Science and nature conservation in the wilderness

J.B. Kirkpatrick
School of Geography and Environmental Studies, University of Tasmania, Private Bag 78, GPO, Hobart, Tasmania, Australia 7001
Email: J.Kirkpatrick@utas.edu.au

Abstract

A personal account of some of my experiences of, feelings about, and attachments to the Tasmanian wilderness is followed by a dry discussion of the virtues of wilderness, in general, for nature conservation and scientific knowledge, using the Tasmanian Wilderness World Heritage Area as a case study. The remoteness and primitiveness of wilderness areas makes them some of the most important parts of the surface of the earth for the conservation of biological diversity, although wilderness recreation must be controlled to avoid degrading this resource, and some human intervention may be needed to maintain biodiversity. Scientific investigation in wilderness can provide an understanding of our impacts on other areas, can provide the basis for proper management and can satisfy our curiosity about nature. However, science as a recreational use should not degrade the wilderness resource.

Introduction

The wilderness quality of land is contingent upon its remoteness and primitiveness (eg. Helman et a1 1976; Kirkpatrick and Haney 1980; Lesslie 1991). Land that maintains its primitive qualities may be traversed by roads or rail. Land that is remote from any form of mechanized access may be severely degraded by introduced animals or plants, or by pollutants from industry. In neither of these circumstances would land be considered wilderness. Past a subjective conjoint threshold of remoteness and primitiveness, an increase in either of these qualities results in an increase in wilderness quality. In this paper I address the relationship between wilderness and nature conservation and the importance of wilderness to science, partly repeating the material in an earlier paper of mine (Kirkpatrick 1994). However, before I subside into scientific dryness, I present an account of my experiences of, feelings about, and attachments to the Gondwanan Tasmanian wilderness, in which I have spent much of my scientific life.

A scientist in Gondwanan wilderness

In nature the places that have the greatest variety of life are those where the physical environment has been relatively constant during geological time. The richness rises from within, species evolving to both fill and create niches. The Gondwanan supercontinent must have been a wonderfully rich and varied place, as it lay so long in a warm and

constant world. Its break up is thought to have precipitated the descent into the cold climates of the last two million years. One bit of Gondwanan land lost its richness crossing the equator. In compensation it created the Himalayas, as it crashed into the Asian plate. Another portion of the supercontinent drifted to the South Pole, there to become encased in ice and almost bereft of life. The Australian plate drifted north into aridity, with only a few wet and high parts of Tasmania retaining their Gondwanic biota to any extent or in any richness. Well that is today's story anyway.

In 1969 I was a postgraduate student at the University of Melbourne. My researches involved much travel, as I was studying the southern blue gums, among which is the floral emblem of Tasmania. Tasmania in the late sixties seemed far from the milk bars of Moorabbin and the Administration Building sieges of the universities in Melbourne. It was not even possible to buy a counter lunch, the shops had goods hanging darkly from the ceiling and people wearing beanies sitting around on wooden chairs, and the distances between service stations were monumental. The people in the east of the state were amazingly friendly, very unlike those in the back blocks of New South Wales, where one sensed constant danger to life and limb from the glowering, intolerant inhabitants, and especially from their policemen, clad in black leather and carrying guns to complement their florid physiognomies. But it did rain every night in Tasmania.

With that much rain there seemed little to lose, at least in comfort, by heading for the purportedly wetter west, where there grew few or no blue gums, but where I thought we would find extensive rainforests dominated by the Antarctic beech that filled just a few wonderful gullies among the wet eucalypt forests of southern Victoria. My wife, Sue, and I headed down the Strathgordon Road, a gaping linear wound cut viciously into a khaki and white landscape, unlike anything we had seen before. We camped at a picnic ground which had wood neatly provided, a pipe for a fireplace and a small prefab toilet, all surrounded by tall eucalypts. It turned out to be a bad night, detonators placed in the wood by playful Hydro employees created a visually exciting shower of red hot coals and pieces of our dinner. Atypically, the sky cleared. Afraid of using the wood for heat we crept into our one man tent to start the usual race to get to sleep before our lilos deflated.

