The relative abundance, movement, and growth of rainbow trout (*Salmo gairdneri*) and brown trout (*Salmo trutta*) in the Rangitikei River New Zealand.

A thesis presented in partial fulfilment of the requirements for the degree of Master of Science with Honours in Zoology at Massey University.

Maurice Allan Rodway

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Abstract

The null hypothesis tested was that rainbow and brown trout populations do not move between naturally defined sections of the Rangitikei River. It was found to be true for adult brown trout but false for rainbow trout.

Recaptures of tagged brown trout demonstrated that the majority of these fish living in the mid-reaches do not make seasonal movements between river sections.

Brown trout dwelling in the lower reaches were smaller than mid-reach brown trout. This difference, and the lack of tag returns indicating movement between the two sections, supports the hypothesis.

Recaptures of tagged rainbow trout demonstrated that the majority of these fish migrating from the mid-reaches in autumn and winter travel to the headwaters where they remain the following summer. Those rainbow trout which were recaptured in the headwaters after moving from the mid-reaches tended to migrate earlier in the winter than those captured, then later recaptured, in the mid-reaches.

Similarities in the size of rainbow trout spawning migrants captured in the lower reaches and the mid-reaches suggested that both groups spent at least their second and third years in the same area of the river, but low numbers of tag returns meant that no firm conclusions regarding rainbow trout movement between the mid and lower reaches could be made.

Limited data concerning movement during the summer period suggested that some rainbow and brown trout move within sections but evidence of individuals remaining in one place for extended periods was found also.

Reported behaviour of both species of trout in response to

seasonal physiological changes and agonistic pressure, allied with stream bed morphology probably accounted for the observed distribution of young of the year, year one, year two and adult trout in the river.

Upstream migrating adults, of both species counted at two traps, were found to respond to fluctuations in water flow and were probably affected by moon phase so that migratory activity was saltatory. Rainbow trout tended to migrate earlier in the winter than brown trout. The movement of female brown trout followed the male brown trout migration but similar differences were not observed in the rainbow trout migrants.

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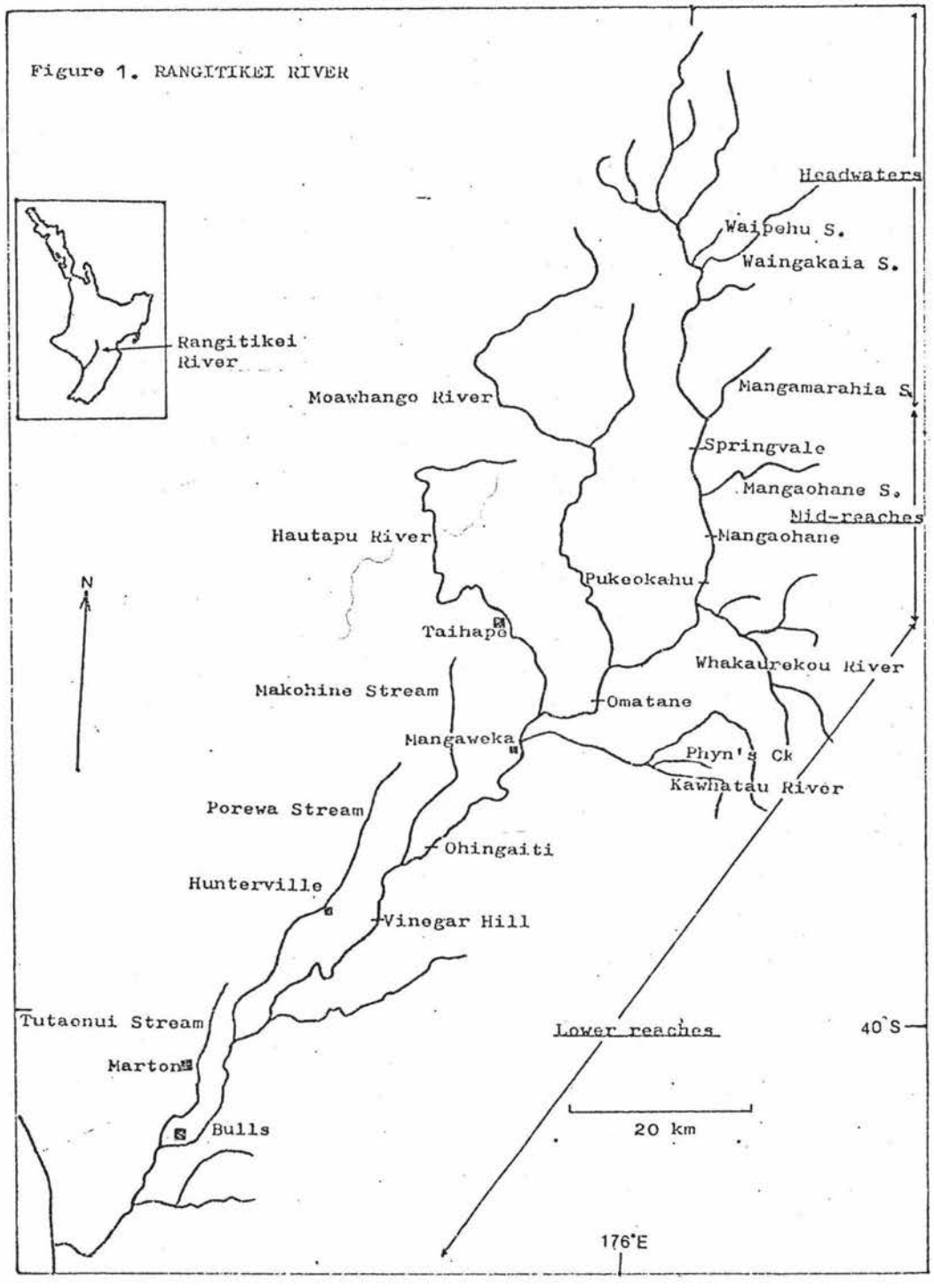


