

RECOMMENDATIONS
FOR THE FUTURE USE
OF THE
WAIMAKARIRI CATCHMENT

A summary of "The Waimakariri Catchment"
Tussock Grasslands and Mountain Lands Institute
Special Publication No. 5

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T U S S O C K G R A S S L A N D S
A N D M O U N T A I N L A N D S
I N S T I T U T E

Special Publication No. 6

This is a synopsis of a 300 page study recently published by the Institute. Copies of the original study are available from the Institute — price \$2.30.

P R E F A C E

This report has been prepared by the staff of the Institute because of the vital importance of the Waimakariri Catchment. It attempts to collect under one cover all the relevant information from known sources and to make a series of recommendations in the light of this assembled knowledge. These recommendations are that a modification of traditional land use is desirable and that it can only be achieved with justice if adequate compensation is offered to the legal occupiers of the upper catchment.

The survey also reveals a very large field of ignorance about the condition and trend of the catchment and about the economics of changes in land use. It recommends that investigation of these fields be undertaken.

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1. THE CATCHMENT

The Area:

The map on pages 12 and 13 shows the location of the Waimakariri River catchment. The area above the Otarama Gorge and including the Kowai catchment is 578,450 acres. The total area of both upper and lower catchment is 906,670 acres. This report is concerned primarily with the upper catchment which is a steep, high altitude area. Table 1 shows that approximately 55 per cent of the catchment is above 3,000 feet.

TABLE 1
Altitudinal Zones in the Waimakariri Catchment

Zone	Altitudinal limits	% of area
Lowland	1000 ft.	1%
Montane	1000 - 3000 ft	40%
Upper montane (grassland) }	3000 - 4500 ft	34%
Sub alpine (scrubland) }		
Alpine	4500 ft	25%

Geology:

Glacial activity, particularly over the last one million years, has been mainly responsible for the steep topography of the area. The most recent glacial activity has been in the west where steep mountains rise sharply from comparatively narrow valleys. In the mid and east of the catchment the mountains are less steep, and are associated with extensive fans, terraces and morainic downs.

The area is formed almost entirely from greywacke, or formations derived from greywacke. The rock fractures easily into irregular lumps which move downslope and accumulate as screes or fans. In the past, soil development and plant succession have tended to slow down the natural rate of erosion. However earthquakes (three in the last 100 years) and cataclysmic storms have occasionally upset the plant-soil parent rock equilibrium, and started new cycles of erosion.

Climate:

The climate of the catchment is characterised by contrasts, and dominated by the north-west wind. This is the prevailing wind, and is also largely responsible for the annual distribution of rainfall. The rainfall gradient from east to west across the catch-

ment is particularly obvious near the Main Divide. Rainfall at Bealey is about 60 inches per year while six miles away at Arthur's Pass, it is about 180 inches. There is also a less obvious precipitation gradient with increasing altitude. At 5,000 feet on the Craigieburn Range snow contributes about 30 per cent of the total annual precipitation, but below this it rapidly becomes less important. Thus the western boundary and the high altitude lands receive the greatest amounts of precipitation.

Severe frosts can occur in any month, and the number of frosts per year increases with altitude. At a site at 5,000 feet on the Craigieburn Range, data from three years suggest that there are only 25-56 days a year in which frosts do not occur. This means that spring growth can be cut back by summer frosts. New growth seldom has time to mature before it is again cut back by autumn frosts.

Soils and Erosion:

Most of the soils are naturally infertile. Moreover there is a sharp fall in nutrient status with soil depth. Where the topsoil has been lost, the infertile subsoil provides an extremely poor medium for plant growth. Also the subsoils are more susceptible to erosion than the topsoils.

A high rate of natural erosion has always been a feature of this catchment, but in general it is now restricted to a small (4.6 per cent) but spectacular area above 5,500 feet. Sheet erosion is the dominant form of induced erosion and this probably started with the Polynesian occupation of New Zealand. At present nearly half the catchment (46 per cent) is severely or extremely eroded. Most of this erosion occurs above about 4,000 feet, and on very steep sites below this.