We were awakened by the roar of a car engine and bright lights fixed on our tent. Wishing I was back in western New South Wales, I leapt out of the tent, hoping to inflict some damage on the obviously crazed inhabitants of western Tasmania before we were subjected to whatever they had in mind. I slipped on the icy ground then relaxed as I saw that it was one of the sweet Tasmanian policemen, who had previously spoken to us only to tell us that the one remaining hubcap had fallen off our bomb. This one suspected us to be a pair of indomitable bush walkers who had failed to return from the mysteries of the wilderness, where they were almost certainly safer than us.

We awoke in a solid tent. After reducing its volume with considerable physical force, we set off again in search of rainforest. There was a little bit on the right of the road. We clambered through the white, bright jumble that was more visible from space than the Great Wall of China, into Antarctic mysteries, sitting above the fog that filled the valleys of the west. Glowing green moss, the absurdness of pandani and the pink dots of climbing heath all helped restore our psychic equilibrium, and made the horrors of the night subside.

In 1972 we returned to Tasmania. I had been appointed a lecturer in Geography at the University. I have since worked my way up from office boy to professor. I avoided western Tasmania for a while. It was hard enough to adjust to clean air, cold weather and the constancy of teaching commitments without subjecting myself to the rigours of an alien environment, especially since I had seldom walked with a pack and was not particularly fit. However, a day stroll up the north-eastern ridge of Mt. Anne was planned by a few of my colleagues who proved later to look less fit than they were, and a glance at a map showed the distance to not be particularly great, although I should have paid more attention to the number of contours, and the forty metre intervals between them.

Clear skies were obviously characteristic of western Tasmania. Our party gathered in the shards of morning air and desultorily kicked at white pebbles as we discussed the day ahead. It seemed that the route was an overgrown bombadier track, followed by navigation between bits of coloured plastic attached to trees. We were almost explorers. One of the real explorers did not return.

Walking through buttongrass plains turned out not to be one of life's greatest pleasures, but it did assure me that I was not likely to suffer from thirst, a common occurrence on my Victorian day walks. We seemed to be walking through this black morass for ever, but at last we milled uncertainly on a bit of plain searching for the plastic ticket to rainforest and ridge. We started our climb among giant eucalypts and their subordinate, but far from pygmy, myrtles. Soon we left the eucalypts and moved between giant myrtle and sassafras, the ground crumbling beneath our feet.

I was used to ground, and trees, being hard, occasionally brittle and crackling, but never disintegrating upon touch. I did not expect forests that had survived the rigours of geological time to be so fuzzy in their contact with the rest of reality. My muscles ached and my mouth was dry. At last we were to stop for refreshment. There was no water, in a rainforest. My colleagues quested for caves and water does not sit for long on limestone. However, there were pools on the ridge itself, which could not be much further on. I did not ask.

I soon forgot my thirst and fatigue. Suddenly we were among King Billy pines and pandani. The pines had trunks that bifurcated well above the ground, and in the crooks of their bifurcations there grew other trees and shrubs. The pandani were tall, leaning in sympathy with the pines, whose branchlets did almost crackle underfoot.

In this pine forest I was out of time. It could as well have been forty-five million years ago, or ten million years in the future. The forest felt independent of people, and very much capable of self-perpetuation I regretted the pieces of plastic, and the pad just beginning to form. I worried a little about the worth of the wood, a worry exacerbated next year with my first visit to the West Coast Range where King Billy Pine was mined in a singularly ruthless fashion, wherever it was not killed by fires lit by loggers and miners. But the first shock was such that I could not believe such actions possible. In Melbourne we had fought hard to keep a thin strip of coastal tea-tree, riddled with virulent weeds from elsewhere in the world, and garnished with rubbish by beachgoers, from being turned into a car park. If that was important surely this place would last forever.

Thirty years after my first visit that forest is still there, in a Tasmanian Wilderness World Heritage Area I helped a little to create. It may even survive for the future. I now know that forests like those on the Northeast Ridge of Mt. Anne are not particularly common, and that many have been destroyed in the last two hundred years. I also know that the King Billy pine stands in the lower part of the altitudinal range of the species depend on infrequent catastrophe for their self-perpetuation, as the pine seedlings are not successful where dense shade is provided by other rainforest trees. The stand that so affected me probably had its origins in reinvasion of King Billy from the edge of a small burned area more than five hundred years ago. Elsewhere the species establishes on landslips. Not many catastrophes are necessary to regenerate a species that can live for thousands of years, and King Billy walks a tightrope between the absence of catastrophic disturbance and its excess. The paradox of combined durability and vulnerability is one that is common among the Gondwanan relicts.

