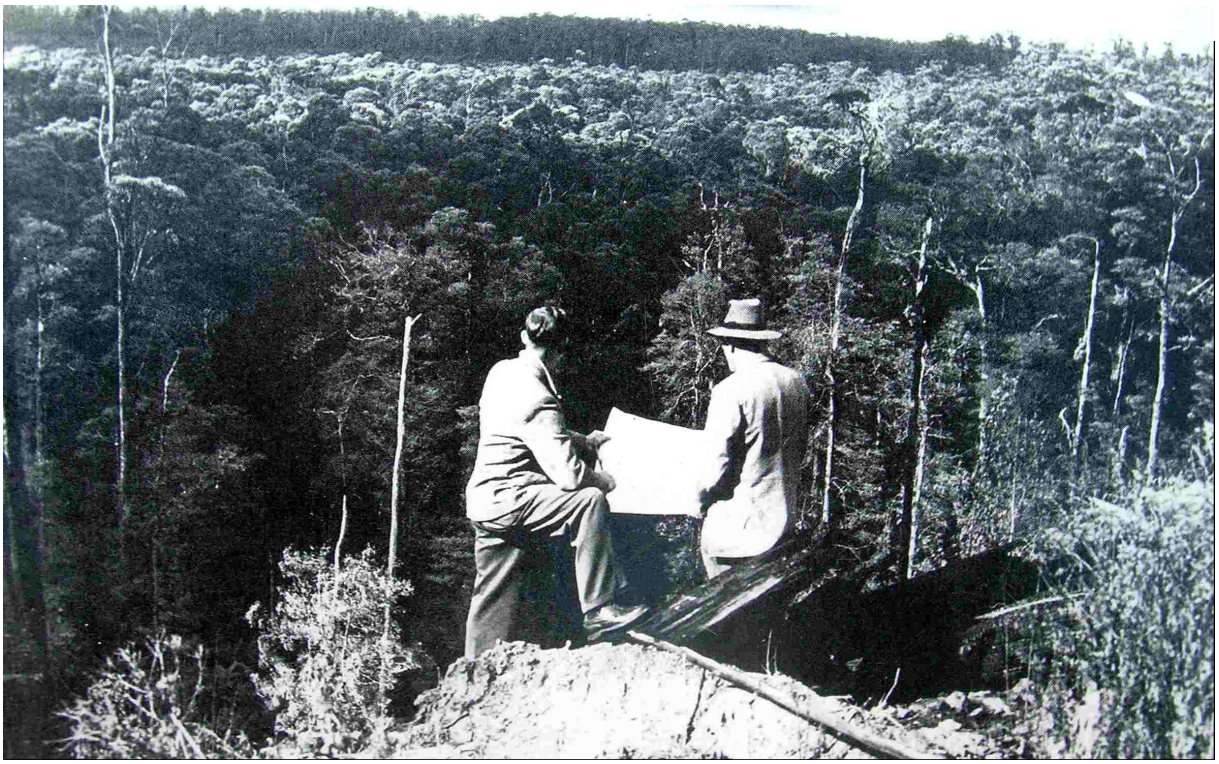
Photo 1: Montagu Swamp prior to drainage and clearing c 1947
(from Brown 1997). Note the flat solutional valley covered with
swamp forest, and steep rims developed on Cambrian metasediments.



UNDERSTANDING, MANAGING AND INTERPRETING TASMANIA'S NORTHWEST KARSTLANDS

- Ian Houshold

The Way to Marrawah

From Smithton to Marrawah the plains go up and down,
With speargrass and button-grass a wave of shining brown,
And white clouds and grey clouds go drifting o'er the lea
For eager is the wooing wind that comes across the sea;
Enchanted are the green hills that beckon from afar,
The wide lands, the long lands,
The uplands, the strong lands,
The lands that stretch from Smithton to verdant Marrawah...

