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Recent Recreation Ecology Research in Australia

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Why do we need recreation ecology research in different countries? Recreational impacts differ considerably between activities and between ecosystems, and Liddle (1997), Sun and Walsh (1998) and Buckley (2004) used these criteria to structure their reviews of research literature. But do findings from one country apply to comparable ecosystems elsewhere?

Different continents and geographical regions have different flora and fauna, even if they have structurally similar vegetation types. Considerable effort has been devoted to identifying the differences as well as the similarities: e.g., for coral reefs (Dubinsky 1990), coastal heaths (van der Maarel 1997), or tropical rainforests (Primack & Corlett 2004).

Except at the crudest level such as wholescale vegetation clearance, recreational impacts are different in different continents. The broad types are similar, but the specific mechanisms, the quantitative relationships, and the shape of stress-response curves may depend on the terrain, climate, evolutionary history of plant and animal species and communities.

In addition, people in different countries tend to take part in different recreational activities, using different equipment and in different ways (Weaver 2001, Buckley 2004, Chizhova 2004, Magro & Amanda de Barros 2004). Land management authorities also use different resource and visitor management tools and techniques. These human differences, however, can be adjusted for much more easily than the ecological differences outlined above.

It is hard to make reliable intercontinental comparisons, because recreation ecology research effort has been heavily skewed to northern developed nations with strong science research funding programs (Buckley 2005). Land management agencies in southern and developing nations have wrongly assumed that research from the UK and USA applies globally. In Australia, the tourism industry has captured research funding programs and suppressed research on impacts.

Australia is one of the world's 17 megadiverse regions (Barlow 1994, Williams et al. 2001). Its flora and fauna have many endemic species, and are generally well adapted to fire, drought and low soil phosphorus, but not to large placental grazing mammals with hard hooves, or to pests and pathogens from elsewhere. We could thus use comparisons between semi-arid ecosystems in Australia, southern Africa and north America, or between subtropical forests in Australia and south-east Asia, to examine how similar recreational activities may produce different impacts in structurally similar but functionally different ecosystems.

Most recreation ecology research in Australia has been on high-impact activities within protected areas, carried out a management level and thus relevant for international comparisons. This includes activities such as: off road driving (Priskin 2003); horse riding (Whinam et al. 1994, Whinam & Comfort 1996, Newsome et al., 2002, Phillips & Newsome 2002); mountain biking (Goeft & Alder 2001); heavily-used backcountry hiking trails (Whinam & Chilcott 1999, 2003, Whinam et al., 2003 McDougall & Wright 2004); camping (Tur-

ton et al. 2000; Smith & Newsome 2002; Talbot et al. 2003); swimming in freshwater dune lakes (Hadwen et al. 2003, 2005); scuba diving on corals (Rouphael & Inglis 1997, Plathong et al. 2000, Rouphael & Inglis 2002); power-boating in freshwater lakes (Mosisch & Arthington 2004) and coastal seas (Byrnes & Warnken 2004); and whalewatching in New Zealand (Higham & Lusseau 2004).

There is also recent work on the impacts of infrastructure, such as: roads and powerlines in rainforest (Goosem 2000, Turton 2003); roads and formed tracks in alpine and subalpine areas (Jones 2000, Johnston & Pickering 2001, McDougall 2001, Johnston & Johnston 2004, Hill & Pickering 2006), and tourism infrastructure on coral reefs and islands (Walker 1991). Most protected area management agencies in Australia also carry out monitoring, but this is generally unpublished and not intended as research.

Several recent Australian studies have advanced recreation ecology research at a global level. Two studies have tested the asymptotic stress-response curve proposed as a general model for the impacts of recreational trampling in North American ecosystems (Cole 2004). Rouphael and Inglis (2002) found that impacts of divers on coral reefs are both spatial and temporally heterogeneous, and do not necessarily increase with increasing use. Some individual divers cause so much more damage than others, that their impacts mask any cumulative effects from larger numbers alone.

Growcock (2005), studying trampling and camping in burnt and unburnt alpine and subalpine vegetation, found that the stress-response curve is commonly sigmoidal, with very little vegetation damage below a lower threshold of use, rapidly increasing damage at intermediate levels, and little increase in damage at the highest levels. The thresholds represent transitions between different types of impact. Below the lower threshold there may be physiological effects on plants, but not loss in cover. Between the lower and upper thresholds there is a loss in overall cover caused by death of individual plants, some species before others. Above the upper threshold the living plant cover is largely gone, and the principal impact is loss of leaf litter and soil.