I gained the top of the Northeast Ridge well in the rear of my companions and in a state of extreme desiccation. I was not charmed by the scoparia that prickled my ankles, and was even less charmed by the total absence of water. However, water there was well below, where a lake sat deep in rainforest in a U-shaped glacial valley. Not quite so far below there was another shelf with occasional bright green patches that hinted of water. The more parched of us headed down. The dense scoparia scratched its way up our bodies until it was overhead, then scratched its way down again. At last there was water, lying among some bright green rocks. Having drunk my fill I was capable of perceiving the environment I had attained with such prodigious effort and hardship.

The glades in Gondwanan forests are the most traditionally beautiful places I have been. No great garden exceeds them in beauty. They are the antithesis of most of the Australian bush, bush that the first Europeans to occupy the continent found grey, monotonous and untidy, but in which I found my Australian identity. The glades are full of contrasts of colour and form, with plants whose symmetry pleases the eye, and are redolent of lands long since extinct. They are the essence of Tasmania.

The vegetable rocks that filled most of the glade in which I now briefly rested were the greatest unexpected delight. I had read of cushion plants in the ecological literature that I perused through interest and necessity, but I did not expect them to be so bright green, billowing and hard, and I was entranced by the miniature gardens that formed on their surfaces. Half a decade later on a small plateau below Federation Peak I came across the mixed species mosaic cushion heaths, again after struggling through scoparia. These form a patchwork quilt of bright blues and greens, each patch equalling one plant. After having worked and played in the high country of Tasmania for three decades I am still delighted and surprised by pattern and detail and its unpredictability, and I still sit and meditate hoping to absorb some of the peace, beauty and spiritual depth that fills these places.

Although it has proved not always to be calm and sunny in Tasmanian Gondwanaland, I have seldom felt any fear. The most dangerous animal stays near his roads, and flimsy material and a bit of stolen down are ample protection against wind, sleet, hail and snow, which all have their own pleasures. But, the wild can be corrupted. At the Walls of Jerusalem there is a place called Dixons Kingdom, Dixon being one of the romantic high

country graziers who broke the fabric of much of the more fertile high country with their fires, cattle and sheep. Much to their chagrin, the mountain cattlemen and their horses have been replaced by hordes of bush walkers attracted to the high cliffs arid grassy, pencil pine forests that may also have lured Dixon. Horse and cattle droppings have been replaced by circles of rock filled with charcoal and silver paper, and the native fauna, always opportunistic, has adapted to the new resource.

No Australian or New Zealander could be surprised to learn that possums have adapted their ways in order to make use of the wilderness tourist resource. There are possums in the middle of Auckland, Melbourne and Sydney. However, many thousands of years have passed since there were marsupial devils anywhere near the sites occupied by these great modern wens. The devil has survived well in Tasmania, developing a taste for dead sheep and cattle, right down to the largest bones. Many a boot has also been lost to a devilish appetite. However, these latter incidents have been sporadic, undoubtedly discouraged by violent men with guns. Bushwalkers are a gentler breed, and have fallen ready victim. While devils do not leap at their throats, they have discovered that packs are transportable and chewable, and that entrance can be gained to tents full of food by the simple expedient of a few seconds chewing and tearing. Although a victim of this corruption of the pure wild, I gain comfort from thinking of it as natures' revenge for silver paper.

The Gondwanan forests in the central mountains of Tasmania have a gentler aspect, devils and possums ignored, than those of the west and south west. Soft herbs and grasses replace hard leaved sedges and shrubs in forest glades, and animals and their signs are more frequently encountered. The pencil pine forests of the Central Plateau are reminiscent of the grass-floored pine forests of the northern hemisphere mountains, but are much more attractive with their close blue-green swards cropped by wallaby and wombat, their squat, twisted, brown-barked older trees and their pyramidal juveniles, only a few centuries old. The trees in these forests were germinates when Terra Australis was Terra Incognito. When the oldest of them germinated, our European ancestors, dwarfed by malnutrition, were subsiding into the Dark Ages from the relative civilization of Roman times.

