

Management of Karst Landscape in the Waikato

Waikawau Valley. Photo: B Hayward



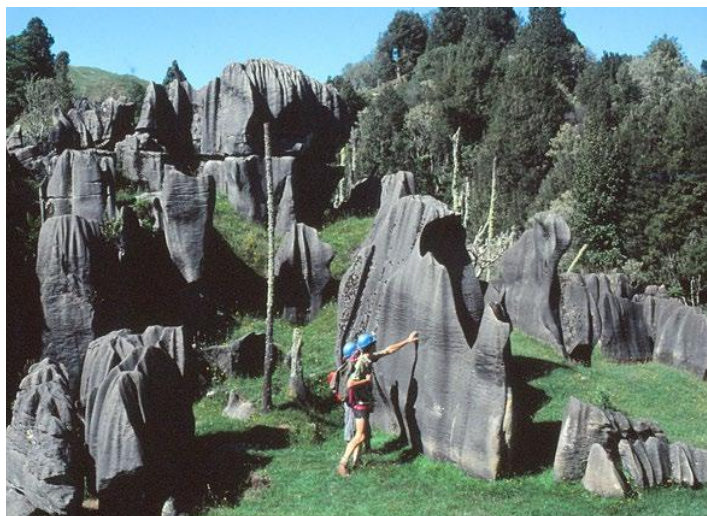
Karst is a limestone landscape with sinkholes, fluted rocky outcrops, disappearing streams, underground rivers, caves, natural bridges and springs. It develops because limestones that are made of calcium carbonate are dissolved by rainfall over time.

The solubility of limestone widens fissures in the bedrock and allows runoff to penetrate underground and to develop caves. Because karst drainage is subterranean the surface has few streams, but subsurface streams are numerous like intricate stormwater sewer systems and can travel several kilometres through caves before reappearing at the surface again. The flow rate in cave streams is about the same as in a surface river and there is little or no filtration so that karst springs in the Waikato are generally no cleaner than surface rivers.

Unique karst landforms and hydrology

Because karst only occurs on rocks that are particularly soluble, the landforms produced are unique and different from those found on most other rocks. Sinkholes, karren and caves are well known features of karst. Valleys are replaced in karst by internally draining sinkholes that direct water underground. Subterranean cave streams may flow in unexpected directions, often crossing beneath surface watersheds. Rivers that have cut right through the limestone onto impervious rocks beneath follow gorges bounded by limestone cliffs. Some of these gorges were once caves that have been unroofed over time by progressive cave ceiling collapse.

Every year in the Waikato about 186 tonnes of limestone is carried away in solution from every square kilometre of karst country.



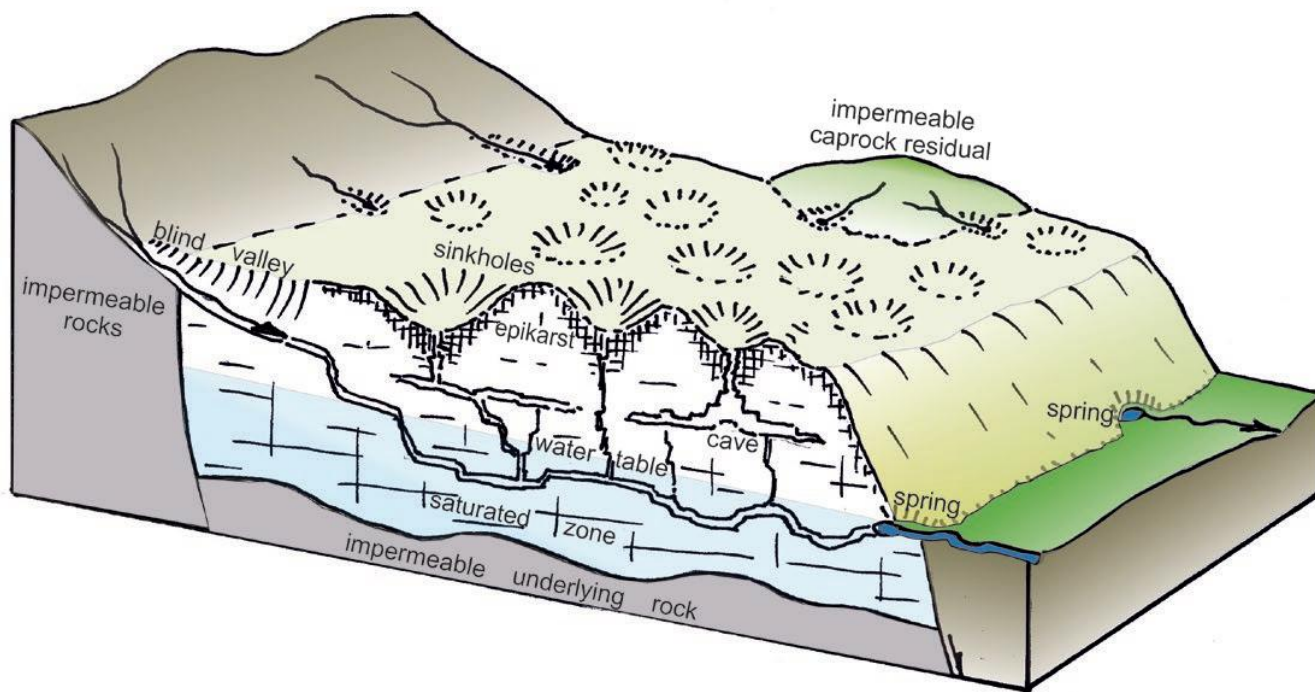
Outcrops of limestone are fluted vertically by solution runnels collectively termed karren. They were originally formed beneath native bush which provided a relatively acidic environment in which limestone solution was enhanced. Photo: P Williams



