Surface Disturbance Threats to Karst Faunas in Tasmania, Australia

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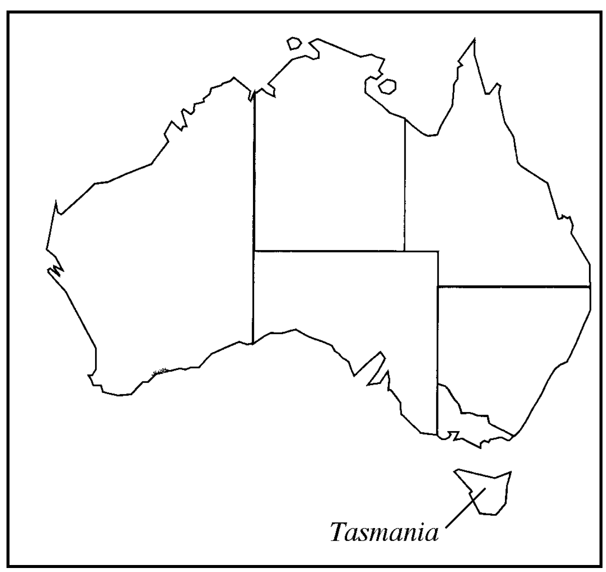
Abstract

Tasmania is the island state of Australia, approximately 160 kilometers (100 miles) south of the Australian mainland. The total karst area in Tasmania is around 3,500 square kilometers (1,345 square miles) representing about 5% of the total Tasmanian land surface of 68,332 square kilometers (26,215 square miles). Some 4,000 caves are reportedly known, mostly found within the 135 documented karst areas; the karst bio-space within these areas contains a diverse array of invertebrates species, aquatic and terrestrial. A number of caves and karst areas in Tasmania have been degraded by land surface disturbance due to mining, road-making, and forestry activity, particularly where the ground-breaking impacts of forestry activity including deforestation occur in upstream catchments. Impacts from surface disturbances have affected karst bio-space ecosystems and food chains leading to disruption of species communities due to a decline in species numbers, species diversity, and actual presence of individual species. The effects of forestry practices including road making and deforestation have lead to increased sediment load and turbidity in cave streams, plus less predictability of stream flow, including a substantial increase in flooding events. Road-making and inefficient conduit of road runoff waters have introduced sediment loads into caves in many parts of Tasmania, impacting on cave faunas. Mining is also threatening several karst areas of Tasmania. In the World Heritage Area Ida Bay karst of southern Tasmania, the limestone quarrying that had impacted on two cave systems, Exit Cave and Bradley-Chesterman Cave, is now being ameliorated by a site rehabilitation of the former Benders Quarry site.

Introduction (and land area comparisons)

Tasmania is the small island State of Australia, lying approximately 160 kilometers (100 miles) south of the Australian continent, separated from the mainland by the Bass Strait. Australia itself is an island—in fact the world's largest island. Size-wise, Australia (including Tasmania) has a land area of 7,686,850 square kilometers (2,971,081 square miles), very similar in size to the 2,960,207-square-mile USA landmass between Canada and Mexico, (excluding Alaska and Hawaii). Despite its large area size, Australia has a small population, around 19 million, roughly as many people as the City of London in England. Some 98-99% of the Australian population lives on the coastal fringe. USA is situated between the latitudes 25°N and 48°N; Australia is situated closer to



the equator: between the latitudes 10°S and 43°S, with the island state of Tasmania at this southern end.

[A few more land area comparisons: Tasmania is a little larger than West Virginia (24,807 square miles); about two-thirds the size of Virginia (39,598 square miles), Kentucky (39,732 square miles) and Tennessee (41,220 square miles); and half the size of Alabama (50,750 square miles) and Georgia (57,919 square miles).]

Caves and Karst in Tasmania

Tasmania is located between latitudes 40 and 43 degrees south; it lies within the cool Temperate Zone and has a weather regime controlled by the influence of westerly winds. Due to topographic influences, the weather pattern in Tasmania has created a moist to wet environment in the mountainous southwestern, western, and Central Plateau areas and a dry central lowland and east coast.