In lots of ways it is better to be alive now than in Mediaeval Europe. While apocalypse and plague obsessed the people of the Dark Ages to at least the same extent as they obsess the people of today, we do live longer and our Day of Judgement, if it comes, will be an act of free choice on the part of at least one human being with his finger on the button. However, the Mediaeval peasant could think, with good cause, that the physical and social landscape occupied by his grandparents would be little different from that occupied by her grandchildren, if her genetic line avoided Viking raids and plagues. The Aborigines had the same expectations. Great events would live in legend for thousands of years, but a comforting continuity of the form and substance of existence prevailed. Husbanding predominated over innovation.

Any intergenerational continuity in the relationships between people and people, and people and landscape, is the exception rather than the rule in contemporary western societies. Constant change breeds insecurity and conflict as well as wasting the earth.

If we lived in a steady state society, like the Aborigines and most of our other ancestors, we would probably appreciate the Gondwanan rainforests of the wilderness in the same way that we would appreciate the view from our verandah or the taste of home grown potatoes, as an important part of an enduring, interesting and hospitable world. In our growth society the they are both much more important and much more vulnerable. They are one of the few strong links to our important past, and the important past of the planet, that has survived the turmoil of the last two hundred years. They can attach us to a past when the future is insecure and unpredictable. They also remind us of our place in the stream of life, in which we are the floating leaves while the forest is the water milfoil.

The particular floating leaf that returned after dark to the Scotts Peak road, in a severely debilitated state, has since drifted widely in the mountains of Tasmania, enduring the punishment by pack, the ordeal by quagmire, and the test by scrub, in order to have the privilege of visiting and revisiting the wilderness, and attempting to describe, understand and conserve its vegetation. I am happy to report that much more remains to be learned, and that there are many places in the Tasmanian fragments from the ancient continent that I will never visit. May they endure for their own sake.

Wilderness and nature conservation

The remoteness of wilderness, in itself, has some direct benefits for the maintenance of biodiversity. These include the absence of artificial barriers to the movement of native organisms, the absence of artificial channels for the movement of exotic organisms and the distance decay effect noticeable with deleterious disturbances such as anthropogenic fire, fertilizer and pesticide drift, pollution drift, exotic disseminule drift and alterations to drainage and water quality.

The benefits to be gained from the reduction of edge effects are enormous for the first 100 m or so of remoteness, but less marked or negligible with increases in remoteness beyond this distance, as most edge effects have a rapid reverse exponential decline with distance. The major exception is upstream hydrological disturbance. In the western Tasmanian wilderness, the damming of the Gordon River for hydroelectric power has had devastating downstream effects, including a threat to the survival of meromictic lakes near the river mouth (Bowling and Tyler, 1984). In 2005, artificial addition of salt water proved necesary to maintain meromixis and the species that depended on it. Highly mobile invasive plants and animals can be another exception. Marram grass (*Ammophila arenaria*) and sea spurge (*Euphorbia paralias*) have spread on sea currents into the previously pristine wilderness beaches of southwest Tasmania, requiring an active and ongoing eradication effort (Balmer et al. 2004). The bumble bee (*Bombus terrestris*) had penetrated into the far depths of the western Tasmanian wilderness less than a decade after its introduction to Tasmania (Hingston et al. 2002).

Given that edge effects penetrate a reasonably constant distance regardless of the area of a piece of wild land, large compactly-shaped ecological reserves sacrifice less of their area to disturbance than small or convolute reserves. Thus, given the same shape a larger reserve

will have a greater proportion of primitive country than a small reserve. Primitive country is generally the cheapest to manage for biodiversity conservation. Thus, the higher the proportion of biodiversity reserves that is wilderness, the cheaper is the management.

The large areas that are necessary before land can be denoted wilderness increase the likelihood of the survival of a large proportion of native species in response to climatic change. Such change has been, and will be, dramatic. For example, only 18,000 years ago the rainforest of the Western Tasmanian Wilderness was confined to a few low altitude valleys, while alpine vegetation covered most of the area (Kirkpatrick and Fowler 1998). Now, alpine vegetation is rare and rainforest common. Even in the last thousand years substantial climatic changes have occurred (Cook et al. 2001). These changes can be complex, with parts of the Tasmanian wilderness becoming colder and drier over the last 50 years, the reverse of the general tendency (Kirkpatrick et al. 2002).