A dry canyon in karst, almost certainly the remains of an unroofed cave. Part of Grand Canyon Cave, Puketiti Station. Photo: P Williams



Karst sinkholes (dolines) on farmland near Waitomo. Photo: P Williams



Three-dimensional characteristics of a limestone landscape in the Waikato region, including its surface karst topography and its subsurface cave and groundwater system.

Sinkholes and tomo

Known scientifically as 'dolines', sinkholes are funnel or bowl-shaped depressions most often formed by solution of the rock, although the steeper sided ones are formed by a collapse into a cave. Smaller collapses at the surface, where a plug of soil has dropped into a bedrock cavity, are locally known as 'tomo'. Sinkholes collect rainwater and funnel it underground, functioning as valleys do in a normal landscape, draining runoff. Every one of these sinkholes directs runoff downslope to a central low point from where it drains into caves, sometimes quickly if there is an open shaft, sometimes slowly if the bottom has a thick covering of soil or if the shaft is blocked with weathered debris.

Blind valleys

Sometimes drainage from other rocks flows onto limestone, where it sinks underground, and the valley ends abruptly. Such features are termed blind valleys.

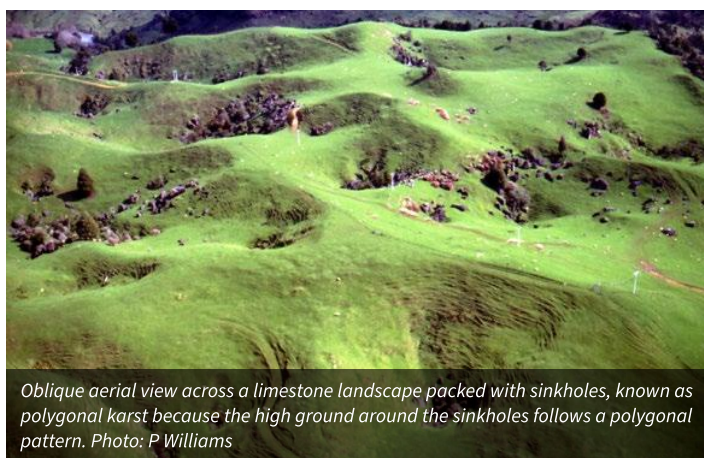
Fluted rock or karren

Solution of limestone bedrock outcrops by rainwater creates small gutters or flutes called 'karren'.

The epikarst

The link between the surface and the subterranean is a zone known as the epikarst. It includes the highly weathered bedrock near the surface and any soil covering it, usually comprising a zone about 10m in thickness. The epikarst occurs because solution of bedrock is faster near the surface and becomes less effective with depth because water loses its acidity as it becomes saturated with calcium carbonate. Water is held in the epikarst because the width of opened fissures tapers downwards, and incoming drainage encounters a bottleneck effect. This provides a habitat for rare aquatic invertebrate species and sustains the drips of stalactites through long dry summers. Importantly, the epikarst catches unwanted spillages and infiltrating wastewater from the surface.

