SECTION 5

UNDERSTANDING ALPINE ENVIRONMENTS – BACKGROUND INFORMATION FOR TEACHERS AND SENIOR STUDENTS

Soda Springs. Creeping clubmoss. *Photos: Alan Cressler*

The information in this section is intended to support learning investigations into alpine environments and activities when visiting alpine areas. It has been split into sections about ecology, geology, geography and sustainability as a means of separating topics, but each section has information valuable to all teachers and learners.

ECOLOGY

Biodiversity within the alpine zones

The alpine zone can be divided into three subzones, based on declining temperature and increased exposure with increasing altitude upwards from the treeline. These zones are home to many well adapted plants and animals, including birds (e.g. rock wren, kea, pipit, takahē, great spotted kiwi), lizards (e.g. skinks and geckos) and many different invertebrates (e.g. wētā, grasshoppers, giant snails, moths and butterflies, spiders, cicada and beetles).

The treeline cut-off occurs at about 900 metres in Southland and about 1450 metres in the north.


Low alpine zone

The low alpine zone

This begins immediately above the treeline with a band of alpine scrub, including a few tall snow tussocks and herbs.


Mid alpine zone

The mid alpine zone

This zone is dominated by snow tussocks from the *Chionochloa* (pronounced Ki-on-no-clo-ah) family. Tussocks provide shelter for tiny plants and animals adapted to the alpine temperature extremes.

The high alpine zone

This zone comprises mainly fellfield, ice and snowfields home to small clumps of hardy, prostrate plants that have adapted to the harsh environment.


High alpine zone
Photos: M McDonald

> ***Activity idea***
> To explore these alpine zones further and research different alpine areas in New Zealand, see the learning activity **Home and expert** on page 7 in Section 2.

Adapting to an alpine environment

Distribution of plant species across the three alpine zones depends on their physiological tolerance and interspecific (species–species) competition. Success in outcompeting other species for space, light or water resources relies on specialised plant adaptations and each alpine species employs a specific strategy to gain these essential components.

Access to pollinators and seed dispersers is also essential for them to successfully reproduce. Reproductive strategies often result in reciprocal exchanges between plants and animals or plants and invertebrates.

For more information about alpine plants, see www.doc.govt.nz/conservation-revealed

For more information and examples of plant and animal adaptations and relationships, go to www.nzgeo.com/stories/heads-in-the-clouds

Activity idea

Use the **Home and expert** activity on page 7 in Section 2, to explore these concepts further.

The following article is an example of scientific literature that can be used during the activity by senior students to start their analysis. It includes information on changes in the distribution of tussock over time, associated invertebrate communities, water production and erosion control.

Mark, A.F.; Barratt, B.I.P.; Weeks, E. 2013: Ecosystem services in New Zealand's indigenous tussock grasslands: conditions and trends. Pp. 1–33 in Dymond, J.R. (Ed): Ecosystem services in New Zealand – conditions and trends. Manaaki Whenua Press, Lincoln, New Zealand. Available at www.landcareresearch.co.nz/__data/assets/pdf_file/0007/77029/1_1_Mark.pdf

Species spotlight

The table on pages 4–5 outlines some key plants and animals across the three alpine zones, where they are found in New Zealand and their key adaptations or specific strategies for survival in alpine environments.

For more information on alpine species, see:

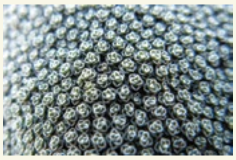
- **Alpine plants:** teara.govt.nz/en/alpine-plants and teara.govt.nz/en/diagram/11043/main-alpine-plants-in-new-zealand
- **Alpine insects:** teara.govt.nz/en/insects-overview/page-9
- **Alpine animals:** teara.govt.nz/en/mountains/page-4

Table of key alpine environment plants and animals and their adaptations

	Species photo	Species name	Key characteristic	Adaptation and outcome
LOW ALPINE ZONE		Mountain snowberry (*Gaultheria depressa*) *Photo: K Hartle*	A prostrate, spreading evergreen shrub (20–30 cm across). Edible white, pink and red berries, 3–4 mm across, that appear January to April. LINK TO MORE INFO: www.terrain.net.nz/friends-of-te-henui-group/plants-native-botanical-names-g-to-l/snowberry-gaultheria-depressa-var-novae-zelandiae.html	• Leaves are thick and leathery, 5–10mm long on very short petioles, for protection against wind and water loss. • Flowers November to February, taking advantage of a productive summer season for pollination.
		Alpine scree wētā (*Deinacrida connectens*) *Photo: M McDonald*	• Found on scree slopes between 1200 m and 3600 m above sea level. • Coloured to match the rock type of the scree in which it lives. LINK TO MORE INFO: ento-ecol.blogspot.co.nz/2013/05/alpine-scree-weta.html	• Often coloured to match the rock type – form of camouflage. • Wētā have a mutualistic relationship with fruiting plants where they disperse seeds by eating berries as food. Larger wētā can eat and disperse seeds to greater distances.
		Speargrass (*Aciphylla squarrosa*) *Photo: K Weston*	• Part of the carrot family. • Long-lived. • Separate male and female plants. • Form a dense cluster of spiky narrow, blue-green leaves. • Pungent tips up to 1 m high. LINK TO MORE INFO: www.terrain.net.nz/friends-of-te-henui-group/new-plant-page/aciphylla-squarrosa-common-speargrass.html	• Easy access, sweet-scented yellow flowers grow from November to January, taking advantage of a productive summer season for pollination. • Stalks covered in razor-sharp spears, as defence against animal consumption. • They can withstand temperatures down to -28° C, adapted to the severe alpine environment.
		Speargrass weevils (Genus: *Lyperobius*) *Photo: M McDonald*	• Seventeen species of *Lyperobius* in the South Island mountains. • Flightless. • Commonly black and white. • Dependent on speargrass. LINK TO MORE INFO: https://www.teara.govt.nz/en/insects-overview/page-9	• Larvae tunnel inside the taproot of speargrass – for protection from predation and the severe environment. • Adults eat and digest speargrass – they are adapted to consume tough alpine plant.
		Pipit/pīhoihoi (*Anthus novaeseelandiae*) *Photo: A Walmsley*	• Slender, small- to medium-sized birds. • Songbirds. • Predominantly streaked grey-brown above and white below. • Habitats range from alpine to sea level. LINK TO MORE INFO: http://nzbirdsonline.org.nz/species/new-zealand-pipit	• New Zealand pipits breed between August and March, taking advantage of warmer spring and summer conditions. • The nest is a sizable cup of woven grass under tussocks, which act as protection for chicks. • Able to adapt foraging methods to a wide range of prey, with a plentiful food source across many habitats and in harsh alpine environments.