Vegetation:

Table 2 shows the major plant communities and their extent. The most widespread communities are the short-tussock grasslands, the snow-tussock grasslands, the mountain beech forests and the bare rock, scree and fell-field communities.

TABLE 2
Plant Communities in the Waimakariri Catchment

		(provisional, Prickett & Howard, in prep.)	
	Acres	Acres	%
GRASSLANDS			
Sown grassland	10,000		1.7
Introduced grassland	3,350		0.6
Red-tussock grassland	2,550		0.4
Short-tussock grassland	156,700		27.2
Snow-tussock grassland	65,850		11.4
Alpine short-tussock grassland	7,850		1.4
	Sub-total	246,300	42.7
SCRUBLANDS			
Montane			
Gorse	800		0.1
Manuka	8,050		1.4
Matagouri	2,900		0.5
Other (montane)	4,100		0.7
Subalpine	7,250		1.3
	Sub-total	23,100	4.0
FOREST		167,450	28.9
RIVERBED AND LAKES		25,950	4.5
BARE ROCK, SCREE AND FELL-FIELD		115,650	19.9
		578,450	100.0

A number of botanical investigations over the last 50 years indicate that the condition of at least some areas of lowland and montane grassland and scrubland has improved. Although some areas are severely depleted, the general condition of these lands is satisfactory from a soil and water conservation point of view.

However the same is not true at higher altitudes. The New Zealand Forest Service has 185 permanently recorded sites within the upper montane and alpine grasslands of the catchment. In 1960 the watershed condition of less than two per cent of these sites was "excellent"; sixteen per cent "good"; thirty-four per cent "fair" and forty-eight per cent were "poor". The present trend of these sites was assessed at: five per cent showed signs of improving; 36 per cent appeared to be stationary; and 59 per cent appeared to be deteriorating. In general it was the drier southern and eastern portion of the catchment in which the condition was generally poor and most frequently found to be deteriorating. This is also the region which carries most of the sheep, and has been most seriously affected by past burning.

PLATE 1.

Natural erosion has always been a feature of this catchment. This plate shows the erosion in the Thomson Creek (Poulter catchment) caused by the 1929 Arthur's Pass earthquake.

(photo: P. Wardle)



About 900-1,000 years ago 70 per cent of the catchment was under forest, but Polynesian fires destroyed $\frac{2}{3}$ of this (Plates 2 and 3). In contrast, Europeans probably destroyed less than two per cent. Forests now cover about 28 per cent of the catchment and almost all of these have been modified by heavy deer populations. Recent animal control operations have substantially reduced the populations but very little response in forest vegetation can be seen. In areas where the damage has been severe it may take 15-20 years to reverse the present downwards trends. On other areas it may never be possible to restore cover by animal control alone.

From 1952 to 1966 official control operations shot 28,000 deer and 9,000 chamois. This represents a kill of 7.5-8.0 animals per day, seven days a week for 14 years.

The River:

In 1865 and again in 1868 the Waimakariri overflowed and joined the Avon. In the latter flood about four feet of water flowed through Fendalton, and water extended into Cathedral Square. Over the last 100 years a number of attempts have been made to control the river and the 1960 estimated replacement costs of the downstream river protection works was \$10 million. At present the North Canterbury Catchment Board is involved in an additional \$2,000,000 project which will give added protection to an area with a capital value of \$450,000,000 (1960). It is estimated that these works will be effective for 25 years.

River flow records show that maximum flow at the Waimakariri Gorge occurs within 24 hours of the start of heavy rain at Arthur's Pass. This is a very "flashy" flow pattern for a basin of this size. This suggests that either the upper catchment has a low storage potential or that much of the flow comes from surface runoff and rapid subsurface flow.

The long term solution to the problem of river control probably lies in controlling the sediment movement of the river. Unlike most Canterbury rivers which grade steeply to the sea, the Waimakariri flattens over the last ten miles. This is the region of greatest sediment accumulation. Between 1930 and 1955, 110,000-200,000 cubic yards of sediment were deposited each year. This raised the "medium" flood level at the Belfast Highway bridge by two feet. However, the removal of 1.3 million cubic yards of gravel to build the Northern Motorway has temporarily taken bed conditions in this area back to those of 30 years.