The extensive, intensely pocked sinkhole country of Waitomo is the best example of polygonal karst (a landscape resembling a giant egg-tray) in New Zealand and the temperate Southern Hemisphere. It developed under dense temperate rainforest and has been evolving in the Waikato for perhaps two million years.



Oblique aerial view across a limestone landscape packed with sinkholes, known as polygonal karst because the high ground around the sinkholes follows a polygonal pattern. Photo: P Williams

Caves

Caves are typical of karst because drainage is routed underground. Most of the biggest caves in the Waikato region are found downstream of stream-sinks in blind valleys. Cave streams behave much like their surface counterparts, except that they flow in a tunnel.

Gardners Gut Cave has the longest surveyed passages in the Waikato region totalling 12.2km.

Karst ecosystems

The karst ecosystem comprises limestone rocks, soil and vegetation, karst landforms, caves, subterranean streams, and their fauna. The ecosystem provides many and varied services:

- Karst is a sink for atmospheric CO₂, consumed during the solution of limestone.
- Karstified limestones store groundwater resources.
- Fissured rocks and cavities provide protected habitats and refugia for rare species.
- The alkaline environment provides specialised niches for rare lime-loving plants.
- Caves act as nature's vaults, storing items that record natural history of the surrounding region.
- Karst landscapes and caves offer numerous unusual tourist attractions.
- Karst country supports forest and agricultural resources.
- Carbonate rocks provide essential resources for industry.
- Karst and caves are of cultural and spiritual significance to Māori.

Karst ecosystems are naturally uncommon and are therefore considered Significant Natural Areas (SNA) for indigenous biodiversity protection in the Waikato region.



Cave spleenwort (*Asplenium cimmeriorum*). Photo: Glowing Adventures

Life in karst: above and below ground

Karst landscapes contribute significantly to the biological diversity of the Waikato region and support some unique animals and plant communities, several confined to this region. Highly fertile limestone soils can have diverse plant communities which in turn support high productivity ecosystems with rich animal assemblages and complex food webs. However, high nutrient content vegetation can favour grazing and browsing by animals and fertile soils are exploited by exotic weeds following forest disturbance.

Plant and animal communities are influenced by the variety in habitat and microclimate found across Waikato's karst landscapes from shaded, moist and cool cave entrances to sunny rock outcrops and salty windblown coastal cliffs.