Bernard Cronin (Tourism promotional literature
c1950's, in Marshall *et al* 1989)

If you take the coast road from Smithton to Marrawah the plains indeed 'go up and down' – this part of Tasmania clearly reflects the effects of Pleistocene neotectonics – where karstic plains which were originally graded to sea-level have, since the last major marine transgression (120 000 years ago) been uplifted by approximately 20 metres.

At the height of the last interglacial the plains were awash, forming shallow tidal inlets. Retreat of the sea with the oncoming glacial period left the karst plains blanketed with sand sheets, dunes and beach ridges, where today sea-shells may often be found tens of kilometres inland. This uplift has caused the lower reaches of the Duck, Montagu and Welcome Rivers to incise steep valleys into the dolomite bedrock, headwardly eroding back into the uplifted surface.

The 'green hills' are remnant Tertiary basalt flows which cover the karst rocks to the west, producing some of the most fertile and consistently watered dairy farms in Australia. However, all of this apparent verdance and tranquillity hides the true nature of much of the country in this district.

Photo 2: Brittons Swamp 2006. The landform strongly resembles a classical polje - an extensive, flat-floored solutional basin. This would have resembled Montagu Swamp (photo 1) before clearance.

THE KARSTIC SWAMPLANDS

The direct, inland route between the two towns traverses the country upstream of the major river knickpoints. With gradients of 1 in 2000 or less these catchments were naturally dominated by extensive Melaleuca and Blackwood swamps, the flatness caused by karstic solution of dolomite to a level controlled by a near-horizontal water-table. (Photo 1). Before drainage for agriculture, rivers such as the Montagu, whilst reasonably well defined by channels in their non-karst tributaries, spread out into ever more complex anastomosing channels as the karstic swamps were approached, and eventually no trace of a channel was found until the downstream knickpoints concentrated flows.

In 1928 surveyor Harrisson described the river entering the Montagu Swamp:

> The Montagu River enters as a small creek, and generally dividing into several smaller streams which again spread out, and lose themselves about a mile from the hills. From here, nearly down to the Marrawah tram it is not much more than a swampy depression in which water is seldom found in summer, for miles at a stretch, but which may be five or ten chains wide during the remainder of the year. (Brown 1997).

One hundred years previously surveyor John Helder Wedge was similarly unmoved towards poetry when he traversed these swamps in 1828:

> MARCH 1828
>
> Wednesday 26
> To Swamp – mid leg deep in water. Thick Tea Tree and Sedge obliged to sleep on the tops of Bushes – during the night I found myself lying at an angle of 20 degrees. Head downwards.
>
> Thursday 27
> Swamp Knee deep in water – wet night – Some of the men slept on the trunks of fallen trees, keeping themselves from falling onto the water by stakes, and I slept on a small mound caused by a tree having given way and raised its roots above the surface of the water, with stakes to keep myself from rolling in. (Binks 1980).

These early articles describe classic karst hydrology, where watertables fluctuate over a far greater range than in other rock types, due to the transmissivity of underlying cavernous rock – a conduit-dominated aquifer will fill and drain far more rapidly than porous or fractured rock aquifers, which are far less responsive to inflows from surrounding catchments. Even in this well-watered country (rainfall approaches 2m per year in parts) dairy farmers in drained and cleared swamplands must irrigate in summer from surrounding catchments or bores. In winter their paddocks flood when karstic springs pour megalitres of water into the lower basins, as aquifers overtop.

Photo 3: An estavelle in Dismal Swamp, dry in summer when water drains through the doline into the groundwater system, and drowned in winter, when water floods into the polje from below.

At a regional scale these karst systems stretch over 50km north-south from the coast to the Arthur River and beyond (Fig 1). Forming a fan-shaped series of valleys and depressions, they are bounded by Precambrian metamorphics and basalt along a spectacularly linear feature (probably a fault) to the east, and high-level marine erosion surfaces planing off quartzite sequences to the west. In between the karst valleys and depressions, ridges of Cambrian metamorphic rock form local surface catchments and drainage divides.

Photo 4: Trowutta Arch spans a cenote in hill karst country to the southeast of the main karst valleys.