Wilderness is generally conceived to be a form of recreational land use. Wilderness recreationalists may be passive, or active. While the passive use of wilderness has no direct impact on this resource, the active use of wilderness may have considerable biophysical consequences. Thus, recreational use may degrade the wilderness quality of primitiveness, and, *in extremis*, destroy the resource.

Walkers have spread the root rot fungus, *Phytophthora cinnamomi*, along most major tracks through the south-western Tasmanian wilderness (Podger and Brown 1989; Podger et al. 1990) and have been the source of several fires that have destroyed areas of fire-sensitive vegetation (Brown et al. 1983; Kirkpatrick and Dickinson 1984; Kirkpatrick 1997). Their feet create permanent scars in sensitive ecosystems (Calais and Kirkpatrick 1986; Whinam and Chilcott 1999, 2003). They dig to bury their wastes (Bridle and Kirkpatrick 2003) which in some environments do not break down, creating coproliths (Bridle and Kirkpatrick 2005). Horse riders can potentially create even more damage (Whinam et al. 1994; Whinam and Comfort 1996), although their numbers in the Tasmanian Wilderness World Heritage Area do not yet present a serious problem. The maintenance of biodiversity will obviously require restriction on the intensity and type of use of wilderness, and other primitive areas by recreationalists, and some degree of management intervention in these same areas (Kirkpatrick 2001). I believe that this intervention needs to be directed towards biodiversity conservation, not the replication of the human-free landscape of the interglacial before humans arrived in Australia, or even necessarily the landscape created by the interaction of gatherer-hunters with the rest of the ecosystem.

The concept of primitiveness that prevails among wilderness recreationalists is that landscapes that lack human disturbance best express this quality. However, total freedom from human disturbance might not be the optimal strategy for biodiversity conservation in landscapes that it now seems have been modified by people through the dramatic climatic and landscape changes of at least the last 34,000 years (Cosgrove and Allan 2001). For example, the cessation of Aboriginal patch burning (Marsden-Smedley 1998) has threatened the orange-bellied parrot in the wilderness of south-west Tasmania (Brown and Wilson 1984), and may lead to other significant landscape changes, suggesting that it might

be desirable to cry to artificially create a facsimile of the Aboriginal fire regime (Marsden-Smedley and Kirkpatrick 2000).

Because the attributes of remoteness and primitiveness have only survived in areas that have been of little use to agricultural and industrial people, the wilderness of today contains only a subset of biodiversity. Thus, while wilderness preservation will greatly increase the chances for long term survival of a substantial proportion of our biota and communities it will be insufficient in itself to ensure biodiversity maintenance in Australia. The priority areas for nature conservation lie in the fragmented natural landscapes of the most heavily modified parts of the continent and in improved control of exotic plants and animals (Kirkpatrick 1991; Kirkpatrick 1999; Mendel and Kirkpatrick 2002).

Wilderness and science

Wilderness can be an impediment to many types of scientific investigation, because of the cost of gaining access and the restrictions on manipulation of the environment imposed by the necessity of maintaining naturalness. On the other hand wilderness provides the opportunity to study ecosystems that have suffered little or no modification as the result of the European invasion of Australia. It also provides benchmark areas that allow the development of understanding of the changes wrought in ecosystems by agricultural and industrial activities. These wilderness benchmark areas are particularly important for processes and patterns that incorporate large tracts of land.

The impact of our agricultural, silvicultural and industrial activities on the soils that ultimately provide all of us with life is relatively poorly understood. Wilderness areas allow us to investigate the degree of change from the natural condition. Similarly, wilderness areas contain some of the few largely natural aquatic systems in Australia, allowing investigations of the degree of change that has occurred with human manipulation. For example, scientists visited Tasmania from Scandinavia to look at naturally acidic waters as part of their investigations of acid rain. Our understanding of forest pathology is aided enormously by the existence of remote forests. For example, the myrtle dieback that is affecting Tasmania's rainforests occurs in the most remote and untouched areas, indicating that it is a natural phenomenon.

Apart from the types of practical scientific investigations indicated above, wilderness areas can teach us much about ecological and evolutionary processes. They are large enough for evolutionary and ecological processes to approximate their pre-agricultural form. Given that they occupy types of landscape that were unattractive to economic development,

they may also contain all or most of some types of ecosystems, species and genotypes. The satisfaction of our curiosity about any of these biological entities must rely on scientific work in wilderness.