Above ground biodiversity

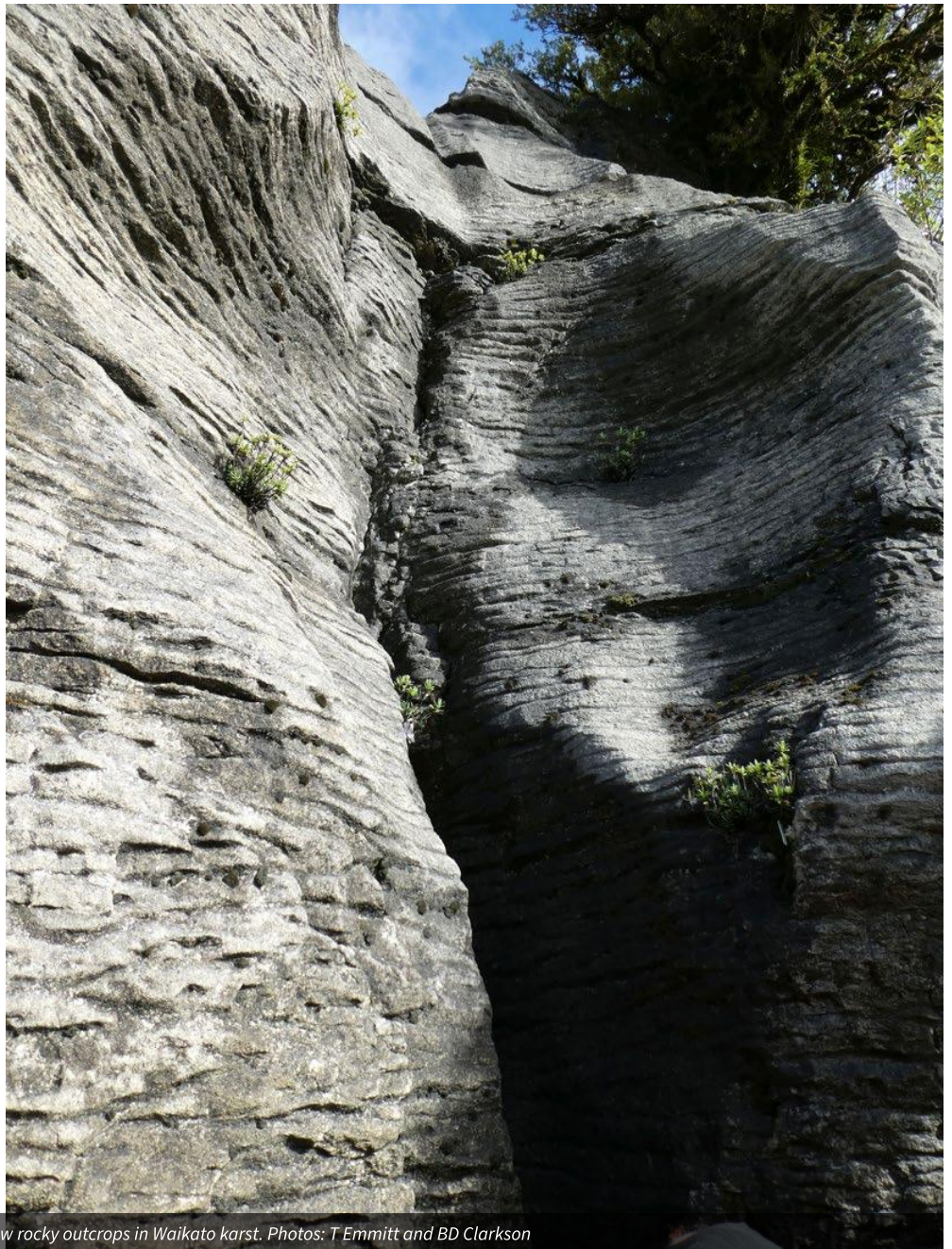
Karst landscapes produce an alkaline soil environment through the weathering of limestone, and this favours plants with a tolerance of, or a preference for, lime-rich soils (known as calcicoles). A few plant species which are most intimately associated with limestone substrate are classified as "threatened" with or "at risk" of extinction due to a combination of both the natural rarity and in many cases degradation of their favoured habitat.

Forest composition across Waikato's karst landscapes is diverse due to the combination of limestone with differing adjacent parent rock materials and the climatic variation from north to south e.g. Port Waikato to Mōkau on the west coast, and from coast to inland e.g. Kāwhia to Waitomo and to Coromandel on the east coast.

- Plants found specifically around **cave entrances** in the Waikato include some characteristic ferns, mosses and liverworts, including the rare *Asplenium cimmeriorum*. Also found in the vicinity of, but not restricted to, forested cave entrances are the rare shrub *Teucrium parvifolium* and king fern (*Ptisana salicina*) and the rata vines *Metrosideros colensoi* and *M. carminea*. The distinctive, orange-flowered shrub *Rhabdothamnus solandri* and the shade-loving groundcover parataniwha (*Elatostema rugosum*) are also often associated with limestone gorges and cave entrances.



Nikau cave waterfall. Photo: Y Deng



Awaroa hebe (Veronica scopulorum) endemic to a few rocky outcrops in Waikato karst. Photos: T Emmitt and BD Clarkson

- **Limestone outcrops with cliffs and crevices** support lime-loving plants and can provide refuge for native vegetation and animals from browsing and predation by pest animals and from land development. The ferns *Asplenium lyallii* and *A. trichomanes* are often associated with this habitat, as is the uncommon small tree *Pittosporum huttonianum* which does not occur south of the Waikato.
- Near the **coast** *Scandia rosifolia* is a cliff-dwelling herb which is largely confined to coastal limestone around Raglan, Kāwhia, Te Anga and further south of the region. At the southern edge of the Waikato region the cliff-dwelling daisy *Brachyglottis turneri* has been recorded on limestone in the Mohakatino catchment, apparently the northern limit for this rare species. *Peperomia urvilleana* is creeping, succulent groundcover herb often found on rocky limestone outcrops near the coast and extending inland around Waitomo.

