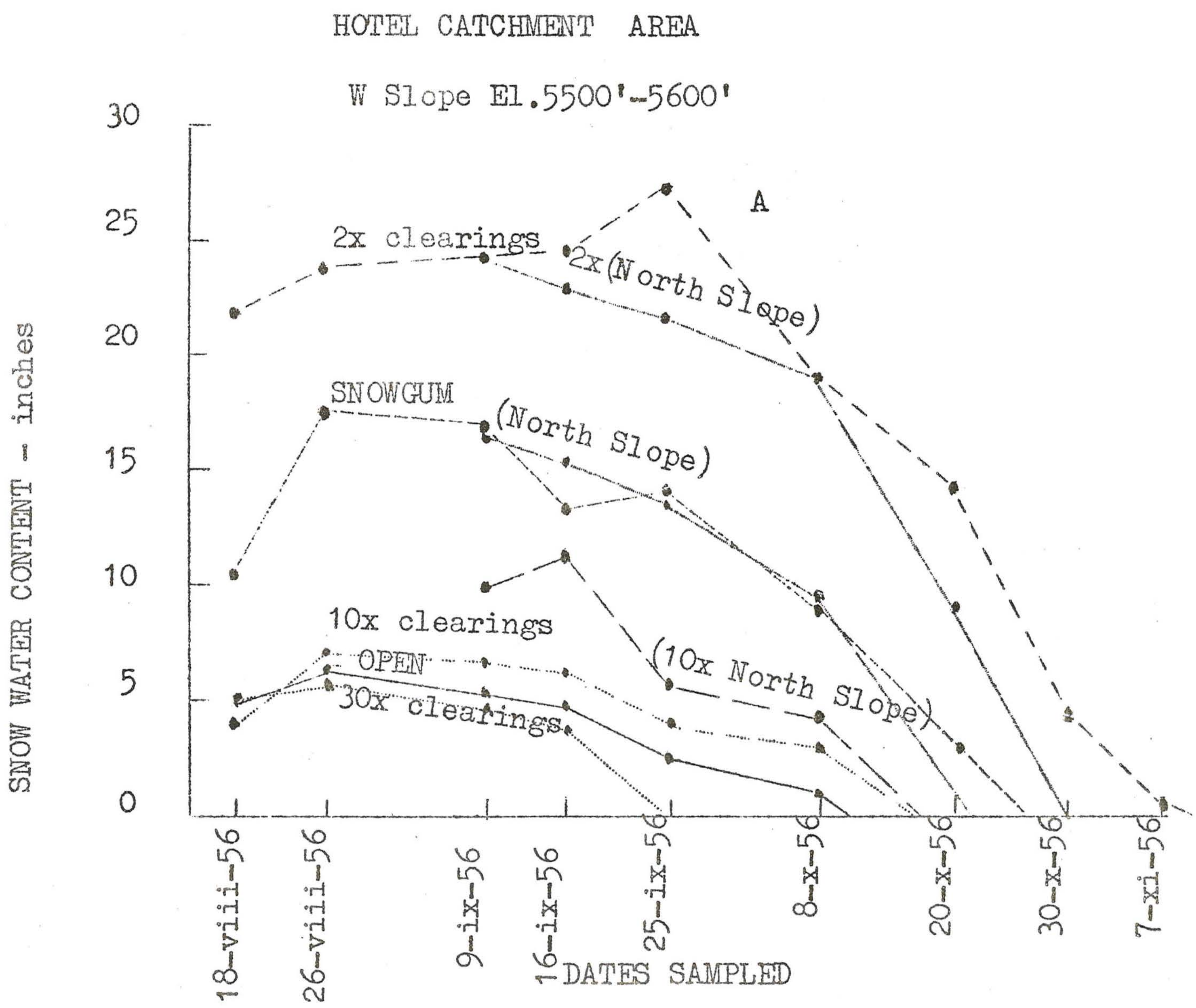
(b) Evapotranspiration

Evapotranspiration is an important component affecting total water yield. Water use by the main communities above 4,000 feet has been characterized by means of gypsum block measurements, and computation of the results is proceeding. Only slight differences between different communities have been obtained, confirming the hypothesis that in moist environments with a large depth of soil accessible to plant roots, meteorological rather than biological conditions determine evapotranspiration loss. Thus, increased water yield is unlikely to result from thinning or changing existing vegetation.

(c) Snow Hydrology (See References)

The accumulation and persistence of snow by trees may affect the amount and regime of water yield. These vegetation - water yield relationships have been investigated since 1956 and were completed this year. The work was carried out both in experimental areas containing a number of different sized clearings, and over the 60-square mile catchment of Guthega Pond.

It was found that small clearings produced greater accumulation and persistence of snow than dense trees, and that accumulation and persistence were greater under trees than in the open. These relationships were affected by aspect, greater protection, (i.e. smaller clearings), being necessary on aspects exposed to the prevailing winds and sun than on sheltered aspects. Snow fences behaved similarly to the trees. The gain in snowwater assocated with trees was not offset by greater evaporation from intercepted snow, which was found to be slight.


HOTEL CATCHMENT AREA
W Slope El.5500'-5600'
A
SNOW WATER CONTENT - inches
30
25
20
15
10
5
0
2x clearings
2x (North Slope)
SNOWGUM
(North Slope)
10x clearings
OPEN
30x clearings
(10x North Slope)
18-viii-56
26-viii-56
9-ix-56
16-ix-56
25-ix-56
8-x-56
20-x-56
30-x-56
7-xi-56
DATES SAMPLED

Extension of these studies to the vegetation of Guthega Catchment as a whole confirmed the results of the clearing experiments. Deforested and naturally treeless areas accumulated 30-50% less snow water than timbered areas, and melting occurred up to one month sooner. In the heavy winter of 1956, the 3,500 acres of dead snowgum lost about 6,000 acre feet of water and in the light winter of 1959 about 1,200 acre feet. Reafforestation would directly benefit hydro-electric production, in addition to aiding soil conservation.