Figure 1. RANGITIKEI RIVER
Rangitikei River
Headwaters
Waipehu S.
Waingakaia S.
Mangamarahia S.
Moawhango River
Springvale
Mangaohane S.
Mid-reaches
Hautapu River
Mangaohane
Pukeokahu
N
Taihape
Whakaurekou River
Makohine Stream
Omatane
Mangaweka
Phyn's Ck
Kawhatau River
Porewa Stream
Ohingaiti
Hunterville
Vinegar Hill
Tutaenui Stream
Lower reaches
40°S
Marton
Bulls
20 km
176°E

1. Introduction

1.1 Physical Parameters

1.1.1 Location

The Rangitikei River (Figure 1) rises in the Kaimanawa Mountains, in the centre of the North Island, where it drains peaks such as Makorako (1727m), Waingakia (1623m) and Ngapuketura (1517m) and flows 241km to the sea at Tangimoana 40km south-east of Wanganui. It is the third longest North Island river and the fifth longest in New Zealand. The average flow of $88m^3$/sec. at Tangimoana rates it about sixth largest in the North Island (Tonkin and Taylor 1980).

Major tributaries from the east drain the Ruahine Ranges. These are the Whakaurekou, Kawhatau and Mangawhariki Rivers which drain peaks such as Remutupo (1545m), Tupori (1524m), Rangioteatua (1703), Ohuinga (1683), Mangahuia (1581m) and Mangaweka (1733m).

The longest tributaries entering from the West are the Moawhango, Hautapu and Porewa. The largest of them, the Moawhango, drains marshy ground in the Western Kaimanawas which is a Defence Reserve. Since 1980 a power development scheme has diverted 62% of the Moawhango water out of the catchment, reducing the mean flow of the Rangitikei below the Moawhango confluence by 13% (Tonkin and Taylor 1980). The Hautapu and Porewa Rivers drain agricultural land.

1.1.2 Geology - Figure 2.

The Ruahine Ranges which comprise the west Rangitikei watershed are mountains of predominantly well-dissected Mesozoic sedimentary strata. There are many faults in the rocks and the whole range is a wedge shaped horst. During the rise of the horst in the late Tertiary and Quarternary, areas to the west and east sank. These depressions filled with thick sequences of sediments.