A range-restricted cliff-dwelling shrub species known only to occur in the Waikato- the Awaroa hebe (*Veronica scopulorum*) is found on only a handful of rock outcrops in the partially forested karst landscape inland from Kāwhia.



A cave wētā species in the Nikau cave. Photo: Y Deng

Cave and subterranean stream fauna

In general, the karst-associated animal species in the Waikato do not display high diversity. This may be for a number of reasons, including the past effects of volcanism on the karst. But the limited studies undertaken have found species which are endemic to or found only in the Waikato karst. These include tiny snails found in surface seepages and in cave streams; aquatic crustacea and mites found in cave streams; and blind cave beetles and pseudoscorpions. One genus of snails, *Leptopyrgus*, with three seepage-dwelling species, is endemic to Waikato region. Two of these snail species are only known from karst sites. The cave beetle *Neanops* has two species found only in southwest Waikato caves.

Many of the outlying, smaller karst areas away from the main west Waikato karst have not been as actively searched for fauna and it is likely that some will have their own species.

The nationally threatened long-tailed bat uses at least two cave sites in Waikato karst. Further native animals associated with, but not limited to, karst landscapes in the Waikato include glow worms, several cave wētā species and threatened fish species including long-fin eel/ tuna.



Caves and sinkholes have immense value in recording evidence of past fauna and flora compositions, paleoclimates and geological histories. The stable environment and high calcium conditions aid fossilisation and the preservation of archaeological sites.

Threats to karst landforms and ecosystems

Indigenous lowland forest or shrubland was once widespread over karst landscapes, now it is much reduced in extent and often consists of secondary forest recovering from burning or logging. Vegetation clearance and agricultural land use damages natural habitats and stream water quality through accelerated soil erosion, increased nutrient and sediment loads and raised temperature in subterranean aquatic ecosystems. Human settlements and infrastructure can cause further soil erosion and introduce pests and pollutants.

Historical forest clearance and poor land management practices are the main threats to karst landscapes.

Patches of remnant native vegetation are often now confined to cliffs or gullies which offer protection from disturbance and these inaccessible landforms become a seed source and refugia for native plants and animals lost from neighbouring habitats.

In many areas forest cover continues to be lost and is degraded from ongoing disturbances associated with forest fragmentation, such as reduced buffering due to the small size and increased distance between remnant patches, while ongoing stock grazing and feral animal browsing can create an open understorey allowing exotic weed invasion.

Forest vegetation buffers drying winds and extreme fluctuations in temperature leading to increased air humidity and soil moisture. This affects the microclimate around cave entrances and throughout entire cave systems. Dense canopy cover also lowers light levels discouraging weed establishment and provides an accumulation of leaf litter and humus into the nutrient cycle.

Native vegetation on and around limestone features is valuable in influencing microclimate, nutrient cycling and animal food webs.

Under natural bush cover trees and their roots restrain soil movement allowing natural rock fissures on the sinkhole floor to remain more open, whereas in cleared areas drainage can become clogged with vegetation debris and eroded soil.

Karst ecosystems are also impacted by the destructive activities of quarrying and the more subtle effects of construction, tourism, forestry harvesting and waste dumping. Damaging activities include:

- Wastewater discharge.
- People in cave systems damaging fragile rock formations, deposits and artefacts and altering air temperature and humidity affecting cave flora and fauna and the growth of rock formations.
- Dumping of chemical pollutants in and around sinkholes can get into groundwater and pollute water sources quickly and unpredictably, potentially emerging again through springs some distance away.
- Forestry increases erosion following harvest and pines produce particularly acidic leaf litter altering the alkaline environment and are not appropriate for reforestation.



Raglan coastal karst. Photo: E Overdyck

Restoring karst ecosystems

The most important step that can be taken to conserve karst, its ecosystem and water quality is to encourage vegetation conservation and restoration to redress forest loss. This will lead to habitat recovery, reduced flooding and sedimentation, and water quality improvement.

The reestablishment of woody and shrub vegetation adjacent to limestone features and along corridors connecting remnant forest patches will provide suitable soil, humidity and light conditions to suppress weeds and encourage further establishment of native shrub and groundcover species. Creating and enhancing corridors will encourage the movement of native animals including bats, birds and insects, restoring food webs and ecosystem processes such as pollination and dispersal of native seed.