PLATES 2 & 3.

Polynesian fires destroyed much of the beech forest and started new cycles of erosion, some of which are still active. Plate 2 shows the Poulter hill which was first burnt 500-1000 years ago, and later burnt and grazed during European occupation. Compare the condition of this area with that of the 5,322ft. unnamed peak in the Nigger stream catchment shown in plate 3.

(photos: R. D. Dick)



2. LAND USE

1961 - 1964

Agricultural and Pastoral

Only half the catchment is used for farming. Eleven runs occupy nearly 300,000 acres and twelve farms occupy nearly 4,500 acres. The largest run is 120,000 acres and the smallest full-time farm is 200 acres. More than 90 per cent of this land is leasehold (Table 3).

TABLE 3
Tenure, Area and Administrative Authority of Agricultural and Pastoral Land within the Waimakariri Catchment.

Tenure	Administered by	Area	% of total
Freehold	Owner	25,433	7.9
Pastoral lease	Lands Department	192,789	60.3
Past. Occ. Lic.	" "	19,250	6.0
Other	" "	4,563	1.4
Leasehold 21 years	Canterbury University	64,037	20.0
„ 1 yr or 21 yrs	Arthur's Pass National Park	7,377	2.3
„ 1 yr or 5 yrs	N.Z. Forest Service	6,405	2.0
Annual lease	N.Z. Railways Dept.	360	0.1
	Selwyn Plantation Board	107	—
	County Councils	27	—
		320,338	100%

The runs carried 82,600 sheep and 1,800 cattle. The sheep numbers were equally distributed between Merinos, half-breds and Corriedales or halfbreds mated to Corriedales. The farms carried 12,500 sheep and 400 cattle. Romneys made up $\frac{2}{3}$ of the number and Corriedales made up the other $\frac{1}{3}$. The total of 95,100 sheep and 2,200 cattle were carried on 288,000 acres of native pasture, 6,000 acres improved native pasture and 10,000 acres of farm and run paddocks.

Table 4 shows that wool was the main source of income on the runs, but not on the farms.

TABLE 4
Sources of Income

		% of income derived from			
		wool	sheep	cattle	produce
Runs	average	71	21	8	—
	range	55-95	5-35	0-15	0-5
Farms	average	32	46	7	15
	range	5-50	30-70	0-15	0-70

Table 5 shows that the gross returns, costs of production, and profit per sheep. On the runs the profits ranged from \$2,000-\$24,000, with a medium of \$8,000. On the farms they ranged from a loss of \$200 to a profit of \$11,000. The median was \$600. This represents an average interest return on capital of 8.4 per cent for the runs and 5.5 per cent for the farms. Of this profit approximately $\frac{2}{3}$ was distributed to beneficiaries, partners or taken as additional wages. Less than two per cent was reinvested as development.

TABLE 5
Income, Costs, Profits and Capital per sheep for runs
and farms within the catchment.

	Runs			Farms			Catchment		
	£	s.	d.	£	s.	d.	£	s.	d.
	(\$c)			(\$c)			(\$c)		
Gross Income									
Wool account	1	9	4½	1	14	1½	1	10	1½
	(2.94)			(3.41)			(3.01)		
Sheep and Lambs	8	6		1	11	3½	12	0	
	(0.85)			(3.13)			(1.20)		
Cattle accounts	3	4½		4	11½		3	7½	
	(0.34)			(0.50)			(0.36)		
Other accounts		1		8	6½		1	4	
	(0.01)			(0.85)			(0.13)		
Total gross farm	2	1	4	3	18	11	2	7	1
Income	(4.13)			(7.90)			(4.71)		
Costs (excluding	1	5	10½	3	1	4	1	11	3
interest, rent	(2.59)			(6.13)			(3.12)		
& development)									
Profit	15	5½		17	7		15	9½	
	(1.55)			(1.76)			(1.58)		
Capital	9	3	5	15	18	11	10	4	1½
	(18.34)			(31.89)			(20.41)		

Recreation:

The Arthur's Pass National Park and Craigieburn Forest Park are popular recreational areas. Visitors to the National Park have increased from 7,000 in 1962 to 16,500 in 1963 to 28,000 in 1964. At weekends during the winter up to 1,000 people a day use the ski fields on the Craigieburn Range.