MID ALPINE ZONE		Mountain daisy/ pekapeka (*Celmisia gracilenta)* *Photo: M McDonald*	• Most common plants in the alpine zone. • Upper surface of leaves are green with a silvery pellicle. • Underside of the leaves are covered in white felt-like tomentum. • Funnel shaped flower heads (>3 cm wide). LINKS TO MORE INFO: www.terrain.net.nz/friends-of-te-henui-group/new-plant-page/celmisia-gracilenta-common-mountain-daisy.html http://naturewatch.org.nz/taxa/400575-Celmisia-gracilenta	• Flower in December and January – taking advantage of a productive summer season. • White felt-like tomentum – protects against wind and ultra violet radiation and reduces transpiration.
		Alpine grasshopper (*Sigaus villosus*) *Photo: M McDonald*	• Highest living grasshopper. • Grey and covered in short hair. • Females twice as big as males. • Flightless. LINKS TO MORE INFO: www.teara.govt.nz/en/insects-overview/page-9 wetageta.massey.ac.nz/Text%20files/Grasshopper%20diversity.html	• Grey and short haired, camouflaged against rocky habitat. • Can float in water, for safety from drowning and land predation. • Long hind legs work like ski poles in snow. • Able to survive winter at all life stages, adapted to severe alpine environment.
		Tussock (Family: *Chionochloa*) *Photo: K Hartle*	• Dominant plant in this zone. • 14 species in the high country. LINKS TO MORE INFO: www.doc.govt.nz/conservation-revealed www.doc.govt.nz/documents/conservation/native-plants/tussock-factsheet.pdf	• Wind pollinated and wind dispersed, for effective dispersal of seeds in alpine environment. • Can survive long periods buried under snow as most of the plant is underground, well adapted to cold alpine environment. • Tussocks provide shelter for tiny plants and animals adapted to the alpine temperature extremes, which aids pollination.
		Alpine stick insect (*Niveaphasma annulata*) *Photo: M McDonald*	• Can survive being frozen. • Grey or brown in colour with distinct flanges and lobes on the body and legs. • Some populations reproduce asexually (parthenogenetic). LINKS TO MORE INFO: www.landcareresearch.co.nz/science/plants-animals-fungi/animals/invertebrates/systematics/phasmatodea/classification/niveaphasma www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11891316	• Can survive ice forming in their tissue by producing ice-nucleating agents in their extracellular body fluid – adaptation to severe alpine environments. • Grey or brown – camouflage.

HIGH ALPINE ZONE

	Genus: *Raoulia* *Photo: M McDonald*	• Highly compressed shrubs. • Multiple branches. • Tightly packed rosettes of tiny, grey woolly leaves. • Cushion shape. • Hard, continuous surface. LINKS TO MORE INFO: www.teara.govt.nz/en/alpine-plants/page-3	• Cushion shape, protects from weight of snow. • Cushion shape, close to ground to avoid strong wind. • Hard continuous surface minimises water evaporation. • As cushion grows, the centre rots forming a spongy peat which recycles water and nutrients, efficiency in harsh climate. • Grey woolly leaves reflect sun rays, protection from radiation and heat. • Hairs on leaves catch water droplets from fog and low cloud, for efficient water collection in a dry climate.
	Wētā/mountain stone (*Hemideina maori*) *Photo: M McDonald*	• World's largest known insect tolerant of freezing. • Higher altitude colonies of wētā have larger bodies. • Females have long oviducts. • Males have larger heads than females. LINKS TO MORE INFO: www.terrain.net.nz/friends-of-te-henui-group/local-insects/weta-mountain-stone-hemideina-maori	• Can freeze solid during cold periods and survive due to ice nucleating agents in their haemolymph and guts, well adapted to freezing alpine conditions. • Eat grass and vegetation, a simple diet in harsh and minimal conditions.
	Black mountain ringlet butterfly (*Percnodaimon merula*) *Photo: M McDonald*	• Found from 800 to 2500 metres high. • Dark wings. • Little black-headed, spotted caterpillar. • Seen between November and March. • Pupa hang horizontally. LINKS TO MORE INFO: www.terrain.net.nz/friends-of-te-henui-group/local-butterflies-moths/black-mountain-ringlet-percnodaimon-merula.html	• Dark wings, which act as a solar panel. • Seen between November and March, using the short alpine summer to advantage. • Eggs are laid on the top of stones, rock warmth speeds up the development of the eggs. • Pupation stage: pupa hangs horizontally under a stone, an adaptation to take advantage of small protected spaces and use the rock's warmth for development. • Caterpillar stage, they eat their eggshells and tussock, are adapted to a minimal diet in a harsh climate.

Activity idea

To introduce/reinforce learning, and support further research about these species, use activities **Home and expert** on page 7 and **What am I?** on page 8 of Section 2.

Recognising the connections in an ecosystem

Alpine environments are a complex of interrelated and interdependent ecological systems making up an ecosystem. The health of the ecosystem relies on intact connectivity where no part of the ecosystem is disrupted. The diagram below describes the key complexities of the alpine ecosystem.

Figure 1 (right): The loop of influence from high alpine zones (minerals and silt) to low alpine zones (insects, bird and early succession colonising trees) is an important biological process in sustaining a full life cycle.

> *Activity idea*
>
> Use activity **Web of life** on page 9 of Section 2 to further explore connections in an ecosystem.

Alpine pests and threats

Introduced mammals

There is increasing evidence that predators (particularly stoats, possums and mice) are contributing to significant declines in alpine species. Many are now threatened with extinction, such as our only true alpine bird – the rock wren.