Geological Divisions

Mesozoic metamorphic schist

Pliocene marine sandstone and siltstone

Glacial aggradational gravel - upper quarternary

Kaimanawa Greywacke - Mesozoic

Ruahine Greywacke - Mesozoic

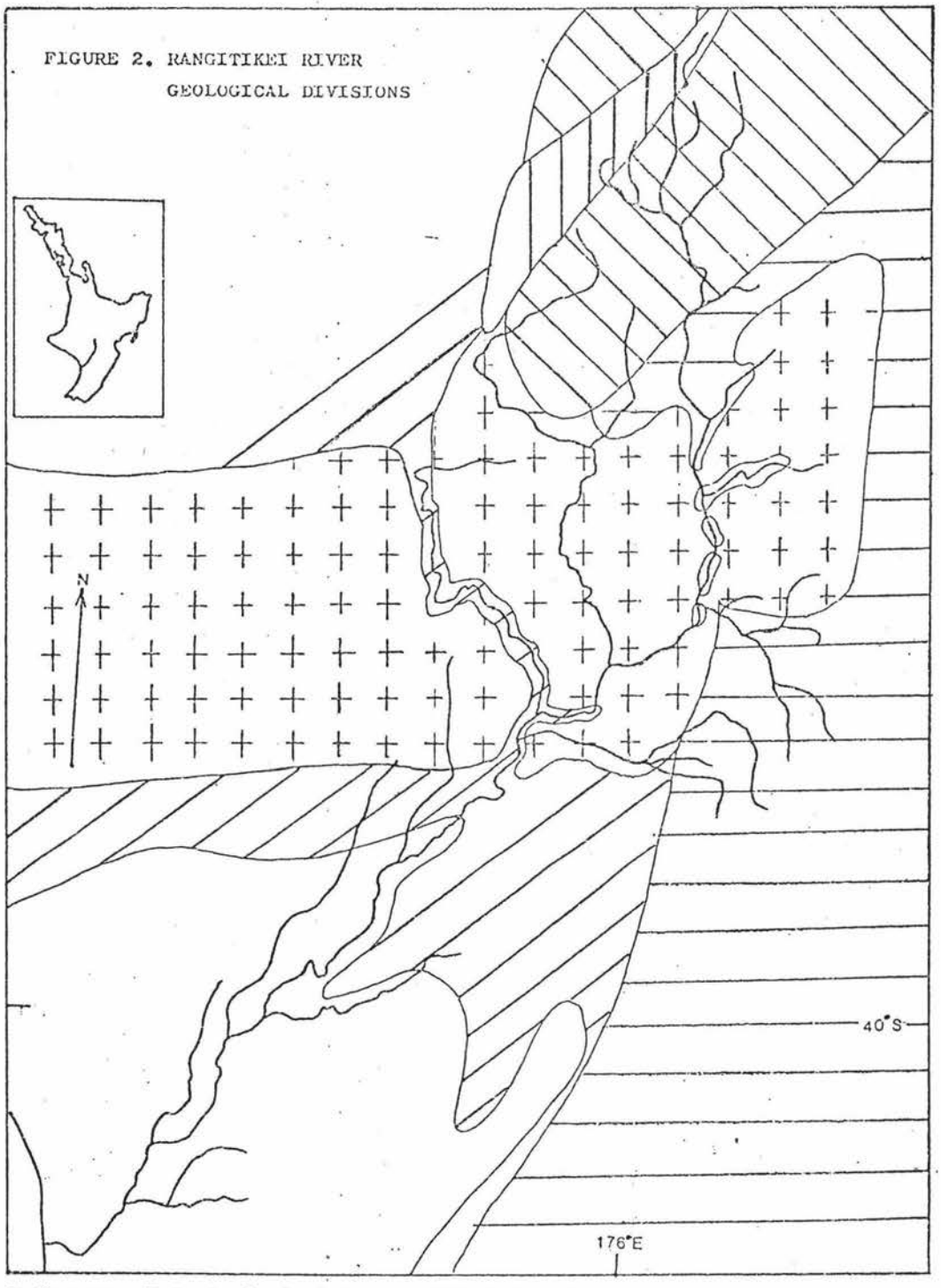


FIGURE 2. RANGITIKEI RIVER
GEOLOGICAL DIVISIONS

Reference: N.Z. Geological Survey 1972 D.S.I.R.