3. POTENTIAL

Land Capability:

A land capability classification separates land into eight classes according to the intensity of use and risk of erosion in each class. Class I has the highest capability and class VIII the lowest. Table 6 shows that about half the catchment is classified as class VIII and only 21 per cent is classified as III, IV or VI.

TABLE 6
Land capability classes in the catchment

						(Prickett & Howard, in prep.)	
						Area	% of catchment
III	...	...	...	...	...	12,950	2.2
IV	...	...	...	...	...	21,750	3.8
VI	...	...	...	...	...	89,400	15.4
VII	...	...	...	...	...	163,150	28.2
VIII	...	...	...	...	...	265,250	45.8
River bed and lakes						25,950	4.5
						578,450	100%

Pastoral Production:

It has been estimated that with adequate plant nutrients and grazing control, the lowlands and montane lands could carry 370,000 sheep. It also seems that the ultimate carrying capacity will depend on the winter feed supply. In general terms, the results of agricultural research suggest that because of the low fertility of many soils, development will be unprofitable unless the treatments are carried out thoroughly. That is, it will be more profitable to intensively use the resources of development on a small area than to spread them thinly over a larger area.

Forest Production:

There are 174,000 acres of land in the area suited to commercial afforestation. It is estimated that the annual yield of pulpwood would be about 22.5 million cubic feet, which would be enough to supply a large modern pulp and paper industry. Because commercial afforestation is unlikely to be economic on a lesser scale, future forest development would probably be on an "all or nothing" basis.

Recreation:

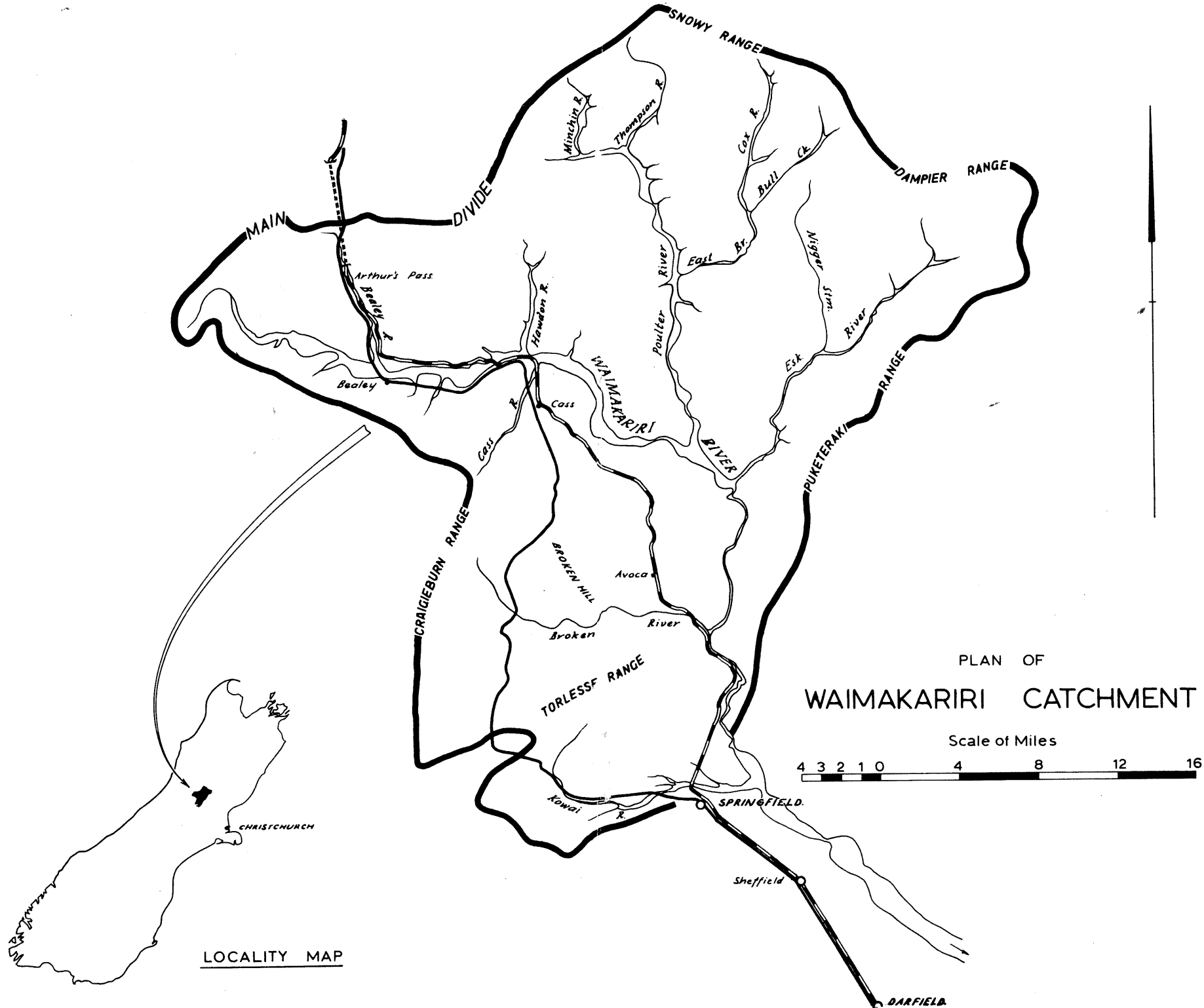
In recent years there has been a dramatic increase in the recreational use of the Arthur's Pass National Park and Craigieburn Forest Park. As the surrounding population increases, and people have more money and more leisure time, there will inevitably be an increase in the recreational use of the area.