- http://www.doc.govt.nz/nature/habitats/alpine/
- http://predatorfreenz.org/stoat-research-not-squeamish/

Rock wren/pīwauwau.
Photo: L Whitwell

Hedgehogs are a threat to our endemic wētā, skinks and the eggs and chicks of ground-nesting birds. More information can be found here:

- www.doc.govt.nz/hedgehogs

Introduced herbivores such as goats, deer and rabbits may also be having an impact on the overall health of the habitat. More information can be found here:

- www.doc.govt.nz/feralgoats
- http://www.doc.govt.nz/Documents/conservation/threats-and-impacts/battle-for-our-birds-2017/battle-for-our-birds-brochure-2017.pdf]

Introduced plants

Heather was originally planted as a food source for introduced game birds like pheasant and grouse. It has since spread throughout alpine areas across New Zealand, smothering native species. It is extremely difficult to control but recent breakthroughs using biological controls like the heather beetle (*Lochmaea suturalis*) seem to be having an effect.

- www.doc.govt.nz/tongariro-pests-and-weeds

> ### *Activity idea*
> To investigate actions being taken to control heather in Tongariro, see activity **Choose your weapon** on page 9 of Section 2.

Climate change

As climate warms, ranges of treeline species are predicted to advance upslope. This will drastically reduce New Zealand's alpine areas and change distribution patterns.

- www.forestandbird.org.nz/saving-our-environment/climate-change
- alpineclub.org.nz/climate-change-in-mountain-environments-part-1/

> ### *Activity idea*
> To further consider the impacts of climate change, see activity **Consequence wheel** on page 6 of Section 2.

GEOLOGY

Understanding geology

The rocks found in New Zealand tell us the story of how this land was formed. The Earth is made up of different layers known as the inner and outer core, the mantle, and the crust. There are three major rock types found on Earth: sedimentary, igneous and metamorphic, based on the processes that form the rock.

For more information on each layer within our Earth, visit the Science Learning Hub 'Under the Earth's surface' page at www.sciencelearn.org.nz/resources/931-under-the-earth-s-surface

For detailed information on each of the rock types, visit the GNS page here: https://www.gns.cri.nz/Home/Learning/Science-Topics/NZ-Geology/Rock-Types

The Earth's outermost layers are divided into tectonic plates that fit together like a jigsaw puzzle. These plates move slowly against each other by between 0 mm and 100 mm per year, driven by convection of the underlying partially molten mantle.

There are three main types of tectonic plate movement:

1. Convergent boundaries: where two plates are colliding
2. Divergent boundaries: where two plates are moving apart
3. Transform boundaries: where two plates slide past each other.

Geological events such as earthquakes, volcanoes, mountain building and oceanic trenches are commonly associated with plate boundaries. The boundary around the Pacific Plate is known as the 'Ring of Fire' as it is the most active in the world, with 75% of the world's volcanoes.

For more information on tectonic plates and plate boundaries, visit the GNS page here:

www.gns.cri.nz/Home/Learning/Science-Topics/Earthquakes/Earthquakes-at-a-Plate-Boundary/Tectonic-Plates-and-Plate-Boundaries

Or alternatively, visit the Science Learning Hub page here:

www.sciencelearn.org.nz/resources/339-plate-tectonics

> ***Activity idea***
>
> You can use the activity **Shake, rattle and roll** on page 10 of Section 2 to explore these concepts further.

Geology of New Zealand

New Zealand comprises roughly 10% of the larger microcontinent, Zealandia, and is currently the only part that emerges from the Pacific Ocean.

A bathymetric map of New Zealand can be found on the NIWA website here:

www.niwa.co.nz/our-science/oceans/bathymetry

The geology of New Zealand comprises all three major rock types that range in age from 500 million years old (e.g. metamorphic and sedimentary basement rocks) to a few thousand years old (e.g. North Island volcanic rock). Alpine environments in New Zealand can comprise anything from geologically recent volcanic material (e.g. lava and ash of Tongariro or Ruapehu) to ancient metamorphosed sediments (e.g. schist and greywacke of the Southern Alps).

For more information on the geology of New Zealand visit the GNS website:

www.gns.cri.nz/Home/Learning/Science-Topics/NZ-Geology

> ***Activity idea***
>
> Encourage your students to learn more about different rock types on Earth by using the activity **What rocks what?** on page 10 of Section 2.