Rock types in the Ruahines and lowland areas vary from Jurassic greywacke - argillites and sandstones - found in the headwaters of the Mangawhariki, Pourangaki and Kawhatau to late Tertiary (Miocene) calcareous sandstones and siltstones in the Taihape area, marine fossiliferous sands and silts with their limestone horizons in the Hunterville area and non-marine undifferentiated sandy gravels, sands and silts in the river itself. In the Northern Ruahines, particularly in the Waikotore Stream watershed, Miocene coquina limestone is found, but in other tributaries of the Whakaurekou Jurassic greywacke, as is found further south, is predominant (New Zealand Geological Survey, Sheet 11).

The southern Kaimanawa ranges are composed of "Kaweka" greywacke, a Triassic-Jurassic dark grey argillite and redeposited sandstone. There are some volcanic bands, silts and limestones along with pumice tuffs in this area. Farther north in the mainstream headwaters the rocks are older - Permian-Triassic dark grey argillite and redeposited sandstone known as Kaimanawa greywacke. There is a small amount of Permian schist which shows strong cataclastic deformation. It is found mainly in the Moawhango watershed. There are a few pockets of grey brown quartzone ignimbrite of early Quarternary age - mainly in the Mangamaire River (New Zealand Geological Survey, Sheet 8).

Soils overlying these geological structures range from sandy Waitarere soils near the coast to loess derived soils inland to Hunterville, and volcanic types where the river drains the central North Island plateau (Tonkin and Taylor 1980) (Figure 3).

1.1.3 Run-off

A dendritic drainage pattern characterises the mid and upper reaches of the river. In the headwaters the river is deeply entrenched into the greywacke. While the slopes in the unit cells are steep the eroding ability of

Figure 3

1. Yellow-brown pumice soils, Urewera - Kaweka steepland

2. Central yellow-brown loams, Ohakune - Pokaka

3. Central yellow-brown earths, Wairama - Mangatea

4. Central yellow-grey earths, Taihape - Turakina steepland

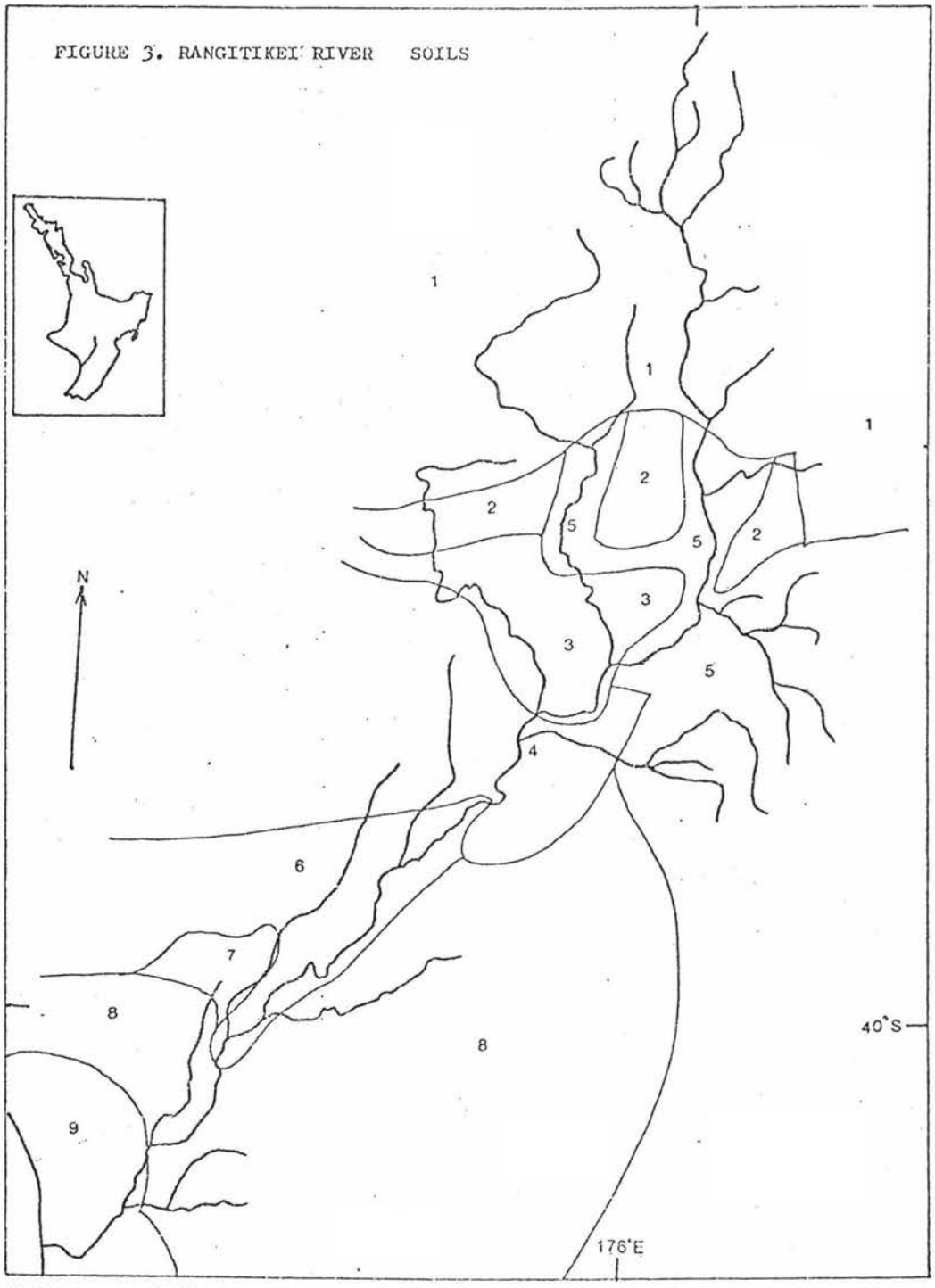
5. Central yellow-brown earths, Raukuaiora - Rimutaka steepland