At the southern apex of the fan, the Arthur River traverses the karst valley, emerging from a sequence of massive, quartzite rich alluvial fans to meander gently over the wide floodplain, before again traversing gorge country to the west. How much of the Arthur river water is diverted north, underground through the karst at this point? Here, a low saddle (less than 15 m high) separates the surface waters of the Arthur from the upper Duck and Montagu Rivers.

This gravel-capped ridge is peppered with dolines confirming subsurface flows. Are the floods in the Montagu related to subsurface flows sourced from the Arthur, or to more local catchments on the Cambrian ridges?

Fish & Yaxley (1996) have suggested that the Duck and Montagu valleys may have been previous courses of the Arthur (the low divide and masses of quartzite gravels covering the karst to the north support this), with surface flow since captured by a west-flowing stream - possibly they still are (although flows are underground!). A hydrological field trip is in order.

Many karst springs are found in the lower reaches of the valleys. Whilst some are cool, many of the major springs are mildly thermal, indicating rapid, pressurised flows from deep aquifers. Most contain high concentrations of calcium, magnesium and bicarbonate, some contain significant quantities of iron and sulphate.

Temperatures are commonly around 20 degrees C, and flows may approach tens of litres per second. The ultimate source of these springs will be very difficult to determine, as water tracing experiments will involve very slow throughflow times, long distances and indirect hydrological pathways through complex subsurface networks.

Most of these springs have deposited extensive areas of tufa, such as the freshwater limestone deposits at Pulbeena. Some of the carbonates have been deposited as mound springs, with the Mella mounds many metres high and hundreds of metres across.

Paralleling the major karstic valleys are discrete, extensive karstic depressions which are partially drained through surface channels (mainly during winter) and internally drained during summer. Brittons Swamp and Dismal Swamp are elliptical depressions, 2-3 km across, bordered by Cambrian metasediments and floored with dolomite. Their form closely resembles classical polje, and the degree of internal drainage present at Dismal Swamp allows it to be classified as such. (Photo 2).

Dismal Swamp is still in almost natural condition. Whilst schemes to drain the swamp for agriculture were proposed last century, growing environmental awareness in the 1970's and 80's allowed people to recognise its ecological value as one of the last remaining intact Blackwood swamps in Tasmania.

Its value as a karst system, linking a hydrological system typical of other dolomite swamps with well-drained sandy soils (rather than peats) and unique associations of Melaleuca and Blackwood forest, has only been recently recognised. However, hydrological and biological work at Dismal Swamp is allowing us to piece together a fascinating ecological story.

The extreme fluctuations in water table level described by early surveyors are still measurable at Dismal. In the northern end of the swamp a doline complex acts as an *estavelle*, draining surface water underground as the water table subsides in summer, and then inundating the swamp with upwelling groundwater as levels rise in winter (Photo 3).

Photo 5. Montagu Cave flooded in winter, and dry in summer.

Photo 6: Montagu Caves – speleothems and Pleistocene bone deposits.

Intact hydrology and ecosystems mean that Dismal Swamp may be used as a reference area for regional environmental restoration works through Landcare and Envirofund programs, to increase the environmental health of surrounding degraded agricultural and forestry lands. Both landforms and biological communities remain as an intact template for rehabilitation.

SURROUNDING HIGH-RELIEF KARST SYSTEMS

In the hillier upstream reaches of the karst systems, where solution has not yet reduced the dolomite to flat-floored valleys, sufficient relief exists to produce more classical karst landforms. Extensive doline fields, some approaching polygonal karst, are found between Trowutta and Julius River. The cenote at Trowutta Arch (Photo 4) and the drowned dolines in the vicinity of Lake Chisolm are both important karst wetlands, the result of collapse on the one hand, and subsidence on the other. The Julius River caves are consist of an underground cut off through a spur in the dolomite, associated with various, mainly vertical systems.

In the downstream valleys, neotectonic uplift and stream incision has drained the plains karst systems, producing accessible caves. Approximately 15km inland, near the 20 metre contour on the west bank of the Montagu River, phreatic network caves are accessible in low dolomite ridges.