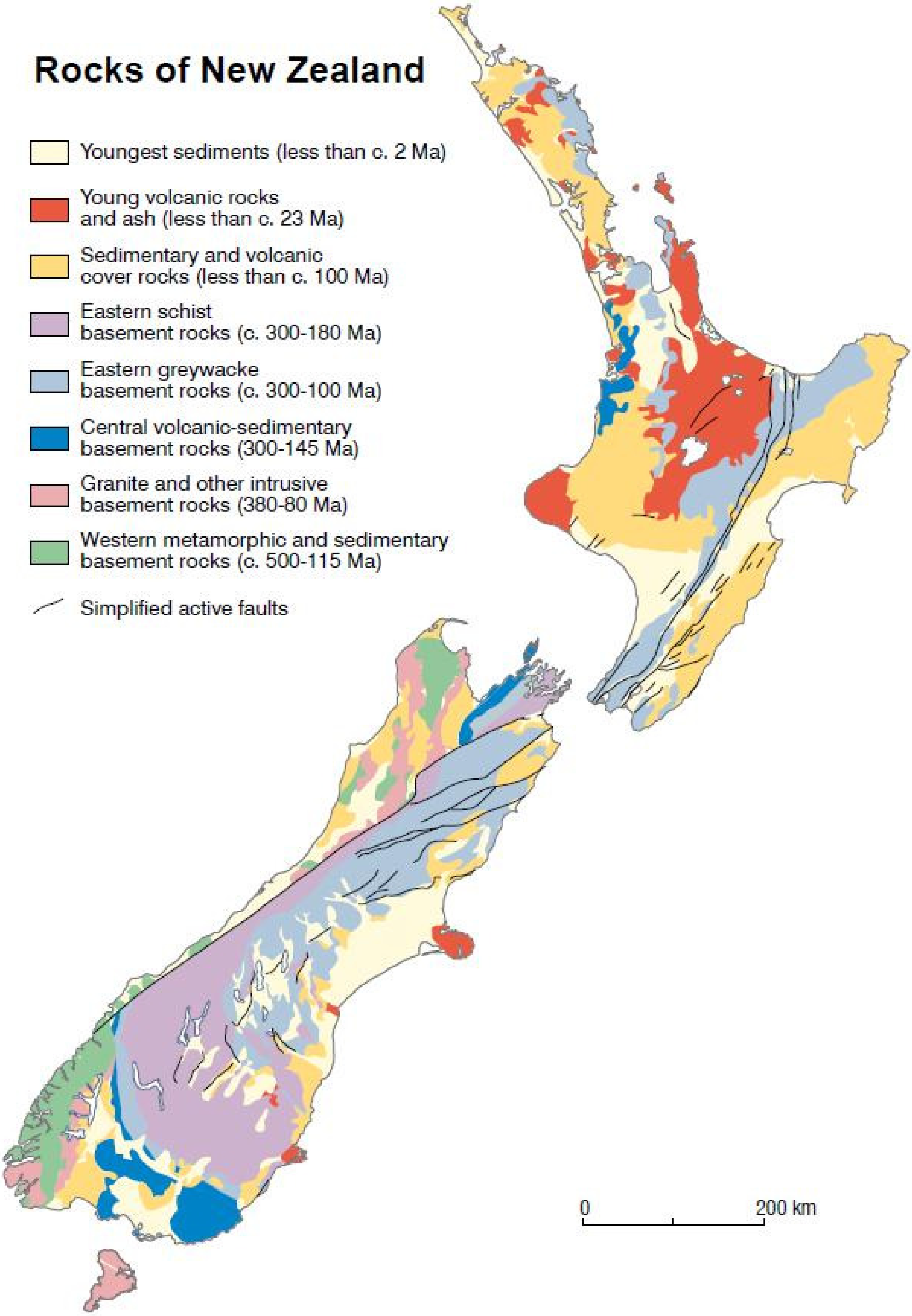


Figure 2: New Zealand geological map, GNS. Available at
www.gns.cri.nz/Home/Learning/Science-Topics/NZ-Geology/New-Zealand-s-Rocks.

Tectonic History of New Zealand – links to alpine environments

The Pacific and Australian tectonic plates meet below New Zealand forming a curved boundary. At the southern end of this boundary (lower South Island), the Australian Plate dives down (subducts) below the Pacific Plate. At the northern end of the boundary (North Island) the Pacific Plate subducts below the Australian Plate.

In the middle of the boundary (the land in between, most of the South Island) the two plates grind past each other along a series of faults, the most famous being the Alpine Fault.

New Zealand and the microcontinent Zealandia has had a varied tectonic history, detailed simply below.

More information on the plate collision under New Zealand can be found here: www.gns.cri.nz/Home/Learning/Science-Topics/Earthquakes/Earthquakes-at-a-Plate-Boundary/Plate-Collision-in-NZ

A brief tectonic history of New Zealand

65 Ma – Zealandia microcontinent splits from Gondwanaland through sea floor spreading (divergent boundary).

55 Ma – Zealandia is drifting slowly north-east.

40 Ma – Subduction begins in the north and some rifting in the south.

23 Ma – Subduction zone extends southwards.

20 Ma – Vigorous plate collision established (volcanism in North Island as a result).

10 Ma – Compression of New Zealand's landmass begins – forming the land we know today.

5 Ma – Uplift of the Southern Alps and erosion creates alpine environments in the South Island, e.g. Aoraki (Mt Cook) and Mt Aspiring.

2 Ma – Extension of northern volcanism forms Central North Island volcanoes.

Present – Sustained plate collision along alpine fault with subduction to the north and south.

(Note: Ma or mega-annum is a million years.)

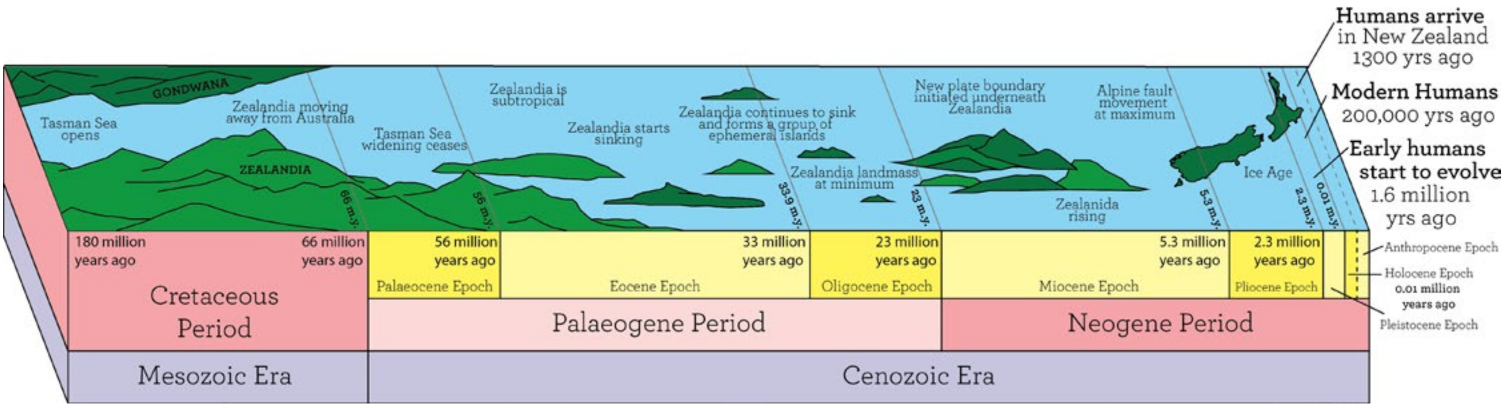


Figure 3: New Zealand on the move – the past 180 million years of change.