6. Central yellow-grey earths, Halcome - Raumai

7. Central yellow-brown earths, Atua - Mangaweka

8. Central yellow-brown earths, Tokomaru - Marton

9. Central yellow-brown sands, Foxton - Pukepuke - Carnarvon.



Reference: Soil Map of New Zealand D.S.I.R. 1963

overland flow is low because of the surface resistance offered by the well developed vegetation cover in the area. In addition in many areas immediately adjacent to the river the slope angle approaches the vertical, lessening the overland flow. A combination of these factors, based on the resistant nature of the greywacke in the headwaters, results in a low sediment yield in the river at Springvale. No measurements have been made here and this assumption is based on calculations for the Moawhango and the characteristically clear flow of the river at Springvale (Tonkin and Taylor 1980).

The Ruahine tributaries are implicated in the increased bed load and sediment yield at Mangaweka which has an average of 3130 tonnes/day (Tonkin and Taylor 1980). The catchment area at Mangaweka is 2787km^2 and includes all the major tributaries. Heavy rainfalls, steeper gradient and more actively faulted rock in the Ruahines contribute to increases in bed load and sediment in the streams there.

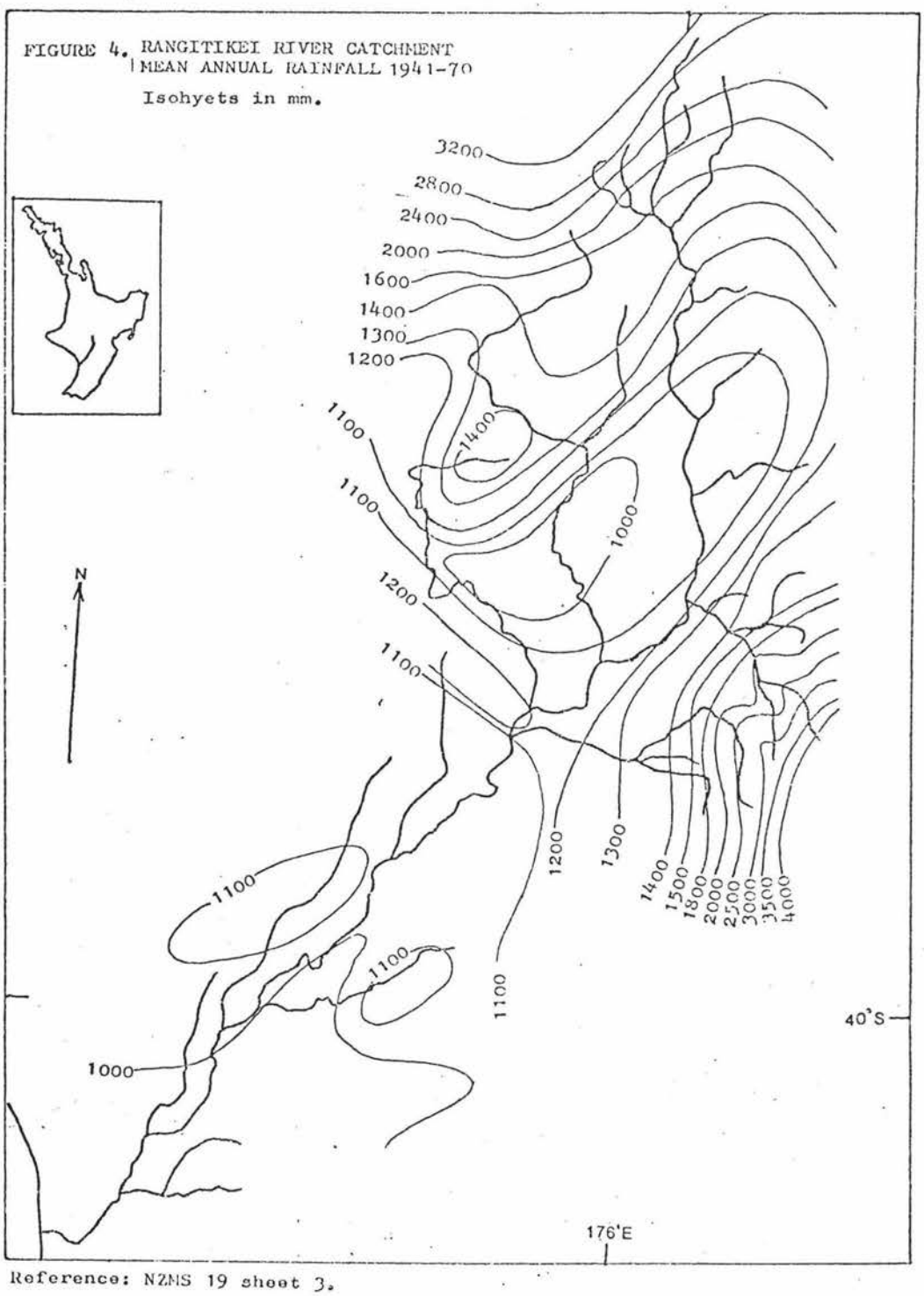
1.1.4 Precipitation

Greatest precipitation in the Rangitikei catchment occurs in the headwaters of the Kawhatau and Whakaurekou Rivers where > 4000mm per year falls. Kaimanawa headwaters receive up to 3000mm and the amount received in the catchment falls coastwards to below Marton where less than 1000mm of rainfall occurs each year (Figure 4).

Rain falls least from January to April and often in September while June and December are often the wettest months (Tonkin and Taylor 1980).