There are approximately 4,000 caves known in Tasmania. Most caves are known from the 135 documented karst areas plus a lesser number of caves from the 40 plus non-karst (pseudokarst and parakarst) areas (Clarke, 1999). Although many of these karst areas are quite small, the total karst area in Tasmania approximates 3,500 square kilometers (1,345 square miles),that is, about 5% of the total Tasmanian land surface of 68,332 square kilometers (26,215 square miles).

In northern and northwestern Tasmania, some karst lies beneath improved pastureland; in western and southwestern Tasmania there is a considerable area of karst underneath either buttongrass sedgeland or alpine vegetation. The actual area of forested karst in Tasmania—predominantly wet or dry, eucalypt dominant, broad-leafed sclerophyl forest and/or myrtle and sassafras dominant rainforest—is probably about 1,800 to 1,900 square kilometers, representing less than 60 percent of the total karst area. There are additional karst areas downstream from forested catchments; some of the catchment forests are being actively logged at present.

Karst areas and cave faunas in Tasmania continue to be threatened by inappropriate forest practices, particularly in karst catchments, along with the effects of road making and mining. The sum-total of these various impacts, either directly below the carbonate rock karst surface or downstream from catchments where groundbreaking disturbances occur, all potentially threaten the faunal component of the karst bio-space.

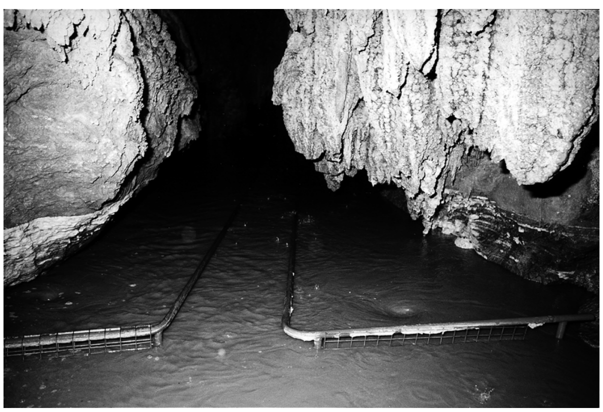
Threatened Cave Fauna Habitats in the Karst Bio-Space

Karst bio-space is a convenient term to describe the total habitat space for aquatic and terrestrial species in carbonate rock karst areas. The karst bio-space is represented as the sum-total of the actual or potential habitats and microhabitats of all living species in karst (Clarke, 1997b, 1997c). This bio-space can be described in dimensional terms as micro-caverns (millimeter), meso-caverns (1 to 15 to 20 millimeters) and macro-caverns (1.5 to 2.0 centimeters) (Clarke, 1997c). Although most of our cave fauna records relate to species known or collected from caves (the macro-cavern component of the bio-space), in many karsts, the saturated (below water table) and unsaturated meso-caverns probably represent the major habitat space component for invertebrate cavernicoles in the karst bio-space. The spatial component of these meso-cavern-sized spaces includes the numerous interstitial voids in cave streambed or streamside substrates as well as the small solution tubes, cracks, and fissures that drain surface waters from the carbonate rock surface mantles, soils, and surface litters.

In Tasmania, there is evidence to show that ground-breaking activity associated with timber plantations, timber harvesting, or mining activity have significantly impacted on karst processes and the habitats of cavernicolous invertebrates (Clarke, 1997a; Eberhard, 1990, 1992b; Kiernan, 1984). The most threatened species are the aquatic species living in the meso-caverns and macro-caverns of the saturated epikarst and endokarst and flooded (phreatic) regions. In some disturbed areas, the hypogean cave faunas in the twilight and transition zones of caves have been replaced by an "invasion" of opportunistic exotic species such as flatworms, snails, and fresh-water crayfish from epigean habitats (Clarke, 1989; Eberhard, 1990). Although the most threatened faunas are the aquatic species, particularly obligate species, any disturbance to the karst bio-space ecosystem and food chain, will ultimately affect terrestrial species.