Data for 1956 in respect of one of the clearing experiments, and the snow-survey of Guthega Catchment, are shown in Figure 1 and Table 5.

Table 5. - Snow-water content in relation to Snowgum and Dead Snowgum, Guthega Catchment.

Mapping Unit	Area (Acres)	Av. Snow-water content (Feet)	
		1956	1959
Snowgum	10,884	3.6	1.0
Dead Snowgum	3,479	1.7	0.6

(d) Interception by Trees of Rain, Cloud and Fog (See References).

The possibility that in moist, cloudy environments trees may increase precipitation by straining out or condensing part of the atmospheric moisture blown through them was examined at four sites between 4,000 and 6,000 feet during 1958-60. A pair of 11-foot diameter collecting trays, of which one tray was placed under the trees and one in the open, was used at each site.

At temperatures above freezing, precipitations under the trees during windless conditions were about the same as, or less than those in the open. During windy periods precipitations were significantly greater under the trees, especially at the higher altitudes where the average increase was about 30%. Most of the extra water collected was from mists and fine rain, rather than from cloud and fog. At freezing temperatures, however, the trees accumulated large amounts of ice and rime from cloud and fog.

In catchments between 4,000 and 5,000 feet, timbered areas probably collect at least 1-2 additional inches of water per year, and 2-5 inches above 5,000 feet. Similar increases would be expected from afforestation of treeless catchments (Tables 6 and 7).

Table 6. - Comparison of Precipitations under Trees and in the Open during Windy Rains (1956-58).

Elevation (ft)	No. Windy Periods	Total Precipitation (ins)		Significance of increase (P)
		Under trees	Open	
4,000	51	29.1	24.3	0.01 - 0.02
5,000	57	39.1	35.8	0.05 - 0.10
5,800	50	46.6	32.9	0.01
6,000	36	25.0	21.6	0.01

Table 7. - Deposition of Ice and Rime on Trees from Freezing Cloud.

Elevation (ft.)	Date	Rate of Deposition
5,000	20-21/7/58	1" per day
5,800	27-28/6/60	0.1 - 0.2" per hour

(e) Hydrology of Sphagum bogs.

Above 5,000 feet groundwater areas comprise up to 10% of the total area, and of this 10% about half used to be Sphagnum bog. The bogs have been seriously damaged by fires and grazing, and the problems which present themselves are:

(i) How do bogs affect the quality, regime and amount of water yield?

(ii) If this effect is favourable as regards catchment values, how can damaged bogs be stabilised and restored?

Question (i) has been examined in terms of the equation:

$$O = P + Si - So - Ev$$

() = Outflow from bog; P = precipitation; Si = seepage into bog; So = seepage out of bog; EV = evapotranspiration).

Outflow, precipitation and incoming seepage have been measured since 1956 by more or less standard recording equipment, but the measurement of outgoing seepage and evapotranspiration have been more difficult. These data were finally obtained in 1960-61 by a series of experiments in which the bog was watered, then successively covered with plastic sheeting and uncovered, until base flow from the outlet of the bog was regained.

Examination of the data is proceeding.

3. Catchment Improvement Techniques

The investigations under (1) and (2) are showing which soil and plant-conditions are most suitable for optimum water yield from high mountain catchment areas. The practical application of these results in terms of land use and catchment management is not the responsibility of C.S.I.R.O. However, a number of research problems remain, especially concerning revegetation of badly eroded land.

One such problem is the stabilisation of eroded alpine soils above 6,500 feet, where the organo-mineral topsoil has been stripped to expose infertile gravel and stones. In these situations a persistent nitrogen-fixing perennial pioneer species is badly needed. No such native species exists, and trials are under way with several promising legumes, especially the clover *Trifolium ambiguum* from the U.S.S.R.

REFERENCES

The following reports are among publications which have appeared since 1955:

1. "Catchment conditions in the Snowy Mountains in relation to grazing". *The Australasian Irrigator* 2, 20. 1957.

2. "A report on the condition of the high mountain catchments of New South Wales and Victoria". Australian Academy of Science, Canberra 1957.

3. "The grazing factor and the maintenance of catchment values in the Australian Alps". CSIRO Div. Plant Industry Tech. Paper 10, 1958.

4. "Vegetation of high mountains in Australia in relation to land use". Ch.26 in "Biogeography and Ecology in Australia", _Mon. Biological_ 8, 1959.

5. "Studies in catchment hydrology in the Australian Alps. I. Trends in soils and vegetation". CSIRO Div. Plant Industry Tech. Paper 13, 1959.

6. "Id. II. Surface run-off and soil loss". CSIRO Div. Plant Industry Tech. Paper 14, 1960.

7. "Id. III. Preliminary snow investigations". CSIRO Div. Plant Industry, Tech. Paper 1961.

8. "Id. IV. Interception by trees of rain, cloud and fog". CSIRO Div. Plant Industry Tech. Paper, 1961.

Papers now in course of preparation, and expected to be ready for publication in 1962, include:

9. "Studies in catchment hydrology in the Australian Alps. V. Evapotranspiration". CSIRO Div. Plant Industry Tech. Paper.

10. "Id. VI. The water economy of _Sphagnum_ bogs". CSIRO Div. Plant Industry Tech. Paper.

11. "Progress report on changes in snow grass pastures protected from grazing since 1958".

APPENDIX 1. - Climatic sequence of soils and vegetation on gneissic granite, Jindabyne to Mt. Kosciusko.