Their form probably reflects that of active systems currently below the water table, upstream of the knickpoint in the river bed. As with the karst valleys and estavelles at Dismal Swamp, the water level in these caves also fluctuates dramatically over the seasons (Photo 5). We are planning to correlate water level fluctuations at Dismal Swamp with those in the Montagu Caves.

These caves also contain fascinating sub-fossil remains of Pleistocene megafauna: *Zygomaturus, Thylacoleo* and *Zaglossus,* the giant echidna, were recovered by Albert Goede and others in the 1970s (Photo 6, Murray et al 1977). In one cave, a tooth from a seal was found, suggesting that this cave was probably located close to the coastline during the last interglacial high sea stand. The story parallels that of neotectonics and sea-level fluctuations in the exposed beach ridge karsts over Bass Strait at Tantanoola, where subfossil seal bones have also been found many kilometres inland.

Megafauna remains have also been recovered from drainage ditches in the surrounding karst valleys – particularly at Mowbray Swamp, where *Diprotodon* has been recovered. Raised beach ridge sequences have also been described at Remarkable Banks on Robbins Island and at Harcus River. Aboriginal middens, some forming hills many metres high, and associated hut depressions have been described from the beach ridges.

The story of changing Pleistocene environments, including karst development, sea and land level change (both locally and through correlations across Bass Strait), megafaunal extinctions and the development of natural forest ecosystems dependent on karst processes forms a rich backdrop to the history of Aboriginal and European use of these karst systems.

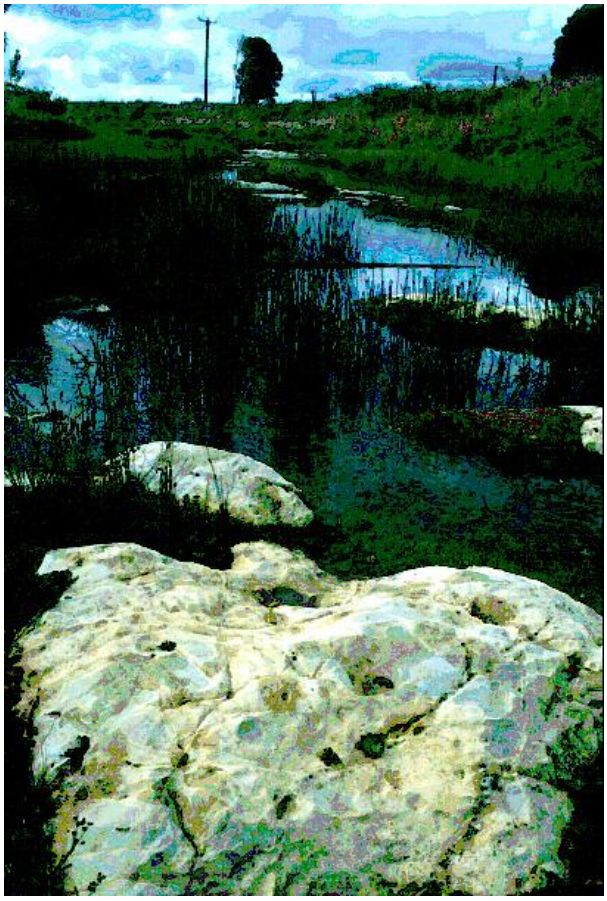


Photo 7: Precambrian dolomite outcropping in the bed of the main drain at Togari (Montagu Swamp) during summer, when streamflow almost ceases. A few metres of sandy marine sediments and wind-blown sand-sheets covers an uneven , but relatively flat karst surface in many of the karst valleys and polje in the northwest.

Photo 8: 'Hump and hollow' drainage of the karst valley at Montagu Swamp (now the district of Togari). This land management system was developed as a direct response to significant seasonal variations in water table depth. Some very productive dairy farms now cover the floors of karst valleys west of Smithton.