Volcanic history of New Zealand – links to alpine environments

New Zealand has a rich volcanic history dating back 35 million years to the Eocene-Oligocene boundary and active volcanism hasn't always just been in the North Island. Banks Peninsula and Dunedin are great examples of ancient volcanism that took place in the South Island. Many of these volcanoes, old and new, have created unique alpine environments across the country. See the link below for more information on New Zealand's volcanoes:

- www.sciencelearn.org.nz/image_maps/42-volcano-map-of-new-zealand
- www.sciencelearn.org.nz/image_maps/43-auckland-volcanic-field

Taupo Volcanic Zone and North Island Volcanic Plateau

The Taupo Volcanic Zone extends from Ruapehu in the south to Whakaari/White Island and the submarine Whakatane volcano in the north. Most of New Zealand's volcanism in the past 1.6 million years has occurred in the Taupo Volcanic Zone. It includes the young and active volcanoes, Ruapehu, Tongariro, Ngauruhoe and Whakaari/White Island as well as Okataina (Tarawera) and Taupo caldera (collapsed) volcanoes.

Looking wider, the Taupo Volcanic Zone forms the southernmost point of a large back-arc basin that extends from Ruapehu in the south to the Kermadec Islands in the north.

The North Island Plateau or **Volcanic Plateau** is the name given to New Zealand's central North Island because of its height above sea level (280 metres at Rotorua, rising to 370 metres at Taupo). The plateau has been largely created by volcanic eruptions.

Location is everything. The reason for the Taupo Volcanic Zone and North Island Plateau is New Zealand's location on the Pacific Ring of Fire.

Subduction of the Pacific Plate and the massive frictional forces and pressure related with that movement creates a great deal of heat that melts the subducting rock material. This molten rock is then able to move upwards through the crust across a series of fractures to the Earth's surface.

Mixing of water from hydrated minerals or ocean sediments as well as the addition of melting continental crust from around the molten rock creates the type of chemistry that produces the lava, andesite. Most of the volcanoes in the North Island Plateau are made up of andesitic material, including Tongariro, Ngauruhoe and Ruapehu, making it the most common rock in the park. Taupo volcano is an exception, instead producing rhyolitic material.

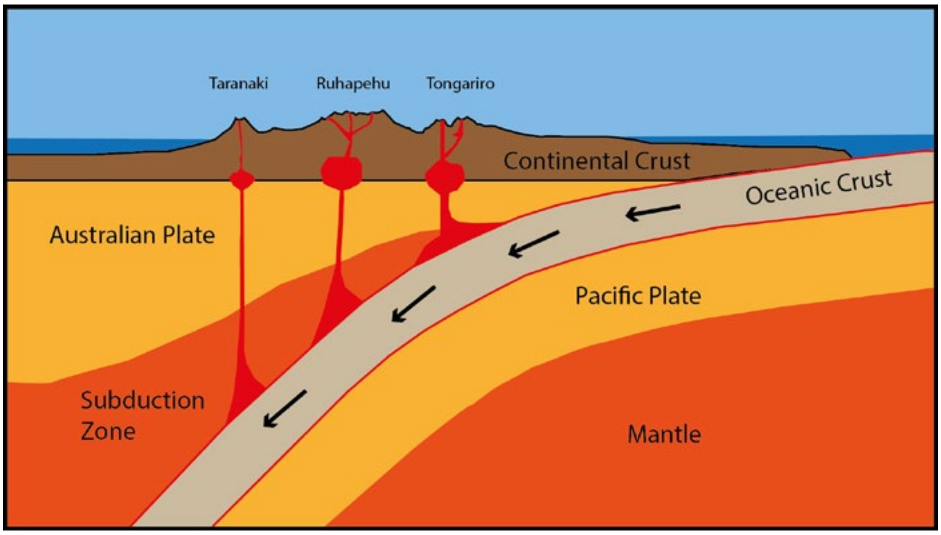


Figure 4: Subduction of the Pacific Plate underneath the Australian Plate creating molten material that rises to form the volcanoes on the North Island Plateau.

New Zealand volcano run down

There are three main types of volcanoes found in New Zealand, listed below:

Stratovolcanoes:

These are made up of alternating layers of tephra (ash, scoria, pumice, rocks) and andesite lava flows:

Tongariro dates back 275,000 years and has had at least 12 vents over its life.

Whakaari/White Island has been active for 150,000 years, is 70% under the sea and is currently New Zealand's most active volcano.

Taranaki began erupting 130,000 years ago and is one of the most symmetrical volcanic cones in the world.

Ruapehu is 10,000 years old and has had 3 summit craters, the most recently active of these being South Crater.

Ngauruhoe is the youngest cone on Tongariro at around 7,000 years old.

Caldera (collapsed) and dome volcanoes:

Taupo Volcano (or supervolcano), a large caldera now partially filled by Lake Taupo, began erupting about 300,000 years ago producing pyroclastic material (ash and rocks) and rhyolitic lava. Most recently, 1,800 years ago, this volcano produced the most violent known eruption on Earth in the past 5,000 years.

Tarawera Volcano is one of the dome volcanoes inside the Okataina Caldera and has been erupting for the last 18,000 years, most recently in 1886.

Volcanic fields:

The Auckland Volcanic Field has been active for roughly 250,000 years and has produced approximately 50 volcanoes, the most recent being Rangitoto in the Hauraki Gulf/Tīkapa Moana.

For more information on these volcanoes and others in New Zealand, download the excellent volcano fact sheets produced by GNS found here:
www.gns.cri.nz/Home/Learning/Science-Topics/Volcanoes/New-Zealand-Volcanoes.

- An excellent site for materials and video links that give specific information in relation to New Zealand's volcanoes and the Earth's structure, fault lines, and plate tectonics can be found on the Science Learning Hub website at:
  www.sciencelearn.org.nz/topics/volcanoes
- A short video outlining the major volcanic events in New Zealand's geological history is available on the Auckland Museum's website here:
  www.aucklandmuseum.com/whats-on/online-exhibitions/living-with-volcanoes/volcanic-forces
- The story of New Zealand's iconic Central North Island volcanoes can be found here:
  www.doc.govt.nz/parks-and-recreation/places-to-go/central-north-island/places/tongariro-national-park/about-tongariro-national-park/central-north-island-volcanoes

Activity idea

To get your students learning more about volcanoes, try the activity **Cut and paste volcanic information** on page 10 in Section 2.

When working in alpine environments it's important to prepare for and know how to respond to natural hazards. Check out the 'What's the Plan Stan' resources from the Ministry of Civil Defence and Emergency Planning at: www.whatstheplanstan.govt.nz

More links on safety preparedness can also be found in Section 4: Learning in Tongariro National Park.