Nature of the Threat to Karst Bio-Space and Faunas

Soil mantles on carbonate rock are generally thin, clayey residual soils. The mobilized grits from clays in disturbed soil profiles can lead to blockages in solution-widened meso-cavern cracks or fissures in the karst bedrock, impeding further karst solution processes and impacting on the karst bio-space. Ground breaking activity in karst catchments usually leads to an increase of sediment influx into streams from surface runoff. Similarly, forest removal or changed vegetation regimes in karst catchments generally lead to altered stream flow conditions. For example, flooding in stream caves often occurs as a result of the increased water yield following forest removal in catchments (see Figure showing high water levels in Gunns Plains Cave). The effect of flooding is heightened where Radiata pine plantations are harvested along with the marked increase in sediment yield and silt loss compared to harvesting of native forests (Clarke, 1989, 1997a). Needle-leafed pine trees have increased evapo-transpiration rates compared to broad-leafed native forests in Tasmania. The growth of pine trees on karst significantly reduces the water intake of carbonate rock surfaces leading to "drying-out" of caves (Clarke, 1997a) and potential desiccation of invertebrate cavernicoles.



Gunns Plains Cave flooding

Aquatic cavernicoles including stygobionts in hypogean (underground) habitats of karst areas will be threatened by the same impacts that affect aquatic species in surface habitats (Clarke, 1997a). The stygobionts from Tasmanian karst areas are mainly represented by species of crustacean groups: copepods, ostracods, bathynellid syncarids, anaspidacean syncarids, phreatoicidean isopods, janirid isopods and crangonyctoid amphipods, plus two other groups: hydrobiid gastropods and paludicolan flatworms (Clarke, 1997a). The effects on cave faunas will be more marked because of the limited mobility of some species to avoid impacts, for example the minute aquatic snails (Eberhard, 1992a, 1992b) or the narrow habitat range due to restricted hydrological system limits imposed by the individual subterranean karst, together with the naturally low nutrient input levels.

Terrestrial cavernicoles in hypogean habitats of karst areas will be directly and indirectly impacted by effects on aquatic species and alterations to stream hydrology that promote sediment deposition, affect moisture input levels, or interfere with natural air current movements. Terrestrial cave faunas will also be directly impacted by disturbances to the epigean karst surface that modify bio-space humidity due to reduced percolation flow or introduce toxic pollutants (including sedimentation) and similarly modify other natural meteorological conditions related to air volumes and air flow (Clarke, 1997a, 1997b).

Ground Breaking Disturbance Impacts of Forestry, Particularly Deforestation

A number of caves and karst areas in Tasmania have been degraded by land surface disturbance in upstream catchments. Turbid floodwaters have been observed emerging from cave effluxes in the Gunns Plains karst in northern Tasmania and in the Weld River karst of southern Tasmania. Both these karsts are situated downstream from logging operations in forested catchments. Some of the cave communities in stream caves in the Gunns Plains karst area contain very few aquatic species and the terrestrial species in these sites appear to be mainly accidental epigean species and trogloxenes. Similar impacts have been reported in sections of the Mole Creek karst as a result of poor management in forested areas, particularly on private landholdings (Kiernan, 1984, 1989).

Forest practices commonly include road making and snigging tracks; quarrying of stone for road emplacement, fill for low-lying areas, or as road gravels; timber harvesting, clearing, windrowing, and burning; plus the development and maintenance of plantations. Most of these forestry practices will lead to significant impacts on cavernicolous faunas. There will be direct effects on aquatic invertebrates and indirect effects on terrestrial species either in those karst areas underneath forest activity or karst downstream from catchments that are being logged or developed for plantation forests. The cave fauna of karst bio-space will be directly impacted by surfaces disturbances in karst (Clarke, 1997b, 1997c) particularly ground breaking activity and the destruction of surface litter or mulch by forestry practices including fire (Holland, 1994).