PEOPLE AND THE KARST ENVIRONMENT

Farming, mining, forestry and tourism sustain the economy of the northwest karstlands. Karst processes and ecosystems provide the backdrop to everyday life although (perhaps not surprisingly) many people do not yet recognise this explicitly. Individual karst landforms are either quite subdued, or on the other hand, so large that the massive solutional valleys and polje are thought of as 'normal' fluvial valley systems. Karst in the area is defined more obviously by the hydrology of springs, streams and wetlands than the classical karst topography and extensive cave systems at Mole Creek, for example.

Heroic efforts to drain the swamps for agriculture, initially by soldier settlers from both world wars, have produced some successful dairy farms (Brown 1997). The karst hydrology of the swamps has aided this, as the seasonally fluctuating watertable has allowed sandy loam soils to develop on the swamp floors. (Other wetlands in the northwest underlain by impermeable rocks are permanently wet, rather than seasonally, and this has produced deep, highly acidic blanket bog peatlands, with low buttongrass heath, typical of much of southwestern Tasmania – almost useless for farmland).

The karstic substrates and hydrology have made it necessary for farmers to develop special water management systems in order to cope with summer drought and winter floods far exceeding those on surrounding rock-types. Hump and hollow drainage networks, incorporating sediment traps, are common throughout the area, the system developed especially for the karst valleys of the northwest. (Photos 7 and 8). Dairy farmers have also utilised the plentiful supply of warm spring water – one enterprising dairyman at Mella has built his dairy on top of a mound spring, and uses the warm water to clean plant and equipment.

Generally, people have adapted to the vagaries of karst hydrology through trial and error, and some interesting adaptations (such as the 'hump and hollow' drainage systems) have resulted. In future, investigations of karst hydrology, geomorphology and soil science in the area will provide a more logical approach to land management, as land use and demand for groundwater for irrigation intensifies. Controlling the effects of acid-sulphate drainage will be challenging, although plenty of dolomite is locally available to help neutralise runoff.

INTERPRETING THE NORTHWEST KARST SYSTEMS

Understanding environmental history, as well as ongoing hydrology, geomorphology, soils and biological processes should underpin land management decisions in any region. Currently, much environmental interpretation focuses on the ecology of an individual reserve, rather than how people manage and interact with these systems at a broader scale. However, by putting the reserve in its regional context, good quality environmental interpretation can both provide local people with an insight into how natural processes operate in their own back yard, and also inform visitors of the special ways that local people interact with surrounding natural systems.

An opportunity to do this has (perhaps temporarily) been lost at Dismal Swamp (Eberhard 2006 in ACKMA Journal 64). Hopefully as the importance of understanding and communicating the special nature of regional landscapes such as the northwest karsts is recognised and spread, quality regional environmental interpretation will replace, or at least complement the 'gimmicks' that currently lure the eco-tourism dollar. Interpreting complex, subtle landscapes such as the northwest karsts will require some thought and imagination, but the raw materials for a fascinating story are found there.

If done well, environmental interpretation is also a powerful tool in regional land management decision-making, as there are very few similar opportunities for this information to be widely spread amongst local communities. Interpreting reserved land as natural 'benchmarks' or reference areas with which the condition of surrounding more intensively developed lands may be compared, will allow people to make better management decisions. The condition and trajectory (improving or worsening condition) of rivers and wetlands may be measured against a known standard. This is also important when Landcare projects aiming to restore or rehabilitate degraded areas require a reference site to provide a template of natural landforms and biological communities.