Discussion

The satisfaction of scientific curiosity about the natural systems of wilderness does have a negative aspect. Part of the spiritual and recreational attraction of wilderness is its mystery. Some wilderness recreationalists have argued that even large scale topographic maps should not be produced, much less detailed geological or vegetation maps. They argue that the human need to accumulate scientific knowledge should, like more material needs, be satisfied elsewhere in the landscape, as the need for mystery and adventure in the unknown fastnesses of nature cannot be satisfied elsewhere than wilderness, whereas scientific investigation is an infinite process that can be undertaken anywhere.

There may be some wilderness areas where unmapped and uninvestigated tracts of land could be regulated to persist without endangering the natural essence of wilderness or the values, other than recreational, that wilderness protects. However, it is hard to know where these areas are without some scientific investigation, and there is no doubt that scientifically-based management prescriptions will be necessary to maintain biological diversity and naturally functioning ecosystems in a large proportion of our wilderness (Robertson et a1. 1992). We have to have the knowledge to keep pathogens, exotic species, unsuitable fire regimes and destructive recreationalists at levels consistent with the maintenance of both wilderness quality and biodiversity. Curiosity–based research could reasonably be considered to be an equally appropriate wilderness activity as peak-bagging and can provide outputs that make the retention of wilderness a prime political object. However, it is critical that scientific activities, like those of other recreationalists, do not degrade the very resource on which they depend (Robertson et al 1992).

References

Balmer, J., Whinam, J., Kelman, J., Kirkpatrick, J.B. and Lazarus, E., 2004. *A Review of the Floristic Values of the Tasmanian Wilderness World Heritage Area*. Nature Conservation Report 2004/3, Department of Primary Industries, Water and Environment, Hobart.

Bowling, L. & Tyler, P., 1984. Endangered lakes of scientific and cultural value in the World Heritage area of south-west Tasmania. *Biological Conservation* 20, 201-209.

Bridle, K.L. and Kirkpatrick, J.B., 2003. The impacts of nutrient addition and digging for waste disposal on natural environments, Tasmania, Australia. *Journal of Environmental Management* 69, 299-306.

Bridle, K.L. and Kirkpatrick, J.B., 2005. An analysis of the breakdown of paper products (toilet paper, tissues and tampons) in natural environments, Tasmania, Australia. *Journal of Environmental Management* 74, 21-30.

Brown, M.J., Kirkpatrick, J.B. and Moscal, A., 1983. The conservation of Tasmanian endemic species found in alpine vegetation. *Proceedings of the Ecological Society of Australia* 12, 168-169.

Brown, P.B. and Wilson, R.I. *Orange-bellied parrot recovery plan.* 1984. Tasmanian National Parks and Wildlife Service, Hobart.

Calais, SS. and Kirkpatrick, J.B., 1986. The impact of trampling on the natural ecosystems of the Cradle Mt. - Lake St. Clair National Park. *Australian Geographer* 17, 6-15.

Cook, E. Bird, T., Peterson, M., Barbetti, M., Buckley, B., D'Arrigo, R., Francey, R. & Tans, P., 1991. Climatic change in Tasmania inferred from a 1089- year tree- ring chronology of Huon pine. *Science* 253, 1266-1268.

Cosgrove, R. and Allen, J., 2001. Prey choice and hunting strategies in the late Pleistocene: evidence from southwest Tasmania. In Anderson, A., O'Connor, S. and Lilley, I. (eds.). *Histories of old ages: essays in honour of Rhys Jones.* Coombs Academic Publishing, ANU, Canberra, pp. 397-429.

Helman, P.M., Jones, A.D., Pigram, J.J. and Smith, J.M.B., 1976. *Wilderness in Australia: Eastern New South Wales and south-eastern Queensland.* Department of Geography, University of New England, Armidale.