Lahars

The term lahar is derived from the Indonesian language meaning a type of flow containing a mixture of water, rock debris, sand and silt originating from a volcano. Lahars pose a major volcanic hazard.

There are two types of lahars: 1) debris flows which are composed of more than 80% sediment (variety of block sizes) and a turbulent flow, and 2) hyper-concentrated flow composed of 60–80% sediment, ice grains and entrained snow and flows as a laminar sheet. Lahars are usually confined to gorges and stream channels where they scour and erode the channels further. They are characterised as dense and fast, known to carry large objects such as rocks, and remnants of buildings.

Lahar case study: Ruapehu and its lahars

Lahars on Ruapehu occur relatively often due to a range of factors. These include eruptions, collapse of crater rims, glacier burst, heavy rain (Keys, 2007) and snow and ice melt (Major and Newhall, 1989). Water is therefore an essential element to lahars (Neall et al., 1999), and most water on Ruapehu occurs in the Crater Lake as well as surrounding snow and ice and occasional heavy rain.

Lahar siren above Whakapapa Village. *Photo: K. Hartle*

Since 1945 there have been approximately 13 lahar episodes (between 1 and 30 individual lahars) on Ruapehu and many have not been associated with an eruption.

The Tangiwai disaster in 1953 occurred due to a dam-break producing a large lahar. **The 1995–96 eruptions** produced at least 30 lahars down the Whangaehu River as well as a build-up of sand and small boulders (tephra) around the crater rim up to 15 m thick. The lake outlet however was occupied by only a 7.5 m wall of tephra, which posed a high risk of failure when the lake rose. That eventually occurred in March 2007 forming a large lahar that flowed down the Whangaehu River. Fortunately, this was being monitored and people were warned beforehand resulting in no injuries.

References

Neall, V.E.; Houghton, B.F.; Cronin, S.J.; Donoghue, S.L.; Hodgson, K.A.; Johnston, D.M.; Lecointre, J.A.; Mitchell, A.R. 1999: Volcanic hazards at Ruapehu Volcano. Volcanic Hazards Information Series 8. Wellington: Ministry of Civil Defence. 30 p.

Lube, G.; Cronin, S. J.; Procter, J.N. 2009: Explaining the extreme mobility of volcanic ice-slurry flows, Ruapehu volcano, New Zealand. Geology 37 (1): 15–18.

Major, J. J.; Newhall, G. C. 1989: Snow and ice perturbation during historical volcanic eruptions and the formation of lahars and floods. Bulletin of Volcanology 52 (1): 1–27.

Keys, H.J.R. 2007: Lahars of Ruapehu Volcano, New Zealand: risk mitigation. Annals of Glaciology 45 (1): 155–162.

GEOGRAPHY

Physical geography

Weathering and erosion

Tectonic forces and volcanic activity have created mountains and these are continuously bombarded by weathering and erosion. What can be seen in New Zealand's alpine regions today is the result of several thousand years of weathering and erosion. For more information on mountain erosion visit:

- www.gns.cri.nz/Home/Learning/Science-Topics/Landforms/Mountains-and-Uplift

The mountains' effect on weather

The following diagram explains the effect mountain ranges have on weather patterns and therefore on the mountain and surrounding landscapes.

For more information, see:

- www.doc.govt.nz/tongariro-weather

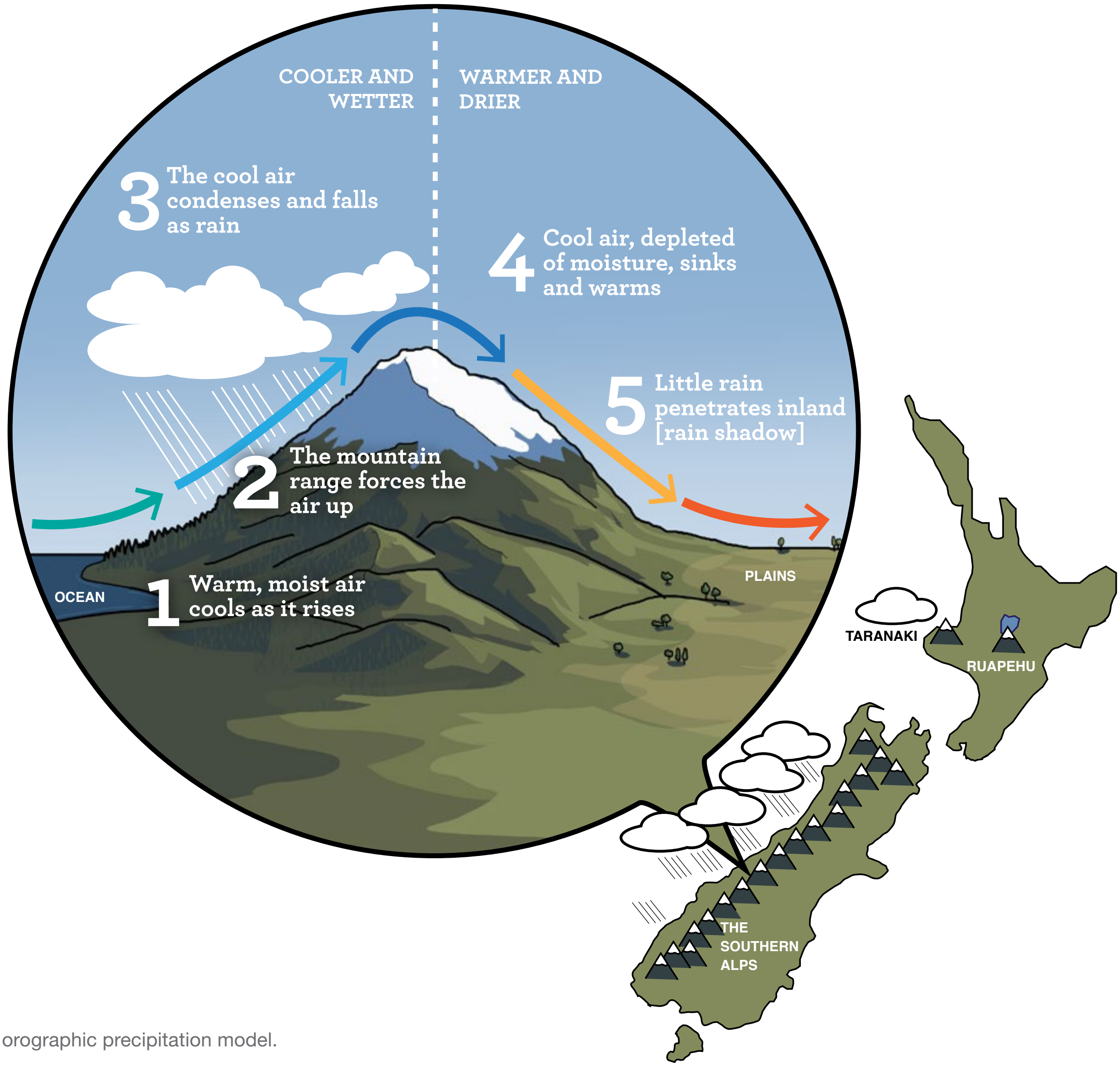


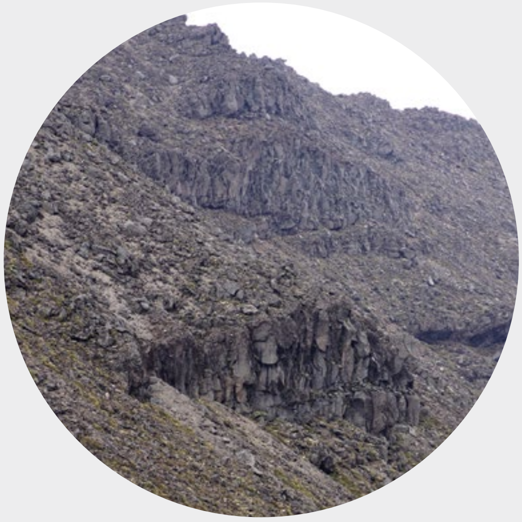
Figure 5: The orographic precipitation model.

Case study: Weathering and erosion on Ruapehu and Tongariro

Weathering (rain, wind and temperature), erosion, earthquakes and excavating lahars on the slopes of Ruapehu and Tongariro have produced a unique landscape and exposed the many surfaces and colours of continually eroding layers of ash, blocks and lava.

Now retreated glaciers from past ice ages have moved large quantities of rock down the mountains, leaving fields of rock and distinctive valleys. The elevation of Ruapehu means this glacial action is still occurring, actively shifting rock down the mountain.

Rocks found on Ruapehu and Tongariro from different eruptions are providing homes for plants that can be seen colonising the rocks. The roots of these plants break down the rock, turning it to soil which adds to the weathering and erosion story. Future eruptions will continue this cycle of burial, plant colonisation, weathering, erosion and exposure making this a harsh and incredibly dynamic landscape to call home.



Weathered surface on Tongariro from Iwikau Village car park. *Photo: K. Hartle*

Human geography

Tourism

A strong link has developed between people enjoying the outdoors and those seeking its protection. DOC is the government agency tasked with conserving New Zealand's natural and historic heritage.

The Department of Conservation Visitor Strategy recognises seven distinct visitor groups. These are:

1. Short-stop travellers
2. Day visitors
3. Overnighters
4. Back-country comfort seekers
5. Back-country adventurers
6. Remoteness seekers
7. Thrill seekers

Activity idea

Explore what these visitors come to alpine environments for using activity **Say-It grids** from page 7 in Section 2.

Access

All visitors to alpine environments have to travel reasonable distances. Sites with nearby airports will see a commensurately greater number of visitors. The better the highway access – the higher the number of visitors, particularly short-stay visitors. DOC can manage the numbers visiting some alpine locations by reducing possible access points.

An interesting idea would be to compare visitors to alpine environments close to major tourist cities such as Taupo, Queenstown and Nelson, with those in more isolated locations.

Attractions

During summer, visitors to alpine environments come to walk, climb, take a chairlift/gondola ride and take advantage of scenic flights. Their visits can vary from day trips to camping holidays and multi-day tramps.

During winter, tourists can ski the managed ski runs, cross-country ski, heli-ski, toboggan, snowboard and take scenic flights or a chairlift ride when the weather permits.

Acknowledging **cultural importance** when visiting an alpine environment is important. Everyone should respect the area's tapu status or sacredness as well as the status of a mountain to local iwi, hapū and whānau. The first action when studying an alpine environment should be to find out the cultural history and respect needed when studying and visiting that maunga.

Human use, such as recreational activities, is an important element of national parks in New Zealand. It is also important to think about how balance can be found between recreational use and the preservation of the conservation land.

Check out the DOC website for the more information on the national park and alpine environment you are studying at:

www.doc.govt.nz/nationalparks.

International visitors and their impact

Some trends in the activities undertaken by international visitors in Tongariro, Whanganui and Taranaki during their visit appear in a 2013 International Visitor Survey by the Ministry of Business, Innovation & Employment. Read the full report at: www.doc.govt.nz/international-visitors-survey of key trends:

- Walking and trekking was the third most popular activity for overseas visitors after shopping and dining. In 2012 more than 1.7 million international visitors walked or trekked during their stay in New Zealand.
- Demand for passive experiences offered on public conservation land, including other scenic/natural attractions, lookouts and viewing platforms had increased.
- Land-based sightseeing declined sharply between 2006 and 2009. Numbers were growing again but were currently 25.9% below their 2005 peak.
- Interest in volcanic/geothermal attractions was static.
- Interest in cultural attractions had been declining since 2005, and interest in historic attractions had also begun to decline.

Analysis of the impacts on four key tourist activities – tramping/hiking, visits to national parks, scenic bush walks and scenic drives due to changes in New Zealand's overseas tourism markets indicated a significant impact on DOC's work.

- Declining UK and USA markets – these tourists have high levels of participation in the four activities above.

- Growth of Australia and China markets – these tourists have lower levels of participation in the four activities above.
- A trend towards shorter stays in New Zealand.

Over time this will lead to a visitor mix with lower participation levels than now. Combined with the trend towards shorter stays in New Zealand, this could lead to static or a decreasing number of international visitors using public conservation land.