1.1.5 Mean Flows

At Springvale the mean flow is 19.8m^3/sec., at Mangaweka it is 62m^3/sec. and at Kakariki (near Bulls) it is 75.2m^3/sec. (Tonkin and Taylor 1980).



Reference: NZMS 19 sheet 3.

1.1.6 Low Flows

Seven day low flows of 15.2m^3|sec. at Kakariki can be expected every 2.33 years (15.2m^3|sec. is the average annual low flow). Seven day low flows of 4.2m^3|sec. and 13.4m^3|sec. at Springvale and Mangaweka respectively are expected each 2.33 years also (Tonkin and Taylor 1980).

1.1.7 Flood Flows

The largest flood ever recorded on the Rangitikei occurred in 1987 and is estimated to have been 3800m^3|sec. Flood flows with return periods of 2.33, 10, 50 and 100 years are 830, 1290, 1750, and 1940m^3|sec. respectively (Tonkin and Taylor 1980).

1.1.8 Oxygen, pH, Coliforms and Salts

The headwaters and mid-reaches are characterised by high quality water:- Oxygen saturation, slight alkalinity, low dissolved salts and few faecal coliforms. There are minute but detectable amounts of Aluminium, Boron, Calcium, Cobalt, Chromium, Copper, Iron, Magnesium, Manganese, Molybdenum, Nickel, Phosphorous, Lead, Sulphur, Selenium, Tin, Strontium, and Zinc in the water at Springvale. Concentrations of Sodium and Calcium are slightly higher with Calcium being the most abundant at 3.8499mg| 1 $\pm$ 0.4%. The only increases detectable at Bulls are in concentrations of Sulphur (1.8140mg| 1 $\pm$ 0.3%), Sodium (4.6794mg| 1 $\pm$ 0.2%), Magnesium (2.1291mg | 1 $\pm$ 0.3%) and Calcium (13.350mg| 1 $\pm$ 0.8%). (Samples collected 17 December 1982 and analysed at the Department of Scientific and Industrial Research, Palmerston North, on 22 December 1982).