Hingston, A.B., Marsden-Smedley, J., Driscoll, D.A., Corbett, S., Fenton, J., Anderson, R., Plowman, C., Mowling, F., Jenkin, M., Kyoshi, M., Bonham, K.J., Ilowski, M., McQuillan, P.B., Yaxley, B., Reid, T., Storey, D., Poole, L., Mallick, S.A., Fitzgerald, M., Kirkpatrick, J.B., Febey, J., Harwood, A.G., Michaels, K.F., Russell, M.J., Black, P.G., Emmerson, L., Visoiu, M., Morgan, J., Breen, S., Gates, S., Bantich, M.N., and Desmarchelier, J.M., 2002. Extent of invasion of Tasmanian native vegetation by the exotic bumblebee *Bombus terrestris* (Apoidea: Apidae). *Austral Ecology* 27, 162-172.

Kirkpatrick, J.B., 1991. The geography and politics of endangerment in Australia. *Australian Geographic Studies* 29, 246-254.

Kirkpatrick, J.B., 1994. Wilderness, biodiversity conservation and science. In Barton, W. (ed.) *Wilderness - the future.* Envirobook, Sydney, pp. 164-169.

Kirkpatrick, J.B., 1997. *Alpine Tasmania: An Illustrated Guide to the Flora and Vegetation*. Oxford University Press, Melbourne

Kirkpatrick, J.B. 1999. *A Continent Transformed- Human Impact on the Natural Vegetation of Australia.* 2nd edition, Oxford University Press, Sydney, 140 pp.

Kirkpatrick, J.B., 2001. Ecotourism, local and indigenous people, and the conservation of the Tasmanian Wilderness World Heritage Area. *Journal of the Royal Society of New Zealand* 31, 819-829.

Kirkpatrick, J.B., Bridle, K. and Lynch, A.J.J., 2002. Changes in vegetation and landforms at Hill One, Tasmania. *Australian Journal of Botany*, 50, 753-759.

Kirkpatnck, J.B. and Dickinson, K. J.M. 1984. The impact of fire on Tasmanian alpine vegetation and soils. *Australian Journal of Botany* 32, 13-629.

Kirkpatrick, J.B. and Fowler, M., 1998. Locating likely glacial refugia in Tasmania using palynological and ecological information to test alternative climatic models. *Biological Conservation*, 85, 171-182.

Kirkpatnck, J.B. and Haney, R.A. 1980. The quantification of developmental wilderness loss - The case of forestry in Tasmania. *Search* 11, 331-335.

Lesslie, R., 1991. Wilderness survey and evaluation in Australia. *Australian Geographer* 22, 35-43.

Marsden-Smedley, J.B., 1998. Changes in southwestern Tasmanian fire regimes since the early 1800s. *Papers and Proceedings of the Royal Society of Tasmania* 132, 15-29.

Marsden- Smedley, J.B. and Kirkpatrick, J.B., 2000. Fire management in Tasmania's Wilderness World Heritage Area: Ecosystem restoration using Indigenous-style fire regimes? *Ecological Management & Restoration* 1, 195-203.

Mendel, L.C. and Kirkpatrick, J.B., 2002. Historical progress of biodiversity conservation in the protected-area system of Tasmania, Australia. *Conservation Biology* 16, 1-11.

Podger, F.D. and M. J. Brown, 1989. Vegetation damage caused by *Phytophthora cinnamomi* on disturbed sites in temperate rainforest in Western Tasmania. *Australian Journal of Botany* 37, 443-480.

Podger, F.D., Mummery, D.C., Palzer, C.R. and Brown, M.J., 1990. Bioclimatic analysis of the distribution of damage to native plants in Tasmania by *Phytophthora cinnamomi*. *Australian Journal of Ecology* 15, 281-289.

Robertson, M., Vang, K. and Brown, A.J., 1992. *Wilderness in Australia – issues and options.* Australian Heritage Commission, Canberra.

Whinam, J., Cannell, E.J., Kirkpatrick, J.B. and Comfort, M., 1994. Studies on the potential impact of recreational horseriding on some alpine environments of the Central Plateau, Tasmania. *Journal of Environmental Management* 40, 103-117.

Whinam, J. and Chilcott, N., 1999. Impacts of trampling on alpine environments in central Tasmania. *Journal of Environmental Management* 57, 205-220.

Whinam, J. and Chilcott, N., 2003. Impacts after four years of experimental trampling on alpine/subalpine environments in western Tasmania. *Journal of Environmental Management* 67, 339-351.

Whinam, J. and Comfort, M., 1994. The impact of commercial horseriding on sub-alpine environments at Cradle Mountain, Tasmania. *Journal of Environmental Management* 47, 61-70.