...From Smithton to Marrawah the air is like draught
Of red wine and white wine on Mount Olympus quaff'd;
On sand-hill and gully-ridge the scarlet pig-face weaves
A purple pattern in and out among the Autumn leaves...
B. Cronin (in Marshall *et al* 1989)

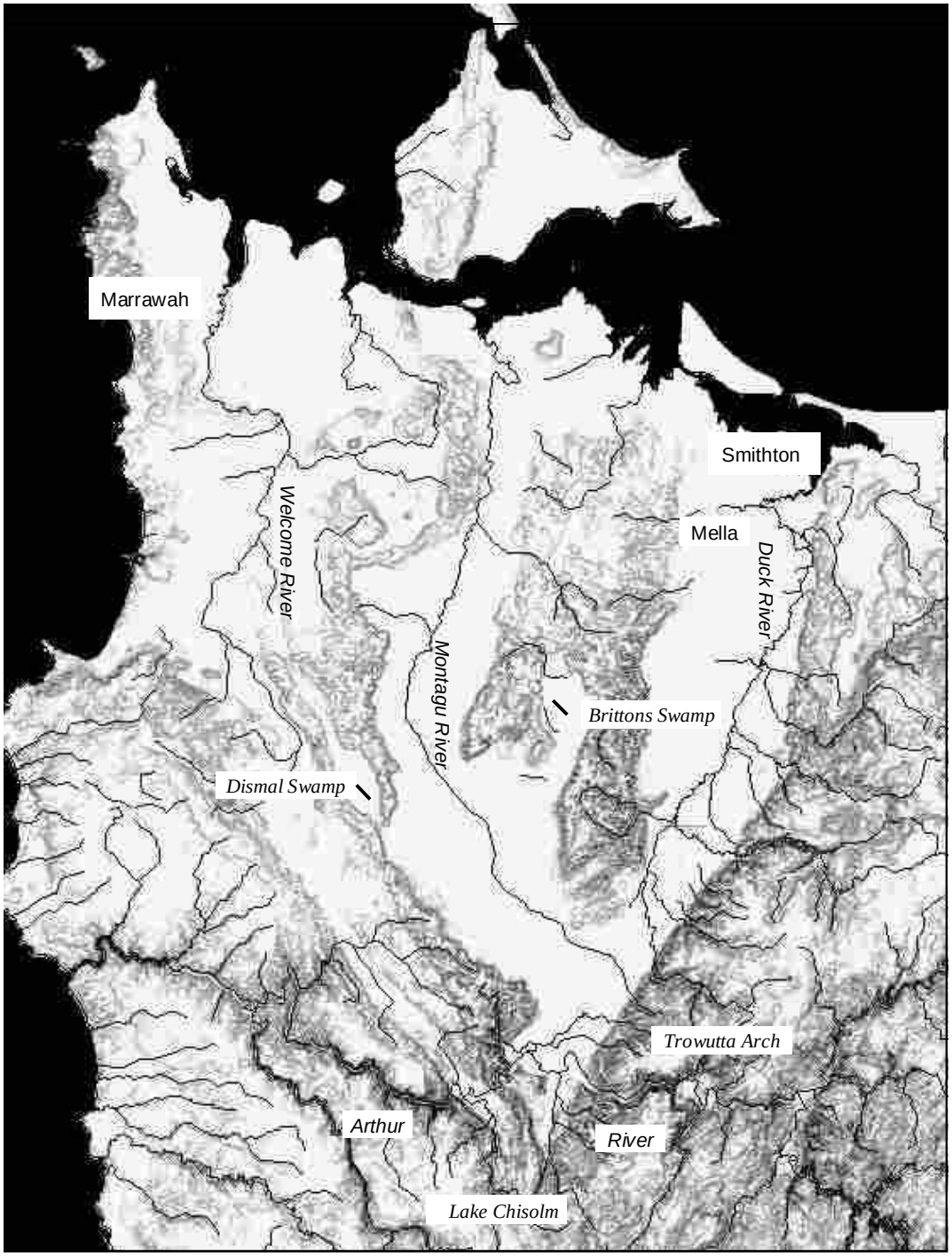


Fig 1: A slope map of the northwest karst systems, derived from a 10 metre digital elevation model. Darker shading represents steeper slopes. The flat solutional valleys are developed on Precambrian dolomite. The polje at Dismal Swamp (and potentially Brittons Swamp) are clearly shown by elliptical basins adjacent to main valleys. Note the meandering course of the Arthur River as it traverses the karst valley in the south.

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