While there are lower levels of participation among Australian and Chinese visitors, it does not appear that this is necessarily because they lack interest in the outdoors. There is an opportunity to grow the number of Australian and Chinese visitors using public conservation land if the barriers to their participation are understood and the right opportunities are provided.

SUSTAINABILITY

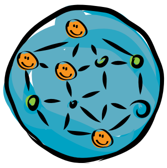
Activity idea

To explore these concepts and results further, see activity **Home and expert** on page 7 of Section 2

Why is this important?

DOC Big Picture ideas at www.doc.govt.nz/bigpicture

The planet's diversity is critical to our survival
Toitū te marae a Tāne, Toitū te marae a Tangaroa, Toitū te Tangata
If we care for the resources of the land and the sea, we, the people, will survive



People are part of the natural world
He nohonga ngātahitanga ahau me te taiao
We live as one with our natural world

Education for sustainability includes learning about:

- The environment – water, land, ecosystems, energy, waste, urban living, transportation.
- The interactions between the natural environment and human activities, and the consequences of these.
- The choices and actions we can take to prevent, reduce or change activities harmful to the environment.
- Leaving sufficient natural resources for future generations.

Central concepts to help students develop understanding include:

- Sustainability – the ability of individuals, groups and communities to meet their needs and aspirations without compromising the ability of future generations to meet theirs.
- Equity – respect for all life, social justice, intergenerational equity, finite resources.
- Interdependence – biodiversity, community, cultural diversity, democracy, globalisation.
- Responsibility for action – taking action, informed decision-making, citizenship, consumerism, enterprise, resilience and regeneration.

What do we want for our young people? (See the New Zealand Curriculum, pg. 8.)

- To be part of securing a sustainable social, cultural, economic and environmental future for our country.
- To be connected – able to relate well to others, connect to the land and environment, and be members of communities.
- To be actively involved – to participate in a range of life contexts and contribute to the well-being of New Zealand, socially, culturally, economically, and environmentally.

A sustainable future

A sustainable future will require citizens who can:

- Recognise that people's actions can impact both negatively and positively on the environment.
- Consider their values and actions in terms of a sustainable future, with environmental, social, cultural and economic consequences.
- Believe that individuals, especially young people, can make a positive difference to ecosystems.

Activity idea

To help explore concepts of sustainability, use the following activities: **Consequence wheel**, **Say-it grids**, **Web of life**, **Investigating the impact of waste** on pages 6 – 9 of Section 2.

Case study 1 – Ski lights vs moths and birds

Lighting ski runs for night skiing vs the effect on moths being killed at the lights and not reproducing (they are pollinators) and birds going off course because of the lights. This has proved to be a significant issue in skifields overseas. Research has shown that green and blue lights have much less impact on insects and birds. Ruapehu Alpine Lifts have the capability to light Happy Valley through to February. There is scope for a lot more research and discussion on this.

Ski chairlift in front of rocky Ruapehu face. *Photo: K. Hartle*

Case study 2 – Tongariro Alpine Crossing

A review to improve the experience and manage growing visitor numbers on the Tongariro Alpine Crossing is underway. DOC has been working closely with Ngāti Hikairo ki Tongariro and all interested parties to improve the visitor experience. Under review are: infrastructure upgrades, a longer-term strategy to manage visitor flows, and the cultural and environmental values of the experience as well as recognising the economic contribution and importance of the Tongariro Alpine Crossing at a local and national level.

Visitors to the 20 km Tongariro Alpine Crossing in Tongariro National Park dual World Heritage Area enjoy spectacular terrain and stunning views. On clear days, they can see Mount Ngauruhoe, Mount Taranaki in the west, the Kaimanawa Ranges, Lake Taupo and beyond.

Popularity of the Tongariro Crossing has been growing steadily and in 2015 there were 125,000 visitors.

For more detailed information, this New Zealand Herald article is useful:

- http://m.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11802549

Or view this video on the Tongariro Northern Circuit:

- www.youtube.com/watch?v=3s2BYVLSB6Y

The Tongariro Alpine Crossing

Case study 3 – Ski club huts

The ski club huts on Mt Ruapehu were built before the park management was taken over by DOC. They are owned by clubs and no more huts will be permitted to be built. There are 38 lodges, each able to sleep a maximum of 32 people and 2 caretakers.

Each ski lodge must conform to the rules of their licence. This covers the building materials, paint colour, outside clear ground, maintenance and the removal of all waste – including human waste products. Upkeep on buildings that spend at least 6 months of the year in snow or extremely cold conditions can cause many problems for small clubs to finance. Any work done on the club buildings requires approval from DOC.

The clubs provide accommodation that is highly valued by skiers – very few other places would give them such close access to the snow. This access can come at a high price to the environment. Diesel spills require the club to pay for contaminated soil to be helicoptered off the mountain, treated, then returned to the mountain and spills from septic holding tanks need to be pumped out and cleaned up.


Ski hut on Ruapehu.
Photo: M. McDonald

If a club is unable to repair a hut they are responsible for removing it from the mountain. If they 'walk away', DOC will face the cost of removal – probably around $100,000.

Are the clubs sustainable? Consider the environmental, social, cultural and economic factors:

- Skiers driving to the mountain at the start of their holiday then driving away at the end put less pressure on the road to Iwikau Village and less pollution into the atmosphere.
- Club members who are keen to retain their huts have an investment in maintaining the huts and the surrounding areas. They may be more likely to be careful on the mountain OR take it as their right to be there and their licence means they can act as they please.
- A clubhouse to relax in at the end of a day on the mountain provides a safe environment for social interaction and learning.
- Skiers and trampers who come to the mountain regularly are likely to be able to help visitors should the eruption alarms start.
- The ski and tramping facilities as well as the scenery bring hundreds of thousands of visitors to the mountain every year. If the club huts were removed, those members may not be able to use the ski facilities so often but commercial accommodation hosts would gain more business.
- Rights given to club members who are financially able to join a club or able to join through attendance at a university is not seen as providing equitable access to the national park.

Ski huts on flanks of Ruapehu.
Photo: M. McDonald

What other factors need to be considered in a discussion on the club huts?