PLATE 4.

While the high altitude lands are in general severely eroded and must be withdrawn from grazing, the lower lands have a definite agricultural potential. This plate shows pasture improvement on the Ribbonwood fan, Cass. This oversowing and topdressing has been both productive and profitable.

(photo: J. H. Stone)



4. RECOMMENDATIONS

Land Retirement:

It has been accepted both in New Zealand and overseas that long term river control must involve both the lower reaches of the river, and its upper catchment. Because of the severe erosion in the upper catchment, and the high capital investment in its flood plain, it is necessary to re-examine some aspects of present use.

The upper montane and alpine lands have been described as steep, unstable and infertile. They receive high total precipitation and have a severe climate. Traditionally some of these high altitude lands have provided grazing for sheep and noxious animals.

The arguments for and against destocking this type of land have been discussed by many authors over the last 20-30 years. The main reasons for retaining its use appear to be:

1. Although there is extensive erosion over these high altitude lands, most of it predates European occupation. Early run practices may have aggravated the situation but burning is not now practised, flocks are smaller than they were, and stock limitations are now imposed to ensure that the country is not abused. So far there has been no proof that the present flocks are causing deterioration. On the contrary many runholders claim that the condition of these lands has not changed in their lifetimes.

2. There is no evidence to suggest that destocking would improve the condition of the vegetation. However, it would create many problems for the runholder. These lands are used for summer grazing and some of the lower lands are valuable for winter grazing. Their loss would force runholders to change to a system of management which is as yet unproven.

3. Whether or not research studies show that the present pastoral system is in conflict with other more important uses, the runholder is entitled by law to occupy and use this land.

On the other hand the main arguments in favour of destocking in this catchment appear to be:

1. Large areas of the upper montane and alpine grasslands are in poor watershed-condition and are deteriorating. This is greatest in those areas where sheep and noxious animals graze.

2. While it has not been shown that the country will improve if the animals are removed it is contended that there will be no real improvement in the presence of stock.

3. The benefits from grazing cannot justify the risks involved. Of the 320,000 acres used for pastoral production 150,000-170,000 acres are in the upper montane and alpine zones. While it is difficult to assess the income derived from this area it is estimated that retirement would mean a direct annual loss of \$40,000-\$60,000 of pastoral income. This is 10-15 per cent of the gross catchment income and insignificant when compared to the capital investment in the flood plain of the river.