Problems of Road Making and Logging with Suggested Solutions

Road making in karst catchments of Crown lands and private lands should follow strict guidelines, such as those in the Tasmanian Forest Practices Code (Forestry Commission, 1993). Roads should be constructed in a manner that avoids sediment input to streams. Ideally, where possible, roads in karst catchments should follow ridgelines; if not on ridgelines, roads should run parallel to and at least 100 metres distant from major watercourses and incorporate sufficient sized drainage channels and sediment traps or settling pits to prevent sediment-laden waters reaching watercourses. If sediment overload is likely to be a problem, filtering mechanisms (such as tea-tree brush or pea-straw bales) should be deployed. Karst catchments should only be partially logged in any given season and logging coupe sizes should be minimal to reduce runoff and altered flow regimes in streams draining into karst areas that are known or likely to contain cave fauna communities.

Where sealed roads traverse across karst, there is a necessity for appropriately designed ducting, conduits, or open table drains (with a sealed base) to convey water off the karst. Where runoff water has to drain into karst from roads or roadside guttering, the runoff water should be transferred via settling ponds or sediment traps as mentioned above.

Threats from Mining

In the Ida Bay karst of southern Tasmania, limestone quarrying has impacted on two cave systems which have related hydrological drainage during periods of high recharge: Exit Cave and Bradley-Chesterman Cave (Clarke, 1989, 1991; Houshold 1995; Kiernan 1993). While the nearby Benders Quarry was operating upstream from Bradley-Chesterman Cave, there was an almost constant smell of petroleum products in the cave streamway, along with an absence of cavernicolous aquatic species (Clarke 1989; Eberhard, 1990, 1997). During the time when the quarry was working there was frequent turbidity in Eastern Passage, one of the major side passages in Exit Cave. Subsequent investigations indicated that the headwaters of Eastern Passage drained from Benders Quarry and the turbidity was due to flocculation of an accumulated bedload of semi-compacted clays derived from the mobilization of the clayey palaeokarst fills in the former Benders Quarry (Clarke, 1991; Houshold, 1992; Kiernan, 1993). Baseline studies in *Exit Cave* indicated reduced population densities of aquatic snails and less diversity in aquatic species in the passages draining to Exit Cave from the quarry (Eberhard, 1990, 1992b, 1997). The minute pinhead-sized hydrobiid snails are known to be a good indicator of water quality (Eberhard, 1992a; Barmuta, 1998); the sparse numbers of hydrobiids in the cave passage leading from Benders Quarry were quite apparent when compared to population numbers and densities in other passages in Exit Cave.

In other parts of Exit Cave, upstream from, or not connected to the side passages draining the quarry, the species diversity was unaffected. For example, four aquatic obligates (all believed to be stygobites) were observed in a short (meter long) stream section of Western Passage: anaspidean syncarids, crangonyctoid amphipods, paludicolan flatworms and minute 1-millimeter sized hydrobiid gastropods (Clarke, 1997a). Benders Quarry was closed in 1992 and since the extensive quarry rehabilitation began in 1993-1994, population densities of hydrobiid snails in Eastern Passage have been slowly increasing. Similarly, recent observations in Bradley-Chesterman Cave indicate that a number of previously unseen cavernicolous species are now appearing in the cave streamway.

Another limestone-quarrying proposal is currently being considered in an area of glaciated polygonal karst at Mt. Cripps in northwest Tasmania—a karst area also covered by a pristine, unlogged myrtle dominant rainforest. Caves in this Mt. Cripps karst area contain many significant invertebrate species, including endemic species known only from single caves in this karst area. At time of writing, the objections to the exploration license for this quarry proposal are still before the Mining Tribunal court in Tasmania.

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About the Author

Arthur Clarke: active as a speleologist on both local (Tasmania) and national (Australian) scene with a background in geology, karst geomorphology, and invertebrate zoology (biospeleology). Actively involved with management aspects in the re-development of the Hastings Caves tourist complex in southern Tasmania. Currently in full time post graduate studies studying for a Masters Degree at School of Zoology, University of Tasmania, (Sandy Bay, Tasmania, Australia) looking at factors affecting the biodiversity and distribution of invertebrate species in cave ecosystems in two adjoining karst areas of southern Tasmania: in Cambrian Dolomite and Ordovician Limestone.

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ASF State Area Co-ordinator for Cave Documentation for Tasmania;

Executive Committee Member and ASF Liaison Officer for the Australasian Cave & Karst Management Association (ACKMA);

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