Restoration of karst landscapes should involve careful planning and consider the appropriate measures to take and in what order (see Appendix I). This will vary with differing karst landforms and levels of degradation. Riparian margin protection for springs and streams that connect to cave systems and protecting catchments around sinkholes or tomo is valuable in reducing sediment and nutrient runoff into cave systems. Planting around limestone rock outcrops or cliffs will buffer these special habitats. Broad habitat protection can involve stock exclusion and the control or exclusion of large pest animals (goats, deer, pigs) while more site-specific activities may include control of small pest animals (possums, rodents, mustelids, hares and rabbits), exotic weed control and planting of suitable native species.

Good stewardship practices in agriculture, forestry and feral animal and weed control that apply to other landscapes are also required in karst landscapes, as they are no less vulnerable.

How do I protect karst on my property?

Use the action plan in Appendix I of this factsheet to help you identify priorities for the management of karst ecosystems on your land. Websites with further information e.g. restoration planting, predator control and funding are also listed. Seek advice if you need help identifying the management issues for your site.

- Please contact Waikato Regional Council to find out about 1) rules around water abstraction or discharge, undertaking earthworks, vegetation removal or overburden and small-scale cleanfill disposal and 2) assistance with restoration of on karst land including fencing and pest control funding. Freephone 0800 800.
- Please contact your local district council to find out about rules relating to land development on karst areas in your district including forestry, extractive industries, vegetation clearance, earthworks and fill placement and establishing structures.

Appendix I: Choosing actions to protect your karst ecosystem.

Reproduced from BD Clarkson, M Cursey and K Denyer 2006 (updated 2018) *Restoring Waikato's Indigenous Biodiversity: Ecological Priorities and Actions*. The Waikato Biodiversity Forum, pp 68-69. See link below.

ACTION AND PRIORITY	COMMENTS
<p>Protect water table</p> <p>Avoid damming or diverting water</p>	<p>Karst ecosystems are created by the erosive effects of water. Changes in water supply can damage cave systems. Major dams, in-cave dams and major water takes could create an issue.</p> <p>Talk to Waikato Regional Council if you are concerned about possible damming or diverting.</p>
<p>Reduce pollution</p> <ul style="list-style-type: none"> - Sediment - Nutrient run-off 	<p>If your cave system has a stream flowing into it, consider retiring the riparian margin and providing a planted swale to absorb excess nutrients out of the water. See planting below to deal with run-off.</p>
<p>Reduce human damage</p> <ul style="list-style-type: none"> - Don't take 'trophies' - Limit trampling - Take all rubbish from cave 	<ul style="list-style-type: none"> • Cave formations can be damaged by touching. Leave some caves 'untouched' and use well visited caves to reduce the number damaged by humans. • Never touch, break off or damage cave formations. Leave them for others to enjoy. Take only photos. Even broken bits of stalactite should always be left in the cave. • Use designated tracks where marked to reduce trampling damage in caves. Avoid bone deposits and untrampled cave floor surfaces. • Take out all rubbish and human waste and dispose appropriately. • Go caving with a leader who understands cave conservation and cave safety.
<p>Control stock</p>	<p>If grazing animals can enter your site they will trample the soil and eat the plants, and their dung and urine will pollute the site. Heavier animals, such as cattle are generally more damaging. Even a hot wire will be a good start to keep cattle out. A more robust type of fence will be required to keep out deer, pigs and goats. Priorities for fencing include bush margins, stream margins, spring heads and cave entrances. Be ready to tackle weeds as soon as the last stock are out, you may find the weeds 'take off' when grazing stops.</p>
<p>Control weeds</p> <ul style="list-style-type: none"> - Regional plant pests - Limestone specialists - Other weeds 	<ul style="list-style-type: none"> • While weeds won't grow in the dark of underground karst ecosystems, they can reduce the natural value of the landscape on the surface and around cave entrances. • Deal with weeds you are legally obliged to. See the plant and animal pests section in Waikato Regional Council's website. Be vigilant for weeds in nearby sites that are not in your site - yet! • Weed control may need to be targeted in relation to karst-reliant native plants. A particular weed of karst landscapes is <i>Geranium robertianum</i> - the common herb robert - which grows in limestone rock cracks that could be habitat to rare ferns. • Note also that getting rid of some weeds can just encourage others! Get good advice on weed management.
<p>Control pests</p> <ul style="list-style-type: none"> - Hoofed animals - Possums, rodents, mustelids, cats - Rabbits/hares (if planting) 	<p>Pests cause damage to the special forest systems that grow on the surface in karst landscapes. Pests include deer, pigs, goats, rodents, possums, mustelids, rabbits, hares and feral cats. It is also likely that rats impact on cave ecosystems.</p> <p>Target the large animals first - they will be easier to find and if the site is well fenced may be able to be eliminated. Use a trained hunter to shoot deer, goats and pigs. Other pests will need ongoing control using traps or poisons. Seek advice from the Department of Conservation regarding control methods and best practice.</p>
<p>Planting</p> <ul style="list-style-type: none"> - Buffer - Enhance - Connections - Maintain 	<ul style="list-style-type: none"> • Firstly, you should consider planting the edges of streams, springs, tomo and cave entrances to trap sediment and run-off. Also consider planting to buffer existing native bush remnants. • If the site is of unnaturally low diversity and isolated from natural seed sources, consider enhancement plantings. Make sure they are appropriate to the site - get advice. If you have to remove a lot of weeds, consider enhancement planting of natives as soon as possible to reduce the chance of another weed filling the space. • If your site is isolated from other natural areas, consider planting corridors of vegetation to encourage birds to move between them. Retirement and planting of streams will provide for this. • Keep your plantings weed free until the plants are well established. Small plants can be smothered by rank grass. Protect from rabbits, hares, and stock. • Retiring areas around cave entrances, including shaft entrances, will help the caves.