In assessing the evidence for and against the continued pastoral use of these lands, it is evident that recent work by the New Zealand Forest Service throws doubt on the contention that grazing does **not** cause deterioration. The principal arguments for retaining the use of these lands then rest on the runholders legal rights and their concern about farming without them.

However, a legal right does not imply that a practice is either correct or cannot be changed. Also, the problems of farming without these lands are no justification for their continued use. It has frequently been suggested that the decision to destock should not be made until research results have established the case beyond all reasonable doubt. However in 1957 Dr. L. Ellison noted that "if one must wait until all the research results are in, and only then bring public opinion to bear I think the eastern slopes of the New Zealand Alps will be without any soil at all".

Although the evidence for destocking is incomplete, and often based on assumption and opinion this Institute believes that in this catchment it is sufficient to establish the case for retirement. Throughout much of the South Island high country the retirement of class VIII land has been accepted. However it is contended that in **this** catchment the high altitude class VII land must also be retired for an indefinite period.

The Tussock Grasslands and Mountain Lands Institute therefore recommends:

That land classified as capability classes VII and VIII in the upper montane and alpine zones of the Waimakariri catchment be progressively destocked of domestic animals.

It must be emphasised that retirement is not an end in itself. This land is required for watershed protection but its present condition is such that it is incapable of meeting this requirement.

Future Farming:

The problems of deterioration are less important in the low-land and montane zones where improvement is possible with the known techniques of oversowing, topdressing, fencing and grazing. Although some critical areas would require careful management it is contended that these lands could be farmed intensively and still fulfill their watershed protection requirements. At present less than 15 per cent of the land potentially suitable for improvement has been improved, much of that only partially. The productive capacity of the basin could be substantially increased even with the retirement of large areas.

Compensation for loss of income when land is retired:

Although it is essential that the high altitude lands be retired, the runholder's legal rights are recognised. To ensure that there is no breach of faith between landlord and tenant, and that a measure of economic justice is achieved, it is proposed that the runholder should be compensated where the retirement of land results in a loss of income. Compensation should be based on the capitalised productive value of the retired land. For example the retirement of a block which carried 1,050 wethers would mean an annual loss of about \$1,600 to the runholder (Table 5). Compensation would therefore be the sum required to return annually \$1,600. At an interest rate of five per cent, this would be \$32,000. Assuming that over the whole affected area 12,000 sheep would be displaced, this represents an annual loss of profits of about \$18,000. Compensation would therefore be in the order of \$360,000.

However it is not suggested that compensation should be an unconditional "hand out". Rather it is recommended that the money should be reinvested in the catchment.

Compensation to runholders may be disputed on the grounds that, as they contributed to the problems, they should carry out the repair work. Some run management practices have certainly contributed to the problems of erosion and depletion, but it does not necessarily follow that the runholder is entirely to blame. If blame is to be apportioned then the ultimate responsibility rests with the people of New Zealand and their Departments of State

who accepted and even encouraged the past systems of management. As the proposals are of benefit to a large community, the nation must accept its responsibilities and share the costs.

This Institute therefore recommends:

1. That in the Waimakariri catchment the Soil Conservation and Rivers Control Council compensate a runholder where the retirement of land represents a direct loss of profits.

2. That this compensation be based on a capitalised productive value of the retired land, or its equivalent by way of liberal subsidy.

3. That any payment of such compensation be conditional upon its reinvestment in the property.

Retirement and Fencing:

In addition to natural boundaries 150 miles of retirement fencing could be needed. At \$1,200 a mile the total cost could be in the order of \$180,000. The Soil Conservation and Rivers Control Council at present pays the total cost of a retirement fence. This Institute recommends that it should continue to do so.

Future Tenure:

It is suggested that when the higher altitude lands are retired, capability class I-VI farm lands in lowland and montane zones should be reclassified at Renewable Lease. This would have several advantages and be in keeping with Lands Department policy on other farm lands. Renewable Lease provides the opportunity to freehold, and this may be an attraction for farmers contemplating intensive development. By definition this land has a low erosion risk but if it were misused, the Soil Conservation and Rivers Control Council has the power to acquire it under the 1928 Public Works Act.