These impacts have been identified and quantified previously (Cole 1995, 2004, Monz et al. 1996, Liddle 1997). The strength of Cole's work was to identify one parameter, number of passes yielding 50% cover loss, to compare results from different times and places. The key contribution of Growcock's (2005) approach is that it allows the disaggregation of a rather generalised parameter, loss of plant cover, into a series of successive ecological effects each with its own identifiable mechanism.

There have also been several methodological innovations. Giese et al. (1999) used artificial eggs with monitoring devices and remote telemetry to examine physiological stress suffered by nesting penguins approached by tourists. Bridle and Kirkpatrick (2003, 2005) examined the breakdown of human waste of various types, in various ecosystems, and under various weather conditions using novel forms of synthetic human waste.

Some recreational impacts are hard to detect but still significant ecologically. Warnken and Buckley (2004) distinguished microbiological impacts of hikers swimming in rainforest creeks, from the numerically much larger changes due to natural rainfall fluctuations. Buckley et al. (1998) identified previously unrecorded waterborne pathogens, introduced by tourists, in pristine Australian rainforest creeks. Various nocturnal marsupial species respond differently to spotlights of different colours as well as intensities.

Recreational impacts can occur through complex ecological mechanisms. There is recent Australian research on: effects of trackside weeds on pollination success of native plant species; effects of food supplementation by tourists on community ecology of bird populations (Oost 2006 in prep.); effects of backcountry hiking trails on predation by quolls and feral dogs; and effects of snow compaction on small marsupials which travel through subniveal space (Sanecki et al. 2006). One particular issue which has vexed recreation ecologists and protected area managers for some years is the degree to which an education and interpretation program can reduce visitor impacts, actual rather than self reported. Controlled experimental tests are not easy to design, but have been carried out successfully for guided walks in a rainforest World Heritage area (Littlefair 2004).

Transport of weeds is a major recreational impact in Australia (Lonsdale & Lane 1994). Whinam et al. (2005) found ~1000 weed propagules on clothing and equipment from 64 expeditioners to sub-Antarctic islands. Hill and Pickering (2005) examined weeds alongside formed walking tracks in the Australian Alps. Raised steel-mesh walking tracks have far less impact than gravel, paved or informal tracks. In Australia, tourism use of protected areas is a major factor in the spread of the root rot fungus *Phytophthora cinnamomi*, which threatens a wide range of plant species, many of them already at risk of extinction from other causes (Kelly et al. 2003, Schahinger et al. 2003, Buckley et al. 2004, DPIWE 2005, Turton 2005).

Introduced foxes are a threat to many native marsupials in Australia. In the Australian Alps, foxes occur at higher densities immediately around ski resorts, leading to increased predation on native marsupials (Green & Osbourne 1994). Snow grooming in winter increases predation even further, since compaction of subniveal space forces native marsupials onto the snow surface where they are more vulnerable to foxes (Sanecki et al. 2006). Even minor additions of nutrients by tourists can result in significant impacts in some Australian ecosystems. In freshwater dune lakes on Fraser Island, a World Heritage site, increased use by tourists causes algal growth, both by direct nutrient input and through resuspension of sediment (Hadwen et al. 2003, 2005, Hadwen & Bunn 2004). Similar mechanisms were reported for rainforest streams by Warnken and Buckley (2004).

Despite such research, we don't know whether Australian species and ecosystems behave like international counterparts. Are trampling impacts in the Australian Alps different from North America because of the species or the experimental design? Do birds on Australian lakes or shorelines take flight at similar distances from approaching tourists as those in North America or Europe? Do vehicle passes along a sandy beach crush the same number of tern eggs or burrowing crabs? Do marsupials subject to spotlighting behave similarly to placentals?

Key opportunities for international comparisons include the following. We could compare: types and intensities of impacts from the same recreational activities in similar ecosystems on different continents; and the relative ecological significance of different types of impact in different ecosystems. We could set out to identify and test subtle and indirect mechanisms of recreational impacts on particular plant and animal species and communities, by applying other specialist ecological disciplines such as pollination ecology, fire ecology, ecotoxicology, population ecology, predation ecology, reproductive ecology and foraging ecology. We could also examine the indirect impacts of tourism and recreation in altering ecosystem functions, e.g. in dune lakes, snow country, rainforests and coral reefs.

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