ACTION AND PRIORITY	COMMENTS
<p>Enhance native fauna</p> <ul style="list-style-type: none"> - Cave species - Surface fauna 	<ul style="list-style-type: none"> • Cave fauna are often present in low numbers and are vulnerable to impacts. Help protect them by reducing pollution and human damage (see previous page). • Surface fauna such as forest birds and/or bats will benefit from the actions noted above (particularly pest control and fencing).
<p>Monitoring</p> <ul style="list-style-type: none"> - Measure change 	<p>It is important to be able to measure the effect of any management activities on karst features.</p> <p>Having baseline data is important. Take photos of your site prior to any action. Undertake photo monitoring at set intervals. Visual inspections and biological surveys may also be useful. In terms of any restoration planting, keep records of which plants survived and those that didn't so you can learn for next time. If the project is large and needs a lot of funding get a professional monitoring programme in place, to justify the next round of grants.</p>
<p>Legal protection</p>	<p>If a site is not legally protected as a reserve or private covenant, it's generally best to seek legal protection when the site is in good condition. However, if you are planning to protect the site and you need to fence it, it pays to contact QEII National Trust first, as they usually share the fencing costs. Talk to the Department of Conservation about other options for protecting karst and cave features.</p>

Further Information

- Waikato Regional Council waikatoregion.govt.nz/
- Waitomo District Council waitomo.govt.nz/
- Waitomo Museum waitomocavesmuseum.nz/
- QEII National Trust qeii-national-trust.org.nz/
- Waikato Biodiversity Forum: Biodiversity resources (Restoring Waikato's Indigenous Biodiversity: Ecological priorities and actions) waikatobiodiversity.org.nz/resources/
- Waikato Regional Council Funding: Natural Heritage Fund waikatoregion.govt.nz/natural-heritage-fund/
- Waikato Regional Council Funding: Small Scale Community Initiatives Fund waikatoregion.govt.nz/small-scale-community-initiatives-fund/
- Waikato Regional Council: Native plant nurseries supplying the Waikato waikatoregion.govt.nz/native-plant-nurseries/
- Department of Conservation: Planting guide for Western Waikato (includes karst landscapes) doc.govt.nz/globalassets/documents/conservation/native-plants/waikato-ecological-restoration/planting-guide-western-waikato.pdf
- Department of Conservation: Predator free 2050 How to trap in your community doc.govt.nz/nature/pests-and-threats/predator-free-2050/community-trapping/

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Nikau Cave entrance. Photo: Y Deng