The retired VII and VIII land in the upper montane and alpine zones could either be reclassified as Unalienated Crown Land, or Pastoral Occupation Licence should the runholder want to retain a licence over it. This licence, however, would not include the right to grazing. During the transition from the extensive system of management to a more intensive one, it may be necessary to allow emergency grazing of the retired land. Such

use would have to be restricted to genuine emergencies, and as compensation would have been paid for this land, the Crown should charge a grazing rental.

This Institute therefore recommends:

1. That favourable consideration be given to reclassifying land up to, and including capability class VI in the lowland and montane farmlands as Renewable Lease, if requested by the runholder.

2. That in the event of freehold title being taken over the lowland and montane farmlands, access to the unoccupied Crown lands above shall be guaranteed.

3. That land classified as capability classes VII and VIII in the lowland and montane zones be reclassified as Pastoral Occupation Licence. The conditions under which it may be used for pastoral production are to be dependent on its condition.

4. That land capability classes VII and VIII in the upper montane and alpine zones be reclassified as Pastoral Occupation Licence, or Unoccupied Crown Land. Pastoral use of this area shall be restricted to grazing during the period of changing run management. On such occasions the Crown should have the right to demand a grazing rental.

Soil Conservation Subsidies:

The payment of lump sum compensation would reduce the need for some soil conservation subsidies, particularly those related to off site grazing.

This Institute therefore recommends:

That in view of the recommendations related to compensation the Soil Conservation and Rivers Control Council's conservation subsidy scheme be re-examined for properties in the Waimakariri catchment.

Economic appraisal of farm plans:

Runholders have two principal points of concern about intensive farming in a high country environment. The first "can it be done?" the second, "will it pay?" Before a runholder can be expected to forego the system he knows and trusts, every possible

effort must be made to predict his future position, in particular his financial position. It is possible that on some properties, conservation practices may be only marginally profitable for the runholder. In such cases special attention must be given to the level of subsidy support. This support should be based on the costs and returns to the farmer of practices which are considered to be of community benefit.

This Institute therefore recommends:

1. That Catchment Board farm plans be costed and budgeted as accurately as possible.

2. That where a change in the management system is required for the purposes of soil and water conservation and the profitability of the new system appears doubtful, the Soil Conservation and Rivers Control Council give special consideration to the level of subsidy support.

Demonstration of farm and run practices:

It has been suggested that in future the pastoral use of the catchment will involve intensive farming of the lowlands and montane zones. However it must be emphasised that the success of this system has not been demonstrated on a run scale. There is a wide gap between research findings and run practices. It is suggested that the Departments of Lands and Agriculture, the Soil Conservation and River Control Council and this Institute should initiate run or large paddock demonstrations of high country development. Some of the practices and techniques which should be investigated for their economics and feasibility include: winter feeding, optimum paddock size, use of insecticides, pasture conservation, weed control and the place of cattle.

Leasing authorities:

At present there are six authorities which lease land in the catchment. If the recommendations of the report are to be adopted it will be desirable to have as few leasing authorities as possible. The New Zealand Forest Service, the Arthur's Pass National Park Board, the Selwyn Plantation Board, and the Railway's Department will be largely unaffected by the recommendations. The role of Canterbury University is not clear. For a number of reasons it is suggested that the University should dispose of its endowment lands in the Waimakariri catchment.

This Institute therefore recommends:

- 1. That the University of Canterbury be encouraged to dispose of its endowment lands in the Waimakariri catchment.**
- 2. That this Institute will support any request made to the Government, by the Lands Department, for additional funds to enable that Department to purchase these properties for the Crown.**

Boundary adjustments and subdivision:

The present boundaries are not necessarily those of the future. Where retirement threatens to leave an uneconomic unit reconsideration of the boundaries is essential. This should be done with regard to possible future subdivision. It is estimated that the present economic unit should be able to carry 4,000 sheep. It is suggested that in this difficult environment there should be a few strong units rather than a number of smaller ones.