Slight increases in coliform levels occur below the Hautapu and Moawhango confluence. Inputs from the Kawhatau and Whakaurekou Rivers at normal flows tend to increase the water quality by diluting the bacterial load but at high flows turbidity in the form of suspended solids and bed load is increased by these rivers. Lower tributary inflows tend to be high in faecal coliform levels and dissolved salts but because they

are small in relation to the main flow they have a minor impact on the river.

There is a general change in water quality (increase in temperature, faecal coliforms and dissolved salts) downstream but dissolved oxygen levels remain close to 100 percent saturation. These parameters exhibit greater variability downstream because of increased bacterial and nutrient loading from the developed catchment. Increased nutrient availability leads to greater algal growth - when combined with stable flows - and subsequent entrapment of inorganic suspended sediment. The products of photosynthesis and respiration (oxygen and carbon dioxide) and the use of these gases by algae results in a diurnal fluctuation of dissolved oxygen and pH.

1.1.9 Temperature

Greatest fluctuations occur in the area from Kakariki downstream where they may be as much as 20°C annually (5.2 - 25.3°C, Tonkin and Taylor 1980). In the mid and upper reaches temperatures reach at least 22°C (recorded at Springvale on 8 January 1984 at 1300 hours). In the winter in the Kaimanawa reaches 2°C has been recorded in the mainstream (Wildlife Service Drift Dive Survey June 1983). At Springvale in June and July 1983 when a few recordings were made the water temperature ranged from 2°C - 4°C - temperature taken at 10-11 a.m. And see Fig 24 1984 Temperatures.

1.1.10 Catchment and riparian Vegetation

Areas of greatest elevation in the Rangitikei Catchment are characterised by alpine vegetation. The tree line occurs at about 1400m and above this the dominant plants are snow tussocks, the most widespread of these is Chionochloa pallens, the mid ribbed snow tussock. Herbs such as Ranunculus spp. and Celmisia spp. are found in these areas but the most browse-

resistant are dominant where ungulate and possum numbers are high. These plants include Aciphylla spp. and the less palatable Celmisias . Subalpine (1400 - 1430m) vegetation in the Ruahines is dominated by Olearia colensoi, particularly in the south, and Dracophyllum recurvum.

Forest vegetation occurs from 1400m down to about 1000m in the Kaimanawas where scrublands occur. Much of this vegetation has been modified by fire, caused by volcanic activity and forest clearance by human settlers. Patches of forest occur well below 1000m but much ungrazed land is now dominated by manuka (Leptospermum scoparium) and kanuka (L. ericoides).

The forest in the northern part of the Kaimanawas is pure mountain beech (Nothofagus solandri var. cliffortoides) with local understories of kamahi (Weinmania racemosa) and broadleaf (Griselinia littoralis), but in general there is a complete lack of other tree species.

Red beech (Nothofagus fusca) is found at lower altitudes in the forest zone. Bordering the river from Springvale to the Mangamaire River are dense stands of manuka and kanuka interspersed with beech, totara (Podocarpus totara) and a thick understory of mingimingi (Cyathodes spp.).

Ruahine forest is more varied than that of the Kaimanawas with highland softwood and beech mixtures occurring above the altitudinal limit of rimu (Dacridium cupressium) and pure beech associations in many areas. In the Waimaka and Kawhatau headwaters mountain beech is dominant with locally frequent Libocedrus spp. and understories of Phyllocladus alpinus Dacrydium biforme and Griselinia littoralis (Nichols 1970).

Agricultural development in the Rangitikei from Springvale downstream has altered the dominant riparian vegetation to introduced pasture grasses and discontinuous stands of totara and kowhai (Sophora spp.). The same applies to the main tributaries

in the east - the Hautapu and the Moawhango, both having denser riparian cover than the main stream. Western tributaries, from Mangaweka upstream, flow from the Ruahine type vegetation through more open shingle riverbeds to the main river.

Willows (Salix spp.) are the dominant riverbank flora in the main river from Mangaweka to the sea. They are ubiquitous in the lower tributaries also.

Extensive areas of lupin (Lupinus sp.) and broom (Cytisus scoparius) occur in the shingle and sand of the large western tributaries and the main river downstream of these.

1.1.11 Aquatic Flora

Macrophytes are uncommon in most of the river. Filamentous green algae, stalked diatoms, and colonial blue-green algae occur in the main river. The green alga Ulothrix zonata is seasonally abundant and flourishes at times of low flow even in the cold mid-reaches in winter. Other filamentous algae such as Spirogyra grow abundantly in low flow summer periods in the lower and mid-reaches (B. Hicks, pers.comm.).

1.2 The Trout

1.2.1 Introduction of Stocks - refer also to the Appendix

1.2.1.1 Brown Trout (Salmo trutta)

According to Wellington Acclimatisation Society records, the first brown trout were introduced into the Rangitikei in 1887 when 50 "Lochleven" trout were liberated. While these trout were not recognised as brown trout at that time, taxonomists now consider these and many other local races or ecotypes to be one species (S. trutta) (Frost and Brown 1967, Stokell 1955). The first importations of brown trout to New Zealand came from the River Itchen, Bishopstoke, England. These fish were

brought as eggs to Tasmania in 1864 where the fish became established (Scott. 1964). The Canterbury Acclimatisation Society first introduced trout from these stocks in 1867 when 800 ova were obtained. Until 1874 other South Island Societies imported trout from the same stock and successful liberations were made, at least by the Otago and Canterbury Societies (Scott 1964). In 1883 the Wellington Society imported Lochleven trout which they raised successfully and liberated in "great quantities" (Stokell 1955). The Wellington Society maintained rearing ponds at Masterton and distributed trout to the Hawke's Bay Acclimatisation Society and Feilding Acclimatisation Society who liberated trout into the Rangitikei.

Sea trout - also S.trutta - were imported from the River Tweed and Hodder in Britain in 1868 and the early 1870s by the Otago, Southland and Canterbury Acclimatisation Societies. These fish became established in the southeast of the South Island (Scott 1964). The Wellington Society probably liberated sea trout into the Rangitikei, since from 1904 until 1919 sea trout were brought from the Opihi, and Temuka streams and Hakataramea hatchery.

The author of the "Pisciculture" section of the 1908 W.A.S. Annual report states: "The brown trout ova obtained from the Government Hatchery at Hakataramea was of most excellent quality, and coming from the magnificent sea run trout of the southern rivers, cannot fail to be a most beneficial change of blood". The Rangitikei received 585,000 of these fish (as fry) from 1906 to 1915. However, that these fish were sea trout is in dispute and the Wellington Society may have been correct when they called them sea-run brown trout since some members of mainly-river dwelling populations of brown trout migrate to and from the sea during their life (Scott 1964).

1.2.1.2 Rainbow Trout (S.gairdneri)

The first importations of rainbow trout to New Zealand

were made by the Auckland Acclimatisation Society (A.A.S.) who imported live rainbow trout ova from Sonoma Creek, a tributary to San Francisco Bay, California (Scott et al. 1978). The basis of New Zealand's rainbow trout stocks have been derived from 22,000 ova imported in March and April 1983. At the time they were believed to be brook charr (Salvelinus fontinalis) but by 1886 when they had matured it was realised they were S. gairdneri. The trout are of a migratory ecotype known on the West Coast of North America as steelhead.

In New Zealand these trout became established as self maintaining populations in the lakes of the Central North Island rather more rapidly than in the rivers of the country. The first record of rainbow trout being distributed to the Rangitikei River area was on 18 September 1899 when W.C. Birch of Moawhango received 1500 fry. On 7 October of that same year the Marton sub-committee of the W.A.S. received 1000 rainbow trout fry. Stokell (1955) observed of rainbow trout that "the fish has shown no evidence of ability to maintain itself permanently in streams". This was also noted in the 1920 Annual report of the W.A.S. despite good catches in the Rangitikei in 1914 and 1915. However in 1926 the Society reported that the Moawhango was "teeming with small rainbows", indicating that considerable natural reproduction was occurring. Rainbow trout liberations of fish purchased from Turangi and Rotorua continued until 1978 and at present a self sustaining population occurs in the river and several tributaries.