Therefore this Institute recommends:

- 1. That where the retirement of land threatens to leave "undesirable" properties, or uneconomic units, the Lands Department in consultation with the North Canterbury Catchment Board, consider boundary adjustments.**
- 2. That such boundary adjustments should be made as part of a regional plan.**

Implementation:

The North Canterbury Catchment Board's conservation farm plan is the best method of implementing the pastoral use proposals outlined in the report. On the assumption that economic assessments will be made of the plans, this Institute reaffirms its support for the conservation farm plan.

Forest Land Use:

The technical economic and social implication of large scale forest use demand close scrutiny.

This Institute therefore recommends:

- 1. That Government be asked to undertake as soon as possible a detailed investigation of the possibilities of afforestation within the catchment.**

2. That the New Zealand Forest Service be asked to extend both their experimental and operational plantings in the production and protection forest zones.

Recreation:

The increasing demands on the area for recreation will be catered for by individuals, organisations and commercial firms. However, recreational facilities must be developed in an orderly manner to ensure that there is no deterioration in watershed or scenic values. The Institute therefore recommends:

1. That recreational use of the area be encouraged as long as it does not conflict with aims and objectives of soil conservation and rivers control, or pastoral use.

2. That all proposals concerned with recreation outside the Arthur's Pass National Park and Craigieburn Forest Park be approved by the North Canterbury Catchment Board, as well as other authorities.

3. That the local Country be asked to ensure that the standard and siting of all buildings be such that they do not detract from the beauty of the area.

4. That where areas of recreational value, or potential value, may become isolated, public access to such areas be provided.

5. RECOMMENDATIONS FOR RESEARCH

The recommendations for future land use have been made with incomplete knowledge. Research studies in four fields would allow future decisions on land use to be more complete.

Land use hydrology:

A major gap in our present knowledge is the influence of upper catchment management on downstream flooding and sediment movement. The recommendations for future land use have been made in the belief that sound management in the upper catchment will produce downstream benefits. While this may be true in a general way, there is no quantitative information to suggest the amount of benefit which can be obtained from a given treatment. Many studies, both in New Zealand and overseas have attempted to solve this problem. All have tended to fail, because they have lacked a satisfactory method of study. **It is therefore recommended that this Institute and the Agricultural Engineering Department of Lincoln College formulate a comprehensive method of stream flow prediction.**

The development of such a method will depend, to a large extent, on having adequate basic data about stream flow and catchment characteristics.

The Institute therefore recommends that the North Canterbury Catchment Board, Ministry of Works and New Zealand Forest Service should expand their present data collecting activities to provide more detailed information about the climate and stream flow of the catchment.

Economics:

The economic implications of changing the present systems of land use are largely unknown. Eight aspects of economic research were identified by Dr. R. E. Dils in 1965, and it is recommended that:

- 1. This Institute encourage all agencies concerned with the high country to extend their interests further into the field of economics.**
- 2. That this Institute appoint an economist to study *inter alia* the economic implications of changing the present pastoral system of land use.**

Revegetation:

Research into natural and artificial revegetation is needed to determine the nature of the treatments which should be applied to the retired lands.

Accordingly the Institute recommends:

1. That the New Zealand Forest Service Experiment Station be encouraged to continue and expand its present programme of condition and trend in the upper montane and alpine grasslands.

2. That the North Canterbury Catchment Board be encouraged to present results from the line transects and plot exclosures it has established, and that this work be continued in the future.

3. That this Institute concurrent with its studies on revegetation on eroded lands study condition and trend of the tussock grasslands.

Techniques of Agricultural Improvement:

Additional research is needed in the fields of fertilizers, soil productive capacities, winter pasture production and pasture establishment.

Accordingly it is recommended:

1. That the Department of Agriculture should expand its work in soil fertility studies and make available any such information currently held in files.

2. That the Department of Agriculture be encouraged to assess the productive capacities of each soil type found within the Waimakariri catchment.

3. That the Department also assess the costs of production so that the costs and benefits of production for each soil can be compared.

4. That the Grasslands Division of the Department of Scientific and Industrial Research be encouraged to study the problems of winter pasture and crop production in this type of environment.

5. That the Department of Agriculture make known the results of the pasture establishment, pasture species and manurial treatment trials at Broken River.

6. That field husbandry research requirements be reconsidered when the results of trial work at Broken River are known.

